An Introduction

Pediatric surgery is a subspecialty of surgery including the surgery of babies, newborn children, kids, teenagers, and youthful grown-ups.

Pediatric surgery emerged amidst the twentieth century as the surgical consideration of birth imperfections required novel strategies and techniques and turned out to be all the more generally based at youngsters’ doctor’s facilities. One of the locales of this advancement was Children’s Hospital of Philadelphia. Starting in the 1940s under the surgical initiative of C. Everett Koop, more up to date procedures for endotracheal anesthesia of babies permitted surgical repair of already untreatable birth surrenders. By the late 1970s, the newborn child passing rate from a few noteworthy inborn mutation disorders had been diminished to close to zero.

Other areas of surgery also have pediatric specialties of their own that require further training during the residencies and in a fellowship: pediatric cardiothoracic (surgery on the child’s heart and/or lungs, including heart and/or lung transplantation), pediatric nephrological surgery (surgery on the child’s kidneys and ureters, including renal, or kidney, transplantation), pediatric neurosurgery (surgery on the child’s brain, central nervous system, spinal cord, and peripheral nerves), pediatric urological surgery (surgery on the child’s urinary bladder and other structures below
the kidney necessary for ejaculation), pediatric emergency surgery, surgery involving fetuses or embryos (overlapping with obstetric/gynecological surgery, neonatology, and maternal-fetal medicine), surgery involving adolescents or young adults, pediatric hepatological (liver) and gastrointestinal (stomach and intestines) surgery (including liver and intestinal transplantation in children), pediatric orthopedic surgery (muscle and bone surgery in children), pediatric plastic and reconstructive surgery (such as for burns, or for congenital defects like cleft palate not involving the major organs), and pediatric oncological (childhood cancer) surgery.

Subspecialties of pediatric surgery itself include: neonatal surgery and fetal surgery.

Common pediatric diseases that may require pediatric surgery include:

- congenital malformations: lymphangioma, cleft lip and palate, esophageal atresia and tracheoesophageal fistula, hypertrophic pyloric stenosis, intestinal atresia, necrotizing enterocolitis, meconium plugs, Hirschsprung’s disease, imperforate anus, undescended testes
- abdominal wall defects: omphalocele, gastroschisis, hernias
- chest wall deformities: pectus excavatum
- childhood tumors: like neuroblastoma, Wilms’ tumor, rhabdomyosarcoma, ATRT, liver tumors, teratomas
- Separation of conjoined twins.
An Introduction

WHAT IS A PEDIATRIC SURGEON?

Surgical issues seen by pediatric specialists are frequently very unique in relation to those regularly observed by grown-up or general specialists. Uncommon preparing in pediatric surgery is essential.

TRAINING OF PEDIATRIC SURGEONS

Pediatric specialists are restorative specialists who have had:
• At slightest 4 years of medicinal school
• Five extra years of general surgery
• Two extra years of residency preparing in pediatric surgery
• Certification by the American Board of Surgery

Pediatric specialists treat youngsters from the infant stage through late pre-adulthood.

They make pediatric consideration the center of their restorative practice, and the exceptional way of therapeutic and surgical consideration of youngsters is found out from cutting edge preparing and involvement by and by.

Types of Treatments in Pediatric Surgeons

Pediatric surgeons diagnose, treat, and manage children’s surgical needs including:
• Surgery for abnormalities of the groin in childhood and adolescence which include undescended testes, hernias, hydroceles and varicoceles
• Surgical repair of birth defects
• Serious injuries that require surgery (for example, liver lacerations, knife wounds, or gun shot wounds)
• Diagnosis and surgical care of tumors
• Transplantation operations
• Endoscopic procedures (bronchoscopy, esophagogastrroduodenoscopy, colonoscopy)
• All other surgical procedures for children
Pediatric Surgeon

Pediatric surgeons practice in a variety of medical institutions including children’s hospitals, university medical centers, and large community hospitals.

Pediatric Surgeons — The Best Care For Children

Children are not just small adults. They cannot always say what is bothering them. They cannot always answer medical questions, and are not always able to be patient and helpful during a medical examination. Pediatric surgeons know how to examine and treat children in a way that makes them relaxed and cooperative. In addition, pediatric surgeons use equipment and facilities specifically designed for children. Most pediatric surgical offices are arranged and decorated with children in mind. This includes the examination rooms and waiting rooms, which may have toys, videos, and reading materials for children. This helps create a comfortable and nonthreatening environment for your child.

If your pediatrician suggests that your child see a pediatric surgeon, you can be assured that he or she has the widest range of treatment options, the most extensive and complete training, and the greatest expertise in dealing with children and in treating surgical disorders.

DIFFERENT TYPES OF PEDIATRIC SURGERY

Chest Wall Deformity

_Pectus Excavatum and Carinatum_

Mid-section divider disfigurements incorporate a range of scatters that reach from extremely depressed into seriously distended and each degree in the middle. Some can be subtle to the point that the disfigurement is not perceptible immediately and may not require surgical redress. Specialists at Children’s Hospital of Pittsburgh of UPMC work in pediatric consideration give the two driving strategies to right mid-section divider
An Introduction

disfigurements. Pectus Excavatum is an indented or discouraged state of the sternum, which is the bone at the front of the rib confine. Despite the fact that pectus excavatum is moderately regular, it is not effortlessly perceptible in milder cases. The distortion can bring about physiological anxiety to inner organs. Frequently, the heart is compacted and the lungs have less space in which to ventilate. The heart can’t fill totally on the grounds that real veins can be crimped. Generally the patient experiences difficulty breathing when physically dynamic and has less stamina than other youngsters.

Pectus Carinatum is nicknamed “pigeon mid-section” since it causes the ribs to jut, looking flying creature like. Pectus Carinatum does not commonly include the interior organs as pectus excavatum does, yet there are physical inconveniences to the distortion. Notwithstanding changing the physical arrangement of the rib confine, now and then pectus carinatum causes hilter kilter bone development and distending bumpy sores on the ribs.

Treatment Options

The pediatric specialists at Children’s Hospital of Pittsburgh are specialists on the most recent strategies and innovation for repairing both pectus excavatum and pectus carinatum including the Ravitch Procedure and the Nuss Procedure.

The Ravitch Procedure includes an entry point to expel damaged ligament and to repair, or reshape, the sternum. Both pectus excavatum and pectus carinatum can be redressed utilizing this methodology.

A later strategy, named the Nuss Procedure, is less intrusive, however just accessible to repair pectus excavatum. Littler entry points are made and a bar is utilized to push out the mid-section. The impact is like supports on the teeth. The mid-section can be rebuilt in two years. The Nuss methodology is prominent in light of the fact that it is less intrusive, yet not all patients are qualified for this strategy. How discouraged or distended a sternum is figures out if a youngster meets the criteria for surgery. The Ravitch
method is commonly performed somewhere around 13 and 22 years old. The Nuss Procedure, since it is less intrusive, can be performed from roughly 9 years and more established. Very qualified pediatric specialists at Children’s Hospital evaluate and perform both strategies, giving help and getting kids back to ordinary lives.

Schedule a Consultation

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SURGICAL TREATMENT OF CHILDHOOD CANCER

Children’s Hospital of Pittsburgh of UPMC is a major referral center for childhood cancer in the region and includes a comprehensive pediatric surgical oncology program. It is a charter member of the Children’s Oncology Group and one of its most active participants. This program specializes in the management of infants, children, teens and young adults with the following conditions.

Genital Tumors

Genital tumors are more accurately called germ cell tumors. Germ cells are the reproductive cells found to develop into testicles for males and ovaries in females. Germ cell cancers are rare, occurring in only 4 percent of all childhood cancers. Learn more about genital tumors.

Kidney Tumors

A variety of tumors make up the spectrum of childhood kidney cancers. Tumors of the kidney are often not diagnosed until they are fairly large and cause pain or swelling. Wilms tumor is the most common, making up about 8 percent of all childhood cancers. Learn more about kidney tumors.
Liver Tumors

Although it is unknown exactly how cancers of the liver develop, it is believed to begin during the growth of the liver cells. If a mistake occurs during the growth of these cells, the cells begin to multiply at an abnormally fast rate, causing a tumor. Tumors originating in the liver account for 1 to 2 percent of all childhood cancers. Learn more about liver tumors.

Mediastinal and Chest Wall Tumors

Mediastinal tumors occur in the chest cavity, which contains the heart, large blood vessels, trachea, thymus gland and connective tissues between the lungs. Chest wall masses in infants and children may be secondary tumors or the result of other cancers that have spread. Primary mediastinal tumors include neuroblastomas and lymphomas. Learn more about mediastinal and chest wall tumors.

Neuroblastomas

Neuroblastoma is a solid tumor that usually develops in the nerve tissue of the adrenal glands, located on the top of each kidney. Tumors are sometimes also found in the pelvis, neck or chest. Neuroblastoma is typically diagnosed under the age of 5 years old and makes up approximately 7.5 percent of all childhood cancers. Learn more about neuroblastomas.

Soft-tissue Sarcoma

Soft tissues connect, support, and surround body parts. Muscles, tendons, ligaments, fat, blood vessels and nerves are all considered soft-tissue structures. Soft-tissue sarcomas (cancers) can be found anywhere in the body, but especially the arms and legs or the chest and abdomen. Learn more about soft-tissue sarcoma.

HEAD AND NECK DISORDERS

Pediatric surgeons at Children’s Hospital of Pittsburgh of UPMC treat a wide variety of head and neck masses, including
inflamed lymph nodes and neck lesions, with specialized expertise and the highest level of care. Our pediatric specialists are able to provide more appropriate care for a child based on size and age, improving recovery and minimizing side effects.

**Enlarged Lymph Node**

The most common head or neck surgery performed at Children’s Hospital of Pittsburgh is on an enlarged lymph node. Most often, the lymph node is enlarged due to an infection elsewhere in the body. Typically the first line of defense is a round of antibiotics. When that doesn’t resolve the inflammation, a pediatric surgeon will biopsy the lymph node to remove it or to send it on for further testing. The procedure is done using the latest techniques, and the child is usually home the same day.

**Neck Lesion or Cyst**

The second most common surgical procedure for the head or neck area is a neck lesion, or cyst. Cysts are usually remnants of structures developing in utero, though sometimes are not evident for years.

These cysts are often filled with sinus mucous or remains of tissues, such as thyroid tissue, left behind during development. They can be located from the jaw line down to the collar bone. For cysts, a basic removal of the mass is performed in a same-day surgical procedure. The primary side-effect is a small scar.

Removing these masses improves recovery and minimizes the risk of recurrence. These masses become evident typically in infants and toddlers, and Children’s Hospital’s pediatric surgeons are experts in treating and caring for the tiniest of patients.

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INFLAMMATORY BOWEL DISEASE

Inflammatory bowel disease (IBD) is a spectrum of disorders related to the colon and small intestine that causes the intestines to become inflamed (red and swollen). The inflammation is painful and typically lasts a long time, returning over and over again.

Children’s Hospital of Pittsburgh of UPMC provides comprehensive, state-of-the-art clinical care, including minimally invasive surgery, to control the symptoms of IBD and to improve the quality of life for children with the disease.

Children’s Hospital of Pittsburgh uses the latest advances in treating patients with an inflammatory bowel disorder. IBD patients treated by a pediatric surgeon often are referred from a pediatric or general gastroenterologist. Most have already received medical treatment in an attempt to manage the disease.

IBD conditions that may be treated surgically include ulcerative colitis (contained in the colon) or Crohn’s disease (can be anywhere in digestive tract). By using the latest minimally invasive surgical techniques, pediatric surgeons at Children’s Hospital facilitate a quicker recovery, allowing patients to eat and return to their normal activities sooner. When possible, a laparoscopic procedure with state-of-the-art equipment and practices is chosen, optimizing recovery time.

In general, surgery involves removing a small section of the affected area. This may mean removing a portion of the colon through a procedure known as an ilioanal pull-through, where a section of the lining of the rectum is separated and repositioned without involving the muscles, allowing stool to pass normally. While surgery may not cure IBD, it provides a better quality of life for a length of time.

The cutting-edge approach by surgeons at Children’s allows patients to manage their disease when other medical treatment has not been effective. Although, it’s estimated that about half of the patients may experience a recurrence within 20 years.
INGUINAL AND SCROTAL DISORDERS

Disorders involving a child’s inguinal (groin) and scrotal area are frequent and the most common condition treated by the pediatric surgeons at Children’s Hospital of Pittsburgh of UPMC. The array of inguinal and scrotal disorders includes hernia, hydrocele, undescended testis, torsion of the testis or appendix testis, and rarely testicular tumors.

While inguinal and scrotal disorders are common, each disorder has unique attributes and treatment.

Inguinal Hernia

The inguinal hernia is the most prevalent of all inguinal and scrotal disorders. In short, a hernia is a sac of tissue that protrudes through the abdominal lining. Usually, the sac closes and disappears before birth. But in about 20 percent of infants, the sac does not close and pushes through the lower abdominal muscles. This sac is typically filled with fluid or tissue.

Hernias are usually noticed first by the parents as a small bulge in the lower abdomen or sometimes an enlarged scrotum in boys. The surgical procedure to repair an inguinal hernia is low-risk done using a general anesthetic. Using a one inch incision, the surgeon can disconnect the sac and suture the remaining tissue.

Hydrocele

Similar to a hernia, a hydrocele is simply a sac of water. Sometimes, a hydrocele is the first stage of a hernia, and can be treated the same as an inguinal hernia. There are, however, several types of hydroceles and each may require a different treatment approach.

Often a painless hydrocele may develop after a child has a virus or has experienced trauma to the testes. These should be examined and monitored, but rarely is surgery needed. They shrink and may disappear on their own. A hydrocele that develops rapidly without explanation, (for example after a viral illness or trauma to the testes), may require an early ultrasound of the scrotum. The
An Introduction

surgical approach is often through the scrotum, after it’s determined that no small hernia is involved. Otherwise an inguinal approach is used, especially in a patient of school-age.

Undescended Testis

An undescended testis occurs when the testicle fails to travel down into the scrotum by the time of birth. At birth, four out of every one hundred males will have an undescended testis; however by one year of age, three of these four will have descended into a satisfactory position.

Although an undescended testis is not a health risk, surgery should be performed to relocate the testis into the scrotum to allow normal development to occur. This procedure is similar to that of the hernia, with a small groin incision. Hernias often result simultaneously with undescended testes. The testis is placed into the scrotum by lengthening the tissue and blood vessels that supply the testis. Occasionally, more than one surgery is required. Rarely, the testis will not continue to develop for unknown reasons.

Torsion

Torsion means twisting of an organ and risks losing the blood supply to that organ. This can be a rather dramatic event and requires a quick and precise diagnosis and treatment. Torsion of the testis may occur when the testis lacks its normal attachments to the scrotum. This is sometimes called the “bell clapper” deformity. When this happens the blood supply to the testis is twisted or kinked, preventing proper flow. Torsion is almost always accompanied by excruciating pain.

Surgery is almost always required to prevent loss of the testis. During surgery, the surgeon will “unkink” the blood flow and sometimes “pex” or affix the testis in place to avoid further twisting. Testicular torsion is most common in the 4 to 11 year old age group and often occurs after moderate activity. Early surgical repair can preserve fertility. For the testis that has been twisted longer than 24 hours, removal is generally recommended.
Testicular Tumors

Tumors of the testis are rare in childhood and usually appear with slowly growing, painless masses. They are often mistaken for a hernia and accidentally found at surgery. Surgery is used to remove the mass through a groin incision. Further treatment depends on the type of tumor and its extent of spread.

Schedule a Consultation

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NEWBORN CONGENITAL ANOMALIES

Newborn congenital anomalies, often referred to as birth defects, have a variety of causes ranging from pregnancy or birth complications to genetic malformations to viral infections in utero. In many cases, however, a congenital anomaly may have no known cause. The surgical treatment of congenital anomalies is cutting edge at Children’s Hospital of Pittsburgh of UPMC. Our pediatric surgeons perform many of the procedures using minimally invasive techniques, (thoracoscopically or laparoscopically), allowing for smaller incisions, less pain, faster healing and shorter lengths of stay in the hospital when a stay is necessary. Collaborative efforts with the other pediatric subspecialties at Children’s Hospital of Pittsburgh allows for all patients to receive multidisciplinary, comprehensive care.

Children’s Hospital takes full advantage of a multi-disciplinary team approach. A team of experts may include diagnostic screenings and psychiatric support in addition to surgical treatments and referrals to pediatric general surgeons, plastic surgeons and orthopaedic surgeons among others.

Chest and Abdomen

Pediatric general surgeons treat a variety of congenital
anomalies of the chest and abdomen. These include tracheoesophageal fistula; duodenal atresia; jejunal and ileal atresia; biliary atresia; choledochal cysts; intestinal duplications; Hirschprung’s Disease; congenital lung masses such as CCAM, CLE and pulmonary sequestration; pectus excavatum and carinatum; gastroschisis; omphalocele; conjoined twins; sacrococcygeal teratoma; meconium ileus; imperforate anus and many others.

Detailed Exam

When a congenital anomaly is discovered, a complete physical examination is important to discover and rule out multiple malformations. A detailed examination should include:

1. Head, neck and facial features
2. Skin
3. Chest wall, heart and lungs
4. Abdomen
5. Genitalia and anus
6. Spine and back
7. Extremities (including hands and feet)
8. Neurological functions and reflexes

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THORACIC SURGERY

In general, pediatric thoracic surgery involves diseases or injuries to the area of the body between the neck and the abdomen. Surgeons at Children’s Hospital of Pittsburgh of UPMC specialize in general pediatric thoracic surgery, whether congenital, such as a birth defect, or acquired, such as pneumonia. Specific operations include removal of a lung growth or tumor, or removal of an abnormality that has been present since birth but which could
become infected, such as a pulmonary sequestration or a congenital cystic adenomatoid malformation.

Pediatric general and thoracic surgeons also perform surgery on the esophagus, as needed, for conditions such as tracheoesophageal fistulas, which describes a communication between the trachea and the esophagus. These operations may be performed through tiny incisions, depending upon the type of procedure and the size of the patient. Regardless of the complexity, the pediatric thoracic surgeons at Children’s Hospital of Pittsburgh maintain the highest-level of care with the latest in technology and education.
An inborn issue, otherwise called an inherent illness, disfigurement, birth deformity, or peculiarity, is a condition existing at or before birth paying little heed to bring about. Of these disarranges, those portrayed by basic deformations are named “inborn irregularities” and include surrenders in a creating baby. Birth deserts shift generally in cause and manifestations. Any substance that causes birth deformities is known as a teratogen. A few issue can be distinguished before birth through pre-birth determination (screening).

Birth imperfections might be the consequence of hereditary or natural components. This incorporates blunders of morphogenesis, contamination, epigenetic modifications on a parental germline, or a chromosomal variation from the norm. The result of the turmoil will rely on upon complex collaborations between the pre-natal shortage and the post-natal environment. Creature considers show that the mother’s (and likely the father’s) eating regimen, vitamin admission, and glucose levels preceding ovulation and origination have long haul impacts on fetal development and juvenile and grown-up ailment. Creature concentrates on have demonstrated that fatherly exposures preceding origination and amid pregnancy result in expanded danger of certain birth imperfections and malignancies. This examination proposes that fatherly nourishment hardship, germ line transformations, liquor use, synthetic mutagens, age, smoking propensities and epigenetic adjustments
can influence birth results. In any case, the relationship between posterity wellbeing and fatherly exposures, age, and way of life are still moderately powerless.

This is likely in light of the fact that fatherly exposures and their impacts on the hatchling are concentrated on far less broadly than maternal exposures.

Birth deformities are available in around 3% of babies in USA. Inborn inconsistencies brought about around 632,000 passings for each year in 2013 down from 751,000 in 1990. The sort with the best quantities of passings are intrinsic coronary illness (323,000), trailed by neural tube deserts (69,000).

**CLASSIFICATION**

Much of the language used for describing congenital conditions predates genomic mapping, and structural conditions are often considered separately from other congenital conditions.

It is now known that many metabolic conditions may have subtle structural expression, and structural conditions often have genetic links. Still, congenital conditions are often classified in a structural basis, organized when possible by primary organ system affected.

**Primarily structural**

Several terms are used to describe congenital abnormalities.

**Terminology**

- A congenital physical anomaly is an abnormality of the structure of a body part. An anomaly may or may not be perceived as a problem condition. Many, if not most, people have one or more minor physical anomalies if examined carefully. Examples of minor anomalies can include curvature of the 5th finger (clinodactyly), a third nipple, tiny indentations of the skin near the ears (preauricular pits), shortness of the 4th metacarpal or metatarsal bones, or dimples over the lower spine (sacral dimples). Some
Congenital Disorder

minor anomalies may be clues to more significant internal abnormalities.

• Birth defect is a widely used term for a congenital malformation, i.e. a congenital, physical anomaly which is recognizable at birth, and which is significant enough to be considered a problem. According to the CDC, most birth defects are believed to be caused by a complex mix of factors including genetics, environment, and behaviors, though many birth defects have no known cause. An example of a birth defect is cleft palate, which occurs during the fourth and seventh week of gestation. Body tissue and special cells from each side of the head grow toward the center of the face. They join together to make the face. A cleft means a split or separation; the “roof” of the mouth is called the palate.

• A congenital malformation is a congenital physical anomaly that is deleterious, i.e. a structural defect perceived as a problem. A typical combination of malformations affecting more than one body part is referred to as a malformation syndrome.

• Some conditions are due to abnormal tissue development:
• A malformation is associated with a disorder of tissue development. Malformations often occur in the first trimester.
• A dysplasia is a disorder at the organ level that is due to problems with tissue development.
• It is also possible for conditions to arise after tissue is formed:
• A deformation is a condition arising from mechanical stress to normal tissue. Deformations often occur in the second or third trimester, and can be due to oligohydramnios.
• A disruption involves breakdown of normal tissues.
• When multiple effects occur in a specified order, it is known as a sequence. When the order is not known, it is a syndrome.
Examples of primarily structural congenital disorders

A limb anomaly is called a dysmelia. These include all forms of limbs anomalies, such as amelia, ectrodactyly, phocomelia, polymelia, polydactyly, syndactyly, polysyndactyly, oligodactyly, brachydactyly, achondroplasia, congenital aplasia or hypoplasia, amniotic band syndrome, and cleidocranial dysostosis.

Congenital anomalies of the heart include patent ductus arteriosus, atrial septal defect, ventricular septal defect, and tetralogy of fallot.

Congenital anomalies of the nervous system include neural tube defects such as spina bifida, meningocele, meningomyelocele, encephalocele and anencephaly.

Other congenital anomalies of the nervous system include the Arnold-Chiari malformation, the Dandy-Walker malformation, hydrocephalus, microencephaly, megalencephaly, lissencephaly, polymicrogyria, holoprosencephaly, and agenesis of the corpus callosum.

Congenital anomalies of the gastrointestinal system include numerous forms of stenosis and atresia, and perforation, such as gastroschisis.

Congenital anomalies of the kidney and urinary tract (CAKUT) include renal parenchyma, kidneys, and urinary collecting system. Defects can be bilateral or unilateral, and different defects often coexist in an individual child.

Primarily metabolic

A congenital metabolic disease is also referred to as an inborn error of metabolism. Most of these are single gene defects, usually heritable. Many affect the structure of body parts but some simply affect the function.

Other

Other well defined genetic conditions may affect the production of hormones, receptors, structural proteins, and ion channels.
CAUSES

Fetal alcohol exposure

The mother’s consumption of alcohol during pregnancy can cause a continuum of various permanent birth defects: cranofacial abnormalities, brain damage, intellectual disability, heart disease, kidney abnormality, skeletal anomalies, ocular abnormalities.

The prevalence of children affected is estimated at least 1 percent in U.S. as well in Canada. Very few studies have investigated the links between paternal alcohol use and offspring health.

However, recent animal research has shown a correlation between paternal alcohol exposure and decreased offspring birth weight. Behavioral and cognitive disorders, including difficulties with learning and memory, hyperactivity, and lowered stress tolerance have been linked to paternal alcohol ingestion. The compromised stress management skills of animals whose male parent was exposed to alcohol are similar to the exaggerated responses to stress that children with Fetal Alcohol Syndrome display because of maternal alcohol use. These birth defects and behavioral disorders were found in cases of both long- and short-term paternal alcohol ingestion. In the same animal study, paternal alcohol exposure was correlated with a significant difference in organ size and the increased risk of the offspring displaying ventricular septal defects (VSD) at birth. VSD has also been correlated with paternal alcohol abuse in humans.

Toxic substances

Substances whose toxicity can cause congenital disorders are called “teratogens”, and include certain pharmaceutical and recreational drugs in pregnancy as well as many environmental toxins in pregnancy. A review published in 2010 identified 6 main teratogenic mechanisms associated with medication use: folate antagonism, neural crest cell disruption, endocrine disruption, oxidative stress, vascular disruption and specific
receptor- or enzyme-mediated teratogenesis. It is estimated that 10% of all birth defects are caused by prenatal exposure to a teratogenic agent.

These exposures include, but are not limited to, medication or drug exposures, maternal infections and diseases, and environmental and occupational exposures. Paternal smoking use has also been linked to an increased risk of birth defects and childhood cancer for the offspring, where the paternal germ line undergoes oxidative damage due to cigarette use. Teratogen-caused birth defects are potentially preventable. Studies have shown that nearly 50% of pregnant women have been exposed to at least one medication during gestation. During pregnancy, a female can also be exposed to teratogens from the contaminated clothing or toxins within the seminal fluid of a partner. An additional study found that of 200 individuals referred for genetic counseling for a teratogenic exposure, 52% were exposed to more than one potential teratogen.

Medications and supplements

The most notorious teratogenic drug is the thalidomide, developed at the end of 1950 by Chemie Grünenthal as a hypnotic and antiemetic and therefore frequently prescribed to pregnant women in almost 50 countries worldwide between 1956-1962. Until William McBride published the study leading to its withdrawal from the market at 1961, about 8-10 000 severely malformed children were born. The most typical disorder induced by thalidomide were reductional deformities of the long bones of the extremities (phocomelia), otherwise a rare deformity, which therefore helped to recognise the teratogenic effect of the new drug. Among other malformations caused by thalidomide were those of ears, eyes, brain, kidney, heart, digestive and respiratory tract. 40% of the prenatally affected children died soon after birth. As thalidomide is used today as a treatment for multiple myeloma and leprosy, several births of affected children were described in spite of the strictly required use of contraception among female patients treated by it.
Vitamin A, or retinol, is the sole vitamin which is embryotoxic even in a therapeutic dose, for example in multivitamins, because its metabolite, the retinoic acid, plays an important role as a signal molecule in the development of several tissues and organs. Its natural precursor, the ß-carotene, is considered safe, whereas the consumption of animal liver can lead to malformation (liver stores lipophile vitamins including retinol). Isotretinoin (13-cis-retinoic-acid; brand name Roaccutane), vitamin A analog, which is often used to treat severe acne, is such a strong teratogen that just a single dose taken by a pregnant woman (even transdermally) may result in serious birth defects. Because of this effect, most countries have systems in place to ensure that it is not given to pregnant women, and that the patient is aware of how important it is to prevent pregnancy during and at least one month after treatment. Medical guidelines also suggest that pregnant women should limit vitamin A intake to about 700 ìg/day, as it has teratogenic potential when consumed in excess. Vitamine A and similar substances can induce spontaneous abortions, premature births, defects of eyes (microphthalmia), ears, thymus, face deformities, neurological (hydrocephalus, microcephalia) and cardiovascular defects, as well as mental retardation.

Tetracycline, an antibiotic, should never be prescribed to women in the reproductive age or children, because of its negative impact on bone mineralization and teeth mineralization. The “tetracycline teeth” have brown or grey colour as a result of a defective development of both the dentine and the enamel of teeth.

Several anticonvulsants are known to be highly teratogenic. Phenytoin, also known as diphenylhydantoin, along with carbamazepine is responsible for the fetal hydantoin syndrome, which may typically include broad nose base, cleft lip and/or palate, microcephalia, nails and fingers hypoplasia, intrauterine growth restriction and mental retardation. Trimethadione taken during pregnancy is responsible for the fetal trimethadione syndrome, characterized by craniofacial, cardiovascular, renal and
spine malformations, along with a delay in mental and physical development. Valproate has anti-folate effects, leading to neural tube closure-related defects such as spina bifida. Lower IQ and autism have recently also been reported as a result of intrauterine valproate exposure.

Hormonal contraception is considered as harmless for the embryo. Peterka and Novotná do however state that syntethic progestines used to prevent miscarriage in the past frequently caused masculinization of the outer reproductive organs of female newborns due to their androgenic activity. Diethylstilbestrol is a synthetic estrogen used from the 1940s to 1971 when the prenatal exposition has been linked to the clear-cell adenocarcinoma of the vagina. Following studies showed elevated risks for other tumors and congenital malformations of the sex organs for both sexes.

All cytostatics are strong teratogenes, abortion is usually recommended when pregnancy is found during or before chemotherapy. Aminopterin, a cytostatic drug with anti-folate effect, was used during the 1950s and 1960s to induce therapeutic abortions. In some cases the abortion didn’t happen, but the newborns suffered a fetal aminopterin syndrome consisting of growth retardation, craniosynostosis, hydrocephalus, facial dismorphities, mental retardation and/or leg deformities.

**Environmental toxical substances**

Drinking water is often a vessel through which harmful toxins travel. Studies have shown that heavy metals, elements, nitrates, nitrites, fluoride can be carried through water and cause congenital disorders.

Nitrate, which is found mostly in drinking water from ground sources, is a powerful teratogen. A case-control study in rural Australia that was conducted following frequent reports of prenatal mortality and congenital malformations found that those who drank the nitrate-infected groundwater, as opposed to rain water, ran the risk of giving birth to children with central nervous system disorders, muscoskeletal defects, and cardiac defects.
Chlorinated and aromatic solvents such as benzene and trichloroethylene sometimes enter the water supply due to oversights in waste disposal. A case-control study on the area found that by 1986, leukemia was occurring in the children of Woburn, Massachusetts at a rate that was four times the expected rate of incidence. Further investigation revealed a connection between the high occurrence of leukemia and an error in water distribution that delivered water to the town with significant contamination manufacturing waste containing trichloroethylene. As an endocrine disruptor, the DDT was shown to induce miscarriages, interfere with the development of the female reproductive system, cause the congenital hypothyroidism and susceptibility childhood obesity.

Fluoride, when transmitted through water at high levels, can also act as a teratogen. Two reports on fluoride exposure from China, which were controlled to account for the education level of parents, found that children born to parents who were exposed to 4.12 PPM fluoride grew to have IQs that were, on average, seven points lower than their counterparts whose parents consumed water that contained 0.91 PPM fluoride. In studies conducted on rats, higher PPM fluoride in drinking water lead to increased acetylcholinesterase levels, which can alter prenatal brain development. The most significant effects were noted at a level of 5 PPM.

The fetus is even more susceptible to damage from carbon monoxide intake, which can be harmful when inhaled during pregnancy, usually through first or second-hand tobacco smoke. The concentration of carbon monoxide in the infant born to a non-smoking mother is around 2%, and this concentration drastically increases to a range of 6%-9% if the mother smokes tobacco. Other possible sources of prenatal carbon monoxide intoxication are exhaust gas from combustion motors, use of dichloromethane (paint thinner, varnish removers) in enclosed areas, defective gas hot water heaters, indoor barbeques, open flames in poorly-ventilated areas, atmospheric exposure in highly polluted areas.
Exposure to carbon monoxide at toxic levels during the first two trimesters of pregnancy can lead to intrauterine growth restriction, leading to a baby that has stunted growth and is born smaller than 90% of other babies at the same gestational age. The effect of chronic exposure to carbon monoxide can depend on the stage of pregnancy in which the mother is exposed. Exposure during the embryonic stage can have neurological consequences, such as telencephalic dysgenesis, behavioral difficulties during infancy, and reduction of cerebellum volume. There are also possible skeletal defects that could result from exposure to carbon monoxide during the embryonic stage, such as hand and foot malformations, hip dysplasia, hip subluxation, agenesis of a limb, and inferior maxillary atresia with glossoptosis. Also, carbon monoxide exposure between days 35 and 40 of embryonic development can lead to an increased risk of the child developing a cleft palate. Exposure to carbon monoxide or polluted ozone exposure can also lead to cardiac defects of the ventrical septal, pulmonary artery and heart valves. The effects of carbon monoxide exposure are decreased later in fetal development during the fetal stage, but they may still lead to anoxic encephalopathy.

Industrial pollution can also lead to congenital defects. Over a period of 37 years, the Chisso Corporation, a petrochemical and plastics company, contaminated the waters of Minamata Bay with an estimated 27 tons of methylmercury, contaminating the local water supply. This led to many people in the area developing what became known as the “Minamata Disease.” Because methylmercury is a teratogen, the mercury poisoning of those residing by the bay resulted in neurological defects in the offspring. Infants exposed to mercury poisoning in utero showed predispositions to cerebral palsy, ataxia, inhibited psychomotor development, and mental retardation.

Landfill sites have been shown to have adverse effects on fetal development. Extensive research has been shown that landfills have several negative effects on babies born to mothers living near landfill sites: low birth weight, birth defects, spontaneous abortion,
and fetal and infant mortality. Studies done around the Love Canal site near Niagara Falls and the Lipari Landfill in New Jersey have shown a higher proportion of low birth babies than communities farther away from landfills. A study done in California showed a positive correlation between time and quantity of dumping and low birth weights and neonatal deaths. A study in the United Kingdom showed a correspondence between pregnant women living near landfill sites and an increased risk of congenital disorders, such as neural tube defects, hypospadias, epispadia, and abdominal wall defects, such as gastroschisis and exomphalos. A study conducted on a Welsh community also showed an increase incidence of gastroschisis. Another study was done on twenty-one European hazardous waste sites and showed that those living within three kilometers had an increased risk of giving birth to infants with birth defects and that as distance from the land increased, the risk decreased. These birth defects included neural tube defects, malformations of the cardiac septa, anomalies of arteries and veins, and chromosomal anomalies. Looking at communities that live near landfill sites brings up environmental justice. A vast majority of sites are located near poor, mostly black, communities. For example, between the early 1920s and 1978, about 25% of Houston’s population was black. However, over 80% of landfills and incinerators during this time were located in these black communities.

Another issue regarding environmental justice is lead poisoning. If the fetus is exposed to lead during the pregnancy, this can result in learning difficulties and slowed growth. A lot of paints (before 1978) and pipes contain lead. Therefore, pregnant women who live in homes with lead paint will inhale the dust containing lead, leading to lead exposure in the fetus. When lead pipes are used for drinking water and cooking water, this water is ingested, along with the lead, exposing the fetus to this toxin. This issue is more prevalent in poorer communities. This is because more well off families are able to afford to have their homes repainted and pipes renovated.
Paternal smoking

Paternal smoking prior to conception has been linked with the increased risk of congenital abnormalities in offspring. Smoking causes DNA mutations in the germ line of the father, which can be inherited by the offspring. Cigarette smoke acts as a chemical mutagen on germ cell DNA. The germ cells suffer oxidative damage, and the effects can be seen in altered mRNA production, infertility issues, and side effects in the embryonic and fetal stages of development. This oxidative damage may result in epigenetic or genetic modifications of the father’s germ line. Research has shown that fetal lymphocytes have been damaged as a result of a father’s smoking habits prior to conception.

Correlations between paternal smoking and the increased risk of offspring developing childhood cancers (including acute leukemia, brain tumors, and lymphoma) before age five have been established. However, further research is needed to confirm these findings. Little is currently known about how paternal smoking damages the fetus, and what window of time in which the father smokes is most harmful to offspring.

Infections

A vertically transmitted infection is an infection caused by bacteria, viruses or, in rare cases, parasites transmitted directly from the mother to an embryo, fetus or baby during pregnancy or childbirth. It can occur when the mother gets an infection as an intercurrent disease in pregnancy.

Congenital disorders were initially believed to be the result of only hereditary factors. However, in the early 1940s, Australian pediatric ophthalmologist Norman Gregg began recognizing a pattern in which the infants arriving at his surgery were developing congenital cataracts at a higher rate than those who developed it from hereditary factors. On October 15, 1941, Gregg delivered a paper which explained his findings—68 out of the 78 children who were afflicted with congenital cataracts had been exposed in utero due to an outbreak in Australian army camps. These findings
confirmed, to Gregg, that there could, in fact, be environmental causes for congenital disorders.

Rubella is known to cause abnormalities of the eye, internal ear, heart, and sometimes the teeth. More specifically, fetal exposure to rubella during weeks five to ten of development (the sixth week particularly) can cause cataracts and microphthalmia in the eyes. If the mother is infected with rubella during the ninth week, a crucial week for internal ear development, there can be destruction of the organ of Corti, causing deafness. In the heart the ductus arteriosus can remain after birth, leading to hypertension. Rubella can also lead to atrial and ventricular septal defects in the heart. If exposed to rubella in the second trimester, the fetus can develop central nervous system malformations. However, because infections of rubella may remain undetected, misdiagnosed, or unrecognized in the mother, and/or some abnormalities are not evident until later in the child’s life, precise incidence of birth defects due to rubella are not entirely known. The timing of the mother’s infection during fetal development determines the risk and type of birth defect. As the embryo develops, the risk of abnormalities decreases. If exposed to the rubella virus during the first four weeks, the risk of malformations is 47 percent. Exposure during weeks five through eight creates a 22 percent chance, while weeks nine to twelve a seven percent chance exists, followed by a percentage of six if the exposure is during the thirteenth to sixteenth weeks. Exposure during the first eight weeks of development can also lead to prematurity and fetal death. These numbers are calculated from immediate inspection of the infant after birth. Therefore, mental defects are not accounted for in the percentages because they are not evident until later in the child’s life. If they were to be included, these numbers would be much higher.

Other infectious agents include cytomegalovirus, the herpes simplex virus, hyperthermia, toxoplasmosis, and syphilis. Mother exposure to cytomegalovirus can cause microcephaly, cerebral calcifications, blindness, chorioretinitis (which can cause blindness), hepatosplenomegaly, and meningoencephalitis in fetuses.
Microcephaly is a disorder in which the fetus has an atypically small head, cerebral calcifications means certain areas of the brain have atypical calcium deposits, and meningoencephalitis is the enlargement of the brain. All three disorders cause abnormal brain function or mental retardation. Hepatosplenomegaly is the enlargement of the liver and spleen which causes digestive problems. It can also cause some kernicterus and petechiae. Kernicterus causes yellow pigmentation of the skin, brain damage, and deafness. Petechiae is when the capillaries bleed resulting in red/purple spots on the skin. However, cytomegalovirus is often fatal in the embryo.

The herpes simplex virus can cause microcephaly, microphthalmus (abnormally small eyeballs), retinal dysplasia, hepatosplenomegaly, and mental retardation. Both microphthalmus and retinal dysplasia can cause blindness. However, the most common symptom in infants is an inflammatory response that develops during the first three weeks of life. Hyperthermia causes anencephaly, which is when part of the brain and skull are absent in the infant. Mother exposure to toxoplasmosis can cause cerebral calcification, hydrocephalus (causes mental disabilities), and mental retardation in infants. Other birth abnormalities have been reported as well, such as chorioretinitis, microphthalmus, and ocular defects. Syphilis causes congenital deafness, mental retardation, and diffuse fibrosis in organs, such as the liver and lungs, if the embryo is exposed.

Lack of nutrients

For example, a lack of folic acid, a vitamin B, in the diet of a mother can cause cellular neural tube deformities that result in spina bifida. Congenital disorders such as a neural tube deformity (NTD) can be prevented by 72% if the mother consumes 4 milligrams of folic acid before the conception and after 12 weeks of pregnancy. Folic acid, or vitamin B₁₂, aids the development of the foetal nervous system. Studies with mice have found that food deprivation of the male mouse prior to conception leads to the offspring displaying significantly lower blood glucose levels.
Physical restraint

External physical shocks or constrainment due to growth in a restricted space, may result in unintended deformation or separation of cellular structures resulting in an abnormal final shape or damaged structures unable to function as expected. An example is Potter syndrome due to oligohydramnios. This finding is important for future understandings of how genetics may predispose individuals for diseases like obesity, diabetes, and cancer.

For multicellular organisms that develop in a womb, the physical interference or presence of other similarly developing organisms such as twins can result in the two cellular masses being integrated into a larger whole, with the combined cells attempting to continue to develop in a manner that satisfies the intended growth patterns of both cell masses. The two cellular masses can compete with each other, and may either duplicate or merge various structures. This results in conditions such as conjoined twins, and the resulting merged organism may die at birth when it must leave the life-sustaining environment of the womb and must attempt to sustain its biological processes independently.

Genetic causes

Genetic causes of congenital anomalies include inheritance of abnormal genes from the mother or the father, as well as new mutations in one of the germ cells that gave rise to the fetus. Male germ cells mutate at a much faster rate than female germ cells, and as the father ages, the DNA of the germ cells mutates quickly. If an egg is fertilized with sperm that has damaged DNA, there is a possibility that the fetus could develop abnormally.

Genetic disorders or diseases are all congenital, though they may not be expressed or recognized until later in life. Genetic diseases may be divided into single-gene defects, multiple-gene disorders, or chromosomal defects. Single-gene defects may arise from abnormalities of both copies of an autosomal gene (a recessive
disorder) or of only one of the two copies (a dominant disorder). Some conditions result from deletions or abnormalities of a few genes located contiguously on a chromosome. Chromosomal disorders involve the loss or duplication of larger portions of a chromosome (or an entire chromosome) containing hundreds of genes. Large chromosomal abnormalities always produce effects on many different body parts and organ systems.

**Socioeconomic status**

A low socioeconomic status in a deprived neighborhood may include exposure to “environmental stressors and risk factors.” Socioeconomic inequalities are commonly measured by the Cartairs-Morris score, Index of Multiple Deprivation, Townsend deprivation index, and the Jarman score. The Jarman score, for example, considers “unemployment, overcrowding, single parents, under-fives, elderly living alone, ethnicity, low social class and residential mobility.” In Vos’ meta-analysis these indices are used to view the effect of low SES neighborhoods on maternal health. In the meta-analysis, data from individual studies were collected from 1985 up until 2008. Vos concludes that a correlation exists between prenatal adversities and deprived neighborhoods. Other studies have shown that low SES is closely associated with the development of the fetus in utero and growth retardation. Studies also suggest that children born in low SES families are “likely to be born prematurely, at low birth weight, or with asphyxia, a birth defect, a disability, fetal alcohol syndrome, or AIDS.” Bradley and Corwyn also suggest that congenital disorders arise from the mother’s lack of nutrition, a poor lifestyle, maternal substance abuse and “living in a neighborhood that contains hazards affecting fetal development (toxic waste dumps).” In a meta-analysis that viewed how inequalities influenced maternal health, it was suggested that deprived neighborhoods often promoted behaviors such as smoking, drug and alcohol use. After controlling for socioeconomic factors and ethnicity, several individual studies demonstrated an association with outcomes such as perinatal mortality and preterm birth.
Role of radiation

For the survivors of the atomic bombing of Hiroshima and Nagasaki, who are known as the *Hibakusha*, no statistically demonstrable increase of birth defects/congenital malformations was found among their later conceived children, or found in the later conceived children of cancer survivors who had previously received radiotherapy. The surviving women of Hiroshima and Nagasaki who were able to conceive, though exposed to substantial amounts of radiation, later had children with no higher incidence of abnormalities/birth defects than in the Japanese population as a whole.

Relatively few studies have researched the effects of paternal radiation exposure on offspring. Following the Chernobyl disaster, it was found that the germ line of irradiated fathers suffered minisatellite mutations in the DNA, which was inherited by descendants. Animal studies have shown that the X-ray irradiation of male mice resulted in birth defects of the offspring.

In the 1980s, a relatively high prevalence of pediatric leukemia cases in children living near a nuclear processing plant in West Cumbria, UK, led researchers to investigate whether the cancer was a result of paternal radiation exposure. A significant association between paternal irradiation and offspring cancer was found, but further research areas close to other nuclear processing plants did not produce the same results.

Father’s age

The effects of paternal age on offspring are not yet well understood and are studied far less extensively than the effects of maternal age. Fathers contribute proportionally more DNA mutations to their offspring via their germ cells than the mother, with the paternal age governing how many mutations are passed on. This is because, as humans age, male germ cells acquire mutations at a much faster rate than female germ cells.

Around a 5% increase in the incidence of ventricular septal defects, atrial septal defects, and patent ductus arteriosus in
offspring has been found to be correlated with advanced paternal age. Advanced paternal age has also been linked to increased risk of achondroplasia and Apert syndrome. Offspring born to fathers under the age of 20 show increased risk of being affected by patent ductus arteriosus, ventricular septal defects, and the tetralogy of Fallot. It is hypothesized that this may be due to environmental exposures or lifestyle choices.

Research has found that there is a correlation between advanced paternal age and risk of birth defects such as limb anomalies, syndromes involving multiple systems, and Down’s syndrome. Recent studies have concluded that 5-9% of Down’s syndrome cases are due to paternal effects, but these findings are controversial. There is concrete evidence that advanced paternal age is associated with the increased likelihood that a mother will suffer from a miscarriage or that fetal death will occur.

**Unknown or multifactorial**

Although significant progress has been made in identifying the etiology of some birth defects, approximately 65% have no known or identifiable cause. These are referred to as sporadic, a term that implies an unknown cause, random occurrence regardless of maternal living conditions, and a low recurrence risk for future children. For 20-25% of anomalies there seems to be a “multifactorial” cause, meaning a complex interaction of multiple minor genetic anomalies with environmental risk factors. Another 10-13% of anomalies have a purely environmental cause (e.g. infections, illness, or drug abuse in the mother). Only 12-25% of anomalies have a purely genetic cause. Of these, the majority are chromosomal anomalies.

**Epidemiology**

Congenital anomalies resulted in about 632,000 deaths per year in 2013 down from 751,000 in 1990. The type with the greatest death are congenital heart disease (323,000), followed by neural tube defects (69,000).
Many studies have found that the frequency of occurrence of certain congenital malformations depends on the sex of the child (table). For example, pyloric stenosis occurs more often in males while congenital hip dislocation is four to five times more likely to occur in females. Among children with one kidney, there are approximately twice as many males, whereas among children with three kidneys there are approximately 2.5 times more females. The same pattern is observed among infants with excessive number of ribs, vertebrae, teeth and other organs which in a process of evolution have undergone reduction—among them there are more females. Contrarily, among the infants with their scarcity, there are more males. Anencephaly is shown to occur approximately twice as frequently in females. The number of boys born with 6 fingers is two times higher than the number of girls. Now various techniques are available to detect congenital anomalies in fetus before birth.

About 3% of newborns have a “major physical anomaly”, meaning a physical anomaly that has cosmetic or functional significance. Physical congenital abnormalities are the leading cause of infant mortality in the United States, accounting for more than 20% of all infant deaths. Seven to ten percent of all children will require extensive medical care to diagnose or treat a birth defect.

The sex ratio of patients with congenital malformations

<table>
<thead>
<tr>
<th>Congenital anomaly</th>
<th>Sex ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects with female predominance</td>
<td></td>
</tr>
<tr>
<td>Congenital hip dislocation</td>
<td>1 : 5.2; 1 : 5; 1 : 8; 1 : 3.7</td>
</tr>
<tr>
<td>Cleft palate</td>
<td>1 : 3</td>
</tr>
<tr>
<td>Anencephaly</td>
<td>1 : 1.9; 1 : 2</td>
</tr>
<tr>
<td>Craniocere</td>
<td>1 : 1.8</td>
</tr>
<tr>
<td>Aplasia of lung</td>
<td>1 : 1.51</td>
</tr>
<tr>
<td>Spinal herniation</td>
<td>1 : 1.4</td>
</tr>
<tr>
<td>Diverticulum of the esophagus</td>
<td>1 : 1.4</td>
</tr>
<tr>
<td>Stomach</td>
<td>1 : 1.4</td>
</tr>
</tbody>
</table>
Neutral defects
Hypoplasia of the tibia and femur  1 : 1.2
Spina bifida  1 : 1.2
Atresia of small intestine  1 : 1
Microcephaly  1.2 : 1
Esophageal atresia  1.3 : 1; 1.5 : 1
Hydrocephalus  1.3 : 1
Defects with male predominance
Diverticula of the colon  1.5 : 1
Atresia of the rectum  1.5 : 1; 2 : 1
Unilateral renal agenesis  2 : 1; 2.1 : 1
Schistocystis  2 : 1
Cleft lip and palate  2 : 1; 1.47 : 1
Bilateral renal agenesis  2.6 : 1
Congenital anomalies of the
  genitourinary system  2.7 : 1
Pyloric stenosis, congenital  5 : 1; 5.4 : 1
Meckel's diverticulum More common in boys
Congenital megacolon More common in boys
All defects  1.22 : 1; 1.29 : 1

* Data obtained on opposite-sex twins. ** — Data were obtained in the period 1983-1994.

P. M. Rajewski and A. L. Sherman (1976) have analyzed the frequency of congenital anomalies in relation to the system of the organism. Prevalence of men was recorded for the anomalies of phylogenetically younger organs and systems.

In respect of an etiology, sexual distinctions can be divided on appearing before and after differentiation of male's gonads in during embryonic development, which begins from eighteenth week. The testosterone level in male embryos thus raises considerably. The subsequent hormonal and physiological distinctions of male and female embryos can explain some sexual differences in frequency of congenital defects. It is difficult to
Congenital Disorder

explain the observed differences in the frequency of birth defects between the sexes by the details of the reproductive functions or the influence of environmental and social factors.

United States

The CDC and National Birth Defect Project studied the incidence of birth defects in the US. Key findings include:

- Down syndrome was the most common condition with an estimated prevalence of 14.47 per 10,000 live births, implying about 6,000 diagnoses each year.
- About 7,000 babies are born with a cleft palate, cleft lip or both.
Mitochondrial disease is a group of disorders caused by dysfunctional mitochondria, the organelles that generate energy for the cell. Mitochondria are found in every cell of the human body except red blood cells, and convert the energy of food molecules into the ATP that powers most cell functions.

Mitochondrial diseases are sometimes (about 15% of the time) caused by mutations in the mitochondrial DNA that affect mitochondrial function. Other causes of mitochondrial disease are mutations in genes of the nuclear DNA, whose gene products are imported into the mitochondria (mitochondrial proteins) as well as acquired mitochondrial conditions. Mitochondrial diseases take on unique characteristics both because of the way the diseases are often inherited and because mitochondria are so critical to cell function. The subclass of these diseases that have neuromuscular disease symptoms are often called a mitochondrial myopathy.

**SIGNS AND SYMPTOMS**

Symptoms include poor growth, loss of muscle coordination, muscle weakness, visual problems, hearing problems, learning disabilities, heart disease, liver disease, kidney disease, gastrointestinal disorders, respiratory disorders, neurological problems, autonomic dysfunction and dementia. The body, and each mutation, is modulated by other genome variants; the
mutation that in one individual may cause liver disease might in another person cause a brain disorder. The severity of the specific defect may also be great or small. Some minor defects cause only “exercise intolerance”, with no serious illness or disability. Defects often affect the operation of the mitochondria and multiple tissues more severely, leading to multi-system diseases.

As a rule, mitochondrial diseases are worse when the defective mitochondria are present in the muscles, cerebrum, or nerves, because these cells use more energy than most other cells in the body.

![Micrograph showing ragged red fibers, a finding seen in various types of mitochondrial diseases.](image)

Although mitochondrial diseases vary greatly in presentation from person to person, several major clinical categories of these conditions have been defined, based on the most common phenotypic features, symptoms, and signs associated with the particular mutations that tend to cause them. An outstanding question and area of research is whether ATP depletion or reactive oxygen species are in fact responsible for the observed phenotypic consequences.

**CAUSES**

Mitochondrial disorders may be caused by mutations, acquired or inherited, in mitochondrial DNA (mtDNA) or in nuclear genes
that code for mitochondrial components. They may also be the result of acquired mitochondrial dysfunction due to adverse effects of drugs, infections, or other environmental causes.

Nuclear DNA has two copies per cell (except for sperm and egg cells), one copy being inherited from the father and the other from the mother. Mitochondrial DNA, however, is strictly inherited from the mother and each mitochondrial organelle typically contains multiple mtDNA copies. During cell division the existing mitochondria segregate randomly between the two new cells, and then those mitochondria make more copies. As mtDNA is copied when mitochondria proliferate, they can accumulate random mutations. If only a few of the mtDNA copies inherited from the mother are defective, mitochondrial division may cause most of the defective copies to end up in just one of the new mitochondria. Mitochondrial disease may become clinically apparent once the number of affected mitochondria reaches a certain level; this phenomenon is called “threshold expression”.

Mitochondrial DNA mutations occur frequently, due to the lack of the error checking capability that mtDNA has. This means that mitochondrial DNA disorders may occur spontaneously and relatively often. Defects in enzymes that control mitochondrial DNA replication (all of which are encoded for by genes in the nuclear DNA) may also cause mitochondrial DNA mutations.

Most mitochondrial function and biogenesis is controlled by nuclear DNA. Human mitochondrial DNA encodes only 13 proteins of the respiratory chain, while most of the estimated 1,500 proteins and components targeted to mitochondria are nuclear-encoded. Defects in nuclear-encoded mitochondrial genes are associated with hundreds of clinical disease phenotypes including anemia, dementia, hypertension, lymphoma, retinopathy, seizures, and neurodevelopmental disorders.

A study by Yale University researchers published in the Feb 12, 2004 issue of the New England Journal of Medicine explores the role of mitochondria in insulin resistance among the offspring
of patients with type 2 diabetes. Other studies have shown that the mechanism may involve the interruption of the mitochondrial signaling process in body cells (intramyocellular lipids). A study conducted at the Pennington Biomedical Research Center in Baton Rouge, LA (Diabetes 54, 2005 1926-33) showed that this in turn partially disables the genes that produce mitochondria.

Examples

Examples of mitochondrial diseases include:

1. Mitochondrial myopathy
2. Diabetes mellitus and deafness (DAD)
   - this combination at an early age can be due to mitochondrial disease
   - Diabetes mellitus and deafness can also be found together for other reasons
3. Leber’s hereditary optic neuropathy (LHON)
   - visual loss beginning in young adulthood
   - eye disorder characterized by progressive loss of central vision due to degeneration of the optic nerves and retina
   - affects 1 in 50,000 people in Finland
4. Leigh syndrome, subacute sclerosing encephalopathy
   - after normal development the disease usually begins late in the first year of life, although onset may occur in adulthood
   - a rapid decline in function occurs and is marked by seizures, altered states of consciousness, dementia, ventilatory failure
5. Neuropathy, ataxia, retinitis pigmentosa, and ptosis (NARP)
   - progressive symptoms as described in the acronym
   - dementia
6. Myoneurogenic gastrointestinal encephalopathy (MNGIE)
   - gastrointestinal pseudo-obstruction
   - neuropathy
7. Myoclonic Epilepsy with Ragged Red Fibers (MERRF)
   • progressive myoclonic epilepsy
   • “Ragged Red Fibers” – clumps of diseased mitochondria accumulate in the subsarcolemmal region of the muscle fiber and appear as “Ragged Red Fibers” when muscle is stained with modified Gömöri trichrome stain
   • short stature
   • hearing loss
   • lactic acidosis
   • exercise intolerance

8. Mitochondrial myopathy, encephalomyopathy, lactic acidosis, stroke-like symptoms (MELAS)

9. mtDNA depletion
   • mitochondrial neurogastrointestinal encephalomyopathy (MNGIE)

Nota bene: Conditions such as Friedreich’s ataxia can affect the mitochondria, but are not associated with mitochondrial proteins.

MECHANISMS

The effective overall energy unit for the available body energy is referred to as the daily glycogen generation capacity, and is used to compare the mitochondrial output of healthy individuals to that of afflicted or chronically glycogen-depleted individuals. This value is slow to change in a given individual, as it takes between 18 and 24 months to complete a full cycle.

The glycogen generation capacity is entirely dependent on, and determined by, the operating levels of the mitochondria in all of the cells of the human body; however, the relation between the energy generated by the mitochondria and the glycogen capacity is very loose and is mediated by many biochemical pathways.

The energy output of full healthy mitochondrial function can be predicted exactly by a complicated theoretical argument, but
this argument is not straightforward, as most energy is consumed by the brain and is not easily measurable.

TREATMENTS

Despite the fact that exploration is continuous, treatment choices are at present constrained; vitamins are regularly recommended, however the confirmation for their adequacy is restricted. Film infiltrating cancer prevention agents, for example, the mitochondria-focused on cell reinforcement MitoQ (mitoquinol mesylate) have the most imperative part in enhancing mitochondrial dysfunction. Pyruvate has been proposed as of late as a treatment alternative. N acetylcysteine inverts numerous models of mitochondrial brokenness.

Shaft exchange, where the atomic DNA is exchanged to another solid egg cell leaving the imperfect mitochondrial DNA behind, is a potential treatment strategy that has been effectively completed on monkeys. Utilizing a comparative pronuclear exchange procedure, scientists at Newcastle University drove by Douglass Turnbull effectively transplanted solid DNA in human eggs from ladies with mitochondrial sickness into the eggs of ladies givers who were unaffected. In such cases, moral inquiries have been raised with respect to natural parenthood, since the kid gets qualities and quality administrative atoms from two distinct ladies. Utilizing hereditary designing as a part of endeavors to deliver babies free of mitochondrial sickness is disputable in a few circles and raises imperative moral issues.

In September 2012 an open counsel was dispatched in the UK to investigate the moral issues included. Human hereditary building was utilized on a little scale to permit fruitless ladies with hereditary deformities in their mitochondria to have youngsters. In June 2013, the United Kingdom government consented to create enactment that would authorize the ‘three-man IVF’ technique as a treatment to alter or dispose of mitochondrial ailments that are passed on from mother to kid. The methodology could be offered from 29 October 2015 once controls had been built up. Embryonic
mitochondrial transplant and protofection have been proposed as a conceivable treatment for acquired mitochondrial malady, and allotopic articulation of mitochondrial proteins as a radical treatment for mtDNA transformation load.

**EPIDEMIOLOGY**

About 1 in 4,000 children in the United States will develop mitochondrial disease by the age of 10 years. Up to 4,000 children per year in the US are born with a type of mitochondrial disease. Because mitochondrial disorders contain many variations and subsets, some particular mitochondrial disorders are very rare.

The average number of births per year among women at risk for transmitting mtDNA disease is estimated to approximately 150 in the United Kingdom and 800 in the United States.

**NOTABLE CASES**

Notable people who suffered from mitochondrial disease include:

- Mattie Stepanek suffered from Dysautonomic Mitochondrial Myopathy. He was a poet, peace advocate, and motivational speaker who died at age 13.
- Rocco Baldelli is a coach and former center fielder in Major League Baseball who had to retire from active play at age 29 due to Mitochondrial Channelopathy.
Esophageal Atresia

Esophageal atresia (or Oesophageal atresia) is an innate restorative condition (birth imperfection) which influences the nutritious tract. It causes the throat to end in a visually impaired finished pocket as opposed to interfacing ordinarily to the stomach. It contains an assortment of inborn anatomic imperfections that are brought on by an anomalous embryological improvement of the throat. It is portrayed anatomically by an innate obstacle of the throat with intrusion of the coherence of the esophageal divider.

FREQUENCY

It happens in roughly 1 in 2500 live births. Innate esophageal atresia (EA) speaks to a disappointment of the throat to create as a persistent section. Rather, it closes as a visually impaired pocket. Tracheoesophageal fistula (TEF) speaks to an irregular opening between the trachea and throat. EA and TEF can happen independently or together. EA and TEF are analyzed in the ICU during childbirth and treated quickly.

The nearness of EA is suspected in a baby with exorbitant salivation (dribbling) and in an infant with dribbling that is every now and again joined by stifling, hacking and wheezing. Whenever sustained, these newborn children swallow typically yet start to hack and battle as the liquid returns through the nose and mouth. The newborn child may get to be cyanotic (turn pale blue because
of absence of oxygen) and may quit breathing as the flood of liquid from the visually impaired pocket is suctioned (sucked into) the trachea.

The cyanosis is a consequence of laryngospasm (a defensive system that the body needs to avoid yearning into the trachea). After some time respiratory misery will create.

![Common anatomical types of esophageal atresia](image)

**Fig. : Common anatomical types of esophageal atresia**

In the event that any of the above signs/side effects are seen, a catheter is delicately passed into the throat to check for resistance. On the off chance that resistance is noted, different studies will be done to affirm the analysis. A catheter can be embedded and will appear as white on a customary x-beam film to exhibit the visually impaired pocket finishing. Here and there a little measure of barium (chalk-like fluid) is set through the mouth to analyze the issues.

Treatment of EA and TEF is surgery to repair the deformity. In the event that EA or TEF is suspected, every single oral nourishing are ceased and intravenous liquids are begun. The newborn child will be situated to deplete discharges and reduction the probability of desire. Babies with EA may once in a while have different issues. Studies will be done to take a gander at the heart, spine and kidneys.

Surgery to repair EA is fundamental as the child won’t have the capacity to sustain and is exceptionally liable to create pneumonia. Once the child is in condition for surgery, a cut is made in favor of the mid-section. The throat can as a rule be sewn
together. Taking after surgery, the infant might be hospitalized for a variable timeframe. Administer to every newborn child is individualized. Its normally found in an infant with imperforate rear-end.

CLASSIFICATION

This condition takes several different forms, often involving one or more fistulas connecting the trachea to the esophagus (tracheoesophageal fistula).

PRESENTATION

*Fig. Plain X-ray of the chest and abdomen showing a feeding tube unable to move beyond an upper esophageal pouch.*
Fig. Plain x-ray with contrast in the upper esophagus above the atresia.

Fig. Surgical treatment of the condition.
Esophageal Atresia

This birth defect arises in the fourth fetal week, when the trachea and esophagus should begin to separate from each other. It can be associated with disorders of the tracheoesophageal septum.

ASSOCIATIONS

Other birth defects may co-exist, particularly in the heart, but sometimes also in the anus, spinal column, or kidneys. This is known as VACTERL association because of the involvement of Vertebral column, Anorectal, Cardiac, Tracheal, Esophageal, Renal, and Limbs. It is associated with polyhydramnios in the third trimester.

DIAGNOSIS

This condition is visible, after about 26 weeks, on an ultrasound. On antenatal USG, the finding of an absent or small stomach in the setting of polyhydramnios was considered a potential symptom of esophageal atresia. However, these findings have a low positive predictive value. The upper neck pouch sign is another sign that helps in the antenatal diagnosis of esophageal atresia and it may be detected soon after birth as the affected infant will be unable to swallow its own saliva. Also, the newborn can present with gastric distention, cough, apnea, tachypnea, and cyanosis. In many types of esophageal atresia, a feeding tube will not pass through the esophagus.
Complications

Any attempt at feeding could cause aspiration pneumonia as the milk collects in the blind pouch and overflows into the trachea and lungs. Furthermore, a fistula between the lower esophagus and trachea may allow stomach acid to flow into the lungs and cause damage. Because of these dangers, the condition must be treated as soon as possible after birth.

Treatment

Treatments for the condition vary depending on its severity. The most immediate and effective treatment in the majority of cases is a surgical repair to close the fistula/s and reconnect the two ends of the esophagus to each other. Although this is usually done through an incision between the ribs on right side of the baby, a technique using three small incisions (thoracoscopy) is being used at some centers.

In a minority of cases, the gap between upper and lower esophageal segments may be too long to bridge. In some of these so-called long gap cases, though, an advanced surgical treatment developed by John Foker, MD, may be utilized to elongate and then join together the short esophageal segments.

Using the Foker technique, surgeons place traction sutures in the tiny esophageal ends and increase the tension on these sutures daily until the ends are close enough to be sewn together. The result is a normally functioning esophagus, virtually indistinguishable from one congenitally well formed. Unfortunately, the results have been somewhat difficult to replicate by other surgeons and the need for multiple operations has tempered enthusiasm for this approach.

The optimal treatment in cases of long gap esophageal atresia remains controversial. Traditional surgical approaches include gastrostomy followed by gastric pull-up, colonic transposition and jejunum transposition. Gastric pull-up has been the preferred approach at many specialized centers, including Great Ormond Street (London) and Mott Children’s Hospital (Ann Arbor).
Gastrostomy, or G-tube, allows for tube feedings into the stomach through the abdominal wall. Often a cervical esophagostomy will also be done, to allow the saliva which is swallowed to drain out a hole in the neck. Months or years later, the esophagus may be repaired, sometimes by using a segment of bowel brought up into the chest, interposing between the upper and lower segments of esophagus.

Post operative complications sometimes arise, including a leak at the site of closure of the esophagus. Sometimes a stricture, or tight spot, will develop in the esophagus, making it difficult to swallow. This can usually be diluted using medical instruments. In later life, most children with this disorder will have some trouble with either swallowing or heartburn or both. Esophageal dismotility occurs in 75-100% of patients.

Tracheomalacia—a softening of the trachea, usually above the carina (carina of trachea), but sometimes extensive in the lower bronchial tree as well—is another possible serious complication. Even after esophageal repair (anastomosis) the relative flaccidity of former proximal pouch (blind pouch, above) along with esophageal dysmotility can cause fluid buildup during feeding. Owing to proximity, pouch ballooning can cause tracheal occlusion. Severe hypoxia (“dying spells”) follows and medical intervention can often be required.

A variety of treatments for tracheomalacia associated with esophageal atresia are available. If not severe, the condition can be managed expectantly since the trachea will usually stiffen as the infant matures into the first year of life. When only the trachea above the carina is compromised, one of the “simplest” interventions is aortopexy wherein the aortic loop is attached to the rear of the sternum, thereby mechanically relieving pressure from the softened trachea. An even simpler intervention is stenting. However, epithelial cell proliferation and potential incorporation of the stent into the trachea can make subsequent removal dangerous.
MAGNETIC COMPRESSION METHOD

A method for repairing long-gap esophageal atresia using magnets has been developed, that does not require replacing the missing section with grafts of the intestine or other body parts. Using electromagnetic force to attract the upper and lower ends of the esophagus together was first tried in the 1970s by using steel pellets attracted to each other by applying external electromagnets to the patient. In the 2000s a further refinement was developed by Mario Zaritzky’s group and others. The newer method uses permanent magnets and a balloon.

1. The magnets are inserted into the upper pouch via the baby’s mouth or nose, and the lower via the gastrotomy feeding tube hole (which would have had to be made anyway to feed the baby, therefore not requiring any additional surgery).

2. The distance between the magnets is controlled by a balloon in the upper pouch, between the end of the pouch and the magnet. This also controls the force between the magnets so it is not strong enough to cause damage.

3. After the ends of the esophagus have stretched enough to touch, the upper magnet is replaced by one without a balloon and the stronger magnetic attraction causes the ends to fuse (anastomosis).

In April 2015 Annalise Dapo became the first patient in the United States to have their esophageal atresia corrected using magnets.
Hirschsprung’s Disease

Hirschsprung’s sickness (HD) is a type of megacolon that happens when part or the majority of the digestive organ or forerunner parts of the gastrointestinal tract have no ganglion cells and in this way can’t work.

Amid typical pre-birth improvement, cells from the neural peak relocate into the digestive organ (colon) to frame the systems of nerves called the myenteric plexus (Auerbach plexus) (between the smooth muscle layers of the gastrointestinal tract divider) and the submucosal plexus (Meissner plexus) (inside the submucosa of the gastrointestinal tract divider).

In Hirschsprung’s illness, the movement is not finished and part of the colon does not have these nerve bodies that manage the action of the colon. The influenced section of the colon can’t unwind and passstool through the colon, making a deterrent. In most influenced individuals, the turmoil influences the part of the colon that is closest the rear-end. In uncommon cases, the absence of nerve bodies includes a greater amount of the colon. In five percent of cases, the whole colon is influenced. Stomach and throat might be influenced as well.

Hirschsprung’s infection happens in around one in 5,000 of live births. It is generally analyzed in kids, and influences young men more regularly than young ladies. Around 10% of cases are familial.
SIGNS AND SYMPTOMS

Typically, Hirschsprung’s disease is diagnosed shortly after birth, although it may develop well into adulthood, because of the presence of megacolon, or because the baby fails to pass the first stool (meconium) within 48 hours of delivery. Normally, 90% of babies pass their first meconium within 24 hours, and 99% within 48 hours. Other symptoms include green or brown vomit, explosive stools after a doctor inserts a finger into the rectum, swelling of the abdomen, lots of gas and bloody diarrhea.

Some cases are diagnosed later, into childhood, but usually before age 10. The child may experience fecal retention, constipation, or abdominal distention. With an incidence of one in 5,000 births, the most cited feature is absence of ganglion cells: notably in males, 75 percent have none in the end of the colon (recto-sigmoid) and eight percent lack ganglion cells in the entire colon.

The enlarged section of the bowel is found proximally, while the narrowed, aganglionic section is found distally, closer to the end of the bowel. The absence of ganglion cells results in a persistent over-stimulation of nerves in the affected region, resulting in contraction.

In some extremely rare cases, the absence of ganglion cells continues to spread after the corrective surgery, resulting in multiple surgeries. Those patients that also have thyroid cancer may be able to digest food properly, but may not be able to use the nutrients properly.

PATHOPHYSIOLOGY

The most accepted theory of the cause of Hirschsprung is that there is a defect in the craniocaudal migration of neuroblasts originating from the neural crest that occurs during the first 12 weeks of gestation. Defects in the differentiation of neuroblasts into ganglion cells and accelerated ganglion cell destruction within the intestine may also contribute to the disorder.
This lack of ganglion cells in the myenteric and submucosal plexus is well-documented in Hirschsprung’s disease. With Hirschsprung’s disease, the segment lacking neurons (aganglionic) becomes constricted, causing the normal, proximal section of bowel to become distended with feces. This narrowing of the distal colon and the failure of relaxation in the aganglionic segment are thought to be caused by the lack of neurons containing nitric oxide synthase. The equivalent disease in horses is Lethal white syndrome.

**Genetic basis**

Several genes and specific regions on chromosomes (loci) have been shown or suggested to be associated with Hirschsprung’s disease:

<table>
<thead>
<tr>
<th>Type</th>
<th>OMIM</th>
<th>Gene</th>
<th>Locus</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSCR1</td>
<td>142623</td>
<td>RET</td>
<td>10q11.2</td>
</tr>
<tr>
<td>HSCR2</td>
<td>600155</td>
<td>EDNRB</td>
<td>13q22</td>
</tr>
<tr>
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<td>600837</td>
<td>GDNF</td>
<td>5p13.1-p12</td>
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<td>20q13.2-q13.3</td>
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<td>HSCR5</td>
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<td>-</td>
<td>605802</td>
<td>ZEB2</td>
<td>2q22.3</td>
</tr>
</tbody>
</table>

Hirschsprung’s disease can also present as part of a multisystem disorder, such as Down syndrome, Bardet-Biedl syndrome, Waardenburg-Shah syndrome, Mowat-Wilson syndrome, Goldberg-Shprintzen megacolon syndrome, cartilage-
hair hypoplasia, multiple endocrine neoplasia type 2, Smith-Lemli-Opitz syndrome and congenital central hypoventilation syndrome.

The RET proto-oncogene accounts for the highest proportion of both familial and sporadic cases, with a wide range of mutations scattered along its entire coding region. A proto-oncogene is a gene that can cause cancer if it is mutated or over-expressed. Research published in 2002 suggested that Hirschsprung’s may be caused by the interaction between two proteins encoded by two variant genes. The RET proto-oncogene on chromosome 10 was identified as one of the two genes involved. The other protein that RET must interact with in order to cause Hirschsprung’s disease is termed EDNRB, and is encoded by the gene EDNRB located on chromosome 13.

Hirschsprung’s disease, hypoganglionosis, gut dysmotility, gut transit disorders and intussusception have been recorded with the dominantly inherited neurovisceral porphyrias (acute intermittent porphyria, hereditary coproporphyria, variegate porphyria). Children may require enzyme or DNA testing for these disorders as they may not produce or excrete porphyrins prepuberty.

**RET proto-oncogene**

RET is a gene that codes for proteins that assist cells of the neural crest in their movement through the digestive tract during the development of the embryo. Those neural crest cells eventually form bundles of nerve cells called ganglions. EDNRB codes for proteins that connect these nerve cells to the digestive tract. Thus, mutations in these two genes could directly lead to the absence of certain nerve fibers in the colon. Research published in June 2004 suggests that there are several genes associated with Hirschsprung’s disease. Also, new research suggests that mutations in genomic sequences involved in regulating EDNRB have a bigger impact on Hirschsprung’s disease than previously thought.

RET can mutate in many ways and is associated with Down syndrome. Since Down Syndrome is comorbid in two percent of
Hirschsprung’s cases, there is a likelihood that RET is involved heavily in both Hirschsprung’s disease and Down Syndrome. RET is also associated with medullary thyroid cancer and neuroblastoma, which is a type of cancer common in children. Both of these disorders are more common in Hirschsprung’s patients than in the general population.

One function that RET controls is the travel of the neural crest cells through the intestines in the developing fetus. The earlier the RET mutation occurs in Hirschsprung’s disease, the more severe the disorder becomes.

Other genes

Common and rare DNA variations in the Neuregulin 1 (NRG1) and NRG3 (NRG3) were first shown to be associated with the disease in Chinese patients through a Genome Wide Association Study (GWAS) by the Hong Kong team in 2009 and 2012 respectively. Subsequent studies in both Asian and Caucasian patients confirmed the initial findings by the University of Hong Kong. Both rare and common variants in these two genes have been identified in additional Chinese, Thai, Korean, Indonesian and Spanish patients. These two genes are known to play a role in the formation of the enteric nervous system, thus, they are likely to be involved in the pathology of Hirschsprung, at least in some cases.

DIAGNOSIS

Definitive diagnosis is made by suction biopsy of the distally narrowed segment. A histologic examination of the tissue would show a lack of ganglionic nerve cells. Diagnostic techniques involve anorectal manometry, barium enema, and rectal biopsy. The suction rectal biopsy is considered the current international gold standard in the diagnosis of Hirschsprung’s disease. Radiologic findings may also assist with diagnosis. Cineanography (fluoroscopy of contrast medium passing anorectal region) assists in determining the level of the affected intestines.
TREATMENT

Treatment of Hirschsprung’s disease consists of surgical removal (resection) of the abnormal section of the colon, followed by reanastomosis.

Colostomy

The first stage of treatment used to be a reversible colostomy. In this approach, the healthy end of the large intestine is cut and attached to an opening created on the front of the abdomen. The contents of the bowel are discharged through the hole in the abdomen and into a bag. Later, when the child’s weight, age, and condition are right, the “new” functional end of the bowel is connected with the anus. The first surgical treatment involving surgical resection followed by reanastomosis without a colostomy occurred as early as 1933 by Doctor Baird in Birmingham on a one-year-old boy.

Swenson, Soave, Duhamel, and Boley procedures

Orvar Swenson, who discovered the cause of Hirschsprung’s, first performed its surgical treatment, the pull-through surgery in 1948. The pull-through procedure repairs the colon by connecting the functioning portion of the bowel to the anus. The pull-through procedure is the typical method for treating Hirschsprung’s in younger patients. Swenson devised the original procedure, and the pull-through surgery has been modified many times.

Currently, there are several different surgical approaches, which include the Swenson, Soave, Duhamel, and Boley procedures. The Swenson procedure leaves a small portion of the diseased bowel. The Soave procedure leaves the outer wall of the colon unaltered. The Boley procedure is a small modification of the Soave procedure, so the term “Soave-Boley” procedure is sometimes used. The Duhamel procedure uses a surgical stapler to connect the good and bad bowel.

For the 15 percent of children who do not obtain full bowel control, other treatments are available. Constipation may be
remedied by laxatives or a high fiber diet. In those patients, serious dehydration can play a major factor in their lifestyle. A lack of bowel control may be addressed by a stoma, similar to a colostomy. The Malone antegrade colonic enema (ACE) is also an option. In a Malone ACE, a tube goes through the abdominal wall to the appendix or, if available, to the colon. The bowel is then flushed daily. Children as young as 6 years of age may administer this daily flush on their own.

If the affected portion of the lower intestine is restricted to the lower portion of the rectum, other surgical procedures may be performed, such as a posterior rectal myectomy. The prognosis is good in 70 percent of cases. Chronic post-operative constipation is present in 7 to 8 percent of the operated cases. Post-operative enterocolitis is a severe manifestation that is present in the 10%–20% of operated patients.

ASSOCIATED SYNDROMES

• Bardet-Biedl syndrome
• Cartilage-hair hypoplasia
• Congenital central hypoventilation syndrome
• MEN2
• Mowat-Wilson syndrome
• Smith-Lemli-Opitz syndrome
• Trisomy 21 (Down syndrome)
• Waardenburg syndrome

Epidemiology

According to a 1984 study conducted in Maryland, Hirschsprung’s disease appears on 18.6 per 100,000 live births. In Japan, Hirschsprung disease occurs at a similar rate of about one in 5,000 births (20 per 100,000). It is more common in male rather than female (4.32:1) and in white rather than non-white. Nine percent of the Hirschsprung cases were also diagnosed as having Down syndrome. Most cases are diagnosed before the patient is 10 years of age.
HISTORY

The first report of Hirschsprung disease dates back to 1691, however, the disease is named after Harald Hirschsprung, the Danish physician who first described two infants who died of this disorder in 1888.

Hirschsprung’s disease is a congenital disorder of the colon in which certain nerve cells, known as ganglion cells, are absent, causing chronic constipation. The lack of ganglion cells is in the myenteric plexus (Auerbach’s Plexus), which is responsible for moving food in the intestine. A barium enema is the mainstay of diagnosis of Hirschsprung’s, though a rectal biopsy showing the lack of ganglion cells is the only certain method of diagnosis.

The first publication on an important genetic discovery of the disease was from Martucciello Giuseppe et al. in 1992. The authors described a case of a patient with total colonic aganglionosis associated with a 46, XX, del 10 (q11.21 q21.2) karyotype. The major gene of Hirschsprung disease was identified in this chromosomal 10 region, it was the RET proto-oncogene.

The usual treatment is “pull-through” surgery where the portion of the colon that does have nerve cells is pulled through and sewn over the part that lacks nerve cells (National Digestive Diseases Information Clearinghouse). For a long time, Hirschsprung’s was considered a multi-factorial disorder, where a combination of nature and nurture were considered to be the cause. However, in August 1993, two articles by independent groups in Nature Genetics said that Hirschsprung’s disease could be mapped to a stretch of chromosome 10. This research also suggested that a single gene was responsible for the disorder. However, the researchers were unable to isolate it.
INTRODUCTION

In spite of acknowledgment that periconceptional folic corrosive supplementation in regenerative age ladies diminishes the danger of fetal neural tube absconds (NTDs), these mutations remain the second most normal genuine fetal birth imperfection in the United States, surpassed just by inborn heart abandons. Screening strategies used to recognize neural tube deformities are presently a segment of routine obstetrical care, and incorporate both second trimester maternal serum alpha-fetoprotein (MSAFP) levels and fetal ultrasonographic assessments.

Once a NTD is recognized, different administration alternatives are accessible for families, including thought of pregnancy end, in utero fetal surgery, and in addition referral to a tertiary watch over administration and conveyance. In this way, it is valuable for the honing obstetricians to know about these complex analytic and administration alternatives for ideal consideration of the obstetric patient and embryo. In this part, the etiologies, antenatal analysis, and administration, and in addition data with respect to anticipation are assessed.
ETIOLOGY: GENETICS AND EMBRYOLOGY

Neurulation is characterized as the embryonic procedure that prompts a definitive improvement of the neural tube, the forerunner to the cerebrum and spinal string. There are two particular periods of neurulation. In the essential stage (weeks 3–4) the cerebrum and the neural tube structure from the caudal locale to the upper sacral level. Optional neurulation (weeks 5–6) finishes the distal sacral and coccygeal districts. The atomic occasions amid neural tube improvement are mind boggling are still not entirely caught on. In a nutshell, current speculations of neural tube improvement are identified with the standard of concurrent expansion (CE), which is thought to guide the extending of cells to make the embryonic hub. This procedure is likely controlled by PCP (planar cell extremity), the procedure in which cells adjust and get to be energized inside epithelium. Numerous qualities manage these complex cell pathways.

The disappointment of neurulation at any stage prompts the arrangement of a neural tube deformity. Recognizable proof of human qualities inclining to NTDs utilizing positional cloning is troublesome because of the intricate etiologies of these sores, and the constrained quantities of huge families with numerous influenced relatives. The hereditary premise of NTDs has concentrated on qualities identified with the folic corrosive pathway and hopefuls qualities from creature thinks about. Albeit numerous qualities have been connected with NTD improvement, no major causative quality has been distinguished. To date, qualities in the PCP pathway embroiled in CE improvement and neural tube arrangement are the most emphatically ensnared in NTD advancement.

Embryology

NTDs are a heterogeneous group of malformations resulting from failure of neural tube closure between the third and fourth week of embryologic development. Approximately 18 days after conception, the neural plate folds inward to form a central neural
groove and bilateral neural folds. The cranial end of the neural tube becomes the forebrain, midbrain, and hindbrain, and a failure of closure results in anencephaly. The caudal end of the neural tube becomes the spinal cord, and a failure of posterior neuropore closure results in spina bifida. Van Allen and colleagues, using reviews of previous published clinical reports, have shown evidence of multisite neural tube closure based on five common sites for NTD lesions. Each closure site may be modified by unique genetic or environmental factors during development. Furthermore, certain closure sites are associated with particular fetal insults or genetic abnormalities. For example, the NTD associated with Meckel-Gruber syndrome is associated with site 4; valproic acid is associated with site 5. Martinez-Frias and colleagues evaluated 774 live born infants with NTDs following the multi-site classification proposed by Van Allen’s group. They classified every case by the multi-site closure model, lending support to this theory of localized cellular disruption. They could therefore estimate the prevalence of each site of closure failure; not all sites were affected with similar frequency.

Anencephaly, encephalocele, and spina bifida are the three most common forms of NTDs. Anencephaly is the most severe of these lesions. With failure of brain development, the cranium does not form (called acrania), and the remaining neural elements are
covered by a thin membrane. Encephaloceles are much less common than anencephaly or spina bifida. They are cystic extensions of the brain through an overlying scalp and skull defect, somewhat analogous to a spina bifida.

A disruption of the vertebral arches often accompanied by underlying spinal cord defects is collectively called spinal dysraphism or spina bifida. It is classified as spina bifida occulta if the disruption involves only bony structures and spina bifida cystica if there is a saccular defect involving neural elements. Meningomyeloceles constitute 90% of spina bifida and are composed of neural tissue covered by meninges that extrude through the vertebral column. Alternatively, a fluid filled sac (not containing neural elements) covered by meninges that protrudes through the bony defect is called a meningocele. Although spinal dysraphism can occur at any region of the vertebral column, the most common site for these defects is the lumbosacral area.

*Fig. : Spina bifida by ultrasound (A) and after delivery (B).*

Spina bifida is frequently accompanied by the Arnold-Chiari malformation. This anomaly results from a downward displacement of the medulla, fourth ventricle, and cerebellum through the foramen magna into the region of the cervical spine. This downward displacement of the hindbrain can hinder the egress of cerebrospinal fluid from the brain, causing an enlargement of the ventricles. This accounts for the 70–90% incidence of hydrocephalus associated with spina bifida.
Other, less common defects include exencephaly (i.e., exteriorization of an abnormally formed brain) and iniencephaly (i.e., defect of the skull base, cervical spine, and underlying neural tissue). Myeloschisis, usually seen as an early fetal defect, describes an open flat neural plate that may be extensive. Myelodysplasia, or occult spinal dysraphism, describes less obvious malformations of the cord resulting from maldevelopment of the caudal region of the neural tube. These defects are often associated with lipomas or cutaneous changes overlying the region such as dimpling, sinus tracts, or hairy patches. These probably result from an embryologic mechanism similar to NTDs and may be associated with neurologic or orthopedic disabilities. Schut and coworkers have extensively reviewed the clinical aspects and variations of these defects.

**INCIDENCE AND RECURRENCE RISKS**

The incidence of NTDs varies with race, geographic location, and various other predisposing factors. In the United States, the incidence is approximately one to two cases per 1000 live births, whereas the incidence in the UK is about four times greater. Since the introduction of the fortification of grain products in 1996, the incidence of NTDs has decreased about 25%. Families who have had a child with an NTD have a 10-fold increase in their recurrence risk. In the United States, a family with an affected child has a 2% recurrence risk of another child with an NTD. If the defect in the first affected pregnancy was anencephaly, the family has a higher risk for recurrence of anencephaly than for recurrence of spina bifida. The risks for other affected US populations. Between 90% and 95% of NTDs occur in families without a prior family history of an NTD.

Eighty-five per cent of NTDs occur by multifactorial inheritance, a genetic predisposition from an interaction between various genes and environmental factors. The etiologic heterogeneity of NTDs was best illustrated by Holmes and coworkers, who reported that, of 106 liveborn or stillborn infants with an NTD, about 12% had identifiable causes. A small proportion
of NTDs occur because of single-gene disorders, chromosomal aneuploidy, and teratogen exposure.

*Table: Estimated incidence of neural tube defects based on specific risk factors in the United States*

<table>
<thead>
<tr>
<th>Population</th>
<th>Incidence/1000 Live Births</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother as reference</td>
<td></td>
</tr>
<tr>
<td>General incidence</td>
<td>1.4–1.6</td>
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<tr>
<td>Women undergoing amniocentesis for advanced maternal age</td>
<td>1.5–3.0</td>
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<tr>
<td>Women with diabetes mellitus</td>
<td>20</td>
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<tr>
<td>Women on valproic acid in first trimester</td>
<td>10–20</td>
</tr>
<tr>
<td>Fetus as reference</td>
<td></td>
</tr>
<tr>
<td>One sibling with NTD</td>
<td>15–30</td>
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<tr>
<td>Two siblings with NTD*</td>
<td>57</td>
</tr>
<tr>
<td>Parent with NTD</td>
<td>11</td>
</tr>
<tr>
<td>Half sibling with NTD</td>
<td>8</td>
</tr>
<tr>
<td>First cousin (mother’s sister’s child)</td>
<td>10</td>
</tr>
<tr>
<td>Other first cousins</td>
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<tr>
<td>Sibling with severe scoliosis secondary to multiple vertebral defects</td>
<td>15–30</td>
</tr>
<tr>
<td>Sibling with occult spinal dysraphism</td>
<td>15–30</td>
</tr>
<tr>
<td>Sibling with sacrococcygeal teratoma or hamartoma</td>
<td>≤15–30</td>
</tr>
</tbody>
</table>

NTD, neural tube defect.

*Risk is higher in UK studies. Risk increases further for three or more siblings or combinations of other close relatives.


Meckel syndrome is the most common of the single-gene disorders associated with an NTD. This autosomal recessive syndrome includes posterior encephalocele, polydactyly, cleft
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...palate, and cystic dysplasia of the kidneys. Because the recurrence risk for such a defect is 25%, it underscores the need for careful evaluation of all infant with NTDs, because recurrence risks depend on the cause of the malformation.

Chromosomal aneuploidy also accounts for a small percentage of NTDs. Of the various types of NTDs, encephaloceles and spina bifida are more likely to be associated with triploidy; with trisomies 13, 18, and 21; and with various unbalanced translocations. The recurrence risk for these disorders varies with the mechanism responsible for the aneuploidy. For example, the recurrence risk for a trisomy is approximately 1% and triploidy is thought to be a sporadic event with a negligible recurrence risk. Recurrence estimates for translocations depend on the specific nature of the translocation and whether they are maternally or paternally transmitted. Significant controversy remains as to whether patients in whom a fetus appears to have an isolated spina bifida should undergo karyotype analysis. Recurrence risk, reproductive decisions, and obstetrical management may be altered if a fetus has a demonstrated chromosomal aneuploidy. Babcook and coworkers retrospectively reviewed sonograms for 63 fetuses with sonographically detected spina bifida and correlated the results with subsequent autopsy or clinical findings. Of fetuses with sonographically isolated spina bifida, 22% had chromosomal aneuploidy. Although this is a small cohort, cytogenetic analysis remains a justifiable method by which to fully evaluate an affected fetus for appropriate recurrence risk counseling.

Several teratogens have been implicated in the cause of NTDs. Two anticonvulsant medications in current use, carbamazepine and valproic acid, have been demonstrated to cause these defects. Robert and Guibaud originally reported an association between valproic acid and NTDs, noting a 1% risk for NTDs in patients taking this medication. This observation has been substantiated in several animal models. Carbamazepine also is associated with a 1% risk of spina bifida. Isotretinoin, an FDA approved oral vitamin an isomer used in the treatment of severe, recalcitrant
nodular and cystic acne is associated with a high incidence of spontaneous abortion and major malformations. Congenital defects include hemifacial microsomia, central nervous system malformations including neural tube defects and hydrocephalus, and severe cardiovascular anomalies. The critical period of exposure is believed to be 14–35 days postconception with approximately a 25% incidence of a major malformation with exposure to the drug during the first 20 weeks of gestation. Although there is no debate regarding its teratogenicity, its unique efficacy and relatively short treatment course of about 15–20 weeks warrants its continued use as dermatologic therapy in specific situations. Therefore, the FDA now regulates the use of oral isotretinoin by a computer based risk management program to ensure restricted distribution and usage. The use of topical isotretinoin preparations is not associated with congenital malformations.

Children of mothers with insulin-dependent diabetes mellitus have a 1–2% risk of NTD and a twofold to threefold (4–9%) increased incidence of congenital malformations compared with the general population. Although glycemic control may not be the sole etiologic factor in malformations in infants of diabetic women, careful preconceptional control is believed to decrease the prevalence of NTDs and other anomalies in these patients.

PERICONCEPTIONAL FOLIC ACID SUPPLEMENTATION

Epidemiologic observations such as geographic and seasonal variation, as well as an association with socioeconomic status, supported a hypothesis that dietary factors might play a role in the occurrence of NTDs. As early as 1965 work of Hibbard and Smithells suggested that folate might be an important dietary factor in the occurrence of NTDs. By the 1980s observational trials and one double-blind randomized controlled trial using high dose folic acid (4 mg daily) appeared to confirm this hypothesis. In 1991 Wald and colleagues published results of the British Medical
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Research Council (MRC) Vitamin Study, a randomized controlled trial showing that administration of 4 mg daily of folic acid for 3 months prior to conception and during early fetal development resulted in a 72% reduction of NTDs in women with a prior NTD pregnancy.

This landmark study used four arms to demonstrate the effect of folic acid and excluded an effect of the concomitant administration of multivitamins or placebo. The relatively high dose of folic acid was selected because of the earlier experience and the desire to avoid a negative result with a lower dose. The lowest effective dose and the shortest duration of treatment prior to conception have not been defined and it is unlikely that definitive studies to determine these limits will ever be conducted. It was subsequently demonstrated by others that a multivitamin with trace elements plus 0.8 mg folic acid compared to a supplement containing trace elements and vitamin C prevented a significant portion of first occurrence of NTDs.

Folic acid is important in transfer and exchange of methyl groups. As such, it is a substrate for the methionine synthase reaction which converts homocysteine to methionine. The production of methionine is important for protein synthesis. One-carbon transfer is also essential to a number of intracellular processes including the synthesis of the purine and pyrimidine building blocks of DNA and RNA. Thus, the relationship of folic acid deficiency to embryopathy is quite plausible. Deficiency of folic acid is marked by microcytic anemia and mild elevation of homocysteine. An elevation of homocysteine has been implicated in thrombogenesis and atherogenesis, and treatment with folic acid reduces the homocysteine elevation. While some portion of the prevention of NTDs by folic acid may relate to dietary deficiency, it is believed that an important effect is compensation for a genetically determined metabolic defect in homocysteine metabolism, e.g., due to MTHFR mutation. These observations are consistent with the epidemiologic observations as well as the familial recurrence patterns. Thus, approximately 70% of isolated
open neural tube defects are considered “folate dependent” while the remaining 30% remain unexplained.

Food folate, in contrast to folic acid, is inconsistently absorbed due to attachment of polyglutamated side chains of variable length. Due to greater bioavailability and ease of compliance with recommended intake, supplementation with the synthetic form of folic acid rather than dietary intervention is a more efficacious approach for prevention neural tube defects. As a result, the US Public Health Service recommended in 1992 that all women of child-bearing age consume at least 400 μg of synthetic folic acid daily in addition to eating a folate-rich diet.

In spite of efforts to educate women and the providers who care for them about these recommendations, fewer than half of the women of reproductive age adhere to the recommendations. Attempts to specifically target women who will become pregnant are hampered by the high rate of unintended pregnancies in the United States.

In 1996 the US FDA considered folic acid enrichment of all cereal and grain products in the United States. This generated substantial debate as potential risks of such a broad sweeping program were considered. A major concern was the impact on elderly patients, particularly those with vitamin B12 deficiency. Ultimately, the FDA mandated fortification by January 1998 at a level of 140 μg/100 g of flour. This is a level of fortification below what is needed to maximize prevention of neural tube defects in the majority of reproductive aged women. Since the implementation of the fortification at the level of 140 μg/100 g, the prevalence of neural tube defects has decreased by 27%. A greater reduction in neural tube defects has been observed in several other countries, e.g., Chile, which fortified at a higher level and where women consume more fortified grain products. Thus, there is reason for renewed debate about increasing the level of fortification. It has been estimated that a 50% reduction in prevalence is obtainable with additional supplementation. Despite hypothetical risks of fortification no adverse effects have been observed and a
comprehensive critical review favors increasing the level of fortification to achieve more effective prevention.

Issues such as the potential benefit of additional vitamin B12 supplementation particularly in women who are strict vegetarians and a reduction in other birth defects continue to be studied. Likewise, the benefits of folic acid with regard to reduction of adult cardiovascular disease and prevention and treatment of the elderly with and without dementia are areas of interest. In the mean time, the recommendation in the United States remains unchanged, i.e., that during the reproductive years, women should take 400 µg (0.4 mg) of synthetic folic acid daily and consume a diet rich in folate. Women in high risk categories should take 4 mg of synthetic folic acid daily for 3 months prior to conception and during early fetal development. The effective use of folic acid for the prevention of a large portion of neural tube defects has been a major advance in the health care of women and children.

SCREENING AND DIAGNOSIS OF NEURAL TUBE DEFECTS

Both ultrasound and MSAFP screening can identify neural tube defects. Ultrasound can visualize the lesion, while MSAFP levels, if elevated, will place the patient in a high risk group to justify a detailed fetal ultrasound survey and/or amniocentesis to confirm the diagnosis. Screening decreases morbidity and mortality by promoting access to earlier diagnosis, enabling families to make informed reproductive choices, and designing appropriate strategies for prenatal care and delivery.

Screening and diagnostic testing

Since its introduction into obstetric practice, MSAFP during the early second trimester remains the most important biochemical marker for open fetal defects. MSAFP is also a component in the biochemical screening for fetal aneuploidy as well as adverse gestational outcome. It is important to note that not all screening or diagnostic strategies for aneuploidy include second trimester
measurement of MSAFP. Any screening protocol that includes second trimester blood testing, such as a quad screen, integrated screen, or sequential screen, includes measurement of MSAFP and a risk assessment for open fetal defects. On the other hand, patients who decline aneuploidy screening or who choose only to undergo first trimester screening or who opt for chorioc villus sampling (CVS) do not have biochemical screening for open fetal defects unless a second trimester MSAFP is also performed. Since second trimester MSAFP and ultrasound are independent screening methods, both can be used to assess an individual patient’s risk. The combination of these two independent screening methods, each with high sensitivity, result in a powerful approach to screening. Given the high sensitivity of second trimester ultrasound of intracranial and spinal anatomy for detection of spina bifida some physicians forego offering second trimester MSAFP to patients who do not have this performed as part of the aneuploidy risk assessment or diagnosis. The rationale for such an approach is that when the defect cannot be seen with ultrasound the clinical implications are more difficult to estimate. The decision to forego offering second trimester MSAFP to these patients is generally based on experience of the sonographer, and the quality of the ultrasound evaluation of the individual patient.

**Alpha-fetoprotein: Biologic Properties**

Normal production of alpha-fetoprotein (AFP) is unique to fetal development, making it an ideal marker for early fetal evaluation. AFP was first isolated in 1956 by Bergstrand and Czar. Its name reflects its location on protein electrophoresis (in the α1 region between albumin and α1-globulin) and its fetal origin. It is structurally and functionally related to albumin. Genes for both proteins originate on chromosome 4, and both proteins have a molecular mass of 69,000 daltons.

Several functions have been postulated for AFP. Like albumin, it may be an intravascular transport protein and may play a role in maintaining oncotic pressure. An immunosuppressive effect of
AFP has also been suggested as a mechanism for protecting paternally derived antigens in the fetus against maternal antibodies. However, because there are reported cases of congenital deficiency of AFP resulting in normal newborns, the actual function of AFP remains speculative.

AFP is produced sequentially by the fetal yolk sac, gastrointestinal tract, and liver. It reaches a peak concentration in fetal serum of approximately 300 mg/dl by the end of the first trimester. The fetal liver produces a constant amount of AFP through the 30th week of gestation, although levels in the fetal blood decrease as the pregnancy advances. This is best explained by a dilutional effect in the enlarging fetal intravascular compartment. After 30 weeks’ gestation, fetal AFP production declines precipitously.

In the maternal circulation, AFP levels rise until the 30th gestational week. Thereafter, levels decline until term and drop precipitously after delivery. During the second trimester, maternal serum AFP levels increase, while fetal serum levels decline. This paradox is not completely understood, but it may result from the enlarging placenta allowing a greater capacity for diffusion of AFP or changes in the permeability of the placenta to AFP. The mechanism for transfer of AFP to the maternal circulation is transplacental (two thirds) and transamniotic (one third).

AFP is also found in high concentrations in amniotic fluid. The decrease in amniotic fluid AFP through the second and third trimester closely parallels the decrease in AFP in fetal blood. A small proportion of AFP enters the amniotic fluid after filtration of the fetal blood through the kidney. As the fetus swallows amniotic fluid, AFP is destroyed by gastrointestinal proteolytic enzymes. AFP concentration in amniotic fluid is approximately 150 times less than that in fetal serum.

In 1972, Brock and Sutcliffe measured AFP in the amniotic fluid of 31 pregnancies with anencephaly and six pregnancies with spina bifida, hydrocephaly, or both conditions. All of the
cases of anencephaly and most of the spina bifida cases before 30 weeks’ gestation demonstrated amniotic fluid AFP levels that were markedly elevated during pregnancy. When the fetus has an open (not skin covered) NTD, AFP leaks from the fetal circulation into the amniotic fluid. In 1974, Wald and coworkers performed a case-controlled study comparing maternal serum AFP levels in seven pregnancies with open NTDs with 14 control pregnancies matched for maternal age, parity, and gestational age. Maternal serum AFP levels in the affected pregnancies were significantly higher than those of the control population. This led to the hypothesis that there would be a role for measuring MSAFP in screening for NTDs. The UK Collaborative study demonstrated the utility of this test for prospective open NTD screening in 1977.

In anencephaly, the malformed skull is not completely covered by overlying skin, and it is therefore the lesion most accurately detected with MSAFP screening. More than 90% of anencephaly cases can be detected by MSAFP screening, and 99% can be detected by ultrasound examination. Approximately 99% of anencephaly cases can also be detected by amniotic fluid AFP and acetylcholinesterase (AChE) testing. In contrast, most encephaloceles are skin covered and therefore are less likely to be identified by MSAFP screening or amniocentesis and are most often detected by ultrasound. Spina bifida and anencephaly occur with equal frequency. Approximately 80% of spinal cord defects are open – the tissue overlying the defect is not skin covered. The remainder of spinal cord defects are covered by skin or by a thick membrane and are not detectable by screening.

In general, MSAFP screening programs detect approximately 85% of open fetal NTDs: 80% of open spina bifida and 90% of anencephaly. Almost all of these open lesions can then be diagnosed by amniotic fluid testing. The object of any screening program is to maximize detection at an acceptable false-positive rate. A screening test cutoff point is a balance between these two factors. The correct MoM value for MSAFP can only be calculated after all the appropriate information regarding the patient is taken into
account. This includes weight (at the time the blood sample was obtained), gestational age, and race, and considers whether the patient has insulin-dependent diabetes mellitus. An MSAFP level is considered elevated if the value is greater than 2.0 or 2.5 times the median value (2.0 or 2.5 MoMs) for normal controls at the same week of gestation.

Consider the hypothetical example given with the protocol. A cohort of 10,000 consecutive women present for MSAFP screening with a level of risk comparable to that of the US population. About 10–15 of these pregnancies would be affected with an NTD. MSAFP screening would detect 8–10 of these defects. At a cutoff of 2.0 MoMs, the false positive rate for this test of 4%, but a screen positive test result would only imply a 3% risk of having a child affected with an open NTD. A positive screening test result increases these patients’ risk from 1.5 per 1000 to 3 per 100. Conversely, 97% of pregnancies with a postive screening test result are unaffected. If a screening cutoff of 2.5 MoM is used, the false positive rate is about 2%.

MSAFP screening is most accurate when performed between 16 and 18 weeks’ gestation, but testing can be performed between 15 and 22 weeks. Screening earlier or later than the optimal gestational age decreases the sensitivity of the test. Screening should be voluntary and should be performed after the patient has been fully informed regarding the benefits and limitations of the test. The patient should understand that a normal MSAFP result does not ensure a child without an abnormality (including an NTD), and that an elevated MSAFP level does not specifically diagnose an abnormality. Instead, an elevated value places the patient in a high-risk group that necessitates further evaluation.

**Amniotic Fluid Alphafetoprotein And Acetylcholinesterase**

Amniocentesis is often used to differentiate the disorders responsible for a maternal serum AFP elevation. If there is an amniotic fluid AFP elevation, a secondary test for the presence or
absence of the acetylcholinesterase (AChE) enzyme by gel electrophoresis is performed on the fluid. AChE is not normally identified in amniotic fluid. Tissues containing AChE are red blood cells, muscle, and neural tissue. Concentrations of AChE are much higher in fetal cerebrospinal fluid than in fetal serum. If the fetus has an open NTD, amniotic fluid AFP and AChE are usually both elevated and the high concentration of AChE in cerebrospinal fluid transudates across the defect into the amniotic fluid. AChE is a sensitive test for confirming an open NTD.

Fetal blood contamination is the most common source of falsely elevated AFP levels in amniotic fluid, and the amniocentesis performed to obtain the sample is the most common cause of fetal blood in the fluid. In such cases, amniotic fluid AFP is usually in the 3–5 standard deviation range. AChE is not detected in 90% of cases because of the relatively low AChE concentrations in the fetal blood. In congenital (Finnish) nephrosis, a rare autosomal recessive disorder, amniotic fluid AFP levels may be very high, and AChE is not identified.

At the time of amniocentesis for elevated MSAFP, karyotype analysis should also be performed regardless of the amniotic fluid AFP result. Omphaloceles and NTDs are both associated with chromosomal aneuploidy. Even when the amniotic fluid AFP level is normal, the addition of chromosome analysis allows more informative counseling regarding perinatal outcome.

**Ultrasound**

Despite the implementation of newer techniques, such as first trimester endovaginal sonography as well as three dimensional imaging, the diagnostic accuracy of detecting neural tube defects is dependent on the time allotted, the quality of the equipment, the ability to obtain adequate images, and the experience of the sonologist. The detection of anencephaly is reported to be 100% at midgestation. With regard to identification of neural tube defects, assessment of the intracranial structures aids the diagnosis of the NTD. Evaluation of the cranial structures through two images of
the transverse sonographic planes yield all relevant anatomic details for the diagnosis of malformations. This includes the superior transventricular plane through the frontal horn, cavum septum pellucidi, and lateral ventricular atria. The second, more inferior view is through the transcerebellar plane, through the thalamus, cerebellum, and cisterna magna.

In almost all cases of neural tube defects, an Arnold-Chiari malformation can be identified, defined as displacement of the cerebellar vermis, fourth ventricle, and medulla through the foramen magnum. The term “banana sign” describes the elongated (as opposed to dumbbell) shape of the cerebellum. The “lemon sign” describes in utero frontal bossing, however, the lemon sign can also be identified in 1–2 % of normal fetuses, and sometimes can be caused by significant pressure during scanning. A variable degree of lateral ventricular atrial enlargement can also be identified in the midtrimester. The sensitivity of cranial signs in detection of spina bifida approaches 99%.

Budorick and colleagues offer a comprehensive review of the technique of fetal spine imaging. In brief, sonography depends on identification of the three ossification centers with the fetal vertebrae. Three imaging planes are used to identify the fetal spine: transverse plane, in which the ossification centers have to be identified, the parasagittal and coronal views. The spine must be imaged completely from the cervical to the sacral region.

Three dimensional imaging can be a powerful complementary adjunct to two dimensional imaging. There may be better localization of the lesion with three dimensional imaging, since both the axial and coronal images can be stored simultaneously and produce a rendered image of the fetal vertebrae. Some current limitations of three dimensional imaging include the additional time it takes to achieve accurate imaging, as well as the amniotic fluid interface necessary to capture and render a three dimensional image.

Current detection of neural tube defects with experienced sonographers and knowledge of MSAFP level should be greater
than 90%. In patients at elevated risk for open fetal defects, Lennon and Gray reported a detection rate for spina bifida by ultrasound of 97% with 100% neonatal ascertainment. However, these data may be limited to their own site and their improved detection may even be affected by the knowledge that this study was being performed as well as the fact that the patients presented at high risk for this disorder. Caution should be used with regard to interpreting this type of ascertainment in general since equipment and ability are so varied. Further, these data cannot be extrapolated to low risk centers in low risk patients undergoing routine sonographic screening evaluations. In the RADIUS trial, when low risk ultrasound was performed with MSAFP screening, the detection rate was about 80%.

Both MSAFP results and ultrasound evaluations in pregnancy are screening tests: that is, they place women in lower or higher risks groups for the detection of open fetal defects. Ultrasound can be diagnostic, but ultrasound examinations have the limitations of the training of the sonographers and quality of the equipment. Therefore, the combination of MSAFP screening with ultrasound is the most powerful combination for detection of neural tube defects: each screens by a different method. As noted above, patients who decline aneuploidy screening, and those who have only first trimester screening or diagnosis with CVS may also be offered second trimester MSAFP screening in addition to second trimester sonographic evaluation. In this situation MSAFP should be ordered as an individual analyte measurement to avoid obtaining unwanted or confusing information.

Given that there is a significant association between neural tube defects and chromosomal aneuploidy, we believe that offering a fetal karyotype to a patient with a fetal NTD is warranted. Approximately 6–16% of isolated appearing NTDs are associated with aneuploidy, these are most often trisomies, triploidy and chromosomal deletions. Knowledge of the etiology of the lesion profoundly affects recurrence rates for a family. A fetus with a trisomy will yield a 1% recurrence risk for future conceptions.
Further, fetal autopsy, to evaluate the fetus for single gene disorders with a recurrence risk for the family at 25% is essential.

**MANAGEMENT COUNSELING REGARDING MORBIDITY AND MORTALITY**

Thorough counseling of patients who have an NTD identified in an ongoing pregnancy is essential. Because anencephaly is uniformly fatal, the most important aspect of counseling is identifying the cause for the purpose of accurate recurrence risk counseling and preparation of the parents for the loss of their child at or shortly after birth. In a review of 181 liveborn infants with anencephaly, 40% were alive at 24 hours of age, and 5% lived to 1 week of age. Encephalocele, although a closed lesion, is a serious condition with a mortality rate of 60–75% during the first year.

The disabilities among survivors with spina bifida are accounted for by the location and extent of the lesion and the presence or absence of hydrocephaly. In general, because neural function is interrupted distal to the lesion, the higher the lesion, the greater is the neurologic deficit. If a patient survives with an NTD, the major morbidities include developmental delay and the ability to ambulate and maintain continence. Eventual outcome for the child varies with perinatal management and availability of support services.

Althouse and Wald evaluated an unselected series of 213 patients born in the UK with spina bifida (including encephaloceles) between 1965 and 1972. Their data reflect the natural history of these lesions before the advent of MSAFP screening. The 5-year survival rate for all patients was 36% for those with open lesions, 60% for those with closed lesions, and 18% for those with lesions that could not be classified. Closed cranial lesions (i.e., occipital meningomyelocele or encephalocele) were more commonly associated with severe handicap (75%) than were closed spinal lesions (23%).

Bamforth and Baird performed a population based study of patients with both spina bifida and hydrocephalus and compared
life expectancy between the cases, which was ascertained from 1962 to 1970 and compared with the group from 1970 to 1986. At least 60% of patients had serious disabilities. These included a cerebrospinal fluid shunt (28%), neurogenic bladder (23%), congenital hip dislocation (23%), talipes equinovarus (23%), spasticity (15%), urinary obstruction (5%), scoliosis (3%), developmental delay (6%), seizures (2%), and blindness (1%). The group of patients ascertained between 1970 and 1986 had a dramatic improvement in the probability of survival to the first birthday. There was no difference in survival between the two cohorts between the ages of 7 and 16 years.

The best outcomes were reported by Hunt. Between 1963 and 1971, 117 consecutive infants with open spina bifida were followed to their 16th birthday. All had surgical repair within 48 hours of life. The overall survival rate was 60%.

Fifty per cent of patients could ambulate more than 50 yards, 25% of patients were continent, and 70% of patients had an IQ of more than 80. If the lesion was at L3 or below, 75% of patients survived. Of the survivors, 90% of patients could ambulate more than 50 yards, 45% were continent, and 80% of patients had an IQ higher than 80.

**FETAL SURGERY FOR MENINGOMYELOCELE**

The survival rate of fetuses with an NTD has increased due to the multidisciplinary team approach with delivery at a tertiary care center. However, due to the significant sequelae of these lesions, the mean longevity of these patients is reduced to less than 40 years of age, with significant compromises to their quality of life. The standard management of these defects is by neonatal surgical repair, including a primary closure of the defect and often a ventriculoperitoneal shunt placement for hydrocephalus. Approximately 14% of the newborns do not survive beyond age 5 years. At least 45% of these children suffer complications from the ventriculoperitoneal shunt placements within the first year of repair.
Evidence in other species supports the implementation of in utero fetal surgery to repair a meningomyelocele (MMC). Cultured rat spinal cords, when exposed to human amniotic fluid at differing gestational ages, demonstrate that, after 34 weeks’ gestation, the amniotic fluid is toxic to the exposed fetal cells. Various methods of intrauterine repair of NTDs have been performed in various species, including rat, mice, rabbit, sheep, pig, and monkeys.

Meuli and coworkers surgically created MMC in fetal sheep. Three sheep underwent surgical laminectomy at 75 days’ gestation. At 100 days’ gestation, they underwent in utero surgical repair using a latissimus dorsi flap. At birth, the sheep demonstrated continence, intact sensation, and significant motor improvement over the control subjects who underwent laminectomy without repair. The controls had the predicted motor and sensory dysfunction and incontinence. Paek and colleagues recently demonstrated hindbrain herniation in sheep with surgically created MMC. At 75 days’ gestation, 20 sheep underwent surgical creation of MMC. Of the sheep that survived repair at 100 days’ gestation, none demonstrated hindbrain herniation, defined as displacement of the cerebellar vermis and medulla through the foramen magnum.

Concerns about these surgically constructed animal models for MMC are related to the later development of these disorders that is not analogous to congenital fetal development of these lesions. Therefore, outcome for these animal models may not reflect outcome for an in utero repair of a naturally occurring lesion. However, since human spinal cord myelination begins at about 15 weeks’ gestation, early closure of an MMC might allow for more spinal cord regeneration, resulting in better long term outcomes. Further, observed deficits in offspring with MMC are generally milder if the defect is protected from amniotic fluid with either skin covering or adipose tissue.

In 1997, Bruner and colleagues reported the first endoscopic repair of an MMC by intrauterine approach. They performed the first in utero repair in 1994. They compared their first four fetoscopic repairs with four open fetal procedures, all performed at a mean...
gestational age of 28+ weeks. Both groups had complications, and, of the survivors, the level of neurologic impairment was not improved by either technique. In 1998, Adzick and colleagues reported the first open fetal repair of an MMC at the Children’s Hospital of Philadelphia. This fetus had an MMC from the eleventh thoracic level to the sacral region. After open repair at 23 weeks’ gestation, the neurologic function of the newborn correlated with L5 on the left and L4 on the right, and there was no evidence of an Arnold-Chiari malformation or hydrocephalus.

Further procedures have not yielded such a dramatic improvement in neonatal outcome. In order to compare outcomes from in utero procedures with standard neonatal management outcomes, a retrospective review of 297 patients managed at the Children’s Hospital of Philadelphia was undertaken. In this series, the overall rate of ventricular shunting was 81%. In 86% of patients, the functional level of the lesion was found to be equal or higher than the radiologic lesion. In a combined series of 104 patients from Vanderbilt and CHOP who underwent intrauterine MMC closure, the overall rate of shunting decreased to 44%. With regard to neurologic function, 15 of 34 neonates with in utero repair at CHOP had an improvement in function at least two spinal levels higher than predicted. Unfortunately, this improvement in neurologic function is not necessarily maintained.

Further, there are risks to both mother and fetus from fetal surgery. Open fetal surgery is performed by accessing the fetus through an incision at the uterine fundus, essentially causing a premature classical incision on the uterus. To date, no reported maternal deaths have been reported from this type of surgery.

Given the evidence, the NICHD introduced the MoMS trial in 2003 as an unblended, randomized controlled trial at three United States Centers to evaluate outcomes from in utero versus neonatal surgery for spina bifida. The goal is enrollment of 200 patients; currently about 140 patients have been enrolled, extending this study about 2 more years (personal communication, Catherine Spong). Patients diagnosed with an MMC between 16 and 26
weeks will be randomized to one of three centers (Children’s Hospital of Philadelphia, Vanderbilt University, or the University of California, San Francisco) and will be randomized to one of two management protocols. This includes either intrauterine repair between 18 and 25 weeks with delivery by cesarean section at 37 weeks’ gestation, versus management by local maternal fetal medicine team, with referral for a 37 week cesarean delivery at one of the three centers with neonatal repair. The primary study endpoints include need for shunt placement and fetal and infant mortality. Secondary endpoints include neurologic function, cognitive outcome, and maternal morbidity.

In utero fetal surgery requires a multidisciplinary team approach. Briefly, the surgical procedure for an in utero spina bifida repair includes an upper segment maternal hysterotomy with care to avoid the placenta. The hysterotomy is stabilized with a uterine stapler to achieve hemostasis. Continuous perfusion of the cavity with Ringers lactate and fetal cardiac sonography often by pulse oximetry. The fetus is not removed from the cavity, but turned to expose the MMC. A dural fascial closure is performed and often dermis graft material may be used to cover the closure. Postpartum management includes multiple tocolytics, with elective delivery by cesarean section at 36 weeks’ gestation following amniocentesis for pulmonary maturity. The major risk to this procedure is preterm delivery due to uncontrollable preterm labor.

**MODE OF DELIVERY FOR PATIENTS CARRYING FETUSES WITH NEURAL TUBE DEFECTS**

There is no conclusive evidence regarding the most appropriate route of delivery for a fetus with an NTD. Cesarean delivery should be considered for appropriate maternal indications, maternal request after counseling, hydrocephalus precluding vaginal delivery, breech presentation, and large fetal lesions. One review of routes of delivery for fetuses with all types of structural anomalies uses the cut off of a lesion measuring 6 cm as a size in which cesarean delivery is justified to decrease the risk of
disruption. Of note, participants in the MoMs trial undergo cesarean delivery for both the in utero fetal surgery cohort as well as the neonatal surgical group to control for delivery route to better evaluate the timing of the repair.

In 1984, Chervenak and colleagues first advocated the use of cesarean delivery to avoid fetal trauma, maintain an aseptic environment, and have more convenient surgical repair for the newborn. While there are multiple small retrospective studies evaluating this issue, the largest series was conducted by Luthy and colleagues. Over a 10 year study period, they reviewed the antenatal and neonatal records of 200 cases of isolated MMC, accounting for 95% of the cases identified in Washington State between 1979 and 1988. Of these, 81 had an antenatal diagnosis, and 119 had a diagnosis made at delivery. A total of 160 infants survived for follow up in the neonatal period. Comparison groups included 47 infants delivered by cesarean delivery prior to labor, 35 delivered by cesarean section after labor, and 78 with vaginal delivery. At 2 years of age, the motor level of paralysis was evaluated by physical therapists. When the motor level was subtracted from the level of the anatomic lesion, infants delivered by cesarean section without labor had a mean level of paralysis 3.3 segments below the anatomic lesions, as compared with infants delivered vaginally (at 1.1 segments below the lesion) or 0.9 segments for those undergoing cesarean delivery after labor. The authors concluded that cesarean delivery prior to labor may result in better long term motor function. The results of this retrospective study may, however, be attributed to selection bias, since the patients undergoing cesarean delivery were prenatally identified, compliant, and well evaluated. Patients who underwent vaginal delivery may have been noncompliant or may not have presented for antenatal care, perhaps affecting long term neonatal outcome as well.

In summary, given the lack of consensus regarding improved outcome with regard to mode of delivery, delivery management at this time should be individualized with a multidisciplinary team.
Consideration should be given to size of the lesion and biparietal diameter at term, maternal indications, and patients’ desires after counseling.

Conclusion

Although preconceptional folic acid supplementation has decreased the prevalence of neural tube defects, they are still common birth defects for the obstetrician to screen, diagnosis, and manage in the pregnant patient. Counseling regarding folic acid supplementation is essential for all women of reproductive age. However, understanding the etiology of NTDs at the genetic and cellular level is limited by the ability to identify large kindreds with similar disorders to develop effective gene mapping. For the clinician, controversy with regard to the use of *in utero* fetal surgery to repair these defects should be resolved by the NIH sponsored randomized clinical trial in the next few years. The most appropriate mode of delivery for affected fetuses is also not clearly defined. Therefore, a multidisciplinary approach to management, involving the obstetrician as well as subspecialists, is essential to ensure the best outcome for the neonates and their families.
At the point when newborn children in the Neonatal Intensive Care Unit (NICU) need surgery the entire family encounters an emergency. Supporting the family, giving imperative data and deciding their level of comprehension are terrifically vital parts of the NICU medical attendant. The data conduct of guardians is changing in the NICU as data is accessible through the web yet guardians still look to the medicinal services group first to answer their inquiries. Data needs change as the newborn child advances through various stages along the disease direction (i.e. pre-agent, intra-agent, post-agent and post-release). This section will portray the data of necessities of guardians along the direction of surgical consideration and how nurture assume a basic part for guardians along the ailment direction. Nursing activities shift along the pre-agent, post-agent and readiness for release continuum. Be that as it may, supporting families is a consistent through these stages.

Family-focused consideration (FCC) is sorted out around a conviction that results are best when families assume a dynamic part to give passionate, social and formative backing to their youngster. (1) Principles of FCC incorporate admiration, respecting differences, supporting guardians’ decision, and fitting practices to individual family’s needs. Correspondence amongst guardians and human services experts (HCPs) should be open, fair and legitimate. At the point when consideration is family-focused,
families feel upheld and that their viewpoint is a critical piece of accomplishing the best result for their kid at all levels of consideration with the goal that they get to be engaged to find their own qualities simultaneously. (2) Surgical consideration of the baby and their family requires steady data sharing amongst HCPs and families.

SUPPORTING GUARDIAN’S DATA NEEDS

Research on guardian’s data looking for conduct in the NICU is missing, albeit numerous creators recognize that guardians get their data from numerous sources. Guardians use numerous data channels including HCPs, composed materials, peers, online networking, electronic sources and varying media materials. Guardians’ data needs and their preparation to learn change through the span of their newborn child’s hospitalization. They may require fortification of educating until they completely get a handle on the data, here and there commonly. It is imperative to keep a record of instructing gave to guardians and to oblige their learning styles. To do this, HCPs need to get some information about their adapting needs and locate the most ideal approaches to bolster those necessities.

Albeit a great part of the writing portrays HCPs as an essential wellspring of data for guardians, guardians additionally give data to the social insurance group that ought not be disregarded. FCC encourages joint effort with guardians as vital data sources and skillful leaders. Guardians absorb data from various suppliers after some time and turn into the master on their newborn children’s conduct, reaction to treatment and past medications and their belongings. This can be particularly genuine when the baby has been looked after in numerous settings (e.g. was conceived in one healing facility, exchanged to another, went to pediatric emergency unit and after that exchanged to NICU). For this situation, it is particularly vital for guardians to be enabled to share their experience along the disease direction as they are their kid’s best supporter.
Medical caretakers ought to expect guardians will look for data from loved ones. It is fundamental and valuable to ask guardians, “What have you found out about this malady or surgery from others? What questions do you have now that you have conversed with the specialist, your companions, and so forth.?“ Help guardians to sort out data from different suppliers by urging them to diary.

Encourage open correspondence by mounting whiteboards to monitor medicines, tests, nourishing and action orders close to the baby’s bedside. Give an anticipated time when guardians can be routinely overhauled. Urge them to partake in day by day rounds when their infant’s consideration is examined and at change of movement if the unit utilizes bedside shift report.

Before birth

The type of information parents need varies across their infant’s illness trajectory just as their readiness for new information and ability to learn new skills changes. Routine ultrasound screenings and assessment of fetal well being may detect surgical anomalies so that parents and the medical team can treat the infant most appropriately at birth. Prior to birth, if surgery is expected, NICU staff can meet with the family and provide anticipatory guidance about the potential for surgery, giving parents resource materials about the infant’s condition. Neonatologists and neonatal nurse practitioners can discuss treatment options and determine family preferences. If transport for surgery is expected, the best method of transport is while the baby is still in utero. That way, mother and baby are kept together after birth as well.

Pre-operative acute phase

During an infant’s acute phase, nursing can support the family by maintaining infant-family contact, providing culturally sensitive care, orienting the family to the NICU environment, and creating opportunities for two-way communication about the infant’s condition. It is important to address parents’ concerns and observations, and support the initiation and maintenance of the
mother’s milk supply. When the infant is critically ill, parents may want to have the baby baptized by their priest or pastor. Honoring parent’s spiritual needs will make them feel supported and the pastoral care department of many hospitals is available to support parents’ spiritual needs.

If transport is necessary after birth, the nurse is an important source of emotional support and information about the transport process and what to expect once they arrive at the receiving hospital. When possible, allow parents to speak with receiving neonatologist or transport team before transport.

A surgical consultation will be necessary and when the surgeon meets with the family, their privacy, comfort and decision-making needs should be considered. The surgeon will share information with parents about the diagnosis, how it will be fixed, where the patient will go after surgery (e.g. PICU, NICU, etc.) and what the risks and benefits of surgery are for the infant. Often, parents may have questions after the surgeon leaves or have trouble remembering what they said. Nurses can encourage parents to keep track of questions that can wait until later and help get their urgent questions answered.

Post-operative

Post-operatively, the infant may still be on the ventilator and have much unfamiliar equipment at the bedside. At this stage, nurses can do their best to support parents and help them manage their stress. Keeping the infant comfortable and developmentally supported while explaining the procedures and treatments to parents are important roles of the nurse. They can encourage parents to maintain contact with their infant, explain the purpose for the equipment and provide guidance for how the post-operative course usually goes. Once the infant is post-operative and starting to improve, nurses encourage parents to participate more in their infant’s care, educate parents to monitor and respond to their child’s cues, provide anticipatory guidance for recovery, and work with parents to celebrate improvements and milestones.
Discharge Planning

When preparing for the transition to home, parents should be given opportunities to practice care that will need to be continued after discharge, helping them to establish a “medical home” for the infant. Parents need to be encouraged to actively participate in caring for their infant, learning how to feed, administer medications, recognize complications, and know when to call for help from medical personnel. At this stage, it may be helpful to make a referral for in-home visits by a public health nurse or for home health care if the infant needs more advanced care. Encouraging parents to repeat back the discharge instructions will help the nurse to know they understand their child’s needs after discharge.

Along the illness trajectory, FCC can support families to participate in their child’s surgical care and convalescence. The NICU course for the surgical infant can be uncertain, but health care professionals have the opportunity to empower parents. FCC approaches empower parents to promote decision-making and healing practices for both the infant and the family.

MINIMALLY INVASIVE SURGERY IN NEONATES AND INFANTS

Negligibly intrusive surgery (MIS) in kids less than 1 year old, requires specific hardware and distinctive procedures auxiliary to the extent of the patient. The specialized improvement has been moderate for neonates since the quantity of specialists prepared and playing out these techniques has been few. Additionally, instrument organizations have been hesitant to contribute cash for such a little gathering of specialists playing out a little number of systems.

The 3-mm entry points are moderately effortless and nearly vanish following a couple of weeks of surgery. The neonatal tissues are friable and fragile, the space in the neonatal mid-section and stomach area is restricted, and the methodology are actually testing.
MIS in babies should be possible for mid-section and stomach systems.

**LAPAROSCOPY**

**Fundoplication**

This is a standout amongst the most well-known pediatric surgical techniques performed in the United States. The laparoscopic approach has indicated lower repeat rates, enhanced insurance of the vagus nerve, and shorter recuperation period. Laparoscopic fundoplication has been appeared to be protected and useful in different studies, incorporating into patients who have had past stomach surgeries, past open fundoplications, and even in those with already repaired umbilical deformities.

The methodology for a laparoscopic Nissen is fundamentally the same as that of an open fundoplication, with tremendously enhanced representation. While this is a typical methodology played out, the laparoscopic form has a precarious expectation to absorb information on account of the utilization of different laparoscopic strategies including suturing.

Ordinarily four to five ports are utilized. We utilize four ports for this strategy: two 5-mm and two 3-mm ports. One 5-mm umbilical port is for the camera; the other 5-mm port is on the right side, around 5 cm parallel to the umbilical port for a consonant surgical blade; one 3-mm port is for a liver retractor set on the right side just underneath the xiphisternum; and the other 3-mm port is on the left side, 5 cm far from the umbilical port. The hiatal suture is set over a size 20-22 bougie and a 2-cm floppy 360° Nissen’s wrap is built by intracorporeal suturing utilizing ethibond.

The neonatal liver is friable and effortlessly harmed. Once there is blood in the field, the effectively restricted space for work gets significantly more bargained, making the repair further difficult. A 3-mm Snowden Pencer precious stone flex liver retractor is exceptionally usefull for tender withdrawal of the liver.
The neonatal tissue is anything but difficult to analyze and is flimsy and friable. Consideration ought to be taken to evade damage to the sensitive neonatal tissues and the vagus nerve. Suturing in a little traded off spot requires ability and a ton of practice.

**Gastrostomy tube/catch arrangement**

Gastrostomy tube placement is a common procedure with relatively few complications. There are multitudes of reasons creating the need for gastrostomy placement and they can be placed as early as the neonatal period if long-term use will be required. Several approaches are available but the one with the best results and the least complications should be chosen.

A new method called Laparoscopic Endoscopic Gastrostomy Tube (LEGT), which is used involving visualization through endoscopy in addition to laparoscopy, decreases the few known complications of other gastrostomy tube placement techniques including entrapment/fistulization of bowel and colon, inadequate pexy of the stomach to the abdominal wall, and inflation of the balloon outside of the gastric cavity.

**LAPAROSCOPIC ENDOSCOPIC GASTROSTOMY TUBE**

A neonatal gastroscope is advanced into the stomach. Thereafter, a 3-mm port is introduced through the scar of the umbilicus and pneumoperitoneum is achieved. The stomach is then insufflated and four “T” fastners are passed into the stomach under gastroscopy and laparoscopy guidance and the stomach is fixed to the abdominal wall. Thereafter, the Mickey button introducer kit or the guide wire peel away technique is used to place a Mickey button directly into the stomach.

**Pyloromyotomy**

An additional benefit of the laparoscopic procedure is the ability to visualize the whole surgical area without having to deliver the pylorus. A 3-mm port is placed through the umbilicus
and a 3-mm, 30° telescope is used. The pylorus is identified. A 3-
mm grasper is then introduced directly without a port on the right
side, about 5 cm above and lateral to the umbilicus, and the
duodenal end of the pylorus is grasped. Thereafter, an arthrotomy
banana knife (Coviedien) is used from another stab incision directly
from the left side, about 5 cm above and lateral to the umbilicus,
and a seromuscular incision is made on the pylorus. A Tan
pyloromyotomy spreader is used to spread the pyloric muscle.
Some surgeons perform a gas leak test to ensure that there is no
mucosal injury.

In a large study comparing open versus laparoscopic
pyloromyotomy, two major benefits were described. One includes
the shorter hospital stay because of the need for lesser anesthetic,
while the other is the cosmetic benefit of the virtually unidentifiable
stab incisions used.

**Inguinal hernia repair**

The current gold standard for pediatric inguinal hernia repair
is open inguinal herniorrhaphy consisting of high ligation of the
hernia sac with herniotomy. Recently, laparoscopic techniques
have gained widespread popularity for treating pediatric inguinal
hernias. One of the main benefits of laparoscopic inguinal hernia
repair, and probably the key advantage, is the ability to visualize
the contralateral inguinal canal to inspect for a contralateral patent
processus vaginalis (PPV).

**OUR TECHNIQUE OF HERNIA REPAIR**

A modified Hassan technique was performed to introduce a
one-step expandable port to gain access to the peritoneal cavity.
Following insufflation with CO\textsubscript{2} at a flow rate of 2 l/minute to a
level of 10 mm of mercury to create a sufficient pneumoperitoneum,
a 2.7-mm, 30° telescope was inserted through the port. In the event
that a PPV was identified on the contralateral side, the operative
plan was modified to include laparoscopic bilateral inguinal hernia
repair. Two 2-mm incisions were created on the left and right sides
of the abdominal wall, 6 cm lateral to the umbilicus. Instruments were introduced directly through the abdominal wall without ports. Atraumatic graspers were first used to reduce the contents of the hernia sac, if present. The laparoscopic scissors or hook cautery was then used to circumferentially incise the peritoneum around the deep inguinal ring, thereby performing the herniotomy. A 3-0 or 4-0 vicryl intracorporeal suture was then used to perform a circumferential purse string suture closure of the defect in the proximal peritoneum, thus mimicking the high ligation performed in the open hernia repair.

By dividing the hernia sac and proximally closing the sac (peritoneum) with a purse string suture, the hernia can be successfully repaired without manipulation of the spermatic cord structures and disturbing the anatomy of the inguinal canal.

**Duodenal atresia**

Duodenal atresia has been successfully repaired laparoscopically. Three 3-mm ports are used (one 3 mm, 30° camera port through the umbilicus and two working ports). An end to end or end to side interrupted anastomosis is done. A suture through the falciform ligament may be used to retract the liver or a fourth port may be placed to retract the liver.

**Hirschsprung’s disease**

Although all techniques and multistage procedures are possible, the most commonly performed procedure is a single-stage, laparoscopically assisted Soave endorectal pull through.

**SINGLE STAGE LAPAROSCOPY ASSISTED SOAVE ANORECTAL PULL THROUGH**

The procedure involves placement of three 3-mm ports abdominally. One port is placed through the umbilicus and the other two are placed on either side, about 5 cm lateral to it. Using the graspers and a pair of scissors, several seromuscular mapping biopsies are taken starting from the rectum to the descending
colon. Once the level of aganglionosis is known, then the dissection is begun laparoscopically. The mesentry of the rectum and sigmoid colon is taken down using the hook diathermy or harmonic scalpel to the point of normal bowel. Once this is done, the procedure is now begun from the anal/perineal end. The dentate line is identified and submucosal dissection is begun about a centimeter above it. A 2-3 cm submucosal dissection is done and a 2-3 cm seromuscular cuff is left behind. The aganglionic bowel is then pulled through the perianal approach and sent for histopathology. The ganglionic bowel is then anastomosed at the dentate line after transecting the aganglionic bowel. The posterior margin of the seromuscular sleeve is split to prevent stenosis. Laparoscopic assistance provides excellent visualization, allows mapping biopsies, allows exact localization of the level of aganglionosis, avoids inadvertent torsion/twist on the pull through colon, and avoids trapping of small bowel. Current limitations of these techniques include long-segment Hirschsprung’s and total colonic aganglionosis.

**Malrotation/Ladd’s procedure**

Three ports are used: one for the camera and two working ports. Ladd’s procedure is done. Appendectomy can also be performed using endoloops. The advantages of the laparoscopic approach includes decreased postoperative ileus and early oral feeds. The recurrence has been reported to be higher than open surgery, and one of the reasons for this may be the decreased adhesion formation after laparoscopy.

**Intestinal atresia and bowel resection**

Laparoscopic visualization allows less bowel manipulation which minimizes postoperative ileus. The anastomosis has been the most difficult part of these laparoscopic repairs. Attempts have been made using various suturing and knot-tying techniques, but the lack of tactile feedback on the small bowel often prevents adequate anastomosis. There are a few reports of successful laparoscopically sutured bowel anastomosis with higher than open
rates of anastomotic leakages. Recently, nitinol clips have been
developed which can approximate the tissue without significant
damage while maintaining a leak-free system. These have not
been universally used. Robotic repair will perhaps be a more
successful method of repair in the future, although small-sized
instruments are not yet available.

**Neonatal necrotizing enterocolitis**

Laparoscopy has been used in the neonatal intensive care unit
as a diagnostic procedure in patients who have perforation but
continue to deteriorate on maximal medical treatment. Experience
is limited and its usefulness is undetermined. Babies are usually
premature and the abdomen is grossly distended with dilated
bowel loops which leave hardly any space for pneumoperitoneum,
making the procedure difficult.

**Liver biopsy**

In biliary atresia and neonatal hepatitis, surgical biopsy can
be done in babies with coagulation disorders. A 3-mm, 30° telescope
is used through the umbilicus and the biopsy needle is passed into
the liver under vision. Two to three biopsies could be taken using
a core biopsy needle. If there is bleeding, a diathermy or argon
laser could be used for coagulation. Harmonic scalpel could be
used to get a wedge biopsy of the liver, if needed.

**Choledochal cyst excision and biliary atresia**

Cyst excision and roux-en-y hepaticojejunostomy can be
performed laparoscopically. Similar techniques are used in patients
with biliary atresia. This procedure has a steep learning curve.
Quite often the cyst excision is complicated by the large size of
the cyst. It is removed as much as possible in order to prevent
future malignancy and the formation of adhesions to structures
as the portal vein. This is a very challenging procedure even in
skilled hands. Most surgeons performing the procedure perform
the hepaticojejunostomy laparoscopically and the
jejunojejunostomy is then performed extracorporeally.
Repair of anorectal malformations

The real role of this procedure is, however, in a recto-bladder neck fistula. Most of the other common ones are still better done via the posterior sagittal anorectoplasty (PSARP) route. The procedure involves placement of three 3-mm ports, one at the umbilicus and the other two about 5 cm away on both sides of the umbilicus. The fistula is dissected from the bladder neck laparoscopically and then suture tied. Some surgeons put a clip. Once this is done, the muscle complex is defined externally and internally, and a one-step expandable port is placed exactly in the center of the muscle complex. The rectum is then pulled through the port and sutured to the anal verge to form a neoanus. It is difficult to find the recto-urethral and recto-vaginal fistulas using this approach and it is mainly useful for recto-bladder neck fistula or long channel cloaca. As the muscle complex is either absent or attenuated in the high anomalies, it would be difficult to assess continence in this group of patients and the long-term results are not yet available.

Peritoneal dialysis catheter placement

Peritoneal dialysis is preferred in children and in infants requiring dialysis. Dialysis using the peritoneum requires patency of the dialysis tubing, which is a major hurdle to successful catheter placement. Lysis of adhesions can easily be done with laparoscopy, and visualization of the pelvic floor can be done to assure lack of inguinal or femoral hernias which can cause morbidity when peritoneal dialysis is being done. Placement complications, rate of infection, and incidence of malfunction are not increased with laparoscopic placement.

The procedure involves placement of a 3- or 5-mm port through the umbilicus. An 18-Gauge needle is passed from the abdominal wall and tunneled subperitoneally for about 3-4 cm pointing toward the urinary bladder. A guide wire is advanced through the needle which is exchanged for a peel away introducer-catheter followed by advancement of the PD catheter through the peel away sheath.
The subperitoneal tunnel holds the catheter onto the abdominal wall preventing recurrent blockages. Functional success is improved with a decreased need for revision of catheter placement which is important in neonates who may require long-term peritoneal dialysis.

**Ovarian cyst and tubal cysts**

If needed, laparoscopy is the current preferred method of cyst removal. The possibility of laparoscopic intervention early in life with minimal morbidity provides definitive treatment for the congenital ovarian cyst if it does not naturally involute or if there is a possibility of complication due to the size of the cyst. Rarely, tubal cysts may also present with complications. Treatment for both entities is conservative, with the stress being on preservation of the tube or ovary as much as possible. Laparoscopic derotation, partial cystectomy, and marsupialization are acceptable and advised procedures.

**Nephrectomy, pyeloplasty, and renal duplication systems**

Urological procedures are also in the forefront of MIS in neonates and infants, including the future role of robotics. They have demonstrated usage of robotic techniques as well in MIS, which will be discussed as the possibility of future MIS in neonates. In nephrectomy, whether partial or complete, studies have shown success in infants less than 10 kg with a transperitoneal approach. Retroperitoneoscopy has also been shown to be effective for easy access to the collecting system in isolation. Laparoscopic isolated pole nephrectomy has been shown to be equally effective with maintenance of functional capacity of the remaining pole. Pyeloplasty is indicated for correction of ureteropelvic junction obstruction. The main improvement with laparoscopic pyeloplasty is a decrease in postoperative pain.

**THORACOSCOPY**

The first described thoracoscopic procedures were used for lung biopsies in neonates. Thoracoscopy not only has the advantage
of small incisions, less pain, and less morbidity as compared to open procedures but also avoids the 30% scoliosis rate reported with open thoracotomy. Thoracoscopy requires ipsilateral lung to be collapsed to allow good vision for performance of the procedures. This requires a skilled anesthetist who can perform single lung ventilation or bronchial blocking technique to completely collapse the ipsilateral lung. Dual lumen tubes like the ones used in adults are not available for neonates.

**Lung biopsy**

Lung biopsy is needed in neonates with diffuse parenchymal disease of unknown origin. Two to three ports are used. A biopsy of the lung could be obtained using an endoloop or one of the energy devices like a Harmonic scalpel or Ligasure. Tissue obtained can be retrieved through the port or the port hole after removal of the port.

**Lung lobectomy**

Majority of the lung lesions are now diagnosed antenatally and most of them are now operated in the first year of life. These include congenital adenomatoid malformation, bronchial atresia, lobar emphysema, hybrid lesions or sequestration. Three ports are used and positioned depending on the lobe to be removed. Dissection is done using energy devices like the Ligasure or enSeal. The pulmonary arterial and venous branches are ligated using energy devices, clips, or suture ligatures. The bronchus is suture ligated or clipped. The lobectomy specimen is removed through one of the port sites piecemeal and a chest drain is left in place for 1-2 days. Complications include massive bleeding, bronchial air leak/broncho-pleural fistula, and chylothorax.

Average hospital stay after thoracoscopic excision of a portion of the lung with any type of malformation is 2.4 days. Infants have tolerated ventilation through one lung while insufflating the affected lung cavity during these procedures. Original difficulty with pediatric lobectomy included a need to change insufflation rates and pressures in order to optimize visualization of the surgical
field while maintaining adequate ventilation. As experience from pediatric anesthesiologists continues to increase, maintaining sufficient ventilation through one lung or partial lung fields will continue to improve. Good communication between both the teams allows for desufflation of the field as necessary. Improvement of endoscopic materials that allows surgeons to seal, divide, and cauterize tissue has improved the ability to remove portions of the lung tissue successfully. This improvement has decreased the thoracoscopic operating time which is one of the many benefits of MIS.

**Congenital diaphragmatic hernia and eventration**

Once stability of the patient is established after birth, repair can be attempted in this population. The procedure could be done laparoscopically or thoracoscopically. Usually, in the neonates, there is not much room in the abdominal cavity and hence the thoracic approach is preferred. Three 3-mm ports are used with the baby in the lateral position with side of the hernia up. One port is placed just below the angle of the scapula and the other two are placed on either side. A positive pressure of 8-10 mmHg in the chest helps pushing the contents into the abdominal cavity and also helps in collapsing the ipsilateral lung, facilitating the repair. If there is a facility for one lung ventilation, it certainly helps, but is not essential for the repair. It is possible to do the repair with conventional intubation. An additional instrument may sometimes be required to hold the knots while tying. A mesh may also be used if there is a large defect or evidence of diaphragmatic agenesis. Sutures can sometimes be tied around the ribs if an adequate rim of the diaphragm is unavailable. Several instruments are now available to complete the repair thoracoscopically. A similar technique is used for diaphragmatic eventration repair.

**Mediastinal masses**

Excision of mediastinal masses or other extrapulmonary masses is also an indication for thoracoscopy. The approach depends on
the location of the mass. The anatomic neighbors of these masses are often critical structures in both the mediastinum and along the thoracic spine, which suggests that direct or even magnified visualization is vital and provides improved outcomes. Masses in pediatrics can include a wide variety of malignancies including bronchogenic cyst, duplication cyst, neuroblastoma, ganglioneuroma, teratoma, lymphoma, schwannoma, and yolk sac tumor.

In addition, thoracoscopy can be used for diagnostic purposes to get adequate tissue for histologic diagnosis in indeterminate masses/nonspecific lymphadenopathy.

**Esophageal atresia and tracheo-esophageal fistula (TEF)**

The endoscopic technique places the patient in a semi-prone position and a posterior approach is used. The fistula is ligated and esophageal anastomosis can be attempted at that time depending on the anatomical allowance. Ligation can be done by sutures: extracorporeal or intracorporeal, but the development of smaller size nitinol clips has allowed clip suturing even at this size.

If the anastomosis needs to be made at a later time, the same minimally invasive approach can be used. Thoracoscopy provides excellent visualization and produces less tension on the two ends of the esophagus, facilitating the repair. There is very little working space and hence good technical skills are essential for the procedure. Mean operative times range from 80 to 130 minutes, depending on the presence of a fistula and the anatomical variant of this diverse congenital anomaly. Initial reports reported a very high leak rate due to the learning curve. Subsequently, the leakage, morbidity, fistula recurrence, and length of hospitalization have all decreased.

**Patent ductus arteriosus ligation**

Thoracoscopic approach is reserved for the older stable infants with respiratory reserve, and in this group both coil occlusion and
thoracoscopic clip ligation have been used with equal efficacy. Ligation has now become better accepted because of the development of 5-mm endoclips which are more suited to the small vessel size of the ductus arteriosus.

**Aortopexy**

The patient is placed supine with a left tilt. Three 3-mm ports are used. Access is obtained from the left chest, and the mediastinal pleura is opened in the angle formed by the internal mammary vessels and the phrenic nerve, anterior to the ascending aorta and posterior to the sternum. This requires either pushing the thymus to the right or resecting it. Sutures are then passed through the sternum anteriorly and then the adventitia of the ascending aorta lifting up the aorta, thus raising the anterior wall of the trachea. The procedure is performed under bronchoscopy control.

**CURRENT LIMITATIONS AND CONSIDERATIONS OF MIS**

Neonates have lesser physiologic reserve than children. Concurrent circulatory and respiratory changes that present during the transition from fetal to neonatal life, lower functional residual capacity of the lung, lower blood pressures, and higher heart rates also increase the challenge of MIS in neonates. One must be also cognizant of the physiology that may be changed during MIS.

Some factors critical to MIS are the same factors that limit its use in neonates and infants. Carbon dioxide insufflation can cause a decrease in oxygen saturation and increase in end tidal CO₂, especially in the thoracic cavity. Abdominal insufflation pressures in a neonate can go up to 10 mmHg, while it may be up to 15 mmHg in an infant. Chest cavity insufflation is a safe procedure if there is close monitoring of end tidal CO₂ as well as the rising blood pressures. Decisions to use intravenous versus inhaled anesthetic agents should also take into account their affect on vasoactivity because of the increased importance of oxygenation during a thoracoscopic procedure. Another concern has been the
drop in temperature that can occur with the large internal body surface areas that are being exposed to room temperature gases. Remedies for this include increasing operating room temperatures, use of radiant warmers in a safe proximity to the infant, and using devices that can warm CO₂.

The degree of movement while using laparoscopic instruments inserted through set points becomes especially pertinent in the small cavity of neonates and infants. Geometric consideration of instrument placement and correct positioning of the patient are important to facilitate leverage and range of motion. Recently, shorter instrument lengths (18 and 26 cm) have greatly improved the responsiveness of instruments in the surgeon’s hands. However, they also amplify small movements of the hands such as tremors. Thus, there is an increased importance of visualizing instruments at all times while within the patient’s body.

The smaller size of patients and the need for decreased insufflation pressures increase the possibility of tissue and vascular trauma during entry of port sites. This can be prevented by new techniques that allow visualization during the introduction of the first port or use of shorter length, blunt trocars.

**FUTURE EVOLUTION OF MIS**

The benefits of MIS for almost all of the procedures described above have to do with the smaller incision sites. Studies have now definitively shown decrease in pain, decreased postoperative hospital stays, and improved surgical site healing. The next step in pediatric MIS involves the evolution of instruments to be able to perform more procedures than that are currently done openly. Two millimeter instruments are now readily available, which can be introduced directly without ports reducing the incision size further. A recent review of a new 3-mm, 14-cm telescope shows efficacy, which is greatly beneficial in the neonate. Surgery using laparoscopic instruments is criticized because of the loss of haptic response, but decrease in mass of the instruments and lack of trocar use can improve this. Both these things have been taken into
consideration in the development of new pediatric instruments. Robotic techniques are also just beginning to be used. The ability of the instruments to articulate in small degree angles allows for increased accuracy and precision.

Evidence-based literature continues to support the effectiveness of MIS. The biggest limitation is the steep learning curve. Pediatric surgeons should familiarize themselves with current available techniques and newer instruments to facilitate their use in pediatric patients.
Pediatric Bariatric Surgery

The United States medicinal services framework is seeing a scourge in youth and juvenile stoutness. Sadly, therapeutic intercessions, for example, caloric lessening diets, forceful physical action projects and family-based behavioral treatment are successful in just 50 percent of patients with high rates of recidivism. Abundant proof exists among grown-ups with grim corpulence that weight diminishment operations are fit for accomplishing maintained weight decrease, inversion of metabolic confusions and an enhanced personal satisfaction with worthy postoperative dismalness rates. Rising confirmation from a few pediatric bariatric focuses in the U.S. also, other created nations bolsters comparative great results after weight lessening operations in extremely chubby youths. Be that as it may, after bariatric surgery, patients must hold fast to numerous dietary and way of life adjustments forever, notwithstanding close restorative and surgical development. This part audits the one of a kind moral contemplations for applying weight diminishment surgery to extremely chubby pediatric patients.

THE MAJOR ETHICAL PRINCIPLES

Value obliges doctors to represent the benefit of the patient, looking for approaches to recuperate, reestablish wellbeing and advance prosperity. With regards to bariatric surgery for pediatric
patients, advantage requires the inversion of physical and mental disabilities securely and with enduring advantages. In fact, advancing usefulness implies that a planned juvenile bariatric quiet experiences careful restorative evaluation of their metabolic and mental status and an observed trial of weight reduction treatment and family guiding before thought for agent treatment. Infringement of advantage would happen in circumstances in which there was lacking preoperative assessment of patient comorbidities, deficient endeavors to accomplish weight decrease by medicinal treatment, or a surgical group and healing facility without the ability for safe perioperative and long haul care.

Nonmaleficence reproves that mischief and damage must be stayed away from over the span of treating patients. The prompt and incessant dangers of bariatric surgery hold the most grounded contention against surgery for pediatric patients, since it might be entirely hard to observe whether a pediatric patient and her/his folks can get a handle on the potential for unexpected outcomes.

Self-sufficiency (educated assent) has expected conspicuousness in dynamic western social orders that spot high moral quality on individual decision and self-administering. In pediatrics, self-sufficiency depends on the inalienable presumption that guardians are in the best position to comprehend what is best for their minor youngsters and to make medicinal/surgical choices on their benefit. Moral worries about educated assent include:

1. the immature patient and family may have an excessively idealistic perspective of bariatric surgery;
2. inability to comprehend that some bariatric systems are irreversible;
3. powerlessness to completely appreciate the dangers of genuine, conceivably life-debilitating postoperative intricacies;
4. absence of comprehension about the need to stick to deep rooted dietary and way of life regimens and
5. the obscure potential for unexpected negative results quite a while after a bariatric operation.
For very big boned youths with formative incapacities, the difficulties of educated basic leadership are expanded, as a result of impeded patient comprehension and the expanded danger of rebelliousness with postoperative treatment. A pediatric bariatric project would be required to have set up solid bolster instruments for the patient and fami y before setting out on a surgical methodology.

Equity as a moral guideline permits that every individual gets a decent amount of wellbeing assets and impartial treatment. The U.S. has a critical dissimilarity for grown-up patients who experience bariatric surgery, with less lowincome people, African Americans and Hispanics having these operations. Albeit no similar information is accessible for pediatric patients, rejection for thought for a bariatric strategy due to absence of protection or monetary assets would abuse the moral guideline of equity.

Ethical Obligations for Research in Pediatric Bariatric Surgery

The impetus to conduct clinical research in surgery rests with uncertainty about the best operation or other treatment for a given condition, a state known as equipoise in which there is a general lack of agreement among surgeons about the optimal operation or treatment. Since there are many “unknowns” about the long term outcomes for adolescents undergoing bariatric operations, pediatric surgeons are in general agreement that clinical research is necessary to determine optimal treatment. Currently, there are two federally funded outcomes projects in the U.S. to evaluate efficacy and safety of the operations and to determine the amelioration of metabolic derangements. Importantly, these clinical research studies emphasize to patients, their families and society that several aspects of pediatric bariatric surgery are yet to be validated by appropriate scientific investigation.

The pediatric institutions that sponsor bariatric programs are ethically obliged to provide sufficient resources for comprehensive pre-and post-operative care, administrative leadership and
oversight for clinical and research activities. Furthermore, transparency should guide all aspects of a pediatric bariatric program, so that the stakeholders remain informed of short and long term outcomes as well as unanticipated adverse events.

ETHICAL PROBLEMS IN PEDIATRICS

Numerous aspects of contemporary society are testing the medicinal services field and request steady reflection about the best proficient demeanors to be taken in an assorted qualities of conditions. In this connection, the present method for showing morals in prescription has been changed and rises above the conventional model of deontological morals. The ethical training and the salvage and development of characteristics and demeanors of a temperate individual required for good medicinal practice (ideals based morals) has been a squeezing need.

The Brazilian Constitution (Article 227) and the Child and Adolescent Statute (Law 8069/90), which locally put into power the International Convention on the Rights of the Child and the Universal Declaration of the Rights of the Child, build up Brazil’s strategy of full security for kids as law. These lawful instruments imagine youngsters as nationals who have full rights and who are liable to defensive need due to their physical, mental and moral weakness.

Nonetheless, in spite of the authoritative and social advances of late decades, Brazil still has noteworthy work to do to propel the consideration and security of kids and young people, particularly with respect to access to quality training and the battle against hunger, youngster work, misuse, disregard and all types of savagery against kids.

Pediatrics, a range with complex interpersonal associations and vigorously affected by feelings, can possibly offer ascent to circumstances including moral issues. Substances occupied with therapeutic instruction have created and discharged key records on moral and expert qualities and qualities wanted for doctors.
A few archives are coordinated to pediatricians and talk about the strategies for showing moral and expert qualities to students and inhabitants in pediatrics.

Be that as it may, there is still a crevice between the moral substance educated in the colleges and the moral issues confronted in clinical practice. Notwithstanding worries about the ampleness of the formal educational modules, the impact of the concealed educational programs, that can lead understudies to learn and rehash the conduct saw in the bosses and instructors, here and there not satisfactory, has been highlighted for quite a while. This requests the ID of the moral issues confronted in all the learning settings and the look for power in moral practices.

Given that it is critical that therapeutic understudies reflect about the best proficient dispositions required to confront the most well-known moral issues that may emerge in the diverse settings where they go to youngsters and teenagers, this study was produced to investigate the moral issues experienced by doctors who have medicinal training and kids and pediatric consideration duties, and if those issues are related to the work environment, their restorative strength and region of clinical practice.

Methods

The study design had a mixed approach: cross-sectional, observational, descriptive and inferential and qualitative exploratory. The study population was composed of physicians who had teaching activities with undergraduate medical students from the Universidade Federal de Santa Catarina (Federal University of Santa Catarina), located in Florianópolis, capital city of Santa Catarina State-Southern Brazil) and/or residents and who attended children and adolescents in teaching hospitals or Basic Healthcare Units (BHUs). From the list provided by the management sectors of these institutions and from the university, the universe of 173 physicians was identified: 136 worked in hospitals and 37 in BHUs. The inclusion criterion included: concurrent role as a provider of children and adolescent health care and of medical education.
(undergraduation and/or residents). The exclusion criteria were: being a resident, being retired or licensed, not having direct contact with trainees in pediatrics and not working with child care.

To ensure that all the pediatric subspecialists working in the settings surveyed would be represented, the sample was selected by convenience. The estimated sample size of 72 participants was calculated using the Epi Info 2000 software and the following parameters: a total of 173 physicians, prevalence of 60% of ethical problems reports, relative risk of 3.0, test power of 80% (beta error type) and a 95% confidence interval (alpha error type).

Initially, 110 physicians were invited to participate in the study; two declined, and 20 (16 from hospitals and 4 from BHUs) accepted to participate but did not complete the data collection instrument. Thus, the final convenience sample was composed of 88 physicians, 72 who worked in hospitals and 16 who worked in BHUs.

After approval of the study project by the Research Ethics Committee of the Joana de Gusmão Children’s Hospital-Florianopolis, Brazil (Report 032/2008), data were collected by a self-applied, semi-structured questionnaire based on Taquette et al., with three sections with the following aspects: 1. Closed-ended questions with socio-demographic and occupational variables: gender, marital status, religious belief, length of time working as a physician, medical specialty, pediatric area of activity, ethics/bioethics training, workplace; 2. Open-ended questions requesting the report of up to three situations experienced in the care of children and adolescents that represented an ethical dilemma, the feelings aroused in those situations, who or what helped and could have helped, what aids were used to the process of decision making and what was done; 3. Open-ended question requesting suggestions for strategies to best approach these situations. A pilot study was performed with 15 eligible participants.

The term *ethical dilemma* was used in the questionnaire, because it is the most used term in the medical field for the situations that
the authors intended to study. Conceptually, dilemma corresponds to a situation in which only two choices are possible and only one of them can be correct. As some situations reported by the participants did not involve dilemmas, to encompass all the situations reported, we opted to use in this study the term ethical problem, a more comprehensive concept, which involves situations for which we are not always able to identify solutions.

Data analysis: A thematic content analysis of the qualitative data was performed. In the pre-analysis the qualitative data were passed to an individual card without the sociodemographic data to ensure the anonymity and the analysis was performed separately by both researchers by grouping the data into units of meaning and then categorizing them. In posterior meetings, the categories listed by each researcher were discussed and the definite categories were decided by consensus.

Those categories were entered as categorical variables into a Microsoft Office Excel database (Microsoft Corporation, U.S.) along with the other variables in the questionnaire. In addition to descriptive analysis, the association between the frequency of each category of ethical problems reported (outcome) and the participant sociodemographic and occupational characteristic (independent variable) was tested using chi2 or Fischer Exact Test when appropriated.

For the outcome “ethical problem category” a Poisson regression was performed, to analyze the prevalence ratios (PR) of the following exposure variables: medical specialty [i.e., pediatrics or family medicine (reference)], area of practice in pediatrics [i.e., pediatric subspecialty, general pediatrician or family physician (reference)] and workplace [i.e., hospital or primary care (reference)]. Because family physicians and other pediatricians who worked in BHUs did not report ethical problems related to end-of-life care, to estimate the PR of this outcome, only the variables general pediatrician versus subspecialist pediatrician were used. This analysis was adjusted for the following confounding variables: gender, age, marital status, religious belief,
training in ethics and bioethics, and length of time working as a physician.

To ensure proportionality, the sample was weighed in relation to the frequency of general pediatricians, subspecialist pediatricians and family physicians in the universe of physicians with teaching activities with students from the Universidade Federal de Santa Catarina and children care practice in the 2 teaching hospitals and in the Basic Healthcare Units. For the statistical analysis, Stata 11.0 (StatCorp, College Station, TX, US) was used. A significance level of $p < 0.05$ was adopted.

**Results**

The average age of the 88 participants was 44.1 years (CI: 42.2-46.1), the average length of time working as a physician was 19.6 years (CI: 17.6-21.5), the average time spent in daily care of patients was 6.8 hours (CI: 6.3-7.4) and that spent on medical students and residents education was 2.3 (CI: 1.8-2.7).

Among the 210 reports, five broad categories of ethical problems were identified. These ethical problems [with their frequencies, including absolute number (n), percentage (%) and 95% Confidence Interval (CI)] were related to:

*a. Physician-patient relationships [n = 61 (29.0%, CI: 2.9-35.1)], which comprised difficult interactions with the patients and/or their families including issues such as:*

- To ensure confidentiality, especially in adolescent care;
- To cope with difficult revelations (communication of bad news, disclosure of diagnosis, disagreement with diagnosis given by other physician);
- To cope with parents non-adherence to patients' treatment;
- To deal with difficult relationship with the patients' parents;
- To cope with unexpected reactions from family members;
- To manage parents beliefs;
- Conflicts involving the autonomy of parents and adolescents.
b. End-of-life care [n = 55 (26.2%, CI: 20.3-32.1)], which involved challenges and conflicts in terminal situations including issues such as:

- To take the decision to withdraw or whether to withhold or not advanced life support, nutritional support and resuscitation;
- To accept the decision of colleagues of admitting the patient in the Intensive Care Unit;
- To accept the decision of colleagues of prescribing futile therapies;
- To deal emotionally with the situation of patients without therapeutic perspectives;
- To diagnose brain death.

c. Health professionals conducts [n = 50 (23.8%, CI: 18.0-29.6)], which comprised disagreement with physicians or other health professionals conducts such as:

- To disagree with colleagues in the indication of procedures;
- To witness workplace inappropriate attitudes of colleagues in their relationship with patients and other colleagues;
- To disagree with inappropriate personal attitudes of physicians from other workplaces;
- To disagree with inappropriate patient relationship of physicians from other workplaces;
- To disagree with the breach of confidentiality, inappropriate use of medicines or inappropriate personal attitudes of other health professionals.

d. Socioeconomic issues and public health policy [n = 31 (14.8%, CI: 10.0-19.6)], which involved challenges concerning socioeconomic conditions and the public health care system that influence patient treatment, management and protection such as:

- To have to take decisions when the absence of inpatient beds threatens the lives of patients and surgeries are postponed;
• To cope with the social reality of patients, which imposes limits to the adequate management of care, resulting in lack of therapeutic success;
• To cope with the difficulty in referring patients to specialists;
• To cope with violence against children, including neglect;
• To experience problems in the workplace, among them, the lack of specialists, of equipments and of material;
• To cope with problems in the health care system that result in difficulties for patients to have access to more sophisticated diagnostic exams and to surgeries.

e. Pediatric Education Process\( n = 13 (6.2\%, \text{CI: 2.9-9.5}) \), which comprised inadequate personal attitudes and interpersonal interactions in the academic environment including relationship between: student-teacher/supervisor, teacher-supervisor, teacher/supervisor-patient, student-patient, teachers-physicians of Basic Health Units such as:

• To witness an ethically reprehensible attitudes of the teachers;
• To witness medical undergraduate students disrespect for the university hierarchy;
• To experience problems such as the allowance by teacher/physician supervisor to residents to act when there is risk to the patient;
• To experience problems in the relationship professor/physician supervisor-patient, such as inadvertent exposure of patients and discussion of cases in corridors;
• To experience problems in the relationship between teachers/physician supervisors, such as public criticism and disrespect authorship in scientific publication;
• To witness problems in the personal attitudes of undergraduates and residents.
Discussion

This study showed that the ethical problems experienced in the daily care of children and adolescents go beyond those usually described in the literature and cover areas that should be planned for and addressed in the curricula for students of pediatrics. Some problems were more specific to certain workplaces, such as those related to end-of-life care situations occurring in hospitals and those related to socioeconomic issues and health policies occurring in primary care. This observation reinforces the conclusion of a meeting of experts in pediatric education which was conducted in 2007. They concluded that the activities of pediatricians in their various work environments and subspecialties are sufficiently different to justify different training depending on the environment in which the professional is located. However, a high frequency of reports concerning interpersonal relationships was noted and was experienced equally in the health care and education settings. These relationships involve physicians, patients and families, the various professionals working in pediatric care, students, residents, teachers and supervisors.

The fact that many reports involved the physician-patient relationship reflects the importance that should be given to this subject in medical education. It is well established that this relationship should be of caring, built in the light of ethics and that it is strongly influenced by the moral values of those involved in this process, by the culture, the society and by the manner which the health care system is structured. To achieve the ideal standard of this interaction, the American Academy of Pediatrics (AAP) has established eight components of professionalism to teaching and assessment in pediatrics. Of these, six are directly related to the attitudes and values expected from the physician in relation to the patient (honesty and integrity, reliability and responsibility, respect for others, compassion and empathy, communication and collaboration, and altruism and defense) and the other two (self-improvement and self-awareness and knowledge of limits) relate to physician singular skills. These
components must be worked on throughout medical education and on an ongoing process of continuing education after graduation.

Ethical problems involving conduct of health professionals also occurred in all surveyed environments. The situations included in this category, such as divergences in personal and professional conduct and difficulties in maintaining privacy, demonstrate the importance of developing negotiating skills and improving interactions with all participants in the health care network. Delany et al. name as “allied health” in Pediatrics the professionals from many specialized health professions who work in the pediatric area in the health care team, attending children and adolescents with acute and chronic diseases or with disabilities. The relationship between physicians and these professionals may lead to ethical problems due to their differing perspectives of what constitutes the best interests of the child, which depend on what the authors call “disciplinary paradigms of care or operational philosophy.” For these authors, it is necessary that the professional who attends the pediatric age group be aware of his role as moral agent, of his professional responsibility and of the impact of his decisions in the children and their families lives when he refers the patient to allied professionals.

Although the PEP ethical problems were reported by teachers and supervisors, the findings coincide with the finding of studies with students reports which involved mainly disrespect when relating with patients, colleagues and students. The study reveal that in the education process it is essential an adequate communication between the parties and that it is expected that the teacher/supervisor be a role model and also that the student have appropriate ethical attitudes, especially a respectful way in the interaction with patients and teachers, and, for achieving this, educational actions are also needed.

The ethical problems related to end of life care were those more closely related to the impact of technological development in health, which require constant reflection of the ethical aspects. For this area, some of the important subjects in the teaching of
Ethics in pediatrics should be emphasized such as the limits of prematurity, advanced life support in children with very limiting disabilities and severe malformations, do-not-resuscitate orders, therapeutic futility and palliative care, technology-dependent children and the use of off-label medications. Previous studies addressing these issues, which were developed in different settings, highlight the difficulties encountered by professionals working in hospitals, especially those in pediatric subspecialties who are entrusted with the care of critically ill children and adolescents. They reinforce the need for physicians to have skills to cope with these situations so that their decision-making can achieve the patient’s best interests.

The socioeconomic context and public health policies are complex and are an inseparable part of medical activity, as they are directly related to the medical work, particularly of those who attend pediatric patients, due to the eco-dependency of the child. Problems of this scope are related to Social and Community pediatrics, which for almost a decade was considered by DeWitt as the greatest challenge for the planning of educational activities, as it requires the inclusion of issues related to equity in child health and social justice. It is in the community context that the student has the opportunity to interact with the social determinants of health, to promote preventive action at different levels and to develop an interest in protecting children’s rights. In recent years, the relevance of teaching pediatrics in the community has been recognized, and efforts have been made to change the predominantly hospital teaching model and insert the students in all levels of care. Decision-making in this context involves interdisciplinary team work, depends on political decisions and is often hampered by the need for changes in the political and social structure in which the child is placed. Pediatrics education must address issues of this nature and there is a need for faculty development to ensure adequate orientation of students at this level. Also, pediatricians and family physicians can contribute positively to the encouragement, support and the establishment
of effective partnerships with families, having active participation in health care teams. The AAP suggests that philosophies, principles and practices should be focused and targeted at health care in the family (family-oriented care), i.e., the family should be considered the unit of care and intervention. This approach makes easier the understanding of the physician responsibilities, since the assessment of the emotional and social problems that affect the welfare of the child must always be included.

The generalizability of the findings of our study is limited, as the topic of ethics is influenced by socio-cultural characteristics and because there are regional differences in the characteristics of pediatric care and medical teaching. Other limitations may be related to the fact that the sample may be representative only of the environment where the research was conducted (Southern Brazil). Despite this fact, we expect that this study contributes as a basis for comparison with other cultures and regions and to the formulation of educational initiatives leading to the teaching of ethics and professionalism geared towards the practice of health care among children and adolescents. In this context, the ethical problems, experienced in different settings, reported in our study by pediatricians and family physicians who participate in the medical education process and attend children and adolescent could be used in the medical undergraduate, graduation and postgraduate curriculum and in faculty development programs as a means to raise critical reflection for and on action and promote ethical attitudes and professionalism.
Pediatric Minimally Invasive Surgery: Laparoscopy and Thoracoscopy

In spite of the fact that kids overall routinely advantage from master utilization of MIS, most pediatric methodology don’t utilize progressed negligibly intrusive strategies. Albeit most offer laparoscopic appendectomy, in a late expansive study of pediatric MIS hones around the world, specialists reported that pretty much 33% perform laparoscopic pyloromyotomy for pyloric stenosis, and just 11% of respondents prescribe the methodology. For more unpredictable methods, the numbers are even lower. Less than one-fifth offer laparoscopic Ladd’s for malrotation, and less than one-tenth have endeavored laparoscopic repair of choledochal blister. In spite of the development in utilization of MIS to pediatric surgical illness in the previous decade, most pediatric specialists by and by today depend to a great extent on standard open strategy for systems less regular than fundoplasty, and even here numerous or even most pediatric specialists report that they don’t prescribe MIS. Minimally obtrusive strategies may have left the edges of pediatric surgical practice, however they don’t yet remain in the middle.

Why not? In this audit, we portray late advance in applying MIS to babies and youngsters. Most audits of negligibly intrusive
strategies concentrate just on the favorable circumstances offered by these new methods. Advantages can be generous: injury, method, speed, cost, length of stay, data. In any case, none of these advantages comes without expenses or dangers, challenges that seem to raise excessively with the declining size of the patient. The confirmation for advantages to the patient are exhibited, and also the extensive, now and again astonishing, mechanical and physiologic difficulties specialists must oversee for sheltered, effective systems.

WHAT IS MIS?

MIS is the basic term for an accumulation of surgical methods that intend to go around the dreariness and cutoff points of “customary” open surgery.

FIGURE: The modern minimally invasive suite is distinguished by advanced technology, most of it dedicated to improved imaging; however, new techniques accompany the technology. In this case, the patient is positioned at the foot of the bed, not the middle, and the surgeon stands below the patient’s feet, not in the traditional place at opposite sides of the patient.
Generally, it has passed by different names: keyhole surgery, band-aid surgery, scarless surgery. Some of its champions incline toward Minimal Access Surgery. MIS was truly a casual name, possibly an advertising term like keyhole surgery, not a specialized portrayal, but rather the name has stuck, and will be the term we use here.

All in all pediatric surgery, MIS alludes to operations in the mid-section, (“thoracoscopy”), and in the guts, (“laparoscopy”). The components of MIS incorporate the telescope, trocars, long instruments, carbon dioxide insufflation to make a working space, and altered surgical method. In pediatric MIS, these components are adjusted even more, and despite the fact that the names are the same, the geometries and techniques have imperative contrasts. These distinctions are regularly, yet not generally, quantitative alterations of chronicled innovations. The principal utilization of laparoscopy as a rule surgery was not until 1985, when Eric Muhe portrayed a laparoscopic cholecystectomy. Driven both by patient interest and by the innovation of charge-coupled-device video innovation, laparoscopic cholecystectomy supplanted the open methodology as the standard of consideration in <10 years. At that point took after a blast of laparoscopic and thoracoscopic techniques by and large surgery.

While MIS was gaining popularity in the adult population, pediatric surgeons resisted adopting these techniques in children. Although some resistance was epistemological, much was technological: the early years of the laparoscopic revolution offered only large (10-mm diameter) telescopes and instruments, clunky endomechanical devices (e.g., trocars and staplers), and relatively unsophisticated CO₂ insufflators. These insufflators delivered large amounts of CO₂ into the abdomen with crude pressure control, creating dangerously high intra-abdominal pressures in small children. Eventually, instrument manufacturers began to offer 5-mm and 3-mm devices and insufflators safe enough for use in small patients. The modern MIS “suite” adds high-definition imaging and other technology, offering the surgeon improved
ergonomics and finer control over image, energy, and pressure. In the mid 1990s, pediatric surgeons began to publish their laparoscopic experience, showing laparoscopy to be a viable alternative for some patients.

Echoing the adult experience, MIS in children began with laparoscopic cholecystectomies and laparoscopic appendectomies. Holcomb et al described the first laparoscopic cholecystectomy in a child in 1991, taking nearly 2 hours for each procedure, and even trying a surgical laser in some. The laser has not become a central pediatric MIS tool, but the advantages of the laparoscopic approach were plain. Appendectomy, splenectomy, and Nissen fundoplication soon entered into the pediatric surgeon’s repertoire. New instruments were more refined (eg, finer tips, stiffer shafts, shorter reaches, less heat spread, better insulation, finer feedback control on energy tools and insufflators, better optics) complementing improved manual skills. Surgeons also invented workarounds for circumstances where technology (eg, endoscopic staplers) had not caught up. This combination of very fine devices, precise movement, and clever workarounds allowed surgeons to attempt minimally invasive procedures on smaller children. When the techniques were applied to infants <28 days old and weighing <5 kg (sometimes much less: procedures in patients <1500 g are feasible), they created the nascent subfield of Neonatal MIS. Now, laparoscopic or thoracoscopic approaches to a large variety of pediatric and neonatal surgical disease have been described.

ADVANTAGES OF MIS

Incision Advantages

Incisional morbidities (pain, scar, infection risk, dehiscence, and herniation) depend directly on a wound’s closing tension. Recently, it has been demonstrated that wound tension is proportional not to the length of the incision, but to the square of incisional length. Consequently, the sum of total tension across all of the small MIS incisions will be a small fraction of the tension across a similar open incision.
This relationship may explain well-established wound advantages. For example, it has been shown that postoperative pain (and length of stay) is markedly reduced with MIS approaches. Moreover, it has been recently shown that MIS produces a relative risk of wound infection of just 0.27, showing that MIS protects from surgical site infections similar to perioperative antibiotics. Similarly, wound dehiscence and hernia are also much less for MIS. All of these body wall advantages likely stem from reduction in total closing tension. Meanwhile, this relationship governs the limits and advantages of single-port and needlescopic techniques.

**Chest Wall Deformity**

These incisional advantages are not confined to the abdomen. Standard posterolateral thoracotomy is an especially painful incision, often requiring long hospital stays, epidural infusions, and relatively large doses of narcotics. Later, the patient is at risk for chest wall deformity and scoliosis, via at least 2 mechanisms. First, division of latissimus and serratus muscles (sometimes with underlying rib resection) may create shoulder girdle instability. Second, tight reapproximation of adjacent ribs creates a tensile component on the lateral chest wall. As the child grows, scoliosis and other distortions of the thoracic cage can manifest, sometimes within months. In contrast, because there are only small incisions between ribs, thoracoscopy cannot create these mechanical distortions.

**Intra-abdominal Advantages**

The advantages offered by MIS are not confined to the body wall. Another major advantage is a reduced propensity to create postoperative adhesions. In particular, MIS produces a tiny fraction of the adhesions as the open approach. The mechanism of this advantage is not proved; but decreased tissue handling, in situ dissection rather than bowel delivery into the wound; and reduced exposure to talc, rubber, or polyisoprene from surgical gloves are posited contributors.
Meanwhile, the surgeon enjoys advantages in visualization and precision. A laparoscopic approach allows better visualization of obscure structures and areas, such as the lower esophageal sphincter complex and the small vagus nerves running along the esophageal muscle.

Modern high-definition digital cameras and monitors dramatically magnify these small details, and angled telescopes allow views around corners simply unavailable in open cases. When this visualization is combined with the meticulous precision possible to the well-practiced MIS surgeon who knows how to "move small," operations may be completed with similar or superior mechanical results as open cases.

For example, authors have reported reductions in both case time and complications for pyloromyotomy, fundoplasty, tracheoesophageal hernia repair, duodenal-atresia repair, and other cases performed in infants.

Cost

That these advantages represent real improvement in pediatric surgical technique is demonstrated by the cost advantage of MIS. For example, a large review comparing open and laparoscopic fundoplication demonstrated that the MIS approach was far less expensive (<$13,000 for laparoscopic vs >$22,000 for open). Not counted in this financial reckoning was reduction in risk-based costs: the MIS approach showed a 51% reduction in the risk of any surgical complication.

However, these cost savings are not all realized up front. At first, the need for specialized equipment and extra training of nurses and technicians creates large up-front costs for hospitals introducing MIS. Once established, however, hospital costs on a per-case basis are generally lower. Still, not all hospitals see this benefit; much appears to depend on the details of specific cases, the skills of the surgeons, and what exactly is counted. More difficult to count are the costs to the patient: What is the added cost of 3 extra days in the hospital on opiates after open surgery?
What is the value of not having to see that large scar every day? Health care financing today destroys pricing information, obscuring objective measures of these and other values. Meanwhile, an ironic demonstration of the cost advantage of MIS comes from insurers who, despite the greater technical difficulty of MIS, often offer decreased reimbursement if the operation was performed by using MIS.

**Precision**

Evidence regarding the effectiveness of MIS compared with open surgery has predictably lagged behind the introduction of new methods. Nevertheless evidence is accumulating regarding the technical integrity of MIS procedures. For many operations, the mechanical result of the procedure is similar or superior to open operations (thymectomy, duodenal atresia, appendectomy, fundoplasty, esophageal atresia). In some cases, however, it is clear that surgeons have more to learn (eg, diaphragmatic hernia).

**Speed**

Closely related to cost and precision is speed. Not only does longer operating times cost more in terms of operating room resources, but longer cases appear to increase the risk of complications. The picture for MIS and operating time is mixed. Early in any given surgeon’s experience, operating times for laparoscopic cases can exceed the expected time for open procedures. The learning curve is well documented; however, as surgeons become more facile, operating times can drop dramatically. For example, laparoscopic pyloromyotomy takes less time than the standard procedure, sometimes far less, but with no “price” of increased complications. Adept surgeons can perform fundoplasty in < 1 hour, even in infants weighing < 3 kg. In skilled hands, thymectomy, tracheo-esophageal fistula, duodenal atresia, colonic pull-through for Hirschsprung disease, and other complex procedures can be done faster by using minimally invasive methods. For these and other operations, speed follows from precision, not the reverse.
Information Gain

MIS offers surgeons new options for resolving clinical uncertainty because the cost to the patient is diminished, the power of exploration is greater than radiographic studies or other tests, or both. For example, in malrotation, an upper gastrointestinal tract study may be nondiagnostic, but the stakes of missing malrotation are large, as volvulus, although rare, may be catastrophic. Laparoscopic exploration reliably diagnoses malrotation, and can provide information that contrast studies cannot. Meanwhile, the laparoscopic Ladd procedure is at least as effective in preventing volvulus as the open Ladd operation.

The laparoscopic approach to malrotation illustrates how the surgeon can exploit information without delay by effecting definitive repair at the same time that the information is gained. In inguinal hernia, game theory (unpublished results) suggests that routine open exploration of an asymptomatic contralateral hernia holds a poor expected value because the low general probability of finding a second hernia and preventing a second operation does not offset the high cost to the patient of blind exploration.

However, laparoscopic exploration quickly confirms or excludes contralateral hernia with high sensitivity and specificity, while also leaving the spermatic cord untouched, whereas laparoscopic inguinal hernia repair appears to provide similar or superior results with new techniques. Similarly, in appendicitis, often the diagnosis is incorrect, even in the age of near-ubiquitous computed tomography scanning.

The laparoscopic approach affords the surgeon the chance to both identify and remedy the real problem (eg, ovarian cyst or a Meckel diverticulitis) at relatively low cost to the patient. Surgeons performing appendectomy through a very small open incision can miss other surgical disease. Similar information gain at low patient cost can be found in pediatric trauma, cancer, and neonatal jaundice, but in these cases, repair or resection may require an open approach.
CHALLENGES TO MIS IN SMALL PATIENTS

Technological Limits

The challenges to MIS in small patients can be as great as the advantages. First, of course, not every pediatric surgical case should be forced into an MIS approach.

For example, although laparoscopy and thoracoscopy can resolve uncertainties in trauma, an MIS approach is not right for, say, a patient with high-velocity penetrating trauma and hemodynamic instability. Not only does the surgeon have diminished degrees of freedom of motion, but palpation is restricted. These limits seem more constraining in small patients, where even small instruments seem large compared with the patient.

![Image of small instruments and a pediatric-size 4 mm x 20 cm telescope still appear large compared with this infant patient, whose left chest is visible through the drapes. Head and feet are outlined (white dotted line). In this 3.5-kg infant, the entire hemithorax volume is only 150 mL, and does not expand. Collapse of the lung may allow, perhaps, recruitment of about one-third this space, confining the work to a volume on the order of a golf ball (~38 cm³).]
Meanwhile, manufacturers have been slow to produce products especially adapted to infants and children. For example, no 3-mm, 20-cm ultrasonic shears are available, leaving surgeons the choice of using a blunt instrument longer than the patient, or altering technique to incorporate different technology.

**Skill and Precision**

Clumsy minimally invasive technique is not “minimally invasive.” For example, a patient has not benefited from MIS when left under general anesthesia for 10 hours while the surgeon struggles with a new approach to a case that normally takes 90 minutes. Meanwhile, ergonomic problems create discomfort and fatigue that degrade fine motor movement, leading to imprecision and “accidental” moves. Minimally invasive methods require a different set of surgical skills, and the difficulties that minimally invasive methods present are magnified in small patients. One center’s experience with laparoscopic repair of duodenal atresia illustrates the point: van der Zee reports that in the early part of the 2000s, their center abandoned laparoscopic duodenal atresia repair in infants after unacceptably high rates of leaks and other complications. Later, they were able to report entirely different results, but only after “considerable adjustments in technique and extensive improvement in experience.” Similar concerns have been raised for Kasai procedures and congenital diaphragmatic hernia repairs.

**Scaling**

Isometric scaling determines the mechanical constraints that vary geometrically with size, such as the familiar increase in body surface area to volume ratio with decreasing body size. A pediatric patient one-half as tall as an adult presents the surgeon with only one-eighth the working volume in the chest or abdomen. This tiny volume demands much finer movements, and limits tolerance for slips. For example, friction in the trocars can bind the instruments slightly, producing a lurch when the static coefficient of friction is translated to the dynamic coefficient. If the working volume is
small, this kind of lurch can seriously damage liver, spleen, or other organs (where slips are made worse by the relatively weaker tissue strength of these organs in infants).

**Hypothermia**

It may seem that MIS protects patients from hypothermia because there is no large incision to allow heat to escape; however, small patients can and do become cold during laparoscopy. Trocars and other instruments leak CO₂, and some leaks may be relatively large. To compensate, the surgeon must increase the CO₂ flow to maintain adequate pneumoperitoneum for visualization. The CO₂ is relatively cool, but more importantly, it is dry. A straightforward thermodynamic calculation shows that this high-flowing gas cools patients, not from the heat energy carried away by the gas, but from evaporative losses.

For example, in a 4-kg infant, dry gas flowing at 6 to 8 L/min can create evaporative cooling that consumes a large fraction of the infant’s metabolic rate. This evaporative cooling occurs despite large per-kilogram metabolic power exhibited by human infants. That same 4-kg infant has a metabolic rate of <“115 kcal/kg/d, or about 5.6 W/kg. In contrast, a 70-kg adult has a metabolic power <“35 kcal/kg/d (1.7 W/kg). On a unit-mass scale, infants burn far more fuel than adults; however, the total metabolic power of the infant is just over 22 W, compared with 119 W for the adult. In the infant, the evaporative loss is just 14 mL of water in an hour (the amount lost if CO₂ becomes 50% saturated while blowing continuously for 5 to 8 L/min). This produces 9 W of heat loss, or nearly 40% of the infant’s metabolic power (however, this is <8% of the adult’s metabolic power). Because the child under anesthesia has no mechanism for raising metabolic rate to match this loss, cooling must follow.

Fortunately, just as physics reveals the cause, it also provides a solution: humidify the gas, and evaporative losses drop to near nothing. Meanwhile, warming the CO₂ theoretically should have no effect (or make the problem worse), and experimentally does
not work. Alternatively, evaporation is attenuated by reducing the amount of gas that leaks from instruments. For this and other reasons, experienced pediatric MIS surgeons often fuss over the design and maintenance of pediatric MIS equipment.

**Hypercarbia**

Hypercarbia produces acidosis, decreased cerebral perfusion, and other hazards. In MIS, CO2 peritoneum and pneumothorax decrease CO2 elimination 2 ways: by increasing the CO2 load by absorption, and by reducing minute ventilation by restricting tidal volume. Both of these effects appear to be magnified in small patients; <“10% to 20% of exhaled CO2 in children during laparoscopy is absorbed by the peritoneum. The anesthesiologist must compensate for this, but is limited by the added pressure in the abdomen. An anesthesiologist who fears “barotrauma” and lets the tidal volume slip during laparoscopy will see the infant’s CO2 rise. Because tidal volume scales isometrically (about 7 to 8 mL/kg/breath), whereas CO2 production scales allometrically, respiratory rate (and thus minute ventilation) must be disproportionately higher in infants. Like metabolic power, respiratory rate varies as an inverse power-law. Infants require not only higher baseline respiratory rates, but disproportionately larger increases in respiratory rate than adults to compensate for insufflation.

**FUTURE DIRECTIONS AND TECHNIQUES**

**Single-Incision Laparoscopic Surgery**

Despite multiple studies showing that laparoscopic surgery produces less pain, shorter hospital stays, and improved cosmesis, surgeons wanted to try to do even better. This impulse led to single-incision laparoscopic surgery. This technique involves placing all of the instruments through 1 tiny incision hidden within the umbilical cicatrix. In 2009, Ponsky et al reported the first experience of single-port surgery in children, describing 72 single-port procedures performed at a single institution over 1 year,
showing the method to be a safe alternative to traditional laparoscopy and open surgery. Pediatric surgeons around the world now perform single-port appendectomies, cholecystectomies, and other operations.

Still, this approach creates mechanical disadvantages that probably limit its use. First, because all of the instruments traverse the same incision, the mechanical advantage is poor. Instruments tend to clash, and the classic “triangulation” of the instruments is lost. Newer, articulated instruments may overcome some limitations, but still require the surgeon to work “backward,” and with reduced degrees of freedom.

These constraints increase operating time, and restrict the complexity of case type that can be attempted to simple appendectomy, uncomplicated cholecystectomy, and a few others. Furthermore, the umbilical incision must be relatively large to fit all of the instruments through the same opening. Although data are scant, theoretically this larger incision may lead to increased postoperative pain and increased wound hernia rates. Single-port surgery in its current form is usually more difficult than the traditional laparoscopic approach, with unpublished reports of increased intraoperative complications and extended operating time. Because the only demonstrated benefit of single-port surgery is cosmetic, more work and, probably, new technology will be needed to fulfill the method’s potential.

“Needlescopic” or “Minilaparoscopy”

Dissatisfaction with single-port methods has led others to explore methods in which working ports use trocars with very small outer diameters, or even in which the 2- or 3-mm instruments are inserted directly through the abdominal wall. These incisions are so small that they can be sealed with dermal glue and no sutures. Free from many constraints of single-port methods, minilaparoscopy produces a similar cosmetically pleasing outcome but is easier for the surgeon. Total wound tensions (and associated complications) are minimized. Minilaparoscopy uses instruments
and methods developed by pediatric surgeons; advanced MIS technique has begun to flow back from the pediatric to the adult surgical world.

**Robotic Surgery**

Robotic surgery uses the same basic techniques of laparoscopic surgery; however, instead of moving the instruments directly, the surgeon guides robotic arms designed to accurately mirror the motion and dexterity of human hands. They do not operate independently. In this way, current surgical “robots” are not really robots at all, but advanced telemanipulators. Nevertheless, the term “surgical robot” has stuck.

The surgeon controls the robot from a remote console consisting of a 3-dimensional viewer and fine finger controls. The surgical robot is a tool for enhancing precision: very advanced manipulations (such as extensive suturing) are often more feasible with the robot than with standard laparoscopy. However, robotic surgery has not gained as much interest as some anticipated. The robot has a large dollar cost, necessitates use of larger trocars, and requires extra training for the staff. In pediatric surgery, as with the early experiences in laparoscopy, it has been easier to show feasibility than advantage.

Albassam et al compared standard laparoscopy in children with robotic surgery and showed no significant differences in postoperative complication rates, postoperative analgesic requirements, or lengths of hospital stay. They concluded that robotic surgery is feasible and safe, but, given the significant cost, should be limited to specific cases. Still, any technology that improves precision and mechanical advantage improves surgical technique. With more advanced technology and reduced costs, robotic surgery may find a more prominent role in pediatric surgery. In particular, combining new robotic equipment with single-incision approaches may overcome the limitations of single-incision methods by taking full advantage of the reach and precision of telemanipulators.
Natural Orifice Transluminal Endoscopic Surgery

Although single-port surgery promises 1 scar, there is interest in performing surgery with no abdominal scar. Natural orifice transluminal endoscopic surgery (NOTES), allows surgeons to perform surgery without any incisions in the abdominal wall. With multichannel endoscopes, the peritoneal cavity is accessed through either the stomach or vagina. Then the operation can be performed by passing specially designed instruments through the working channels of the endoscope. This technique has been described for appendectomies and cholecystectomies. The greatest challenge to NOTES is closure of the hole created in either the stomach or vagina. Although NOTES has not been widely used by pediatric surgeons, a recent report by Velhote and Velhote describe a NOTES technique with transanal endorectal pull-through surgery for a patient with Hirschsprung disease, allowing mobilization of the sigmoid colon without abdominal incisions. Others are investigating hybrid techniques combining NOTES with minilaparoscopy, using NOTES for treating esophageal atresia, and other uses. Despite these explorations, NOTES has barely touched pediatric surgery and its contributions are not yet clear.

ABOUT MINIMALLY INVASIVE SURGERY

Insignificantly obtrusive surgery (MIS) passes by a considerable measure of names: keyhole surgery, bandaid surgery, scarless surgery, negligible access surgery, general endoscopic surgery, and so forth. Whatever it is called, negligibly obtrusive surgery is an arrangement of methods that permit the specialist to work through little entry points utilizing a surgical telescope (a tube containing a camera) and uniquely planned instruments.

The pediatric specialists at The Children’s Hospital of Philadelphia are knowledgeable about the full scope of insignificantly intrusive strategies proper for youngsters. Notwithstanding giving laparoscopic, thorascopic and endoscopic strategies for youngsters, our specialists are growing
new and imaginative insignificantly obtrusive methodology particularly intended for the one of a kind surgical issues kids face.

Amid insignificantly obtrusive surgery, specialists can utilize these degrees to take tissue tests, expel outside bodies and repair harm without making vast and excruciating entry points. While not all conditions are reasonable for negligibly intrusive surgery, it offers a few potential advantages:

- Small cuts hurt less
- It is simpler to begin moving sooner
- The danger of deformation (like scoliosis) is littler
- Less opiate prescription is required
- Hospital stays are shorter, and your tyke can recover quicker and with less torment
- Small entry points look better, lessen scarring, and have a lower danger of difficulties (like disease)
- Visualization of life systems is regularly much better, giving more data to the specialist
- Multiple methodology (if necessary) should be possible through the same arrangement of entry points as opposed to making two bigger cuts, or one much bigger cut

Slash has best in class negligibly obtrusive surgery capacity. The Operating Room complex at the Main Campus is outfitted with 10 superior quality MIS “suites,” each of which is supplied with gadgets uncommonly chosen for use in newborn children and youngsters. The surgical instruments are always kept up by experts who work at CHOP full time. The medical attendants have experienced specific preparing also. The specialists have broad involvement with these systems, especially with the adjustments of the strategies required to expertly apply them in infants and youngsters.

A minimally invasive approach is not always the right choice for your child. Some children have anatomy or physiology that is not conducive to these methods. On the other hand, previous
conventional surgery is not necessarily a contraindication to using minimally invasive surgery. Regardless of the circumstance, CHOP’s MIS capability broadens the available options, so that the operation can better fit your child’s particular needs. Your surgeon can explain more.

MINIMALLY INVASIVE PROCEDURES

The Operating Room complex at the Children’s Hospital of Philadelphia Main Campus has 10 suites specially equipped for minimally invasive procedures, with dedicated support staff and highly trained nurses. This allows us to offer a very broad range of minimally invasive laparoscopic and thoracoscopic operations.

When MIS is done in the abdomen, it is called laparoscopy. In the chest, the method is called thoracoscopy. This is why fundoplication (for reflux disease) may be called a “laparoscopic Nissen” or “laparoscopic Toupet” procedure. Similarly, removal of a malformed lung lobe would be called “thoracoscopic lobectomy.”

Some of the minimally invasive procedures performed by the Division of General Surgery are:

- Adrenalectomy
- Appendectomy
- Biopsy of tumor or organs
- Bleb resection (spontaneous pneumothorax)
- Bowel resection
- Cecostomy
- Chest wall mass excision
- Cholangiogram
- Cholecystectomy
- Choledochal cyst excision and repair
- Colectomy
- Colostomy
- Bowel resection
• Cyst excision
• Decortication
• Diaphragmatic hernia repair
• Diaphragmatic plication
• Duodenal atresia repair
• Duplication cyst excision
• Esophageal stenosis repair
• Exploratory laparoscopy for trauma
• Foreign body removal
• Gastrostomy closure
• Gastrostomy revision
• Heller myotomy for achalasia
• Hepaticoduodenostomy
• Hiatal hernia repair
• Hysterectomy
• Ileoanal pullthru
• Ileostomy
• Intestinal web repair
• Jejunostomy
• Liver biopsy
• Lung biopsy
• Lung lobectomy
• Lung sequestration resection
• Lymph node biopsy
• Lysis of adhesions
• Malrotation, Ladd’s procedure
• Mass resection
• Meckel’s diverticulum
• Mediastinal mass excision
• Morgagni hernia repair
• Nephrectomy
• Nissen fundoplication
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- Oophorectomy
- Orchiopexy (also called orchidopexy)
- Ovarian cystectomy
- Pancreatectomy
- Pancreatic pseudocyst
- Paraspinal mass excision
- Pyloromyotomy (pyloric stenosis)
- Pyloroplasty
- Reduction of intussusception
- Reduction of ovarian torsion
- Soave pull thru (Hirschprung’s)
- Splenectomy
- Splenic cyst removal
- Stricturoplasty
- Swenson pull thru
- Sympathectomy
- Thal fundoplasty
- Thoracic duct ligation
- Thymectomy (myasthenia gravis)
- Toupet fundoplasty
- Tracheoesophageal fistula repair
- Tumor excision
- Urachal cyst excision

ROBOTIC SURGERY

Robotic technologies are helping to advance minimally invasive treatment options for patients. The Division of Pediatric General, Thoracic and Fetal Surgery at CHOP offers patients the option of having daVinci®-assisted laparoscopic and thoracoscopic surgery, also known as robotic surgery.

In certain complex cases, a surgical robot is used to facilitate the procedure. The robotic instruments, which are controlled directly by your pediatric surgeon, use very fine movements
resulting in minimal trauma to tissue. When the surgeon is finished, the laparoscope and other instruments are removed, the incisions are stitched and dressings are applied. While robotic surgery was first used for adult patients, smaller and more precise tools customized for use in children are making daVinci-assisted procedures possible for pediatric patients. These latest advancements in technology allow pediatric surgeons to perform complex, delicate procedures in smaller spaces. The following procedures are among those well-suited for minimally invasive robotic-assisted surgery:

- Adrenalectomy (adrenal tumors)
- Thymectomy (removal of the thymus gland)
- Mediastinal mass excision (chest tumors)
- Heller myotomy (treats achalasia, a disorder of the esophagus)
- Nissen fundoplication (treats gastroesophageal reflux disease)

Robotic technology offers many of the same advantages of traditional minimally invasive surgery techniques, with a few added benefits.

- Improved stereoscopic visualization using 3-D cameras — two high-definition cameras as opposed to the one used in traditional minimally invasive procedures.
- Greater freedom of movement — robotic instruments add a wrist-like movement that allows for expanded range of motion.
- The same cosmetic and recovery advantages of traditional minimally invasive surgery — easy suturing and smaller incisions.
- Mechanisms to ensure safety and successful surgical results in pediatric patients — the machine can detect oscillation and smooth the surgeon’s movements. The delicate tools have the ability to translate movement in a 3 to 1 ratio, meaning that if the surgeon moves the tool 3mm, it will only move 1mm inside the patient.
MINIMALLY-INVASIVE PROCEDURES

Insignificantly intrusive strategies (otherwise called negligibly obtrusive surgeries) have been empowered by the development of various medical advances. Surgery by definition is obtrusive and numerous operations requiring cuts of some size, are alluded to as open surgery. Entry points made can some of the time leave substantial injuries that are excruciating and take quite a while to mend. Negligibly obtrusive surgery alludes to surgical procedures that breaking point the extent of entry points required thus diminishes wound mending time, related torment and danger of disease. An endovascular aneurysm repair for instance of insignificantly intrusive surgery is a great deal less obtrusive in that it includes much littler cuts, than the comparing open surgery method of open aortic surgery. This negligibly intrusive surgery turned into the most widely recognized technique for repairing stomach aortic aneurysms in 2003 in the United States.

The leaders of insignificantly obtrusive methodology were interventional radiologists. By the utilization of imaging methods, interventional instruments could be coordinated all through the body by the radiologists by method for catheters rather than expansive cuts required in conventional surgery. So that numerous conditions once requiring surgery can now be dealt with non-surgically.

Demonstrative strategies that don’t include the puncturing of the skin or cut, or the presentation into the collection of remote articles or materials are known as non-intrusive techniques. There are likewise a few treatment methods that are classed as non-intrusive. A noteworthy case of a non-obtrusive option treatment to surgery is radiation treatment likewise called radiotherapy.

RESTORATIVE USES

Negligibly intrusive methods were spearheaded by interventional radiologists who had initially presented angioplasty and the catheter-conveyed stent. Numerous other negligibly
obtrusive systems have taken after where pictures of all parts of the body can be acquired and used to coordinate interventional instruments by method for catheters (needles and fine tubes). So that numerous conditions once requiring open surgery can now be dealt with non-surgically. A negligibly obtrusive method regularly includes the utilization of arthroscopic (for joints and the spine) or laparoscopic gadgets and remote control of instruments with roundabout perception of the surgical field through an endoscope or vast scale show board, and is brought out through the skin or through a body cavity or anatomical opening. Interventional radiology now offers numerous methods that keep away from the requirement for surgery.

Fig. Arthroscopic surgery

By utilization of a MIP, a patient may require just a band-help on the entry point, instead of numerous join or staples to close a vast cut. This more often than not brings about less disease, a faster recuperation time and shorter healing center stays, or permit outpatient treatment. In any case, the security and viability of every methodology must be shown with randomized controlled trials. The term was begat by John EA Wickham in 1984, who composed of it in British Medical Journal in 1987. An insignificantly obtrusive system is particular from a non-intrusive method, for example, outside imaging rather than exploratory surgery. At the point when there is insignificant harm of natural tissues at the purpose of passageway of instrument(s), the method is called negligibly obtrusive.
PARTICULAR TECHNIQUES

Many medical procedures are called minimally-invasive; those that involve small incisions through which an endoscope is inserted, end in the suffix -oscopy, such as endoscopy, laparoscopy, arthroscopy.

Other examples of minimally-invasive procedures include the use of hypodermic injection, and air-pressure injection, subdermal implants, refractive surgery, percutaneous surgery, cryosurgery, microsurgery, keyhole surgery, endovascular surgery using interventional radiology (such as angioplasty), coronary catheterization, permanent placement of spinal and brain electrodes, stereotactic surgery, the Nuss procedure, radioactivity-based medical imaging methods, such as gamma camera, positron emission tomography and SPECT (single photon emission tomography) and transoral thyroidectomy. Related procedures are image-guided surgery, and robot-assisted surgery.

BENEFITS

Minimally-invasive surgery should have less operative trauma, other complications and adverse effects than an equivalent open surgery. It may be more or less expensive (for dental implants, a minimally-invasive method reduces the cost of installed implants and shortens the implant-prosthetic rehabilitation time with 4-6 months). Operative time is longer, but hospitalization time is
shorter. It causes less pain and scarring, speeds recovery, and reduces the incidence of post-surgical complications, such as adhesions and wound dehiscence (rupture). Some studies have compared heart surgery. However, minimally invasive surgery is not necessarily minor surgery that only requires local anesthesia. In fact, most of these procedures still require general anesthesia to be administered beforehand.

RISKS

Risks and complications of minimally-invasive procedures are the same as for any other surgical operation and include:

- Anesthesia or medication reactions
- Bleeding
- Infection
- Adhesions
- Internal organ injury
- Blood vessel injury
- Vein or lung blood clotting
- Breathing problems
- Death

There may be an increased risk of hypothermia and peritoneal trauma due to increased exposure to cold, dry gases during insufflation. The use of surgical humidification therapy, which is the use of heated and humidified CO₂ for insufflation, may reduce this risk.

Equipment

Special medical equipment may be used, such as fiber optic cables, miniature video cameras and special surgical instruments handled via tubes inserted into the body through small openings in its surface. The images of the interior of the body are transmitted to an external video monitor and the surgeon has the possibility of making a diagnosis, visually identifying internal features and acting surgically on them.
INVASIVE PROCEDURES

Sometimes the use of non-invasive methods is not an option, so that the next level of minimally-invasive techniques are looked to. These include the use of hypodermic injection (using the syringe), an endoscope, percutaneous surgery which involves needle puncture of the skin, laparoscopic surgery commonly called *keyhole surgery*, a coronary catheter, angioplasty and stereotactic surgery.

Open surgery

“Open surgery” is any surgical procedure, where the incision made is enough to allow the surgery to take place. With tissues and structures exposed to the air, the procedure can be performed either with the unaided vision of the surgeon or with the use of loupes or microscopes. Some examples of open surgery used, are for herniated disc commonly called a “slipped disc”, and most types of cardiac surgery and neurosurgery. These techniques have accelerated the healing process of otherwise larger wounds and so also have minimalised the pain associated with large wound healing. Also the more precise methods used, mean that damage to surrounding healthy tissues is greatly reduced.

Non-invasive procedure

A medical procedure is defined as *non-invasive* when no break in the skin is created and there is no contact with the mucosa, or skin break, or internal body cavity beyond a natural or artificial body orifice. For example, deep palpation and percussion are non-invasive but a rectal examination is invasive. Likewise, examination of the ear-drum or inside the nose or a wound dressing change all fall outside the definition of *non-invasive procedure*. There are many non-invasive procedures, ranging from simple observation, to specialised forms of surgery, such as radiosurgery. Extracorporeal shock wave lithotripsy is a non-invasive treatment of stones in the kidney, gallbladder or liver, using an acoustic pulse. For centuries, physicians have employed many simple non-invasive methods based on physical parameters in order to assess body function in health and disease (physical examination and
inspection), such as pulse-taking, the auscultation of heart sounds and lung sounds (using the stethoscope), temperature examination (using thermometers), respiratory examination, peripheral vascular examination, oral examination, abdominal examination, external percussion and palpation, blood pressure measurement (using the sphygmomanometer), change in body volumes (using plethysmograph), audiometry, eye examination, and many others.

**TYPES OF MINIMALLY INVASIVE SURGERY**

**Robotic Surgery**

Advanced robotic systems give doctors greater control and vision during surgery, allowing them to perform safe, less invasive, and precise surgical procedures. During robotic-assisted surgery, surgeons operate from a console equipped with two master controllers that maneuver four robotic arms. By viewing a high-definition 3-D image on the console, the surgeon is able to see the surgical procedure better than ever before. Computer software takes the place of actual hand movements and can make movements very precise. The benefits of minimally invasive robotic surgery can include:

- Small incisions
- Less pain
- Low risk of infection
- Short hospital stay
- Quick recovery time
- Less scarring
- Reduced blood loss.

Some conditions treated at Johns Hopkins using robotic-assisted surgery include:

- General – Pancreatic cancer, benign pancreatic lesions, liver tumors (benign and malignant), gallbladder cancer, severe gastroesophageal reflux disease (GERD), obesity (gastric bypass, bariatric surgery, gastric banding)
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- Lung – Some lung tumors, esophageal cancer and diseases
- Gynecologic – Endometriosis, gynecologic cancers (ovarian/cervical cancer), heavy uterine bleeding, uterine fibroids, uterine prolapse, ovarian cysts, benign cervical disorders
- Head and neck – Head and neck cancer (oropharyngeal cancer), thyroid cancer
- Heart – Mitral valve prolapse and repair, atrial septal defect, atrial fibrillation
- Urological conditions – Bladder cancer, kidney disorders (kidney stones, kidney cysts, kidney blockage), kidney cancer, kidney removal, prostate cancer, incontinence, vaginal prolapse

Not all minimally invasive procedures are completed with robot assistance, and not all medical cases are right for robotic-assisted surgery—some patients may benefit from endoscopic or open (traditional) surgery.

Non-robotic minimally invasive surgery (endoscopic)

Non-robotic minimally invasive surgery is also known as endoscopic surgery. You also may be familiar with terms like laparoscopic surgery, thoracoscopic surgery, or “keyhole” surgery. These are minimally invasive procedures that utilize an endoscope to reach internal organs through very small incisions.

During endoscopic surgery the surgeon inserts a thin, flexible tube with a video camera through a small incision or a natural orifice like the mouth or nostrils. The tube has a channel to utilize tiny surgical instruments, which the surgeon uses while viewing the organs on a computer monitor.

This technique allows the surgeon to see inside the patient’s body and operate through a much smaller incision than would otherwise be required of traditional open surgery. The benefits of endoscopic surgical procedures can include:

- Small incisions, few incisions, or no incision
- Less pain
• Low risk of infection
• Short hospital stay
• Quick recovery time
• Less scarring
• Reduced blood loss.

Some conditions treated at Johns Hopkins using non-robotic minimally invasive surgery include:

• General – Pancreatic cancer, benign pancreatic lesions, hernias, severe gastroesophageal reflux disease (GERD), liver tumors (benign and malignant), gallbladder cancer, obesity (gastric bypass, bariatric surgery, gastric banding), gastrointestinal/rectal conditions, hernias (paraesophageal, ventral, hiatal or incisional)
• Lung – Some lung tumors, esophageal cancer and diseases
• Gynecologic – Gynecologic cancer, benign tumors, endometriosis, uterine fibroids, ovarian cysts, benign cervical disorders, conditions requiring hysterectomy, removal of ovaries and staging of lymph nodes
• Head and neck – Skull base brain tumors, anterior cranial fossa (front skull base) tumors, posterior cranial fossa (back of the skull base) tumors
• Heart – Atrial septal defects, aortic regurgitation, aortic insufficiency, aortic stenosis, mitral valve repair
• Neurosurgery/Spine – Spine conditions, cervical disc hernias, lumbar disc hernias, degenerative disc disease, spinal trauma: skull base brain tumors, anterior cranial fossa (front skull base) tumors, posterior cranial fossa (back of the skull base) tumors
• Vascular – varicose veins, venous insufficiency, peripheral vascular disease

Urological – Kidney disorders, kidney cysts, kidney stones, kidney blockage, kidney donation, prostate cancer, incontinence, vaginal prolapse
Pediatric thoracic injury has exceptional components that separate it from grown-up thoracic injury. Biomechanically, the littler body mass of a youngster brings about more prominent powers connected per unit of body region on traumatic effect. Also, the power is connected to a body that has less fat, less versatile connective tissue, and nearer nearness of key organs, particularly in the thorax. The blood volume of a pediatric patient is regularly 7-8% of the aggregate body weight. Along these lines, a relative little blood volume misfortune can prompt hypovolemia and stun.

Consistence of the pediatric thorax is much more noteworthy than that of the grown-up thorax, in light of the malleability of the ligament and hard structure. In that capacity, the mid-section can ingest a lot of active vitality from the effect, which is in this manner exchanged to the intrathoracic structures. Frequently, the tyke has major intrathoracic harm with insignificant or no damage to the structure of the mid-section. Rib breaks are uncommon and show an immediate hit to the mid-section and outrageous power.

Kids frequently encounter aerophagia and gastric widening, bringing on rise of the stomach and serious trade off of essential limit. In newborn children and youthful kids, this can incline to the sudden advancement of apnea when exhausted. As a consequence of the proportionately littler size of the mid-section
contrasted and the mid-region or head in a youthful kid, huge thoracic injury is quite often joined by harm to other organ frameworks. Therefore, thoracic damage is most fittingly characterized as multisystemic harm. Multisystem damage is connected with expanded mortality.

**EPIDEMIOLOGY**

Trauma is the leading cause of mortality in patients younger than 18 years, accounting for more than 5000 deaths annually. Although thoracic trauma accounts for only 5-12% of admissions to a trauma center, it is second only to head injury as the most common cause of death. Multisystem involvement is reported in more than 50% of children with thoracic trauma and portends a worse prognosis. Mortality is 5% for isolated thoracic trauma, approaches 20% in patients with concomitant abdominal injuries, and exceeds 30% in patients with concomitant head injuries.

Analysis of the National Pediatric Trauma Registry reveals that blunt trauma accounts for approximately 85% of chest injuries serious enough to warrant treatment. Almost three quarters of these chest injuries were caused by motor vehicle accidents, with the remainder attributable to motorcycle-related trauma, falls, and bicycle accidents. Penetrating injuries increase in war-torn countries.

Penetrating trauma constitutes 15% of chest injuries in children, with most caused by gunshots, knife wounds, and injury from other sharp objects. Regardless of the mechanism of thoracic trauma, 15% of children do not survive. According to the analysis of the National Pediatric Trauma Registry, almost half of the deaths in patients with blunt injury result from associated neurologic injury, compared with children who have penetrating chest trauma, in whom all fatalities are from the chest injury itself.

**Initial Assessment**

An exhaustive review of the management of airway, breathing, and circulation (ABCs) in childhood trauma resuscitation is beyond
the scope of this chapter. Nevertheless, the principles of resuscitation do not change. Resuscitation of the child with thoracic trauma begins with a survey for immediate life-threatening injury.

Immediate life-threatening thoracic injuries include the following:

- Airway obstruction and injury
- Lung and chest wall injuries
- Open pneumothorax
- Tension pneumothorax
- Hemopneumothorax
- Flail chest
- Widened mediastinum/aortic transection
- Cardiac tamponade

Potential life-threatening thoracic injuries include the following:

- Pulmonary contusion
- Ruptured tracheobronchial tree
- Ruptured diaphragm
- Esophageal perforation
- Myocardial contusion

Perform the primary survey and identify the injuries as quickly as possible. The immediate recognition of whether the child is agonal and hemodynamically stable and the knowledge of the mechanism of injury are implicit in the ABCs of resuscitation.

Knowledge of the mechanism of the injury is important because children who are agonal with signs of life (ie, spontaneous respirations, palpable pulses, response to stimuli, cardiac electrical activity) after penetrating trauma have a better survival rate than patients with blunt trauma. If the agonal child presents after a penetrating thoracic injury and has lost vital signs in the field or in the emergency department (ED), resuscitative thoracotomy is indicated.

In contrast, children with blunt thoracic trauma but no signs of life in the field should not undergo resuscitative thoracotomy.
However, if a child has blunt trauma and the vital signs are lost in the ED, a resuscitative thoracotomy is indicated. Indications for thoracotomy in the ED include the following:

- Penetrating trauma with vital signs but no response to resuscitative efforts, or vital signs present in the field but lost en route to the ED or upon admission
- Blunt trauma with loss of vital signs en route to the ED or in the ED

The unstable child is one who has vital signs but also has clear signs or symptoms of cardiac or respiratory compromise. Poor skin perfusion (ie, capillary refill >2 sec), tachycardia, abnormal chest wall excursions, obvious mental status changes, and, possibly, hypotension all characterize instability in a child. A search for immediate life-threatening injuries is warranted. If injuries are not detected or diagnosis is delayed, these children may become agonal.

The stable child (ie, one with normal vital signs, adequate ventilation and oxygenation, normal capillary refill, adequate urine output) with thoracic trauma from a blunt or penetrating cause can be more thoroughly evaluated than others, with the added advantage of time. Injuries in stable children are potentially life-threatening, but the survival rate is generally better.

**Airway Injuries**

Airway injuries may be the result of oropharyngeal trauma, a foreign body, or pathology directly within the thorax that leads to a shift of the tracheobronchial tree. The 2 hallmarks of airway injury are obstruction and subcutaneous emphysema.

Oropharyngeal trauma is typically the result of a crush injury or direct blow. The resulting tracheal mucosal edema may be insidious, and breath sounds must be closely monitored.

Inspiratory stridor is the hallmark of airway obstruction at or above the level of the vocal cords. Blood, mucus, vomitus, teeth, or other foreign bodies may cause the stridor. This is a clinical diagnosis and must be emergently recognized and treated with removal of the obstruction.
Other signs and symptoms of airway obstruction include the following:

- Agitation
- Diaphoresis
- Chest wall retractions
- Asymmetry of respirations
- Cyanosis

Ultimately, airway obstruction leads to bradycardia associated with severe hypoxemia. Expiratory stridor is typically the result of pathology below the cords. Children with blunt trauma who have expiratory stridor should be evaluated for a foreign-body aspiration. Diminished breath sounds, wheezing, and loss of volume on plain chest radiography may not be present. A high index of suspicion is imperative. Objects may not be radiopaque, and bronchoscopy should be performed early to avoid pneumonia.

**Subcutaneous emphysema**

Subcutaneous emphysema can result from tracheal disruption in the neck or thorax. Any positive pressure during expiration makes subcutaneous emphysema progress. If subcutaneous emphysema is unrecognized after intubation, it can also be worsened by positive pressure from mechanical ventilation.

**Management of airway injuries**

Standard management begins with head positioning, suctioning, in-line cervical spine stabilization, and administration of supplemental oxygen. Obviously, obstruction above the vocal cords must be recognized and removed. Intubation may be necessary; if intubation is not possible, needle cricothyrotomy or tracheostomy is indicated. In unconscious patients, control of the airway must always be the first management step.

Subcutaneous air solely in the neck may indicate pathology in the trachea. Rupture of the tracheobronchial tree (partial or complete) is relatively uncommon in children because of the elasticity of the chest wall, but a persistent air leak after
decompression of a pneumothorax is suggestive of a bronchial tear. Typical points of disruption include fixed points such as the carina or segmental branches of the bronchus. These injuries are commonly diagnosed with the aid of a bronchoscope, and the injury’s location determines the subsequent treatment approach. However, bronchoscopy frequently leads to an underestimation of the magnitude of the injury. Delays in treatment can be life-threatening because both ventilation and oxygenation can be affected. Nonoperative management may be attempted for small injuries that encompass less than a third of the airway circumference. Short longitudinal tears of a single airway are particularly likely to be successfully managed in this manner.

If the air leak is massive and ventilation is difficult, nonoperative management should not be attempted, even if the injury is less than one third of the circumference of the airway. Injuries to the cervical trachea should be approached via a transverse neck incision. If injury is to the distal trachea or right mainstem bronchus, it should be approached via a right thoracotomy; localized injury to the left mainstem bronchus should be approached via the left chest.

Few patients with a complex injury that involves the carina or both mainstem bronchi require cardiopulmonary bypass. Most tracheobronchial injuries can be primarily repaired, provided that the suture line is tension free. Because of the mechanisms of these injuries, blast effect and reduced blood flow to the perimeter of the injury must be suspected, and if necessary, a widened excision must be performed. After closure of the airway defect, the endotracheal tube should be positioned so that the cuff of the tube does not abut the repair. Moreover, a vascularized tissue flap of pleura, pericardium, or muscle should be used to reinforce the repair.

CHEST WALL AND LUNG INJURIES

Compared with adults, children have more cartilage in their ribs, leading to an elastic and highly compliant thorax. This
compliance diffuses the force of impact, leading to fewer rib fractures than result from similar trauma in an adult. Although splitting from pain is common in children, atelectasis is less common due to the propensity of children to cry.

Diagnosis of acute rib fractures is made with radiography. Multiple rib fractures in a child should always raise the suspicion of child abuse. Oral analgesics are usually sufficient for pain control. Rarely, an intercostal nerve block may be necessary.

Flail segments are defined as 2 or more ribs fractured in 2 or more places. The flail segment results in ventilation-perfusion mismatch, atelectasis, and progressive shunting. In general, patients with an unstable chest wall should be treated with positive pressure and pain control.

Bleeding from within the chest is rare in children, mainly because of the low incidence of rib fractures. When chest bleeding does occur, it can be insidious and life-threatening. Bleeding is typically from an intercostal vessel or vessels, parenchyma, or chest wall. Regardless of the source, a hemothorax must be evacuated to avoid atelectasis, ventilation-perfusion mismatch, fibrothorax, and a restrictive lung. Treatment involves tube decompression.

Initial hemorrhage of more than 20 mL/kg or continued blood loss of more than 2-3 mL/kg/hr for 3 consecutive hours may be an indication for open thoracotomy. Moreover, inability to adequately drain the chest and reexpand the lung is an additional criterion for thoracotomy. Lobectomy is far less common than stapling of bleeding or simple wedge resection.

Minimally invasive thoracoscopy for trauma has become more widespread. Video-assisted thoracic surgery (VATS) can be used as a diagnostic tool in an acute or subacute hemodynamically stable patient with hemothorax.

In certain patients with a large initial drainage or continuing blood loss from chest injury, VATS may aid in avoiding thoracotomy by visualizing a nonbleeding injury, evacuating a
hematoma, allowing tamponade by fully expanding the lung, or cauterizing or ligating bleeding vessels. Moreover, in patients with empyema after chest injury, thoracoscopy can be effective in completely draining the pleural space and in removal of any organizing peel from the lung.

**Pneumothorax**

Pneumothorax may result from puncture of the lung by a rib, by a penetrating chest wall injury, by disruption of the pulmonary parenchyma, or by injury to the tracheobronchial tree. Neither simple pneumothorax nor tension pneumothorax is well tolerated in children because of the lack of fixation of the mediastinum. However, less than 15% of cases of childhood thoracic trauma require thoracotomy. An untreated simple pneumothorax eventually leads to a tension phenomenon.

If the pressure in the pleural space with tension pneumothorax becomes high enough, both respiration and hemodynamics are impaired. The increased intrapleural pressure shifts the mediastinum. This, in turn, compromises venous return, with an obligatory decrease in cardiac output. Pneumothorax is a clinical diagnosis and does not require radiographic confirmation for treatment.

Performing needle decompression through the second intercostal space at the level of the midclavicular line followed by tube decompression, or simply proceeding to tube decompression, is the treatment of choice. Chest radiography should follow to confirm tube position and reinflation of the lung. An open pneumothorax associated with a sucking chest wound causes pathophysiology because a path of less resistance is created for tracheobronchial air. To prevent this airflow, the wound must be covered and tube decompression must follow.

**Pulmonary contusion**

Pulmonary contusion is the most common thoracic injury in children and represents a defining contrast between children and
adults. In contrast to rib fractures in adults after blunt trauma, the kinetic energy of blunt chest trauma is transmitted to the compliant chest wall in children. Thus, both pulmonary contusion and hemorrhage are far more common than pneumothorax. Pulmonary contusion from a car or truck rollover injury in children is a common phenomenon.

Typical chest radiographic findings include multiple opacifications corresponding to intraparenchymal hemorrhage. Hypoxia from shunting and ventilation perfusion mismatch, in addition to radiographic findings, is characteristic of pulmonary contusion. Successful treatment involves aggressive pulmonary toilet and pain management. Resolution of the contusion within a few days is not uncommon. After comparing the clinical findings from chest computed tomography imaging and chest radiographs, Holscher et al. concluded that CT did not add to the management of the trauma and increased the risk from radiation. Sequelae of pulmonary contusion include pneumonia and posttraumatic pseudocysts. These typically resolve with antibiotics and time.

**Penetrating pulmonary injury**

Pulmonary injury secondary to penetrating trauma can vary from small pleural or parenchymal lacerations from a stab wound to massive pulmonary injury secondary to a gunshot wound. The basics of airway, breathing, and circulation management (ABCs) remain paramount. If the patient has sustained a penetrating missile injury and injury to mediastinal structures is suspected, radiographic evaluation of the tracheobronchial tree, esophagus, and great vessels should be performed. Asymptomatic patients with normal chest radiography findings can be safely observed and discharged after an appropriate time interval (minimum of 6 hr).

Most pulmonary lacerations do not require surgery and can be treated with tube thoracostomy. Drainage of the pleural space with reapposition of the pleural surfaces often tamponades low pressure venous bleeding and seals small air leaks. Surgical
exploration of thoracic wounds is not recommended because of the potential to cause pneumothorax and contaminate the pleural space. Absolute indications for surgery include exsanguination and uncontrollable air leak from the chest cavity. If thoracotomy is necessary, parenchymal sparing techniques and nonanatomic resections are preferable.

A posterolateral thoracotomy is used to gain access to the hilum of the lung. Lung isolation is obtained with a double-lumen tube or bronchial blocker. As with all thoracotomies for penetrating thoracic trauma, the hilum and pulmonary vessels are controlled early to allow rapid vascular control, should an unsuspected central injury be present. Stapling with a generous margin around the area of injury should be performed.

Persistent bleeding from deep missile injuries can be opened and exposed by inserting the anvil of the linear stapler into the tract and firing the device to perform a tractotomy. If extensive tissue loss is apparent, anatomic resection of the injured lobe may be necessary.

Air embolism is a potential complication of penetrating lung injury. Seizures and sudden cardiac arrest may be the only clues to this near-fatal event. Treatment involves thoracotomy, clamping of the hilum, and aspiration of air from the left ventricle and aorta.

Penetrating injury to the mediastinum can occur without a pneumothorax. Therefore, a stab wound between the nipples can injure the heart or great vessels without damaging either pleural space. Moreover, because the abdomen begins at the nipple line in children, injury below the diaphragm should be ruled out when a stab wound occurs at this level.

Traumatic asphyxia occurs in children because of their flexible thoracic wall and the absence of valves in the venous system of the inferior and superior vena cava. Direct compression of the chest wall may be sustained when a child is involved in a motor vehicle collision or crush injury. At the time of injury, if the glottis is closed and the thoracoabdominal muscles are tensed, the
increased intrathoracic pressure is transmitted through the central venous system to organs such as the brain, liver, spleen, and kidneys.

The sudden increase in pressure produces subconjunctival hemorrhage and petechiae of the chest, shoulders, and head. In addition, capillaries in the upper body become atonic and dilated. Desaturation of the stagnant capillary blood produces a characteristic bronzed discoloration.

Central nervous system and pulmonary dysfunction can be associated with traumatic asphyxia, but this is rare. These children should be monitored in the intensive care unit for 24 hours because of the potential for airway obstruction secondary to venous hypertension and petechiae generated under the tongue and oropharynx. Despite the cutaneous manifestations, most of the petechiae disappear in a few weeks.

WIDENED MEDIASTINUM AND AORTIC DISRUPTION

Blunt trauma can injure the aorta or branches of the aortic arch. Approximately 95% of patients with blunt tears of the thoracic aorta die before reaching the hospital. These are exceedingly rare injuries in children. The typical mechanism, as in adults, is a rapid deceleration injury sustained in a motor vehicle accident, an auto-pedestrian accident, or a fall from a height. Suspicion of this injury in a stable patient may only come from chest radiography depicting a widened mediastinum.

Radiographic signs of mediastinal pathology are as follows:
- Straightening of the mediastinal borders, with loss of the anteroposterior (AP) window
- Mediastinal diameter greater than that of the hemithorax
- Right shift of an orogastric tube off the vertebral column

Radiographic signs of disruption of the aorta, which typically occurs at the ligamentum arteriosum, include the following:
- Widened mediastinum
• Left pleural effusion
• Apical capping
• Depression of the left main bronchus
• Rightward shift of an orogastric tube off the vertebral column
• Fractures of the first or second rib or scapula

Upper extremity hypertension, interscapular murmurs, and diminished or absent pulses in upper or lower extremities are common physical signs. Aortography is the diagnostic procedure of choice if the child is stable. Computed tomography scanning is an alternative in that it can be rapidly performed in concert with imaging of the brain, abdomen, and pelvis.

Treatment

If a contained hematoma is identified, open repair via a left posterolateral thoracotomy, either with primary anastomosis or placement of synthetic grafts, is the standard of care. In the acute setting, this is associated with significant morbidity and mortality due to multisystem injury. Delaying intervention with the use of beta-blockers and antihypertensive agents until the patient is more stable has improved results, but complications remain high.

Successful surgical intervention is predicated on achieving proximal and distal control of the aorta. Historically, the “clamp-and-sew” technique was favored. However, due to the potential for ischemic injury to the spinal cord, several adjuncts have been developed to maintain distal aortic perfusion during surgical repair.

A heparin-bonded Gott shunt may be used to shunt blood from the proximal aorta to the distal aorta or femoral artery without the use of a pump. Partial left-heart bypass uses a centrifugal pump that draws oxygenated blood from the left atrium, which is reinfused to the distal thoracic aorta or femoral artery. Like the Gott shunt, this technique avoids full systemic heparinization. Nevertheless, both of these techniques require that cannulas be present in the operative field, which often prevents adequate visualization in smaller children.
Femoral-femoral cardiopulmonary bypass using an oxygenator maintains lower-body perfusion, allows for systemic cooling with spinal cord protection, and allows for easy control of hypertension proximal to the aortic cross-clamp. The major disadvantage with this approach is the need for systemic heparinization, which may be a relative contraindication in patients with major associated abdominal injuries or intracranial hemorrhage.

The safety and efficacy of endovascular techniques has been established in adolescents and children. Endovascular stenting allows for definitive treatment of the vascular injury without the need for bypass and reduces the recovery time that is associated with a thoracotomy. Currently, long-term follow-up is required.

A diagnostic dilemma may result when clinicians encounter a stable transected aorta and associated life-threatening abdominal pathology. In a patient with a stable thoracic hematoma, treatment includes evaluation and repair of the abdominal injuries first, followed by a left thoracotomy for management of the transected aorta. In a child with a rapidly expanding hematoma of the chest and concomitant abdominal pathology, thoracotomy should be performed first.

**CARDIAC INJURIES**

Blunt injuries of the myocardium range from mild asymptomatic contusion to cardiac rupture. Myocardial contusion is the most common injury. The pathophysiology involves reduction in blood flow to a contused cardiac muscle, followed by ischemia.

The hallmarks of myocardial contusion are ischemic changes or atrial or ventricular premature contractions or wall motion abnormalities during echocardiography. Sequelae of myocardial contusion are uncommon in patients who demonstrate hemodynamic and cardiac stability upon admission.

No reliable standards for diagnosis have been determined. Studies such as creatine kinase–MB (CK-MB) fraction, troponin I,
and echocardiography are generally not helpful in either diagnosis or treatment planning. The presence of dysrhythmias is suggestive; patients with ectopy or ischemic changes require monitoring in the intensive care unit for 24 hours after injury. Echocardiography is required for any new onset of a murmur. Repair is indicated if ischemia and myocardial dysfunction are severe and salvageable myocardium is found.

Most patients with rupture of the myocardium do not reach the hospital alive. However, the injury is occasionally contained by the pericardium, and the child presents in shock from a combination of hemorrhage and cardiac tamponade. The mechanism of injury is likely sudden severe compression of the chest at the end of diastole. The right ventricle is most frequently involved (46%), followed by the left ventricle (35%), right atrium (26%), and left atrium (6%).

The prognosis of patients with left atrial and right-sided injuries is intermediate, whereas very few survive rupture of the left ventricle. Blunt cardiac rupture is treated surgically via sternotomy or left thoracotomy for isolated left atrial rupture.

**Penetrating cardiac injuries**

Penetrating wounds of the heart usually result in 2 pathophysiologic events. One is that blood leaks from the heart into the pleural space and causes a hemothorax. This diagnosis should be suspected in patients with hemodynamic instability from hemorrhagic shock or persistent bleeding from the chest tube.

The other scenario is accumulation of blood in the pericardial space. Often, the traumatic wound may be occluded by pressure in the pericardial space, preventing frank exsanguination. More commonly, however, the ongoing accumulation of blood leads to pericardial tamponade. Muffled heart sounds, distended neck veins, and hypotension constitute the diagnostic triad (ie, Beck triad) that defines cardiac tamponade.
Penetrating wounds can involve any of the 4 chambers of the heart but are most common in the right ventricle because of its anterior location. The presence of hemopericardium on transthoracic echocardiography or subxiphoid pericardial window mandates urgent sternotomy or thoracotomy for repair of cardiac injury.

Sternotomy is advantageous because it allows access to all cardiac chambers and, if necessary, institution of cardiopulmonary bypass. Repair should be performed using nonabsorbable sutures with atraumatic needles and pledgets to prevent sutures from pulling through myocardium. Nonmyocardial cardiac injuries are also possible. Rupture of the pericardium can occur with or without associated cardiac injury.

Laceration or thrombosis of the coronary arteries from blunt trauma is rare but possible. Diagnosis is made via electrocardiogram and cardiac catheterization.

For cardiac tamponade, subxiphoid needle pericardiocentesis is the treatment of choice. Directing a catheter at a 45° angle toward the left scapula and using a Seldinger technique to maintain the catheter in the pericardial space facilitates continued aspiration of the pericardial sac until emergency left thoracotomy or median sternotomy (depending on the associated pathology) can be performed. Aspiration of as little as 5 mL of nonclotted blood relieves the tamponade in infants.

Time constraints often do not permit application of an alligator clip to avoid puncture of the heart muscle. Radiographic or echocardiographic testing is not needed to make the diagnosis.

Commotio cordis results from a sudden impact of the heart against the anterior chest wall that results in cessation of normal cardiac function. The precordial blow that triggers commotio cordis is not usually perceived to be of a significant magnitude to cause death. The typical scenario is a child who collapses after sustaining a chest blow during a sporting event. Because of the heightened compliance of the pediatric chest, the kinetic energy from the blow
is transmitted to the myocardium. Survival rates have been as low as 15%; however, with the awareness of this condition and increased availability of automatic external defibrillators at schools and athletic facilities, survival for athletes who sustain such injuries should be improved.

**Surgical Strategies for Heart and Great Vessel Injury**

Operative approaches to treat specific thoracic injuries are as follows:

- **Cardiac tamponade**: left anterior or anterolateral thoracotomy (fifth intercostal space)
- **Heart, great vessels, or pulmonary hilum**: median sternotomy and extension into the neck
- **Descending thoracic aorta**: left posterolateral thoracotomy (fourth and fifth intercostal spaces)
- **Ascending aorta**: median sternotomy (cardiopulmonary bypass is usually required to repair a blunt injury; penetrating injuries can be repaired without bypass)
- **Aortic arch**: median sternotomy with extension into the neck for great vessel exposure
- **Innominate artery**: median sternotomy with right cervical extension if necessary
- **Subclavian artery**: cervical extension of median sternotomy for right subclavian artery injury or a supraclavicular approach for left subclavian artery injury (proximal control of either vessel is best via an anterolateral thoracotomy above the nipple)
- **Carotid artery injury**: right cervical incision for right carotid artery injury or, as in innominate artery injury, median sternotomy with left cervical extension for left carotid artery injury
- **Pulmonary artery**: respective side thoracotomy for hilar control
Diaphragm Rupture

An elevated left hemidiaphragm indicates a ruptured diaphragm until proven otherwise. Aids to this diagnosis include the position of an orogastric tube on plain radiograph. In addition, bowel sounds in the chest are suggestive of the injury. Diaphragm injuries are far more common on the left than on the right because of the protection of the liver; they can go unnoticed, especially in an intubated patient. Moreover, relatively common injuries to the liver obscure suspected diaphragmatic injuries on the right side. The diaphragm can rupture in any location, but ruptures of the central tendon and the lateral attachments of the torso wall are the most common.

Management of a ruptured diaphragm must account for the possibility of associated abdominal pathology. The abdomen begins at the nipple level in children, so a high index of suspicion is warranted after blunt or penetrating injury. Laparoscopy is helpful for penetrating injuries that are at or below the nipple and for which there is no apparent pathology on CT scanning of the abdomen. Diaphragmatic rupture that results from blunt trauma should be approached through a laparotomy because of the high incidence of intra-abdominal solid organ injuries.

If the patient is symptomatic and visceral ischemia is a possibility, the approach should always be through the abdomen. A thoracotomy approach may be advantageous for injury or hernias that present in a delayed fashion, especially of the right hemidiaphragm. This approach provides excellent exposure to allow for division of adhesions between trapped viscera and lung parenchyma. When the tear is located, any herniated viscera should be returned to the abdomen and inspected for bleeding or ischemia. The rupture should be repaired with either monofilament nonabsorbable or absorbable sutures. If not already present, a chest tube should be placed on the affected side.

In the event that a tension-free repair cannot be primarily performed, a pedicled intercostal muscle flap can be used to bridge
the defect in children. Other alternatives include fascia lata, bovine pericardium, or synthetic material such as Gore-Tex or Marlex.

**Esophageal Perforation**

Esophageal injuries can be due to various mechanisms. The most common cause is endoscopic trauma from esophagoscopy, dilation, or transesophageal echocardiography. Other causes include the following:

- Blunt trauma
- Barometric trauma (eg, Boerhaave syndrome, air-pressure injury)
- Penetrating trauma
- Caustic injury
- Foreign body

Patients with perforations of the cervical esophagus can present with neck pain, cervical dysphagia, dysphonia, or bloody regurgitation. Intrathoracic perforations can rapidly contaminate the mediastinum, leading to chest pain, tachycardia, tachypnea, fever, and leukocytosis. Expeditious diagnosis of esophageal injury is important because early diagnosis significantly reduces the rate of complication and mortality. Diagnosis of cervical esophageal perforation is aided by lateral roentgenography, which may reveal air in the prevertebral fascial planes. Plain radiography may reveal mediastinal widening with or without an air-fluid level, subcutaneous emphysema, and a pleural fluid collection.

When a leak is suspected, a contrast study should be performed. Water-soluble contrast agents (eg, Gastrografin) are advocated for first-line screening. If no perforation is initially detected with a water-soluble agent, the examination should be repeated with dilute barium sulfate.

A broad clinical spectrum of esophageal trauma is recognized, ranging from contained small leaks that are recognized early to large leaks with severe mediastinal infection. The general principles of management are directed toward limiting contamination,
encouraging healing of the perforation by repair or drainage, and maintaining nutrition of the patient.

The treatment algorithm centers on whether preexisting esophageal disease is present and whether the perforation is contained. Rarely, a well-contained leak can be managed with careful observation, nothing by mouth (NPO), broad-spectrum antibiotics, and intravenous feeding. The barium swallow is repeated at weekly intervals. If the leak is not contained, the site of perforation dictates further management.

Esophageal injury in the neck, if seen early, is repaired and reinforced with adjacent muscle or tissue and drained. If the leak is seen late, only the abscess is drained without an attempt to repair the injury. Esophageal leaks into the chest are managed by thoracotomy and repair, whether discovered early or late. This is a paradigm shift, in that it was previously felt that late repair was associated with failure and increased mortality.

In general, the upper and mid esophagus are best approached through the right side of the chest, whereas the lower third of the esophagus and the esophagogastric junction are best approached through the left side of the chest. Some pleural or intercostal muscular covering should accompany debridement and primary repair. Wide drainage of both the mediastinum and pleural space is mandatory.

If inflammation is substantial and if the injury is extensive, cervical esophagostomy is necessary, followed by eventual esophageal replacement. Surgeons should attempt to use the native esophagus in a growing child by all means possible.

Video-assisted thoracoscopic drainage for esophageal perforation with mediastinitis in children has been shown to be feasible and effective. Peng et al reported no deaths in 8 children treated with thoracoscopic mediastinal debridement, with a mean hospital length of stay of 34 days. Delay between onset of primary perforation and hospitalization ranged from 2-12 days (median length, 5.2 days). All patients had a localized collection on contrast
study. These authors concluded that perforations in children heal with debridement and drainage alone. Although these data are encouraging, they have not been validated.

CHEST TRAUMA IN CHILDREN, SINGLE CENTER EXPERIENCE

Injury is the principal reason for mortality in kids beyond 1 years old in industrialized countries. Mortality from thoracic injury achieves 30%, and its occurrence lessens as kids get more established. This remains constant regardless of the way that thoracic injury speaks to just 4%–12% of the aggregate number of hospitalizations because of injury and that, alone, its mortality is low (6%–10%). The occurrence of thoracic harm recognized amid the auxiliary examination shows that pneumothorax/hemothorax and lung wound are fairly visit in pediatric injury (from 30% to half of patients with mid-section injury), while heart injuries and traumatic wounds to the tracheobronchial tree, aorta, throat and stomach are moderately occasional.

Our goal was to assess the involvement in our middle in regards to shut or infiltrating pediatric mid-section injury, their finding, diverse treatment systems and the clinical results got in these cases in our crisis doctor’s facility division, which is a tertiary reference focus.

PATIENTS AND METHODS

A review study was finished for all mid-section injuries in pediatric patients who went to the crisis focus at Mansoura University Emergency Hospital between January 1997 and January 2007. We got information on patient demographics, injuries, treatment, demonstrative investigations and the clinical results from the patient restorative records. We avoided patients who had already been hospitalized somewhere else in whom the underlying surgical treatment had been done in different focuses.

After the underlying physical examination and the indispensable signs had been settled, mid-section x-beams were
taken in all patients. Thoracic injury was determined to have the mid-section radiographs requested upon permission and throughout the patients’ hospitalizations. In youngsters with a strange mediastinal outline, mid-section figured tomography (CT) was requested.

Related injuries were related to different investigations, for example, stomach ultrasound in kids who were associated with stomach injury or who had torment amid the stomach palpation of the physical examination. In kids who displayed clear cranial injury or were oblivious, cranial CT was requested. In these patients, thoracic CTs were likewise taken. Inflexible bronchoscopy was methodically performed in all cases with suspicion for tracheobronchial injury.

Treatment of injury patients depended on their state. Traditionalist treatment was utilized as a part of instances of straightforward rib breaks, a few instances of pneumonic wound, instances of negligible aspiratory slash and a few instances of surgical emphysema. Thoracostomy tubes were utilized as a part of instances of hemothorax, pneumothorax higher than 20%, hemopneumothorax and instances of monstrous surgical emphysema requiring mechanical ventilation.

Thoracotomy was done in patients with massive hemothorax and hemodynamic instability and in cases where more than 3ml/kg of body weight was drained for 3 consecutive hours. Thoracotomy was also indicated in cases of evident tracheobronchial traumatic injury on diagnostic bronchoscopy, diaphragmatic rupture or traumatic thoracotomy.

The statistical analysis was done with the SPSS statistical program (SPSS 15 Inc., Chicago, IL, USA). The Shapiro–Wilk test was used to evaluate the normal character of the distribution. The continuous variables with normal distribution were presented as mean±standard deviation. The continuous data without normal distribution were presented as median and range. The discrete variable data were presented as number and/or frequency.
**Results**

Between January 1997 and January 2007, our hospital received a total of 472 pediatric patients with chest trauma. The proportion of male:female patients was 3.81:1 (374 boys and 98 girls). Mean patient age was 9.2±4.9.

We observed penetrating trauma in 12 patients (2.1%): stab wounds (7 patients), falls on a sharp object (3 patients) and bullet wounds (2 patients). The most frequent causes of closed trauma were pedestrian accidents, seen in 181 patients (38.3%). Pulmonary trauma lesions consisted of contusions or lacerations, and the rib fractures went from simple cases to cases of flail chest. Tracheobronchial lesions were observed in 5.3% of the cases, diaphragm lesions in 2.1%, and there were traumatic thoracotomies in 0.6% (3 cases). The associated traumatic lesions were very frequent, especially cranial trauma, which was present in 184 patients (38.9%). The incidence of multi-organ lesions was 64.4% (304 patients), while 202 children (42.3%) had affectation of 3 or more systems.

**Discussion**

Mansoura University Emergency Hospital is a tertiary reference center for trauma patients in Egypt that treats the population in the Dakahlia district and adjacent areas. This center specialized in trauma patients serves approximately 15 million people. Trauma is the first cause of death in the pediatric population, and most trauma lesions in childhood are due to closed contusions. The frequency of thoracic injury in children can reach 50% in cases of polytrauma.

Generally, boys are more likely to have trauma injuries than girls due to their greater tendency towards participating in outdoor activities. In our study, the boy:girl ratio was 3.81:1. This result concurs with the 4:1 ratio reported by Bickford in a series of 26 children and adolescents from Liverpool with chest trauma and the 3.3:1 ratio from Kilman and Charnock. Balci et al. and Smyth, however, have reported a proportion of approximately 2 boys for
every girl. Most pediatric chest trauma (80%–90%) is closed trauma. In our study, closed trauma represented 98% of the total. Motor vehicle accidents were the main cause of these contusion traumas. Most children receive this type of trauma as pedestrians who are hit by cars (26%–72% of cases). In our study, 38.8% of the patients included had pedestrian trauma. This incidence is similar to that reported by Peterson et al., which indicated 35% pedestrian trauma, while this number reached 68% in the study by Smyth. In our study, motor vehicle accidents were 28.1%, which concurs with what has been observed in other studies that have reported an incidence of 2%–34%. This contrasts with what is observed in adults, in whom most accidents affect vehicle occupants.

Other mechanisms are bicycle accidents, which in many series have been observed to affect 4%–14% of cases, compared with our percentage of 19.9%. High falls are between 5% and 18% in many studies, and in our case the incidence was 6.7%. Penetrating trauma greatly depends on age and area. In our study, 2.1% of the cases were penetrating trauma, which is similar to Nakayama’s report of 2.9%, but meanwhile this percentage was 12% in the study by Peclet et al.

A fast diagnosis of thoracic injury is often difficult because the symptoms may not appear until after a few hours. Moreover, simple chest radiography in supine decubitus may not detect or may underestimate 38% of the lesions that are visible in the thoracic planes of abdominal CT. There may be atelectasis, parenchymal lacerations, traumatic lung cysts and pneumothorax, although these may not be evident in the initial radiographic examination. During CT to evaluate possible abdominal lesions, the inclusion of several thoracic planes may improve the diagnosis of the existing lesions and contribute to modifying treatment methods in order to improve clinical results.

Children differ from adults because of their greater ribcage flexibility. This explains the lower incidence of flail chest and rib fractures in the population of that age group. In 90% of cases in which there was a demonstrated existence of vital intrathoracic
injuries, there were no fractures. In our study, there were rib fractures in 23.9% of cases, which is a percentage similar to that reported by Garcia et al. in 1990 and by Meller et al. in 1984. On the other hand, the Nakayama group and Inan et al. observed an incidence of 51% and 62%, respectively, of rib fractures in their patients.

Pulmonary contusion is the most frequent chest trauma injury in children, with an incidence of 40%–73%. It was seen in 128 (27.1%) of the children in our study, which is a percentage similar to the report by Balci, who observed lung contusions in 37 out of 137 (27%) children. On the other hand, Nakayama et al. and Smyth observed an incidence of pulmonary contusions of 53.3% and 56%, respectively. In our study, the incidence of pneumothorax was 23.7%. In other reviews, this incidence has oscillated between 12% (Peclet et al.) and 38% (according to what is described Nakayama et al.). Our incidence of hemothorax (18%) coincides with that of Balci (18.2%), while the incidence observed in other studies has gone from 4% in the study by Smyth or 14% in those by Nakayama et al. and Peclet et al., to 39% according to the data by Black et al. and Inan et al.

The presence of a tracheobronchial lesion should be suspected in cases of persistent subcutaneous emphysema and pneumothorax, despite the presence of properly functioning thoracic tubes. An emergency bronchoscopy should be done to confirm this diagnosis, which is very uncommon in children. The incidence of tracheobronchial lesions in our study is 5.3%, which is similar to the incidence reported by Smyth (5%), while Nakayama and Balci indicated lower incidences (2.9% and 1.4%, respectively). The rupture of the diaphragm is more frequent on the left side. We should suspect its presence when a child has been crushed. This incidence of diaphragm rupture in our study is 2.1%, similar to the reports by Balci et al. (2.9%) and Smyth (3%).

Associated extrathoracic trauma lesions are frequent but they are not affected by age. These injuries make a significant contribution towards mortality. Cranial trauma is the most
frequently recorded extrathoracic trauma (64% in adults, 83% in children). In our study, this incidence is 38.9%, which corresponds with the study by Nakayama et al., who observed cranial trauma in 37% of their patients. Meanwhile, Smyth and Balci et al. observed lower incidences of cranial trauma (20% and 26%, respectively).

Intra-abdominal lesions are seen in approximately 50% of adults and children, with a notable increase in splenic injuries in this latter group. We have observed an incidence of 16.7% of lesions of this type, while the incidence reported by other authors ranges between 10% described by Smyth or 11% by Balci et al. and 23% observed by Nakayama et al. In our study, osteoarticular trauma was seen in 33.5% of the cases, which agrees with reports from Nakayama et al., who observed them in 38% of patients, while Smyth and Balci et al. described an incidence of 21%.

The use of thoracotomy is very infrequent and is only indicated in cases of persistent hemorrhage through the thoracic drain, a high suspicion of mediastinal lesion or uncontrollable shock. The overall percentage of thoracic trauma requiring surgery is around 5%-10%. In our study, thoracotomy was used in 12.1% of patients; in 8 cases (66%) there were penetrating causes. Although penetrating traumas are a low percentage of chest injuries, they are the cause of a high proportion of thoracotomies. Peterson et al. observed a lack of difference in the frequency of thoracotomies due to closed trauma in children, adolescents and adults (2%-8%). However, in the cases of penetrating wounds, the incidence of thoracotomy in children (40%) was more than double of what was seen in other age groups.

The rate of mortality due to thoracic trauma ranges between 6.7% and 25%. In our case, the mortality rate (7.2%) was within these limits. Mortality in children with isolated chest trauma in our study was 17.6%, compared with 23.5% for chest and abdominal trauma and 58.8% for cranial and chest trauma. Peclet et al. described a mortality rate of 26% and the presence of multisystem trauma lesions in 82% of patients. Rielly et al. indicated that 25% of patients with closed trauma died, generally as a consequence
of associated cranial trauma. Nakayama et al. indicated that 68% of their patients with chest trauma also presented extrathoracic trauma injuries, with a mortality rate of 7%.

Our conclusion is that closed trauma is the most frequent chest trauma seen in children, and that this type of trauma is often caused by pedestrian accidents. Rib fractures and lung contusions are the most frequent types of trauma. Delayed diagnoses and polytrauma are associated with a high incidence of mortality.
Congenital Lung Malformations

BACKGROUND

Intrinsic lung deformities considered in this section are those happening in the lung underneath the carina. Aviation route, pleural-space, and mid-section divider abnormalities are considered somewhere else.

The point here is to give a succinct way to deal with innate lung abnormalities. Accordingly, this section examines bronchogenic sore, aspiratory agenesis and hypoplasia, polyalveolar flap, alveolocapillary dysplasia, sequestration including arteriovenous abnormality (AVM) and scimitar disorder, pneumonic lymphangiectasis, intrinsic lobar emphysema (CLE), and cystic adenomatoid distortion (CAM) and other lung growths.

Despite the fact that they emit the amniotic liquid, the lungs are superfluous as organs of breath in fetal life. In any case, their advancement must happen with the goal that air trade may occur during childbirth. The lungs experience embryonic, pseudoglandular, canalicular, saccular, and alveolar stages.

The early division and development of the lung bud is coordinated by the epithelial-mesenchymal collaboration. Hence, asymmetry of lung buds (3 primary bronchi on the right, 2 on the
left) is obvious in the embryonic stage. Right now the pneumonic vessels structure, emerging from the 6th pharyngeal curve.

The 16 eras of the directing division are set down in the pseudoglandular stage (8-16 weeks’ incubation), which is portrayed by cubic epithelium encompassed by mesenchyma. The lung resembles an organ. Bombesin-related gastrin-discharging peptide assumes a vital part in lung development, reaction to harm, and tumorigenesis. Sort II pneumocytes (the alveolar cells) show up.

In the following stage (16-24 weeks’ development), canaliculi with a more extensive lumen, more vessels, and compliment epithelial cells branch out of the terminal bronchioles and structure the respiratory parenchyma. The sort II pneumocytes start to create the surfactant and the proportion of lecithin to sphingomyelin increments in the amniotic liquid.

The last, seventh era of air spaces in the respiratory division create toward the end of the saccular stage (24-36 weeks’ incubation). Subsequently, 16 eras of aviation routes are noted in the directing division, and 7 eras are noted in the respiratory division.

Huge number of alveoli then bud from the airspaces in the alveolar stage, which proceeds in the postnatal life. Epimorphin/syntaxin-2 complex intercedes spreading of ductal structures by impacting cell bond and quality enactment.

**History of the Procedure**

Surgery for congenital lung malformation was made possible relatively recently. Early 20th century thoracic surgery consisted of mainly thoracoplasty to collapse a tuberculoid lung or to drain an empyema. Only with the regular use of endotracheal intubation and mechanical ventilation in the 1950s did intrathoracic procedures become routine. These techniques were not widely applied to newborns until the 1950s. Although Evarts Graham performed pneumonectomy with mass ligature of the hilum, Churchill was the first to regularly perform lobectomy with hilar dissection. Gross and Lewis successfully treated a patient with
congenital lobar emphysema with lobectomy in 1943. Bronchogenic cysts are increasingly excised thoracoscopically. Rodgers vigorously promoted endoscopic surgery, which has become prevalent with the plethora of new instrumentation available and with the expansion of minimally invasive laparoscopy and thoracoscopy. Most thoracic surgical procedures, such as resection of masses (e.g., neurogenic tumors, bronchogenic cysts) and pulmonary lobectomy, are now accomplished with minimally invasive surgery, although the benefits of this approach for cystic adenomatoid malformations are unclear.

Fetal surgery has been advocated for cystic adenomatoid malformation with hydrops, although it has been abandoned for congenital diaphragmatic hernia (CDH). The extraterine intrapartum (EXIT) procedure involves delivery of the baby in which the umbilical circulation is left intact if the baby has a congenital high airway obstruction. This procedure allows relief of the obstruction while providing gas exchange across the placenta.

In 2008, RespiRare, a database of children born with congenital lung malformations, was established in France to record patient information and for the prospective collection of clinical data. One recent study looked at the database and found the median gestational age at diagnosis to be 22 weeks. The malformations were unilateral in all 89 fetuses. Of these neonates, 60% were males. Tachypnea and/or dyspnea were seen in 25% of cases. Only 13% required oxygen therapy, and 11% required ventilation. Polyhydramnios and/or fetal ascites were more specific for severe respiratory distress at birth. Congenital pulmonary malformation volume ratio (CVR) greater than 0.84 was the most sensitive risk factor for oxygen requirement at birth. The authors suggest delivery at a tertiary care center for CVR greater than 0.84, polyhydramnios, and fetal ascites.

**Problem**

Although congenital lung malformations are rare, they are important disorders because they may lead to considerable
morbidity and mortality (eg, infection, hemorrhage, respiratory failure). Prognosis depends on the size of the lesion, and the degree of functional impairment. Small lesions may remain asymptomatic. Failure to recognize a malformation may lead to inappropriate intervention. For example, placement of a chest tube to manage suspected tension pneumothorax in a patient with congenital lobar emphysema may lead to lung contusion and ventilation through the chest tube instead of into the remaining healthy lung. Healthy lung is composed of an orderly system of tubes (airways) and sacs (airspaces or alveoli) in a strict relationship to pulmonary blood vessels (arterial from the right ventricle and venous return to the left atrium). Also present is a systemic blood supply (aorta to superior vena cava) and lymphatic drainage. Congenital lung malformations arise whenever one or more of these structures are abnormal or when their relationships are altered.

**Bronchogenic cysts**

![Bronchogenic cyst. Media file shows a right paratracheal mass.](image)
Bronchogenic cysts are also known as foregut duplication. They arise from an abnormal budding of the ventral foregut. Approximately 85% are mediastinal, and 15% are intrapulmonary. The peripheral cysts are multiple and appear late in gestation. They may be filled with air or fluid, or they may have air-fluid levels. The cysts can be central or peripheral. Many are asymptomatic, but incidental findings may be observed on chest radiography. Infection, hemorrhage, and, in rare cases, malignancy can occur. Respiratory distress may result in a stridor or wheeze. Airtrapping may lead to emphysema, atelectasis, or both. Dysphagia, chest pain, and epigastric discomfort can occur.

**Pulmonary agenesis and hypoplasia**

Both pulmonary agenesis and hypoplasia may be accompanied by renal anomalies, which are usually apparent soon after birth and associated with respiratory distress. Cardiac defects occur in 50% of patients.

Pulmonary agenesis is differentiated from lung aplasia by the absence of the carina in the latter. Lung agenesis is less common than aplasia, about 75% of cases affect the left side, and it is lethal in half of all patients. It may be associated with other manifestations of the syndrome of abnormalities of the vertebrae, anus, cardiovascular tree, trachea, esophagus, renal system, and limb buds (VACTERL syndrome). The survival rate is better with left-sided lung agenesis than with right-sided agenesis because the right lung is the larger of the two.

In pulmonary hypoplasia, development of the distal lung tissue is incomplete. The earlier the delivery of a child, the higher the incidence of lung hypoplasia. In babies delivered before 28 weeks’ gestation, the incidence approaches 20%. Pulmonary hypoplasia results from conditions that restrict lung growth, such as oligohydramnios, Potter syndrome (with bilateral renal agenesis or dysplasia), abnormalities of the thoracic cage, Scimitar syndrome (right-sided pulmonary hypoplasia), and diaphragmatic hernia (usually left-sided hypoplasia).
More than 50% of patients have associated cardiac, gut, or skeletal malformations. They may have a small thoracic cage, decreased breath sounds on the affected side, and a mediastinal shift to the side of the lesion. Therefore, aplasia of the right lung can be confused with dextrocardia. Patients may present with lung infections, dyspnea upon exertion, and/or scoliosis.

**Pulmonary isomerism**

Pulmonary isomerism is an anomaly of the number of lung lobes. In the common variety of pulmonary isomerism, the right lung has 2 lobes, whereas the left has 3. This anomaly may be associated with situs inversus, asplenia, polysplenia, and/or anomalous pulmonary drainage.

**Azygous lobe**

An azygous lobe is a malformation of the right upper lobe caused by an aberrant azygous vein suspended by a pleural
mesentery. An azygous lobe is a radiographic curiosity without clinical significance that occurs in 0.5% of the general population.

**Pulmonary sequestration**

Pulmonary sequestration accounts for 6% of all congenital lung malformations and mostly occurs in the lower lobes. A sequestration is a bronchopulmonary mass without a normal bronchial communication and with normal or anomalous vascular supply. Sequestered lung may be intralobar or extralobar. The involved lung segments can be classified on the basis of their pleural coverage into intrapulmonary or extrapulmonary types. Variants of pulmonary sequestration are described as disconnected or abnormally communicative bronchopulmonary masses with normal or anomalous vascular supply. The lesions may have some sort of communication with the gut.

Children present with recurrent respiratory problems in the same anatomic location. Associated anomalies include diaphragmatic hernia and eventration. Patients may have exercise intolerance if they have large systemic arterial venous shunts. The extrathoracic variety can be associated with hydrops fetalis or increased lymphatic transudate in the thorax.

About 50% of pulmonary sequestration cases are intrapulmonic, and 60% of intrapulmonic cases occur in the left lower lobe with equal sex distributions. Patients with intrapulmonary sequestration usually present late. They may have a chronic cough, recurrent pneumonias, or poor exercise performance. Systemic arterial flow may produce a murmur, and shunts may lead to congestive cardiac failure. Squamous cell carcinoma, adenocarcinoma, and rhabdomyosarcoma may arise in the sequestration.

Approximately 95% of extrapulmonary cases are left sided. Most extrapulmonary cases are detected in infancy, with boys affected 4 times more than girls. Infants usually present with a chronic cough and recurrent chest infections. Radiographs may reveal signs of consolidation. If communication with the gut is
present, children may present with vomiting, failure to thrive due to poor oral intake, and abdominal pain.

**Scimitar syndrome**

The constant feature of this syndrome is partial or total anomalous pulmonary venous return to the inferior vena cava. This abnormal vein on the chest radiography creates a gentle curve bulging into the right chest from the mediastinum that some believe resembles the Turkish sword called a scimitar. Other features of the syndrome are variable and may include dextrocardia, hypoplasia of the right lung and/or pulmonary artery, malformation of the bronchi, and systemic arterial supply to the right lung. The clinical features vary according to age. Infants almost always present with congestive heart failure and severe pulmonary hypertension. Adults are generally asymptomatic.

**Hamartoma**

Hamartomas are lung nodules contain cartilage, respiratory epithelium, and collagen. They may be in the lung tissue or the bronchial lumen. They are presumed to be congenital because they are usually found on chest radiographs in asymptomatic adults. They can cause airway obstruction and are usually excised for diagnosis.

**Pulmonary arteriovenous malformation**

Pulmonary arteriovenous malformations are abnormal communications between the pulmonary arterial and venous systems without interposed capillaries. Arteriovenous malformations with a systemic arterial supply are unusual in the lung. As with arteriovenous malformations elsewhere, they can lead to high-output cardiac failure. Symptoms are unusual in childhood. However, by adulthood, 50% of patients have at least exertional dyspnea. Hemoptysis is most common in patients who also have cutaneous telangiectasis. A continuous bruit is often heard over the lesion. The fistulas are usually seen as well-defined opacities on chest radiography, and are multiple in as many as
50% of patients and bilateral in 10%. Most of the fistulas are subpleural, and more often occur in the lower lobes. CT findings are usually diagnostic. Complications include bleeding, infection, and embolus. Patients with cutaneous telangiectasis are likely to have Rendu-Osler-Weber disease (also known as hereditary hemorrhagic telangiectasia). They are likely to have multiple pulmonary arteriovenous malformations and progressive symptoms. Treatment is resection. If this is not possible, the lesions can be embolized.

**Alveolar capillary dysplasia**

In alveolar capillary dysplasia, a fatal condition, the distal arteriolar blood supply is reduced, the pulmonary veins are misaligned, and the connective tissue between the alveolar epithelium and the capillary endothelium is increased. The alveolar circulation is impaired, and the response to nitric oxide is poor. Affected babies do well with venoarterial extracorporeal membrane oxygenation (ECMO), but they cannot be weaned from it.

The clinical presentation of alveolar capillary dysplasia is that of persistent pulmonary hypertension of the newborn. Hypoxemia leads to arteriolar muscular hypertrophy. Patients may have associated anomalies in the heart or urinary system. Open lung biopsy and cardiac catheterization are suggested as diagnostic tools to look for or exclude pulmonary capillary blush.

**Pulmonary lymphangiectasis**

Pulmonary lymphangiectasis is a rare disorder in which the normal pulmonary lymphatics are dilated. It may be associated with congenital heart disease in which the pulmonary venous pressure is elevated. Pulmonary lymphangiectasis can also be observed with lymphangiomatosis, in which proliferation of the lymphatic tissue and channels occurs. The disease can also be part of a syndrome of lymphangiomas in many organs; it is sometimes associated with vanishing bones. Pulmonary lymphangiectasis is congenital, but symptoms of respiratory insufficiency usually do not appear until adulthood.
Congenital lobar emphysema

 Massive overinflation of one or more lung lobes occurs postnatally in congenital lobar emphysema. Causes include intrinsic absence or abnormality (bronchomalacia) of cartilaginous rings or external compression by a large pulmonary artery. (Compression of the cartilage usually leads to malacia.) Hyperexpansion of a pulmonary lobe is present after birth when, with negative inspiratory pressure, air can enter the lung. However, the air cannot exit easily because positive pressure causes the softened airway to collapse. The remaining normal lung is then compressed.

 Congenital lobar emphysema primarily involves the upper lobes. The left upper lobe is involved in 41% of patients; the right middle lobe, in 34%; and the right upper lobe, in 21%. Involvement of the lower lobes is rare, occurring in fewer than 5% of patients. Congenital cardiac anomalies may be present in as many as 10% of patients. Lesions most commonly occur in whites, in male individuals (male-to-female ratio, 3:1), and in young infants.

 Most patients with congenital lobar emphysema present before 6 months of life. Neonates may present with mild-to-moderate respiratory distress. Mediastinal shift may be present, with hyperresonance and decreased breath sounds on the involved side. Infants present with cough, wheezing, respiratory distress, and cyanosis. Older children may present with recurrent chest infections. On images obtained in neonates, the affected lobe may be slightly opacified, rather than lucent, because it is still filled with fluid. Associated cardiac anomalies occur in as many as 10% of patients.

 Cystic adenomatoid malformation

 Cystic adenomatoid malformation is a defect in the development of the terminal bronchioles. A hamartomatous proliferation of cysts occurs and resembles bronchioles (airways without cartilage).

 Cystic adenomatoid malformation accounts for 25% of all congenital lung malformations. Respiratory distress occurs in the
neonatal period, when collateral pores of Kohn ventilate the alveolar tissue present. This process is responsible for the cystic appearance on radiographs. Patients may have mediastinal shift and a pneumothorax. The affected area is dull on percussion, and air entry is decreased. The radiographic depiction of a solid or cystic mass on one side of the thorax suggests the diagnosis.

Three histologic categories of cystic adenomatoid malformation are described: (1) macrocystic (13%), which has the best prognosis and in which one or more large (>5 mm on prenatal ultrasound) cysts are lined with normal pseudostratified ciliated epithelium; (2) microcystic (73%), which has small cysts lined with ciliated columnar or cuboidal epithelium; and (3) solid cystic adenomatoid malformation (13%), which has the worst prognosis and is an airless tissue mass composed of cuboidal epithelium-lined bronchioles. The difference in prognosis may be because the solid and microcystic lesions involve a relatively large amount of lung tissue. Macrocystic lesions are comprised of large, air filled, nonfunctioning spaces involving smaller areas of lungs. Polyhydramnios may be present if the cystic adenomatoid malformation presses on the esophagus. Pressure on the heart and large vessels may lead to hydrops fetalis. In approximately 60% of patients, cystic adenomatoid malformation manifests soon after the neonatal period. It results in recurrent infections because the mucociliary clearance is poor. Malignancy can occur in the cystic adenomatoid malformation (pulmonary blastoma, rhabdomyosarcoma, and bronchoalveolar carcinoma).

**Lung cyst**

Lung cysts are rare lesions that may arise from any of the parenchymal tissues of the lung. They can cause symptoms if they enlarge and occupy substantial space. Resection is performed to diagnose lung cyst and to stop the progression of symptoms.

**Polyalveolar lobe**

In a polyalveolar lobe, the number of alveoli increased to more than 3 times normal. The alveoli are counted microscopically in
random lung sections. When extra lung fluid is retained, respiratory distress may occur in the first days of life. This generally benign anomaly may be associated with some cases of congenital lobar emphysema.

**EPIDEMIOLOGY**

**Frequency**

Congenital lung malformations represent 5-18.7% of all congenital anomalies. This range may be an underestimate because of the high frequency of undetected or asymptomatic lesions.

**ETIOLOGY**

**Bronchogenic cysts**

Bronchogenic cysts represent outpouchings of the ventral foregut in the early part of gestation. These outpouchings generally arise close to the bronchial tree. A cyst may become infected, or it may compress adjacent structures to produce signs and symptoms. Chronic infection and inflammation may predispose the patient to malignancy. Peripheral cysts appear late in gestation and are multiple.

**Pulmonary agenesis**

In lung agenesis, the entire lung and bronchial tree may be absent on one side. The bronchial tree may form without development of the alveoli. Pulmonary hypertension complicates lung agenesis because of a combination of factors: normal blood volume passing through reduced lung tissue, hypoxemia leading to pulmonary vasoconstriction, and any associated left-to-right shunting cardiac lesion.

**Pulmonary hypoplasia**

Intrathoracic or extrathoracic lesions can cause pulmonary hypoplasia. Therefore, prolonged rupture of membranes, renal dysplasia, neuromuscular diseases, and congenital diaphragmatic
Congenital Lung Malformations

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Pulmonary sequestration

If an accessory lung bud forms early enough, it leads to the formation of sequestration in the normal lung tissue. Development late in gestation leads to extrapulmonic sequestration. Both types obtain their blood supply from the aorta or its branches. Patients may present with exercise intolerance due to these vascular shunts. Sequestrations may also be connected to the GI tract.

Congenital lobar emphysema

Causes of congenital lobar emphysema include bronchial cartilage deficiency, extrinsic compression by a bronchogenic cyst, a large pulmonary artery, or mucus plugs. Lobar overdistention and airtrapping lead to compressive changes in the rest of the lung.

Cystic adenomatoid malformation

Cystic adenomatoid malformation results when the terminal bronchiolar component of the advancing endodermal lung bud
proliferates haphazardly because of disruption of humoral factors from the surrounding mesenchyme. Apoptosis in the advancing lung bud is decreased.

Glial cell–derived neurotrophic factor is a growth factor that is abnormally expressed in the epithelial cells of the cystic adenomatoid malformation.

Cystic adenomatoid malformations usually appear before 7 weeks’ gestation but can occur in the mid stage of lung development. The growth is thought to plateau at 28 weeks’ gestation. Communication with the normal airways can lead to overinflation and compression of the surrounding lung tissue. The larger the sonographic volume of cystic adenomatoid malformation in relation to head circumference, the greater the chance for developing hydrops because of more severe central venous compression.

INDICATIONS

Bronchogenic cyst

Resection is recommended because of the potential for infection, hemorrhage, and respiratory compromise. Resection is especially important in the peripheral lesions, which are usually multiple. These can frequently be excised thoracoscopically because they seldom have a major blood supply.

Pulmonary agenesis and pulmonary hypoplasia

Patients with pulmonary agenesis and pulmonary hypoplasia seem to have one of 3 presentations. The first group consists of patients with insufficient lung tissue who may have received mechanical ventilation for some time. However, ventilator-induced lung injury results in slow decompensation and death. The second group of patients is identified serendipitously when chest radiography is obtained to assess a minor complaint. These patients require no intervention. The third group does not have respiratory distress requiring mechanical ventilation, but they have respiratory
limitations to activity or kinking of the airway with shift of the lung to the contralateral side of the chest. In addition to the aplasia or hypoplasia, congenital narrowing of the upper airway also affects many patients.

**Pulmonary sequestration**

Resection is recommended, even in asymptomatic patients, to prevent infection, hemorrhage, shunting from arteriovenous anastomoses, or compression of normal lung mass leading to respiratory distress. Lobectomy can usually be performed. For patients with intralobar sequestration, segmentectomy may suffice. Segmentectomy is relatively difficult, but preserves additional functioning lung tissue.

Since the advent of staplers, most surgeons wedge out the lesion with staplers rather than perform the tedious dissection and stripping of segmentectomy that is prone to air leakage and often bloody. In many sequestrations, the mass is airless and separate from the other lung tissue. The surgeon must remain vigilant in searching for the systemic arterial supply. Its origin cannot be predicted, and it may be from below the diaphragm. Bleeding from inadvertently crossing this vessel may be troublesome or even dangerous. For this reason, some surgeons insist on obtaining an arteriogram before surgery.

At least a few thoracoscopic surgeons have accomplished pulmonary resection, even in children. In children, the difficulty in finding enough space in the chest to work while the lungs are being ventilated and the risk of injuring the delicate pulmonary vessels has limited wide adoption of this technique.

**Scimitar syndrome**

When symptoms of scimitar syndrome are related to anomalous pulmonary venous return, this return can be redirected surgically. Symptoms are often related to the bronchial abnormalities and chronic infection. In these cases, pneumonectomy is indicated.
Hamartoma and pulmonary arteriovenous malformation

Resection is usually performed for diagnosis when a lesion is noted on chest radiography. Symptoms of airway obstruction or high cardiac output are occasionally indications for surgery as well.

Congenital lobar emphysema

Progressive airtrapping leads to respiratory and circulatory compromise in infancy. Emergency lobectomy may be required. A patient with respiratory distress whose chest radiograph reveals a hyperlucency on one side and mediastinal shift usually has a tension pneumothorax. However, one must consider congenital lobar emphysema (CLE), especially in the newborn. The diagnosis can usually be determined by looking at the edges of the hyperlucent area. In pneumothorax, the edges are convex and outline the chest wall, whereas in congenital lobar emphysema, they are concave and outline the cystic structure of an overexpanded lobe.

Placing a chest tube in the hyperlucent airspace of congenital lobar emphysema decreases ventilation as air takes the path of least resistance out the chest tube from the bronchus rather than expanding the stiff infant lung in the remaining lobes. Prompt thoracotomy relieves the pressure inside a hyperexpanded lobe and allows the other compressed areas to ventilate. This overexpansion often stretches and dissects the bronchi and vessels, facilitating lobectomy. In cases that are detected early or surgically treated because of radiographic findings and not because of symptoms, the abnormal lobe may be difficult to identify during surgery. Therefore, in these cases, radiographs and CT scans must be carefully reviewed preoperatively.

Cystic adenomatoid malformation

In cystic adenomatoid malformation (CAM), resection of even asymptomatic masses is recommended because of the risk for infection, hemorrhage, acute respiratory compromise (which may
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...occur anytime), and neoplastic transformation. This disease is usually segmental; however, as noted for sequestration, lobectomy may reduce morbidity.

**Lung cysts**

During surgery, lung cysts are often found to be cystic adenomatoid malformations (CAMs), though simple cysts do occur. Some lesions can be shelled out or unroofed. If they are not congenital but related to barotrauma, they may communicate directly with small bronchi. In this case, unroofing leads to major air leaks. These lesions can sometimes be controlled sutures, but wedge resection, segmentectomy, or even lobectomy may be required to avoid a bronchopleural fistula.

**Fetal intervention for congenital lung malformations**

Many centers perform antenatal aspiration of lung cysts. This procedure is often successful in that no lung cyst appears on postnatal chest radiography. However, many cysts observed on antenatal ultrasonography also spontaneously resolve. The few groups who are pursuing open fetal surgery also perform in utero lobectomy to manage cystic adenomatoid malformation if it is associated with fetal hydrops. This is an unusual situation, and the benefits have not yet been determined.

**RELEVANT ANATOMY**

The lungs continue to mature after birth. Embryologic development progresses from the conductive initial lung bud down to the highly functional respiratory alveoli. Major bronchiolar development ceases around 16 weeks’ gestation. Vascular beds form, and the basic acinus framework is then laid down from 17-28 weeks’ gestation. Alveolar development starts at 24 weeks’ gestation and may continue until adolescence. Most of this increase in the alveoli occurs in the first 8 years of life. Aortic branches initially supply the bronchial buds; later, the pulmonary arteries take over as the lung develops.
The timing and severity of various insults may determine the resultant lesions. These lesions may vary from complete agenesis to bronchial stenosis and sequestration of a lung lobe with retention of the aortic flow. Peripheral pulmonary lesions, such as congenital lobar emphysema (CLE), appear late in development.

Other theories try to account for the abnormal lung vessel communications. The vascular traction theory suggests that the lung tissue is sequestered when the systemic blood vessels move caudally. Another theory is that the pulmonary vessels fail to develop and lead to abnormal persistence of systemic vessels.

**Bronchogenic cysts**

Bronchogenic cysts are most commonly mediastinal in a pericarinal, paratracheal, or retrocardiac location. The cysts are thin walled and lined with columnar epithelium. The common central cysts represent outpouchings of the ventral foregut in the early part of gestation.

**Pulmonary agenesis and hypoplasia**

The entire lung and bronchial tree may be absent on one side. The bronchial tree may form without development of the alveoli. Agenesis is a primary defect in organogenesis, and hypoplasia is often secondary to extrinsic compression. Both lesions may be associated with other anomalies. In physiologic terms, the 2 lesions behave similarly.

Schechter has pointed out the many possible variations. In addition to absence of the entire lung and bronchial tree, an interrupted bronchial tree may be present, but the alveoli are absent or the lung may be reduced in size, or one lobe may be absent.

Pulmonary hypertension complicates lung agenesis because of a combination of factors, including normal blood volume passing through reduced lung tissue, hypoxemia leading to pulmonary vasoconstriction, and any associated left-to-right shunting cardiac lesion.
Pulmonary isomerism

In pulmonary isomerism, the lungs are asymmetric, and the number of lobes on both sides may vary. Associated findings may include situs inversus and splenic anomalies. Anomalous pulmonary venous drainage is almost always present.

Scimitar syndrome

A constant feature of Scimitar syndrome is aplasia of one or more lobes of the right lung. Variable features include the following:

- Partial anomalous pulmonary venous return (scimitar-shaped vein) draining to the inferior vena cava and leading to a left-to-right shunt
- Small pulmonary artery
- Arterial supply from aorta
- Anomalies of hemidiaphragm on affected side
- Rib cage anomalies

Pulmonary sequestration

Pulmonary sequestration may be present in the normal lung or outside it, in the thoracic cavity, in the diaphragm, or in a subdiaphragmatic position. Alveoli and bronchioles have normal histology. However, they do not communicate with the normal airways, or they may have an abnormal communication with the gut. Sequestration is fundamentally an abnormal vascular supply to the affected lung, and accelerated atherosclerosis may be found in vessels exposed to high systemic pressures. Branches from the descending thoracic aorta supply the intralobar sequestration, which is drained by pulmonary veins. An infradiaphragmatic source may supply the extralobar variety in as many as 20% of patients, and the azygous venous system drains it.

Congenital lobar emphysema

In congenital lobar emphysema, a single lobe is commonly involved. The bronchi at the involved site may be devoid of cartilage. The number of alveoli may be fewer than normal
Cardiac anomalies may be present in 10% of patients. The lung parenchyma is normal, unlike what is seen in cystic adenomatoid malformation (CAM).

**Cystic adenomatoid malformation**

One lobe, multiple lobes, or multiple segments on both sides may be affected. The upper lobes are usually involved. The bronchiolar proliferation is terminal without much alveolar development. The abnormal hamartomatous proliferation usually retains its communication with the normal bronchiolar tree. However, no cartilage or bronchiolar tubular glands are present in the malformation itself. Columnar mucinous epithelium is present.

Three types of congenital lobar emphysema have been identified. In type I, one or more cysts of 2-10 cm are accompanied by smaller cysts, which cysts can become infected. The cysts are lined with pseudostratified columnar epithelium. Mucin is produced. The most common presentation includes respiratory distress caused by overdistention and mediastinal shift. In type II, multiple 0.5-cm to 2-cm cysts are lined with cuboidal epithelium. The cysts resemble bronchioles. Type II is commonly associated with other congenital anomalies, like renal agenesis and dysplasia, prune belly syndrome, undescended testes, pectus excavatum, and syringomyelia. In type III, a solid mass (< 5 cm) consists of microscopic cysts. Types II and III can be associated with sequestration and receive blood supply from systemic arteries.

In a study of 12 patients with late-onset cystic adenomatoid malformation, 7 had type I cystic adenomatoid malformation, and 4 had type II cystic adenomatoid malformation.

**CONGENITAL PULMONARY MALFORMATIONS (CPMS)**

CPMs are a gathering of uncommon lung variations from the norm influencing the aviation routes, parenchyma, and vasculature.
They speak to a range of irregular advancement as opposed to discrete neurotic elements. They are brought on by distorted embryological lung improvement which happens at various phases of intrauterine life.

With enhanced determination of fetal sonography and Doppler examines, a hefty portion of these injuries are recognized “in utero.” Their characteristic history can be very factor. Sores may resolve before birth. Some CPMs may show in the early neonatal period with respiratory trouble because of a mass impact, while others might be asymptomatic just to be distinguished in later life on CXRs performed for different reasons. Certain types of CPM can possibly experience harmful change. On the other hand, pleuropulmonary blastoma may take on the appearance of a few types of CPM. At the point when sores are symptomatic in early life there can be probably surgical resection is the main choice. In any case, the basic leadership process turns out to be more unpredictable when clinicians experience asymptomatic sores, in solid babies, which have been distinguished either by antenatal USS or accidental mid-section radiograph.

The presentation, regular history, determination and administration of innate pneumonic aviation route distortion, inherent lobar emphysema, aspiratory sequestration, bronchogenic growth, and pleuropulmonary blastoma will be talked about.

**CONGENITAL PULMONARY AIRWAY MALFORMATION (CPAM)**

Intrinsic aspiratory aviation route abnormality (CPAM) was already known as inborn cystic adenomatoid contortion (CCAM). Histologically, the sore of CPAM is portrayed by strong adenomatous zones, which comprise of firmly stuffed tubular structures taking after terminal bronchioles without full grown alveoli. These regions nearly look like typical fetal lung at 16-week development. Scattered with these adenomatous ranges are blisters. Postnataally the downstream alveoli must be ventilated correspondingly by means of the pores of Kohn.
The rate of CPAM is 1 for every 8300 to 35,000. It generally influences a solitary projection and it is no relationship with sex inclination. There are five subtypes of CPAM (0–4) contingent upon the extent of sores and adenomatous tissue and the overwhelming cell sorts. Sorts 1 and 2 happen with most recurrence. Sort 1 injuries are typically unicystic or paucicystic and may contain liquid, they contain practically no adenomatous part. The pimples are more prominent than 2 cm in breadth and fixed with pseudostratified columnar epithelium. Sort 2 injuries contain more uniform little blister of under 1 cm in measurement. Mucous cells and ligament are found in sort 1, however not sort 2. Smooth and striated muscle filaments are found in sorts 1 and 2, individually. A concurrent CPAM sort 2 has been accounted for in half of the patients with extralobar sequestration (ELS), however the detachment from the lung and the nearness of a systemic blood supply are useful to recognize these substances. Sort 4 injuries contain expansive sores fixed with level alveolar cells, some of which contain surfactant. They include more fringe lung. They can give strain pneumothorax. Sort 4 CPAM was considered inside sort 1, in more seasoned distributions, as both sorts are made out of expansive pimples (up to 10 cm in width). Vast blisters are generally watched and pneumothorax can happen in Type 1 PPB, which has a histological cover with sort 4 CPAM. It is not effortlessly conceivable to separate between both substances on histology alone.

**Natural History**

The natural history of CPAM can be quite variable. Spontaneous regression during the course of gestation is not uncommon. In 29 patients with CPAM, during fetal life, the size of the lesion decreased in 8 patients, of whom 7 required postnatal surgical resection, and disappeared in 4 patients, of whom 3 required postnatal surgical resection. In children with disappearing fetal lung masses, postnatal CT scans are needed to exclude the persistent abnormalities, which are often subtle or not apparent on plain radiographs.
Prenatal versus Postoperative Pathological Diagnoses

With improved resolution of foetal sonography, many of the CPAM lesions are detected “in utero.” However appropriate postnatal investigations, rather than antenatal diagnosis, are essential for surgical decision. No correlation between antenatal ultrasound features and histological diagnosis after surgery has been reported. In one hundred and five complete records of asymptomatic children with prenatally diagnosed lung lesions, the postoperative pathologic diagnoses were different from preoperative radiological findings in 9 patients. In a study of 17 fetuses diagnosed with CPAM by prenatal ultrasound, pathological diagnosis was confirmed in 57% of those with known pathological diagnosis. Tsai et al. showed that, in one hundred and five complete records of asymptomatic children with prenatally diagnosed lung lesions, the postoperative pathologic diagnoses were different from preoperative radiological findings in 9 patients.

Clinical Presentation

CPAM may present in the early neonatal period with respiratory distress due to a mass effect, while others may be asymptomatic only to be detected in later life on CXRs performed for other reasons. Sauvat et al., reported that 3 out of 29 patients with CPAM experience symptoms during the first weeks of life. As many as 86% (18 out of 21) of patients, who were asymptomatic at birth, had become symptomatic by 13 years of age (median age of 2 years). In patients with CPAM, pneumonia with or without infected CPAM was reported in 43%, respiratory distress in 14%, and spontaneous pneumothorax in 14%. In 31 patients with bronchopulmonary malformations, CPAM, pulmonary sequestrations, bronchogenic cysts, congenital lobar emphysemas, Shanmugam et al. reported that respiratory distress, respiratory infections/pneumonias, and dyspnoea occurred in 9, 22, and 9 out of these 31 patients, respectively. In 16 patients with CPAM, neonatal respiratory impairment, pneumothorax, and recurrent respiratory tract infections occurred in 12, 1, and 3 patients, respectively.
Postnatal Diagnosis

The diagnosis is suggested by CXR, however, a thoracic CT scan is required to confirm the diagnosis. Winters et al. reported that CXR features can be subtle in children with disappearing fetal lung masses, hence postnatal CT scan is needed. In 29 patients with CPAM, postnatal X-ray and CT scan were abnormal in 17 and 25, respectively. CPAM lesions may be confused for a congenital diaphragmatic hernia. Heij et al. showed that 4 out of 16 patients with CCAM had laparotomy for presumed diaphragmatic hernia. In these circumstances, CT scan can be helpful.

Association between CPAM and Malignancy

An association between type 1 CPAM and bronchoalveolar carcinoma has been reported. In patients with type 1 CPAM, Langston showed that microscopic foci of bronchoalveolar carcinoma and focal mucous cell hyperplasia could occur in up to 5/16 and 2/16 of patients. In those with type 4 CPAM, focal stromal hypercellularity and pleuropulmonary blastoma were documented in 4/8 and 1/8 of patients. The distinction between type 4 CPAMs and grade 1 pleuropulmonary blastomas may not be possible on histology alone. Primary pulmonary rhabdomyosarcoma (RMS) has been reported in 13-month-old boy with CPAM.

Maternal Steroid and Fetal Therapy

In 13 patients with predominantly microcystic CPAM, Curran et al. showed that fetuses, who had CPAM volume-to-head ratio >1.6 or nonimmune hydrops, experience an improvement following prenatal betamethasone. In these patients, hydrops and CPAM volume-to-head ratio improved in 77.8% and 61.5% of the patients, respectively. Adzick reported two fetuses (>32-week gestation), with lung lesion and hydrops, experienced an ex utero intrapartum therapy strategy with resection of the lesion and survived. In fetuses with CPAM and hydrops, fetal resection or thoracoamniotic
shunt is recommended. Serial fetal thoracenteses may be an alternative or an adjunct to fetal surgery in selected cases. Adzick et al. showed that hydrops resolution and neonatal survival occurred in 8 out of 13 fetuses, with CPAM and nonimmune hydrops, who experienced fetal surgical resection of the lesions at 21 to 29 week of gestation. Five out of six fetuses, with a very large solitary cyst, who had thoracoamniotic shunting, survived. In 67 fetuses with cystic lung lesions, percutaneous intrauterine laser therapy and thoracoamniotic shunts had been performed in 1 and 3 fetuses, respectively.

Recommendation and Management

Air travel in children suffering from cystic lung lesions is controversial because of the risk of pneumothorax. Most clinicians caution against air travel in children with enlarging cystic lesions. All infants with antenatally diagnosed CPAM should be evaluated. Symptomatic children require surgical resection. When CPAM is asymptomatic some clinicians prefer to observe rather than refer for surgery. However, when one considers the risk of pulmonary compression, infection, and the low risk for malignancy, it is not surprising that many clinicians prefer the operative approach. In the majority of cases, pulmonary resection is indicated as soon as the diagnosis is made, with emergency resection in those with severe respiratory distress.

BRONCHOGENIC CYST (BC)

Bronchogenic cyst is a rare CPM, with a prevalence rate of 1 per 68,000. BC represents part of the spectrum of broncho-pulmonary foregut malformations. The primitive foregut gives rise through a central outpunching to the trachea-bronchial tree. Between the 5–16th week of gestation the bronchi develop by a process of budding and branching. Buds can develop at any site along the trachea-bronchial tree which, if their development arrests, become BC. The cysts contain tissue normally found in the airways (mucous glands, smooth muscle, elastic tissue, and cartilage). BC
may occur in paratracheal, carinal, paraesophageal, hilar, suprasternal notch, and miscellaneous locations. The latter occurs when buds detach and migrate to ectopic sites, for example, pericardial, cervical, and abdominal.

**Diagnosis and Presentation**

BC may be detected as incidental findings on chest radiographs and account for 10% of mediastinal masses in children. The postnatal diagnosis of BC may be suspected on chest radiograph but a thoracic CT scan is needed to confirm the diagnosis. In a case series of 33 patients with bronchogenic cysts, the lesions usually presented as spheroid mediastinal masses, near the carina or right paratracheal area. Newborns with large cysts can develop respiratory distress, cyanosis, and feeding difficulty. Compression of the trachea and respiratory arrest has been reported in infants with BC. BC in a bronchial location may present with wheeze and recurrent pneumonia. If the airway obstruction is only partial and gives rise to a ball-valve effect, then hyperinflation of the distal lung will occur which may mimic CLE. Where the obstruction is complete, atelectasis of the distal lung may occur leading to infection. High tracheal BC may present with stridor. Cysts may communicate with the airway and become infected and rupture. Paraesophageal cyst may give rise to dysphagia. Pericardial BC may present with Superior Vena Cava obstruction. In a series of 10 infants and children (age between 16 days and 6 years) with bronchogenic cyst, respiratory distress, cyanosis, chronic cough, and fever and dysphagia were reported in 70%, 40%, 50%, and 20% of patients, respectively. The differential diagnosis depends on location and may include lymphadenopathy, oesophageal duplication cyst, neuroblastoma, cystic hygroma, and dermoid cyst.

**Association between BC and Malignancy**

A rare association between BC and neuroblastoma had been reported in 2 children. A recent meta-analysis of bronchogenic cysts found that 45% of 683 asymptomatic adults progressed to
develop complications and that there was a small risk 0.7% of malignant transformation within the cyst. Bronchoalveolar cell carcinoma is the most common form of malignancy associated with BC.

**Management**

Surgical excision should be considered in all cases because of the likelihood of eventual development of symptoms and malignant change.

**CONGENITAL LOBAR EMPHYSEMA (CLE)**

CLE is relatively rare affecting 1 in 20,000 live births. It occurs more commonly in males and most frequently affects the left upper lobe. Most series report that within the affected lobe the alveoli are anatomically and numerically normal. It is postulated that the condition is caused by either absence or maldevelopment of cartilaginous rings or bronchomalacia of a proximal airway due to extrinsic compression “in utero.” However, in 50% of cases the airway appears normal. The net effect is air trapping in the affected lobe.

**Presentation and Diagnosis**

Lesions may be asymptomatic or present with respiratory distress in the newborn period. Later, infants may experience dyspnoea (57%) or recurring respiratory infection (28%). On CXR, hyperluency of the affected lobes is the characteristic feature. The diagnosis may be confirmed on chest CT. The differential diagnosis includes type 1 unicystic CPAM, pneumothorax, Swyer-James syndrome, bronchogenic cyst, and diaphragmatic hernia.

**Association with Malignancy and Heart Diseases**

Type I pleurapulmonary blastoma may mimic CLE. In one report of a patient with asymptomatic CLE, the lesion was resected due to increasing size and pleuro-pulmonary blastoma type I was confirmed on histology. This overlap in the spectrum of diagnoses prompts the surgical view to resect CPM. A cardiac evaluation is
required because as many as 15% of cases may have congenital heart disease.

Management

Early surgical excision is required for newborns with respiratory distress. However, infants and older children who are asymptomatic or have minimal symptoms can be treated conservatively. Surgical excision of the affected lobe is the appropriate treatment in all infants under 2 months of age and in infants older than 2 months presenting with severe respiratory symptoms. Infants older than 2 months presenting with mild to moderate respiratory symptoms associated with normal bronchoscopic findings can be treated conservatively.

BRONCHOPULMONARY SEQUESTRATION (BPS)

BPS is a rare congenital malformation of the lower respiratory tract and comprises 0.15 to 6.4% of all CPM. The incident rate of pulmonary sequestration is 0.29%. It is an area of nonfunctioning lung tissue that commonly receives its arterial blood supply from the descending aorta. The sequestered lobe has no communication with the tracheobronchial tree. BPS is classified as either intralobar sequestration (ILS), in which the lesion is located within a normal lobe and lacks its own visceral pleura or extralobar (ELS), in which the lesion is located outside the lung and has its own visceral pleura.

ILS lesions account for 80% of sequestrations. The sequestration commonly occurs in the lower lobe, primarily in the left posterior basal segment. With respect to ILS, the venous drainage is usually to the pulmonary circulation. However, ELS frequently have systemic venous drainage.

Other congenital anomalies occur in 3/18 and 3/4 of ILS and ELS, respectively. In 28 patients with BPS, diaphragmatic hernia, atrial septal defect, dextrocardia, double superior caval vein, and a sliding hernia and an esophageal bronchus communicating with an ELS have been seen in 2 and 1 each, respectively. Gezer et al.
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reported a case of diaphragmatic hernia in 1 (12.5%) patient with ELS. In one series, the association between ELS and type 2 CPAM has been reported in as many as 50% of patient.

Prenatal and Postnatal Diagnosis

In a previous study of pregnant women with antenatally diagnosed ELS, the lesions regressed before delivery in 28/41 (68%) cases. Postnatal diagnosis of ELS often can be made from chest radiograph appearance. However, ultrasonography with Doppler imaging or thoracic CT with contrast may be used to define the lesion. ELS are often discovered in infants who present with other conditions for example, heart failure, polyhydramnios, or prematurity.

PRESENTATION

The age of presentation is variable in children with ELS. In a case series of 50 patients with ELS, 24% were diagnosed prenatally and 61% were diagnosed by three months of age. In 27 patients (age between 3.5 and 51 years) with BPS, 10, 6, 2, and 2 experience recurrent pneumonia, chest pain, hemoptysis, and shortness of breath, respectively. The adjacent lung is frequently bronchiectatic in resected ILS specimens. The differential diagnosis of BPS includes CPAM, congenital diaphragmatic hernia, bronchogenic cyst, and mediastinal tumour.

Complications

These include haemoptysis, haemothorax, and malignant transformation. Levine et al., documented severe congestive heart failure in 2 infants with BPS and large arterio-venous shunts. A localised carcinoma in the sequestrated lung tissue has also been reported.

Fetal Therapy

In fetuses with BPS and hydrops, open fetal surgery, coagulation of the blood supply, or thoracoamnionic shunting has been recommended. BPS with hydrops has been treated
successfully with laser coagulation of the feeding systemic artery of the sequestration under ultrasound guidance. Rammoss et al. reported 2 babies, with BPS, who required postnatal thoracotomy performed on the 10th day of life in spite of prenatal amnioperitoneal shunt, pleural drainage, and laser ablation of the feeding artery.

Management

Immediate surgical intervention is required in patients with respiratory distress. In view of the high rate of complications, elective resection is often recommended even in asymptomatic patients with BPS. Ayed and Owayed reported that the age of intervention was 11 weeks (range, 13–43 weeks), in those with pulmonary sequestration.

PLEUROPULMONARY BLASTOMA (PPB)

It is a rare tumor of pleura and lung in young children. The incidence of PPB is 1 in 250,000 live births. There are 3 different types of PPB. Type 1 lesion presents in a cystic form, which is indistinguishable from benign lung cyst. However, nodules within the cystic lesions and solid masses are present in types 2 and 3, respectively. PPB is the most frequent malignancy associated with childhood lung cysts. A quarter of PPBs are associated with a familial predisposition to dysplasia. PPB should be considered in infants and children presenting with lung cysts and pneumothorax, bilateral lung cysts, or a family history of PPB-associated conditions, including renal cystic disease and small bowel polyps. Cerebral metastases had been reported in types 2 and 3 PPB. This suggests routine brain imaging to monitor development of metastasis in patients with PPB.
Gastroesophageal Reflux Disease (GERD)

Gastroesophageal reflux infection, or GERD, is a digestive issue that influences the lower esophageal sphincter (LES), the ring of muscle between the throat and stomach. Numerous individuals, including pregnant women, experience the ill effects of indigestion or corrosive acid reflux created by GERD. Specialists trust that a few people experience the ill effects of GERD because of a condition called hiatal hernia. By and large, GERD can be eased through eating regimen and way of life changes; nonetheless, a few people may require solution or surgery.

GASTROESOPHAGEAL REFLUX

Gastroesophageal alludes to the stomach and throat. Reflux intends to stream back or return. Accordingly, gastroesophageal reflux is the arrival of the stomach’s substance go down into the throat.

In typical processing, the lower esophageal sphincter (LES) opens to permit sustenance to go into the stomach and closes to anticipate nourishment and acidic stomach juices from streaming over into the throat. Gastroesophageal reflux happens when the LES is powerless or unwinds improperly, permitting the stomach’s substance to stream up into the throat.
OTHER FACTORS CONTRIBUTE TO GERD

Dietary and way of life decisions may add to GERD. Certain nourishments and drinks, including chocolate, peppermint, broiled or greasy sustenances, espresso, or mixed refreshments, may trigger reflux and indigestion. Examinines demonstrate that cigarette smoking relaxes the LES. Stoutness and pregnancy can likewise assume a part in GERD side effects.

Symptoms of Heartburn

Heartburn, also called acidindigestion, is the most common symptom of GERD and usually feels like a burning chest pain beginning behind the breastbone and moving upward to the neck and throat. Many people say it feels like food is coming back into the mouth leaving an acid or bitter taste.

The burning, pressure, or pain of heartburn can last as long as 2 hours and is often worse after eating. Lying down or bending over can also result in heartburn. Many people obtain relief by standing upright or by taking an antacid that clears acid out of the esophagus. Decreasing the size of portions at mealtime may also help control symptoms. Eating meals at least 2 to 3 hours before bedtime may lessen reflux by allowing the acid in the stomach to decrease and the stomach to empty partially. In addition, being overweight often worsens symptoms. Many overweight people find relief when they lose weight. Cigarette smoking weakens the LES. Stopping smoking is important to reduce GERD symptoms. Elevating the head of the bed on 6-inch blocks or sleeping on a specially designed wedge reduces heartburn by allowing gravity to minimize reflux of stomach contents into the esophagus. Do not use pillows to prop yourself up; that only increases pressure on the stomach. Along with lifestyle and diet changes, your doctor may recommend over-the-counter or prescription treatments.

Heartburn or GERD Symptoms Persist

People with severe, chronic esophageal reflux or with
symptoms not relieved by the treatments described above may need more complete diagnostic evaluation. Doctors use a variety of tests and procedures to examine a patient with chronic heartburn. An upper GI series may be performed during the early phase of testing. This test is a special X-ray that shows the esophagus, stomach, and duodenum (the upper part of the small intestine). While an upper GI series provides limited information about possible reflux, it is used to help rule out other diagnoses, such as peptic ulcers.

Endoscopy is an important procedure for individuals with chronic GERD. By placing a small lighted tube with a tiny video camera on the end (endoscope) into the esophagus, the doctor may see inflammation or irritation of the tissue lining the esophagus (esophagitis). If the findings of the endoscopy are abnormal or questionable, biopsy (removing a small sample of tissue) from the lining of the esophagus may be helpful.

Esophageal manometric and impedance studies — pressure measurements of the esophagus — occasionally help identify low pressure in the LES or abnormalities in esophageal muscle contraction. For patients in whom diagnosis is difficult, doctors may measure the acid levels inside the esophagus through pH testing. Testing pH monitors the acidity level of the esophagus and symptoms during meals, activity, and sleep. Newer techniques of long-term pH monitoring are improving diagnostic capability in this area.

**GASTROESOPHAGEAL REFLUX DISEASE AND INDIGESTION**

Gastroesophageal reflux infection (GERD), otherwise called indigestion, is a long haul condition where stomach substance return up into the throat bringing about either manifestations or complexities. Side effects incorporate the essence of corrosive in the back of the mouth, indigestion, awful breath, mid-section torment, retching, breathing issues, and wearing without end of the teeth. Confusions incorporate esophagitis, esophageal strictures,
and Barrett’s throat. Gastroesophageal reflux infection (GERD), otherwise called indigestion, is a long haul condition where stomach substance return up into the throat bringing about either manifestations or complexities. Side effects incorporate the essence of corrosive in the back of the mouth, indigestion, awful breath, mid-section torment, retching, breathing issues, and wearing without end of the teeth. Confusions incorporate esophagitis, esophageal strictures, and Barrett’s throat.

Hazard variables incorporate weight, pregnancy, smoking, rest hernia, and taking certain prescriptions. Meds included include antihistamines, calcium channel blockers, antidepressants, and dozing solution. It is because of poor conclusion of the lower esophageal sphincter (the intersection between the stomach and the throat). Finding among the individuals who don’t enhance with basically measures may include gastroscopy, upper GI arrangement, esophageal pH checking, or esophageal manometry. Treatment is ordinarily through way of life changes, pharmaceuticals, and now and again surgery. Way of life changes incorporate not resting for three hours in the wake of eating, getting in shape, maintaining a strategic distance from specific sustenances, and halting smoking. Meds incorporate acid neutralizer, H2 receptor blockers, proton pump inhibitors, and prokinetics. Surgery might be a choice in the individuals who don’t enhance with different measures. In the Western world somewhere around 10 and 20% of the populace are influenced by GERD. Gastroesophageal reflux (GER) once in for a short time, without huge side effects or difficulties, is more normal. The condition was initially portrayed in 1935 by Asher Winkelstein. The great side effects had been portrayed before in 1925.

SIGNS AND SIDE EFFECTS

Grown-ups

The most-well-known manifestations of GERD in grown-ups are indigestion an acidic taste in the mouth, and spewing forth.
Less-basic side effects incorporate torment with gulping/sore throat, expanded salivation (otherwise called water brash), sickness, mid-section agony, and hacking.

GERD some of the time causes harm of the throat. These wounds may incorporate one or a greater amount of the accompanying:

- Reflux esophagitis – putrefaction of esophageal epithelium creating ulcers close to the intersection of the stomach and throat
- Esophageal strictures – the constant narrowing of the throat created by reflux-actuated aggravation
- Barrett’s throat – intestinal metaplasia (changes of the epithelial cells from squamous to intestinal columnar epithelium) of the distal throat
- Esophageal adenocarcinoma – a type of disease.

A few people have suggested that side effects, for example, sinusitis, intermittent ear diseases, and idiopathic pneumonic fibrosis are because of GERD; in any case, a causative part has not been set up.

**Kids**

GERD may be difficult to detect in infants and children, since they cannot describe what they are feeling and indicators must be observed. Symptoms may vary from typical adult symptoms. GERD in children may cause repeated vomiting, effortless spitting up, coughing, and other respiratory problems, such as wheezing. Inconsolable crying, refusing food, crying for food and then pulling off the bottle or breast only to cry for it again, failure to gain adequate weight, bad breath, and burping are also common. Children may have one symptom or many; no single symptom is universal in all children with GERD.

Of the estimated 4 million babies born in the US each year, up to 35% of them may have difficulties with reflux in the first few months of their lives, known as ‘spitting up’. One theory for
this is the “fourth trimester theory” which notes most animals are
born with significant mobility, but humans are relatively helpless
at birth, and suggests there may have once been a fourth trimester,
but children began to be born earlier, evolutionarily, to
accommodate the development of larger heads and brains and
allow them to pass through the birth canal and this leaves them
with partially undeveloped digestive systems. Most children will
outgrow their reflux by their first birthday. However, a small but
significant number of them will not outgrow the condition. This
is particularly true when a family history of GERD is present.

**Barrett’s esophagus**

GERD may lead to Barrett’s esophagus, a type of intestinal
metaplasia, which is in turn a precursor condition for esophageal
cancer. The risk of progression from Barrett’s to dysplasia is
uncertain, but is estimated at about 20% of cases. Due to the risk
of chronic heartburn progressing to Barrett’s, EGD every five
years is recommended for people with chronic heartburn, or who
take drugs for chronic GERD.

**CAUSES**

GERD is caused by a failure of the lower esophageal sphincter.
In healthy patients, the “Angle of His” — the angle at which the
esophagus enters the stomach — creates a valve that prevents
duodenal bile, enzymes, and stomach acid from traveling back
into the esophagus where they can cause burning and inflammation
of sensitive esophageal tissue.

Factors that can contribute to GERD:

- Hiatal hernia, which increases the likelihood of GERD due
to mechanical and motility factors.
- Obesity: increasing body mass index is associated with
more severe GERD. In a large series of 2,000 patients with
symptomatic reflux disease, it has been shown that 13%
of changes in esophageal acid exposure is attributable to
changes in body mass index.
Gastroesophageal Reflux Disease (GERD)

- Zollinger-Ellison syndrome, which can be present with increased gastric acidity due to gastrin production.
- A high blood calcium level, which can increase gastrin production, leading to increased acidity.
- Scleroderma and systemic sclerosis, which can feature esophageal dysmotility.
- The use of medicines such as prednisolone.
- Visceroptosis or Glénard syndrome, in which the stomach has sunk in the abdomen upsetting the motility and acid secretion of the stomach.

GERD has been linked to a variety of respiratory and laryngeal complaints such as laryngitis, chronic cough, pulmonary fibrosis, earache, and asthma, even when not clinically apparent. These atypical manifestations of GERD are commonly referred to as laryngopharyngeal reflux (LPR) or as extraesophageal reflux disease (EERD).

Factors that have been linked with GERD, but not conclusively:
- Obstructive sleep apnea
- Gallstones, which can impede the flow of bile into the duodenum, which can affect the ability to neutralize gastric acid

In 1999, a review of existing studies found that, on average, 40% of GERD patients also had *H. pylori* infection. The eradication of *H. pylori* can lead to an increase in acid secretion, leading to the question of whether *H. pylori*-infected GERD patients are any different than non-infected GERD patients. A double-blind study, reported in 2004, found no clinically significant difference between these two types of patients with regard to the subjective or objective measures of disease severity.

**DIAGNOSIS**

The diagnosis of GERD is usually made when typical symptoms are present. Reflux can be present in people without symptoms and the diagnosis requires both symptoms or complications and
reflux of stomach content. Other investigations may include esophagogastroduodenoscopy (EGD). Barium swallow X-rays should not be used for diagnosis. Esophageal manometry is not recommended for use in diagnosis being recommended only prior to surgery. Ambulatory esophageal pH monitoring may be useful in those who do not improve after PPIs and is not needed in those in whom Barrett’s esophagus is seen. Investigation for H. pylori is not usually needed.

The current gold standard for diagnosis of GERD is esophageal pH monitoring. It is the most objective test to diagnose the reflux disease and allows monitoring GERD patients in their response to medical or surgical treatment. One practice for diagnosis of GERD is a short-term treatment with proton-pump inhibitors, with improvement in symptoms suggesting a positive diagnosis. Short-term treatment with proton-pump inhibitors may help predict abnormal 24-hr pH monitoring results among patients with symptoms suggestive of GERD.

**Endoscopy**

Endoscopy, the looking down into the stomach with a fibre-optic scope, is not routinely needed if the case is typical and responds to treatment. It is recommended when people either do not respond well to treatment or have alarm symptoms, including dysphagia, anemia, blood in the stool (detected chemically), wheezing, weight loss, or voice changes. Some physicians advocate either once-in-a-lifetime or 5- to 10-yearly endoscopy for people with longstanding GERD, to evaluate the possible presence of dysplasia or Barrett’s esophagus.

Biopsies performed during gastroscopy may show:

- Edema and basal hyperplasia (nonspecific inflammatory changes)
- Lymphocytic inflammation (nonspecific)
- Neutrophilic inflammation (usually due to reflux or *Helicobacter gastritis*).
• Eosinophilic inflammation (usually due to reflux): The presence of intraepithelial eosinophils may suggest a diagnosis of eosinophilic esophagitis (EE) if eosinophils are present in high enough numbers. Less than 20 eosinophils per high-power microscopic field in the distal esophagus, in the presence of other histologic features of GERD, is more consistent with GERD than EE.
• Goblet cell intestinal metaplasia or Barrett’s esophagus
• Elongation of the papillae
• Thinning of the squamous cell layer
• Dysplasia
• Carcinoma

Reflux changes may not be erosive in nature, leading to “nonerosive reflux disease”.

Severity

Severity may be documented with the Johnson-DeMeester’s scoring system: 0 - None 1 - Minimal -occasional episodes 2 - Moderate - medical therapy visits 3 - Severe - interfere with daily activities

Differential diagnosis

Other causes of chest pain such as heart disease should be ruled out before making the diagnosis. Another kind of acid reflux, which causes respiratory and laryngeal signs and symptoms, is called laryngopharyngeal reflux (LPR) or “extraesophageal reflux disease” (EERD).

Unlike GERD, LPR rarely produces heartburn, and is sometimes called silent reflux.

TREATMENT

The treatments for GERD include lifestyle modifications, medications, and possibly surgery. Initial treatment is frequently with a proton-pump inhibitor such as omeprazole.
Lifestyle

Certain foods and lifestyle are considered to promote gastroesophageal reflux, but most dietary interventions have little supporting evidence. Avoidance of specific foods and of eating before lying down should be recommended only to those in which they are associated with the symptoms. Foods that have been implicated include coffee, alcohol, chocolate, fatty foods, acidic foods, and spicy foods. Weight loss and elevating the head of the bed are generally useful. Moderate exercise improves symptoms; however in those with GERD vigorous exercise may worsen them. Stopping smoking and not drinking alcohol do not appear to result in significant improvement in symptoms.

Medications

The primary medications used for GERD are proton-pump inhibitors, H₂ receptor blockers and antacids with or without alginic acid. Proton-pump inhibitors (PPIs), such as omeprazole, are the most effective, followed by H₂ receptor blockers, such as ranitidine. If a once daily PPI is only partially effective they may be used twice a day.

They should be taken one half to one hour before a meal. There is no significant difference between agents in this class. When these medications are used long term, the lowest effective dose should be taken. They may also be taken only when symptoms occur in those with frequent problems. H₂ receptor blockers lead to roughly a 40% improvement.

The evidence for antacids is weaker with a benefit of about 10% (NNT=13) while a combination of an antacid and alginic acid (such as Gaviscon) may improve symptoms 60% (NNT=4). Metoclopramide (a prokinetic) is not recommended either alone or in combination with other treatments due to concerns around adverse effects. The benefit of the prokinetic mosapride is modest.

Sucralfate has a similar effectiveness to H₂ receptor blockers; however, sucralfate needs to be taken multiple times a day, thus
limiting its use. Baclofen, an agonist of the GABA<sub>9</sub> receptor, while effective, has similar issues of needing frequent dosing in addition to greater adverse effects compared to other medications.

**Surgery**

The standard surgical treatment for severe GERD is the Nissen fundoplication. In this procedure, the upper part of the stomach is wrapped around the lower esophageal sphincter to strengthen the sphincter and prevent acid reflux and to repair a hiatal hernia. It is recommended only for those who do not improve with PPIs. Benefits are equal to medical treatment in those with chronic symptoms. In addition, in the short and medium term, laparoscopic fundoplication improves quality of life compared to medical management. When comparing different fundoplication techniques, partial posterior fundoplication surgery is more effective than partial anterior fundoplication surgery.

In 2012 the FDA approved a device called the LINX, which consists of a series of metal beads with magnetic cores that are placed surgically around the lower esophageal sphincter, for those with severe symptoms that do not respond to other treatments. Improvement of GERD symptoms is similar to those of the Nissen fundoplication, although there is no data regarding long-term effects. Compared to Nissen fundoplication procedures, the procedure has shown a reduction in complications such as gas bloat syndrome that commonly occur. Adverse responses include difficulty swallowing, chest pain, vomiting, and nausea. Contraindications that would advise against use of the device are patients who are or may be allergic to titanium, stainless steel, nickel, or ferrous iron materials. A warning advises that the device should not be used by patients who could be exposed to, or undergo, magnetic resonance imaging (MRI) because of serious injury to the patient and damage to the device.

In those with symptoms that do not improve with PPIs surgery known as transoral incisionless fundoplication may help. Benefits may last for up to six years.
Pregnancy

In pregnancy, dietary modifications and lifestyle changes may be attempted, but often have little effect. Calcium-based antacids are recommended if these changes are not effective. Aluminum- and magnesium-based antacids are also safe, as is ranitidine and PPIs.

Infants

Infants may see relief with changes in feeding techniques, such as smaller, more frequent feedings, changes in position during feedings, or more frequent burping during feedings. They may also be treated with medicines such as ranitidine or proton pump inhibitors. Proton pump inhibitors however have not been found to be effective in this population and there is a lack of evidence for safety.

Overtreatment

The use of acid suppression therapy is a common response to GERD symptoms and many patients get more of this kind of treatment than their individual case merits. The overuse of this treatment is a problem because of the side effects and costs which the patient will have from undergoing unnecessary therapy, and patients should not take more treatment than they need.

In some cases, a person with GERD symptoms can manage them by taking over-the-counter drugs and making lifestyle changes. This is often safer and less expensive than taking prescription drugs. Some guidelines recommend trying to treat symptoms with an H₂ antagonist before using a proton-pump inhibitor because of cost and safety concerns.

EPIDEMIOLOGY

In Western populations, GERD affects approximately 10% to 20% of the population and 0.4% newly develop the condition. For instance, an estimated 3.4 million to 6.8 million Canadians are GERD sufferers. The prevalence rate of GERD in developed nations
is also tightly linked with age, with adults aged 60 to 70 being the most commonly affected. In the United States 20% of people have symptoms in a given week and 7% every day. No data support sex predominance with regard to GERD.

**History**

An obsolete treatment is vagotomy (“highly selective vagotomy”), the surgical removal of vagus nerve branches that innervate the stomach lining. This treatment has been largely replaced by medication.

**Research**

A number of endoscopic devices have been tested to treat chronic heartburn.

- **Endocinch**, puts stitches in the lower esophageal sphincter (LES) to create small pleats to help strengthen the muscle. However, long-term results were disappointing, and the device is no longer sold by Bard.

- **Stretta procedure**, uses electrodes to apply radio-frequency energy to the LES. A 2015 systematic review and meta-analysis in response to the systematic review (no meta-analysis) conducted by SAGES did not support the claims that Stretta was an effective treatment for GERD. A 2012 systematic review found that it improves GERD symptoms.

- **NDO Surgical Plicator** creates a plication, or fold, of tissue near the gastroesophageal junction, and fixates the plication with a suture-based implant. The company ceased operations in mid-2008, and the device is no longer on the market.

Transoral incisionless fundoplication, which uses a device called Esophyx, may be effective.

**CONDITION OF GASTROESOPHAGEAL REFLUX DISEASE**

Gastroesophageal reflux illness (GERD) is a condition in which
the stomach substance spill in reverse from the stomach into the throat (the tube from the mouth to the stomach). This can chafe the throat and cause acid reflux and different indications.

CAUSES

When you eat, sustenance goes from the throat to the stomach through the throat. A ring of muscle filaments in the lower throat keeps gobbled sustenance from moving go down. These muscle filaments are known as the lower esophageal sphincter (LES).

When this ring of muscle does not close the distance, stomach substance can spill once more into the throat. This is called reflux or gastroesophageal reflux. Reflux may bring about manifestations. Cruel stomach acids can likewise harm the covering of the throat.

The danger elements for reflux include:

- Use of liquor (perhaps)
- Hiatal hernia (a condition in which part of the stomach moves over the stomach, which is the muscle that isolates the mid-section and stomach depressions)
Acid reflux and gastroesophageal reflux can be brought on or aggravated by pregnancy. Indications can likewise be brought on by specific prescriptions, for example,

- Anticholinergics (for instance, nausea solution)
- Beta-blockers for hypertension or coronary illness
- Bronchodilators for asthma
- Calcium channel blockers for hypertension
- Dopamine-dynamic medications for Parkinson ailment
- Progestin for strange menstrual draining or anti-conception medication
- Sedatives for sleep deprivation or nervousness
- Tricyclic antidepressants

Converse with your social insurance supplier on the off chance that you think 1 about your drugs might bring about indigestion. Never show signs of change or quit taking a medication without first conversing with your supplier.

**SYMPTOMS**

Common symptoms of GERD include:

- Feeling that food is stuck behind the breastbone
- Heartburn or a burning pain in the chest
- Nausea after eating

Less common symptoms are:

- Bringing food back up (regurgitation)
- Cough or wheezing
- Difficulty swallowing
- Hiccups
- Hoarseness or change in voice
• Sore throat

Symptoms may get worse when you bend over or lie down, or after you eat. Symptoms may also be worse at night.

Exams and Tests

You may not need any tests if your symptoms are mild.

If your symptoms are severe or they come back after you have been treated, your doctor may perform a test called an upper endoscopy (EGD).

• This is a test to examine the lining of the esophagus (the tube that connects your throat to your stomach), stomach, and first part of the small intestine.
• It is done with a small camera (flexible endoscope) that is inserted down the throat.

You may also need 1 or more of the following tests:

• A test that measures how often stomach acid enters the tube that leads from the mouth to the stomach (called the esophagus)
• A test to measure the pressure inside the lower part of the esophagus (esophageal manometry)

A positive stool occult blood test may diagnose bleeding that is coming from the irritation in the esophagus, stomach, or intestines.

Treatment

You can make many lifestyle changes to help treat your symptoms.

Other tips include:

• If you are overweight or obese, in many cases, losing weight can help.
• Avoid drugs such as aspirin, ibuprofen (Advil, Motrin), or naproxen (Aleve, Naprosyn). Take acetaminophen (Tylenol) to relieve pain.
• Take all of your medicines with plenty of water. When your doctor gives you a new medicine, ask whether it will make your heartburn worse.

You may use over-the-counter antacids after meals and at bedtime, although the relief may not last very long. Common side effects of antacids include diarrhea or constipation.

Other over-the-counter and prescription drugs can treat GERD. They work more slowly than antacids, but give you longer relief. Your pharmacist, doctor, or nurse can tell you how to take these drugs.

• Proton pump inhibitors (PPIs) decrease the amount of acid produced in your stomach
• H2 blockers also lower the amount of acid released in the stomach

Anti-reflux surgery may be an option for people whose symptoms do not go away with lifestyle changes and medicines. Heartburn and other symptoms should improve after surgery. But you may still need to take drugs for your heartburn. There are also new therapies for reflux that can be performed through an endoscope (a flexible tube passed through the mouth into the stomach).

**Outlook (Prognosis)**

Most people respond to lifestyle changes and medicines. However, many people need to continue taking medicines to control their symptoms.

**Possible Complications**

Complications may include:

• Worsening of asthma
• A change in the lining of the esophagus that can increase the risk of cancer (Barrett esophagus)
• Bronchospasm (irritation and spasm of the airways due to acid)
• Chronic cough or hoarseness
• Dental problems
• Ulcer in the esophagus
• Stricture (a narrowing of the esophagus due to scarring)

When to Contact a Medical Professional

Call your health care provider if symptoms do not improve with lifestyle changes or medicine.

Also call if you have:
• Bleeding
• Choking (coughing, shortness of breath)
• Feeling filled up quickly when eating
• Frequent vomiting
• Hoarseness
• Loss of appetite
• Trouble swallowing (dysphagia) or pain with swallowing (odynophagia)
• Weight loss
Gallbladder: Problems and Symptoms

GALLBLADDER

Your gallbladder is a 4-inch, pear-shaped organ. It’s positioned under your liver in the upper right section of your abdomen. The gallbladder stores bile, a combination of fluids, fat, and cholesterol. Bile helps break down fat from food in your intestine. The gallbladder delivers bile into the small intestine. This allows fat-soluble vitamins and nutrients to be more easily absorbed into the bloodstream.

Potential Gallbladder Problems

Any disease that affects your gallbladder is considered a gallbladder disease. The following conditions are all gallbladder diseases:

Inflammation

Inflammation of the gallbladder is called cholecystitis. Cholecystitis can be either chronic (long-term) or acute (short-term). Chronic inflammation is the result of several acute cholecystitis attacks. Inflammation may eventually damage the gallbladder, making it lose its ability to function correctly.
Gallstones

Gallstones are small, hardened deposits that form in the gallbladder. These deposits can develop and go undetected for years. In fact, many people have gallstones and aren’t aware of them. They eventually cause problems, including inflammation, infection, and pain. Gallstones typically cause short-term cholecystitis.

Gallstones are usually very small, no more than a few millimeters wide. But they can grow to several centimeters. Some people develop only one gallstone, while others develop several. As the gallstones grow in size, they can begin to block the channels that lead out of the gallbladder.

Most gallstones are formed from cholesterol found in the gallbladder’s bile. Another type of gallstone, a pigment stone, is formed from calcium bilirubinate. Calcium bilirubinate is a chemical that’s produced when your body breaks down red blood cells. This type of stone is more rare.

COMMON BILE DUCT STONES
(CHOLEDOLITHIASIS)

Gallstones can occur in the common bile duct. The common bile duct is the channel that leads from the gallbladder to the small intestine. Bile is ejected from the gallbladder, passed through small tubes, and deposited in the common bile duct. It’s then ushered into the small intestine.

In most cases, common bile duct stones are actually gallstones that developed in the gallbladder and then passed into the bile duct. This type of stone is called a secondary common bile duct stone, or secondary stone.

Sometimes stones form in the common bile duct itself. These stones are called primary common bile duct stones, or primary stones. This rare type of stone is more likely to cause an infection than a secondary stone.
Gallbladder Disease Without Stones

Gallstones don’t cause every type of gallbladder problem. Gallbladder disease without stones, also called acalculous gallbladder disease, can occur. In this case, you may experience symptoms commonly associated with gallstones without actually having stones.

Common Bile Duct Infection

An infection may develop if the common bile duct is obstructed. Treatment for this condition is successful if it’s found early. If it’s not, the infection may spread and become fatal.

Abscess of the Gallbladder

A small percentage of patients with gallstones may also develop pus in the gallbladder.

This condition is called empyema. Pus is a combination of white blood cells, bacteria, and dead tissue. The development of pus leads to severe abdominal pain. If the condition isn’t diagnosed and treated, it can become life-threatening as the infection spreads to other parts of the body.

Gallstone Ileus

A gallstone may travel into the intestine and block it. This condition is rare but can be fatal. It’s most common among individuals over age 65.

Perforated Gallbladder

If you wait too long to seek treatment, gallstones can lead to a perforated gallbladder. This is a life-threatening condition. If the tear isn’t detected, a dangerous widespread abdominal infection may develop.

Gallbladder Polyps

Polyps are growths that develop. These growths are typically benign, or noncancerous. Small gallbladder polyps may not need to be removed. In most cases, they don’t pose any risk to you or
your gallbladder. But larger polyps may need to be surgically removed before they develop into cancer or cause problems.

Porcelain Gallbladders

A healthy gallbladder has very muscular walls. Over time, calcium deposits can stiffen gallbladder walls, making them very rigid. This condition is called porcelain gallbladder. Those with this condition have a very high risk of developing gallbladder cancer.

Gallbladder Cancer

Gallbladder cancer is very rare. However, it can spread beyond the gallbladder quickly if it’s not detected and treated.

SYMPTOMS OF A GALLBLADDER PROBLEM

These gallbladder conditions share similar symptoms. These include:

- Pain: The most common symptom of a gallbladder problem is pain. This pain usually occurs in the mid- to upper-right section of your abdomen. It can be mild and intermittent, or it can be quite severe and frequent. In some cases, the pain will begin to radiate to other areas of the body, including the back and chest.
- Nausea or Vomiting: Nausea and vomiting are common symptoms among all types of gallbladder problems. But only chronic gallbladder disease may cause digestive problems, such as acid reflux, gas, nausea, and vomiting.
- Fever or Chills: An unexplained fever may signal that you have an infection. If you have an infection, you need treatment before it worsens and becomes dangerous. The infection can become life-threatening if it’s allowed to spread to other parts of the body.
- Chronic Diarrhea: Having more than four bowel movements a day for at least three months may be a sign of chronic gallbladder disease.
• Jaundice. Yellow-tinted skin may be a sign of a common bile duct block or stone.
• Unusual Stools or Urine: Lighter-colored stools and dark urine are possible signs of a common bile duct block.

UNDERSTANDING GALLBLADDER PROBLEMS

Symptoms of a gallbladder problem may come and go. However, you’re more likely to develop a gallbladder problem if you’ve previously had one. While gallbladder problems are rarely deadly, they should still be treated. You can prevent gallbladder problems from worsening if you take action and see a doctor.

WHAT IS THE GALLBLADDER?

Life Without a Gallbladder

To treat certain gallbladder problems, sometimes the gallbladder must be surgically removed. But not to worry — the gallbladder is one organ your body can do without. People who undergo surgical removal of the gallbladder rarely have any problems with biliary system function after surgery, says Rogula.

The body can cope with losing its extra storage space for bile by filling the bile ducts — which transport bile from the liver to the small intestine — and using them to store the excess bile. Sometimes, as a result of this surgery, Rogula notes that the bile ducts may become slightly distended, but this generally isn’t a big concern.

Gallbladder Disorders

By far the most common gallbladder problem is gallstones — tiny stones that form from hardened bile and cholesterol. Gallstones can block the release of bile from the gallbladder and cause:
• Severe pain, particularly after eating fatty or greasy foods
• Jaundice (yellowing of the skin and eyes)
• Inflammation and irritation of the gallbladder walls
Other gallbladder problems may also occur, but these are extremely rare:

- Gallbladder cancer
- Perforation (tearing or rupture) of the gallbladder
- Gangrene, if adequate blood flow to the gallbladder is blocked
- Pancreatitis, caused by gallstones migrating out of the gallbladder and then blocking the pancreatic ducts
- Bowel obstruction, caused by a gallstone passing into the intestine and then blocking the intestines

Gallbladder problems like gallstones may never cause any pain at all, but that doesn’t mean that they will resolve themselves. If you experience pain in your upper right abdomen — particularly after eating very fatty, heavy, or greasy foods — think about your gallbladder first.

**WHAT ARE GALLSTONES?**

Gallstones can cause severe abdominal pain — or, you may have no symptoms at all. Having gallstones, also called cholelithiasis, is a very common problem. It’s most common among women, people older than age 40, and Native Americans. The gallbladder is a sac that stores a substance called bile, which is produced by the liver. After meals, the gallbladder contracts and releases bile into the intestines to aid in digestion. Gallstones occur when one of the substances that make up the bile (usually a waste product called bilirubin, or cholesterol) becomes too concentrated and forms a hard stone. Often gallstones just sit in the gallbladder and don’t cause problems. But sometimes they block the exit from the gallbladder, called the cystic duct. When this occurs, the gallbladder goes into spasms and becomes inflamed, a condition called cholecystitis.

An episode of cholecystitis may resolve on its own, or it may progress to a more serious condition involving bacterial infection of the inflamed gallbladder.
Causes of Gallstones

Many different factors can cause gallstones. Some possible causes include:

- Excess bilirubin in the bile
- Excess cholesterol in the bile
- A non-stone-related blockage in the gallbladder that prevents proper emptying
- Low bile concentration of a substance called bile salts

Risk Factors

The risk factors for gallstones include:

- A family history of gallstones
- Taking medications to lower cholesterol levels
- Having diabetes
- A rapid, large loss of weight
- Taking birth control pills or hormone replacement therapy
- Being pregnant
- Being overweight
- Eating a diet rich in fat and cholesterol and without enough fiber

Gallstone Symptoms

It’s not uncommon for gallstones to cause no symptoms at all, and to be diagnosed during screening and testing for some other health problem.

But, in many people, gallstones can cause the symptoms of cholecystitis, including:

- Abdominal pain in the right upper part of the abdomen
- Back pain, particularly located between your shoulder blades
- Pain beneath the right shoulder blade
- Pain in those areas which comes on quickly, worsens, and persists for at least 30 minutes, and may even last for a few hours
• Fever with chills
• Vomiting and nausea
• Jaundice (yellowing of the skin and whites of the eyes)
• Stools the color of clay
• Pain that strikes after eating a fatty meal
• Indigestion, bloating, and gas

If you have any of these symptoms, it’s possible that gallstones may be to blame, so it’s important to head to your doctor for an exam and to get started on treatment.

Gallstones may also rarely be an indication of gallbladder cancer, so it’s best to get the problem correctly diagnosed right away.

Diagnosis

If gallstones are suspected, your doctor may order an imaging test. This might include an ultrasound, which uses sound waves to visualize the area. Another frequently used test is an oral cholecystogram (OCG), which uses X-rays to show the gallbladder after the patient swallows pills containing a dye. Another procedure, called a HIDA scan, involves injection of a small amount of a harmless radioactive substance. Sometimes gallstones show up as an incidental finding on other tests, such as a CT scan.

Gallstone Treatment

There are a number of options for treating gallstones, depending on symptoms and how severe they are.

Possible treatment methods for gallstones include:

Surgery: The gallbladder is often surgically removed, but generally only if you experience severe symptoms.

Significant advancements have been made with cholecystectomy, or gallbladder removal surgery. It’s now a less invasive procedure using laparoscopic technology.

Tiny incisions are made, recovery is quick, and you may not even have to spend the night in the hospital following surgery.
Dietary changes: Your doctor may recommend that you switch to a healthier, low-fat diet to help relieve your gallstone symptoms.

Medication: A few types of medications, including bile salts, work to slowly break down small gallstones to reduce pain and symptoms.

Not everyone is a good candidate for this type of gallstone therapy, however.

Lithotripsy: Forceful sound waves are aimed directly at the gallstones to break them into tiny fragments, usually followed by medications to dissolve these pieces.

Painkillers: These may be recommended to control pain during an acute attack of cholecystitis.

As for new treatment techniques, one experimental gallstone treatment involves injecting the gallbladder with a medication that dissolves the gallstones in a matter of days. But there are side effects. This therapy is being tested in patients whose gallstones are small.

SYMPTOMS OF GALLBLADDER PROBLEMS

The gallbladder is a little sac that stores bile from the liver, and it's found just beneath your liver.

The gallbladder releases bile, via the cystic duct, into the small intestine to help break down the foods you eat — particularly fatty foods. Typically the gallbladder doesn't cause too many problems or much concern, but if something slows or blocks the flow of bile from the gallbladder, a number of problems can result.

What Can Go Wrong

Some common gallbladder problems include:

Gallstones (cholelithiasis): This is the name of the condition when small stones, or sometimes larger ones, develop inside the gallbladder. Gallstones may cause pain known as biliary colic, but about 90 percent of people with gallstones will have no symptoms.
Most symptomatic gallstones have been present for a number of years. For unknown reasons, if you have gallstones for more than 10 years, they are less likely to cause symptoms.

Biliary colic: This is the term often used for the severe episodes of pain that can be caused by gallstone blockage of the cystic duct. The gallbladder contracts vigorously against the blockage, causing spasmodic (or sometimes constant) severe pain.

Biliary colic episodes usually last only an hour or two. They may recur infrequently, often years apart. Inflamed gallbladder (cholecystitis): Inflammation of the gallbladder can be caused by gallstones, excessive alcohol use, infections, or even tumors that cause bile buildup. But the most common cause of cholecystitis is gallstones. The body can react to the gallstone irritation by causing the gallbladder walls to become swollen and painful.

The episodes of inflammation can last for several hours, or even a few days. Fever is not unusual. About 20 percent of the time, the sluggish, inflamed gallbladder is invaded by intestinal bacteria, and becomes infected. Occasionally, the gallbladder actually ruptures, which is a surgical emergency.

Suspected episodes of cholecystitis always require medical attention, particularly if fever is present.

Dysfunctional gallbladder or chronic gallbladder disease: Here, the gallbladder may become rigid and scarred from gallstones and repeated episodes of inflammation. Symptoms are more constant, but tend to be vague, including abdominal fullness, indigestion, and increased gas. Chronic diarrhea is a common symptom, usually occurring after meals, and up to 10 times per day.

**Common Gallbladder Symptoms**

Specific symptoms may vary based on what type of gallbladder condition you have, although many symptoms are common among the different types of gallbladder problems. But most gallbladder symptoms start with pain in the upper abdominal area, either in the upper right or middle.
Below are common symptoms of gallbladder conditions:

- Severe abdominal pain
- Pain that may extend beneath the right shoulder blade or to the back
- Pain that worsens after eating a meal, particularly fatty or greasy foods
- Pain that feels dull, sharp, or crampy
- Pain that increases when you breathe in deeply
- Chest pain (angina)
- Heartburn, indigestion, and excessive gas
- A feeling of fullness in the abdomen
- Vomiting, nausea, fever
- Shaking with chills
- Tenderness in the abdomen, particularly the right upper quadrant
- Jaundice (yellowing of the skin and eyes)
- Stools of an unusual color (often lighter, like clay)

Some gallbladder problems, like simple gallstones that are not blocking the cystic duct, often cause no symptoms at all. They’re most often discovered during an X-ray or CT scan that’s performed to diagnose a different condition, or even during an abdominal surgery.

If you spot any symptoms of gallbladder trouble, head to your doctor for a diagnosis and prompt treatment to get your digestive tract running smoothly again.

**CHOLECYSTITIS**

Cholecystitis is a big word for the simple — but potentially painful — problem of gallbladder inflammation. The gallbladder holds bile from the liver, and releases it into the small intestine.

When a gallstone forms, it can wedge itself in the duct that releases bile — causing bile buildup and a painful condition called cholecystitis. Cholecystitis, or gallbladder inflammation, occurs
when bile can’t circulate out of the liver as it normally does. When bile builds up, it causes the gallbladder to thicken, harden, swell, and become irritated. The abdomen becomes painful, and infection can occur if bile can’t flow properly.

**Symptoms of Cholecystitis**

The most common symptoms of cholecystitis are:

- Fever
- Severe and sudden pain in the upper right portion of the abdomen
- Pain that persists for more than six hours
- Pain after eating a meal
- Nausea
- Vomiting
- Bloating
- Soreness in the right part of the abdomen

Although it’s easy to mistake the symptoms of cholecystitis for some other simple problem, it’s important to get a proper medical diagnosis.

Untreated cholecystitis can lead to complications, so don’t brush off these symptoms as just a little indigestion or a stomach bug.

Cholecystitis can be chronic — persistent and long-lasting swelling and damage to the gallbladder — or acute, a sudden “attack” that causes swelling and irritation of the gallbladder. Persistent acute attacks of cholecystitis can lead to chronic cholecystitis.

**Causes of Cholecystitis**

Some of the most common causes of cholecystitis include:

- Gallstones becoming lodged in the duct of the gallbladder, preventing bile from emptying
- Complications from some other health condition like diabetes or HIV
• Persistent cholecystitis attacks and consistent swelling
• Gallbladder sludge — a thick substance that pollutes the gallbladder and can’t be absorbed. Pregnant women and people who have lost a lot of weight in a short period of time can experience this.
• A tumor in the liver or pancreas
• Reduced blood flow to the gallbladder
• Bacterial infection that strikes the bile duct system, which empties bile from the gallbladder

Treatment of Cholecystitis

Cholecystitis can be easily diagnosed with an exam, medical history, ultrasounds, X-rays, and some imaging tests to detect gallbladder inflammation.

Once diagnosed, cholecystitis can be treated with:
• Cholecystectomy, the surgical removal of the gallbladder—the most common treatment
• Switching to a low-fat diet
• Medications to manage pain
• Medications to dissolve the gallstones
• Medications to keep gallstones from forming

People with mild cholecystitis may just have to adjust their diet, take antibiotics, and drink plenty of fluids to allow the inflammation to subside.

More serious cases of cholecystitis require more involved methods. Treatment generally requires a stay in the hospital, as well as antibiotics to manage inflammation and infection in the gallbladder.

Treatment is necessary to prevent complications of cholecystitis, such as jaundice, pancreatitis (inflammation of the pancreas), gallbladder cancer, or gallbladder inflammation that just gets worse. Which treatment is right for you will depend on your symptoms, your age, how well you can tolerate the treatment, and your general health.
If you have symptoms, you should see a doctor about a diagnosis and figure out the right treatment plan to tackle cholecystitis.

**GALLBLADDER CANCER**

Gallbladder cancer doesn’t strike often, but when it does, it’s often diagnosed at a late stage.

Gallbladder cancer is rare, with fewer than 5,000 new diagnoses each year in the United States.

Of those, fewer than 1,700 people will die from the disease.

Gallbladder cancer is the most common type of cancer found in the bile tract, and is more common in women and people older than age 60.

**Risk Factors**

Though gallbladder cancer doesn’t affect a huge number of Americans each year, it’s still a concern. Most of the time, it’s diagnosed at a late stage — making treatment difficult. Only about one in three cases of gallbladder cancer is diagnosed early, before the cancer spreads beyond the gallbladder.

Some of the most common risk factors for gallbladder cancer are:

- Gallstones
- Gallbladder polyps
- Being overweight or obese
- Being of Native American descent
- Being older than age 65
- Being female
- A condition called porcelain gallbladder, in which the gallbladder wall hardens with deposits of calcium
- Having had typhoid (very rare in the United States)
- Choledochal cysts — sacs of bile that form on the common bile duct
• An abnormality of the bile ducts
• A family history of gallbladder cancer

Gallstones are the biggest indicator of a person’s likelihood of developing gallbladder cancer, but the relationship can be tricky to understand. About three out of four people who have gallbladder cancer also have gallstones at diagnosis.

But gallstones happen very frequently — and gallbladder cancer is very rare. So although people with gallbladder cancer are more likely to also have gallstones, only a very small percentage of people with gallstones will develop gallbladder cancer.

**Gallbladder Adenocarcinomas**

There are a few types of gallbladder cancer, but the most common are adenocarcinomas — 9 out of 10 cases of gallbladder cancer are adenocarcinomas. Adenocarcinoma gallbladder cancer begins in gland-like cells that are found in the digestive tract’s lining, including the gallbladder. There’s a subtype of gallbladder adenocarcinoma called papillary adenocarcinoma, also called papillary cancer. Papillary adenocarcinomas make up about 6 percent of all types of gallbladder cancer.

This type of gallbladder cancer can be distinguished under a microscope, as the cancer cells growth looks like fingers. The prognosis for papillary adenocarcinoma is often better than other gallbladder cancer types, as it is less likely to affect lymph nodes and the liver.

**Gallbladder Carcinomas**

Other types of gallbladder cancers are even rarer than the adenocarcinomas:

• **Squamous cell carcinomas**: These cancers initially form in the squamous cells — flat, skin-like cells that line parts of the digestive tract.

• **Adenosquamous carcinomas**: This type of gallbladder cancer is made up of two different kinds of cells, squamous cells and the glandular cells found in adenocarcinomas.
• Small-cell carcinomas: Also called oat cell carcinoma, this type of gallbladder cancer is a very dangerous cancer whose cells are round or oat-shaped.

• Neuroendocrine gallbladder tumors: These types of gallbladder cancer tumors grow from tissues that produce hormones. The most common form is the carcinoid tumor.

• Sarcoma gallbladder cancer: Sarcomas are a type of cancer arising from the connective tissues in the body. Connective tissues support and protect the body, and include nerves, muscles, and blood vessels. In the gallbladder, sarcomas form in the muscular tissue of the gallbladder.

• Gallbladder lymphoma: This is an extremely rare type of gallbladder cancer. Treatment is often different than for other types of gallbladder cancer, and often may be treated with chemotherapy and radiation therapy instead of surgery.

Though all types of gallbladder cancer are rare, it’s important to understand the risk factors for gallbladder cancer and what types may strike. The earlier gallbladder cancer can be diagnosed, the better the prognosis may be.

GALLBLADDER SURGERY

Doctors use several different surgical procedures to help treat your gallbladder disease. If you’re having gallbladder symptoms caused by gallstones or other conditions, your doctor may recommend a surgical procedure as part of your treatment. But there’s no such thing as a one-size-fits-all gallbladder surgery. Here are some gallbladder surgery options that your doctor might discuss with you.

Cholecystectomy

This is the medical term for a surgery to completely remove the gallbladder. Remarkably, your body doesn’t need a gallbladder to digest food. In the United States, cholecystectomy is a very common operation.
If possible, most surgeons will opt for the laparoscopic form of this gallbladder surgery, in which the gallbladder is removed through a small incision in the abdomen. “It’s a ‘Band-Aid’ surgery, and the recovery is much easier,” says Harold Berenzweig, MD, a gastroenterologist at Texas Health Harris Methodist in Fort Worth, Texas. Some patients can go home the same day, Berenzweig adds. Others may spend one night in the hospital. However, if the surgeon cannot reach your gallbladder laparoscopically, or other complications occur, your surgeon may opt for an open cholecystectomy, which involves making an incision on the upper right side of your abdomen to remove the gallbladder.

This type of gallbladder surgery is necessary in about 5 percent of cases. In laparoscopic surgery, four tiny incisions are made in the abdominal wall, just big enough for the surgeon’s laparoscope and small instruments (the gallbladder is also pulled out through one of these incisions).

In an open cholecystectomy, a large (six inches across) incision is made in the right upper quadrant of the abdomen. This larger incision cuts through muscles, which results in more pain and discomfort. Healing time is usually longer for the open cholecystectomy because of the larger incision made.

**Endoscopic Retrograde Cholangiopancreatography (ERCP)**

This procedure, generally called ERCP, is used when one or more gallstones have migrated out of the gallbladder and into the common bile duct, which carries bile to the small intestine to aid in digestion. During ERCP, an endoscope — a long tube with a camera in it — is guided down your throat into the stomach and then into the common bile duct.

If gallstones are present, an instrument can be inserted into the endoscope to remove them. Patients are generally awake during an ERCP, but are given a sedative to help them relax.

ERCP is usually performed in conjunction with gallbladder removal. “You can’t take out the stones and leave the gallbladder, because you’re going to form more stones,” Berenzweig says.
Gallbladder Draining (Cholecystostomy)

During this minimally invasive procedure, also known as a cholecystostomy, the doctor will insert a needle through the abdomen to drain the gallbladder of bile and decompress it. This is usually performed on patients with severe gallbladder problems as well as other medical conditions who might not be able to withstand surgery to remove the gallbladder.

With cholecystostomy, “you’re still left with a gallbladder full of gallstones,” Berenzweig says. “It’s not done very commonly at all anymore.” After a cholecystostomy, some patients improve and are later able to have their gallbladders removed.

A Non-Surgical Option

The gallbladder can also be treated with non-surgical techniques like lithotripsy, which uses high-energy sound waves to break gallstones into tiny pieces so they can drain out of the gallbladder. Although it is most commonly used to treat kidney stones, it can also be used on gallstones.

However, it’s unlikely that your surgeon will recommend lithotripsy for gallstones. “I don’t know of anyone who’s had that done lately,” Berenzweig says.

GALLBLADDER DISEASE

The gallbladder is a sac situated under the liver. It stores and amasses bile delivered in the liver. Bile helps in the absorption of fats, and is discharged from the gallbladder into the upper small digestive tract (duodenum) in light of sustenance, particularly fats.

Sorts of gallbladder illness include:
- Cholecystitis (irritation of the gallbladder)
- Cholelithiasis (gallstones)

You can have gallstones with no indications. Notwithstanding, if the stones are huge, they can obstruct the channel that leads from the gallbladder. This can bring about agony and require
treatment. At first they may obstruct the conduit and move away, bringing about just intermittent agony. Nonstop blockage of the conduit, in any case, can be life undermining and requires surgical evacuation of the gallbladder.

**Signs and Symptoms**

- Pain, generally on the upper right half of the midriff
- Pain taking after suppers, prejudice of greasy sustenances
- Nausea and retching
- Loss of craving

**Causes**

A gallbladder assault more often than not happens in light of the fact that a stone is hindering a path in the gallbladder. Gallstones create in the gallbladder when substances in bile frame hard particles. They can be as little as a grain of sand or as extensive as a golf ball. Ladies are at higher danger of creating gallstones than men, and the danger expands the more youngsters a lady has had.

Pregnancy is additionally a danger for gallstone arrangement. The expanded danger connected with having kids can be counterbalanced by breastfeeding. Ladies who use hormone substitution treatment are additionally at higher danger of creating gallstones. Being overweight and quick weight reduction took after by weight addition are other danger components for gallstones. Having coronary supply route illness is additionally connected with gallbladder malady.

**Expect at Your Doctor’s Office**

On the off chance that you are having a gallbladder assault, you will feel delicacy when the upper right half of your midriff is touched. Jaundice (yellowing of the skin) happens when the bile channel (a tube between the liver and gallbladder) is additionally blocked. On the off chance that your specialist supposes you have a gallstone, you will likely need a ultrasound. Amid a ultrasound,
sound waves take photos of your gallbladder. This test is quick and easy.

**Treatment Options**

Doctors typically remove gallbladders that cause pain. There are no known problems caused by living without a gallbladder. Today, most gallbladder surgeries are performed with a laparoscope. This instrument shows the surgeon pictures of your gallbladder as it is being removed. The minimally invasive procedure allows for a smaller incision and a shorter hospital stay than traditional surgery.

Some drugs can dissolve stones, eliminating the need for surgery. They include:

- An oral bile acid, ursodeoxycholic acid (Ursodiol), can dissolve cholesterol stones that are quite small (less than 15 mm in diameter). The drug is successful in about 40% of patients.
- Methyl tert-butyl ether and monoctanoin (Moctanin) are solvents that are infused directly into the bile duct or the gallbladder to dissolve stones.
- Doctors may use shock wave therapy (lithotripsy) to break up stones.

However, it can take 2 years for a stone to dissolve, and gallstones often return.

**COMPLEMENTARY AND ALTERNATIVE THERAPIES**

Gallstones should always be treated by a doctor. If you would like to add complementary remedies to your treatment, see your doctor for tests before you start any therapies. This will help determine the remedies that are right for the size of your stone and your condition. DO NOT attempt complementary and alternative therapies (CAM) on your own. Work with an experienced provider. Keep all of your physicians informed.
regarding CAM, as some therapies may interfere with conventional medical treatments. Work with a provider who is knowledgeable in complementary medicine to find the right mix of treatments for you. If you are pregnant, or thinking about becoming pregnant, do not use any CAM therapies unless directed to do so by your physician.

**Nutrition and Supplements**

These nutritional tips may help reduce symptoms:

- Eliminate suspected food allergens, such as dairy (milk, cheese, and ice cream), wheat (gluten), soy, corn, preservatives and chemical food additives. Eggs, especially, may irritate the gallbladder. Your doctor may test you for food allergies.

- Eat foods high in B-vitamins and iron, such as whole grains (if no allergy), dark leafy greens (such as spinach and kale), and sea vegetables.

- Eat antioxidant-rich foods, including fruits (such as blueberries, cherries, and tomatoes), and vegetables (such as squash and bell peppers).

- Avoid refined foods, such as white breads, pastas, and sugar.

- Eat fewer red meats and more lean meats, cold-water fish, tofu (soy, if no allergy), or beans for protein.

- Eat more fiber. Consider fiber supplements, such as flaxmeal. Combine 1 heaping tsp. of flaxmeal in 8 oz. of apple juice for a drink high in fiber and pectin.

- Use healthy cooking oils, such as olive oil or coconut oil.

- Reduce or eliminate trans fatty acids, found in commercially-baked goods, such as cookies, crackers, cakes, French fries, onion rings, donuts, processed foods, and margarine.

- Avoid alcohol, and tobacco. Some evidence suggests that people who drink caffeinated coffee have a lower risk of gallstones, though study results are mixed. Talk to your
doctor before increasing your caffeine intake, as caffeine can affect several conditions and interact with medications.

- If possible, exercise lightly 5 days a week.

You may address nutritional deficiencies with the following supplements:

- A daily multivitamin, containing the antioxidant vitamins A, C, E, the B-complex vitamins, and trace minerals, such as magnesium, calcium, zinc, and selenium.
- Vitamin C, as an antioxidant and for immune support.
- Phosphatidylcholine, may help dissolve gallstones. May interfere with some medications, including anticholinergic medications used in the treatment of Alzheimer disease and glaucoma, among others. Talk to your doctor.
- Alpha-lipoic acid, for antioxidant support. It is possible that alpha-lipoic acid could interact with some chemotherapy agents.
- Magnesium, for nutrient support. Magnesium can potentially react with a variety of medications, including some antibiotics, blood pressure medicines, diuretics, muscle relaxers, and others. Large doses of magnesium may result in dangerously low blood pressure and slow breathing. People with kidney disease may have problems clearing magnesium from their body.
- Taurine, for nutrient support. Taurine can potentially interact with lithium. People with a history of bipolar disorder should take taurine with extreme care.
- Vitamin D, for immune support. Preliminary studies suggest a link between vitamin D deficiency and gallstones.

**Herbs**

Herbs are a way to strengthen and tone the body’s systems. As with any therapy, you should work with your doctor before starting any treatment. You may use herbs as dried extracts (capsules, powders, or teas), glycerites (glycerine extracts), or
tinctures (alcohol extracts). People with a history of alcoholism should not take tinctures. Unless otherwise indicated, make teas with 1 tsp. herb per cup of hot water. Steep covered 5 to 10 minutes for leaf or flowers, and 10 to 20 minutes for roots. Drink 2 to 4 cups per day. You may use tinctures singly or in combination as noted. If you are pregnant or nursing, speak to your doctor before using any herbal products.

A gallbladder attack can be a medical emergency. DO NOT use herbs to treat gallbladder disease on your own. Work with a trained herbal practitioner under the supervision of your doctors. The following herbs are sometimes used to treat gallbladder disease:

- Green tea (*Camellia sinensis*). For antioxidant effects. You may also prepare teas from the leaf of this herb. Note: green tea extracts may contain caffeine. Look for decaffeinated products.

- Milk thistle (*Silybum marianum*). For liver and gallbladder detoxification support. Patients with allergies to ragweed or a history of hormone-sensitive cancers should take milk thistle with caution.

- Globe artichoke (*Cynara scolymus*). For support of gallbladder and liver function. Due to its ability to increase bile production, globe artichoke could trigger a gallbladder attack if there is bile duct obstruction. Talk to your doctor.

- Turmeric (*Curcuma longa*) standardized extract. For support of liver function. High doses of turmeric can have blood thinning effects. Care should be taken if you are on other blood-thinning medications.

**Homeopathy**

Few clinical studies have examined the effectiveness of specific homeopathic remedies. However, a professional homeopath may recommend one or more of the following treatments for gallbladder disease based on their knowledge and clinical experience. Before prescribing a remedy, homeopaths take into account a person’s constitutional type, includes your physical, emotional, and
intellectual makeup. An experienced homeopath assesses all of these factors when determining the most appropriate remedy for a particular individual.

Some of the most common remedies are listed below. A common dose is 3 to 5 pellets of a 12X - 30C remedy every 1 to 4 hours until your symptoms improve.

- *Colocynthis.* For colicky abdominal pains that are lessened by pressure or bending double.
- *Chelidonium.* For abdominal pain that moves to the right shoulder area.
- *Lycopodium.* For abdominal pain that is worse with deep breaths.

**Physical Medicine**

Castor oil pack. Apply oil to a clean, soft cloth and place on abdomen. Cover with plastic wrap, place a heat source (hot water bottle or heating pad) over the pack, and let sit for 30 to 60 minutes. For best results, use for 3 consecutive days. Apply to abdomen, especially the gallbladder area, to help reduce swelling.

**Acupuncture**

Acupuncture may be especially helpful in pain relief, reducing spasm, easing bile flow, and restoring proper liver and gallbladder function.

**Following Up**

Early surgery usually ends symptoms and recurrence. Stones may appear again in the bile duct, however.

**Special Considerations**

If you have diabetes or are pregnant, you have a higher risk of complications from gallbladder attacks. If you are pregnant, use choleretic (bile-stimulating) herbs with caution. Milk thistle and dandelion root are safe in pregnancy. Talk with your health care provider before you take any medication or supplement.
GALLSTONES AND GALLBLADDER DISEASE

Gallstones are small, hard deposits that form in the gallbladder, a sac-like organ that lies under the liver in the upper right side of the abdomen. They are common in the wealthy countries, affecting 10-15% of adults. Most people with gallstones don’t even know they have them. But in some cases a stone may cause the gallbladder to become inflamed, resulting in pain, infection, or other serious complications.

BILE AND THE GALLBLADDER

The formation of gallstones is a complex process that starts with bile, a fluid composed mostly of water, bile salts, lecithin (a fat known as a phospholipid), and cholesterol. Most gallstones are formed from cholesterol.

- Bile is important for the digestion of fat. It is first produced by the liver and then secreted through tiny channels that eventually lead into a larger tube called the common bile duct, which leads to the small intestine.
- Only a small amount of bile drains directly into the small intestine, however. Most flows into the gallbladder through the cystic duct, which is a side branch off the common bile duct. This system of ducts through which bile flows is called the biliary tree.
- The gallbladder is a 4-inch sac with a muscular wall that is located under the liver. Here, most of the fluid is removed from the bile (about 2 - 5 cups a day), leaving a few tablespoons of concentrated bile.
- The gallbladder serves as a reservoir until bile is needed in the small intestine to digest fats. This need is signaled by a hormone called cholecystokinin, which is released when food enters the small intestine.
- Cholecystokinin causes the gallbladder to contract and deliver bile into the intestine. The force of the contraction propels the bile down the common bile duct and into the
small intestine, where it emulsifies (breaks down) fatty molecules.

- This part of the digestive process enables the emulsified fat, along with important fat-absorbable nutrients (such as vitamins A, D, E, and K), to pass through the intestinal lining and enter the bloodstream.

**Formation of Gallstones (Cholelithiasis)**

The process of gallstone formation is referred to as cholelithiasis. It is generally a slow process, and usually causes no pain or other symptoms. The majority of gallstones are either the cholesterol or mixed type. Gallstones can range in size from a few millimeters to several centimeters in diameter.

About 70% of gallstones are formed from cholesterol. Pigment stones (black or brown) are also very common and account for the remaining 30% of stones. Patients can have a mixture of the two gallstone types.

**Cholesterol Stones.** Although cholesterol makes up only 5% of bile, about three-fourths of the gallstones found in the US population are formed from cholesterol. Cholesterol gallstones typically form in the following way:

- Cholesterol is not very soluble, so in order to remain suspended in fluid it must be transported within clusters of bile salts called *micelles*. If there is an imbalance between these bile salts and cholesterol, then the bile fluid turns to sludge. This thickened fluid consists of a mucus gel containing cholesterol and calcium bilirubinate.

- If the imbalance worsens, cholesterol crystals form (a condition called *supersaturation*), which can eventually form gallstones.

Supersaturation and cholelithiasis can occur as a result of various abnormalities, although the cause is not entirely clear. There are many events that may promote cholelithiasis:

- The liver secretes too much cholesterol into the bile.
• The gallbladder may not be able to empty normally, so bile becomes stagnant.
• The cells lining the gallbladder may not be able to efficiently absorb cholesterol and fat from bile.
• There are high levels of bilirubin. Bilirubin is a substance normally formed by the breakdown of hemoglobin in the red blood cells. It is removed from the body in bile. Some experts believe bilirubin may play an important role in the formation of cholesterol gallstones.

_Pigment Stones._ Pigment stones are composed of calcium bilirubinate. Pigment stones can be black or brown.

• Black stones form in the gallbladder and are the more common type. They represent 20% of all gallstones in the U.S. They are more likely to develop in people with hemolytic anemia (a relatively rare anemia in which red blood cells are broken down at an abnormally high rate) or cirrhosis (scarred liver).
• Brown pigment stones are more common in Asian populations. They contain more cholesterol and calcium than black pigment stones and are more likely to occur in the bile ducts. Infection plays a role in the development of these stones.

_Mixed stones._ Mixed stones are a mixture of cholesterol and pigment stones.

**Choledocholithiasis (Common Bile Duct Stones)**

Gallstones can also be present in the common bile duct, rather than the gallbladder. This condition is called choledocholithiasis.

*Secondary Common Bile Duct Stones.* In most cases, common bile duct stones originally form in the gallbladder and pass into the common duct. They are then called secondary stones. Secondary choledocholithiasis occurs in about 10% of patients with gallstones.

*Primary Common Bile Duct Stones.* Less often, the stones form in the common duct itself (called primary stones). Primary common
duct stones are usually of the brown pigment type and are more likely to cause infection than secondary common duct stones.

**Gallbladder Diseases without Stones (Acalculous Gallbladder Disease)**

Gallbladder disease can occur without stones, a condition called acalculous gallbladder disease. This refers to a condition in which a person has symptoms of gallbladder stones, yet there is no evidence of stones in the gallbladder or biliary tract. It can be acute (arising suddenly) or chronic (persistent).

- Acute acalculous gallbladder disease usually occurs in patients who are very ill from other disorders. In these cases, inflammation occurs in the gallbladder. Such inflammation usually results from reduced blood supply or an inability of the gallbladder to properly contract and empty its bile.
- Chronic acalculous gallbladder disease (also called biliary dyskinesia) appears to be caused by muscle defects or other problems in the gallbladder, which interfere with the natural contractions needed to empty the sac.

**SYMPTOMS**

About 90% of gallstones cause no symptoms. There is a very small (2%) chance of developing pain during the first 10 years after gallstones form. After 10 years, the chance for developing symptoms declines. On average, symptoms take about 8 years to develop. The reason for the decline in symptoms after 10 years is not known, although some doctors suggest that “younger,” smaller stones may be more likely to cause symptoms than larger, older ones. Acalculous gallbladder disease will often cause symptoms similar to those of gallbladder stones.

**Biliary Pain or Colic**

The mildest and most common symptom of gallbladder disease is intermittent pain called *biliary colic*, which occurs either in the
mid- or the right portion of the upper abdomen. Symptoms may be fairly nonspecific. A typical attack has several features:

• The primary symptom is typically a steady gripping or gnawing pain in the upper right abdomen near the rib cage, which can be severe and can radiate to the upper back. Some patients with biliary colic experience the pain behind the breast bone.
• Nausea or vomiting may occur.
• Changing position, taking over-the-counter pain relievers, and passing gas do not relieve the symptoms.
• Biliary colic typically disappears after 1 to several hours. If it persists beyond this point, acute cholecystitis or more serious conditions may be present.
• The episodes typically occur at the same time of day, but less frequently than once a week. Large or fatty meals can trigger the pain, but it usually occurs several hours after eating and often awakens the patient during the night.
• The condition commonly returns, but attacks can be years apart.

Digestive complaints, such as belching, feeling unusually full after meals, bloating, heartburn (burning feeling behind the breast bone), or regurgitation (acid back-up in the food pipe), are not likely to be caused by gallbladder disease. Conditions that may cause these symptoms include peptic ulcer, gastroesophageal reflux disease, or indigestion of unknown cause.

**Symptoms of Gallbladder Inflammation**

Between 1 - 3% of people with symptomatic gallstones develop inflammation in the gallbladder (*acute cholecystitis*), which occurs when stones or sludge block the duct. The symptoms are similar to those of biliary colic but are more persistent and severe. They include the following:

• Pain in the upper right abdomen that is severe and constant, and may last for days. Pain frequently increases when drawing a breath.
Pain may also radiate to the back or occur under the shoulder blades, behind the breast bone, or on the left side.

About a third of patients have fever and chills, which do not occur with uncomplicated biliary colic.

Nausea and vomiting may occur.

Anyone who experiences such symptoms should seek medical attention. Acute cholecystitis can progress to gangrene or perforation of the gallbladder if left untreated. Infection develops in about 20% of patients with acute cholecystitis, and increases the danger from this condition. People with diabetes are at particular risk for serious complications.

Symptoms of Chronic Cholecystitis or Dysfunctional Gallbladders

Chronic gallbladder disease (chronic cholecystitis) involves gallstones and mild inflammation. In such cases the gallbladder may become scarred and stiff. Symptoms of chronic gallbladder disease include the following:

- Complaints of gas, nausea, and abdominal discomfort after meals; these are the most common symptoms, but they may be vague and difficult to distinguish from similar complaints in people who do not have gallbladder disease.
- Chronic diarrhea (4 - 10 bowel movements every day for at least 3 months).

Symptoms of Stones in the Common Bile Duct (Choledocholithiasis)

Stones lodged in the common bile duct can cause symptoms that are similar to those produced by stones that lodge in the gallbladder, but they may also cause the following symptoms:

- Jaundice (yellowish skin)
- Dark urine, lighter stools, or both
- Rapid heartbeat and abrupt blood pressure drop
- Fever, chills, nausea and vomiting, and severe pain in the
upper right abdomen. These symptoms suggest an infection in the bile duct (called cholangitis).

As in acute cholecystitis, patients who have these symptoms should seek medical help immediately. They may require emergency treatment.

PROGNOSIS AND COMPLICATIONS

Gallstones that do not cause symptoms rarely lead to problems. Death, even from gallstones with symptoms, is very rare. Serious complications are also rare. If they do occur, complications usually develop from stones in the bile duct, or after surgery.

Gallstones, however, can cause obstruction at any point along the ducts that carry bile. In such cases, symptoms can develop.

- In most cases of obstruction, the stones block the cystic duct, which leads from the gallbladder to the common bile duct. This can cause pain (biliary colic), infection and inflammation (acute cholecystitis), or both.
- About 10% of patients with symptomatic gallstones also have stones that pass into and obstruct the common bile duct (choledocholithiasis).

Infections

The most serious complication of acute cholecystitis is infection, which develops in about 20% of cases. It is extremely dangerous and life threatening if it spreads to other parts of the body (a condition called septicemia), and surgery is often required. Symptoms include fever, rapid heartbeat, fast breathing, and confusion. Among the conditions that can lead to septicemia are the following:

- Gangrene or Abscesses. If acute cholecystitis is untreated and becomes very severe, inflammation can cause abscesses. Inflammation can also cause necrosis (destruction of tissue in the gallbladder), which leads to gangrene. The highest risk is in men over 50 who have a history of heart disease and high levels of infection.
• **Perforated Gallbladder.** An estimated 10% of acute cholecystitis cases result in a perforated gallbladder, which is a life-threatening condition. In general, this occurs in people who wait too long to seek help, or in people who do not respond to treatment. Perforation of the gallbladder is most common in people with diabetes. The risk for perforation increases with a condition called *emphysematous cholecystitis*, in which gas forms in the gallbladder. Once the gallbladder has been perforated, pain may temporarily decrease. This is a dangerous and misleading event, however, because peritonitis (widespread abdominal infection) develops afterward.

• **Empyema.** Pus in the gallbladder (empyema) occurs in 2-3% of patients with acute cholecystitis. Patients usually experience severe abdominal pain for more than 7 days. The physical exam often fails to reveal the cause. The condition can be life threatening, particularly if the infection spreads to other parts of the body.

• **Fistula.** In some cases, the inflamed gallbladder adheres to and perforates nearby organs, such as the small intestine. In such cases a fistula (channel) between the organs develops. Sometimes, in these cases, gallstones can actually pass into the small intestine, which can be very serious and requires immediate surgery.

• **Gallstone Ileus.** A gallstone blocking the intestine is known as gallstone ileus. It primarily occurs in patients over age 65, and can sometimes be fatal. Depending on where the stone is located, surgery to remove the stone may be required.

• **Infection in the Common Bile Duct (Cholangitis).** Infection in the common bile duct from obstruction is common and serious. If antibiotics are administered immediately, the infection clears up in 75% of patients. If cholangitis does not improve, the infection may spread and become life threatening. Either surgery or a procedure known as
endoscopic sphincterotomy is required to open and drain the ducts. Those at highest risk for a poor outlook also have one or more of the following conditions:
  o Kidney failure
  o Liver abscess
  o Cirrhosis
  o Age above 50 years
• Pancreatitis. Common bile duct stones are responsible for most cases of pancreatitis (inflammation of the pancreas), a condition that can be life threatening. The pancreatic duct, which carries digestive enzymes, joins the common bile duct right before it enters the intestine. It is therefore not unusual for stones that pass through or lodge in the lower portion of the common bile duct to obstruct the pancreatic duct.

Other Complications and related biliary tract conditions

Gallbladder Cancer: Gallstones are present in about 80% of people with gallbladder cancer. There is a strong association between gallbladder cancer and cholelithiasis, chronic cholecystitis, and inflammation. Symptoms of gallbladder cancer usually do not appear until the disease has reached an advanced stage and may include weight loss, anemia, recurrent vomiting, and a lump in the abdomen.

Research shows that survival rates for gallbladder cancer are on the rise, although the death rate remains high because many people are diagnosed when the cancer is already at a late stage. When the cancer is caught at an early stage and has not spread beyond the mucosa (inner lining), removing the gallbladder can cure many people with the disease. If the cancer has spread beyond the gallbladder, other treatments may be required.

This cancer is very rare, even among people with gallstones. Certain conditions in the gallbladder, however, contribute to a higher-than-average risk for this cancer.
Gallbladder Polyps. Polyps (growths) are sometimes detected during diagnostic tests for gallbladder disease. Small gallbladder polyps (up to 10 mm) pose little or no risk, but large ones (greater than 15 mm) pose some risk for cancer, so the gallbladder should be removed.

Patients with polyps 10 - 15 mm have a lower risk, but they should still discuss gallbladder removal with their doctor.

Primary Sclerosing Cholangitis. Primary sclerosing cholangitis is a rare disease that causes inflammation and scarring in the bile duct.

It is associated with a lifetime risk of 7 - 12% for gallbladder cancer.

The cause is unknown, although it tends to strike younger men with ulcerative colitis. Polyps are often detected in this condition and have a very high likelihood of being cancerous.

Anomalous Junction of the Pancreatic and Biliary Ducts. With this rare condition, which is present at birth (congenital), the junction of the common bile duct and main pancreatic duct is located outside the wall of the small intestine and forms a long channel between the two ducts.

This problem poses a very high risk of cancer in the biliary tract.

Porcelain Gallbladders. Gallbladders are referred to as porcelain when their walls have become so calcified (covered in calcium deposits) that they look like porcelain on an x-ray.

Porcelain gallbladders have been associated with a very high risk of cancer, although recent evidence suggests that the risk is lower than was previously thought.

This condition may develop from a chronic inflammatory reaction that may actually be responsible for the cancer risk.

The cancer risk appears to depend on the presence of specific factors, such as partial calcification involving the inner lining of the gallbladder.
More than 25 million Americans have gallstones, and a million are diagnosed each year. However, only 1 - 3% of the population complains of symptoms during the course of a year, and fewer than half of these people have symptoms that return.

Risk Factors in Women

Women are much more likely than men to develop gallstones. Gallstones occur in nearly 25% of women in the U.S. by age 60, and as many as 50% by age 75. In most cases, they have no symptoms. In general, women are probably at increased risk because estrogen stimulates the liver to remove more cholesterol from blood and divert it into the bile.

Pregnancy. Pregnancy increases the risk for gallstones, and pregnant women with stones are more likely to develop symptoms than women who are not pregnant. Surgery should be delayed until after delivery if possible. In fact, gallstones may disappear after delivery. If surgery is necessary, laparoscopy is the safest approach.
Hormone Replacement Therapy. Several large studies have shown that the use of hormone replacement therapy (HRT) doubles or triples the risk for gallstones, hospitalization for gallbladder disease, or gallbladder surgery. Estrogen raises triglycerides, a fatty substance that increases the risk for cholesterol stones. How the hormones are delivered may make a difference, however. Women who use a patch or gel form of HRT face less risk than those who take a pill. HRT may also be a less-than-attractive option for women because studies have shown it has negative effects on the heart and increases the risk for breast cancer.

Risk Factors in Men

About 20% of men have gallstones by the time they reach age 75. Because most cases do not have symptoms, however, the rates may be underestimated in elderly men. One study of nursing home residents reported that 66% of the women and 51% of the men had gallstones. Men who have their gallbladder removed are more likely to have severe disease and surgical complications than women.

Risks in Children

Gallstone disease is relatively rare in children. When gallstones do occur in this age group, they are more likely to be pigment stones. Girls do not seem to be more at risk than boys. The following conditions may put children at higher risk:

- Spinal injury
- History of abdominal surgery
- Sickle-cell anemia
- Impaired immune system
- Receiving nutrition through a vein (intravenous)

Ethnicity

Because gallstones are related to diet, particularly fat intake, the incidence of gallstones varies widely among nations and regions. For example, Hispanics and Northern Europeans have a higher risk for gallstones than do people of Asian and African descent.
People of Asian descent who develop gallstones are most likely to have the brown pigment type.

Native North and South Americans, such as Pima Indians in the U.S. and native populations in Chile and Peru, are especially prone to developing gallstones. Pima women have an 80% chance of developing gallstones during their lives, and virtually all native Indian females in Chile and Peru develop gallstones. Such cases are most likely due to a combination of genetic and dietary factors.

**Genetics**

Having a family member or close relative with gallstones may increase the risk. Up to one-third of cases of painful gallstones may be related to genetic factors. A mutation in the gene ABCG8 significantly increases a person’s risk of gallstones. This gene controls a cholesterol pump that transports cholesterol from the liver to the bile duct. It appears this mutation may cause the pump to continuously work at a high rate. A single gene, however, does not explain the majority of cases, so multiple genes and environmental factors play a complex role.

Defects in transport proteins involved in biliary lipid secretion appear to predispose certain people to gallstone disease, but this alone may not be sufficient to create gallstones. Studies indicate that the disease is complex and may result from the interaction between genetics and environment. Some studies suggest immune and inflammatory mediators may play key roles.

**Diabetes**

People with diabetes are at higher risk for gallstones and have a higher-than-average risk for acalculous gallbladder disease (without stones). Gallbladder disease may progress more rapidly in patients with diabetes, who tend to have worse infections.

**Obesity and Weight Changes**

*Obesity.* Being overweight is a significant risk factor for gallstones. In such cases, the liver over-produces cholesterol, which is delivered into the bile and causes it to become supersaturated.
Weight Cycling. Rapid weight loss or cycling (dieting and then putting weight back on) further increases cholesterol production in the liver, which results in supersaturation and an increased risk for gallstones.

- The risk for gallstones is as high as 12% after 8-16 weeks of restricted-calorie diets.
- The risk is more than 30% within 12-18 months after gastric bypass surgery.

About one-third of gallstone cases in these situations have symptoms. The risk for gallstones is highest in the following dieters:

- Those who lose more than 24% of their body weight
- Those who lose more than 1.5 kg (3.3 lb.) a week
- Those on very low-fat, low-calorie diets

Men are also at increased risk for developing gallstones when their weight fluctuates. The risk increases proportionately with dramatic weight changes as well as with frequent weight cycling.

Bariatric Surgery. Patients who have either Roux-en-Y or laparoscopic banding bariatric surgery are at increased risk for gallstones. For this reason, many centers request that patients undergo cholecystectomy before their bariatric procedure. However, doctors are now questioning this practice.

Metabolic Syndrome

Metabolic syndrome is a cluster of conditions that includes obesity (especially belly fat), low HDL (good) cholesterol, high triglycerides, high blood pressure, and high blood sugar. Research suggests that metabolic syndrome is a risk factor for gallstones.

Low HDL Cholesterol, High Triglycerides and Their Treatment

Although gallstones are formed from the supersaturation of cholesterol in the bile, high total cholesterol levels themselves are not necessarily associated with gallstones. Gallstone formation is associated with low levels of “good” HDL cholesterol and high
triglyceride levels. Some evidence suggests that high levels of triglycerides may impair the emptying actions of the gallbladder.

Unfortunately, some fibrates (drugs used to correct these conditions) actually increase the risk for gallstones by increasing the amount of cholesterol secreted into the bile. These medications include gemfibrozil (Lopid) and fenofibrate (Tricor). Other cholesterol-lowering drugs do not have this effect.

Other Risk Factors

Prolonged Intravenous Feeding. Prolonged intravenous feeding reduces the flow of bile and increases the risk for gallstones. Up to 40% of patients on home intravenous nutrition develop gallstones, and the risk may be higher in patients on total intravenous nutrition. It is suspected that the cause is lack of stimulation in the gut, because patients who also take some food by mouth have less risk of developing gallstones. However, treatment for gallstones in this population is associated with a low risk of complications.

Crohn’s Disease. Crohn’s disease, an inflammatory bowel disorder, leads to poor reabsorption of bile salts from the digestive tract and substantially increases the risk of gallbladder disease. Patients over age 60 and those who have had numerous bowel operations (particularly in the region where the small and large bowel meet) are at especially high risk.

Cirrhosis. Cirrhosis poses a major risk for gallstones, particularly pigment gallstones.

Organ Transplantation. Bone marrow or solid organ transplantation increases the risk of gallstones. The complications can be so severe that some organ transplant centers require the patient’s gallbladder be removed before the transplant is performed.

Medications. Octreotide (Sandostatin) poses a risk for gallstones. In addition, cholesterol-lowering drugs known as fibrates and thiazide diuretics may slightly increase the risk for gallstones.
Blood Disorders. Chronic hemolytic anemia, including sickle cell anemia, increases the risk for pigment gallstones.

Heme Iron. High consumption of heme iron, the type of iron found in meat and seafood, has been shown to lead to gallstone formation in men. Gallstones are not associated with diets high in non-heme iron foods such as beans, lentils, and enriched grains.

PREVENTION

Diet may play a role in gallstones. Specific dietary factors may include:

Fats. Although fats (particularly saturated fats found in meats, butter, and other animal products) have been associated with gallstone attacks, some studies have found a lower risk for gallstones in people who consume foods containing monounsaturated fats (found in olive and canola oils) or omega-3 fatty acids (found in canola, flaxseed, and fish oil). Fish oil may be particularly beneficial in patients with high triglyceride levels, because it improves the emptying actions of the gallbladder.

Fiber. High intake of fiber has been associated with a lower risk for gallstones.

Nuts. Studies suggest that people may be able to reduce their risk of gallstones by eating more nuts (peanuts and tree nuts, such as walnuts and almonds).

Fruits and Vegetables. People who eat a lot of fruits and vegetables may have a lower risk of developing symptomatic gallstones that require gallbladder removal.

Sugar. High intake of sugar has been associated with an increased risk for gallstones. Diets that are high in carbohydrates (such as pasta and bread) can also increase risk, because carbohydrates are converted to sugar in the body.

Alcohol. A few studies have reported a lower risk for gallstones with alcohol consumption. Even small amounts (1 ounce per day) have been found to reduce the risk of gallstones in women by 20%.
Moderate intake (defined as 1 - 2 drinks a day) also appears to protect the heart. It should be noted, however, that even moderate alcohol intake increases the risk for breast cancer in women. Pregnant women, people who are unable to drink in moderation, and those with liver disease should not drink at all.

Coffee. Research suggests that drinking coffee every day can lower the risk of gallstones. The caffeine in coffee is thought to stimulate gallbladder contractions and lower the cholesterol concentrations in bile. However drinking other caffeinated beverages, such as soda and tea, does not seem to have the same benefit.

Preventing Gallstones during Weight Loss

Maintaining a normal weight and avoiding rapid weight loss are the keys to reducing the risk of gallstones. Taking the medication ursodiol (also called ursodeoxycholic acid, or Actigall) during weight loss may reduce the risk for people who are very overweight and need to lose weight quickly. This medication is ordinarily used to dissolve existing gallstones. Orlistat (Xenical), a drug for treating obesity, may protect against gallstone formation during weight loss. The drug appears to reduce bile acids and other components involved in gallstone production.

The Effects of Cholesterol-Lowering Drugs

Although it would be reasonable to believe that drugs used to lower cholesterol would protect against gallstones, most evidence has found no gallstone protection from these drugs. Reducing blood cholesterol levels does not have any effect on cholesterol gallstones.

DIAGNOSIS

The challenge in diagnosing gallstones is to verify that abdominal pain is caused by stones and not by some other condition. Ultrasound or other imaging techniques can usually detect gallstones. Nevertheless, because gallstones are common
and most cause no symptoms, simply finding stones does not necessarily explain a patient’s pain, which may be caused by any number of ailments.

**Ruling out Other Disorders**

In patients with abdominal pain, causes other than gallstones are usually responsible if the pain lasts less than 15 minutes, frequently comes and goes, or is not severe enough to limit activities.

*Irritable Bowel Syndrome.* Irritable bowel syndrome (IBS) has some of the same symptoms as gallbladder disease, including difficulty digesting fatty foods. However, the pain of IBS usually occurs in the lower abdomen.

*Pancreatitis.* It is sometimes difficult to differentiate between pancreatitis and acute cholecystitis, but a correct diagnosis is critical, because treatment is very different.

About 40% of pancreatitis cases are associated with gallstones. The risk for gallstone-associated pancreatitis is highest in older Caucasian and Hispanic women. About 25% of pancreatitis cases are severe, and the rate is much higher in people who are obese.

Blood tests showing high levels of pancreatic enzymes (amylase and lipase) usually indicate a diagnosis of pancreatitis. Elevated levels of the liver enzyme alanine aminotransferase (ALT) are helpful in identifying gallstone pancreatitis.

Imaging techniques are useful in confirming a diagnosis. Ultrasound is often used. A computed tomography (CT) scan, along with a number of laboratory tests, can determine the severity of the condition.

*Other Conditions with Similar Symptoms.* Acute appendicitis, inflammatory bowel disease (Crohn’s disease or ulcerative colitis), pneumonia, stomach ulcers, gastroesophageal reflux and hiatal hernia, viral hepatitis, kidney stones, urinary tract infections, diverticulosis or diverticulitis, pregnancy complications, and even a heart attack can potentially mimic a gallbladder attack.
Physical Examination

In patients with known gallstones, the doctor can often diagnose acute cholecystitis (gallbladder inflammation) based on classic symptoms (constant and severe pain in the upper right part of the abdomen). Imaging techniques are necessary to confirm the diagnosis. There is usually no tenderness in chronic cholecystitis.

Laboratory Tests

Blood tests are usually normal in people with simple biliary colic or chronic cholecystitis. The following abnormalities may indicate gallstones or complications:

- Bilirubin and the enzyme alkaline phosphatase are usually elevated in acute cholecystitis, and especially in choledocholithiasis (common bile duct stones). Bilirubin is the orange-yellow pigment found in bile. High levels of bilirubin cause jaundice, which gives the skin a yellowish tone.

- Levels of liver enzymes known as aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are elevated when common bile duct stones are present.

A high white blood cell count is a common finding in many patients with cholecystitis.

Imaging and Diagnostic Techniques

Ultrasound of the Abdomen (Ultrasonography). Ultrasound is a simple, rapid, and noninvasive imaging technique. It is the diagnostic method most frequently used to detect gallstones and is the method of choice for detecting acute cholecystitis. If possible, the patient should not eat for 6 or more hours before the test, which takes only about 15 minutes. During the procedure, the doctor can check the liver, bile ducts, and pancreas, and quickly scan the gallbladder wall for thickening (characteristic of cholecystitis).
How well ultrasound can help in the diagnosis varies based on the patient’s situation:

- Ultrasound accurately detects gallstones as small as 2 mm in diameter. Some experts recommend that the test be repeated if an ultrasound does not detect stones, but the health care provider still strongly suspects gallstones.
- Air in the gallbladder wall may indicate gangrene.
- Ultrasound does not appear to be very useful for identifying cholecystitis in patients who have symptoms but do not have gallstones.
- Ultrasound is also not as accurate for identifying common bile duct stones or imaging the cystic duct. Stones or a dilated bile duct may only be detected during ultrasound less than 50% of the time. Nevertheless, normal ultrasound results, along with normal bilirubin and liver enzyme tests are very accurate indications that there are no stones in the common bile duct.

**Endoscopic Ultrasound.** In an ultrasound variation called endoscopic ultrasound (EUS), the physician places an endoscope (a thin, flexible plastic tube containing a tiny camera) into the patient’s mouth and down the esophagus, stomach, and then the first part of the small intestine. The tip of the endoscope contains a small ultrasound transducer, which provides “close-up” ultrasound images of the anatomy in the area. EUS is useful and quite accurate when the health care provider suspects common bile duct stones, but they are not seen on a regular ultrasound and the patient is not clearly ill. However, if common duct stones are detected, they cannot be removed using this method.

**Computed Tomography.** Computed tomography (CT) scans may be helpful if the doctor suspects complications, such as perforation, common duct stones, or other problems such as cancer in the pancreas or gallbladder. Helical (spiral) CT scanning is an advanced technique that is faster and obtains clearer images. With this process, the patient lies on a table while a donut-like, low-radiation x-ray tube rotates around the patient.
Magnetic Resonance Cholangiography (MRCI), or Magnetic Resonance Cholangiopancreatography (MRCP). A dye is injected into the patient’s veins that helps visualize the biliary tract. It is most likely to be useful in a small group of patients who have symptoms that suggest gallbladder or biliary tract problems, but whose ultrasound and other routine tests have been negative. For these patients, performing a MRCP can eliminate the need for ERCP and its side effects. MRCP is extremely sensitive in detecting biliary tract cancer.

Advances in technology have made ultrasonography, CT, and MRI the primary imaging tests for suspected gallbladder disease.

X-Rays. Standard x-rays of the abdomen may detect calcified gallstones and gas. Variations include oral cholecystography or cholangiography.

- In oral cholecystography, the patient takes a tablet containing a dye the night before the test. The dye fills the gallbladder, and x-ray images are taken the next day. The test has largely been replaced by ultrasound; however, it may be useful in some cases for determining the structural and functional status of the gallbladder, often before nonsurgical procedures.

- In cholangiography, a dye is injected into the bile duct and x-rays are used to view the duct. It is typically used during operations to provide a clear image of the biliary tract.

Cholescintigraphy (Also Called Gallbladder Radionuclide Scan or HIDA scan). Cholescintigraphy, a nuclear imaging technique, is more sensitive than ultrasound for diagnosing acute cholecystitis. It is noninvasive but can take 1 - 2 hours or longer. The procedure involves the following steps:

- A tiny amount of a radioactive dye is injected intravenously. This material is excreted into bile.

- The patient lies on a table under a scanning camera, which detects gamma (radioactive) rays emitted by the dye as it passes from the liver into the gallbladder.
• The test can take up to 2 hours, because each image takes about a minute, and images are taken every 5 - 15 minutes.

If the dye does not enter the gallbladder, the cystic duct is obstructed, indicating acute cholecystitis. The scan cannot identify individual gallstones or chronic cholecystitis.

Occasionally, the scan gives false positive results (detecting acute cholecystitis in people who do not have the condition). Such results are most common in alcoholic patients with liver disease or patients who are fasting or receiving all their nutrition intravenously.

Endoscopic Retrograde Cholangiopancreatography (ERCP). Endoscopic retrograde cholangiopancreatography (ERCP) was once the gold standard for detecting common bile duct stones, particularly because stones can be removed during the procedure.

However, this technique is invasive and carries a risk for complications, including pancreatitis.

With the technological advancement of noninvasive imaging techniques, ERCP is now generally limited to patients who have severe cholangitis and a high likelihood of common bile duct stones, which would need to be removed. It may also be used to diagnose biliary dyskinesia.

Virtual Endoscopy. Virtual endoscopy is an experimental technique that uses data from CT and MRI scans to generate a three-dimensional view of various body structures. The images resemble those used in endoscopy (an invasive procedure), but the procedure is noninvasive. Virtual endoscopy may be able to detect smaller stones in the common bile duct than MRI.

TREATMENT

Acute pain from gallstones and gallbladder disease is usually treated in the hospital, where diagnostic procedures are performed to rule out other conditions and complications. There are three approaches to gallstone treatment:
• Expectant management
• Nonsurgical removal of the stones
• Surgical removal of the gallbladder.

Expectant Management of Asymptomatic Gallstones

Guidelines from the American College of Physicians state that when a person has no symptoms, the risks of both surgical and nonsurgical treatments for gallstones outweigh the benefits. Experts suggest a wait-and-see approach, which they have termed expectant management, for these patients.

Exceptions to this policy are people who cholangiography shows are at risk for complications from gallstones, including the following:
• Those at risk for gallbladder cancer
• Pima Native Americans
• Patients with stones larger than 3 cm

Very small gallstones (smaller than 5 mm) may increase the risk for acute pancreatitis, a serious condition.

There are some minor risks with expectant management for people who do not have symptoms or who are at low risk. Gallstones almost never spontaneously disappear, except sometimes when they are formed under special circumstances, such as pregnancy or sudden weight loss.

At some point, the stones may cause pain, serious complications, or both, and require treatment. Some studies suggest the patient’s age at diagnosis may be a factor in the possibility of future surgery. The probabilities are as follows:
• 15% likelihood of future surgery at age 70
• 20% likelihood of future surgery at age 50
• 30% likelihood of future surgery at age 30

The slight risk of developing gallbladder cancer might encourage young adults who do not have symptoms to have their gallbladder removed.
Symptomatic patients

Gallstones are the most common cause for emergency room and hospital admissions of patients with severe abdominal pain. Many other patients experience milder symptoms. Results of diagnostic tests and the exam will guide the treatment, as follows:

*Normal Test Results and No Severe Pain or Complications.* Patients with no fever or serious medical problems who show no signs of severe pain or complications and have normal laboratory tests may be discharged from the hospital with oral antibiotics and pain relievers.

*Gallstones and Presence of Pain (Biliary Colic) but No Infection.* Patients who have pain and tests that indicate gallstones, but who do not show signs of inflammation or infection, have the following options:

- Intravenous painkillers for severe pain. Such drugs include meperidine (Demerol) or the potent NSAID ketorolac (Toradol). Kotorolac should not be used for patients who are likely to need surgery. These drugs can cause nausea, vomiting, and drowsiness. Opioids such as morphine may have fewer adverse effects, but some doctors avoid them in gallbladder disease.
- Elective gallbladder removal. Patients may electively choose to have their gallbladder removed (called cholecystectomy) at their convenience.
- Lithotripsy. A small number of patients may be candidates for stone-breaking techniques called lithotripsy, using a laser or electric charge. The treatment works best on solitary stones that are less than 2 cm in diameter.
- Drug therapy. Drug therapy for gallstones is available for some patients who are unwilling to undergo surgery, or who have serious medical problems that increase the risks of surgery. Recurrence rates are high with nonsurgical options, and the introduction of laparoscopic cholecystectomy has greatly reduced the use of nonsurgical
therapies. Note: Drug treatments are generally inappropriate for patients who have acute gallbladder inflammation or common bile duct stones, because delaying or avoiding surgery could be life threatening.

Acute Cholecystitis (Gallbladder Inflammation). The first step if there are signs of acute cholecystitis is to “rest” the gallbladder in order to reduce inflammation. This involves the following treatments:

- Fasting
- Intravenous fluids and oxygen therapy
- Strong painkillers, such as meperidine (Demerol). Potent NSAIDs, such as ketorolac, may also be particularly useful. Some doctors believe morphine should be avoided for gallbladder disease.
- Intravenous antibiotics. These are administered if the patient shows signs of infection, including fever or an elevated white blood cell count, or in patients without such signs who do not improve after 12 - 24 hours.

People with acute cholecystitis almost always need surgery to remove the gallbladder. The most common procedure now is laparoscopy, a less invasive technique than open cholecystectomy (which involves a wide abdominal incision). Surgery may be done within hours to weeks after the acute episode, depending on the severity of the condition.

Gallstone-Associated Pancreatitis. Patients who have developed gallstone-associated pancreatitis almost always have a cholecystectomy during the initial hospital admission or very soon afterward. For gallstone pancreatitis, immediate surgery may be better than waiting up to 2 weeks after discharge, as current guidelines recommend. Patients who delay surgery have a high rate of recurrent attacks before their surgery.

Common Duct Stones. If noninvasive diagnostic tests suggest obstruction from common duct stones, the doctor will perform endoscopic retrograde cholangiopancreatography (ERCP) to
confirm the diagnosis and remove stones. Transoral techniques may also be performed. This technique is used along with antibiotics if infection is present in the common duct (cholangitis). In most cases, common duct stones are discovered during or after gallbladder removal.

**Management of Common Bile Duct Stones**

Common bile duct stones pose a high risk for complications and nearly always warrant treatment. There are various options available. It is not clear yet which one is best.

- In the past, when common bile duct stones were suspected, the approach was open surgery (open cholecystectomy) and surgical exploration of the common bile duct. This required a wide abdominal incision.
- Endoscopic retrograde cholangiopancreatography (ERCP) with endoscopic sphincterotomy (ES) is now the most frequently used procedure for detecting and managing common bile duct stones. The procedure involves the use of an endoscope (a flexible telescope containing a miniature camera and other instruments), which is passed down the throat to the bile duct entrance.
- Laparoscopic cholecystectomy has taken a secondary role in the detection and removal of common bile duct stones. This is an approach through the abdomen, but it uses small incisions instead of one large incision. It is used in combination with ultrasound or a cholangiogram (an imaging technique in which a dye is injected into the bile duct and moving x-rays are used to view any stones).

Experts are currently debating the choice between laparoscopy and ERCP. Many surgeons believe that laparoscopy is becoming safe and effective, and should be the first choice.

Still, laparoscopy for common bile duct stones should only be performed by surgeons who are experienced in this technique. In skilled centers, endoscopic (including transoral) techniques are becoming the gold standard.
Dissolution Therapies

Oral drugs used to dissolve gallstones and lithotripsy (alone or in combination with other drugs) gained popularity in the 1990s. Oral medications have lost favor with the increased use of laparoscopy, but they may still have some value in specific circumstances.

*Oral Dissolution Therapy.* Oral dissolution therapy uses bile acids in pill form to dissolve gallstones, and may be used in conjunction with lithotripsy, although both techniques are rarely used today. Ursodiol (ursodeoxycholic acid, Actigal, UDCA) and chenodiol (Chenix) are the standard oral bile acid dissolution drugs. Most doctors prefer ursodeoxycholic acid, which is considered to be one of the safest common drugs. Long-term treatment appears to notably reduce the risk of biliary pain and acute cholecystitis. The treatment is only moderately effective, however, because gallstones return in the majority of patients.

Patients most likely to benefit from oral dissolution therapy are those who have normal gallbladder emptying and small stones (less than 1.5 cm in diameter) with a high cholesterol content.

Patients who probably will *not* benefit from this treatment include obese patients and those with gallstones that are calcified or composed of bile pigments.

There is some conflicting evidence on its effectiveness as an add-on to biliary stenting. Only about 30% of patients are candidates for oral dissolution therapy. The number may actually be much lower because compliance is often a problem. The treatment can take up to 2 years and can cost thousands of dollars per year.

*Contact Dissolution Therapy.* Contact dissolution therapy requires the injection of the organic solvent methyl tert-butyl ether (MTBE) into the gallbladder to dissolve gallstones. This is a technically difficult and hazardous procedure, and should be performed only by experienced doctors in hospitals where research on this treatment is being done. Preliminary studies indicate that MTBE rapidly dissolves stones — the ether remains liquid at body
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temperature and dissolves gallstones within 5 - 12 hours. Serious side effects include severe burning pain.

**SURGERY**

The gallbladder is not an essential organ, and its removal is one of the most common surgical procedures performed on women. It can even be performed on pregnant women with low risk to both the baby and mother. The primary advantages of surgically removing the gallbladder over nonsurgical treatment are that it can eliminate gallstones and prevent gallbladder cancer.

*Open Procedures Versus Laparoscopy.* Open cholecystectomy involves the removal of the gallbladder through a wide 6 - 8 inch abdominal incision. Small-incision surgery, using a 2 - 3 inch incision is a minimally invasive alternative.

However, laparoscopic cholecystectomy (commonly called lap choly), which uses small incisions, is the most commonly used surgical approach. First performed in 1987, lap choly is now used in most cholecystectomies in the United States. Of concern is a significant increase in its use in patients who have inflammation in the gallbladder but no infection or gallstones, and in those who have gallstones but no symptoms.

Laparoscopy has largely replaced open cholecystectomy because it offers some significant advantages:

- The patient can leave the hospital and resume normal activities earlier, compared to open surgery.
- The incisions are small, and there is less postoperative pain and disability than with the open procedure.
- There are fewer complications.
- It is less expensive than open cholecystectomy over the long term. The immediate treatment cost of laparoscopy may be higher than the open procedure, but the more rapid recovery and fewer complications translate into shorter hospital stays and fewer sick days, and therefore a greater reduction in overall costs.
Some experts believe, however, that the open procedures, including small-incision, still have many advantages compared to laparoscopy:

- It is faster to perform.
- It poses less of a risk for bile duct injury compared with laparoscopy. However, open surgery has more overall complications than laparoscopy, and bile-duct injury rates with laparoscopy are declining.
- Small incision appears to offer the shortest surgical time and lowest cost.

The type of surgery performed on specific patients may vary depending on different factors.

**Appropriate Surgical Candidates.** Candidates for gallbladder removal often have, or have had, one of the following conditions:

- A very severe gallstone attack
- Several less severe gallstone attacks
- Endoscopic sphincterotomy for common bile duct stones (in patients with residual gallbladder stones)
- Cholecystitis (gallbladder inflammation)
- Pancreatitis (inflammation of the pancreas) secondary to gallstones
- High risk for gallbladder cancer (such as patients with anomalous junction of the pancreatic and biliary ducts or patients with certain forms of porcelain gallbladder)
- Chronic acalculous gallbladder disease (also called biliary dyskinesia), in which the gallbladder does not empty well and causes biliary colic, even though there are no gallstones present

The best candidates are those with evidence of impaired gallbladder emptying. Pregnant women who have gallstones and experience symptoms are also candidates for surgery.

**Timing of Surgery.** Cholecystectomy may be performed within days to weeks after hospitalization for an acute gallbladder attack, depending on the severity of the condition.
• Emergency gallbladder removal within 24 - 48 hours is warranted in about 20% of patients with acute cholecystitis. Indications for surgery include deterioration of the patient's condition, or signs of perforation or widespread infection.

• Under debate is what type of surgery and timing are most appropriate for patients with acute cholecystitis whose condition improves and who have no signs of severe complications. Previously, the standard was open cholecystectomy between 6 - 12 weeks after the acute episode. Some evidence now suggests that patients who have early surgery (performed between 72 - 96 hours after symptoms begin) have fewer complications than those who wait to have surgery.

General Outlook. Although cholecystectomy is very safe, as with any operation there are risks of complications, depending on whether the procedure is done on an elective or emergency basis.

• When cholecystectomy is performed as an elective surgery, the mortality rates are very low. (Even in the elderly, mortality rates are only 0.7 - 2%.)

• Emergency cholecystectomy has a much higher mortality rate (as high as 19% in ill elderly patients).

Long-Term Effects of Gallbladder Removal. Removal of the gallbladder has not been known to cause any long-term adverse effects, aside from occasional diarrhea.

Laparoscopic Cholecystectomy

The Procedure. With laparoscopy, gallbladder removal is typically performed as follows:

• Laparoscopic cholecystectomy requires general anesthesia, although it is now mostly done as outpatient surgery. Antibiotics may be necessary to prevent or treat infection.

• The surgeon inserts a needle through the navel and pumps carbon dioxide gas through it to create space in the abdomen. This step may raise blood pressure.
Antihypertensive drugs may be helpful during surgery to protect patients who have high blood pressure or heart or kidney disease.

- One 10 - 12 mm (about one-half inch) and two-three 5 mm (about one-fifth of an inch) incisions are made in the abdomen. This is often referred to as 4 port laparoscopic cholecystectomy (4PLC).
- The surgeon inserts a laparoscope (a thin fiber optic scope), which contains a small surgical instrument and a tiny camera that relays an image to a video monitor.
- The surgeon separates the gallbladder from the liver and other areas, and removes it through one of the incisions.
- Evidence suggests that the use of cholangiography during the operation helps prevent injury in the bile ducts, a serious complication of cholecystectomy. With this procedure, dye is injected into the bile duct, and moving x-rays are used to view the duct.
- Often patients will need to stay in the hospital overnight. However, some patients can go home the same day.

**Robot-assisted surgery.** Laparoscopic surgery may be performed using tiny keyhole incisions and 3 - 4 tiny robotic arms. A computerized program guides the arms during surgery. A systematic review comparing robot-assisted and human assisted removal of the gallbladder showed no difference in morbidity, conversion to open surgery, total operating time, or hospital stay. Robot-assisted surgery requires longer overall surgical time and is more costly.

**Risk Factors for Conversion from Laparoscopy to an Open Procedure.** In about 5 - 10% of laparoscopies, conversion to open cholecystectomy is required during the procedure. The rate of conversion to open surgery is higher in men than in women. This may be due to the higher rate of inflammation and fibrosis in men with symptomatic gallstones. Other reasons for conversion from laparoscopic to open surgery include:
• Possible or known injury to major blood vessels
• Internal structures are not clearly visible
• Unexpected problems that cannot be corrected with laparoscopy
• Common bile duct stones that cannot be removed with laparoscopy or subsequent ERCP
• Previous endoscopic sphincterotomy
• A thickened gallbladder wall

Complications and Side Effects of Surgery

• Pain and fatigue are common side effects of any abdominal surgery. Patients should avoid light recreational activities for about 2 days and from work and more strenuous activities for about a week.
• There is a relatively high incidence of nausea and vomiting after laparoscopic cholecystectomy, which can be treated with injections of metoclopramide. Patients may take anti-nausea medications such as granisteron before surgery to help prevent these effects. Local anesthesia at the incision sites (in addition to general anesthesia) before surgery may reduce pain and nausea afterward.
• Injury to the bile duct is the most serious complication of laparoscopy. It can include leakage, tears, and the development of narrowing (strictures) that can lead to liver damage. In order to minimize such injuries, some experts recommend that surgeons perform laparoscopy with cholangiography. Bile duct injury has been a more common problem in laparoscopy compared to the open procedure, but increasing surgical experience and the use of cholangiography is reducing this complication. Studies are reporting more comparable rates between the two procedures.
• In about 6% of procedures, the surgeon misses some gallstones, or they spill and remain in the abdominal cavity. In a small percentage of these cases, the stones cause
obstruction, abscesses, or fistulas (small channels) that require open surgery.

• As with all surgeries, there is a risk for infection, but it is very low.

Patients should not be shy about inquiring into the number of laparoscopies the surgeon has performed (the minimum should be 40). Obese patients were originally thought to be poor candidates for laparoscopic cholecystectomy, but recent research indicates that this surgery is safe for them.

**Open Cholecystectomy**

Before the development of laparoscopy, the standard surgical treatment for gallstones was open cholecystectomy (surgical removal of the gallbladder through an abdominal incision), which requires a wide 6 - 8 inch incision and leaves a large surgical scar. In this procedure, the patient usually stays in the hospital for 5 - 7 days and may not return to work for a month. Complications include bleeding, infections, and injury to the common bile duct. The risks of this procedure increase with other factors, such as the age of the patient, or the need to explore the common bile duct for stones at the same time.

Candidates for whom cholecystectomy may be a more appropriate choice:

• Patients who have had extensive previous abdominal surgery
• Patients with complications of acute cholecystitis (such as empyema, gangrene, and perforation of the gallbladder)

**Small-incision or Mini-Laparotomy Cholecystostomy.** Mini-laparotomy cholecystostomy uses small abdominal incisions but, unlike laparoscopy, it is an “open” procedure, and the surgeon does not operate through a scope. The surgical instruments used are very small (2 - 3 mm in diameter, or about a tenth of an inch). Comparison with laparoscopic techniques has found little difference in recovery time, mortality or complications.
Older patients. Patients who are over 80 years old are likely to have lower complication rates from open cholecystectomy than laparoscopy, although laparoscopy may also be appropriate in these patients.

Whether or not to insert a drain in the wound after surgery is under debate. Many surgeons implant drains to prevent abscesses or peritonitis. That practice may change. One analysis found that patients who received drains had a dramatically increased risk of wound and chest infection, regardless of the type of drain used.

ERCP with Endoscopic Sphincterotomy (ES)

Reasons for performing the procedure:

- Before gallbladder surgeries, when there is a strong suspicion that common bile duct stones are present.
- At the end of a cholecystectomy, if the surgeon detects stones in the common bile duct (only if there are experts in ERCP present, and equipment is available).
- For patients with gallstone cholangitis (serious infection in the common bile duct). In such cases urgent ERCP and antibiotics are required.
- When acute pancreatitis is caused by gallstones, urgent ERCP, along with antibiotics, may be used. The use of ERCP compared to conservative treatment has been controversial.

The ERCP and ES Procedure. A typical ERCP and endoscopic sphincterotomy (ES) procedure includes the following steps:

- The patient is given a sedative and asked to lie on his or her left side.
- An endoscope (a tube containing fiber optics connected to a camera) is passed through the mouth and stomach and into the duodenum (top part of the small intestine) until it reaches the point where the common bile duct enters. This does not interfere with breathing, but the patient may have a sensation of bloating.
• A thin catheter (tube) is then passed through the endoscope.
• Contrast material (a dye) is injected through the catheter into the opening of the duct. The dye allows x-ray visualization of the biliary tree (the system of ducts through which bile flows, including the common bile duct) and any stones contained in the area.
• Instruments may also be passed through the endoscope to remove any stones that are detected.
• The next phase of the procedure is known as endoscopic sphincterotomy (ES). (It is also sometimes referred to as papillotomy, although this is a slightly different variation.) ES widens the junction between the common bile duct and intestine (the ampulla of Vater) so that the stones can be extracted more easily. With ES, a tiny incision is usually made in the opening of the common bile duct and through the muscles that enclose the lower common bile duct (the sphincter of Oddi).
• One recent alternative to ES is the use of a small inflatable balloon (a procedure known as endoscopic balloon dilation) that opens up the ampulla of Vater to allow stones to pass. This variation does not involve cutting muscles, and offers a lower risk of bleeding and injury to internal structures.
• Once the junction has been opened, the stones may pass on their own, or they may be extracted with the use of tiny balloons, or sometimes baskets.

Complications. Complications of ERCP and ES occur in 5 - 8% of cases, and some can be serious. Mortality rates are 0.2 - 0.5%. Complications include the following:
• Pancreatitis (inflammation of the pancreas) occurs in 3 - 9% of cases and can be very serious. Younger adults are at higher risk than the elderly. The risk is also higher with more complex procedures. The drugs somatostatin or gabexate are sometimes used to reduce the risk, although recent evidence suggests somatostatin may not actually
reduce this risk. Gabexate appears to be more effective, although studies are mixed on whether its benefits are significant, particularly with short-term treatment.

- Postoperative infection. Antibiotics may be given before the procedure to prevent infection, although one study reported that they had little benefit.

- Bleeding occurs in 2% of cases. There is an increased risk for bleeding in patients taking anti-clotting drugs, and those who have cholangitis. This complication is treated by flushing the area with epinephrine.

- Perforations (rare)

- Long-term complications include stone recurrence and abscesses.

- Larger bile duct stones (>10-15mm) are more difficult to remove and often require additional procedures.

ERCP and ES are difficult procedures, and patients must be certain that their doctor and medical center are experienced. ERCP can usually be performed successfully by an experienced doctor, even in critically ill patients who are on mechanical ventilators. ERCP and Gallbladder Removal (Cholecystectomy). ERCP may be performed before, during, or after gallbladder removal. ERCP is often performed after gallstones in the common duct are discovered during cholecystectomy. In some cases, stones in the gallbladder are detected during ERCP. In such cases, laparoscopic cholecystectomy is usually warranted. There is some debate about whether the gallbladder should be removed at the same time as ERCP, or if patients should wait.

**OPEN OR LAPAROSCOPIC COMMON BILE DUCT EXPLORATION (CHOLEDODHOLITHOTOMY)**

**Laparoscopic Exploration and Cholangiography**

Surgeons are now increasingly using laparoscopy with cholangiography instead of ERCP when common duct stones are suspected. Laparoscopy with cholangiography should only be
done in centers with expertise in this procedure. This procedure should be done for the following reasons:
• As an alternative to ERCP before gallbladder surgeries, when there is a high suspicion of common bile duct stones.
• During gallbladder surgeries when common duct stones are detected or highly suspected.

The procedure usually involves the following steps:
• The initial approach is the same as with laparoscopic cholecystectomy. One or two 10 - 12 mm (around half an inch) incisions and three 5 mm (about a fifth of an inch) incisions are made in the abdomen.
• A tiny opening is made in the cystic duct that connects the gallbladder to the bile duct, and a thin tube is introduced to perform a cholangiography.
• If stones are identified, the surgeon inserts a tube with an inflatable balloon to widen the duct.
• Stones are usually retrieved or withdrawn from the duct with either a balloon or tiny basket.
• If laparoscopy is unsuccessful, ERCP or open surgery is performed.

Experts are debating whether this procedure is better than ERCP. Many surgeons believe that laparoscopy is becoming safe and effective, and should be the first choice of treatment.

**Open Common Bile Duct Exploration**

Choledocholithotomy, or common bile duct exploration, is used:
• To remove large stones
• When the duct anatomy is complex
• During or after some gallbladder operations when stones are detected. If the procedure is being performed laparoscopically, the surgeon may convert to an open procedure, though this happens less often now.
• When ERCP or laparoscopic procedures are not available.
In this procedure, the doctor performs open abdominal surgery and extracts gallstones through an incision in the common bile duct. Routinely, a “T-tube” is temporarily left in the common bile duct after surgery and the doctor x-rays the bile duct through the tube 7 - 10 days after surgery, to determine whether any stones remain in the duct.

**EXTRACORPOREAL SHOCK WAVE LITHOTRIPSY**

Gallstone fragmentation by extracorporeal shock wave lithotripsy (ESWL) may be an appropriate therapy for some patients with pain, normal gallbladder emptying and no other complications, but it is no longer widely used. The treatment works best on a single stone that is less than 2 centimeters in diameter. Less than 15% of patients are good candidates for lithotripsy. The typical procedure is performed as follows:

- The patient sits in a tub of water.
- General anesthesia or conscious sedation is given to reduce pain.
- High-energy, ultrasound shock waves are directed through the abdominal wall toward the stones.
- The shock waves travel through the soft tissues of the body and break up the stones.
- The stone fragments are then usually small enough to be passed through the bile duct and into the intestines.
- Lithotripsy is generally combined with oral dissolution treatment to help dissolve the fragmented pieces of the original gallstone.
- Multiple sessions are generally necessary to clear all stone fragments.
PHENOTYPE

Pediatricians are most familiar with the clinical findings that prompt the diagnosis of Turner syndrome in children, namely, short stature and other features, such as lymphedema, webbed neck, low posterior hairline, and cubits values. A wide range of clinical abnormalities, including cardiac and renal anomalies, may be found. Turner syndrome, however, is not always accompanied by distinctive features and most often is not diagnosed in infancy. Later in childhood, Turner syndrome may be suspected primarily because of short stature. Other prominent presenting features in teenage years are delayed puberty and delayed menarche, and in adult women, an ovulation and infertility.

Growth in children with Turner syndrome is characterized by a slight intrauterine growth restriction, slow growth during infancy and childhood, and lack of a pubertal growth spurt. Because of delayed epiphyseal closure, small gains in height may occur even after 20 years of age. Average height is rarely achieved, except in girls with mosaicism (the presence in an individual of 2 or more chromosomally different cell lines, both originating from the same zygote) or those whose parents are of above average height. The anticipated adult height is approximately 143 cm and rarely exceeds 150 cm.6,7
Although intelligence is normal, individuals with Turner syndrome are at risk of impairments in the cognitive, behavioral, and social domains. These include learning disabilities, particularly with regard to spatial perception, visual-motor integration, mathematics, memory, the ability to formulate goals and plan action sequences to attain them, and attention span. As a result, the nonverbal IQ in persons with Turner synrome tends to be lower than the verbal IQ. The behavioral abnormalities differ by age. Younger girls may be hyperactive, immature, and anxious, and anxiety, depression, and unsatisfactory peer relationships are more common in older girls.

A female with 45,X Turner syndrome may manifest an X-linked recessive disorder, such as hemophilia, because she has only 1 X chromosome. Therefore, when an X-linked disorder is identified in a female, the possibility of Turner syndrome caused by monotony X (absence of an X chromosome: 45,X) or a structural abnormality of an X chromosome should be considered.

**CYTOGENETICS**

Most characteristics of Turner syndrome appear to result from haploinsufficiency of specific genes on the X chromosome, although abnormal pairing of the sex chromosomes during meiosis is the major factor in acolyte loss and gonadal digenesis. Haploinsufficiency refers to the presence in the cell of 1 set of genes rather than the usual 2 sets. In 46,XX female embryos, inactivation of 1 X chromosome, referred to as lionization, occurs in every somatic cell shortly after fertilization. Some genes involved in Turner syndrome, however, seem to escape inactivation. Thus, the 46,XX female embryo has a functional diploid set of these “pseudo-autosomal” genes. These genes also seem to have homology on the Y chromosome, which accounts for the normal growth and development in XY male embryos.

Current evidence indicates that the genes involved in Turner syndrome are mainly located on the short arm of the X chromosome: X. A distal homeobox gene (SHOX), located in
the pseudoautosomal region of the X chromosome (PAR1), has been shown to contribute to short stature and some of the skeletal abnormalities observed in individuals with Turner syndrome. Haploinsufficiency of this gene has been associated with Leri-Weil's syndrome, an osteochondrodysplasia characterized by short stature, mesomelic dwarfism, Madelung deformity, and other skeletal abnormalities. Loci contributing to normal ovarian function and fetal viability have been identified on the long arm of the X chromosome.

In approximately 80% of girls with 45,X Turner syndrome, the single remaining X chromosome is inherited from the mother, and in 20% of these girls, it is inherited from the father. Imprinting (an alteration in the expression of a gene or a chromosome, depending on whether the genetic material is inherited from the mother or father) does not seem to operate, because the phenotype of an individual with 45,X Turner syndrome does not vary according to the parental origin of the X chromosome. A recent study identified a putative imprinted X-linked gene related to cognitive function, but this has not yet been confirmed. When the diagnosis of Turner syndrome is suspected, the appropriate test for confirmation is chromosome analysis.

A wide range of karyotypic abnormalities exists within Turner syndrome. When conventional karyotyping is performed using lymphocyte cultures, about 50% of patients show a 45,X chromosome constitution.

Another karyotype found with Turner syndrome is mosaicism of 45,X with other cell lines, such as 46,XX, 46,XY, or 47,XXX. Although mosaicism with a 46,XX line (which is the most frequent mosaicism found with 45,X) tends to result in a subtler phenotype on average, the clinical findings cannot be predicted in an individual case. Structural anomalies of an X chromosome, such as isochromosomes (an abnormal chromosome with equal arms originating from a transverse division of the centromere during cell division, instead of the normal longitudinal division), deletions, rings, or translocations, also may be found in a person with Turner
syndrome. Structural X anomalies are often mosaic with 45,X or 46,XX cells.

Mosaicism in individuals with Turner syndrome may be more common than was previously thought.

When 2 tissues (lymphocytes and fibroblasts) were examined, approximately 80% of patients with 45,X Turner syndrome were found to have mosaicism.27 Mosaicism in live-born girls with Turner syndrome is more common than that in fetuses with Turner syndrome, suggesting that a second sex chromosome (or a critical portion of a second sex chromosome) may be necessary for fetal survival and that most, or perhaps all, individuals with Turner syndrome have mosaicism. A Y chromosome is present in 5% to 6% of individuals with Turner syndrome, and an additional 3% have a marker chromosome (a structurally abnormal chromosome that cannot be identified by conventional cytogenetic methods) derived from either the Y or another chromosome.

Girls with 45,X Turner syndrome should have an adequate cytogenetic examination for covert Y chromosome mosaicism, including fluorescence in situ hybridization. Routine use of polymerase chain reaction to identify cryptic Y chromosomal material is not recommended. However, when the karyotype shows a marker chromosome of unknown origin, molecular studies using Y chromosome DNA probes may be helpful in the diagnosis. The possibility of Y chromosome mosaicism also should be investigated thoroughly if clitoromegaly or masculinized genitalia are present at birth or if virilization occurs at puberty. When Y chromosome mosaicism is present, there is an increased risk, estimated from 7% to 10%, for developing gonadoblastoma or dysgerminoma in the dysgenetic gonads, and prophylactic gonadectomy is recommended.

Buccal smears for X chromatin bodies (Barr bodies) should not be used to screen for or diagnose Turner syndrome. They do not have sufficient sensitivity and specificity, because individuals with mosaicism or a structural X abnormality are often
X chromatin positive. Also, a Y chromosome would not be detected in a routine buccal smear that only looks for X chromatin bodies.

HEALTH SUPERVISION

Turner syndrome, as used in this report, refers to a condition characterized by short stature and ovarian digenesis in females who have a single X chromosome and absence of all or part of the second sex chromosome (X or Y). No chromosomal gonad digenesis is excluded. The birth prevalence of Turner syndrome has been estimated to be from 1 in 2000 to 1 in 5000 female live births. Approximately 1% to 2% of all conceptuses have a 45,X chromosome constitution.

The majority (99%) of these spontaneously abort, usually during the first trimester of pregnancy. With the more frequent use of ultrasonography, it is recognized that some pregnancies with a fetal 45,X chromosome constitution progressing into the second trimester are associated with uncial cysts, severe lymph edema, or hydrous fetal is. These pregnancies are associated with a high frequency of fetal death.

MEDICAL TREATMENT

Short Stature

Growth hormone (GH) therapy is standard care for a child with Turner syndrome and is usually begun after the child’s height falls below the fifth percentile for healthy girls in the same age cohort. More than one half of girls with Turners syndrome will have fallen below the fifth percentile by 2 years of age. For those who experience early growth failure, it appears reasonable to begin GH therapy as early as 2 years of age.

A multicenter study of the efficacy and safety of GH initiated at even earlier ages is currently being conducted. Biosynthetic human GH increases the rate of growth in most girls with Turners syndrome without advancing the bone age. Some reports indicate increases in final adult height of 8 to 10 cm if they receive at least 6 years
of GH therapy and estrogen production is delayed. Greater height gains have recently been achieved even without delaying estrogen production by initiating GH at an early age and at high doses.

**Cardiovascular Abnormalities**

The prevalence of cardiovascular abnormalities among patients with Turner syndrome varies in different series between 20% and 40%. It is higher in patients with monosomy X than in those with structural abnormalities of the X chromosome and in girls with a more pronounced clinical phenotype, such as those with congenital lymphedema and webbed neck, than in those with milder clinical manifestations. Cardiovascular abnormalities typically involve the left side of the heart. Bicuspid aortic valve is the most common malformation, followed by coarctation of the aorta. Other less common but still significant cardiovascular defects in individuals with Turner syndrome are mitral valve prolapse, partial anomalous pulmonary venous drainage, and hypoplastic left heart syndrome.

Many of these malformations result in an increased susceptibility to endocarditic, and therefore, prophylactic administration of antibiotics before dental or surgical procedures is essential.

Aortic root dilatation, present in 3% to 8% of patients with Turner syndrome, may lead to dissecting aneurysm, rupture, and death. Although in most cases aortic dilatation precedes recognized aortic dissection, not all cases end in dissection and not all cases of dissection have antecedent aortic root dilatation. Bicuspid aortic valve, forestation of the aorta, and systemic hypertension has been identified in approximately 90% of patients with aortic dilatation and dissection. These are the same risk factors that are associated with aortic root dilatation in the general population.

However, because of the current lack of knowledge about the natural history of aortic dilatation, additional research will be required to identify the best strategy for timely discovery of the
problem. In the absence of natural history data, some authorities would advise aortic arch imaging of such patients by echocardiogram or magnetic resonance imaging (MRI) as frequently as every 3 years.

Although most instances of aortic dilatation or dissection in individuals with Turner syndrome have been reported among adults, reports of its occurrence in females 21 years or younger raise the possibility that surveillance imaging of the aortic arch for young patients with Turner syndrome could be valuable.

The observation of cystic medial necrosis in individuals with aortic root dilatation has led some to postulate that the aortic abnormality may be caused by a mesenchymal defect. This contention is supported by the evidence of other connective tissue abnormalities, such as those involving the skeletal and lymphatic systems, in patients with Turner syndrome.

On the basis of these considerations, it is recommended that, as part of the initial evaluation, all patients with Turner syndrome have a baseline cardiology evaluation. This may include an echocardiogram, preferably performed at a centre experienced in pediatric cardiology, because data indicate that more than one half of echocardiograms performed in children at facilities mostly devoted to adult studies are technically not adequate for interpretation.

The schedule and nature of the cardiology follow-up should be directed by the pediatric cardiologist in concert with the primary care pediatrician and individualized to the patient’s needs and the type of defect(s) identified.

Patients with bicuspid aortic valve, aortic stenosis, coarctation of the aorta, or systemic hypertension need close follow-up for aortic dilatation. The cardiologist should decide the periodicity of the evaluations and the method of appraisal (MRI versus echocardiography). Although echocardiography is considered the mainstay of diagnosis, MRI can detect dilatation missed on echocardiography.
In addition, MRI should be used when aortic root dilatation is detected to evaluate its severity and provide more precise measurements for follow-up, when findings on echocardiography are equivocal, and when there are technical difficulties because of chest wall configuration or obesity. MRI also can be valuable in assessing the possibility of aortic dissection.

In patients in whom the cardiology evaluation during childhood is normal, the primary care pediatrician should pay special attention to the cardiovascular examination, including blood pressure, peripheral pulses, and murmurs. Although there are no evidence-based data regarding the need for a follow-up cardiology evaluation, some have proposed a repeat cardiologic examination during adolescence, ideally performed by a pediatric cardiologist, to look for asymptomatic aortic dilatation.

Primary care pediatricians and pediatric cardiologists need to be aware of the risk of aortic dissection and educate their patients with Turner syndrome about the signs and symptoms of this complication.

Although there has been reassurance that GH does not cause cardiac hypertrophy in girls without cardiac malformation, there is inadequate information about its use in girls with underlying aortic stenosis, with or without underlying bicuspid aortic valve.

**Hypertension**

Up to 40% of girls with Turner syndrome have hypertension, and when identified, it should be treated vigorously. Although in most cases hypertension is idiopathic, a careful search for cardiovascular or renal causes should be made.

**Hearing Loss**

Hearing loss is common in individuals with Turner syndrome. Recurrent otitis media occurs in most girls with Turner syndrome. In addition, a progressive infrequency sensor neural hearing loss often occurs, which necessitates the use of hearing
aids in some children and more than 25% of women by their mid-
forties.

The Prenatal Visit

When a prenatal diagnosis of 45,X Turner syndrome or another karyotype associated with Turner syndrome is detected, counseling is ordinarily provided for the family by a medical geneticist, a pediatric endocrinologist, or another physician with special knowledge of Turner syndrome. Sometimes, because of a previous relationship with the family, the pediatrician may be asked to review the information and to assist the family in decision making.

Turner syndrome may be diagnosed or suspected prenatally because of ultrasonographic evidence of fetal edema or nuchal cystic hygroma. Ultrasonography showing a left-sided cardiac defect, renal anomalies, growth retardation, or relatively short limbs also may suggest Turner syndrome. A Turner syndrome karyotype may be discovered fortuitously when fetal chromosome analysis is performed for reasons not associated with an increased incidence of Turner syndrome, such as advanced maternal age. Karyotyping performed when the results of maternal serum screening with multiple markers (maternal serum α-fetoprotein, human chorionic gonadotropin, and unconjugated estriol) project an increased risk for Down syndrome also has detected some fetuses with Turner syndrome. If an abnormality associated with Turner syndrome is diagnosed by ultrasonography or if multiple marker screening is positive, the recommended follow-up is fetal karyotyping using amniotic fluid cells obtained by amniocentesis or fetal blood obtained by percutaneous umbilical blood sampling when the karyotype is needed more rapidly.

The spectrum of clinical findings cannot be predicted from the fetal karyotype alone, even in nonmosaic 45,X Turner syndrome. The variability may be increased by mosaicism, which is often not detected in the fetal chromosome analysis. A diagnosis of Turner syndrome made solely by fetal karyotyping should be
followed up with careful ultrasonography to define the phenotypic abnormalities as accurately as possible.

Most instances of mosaicism of 45,X and 46,XY diagnosed prenatally have been associated with phenotypically healthy male newborn infants, although the possibility of some clinical abnormality later in life cannot be excluded. If a 45,X or 46,XY fetal karyotype is found, ultrasonographic examination is helpful in diagnosing normal-appearing male genitalia. Determination of amniotic fluid follicle-stimulating hormone (FSH) and testosterone concentrations also may be helpful in confirming the male phenotype.

**Anticipatory Guidance**

The pediatrician should discuss the diagnosis of Turner syndrome, the phenotype, and the variability of the phenotype. Both parents should be present if possible. They need to know that short stature and infertility are likely, mental retardation is unlikely, some congenital anomalies may be present, and some learning difficulties are expected for most but not all individuals. Discuss the treatments and interventions available, such as growth-enhancing therapy and sex hormone replacement, and emphasize that with medical supervision and psychosocial counseling and support, girls with Turner syndrome may lead healthy, satisfying lives. In cases of early prenatal diagnosis, however, some parents may decide to terminate the pregnancy.

Most often, Turner syndrome is a sporadic event, and the risk of recurrence is not increased for subsequent pregnancies. There may be some rare exceptions, however, such as inheritance of a structural X anomaly and inherited mosaicism.

**Newborn**

- Confirm the diagnosis of Turner syndrome and review the karyotype. If a prenatal diagnosis was made, discuss with the geneticist whether further cytogenetic studies should be performed. Chromosome analyses from peripheral blood
or other tissue samples may be indicated, depending on the adequacy of the prenatal study and the possibility of mosaicism, especially for the Y chromosome. Evaluate the child for typical features of Turner syndrome as follows.

- Examine the child’s hips for dysplasia. Repeat the examination several times during early infancy.
- Review results of the newborn hearing screening.
- Inform the family that lymphedema may persist for months or longer and may recur.
- Discuss the possibility of feeding problems. Some infants with Turner syndrome have inefficient sucking and swallowing reflexes because of impaired oral motor function.
- Obtain an initial consultation with a pediatric endocrinologist to discuss the current status of endocrine therapy for growth and for the development of secondary sex characteristics. Indicate that infertility is almost always present, although assisted reproduction techniques may enable infertile women with Turner syndrome to have children.
- Discuss subacute bacterial endocarditis prophylaxis if a cardiac anomaly is present.
- Talk about how and what to tell other family members and friends.

**Infancy**

- Assess the infant’s weight, taking into account that many infants want to developmental intervention programs if neuromuscular development is delayed.

**Early Childhood**

- Follow the child’s growth and have her evaluated by a pediatric endocrinologist if growth failure occurs. The age at which GH therapy is initiated varies but can be considered at as early as 2 to 3 years of age for girls who
are below the fifth percentile for height in the growth chart for healthy girls of the same age. Early initiation of GH therapy may allow for greater gain and normalization of the timing of puberty. Plot growth on the Turner syndrome-specific growth curve starting at 2 years of age (Fig).

- Evaluate the child’s hearing and check for serous otitis and otitis media during every visit.
- Continue to evaluate the child’s renal status (urinalysis and culture, as indicated) if a renal anomaly is present.
- If hypertension is present, treat it aggressively and perform a careful search for cardiovascular or renal causes.

**Late Childhood**

- Discuss the diagnosis and treatment of Turner syndrome with the child as soon as she is able to understand as well as with the parents.
- Monitor the child for urinary tract infections if urinary tract abnormalities are present.
- Check blood pressure and peripheral pulses during each physical examination. A careful comparison of arm and leg systolic pressure is important to evaluate for possible coarctation.
- Check the child’s dentition for malocclusion.
- Continue testing for thyroid function at 1- or 2-year intervals.
- Check for scoliosis yearly. Lordosis and kyphosis are also seen more frequently in girls with, than in girls without, Turner syndrome.
- Discuss adjustment to short stature with the parents and separately with the child.
- If hypertension is present, treat it aggressively and perform a careful search for cardiovascular or renal causes.
- Counsel the family regarding the importance of optimizing bone density, and advise that the patient receive the
recommended daily requirements for Vitamin D and calcium through diet or supplementation.

Adolescence to Early Adulthood

- Continue to test the adolescent’s thyroid function every 1 to 2 years.
- If hypertension is present, treat it aggressively and perform a careful search for cardiovascular or renal causes.
- If otitis media is present, institute aggressive treatment.
- If lymphedema is exacerbated by estrogen therapy, combined decongestivetherapy that uses manual lymphatic drainage, low-stretch support garments, and exercises may be effective. Some physicians also use diuretics.
- Continue to monitor school function and behaviour.
- Discuss social adaptation. Girls with Turner syndrome tend to be socially immature for their age and need support in developing independence and social interactions. Support groups of girls with Turner syndrome are especially helpful. Provide psychosexual counseling.
- Present information on reproductive options to bearing children, such as adoption and medically assisted reproduction.
- Provide counseling regarding sexuality and sexually transmitted diseases.
- Refer the rare girl with Turner syndrome who has sufficient ovarian function to ovulate and who may become pregnant for genetic counseling and prenatal diagnosis (if pregnant). These girls are at increased risk of having a fetus with chromosome abnormalities and having miscarriages. Offer contraception advice when appropriate.
- Facilitate transfer of the adolescent to adult medical care.
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Preface

Pediatric surgery is a subspecialty of surgery including the surgery of babies, newborn children, kids, teenagers, and youthful grown-ups.

Pediatric surgery emerged amidst the twentieth century as the surgical consideration of birth imperfections required novel strategies and techniques and turned out to be all the more generally based at youngsters’ doctor’s facilities. One of the locales of this advancement was Children’s Hospital of Philadelphia. Starting in the 1940s under the surgical initiative of C. Everett Koop, more up to date procedures for endotracheal anesthesia of babies permitted surgical repair of already untreatable birth surrenders. By the late 1970s, the newborn child passing rate from a few noteworthy inborn mutation disorders had been diminished to close to zero. The technical and technological aspects of pediatric MIS show that MIS is more than technique and technology; it is a choice. The hospital must choose to install the right equipment, bear higher instrument attrition costs, specially train the staff, and tolerate new learning curves.

The surgeon must choose to add unfamiliar and uncomfortable methods to his repertoire, often after his formal training has ended. He must also choose the patients for whom MIS can really reduce risks: there is a demonstrable gap between “can” and “should.” Still, promised benefits are driving pediatric surgeon adoption as well as parental demand, and spurring innovations to overcome the challenges. Properly applied, MIS may offer better information, similar (or superior) mechanical results, more surgical options, shorter hospital stays, and lower costs, both in terms of dollar amount and risks to the pediatric patient.
Especially various congenital malformations of newborn babies and many surgical diseases that often occur at this age require accurate diagnosis and appropriate treatment customized to each disease. Therefore AMC makes ceaseless efforts to provide the best treatment by linking with the Fetal Treatment Center of the Department of Obstetrics and Gynecology and the Neonatal Incentive Care Unit. For instance, congenital hiatal hernia is classified as the disease with high mortality rates, but its survival rates increase as surgery is performed after stabilizing patients with active treatments such as HFV (frequency oscillatory ventilation), nitrogen oxide, ECMO (extracorporeal membrane oxygenation) in the Neonatal Incentive Care Unit immediately after birth. All the matter is just compiled and edited in nature. Taken from the various sources which are in public domain.

It is hoped that the book will serve the purpose of students and scholars on the subject and can be useful to them in allied fields.

—Editor
ABOUT THE BOOK

Pediatric surgery is a subspecialty of surgery including the surgery of babies, newborn children, kids, teenagers, and youthful grown-ups. Pediatric surgery emerged amidst the twentieth century as the surgical consideration of birth imperfections required novel strategies and techniques and turned out to be all the more generally based at youngsters’ doctor’s facilities. One of the locales of this advancement was Children’s Hospital of Philadelphia. The Department of Pediatric Surgery is a specialty involving treatment of surgical patients from newborn babies to adolescents under the age of sixteen. Children are separately managed because they need to receive customized treatment depending on their development stages and physical/physiological changes at each age. Since the Department of Pediatric Surgery performs as extensive surgical procedures and treatments as diseases handled in the Department of Pediatrics, more specialized medical skills are required. The technical and technological aspects of pediatric MIS show that MIS is more than technique and technology; it is a choice. The hospital must choose to install the right equipment, bear higher instrument attrition costs, specially train the staff, and tolerate new learning curves. It is hoped that the book will serve the purpose of students and scholars on the subject and can be useful to them in allied fields.

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An Introduction; Congenital Disorder; Mitochondrial Disease; Esophageal Atresia; Hirschsprung’s Disease; Fetal Neural Tube Defects: Diagnosis, Management, and Treatment; Surgical Neonate; Pediatric Bariatric Surgery; Pediatric Minimally Invasive Surgery: Laparoscopy and Thoracoscopy; Pediatric Thoracic Trauma; Congenital Lung Malformations; Gastroesophageal Reflux Disease (GERD); Gallbladder: Problems and Symptoms; Pediatric Nursing