Anesthesia

In the practice of medicine (especially surgery) and dentistry, anesthesia or anaesthesia is a temporary induced state with one or more of analgesia (relief from or prevention of pain), paralysis (muscle relaxation), amnesia (loss of memory), and unconsciousness. A patient under the effects of anesthetic drugs is referred to as being anesthetized.

Anesthesia enables the painless performance of medical procedures that would cause severe or intolerable pain to an unanesthetized patient. Three broad categories of anaesthesia exist:

• General anesthesia suppresses central nervous system activity and results in unconsciousness and total lack of sensation.
• Sedation suppresses the central nervous system to a lesser degree, inhibiting both anxiety and creation of long-term memories without resulting in unconsciousness.
• Regional anesthesia and local anesthesia, which block transmission of nerve impulses between a targeted part of the body and the central nervous system, causing loss of sensation in the targeted body part. A patient under regional or local anesthesia remains conscious. Two broad classes exist:
Peripheral blockade inhibits sensory perception in an isolated part of the body, such as numbing a tooth for dental work or administering a nerve block to inhibit sensation in an entire limb.

Central, or neuraxial, blockade administers the anesthetic in the region of the central nervous system itself, suppressing incoming sensation from outside the area of the block. Examples include epidural anaesthesia and spinal anaesthesia.

In preparing for a medical procedure, the health care provider giving anesthesia chooses and determines the doses of one or more drugs to achieve the types and degree of anesthesia characteristics appropriate for the type of procedure and the particular patient.

The types of drugs used include general anesthetics, hypnotics, sedatives, neuromuscular-blocking drugs, narcotic, and analgesics.

There are both major and minor risks of anesthesia. Examples of major risks include death, heart attack and pulmonary embolism whereas minor risks can include postoperative nausea and vomiting and hospital readmission. The likelihood of a complication occurring is proportional to the relative risk of a variety of factors related to the patient’s health, the complexity of the surgery being performed and the type of anesthetic.

Of these factors, the person’s health prior to surgery (stratified by the ASA physical status classification system) has the greatest bearing on the probability of a complication occurring. Patients typically wake within minutes of an anesthetic being terminated and regain their senses within hours. One exception is a condition called long-term post-operative cognitive dysfunction, characterized by persistent confusion lasting weeks or months, which is more common in those undergoing cardiac surgery and in the elderly.
MEDICAL USES

The purpose of anesthesia can be distilled down to three basic goals or end points:

• hypnosis (a temporary loss of consciousness and with it a loss of memory. In a pharmacological context, the word hypnosis usually has this technical meaning, in contrast to its more familiar lay or psychological meaning of an altered state of consciousness not necessarily caused by drugs).

• analgesia (lack of sensation which also blunts autonomic reflexes)

• muscle relaxation

Different types of anesthesia affect the endpoints differently. Regional anesthesia, for instance, affects analgesia; benzodiazepine-type sedatives (used in twilight sleep) favor amnesia; and general anesthetics can affect all of the endpoints.

The goal of anesthesia is to achieve the endpoints required for the given surgical procedure with the least risk to the patient.

To achieve the goals of anesthesia, drugs act on different but interconnected parts of the nervous system. Hypnosis, for instance, is generated through actions on the nuclei in the brain and is similar to the activation of sleep.

The effect is to make people less aware and less reactive to noxious stimuli.

Loss of memory (amnesia) is created by action of drugs on multiple (but specific) regions of the brain. Memories are created as either declarative or non-declarative memories in several stages (short-term, long-term, long-lasting) the strength of which is determined by the strength of connections between neurons termed synaptic plasticity.

Each anesthetic produces amnesia through unique effects on memory formation at variable doses. Inhalational anesthetics
will reliably produce amnesia through general suppression of the nuclei at doses below those required for loss of consciousness. Drugs like midazolam produce amnesia through different pathways by blocking the formation of long-term memories.

Tied closely to the concepts of amnesia and hypnosis is the concept of consciousness. Consciousness is the higher order process that synthesizes information. For instance, the “sun” conjures up feelings, memories and a sensation of warmth rather than a description of a round, orange warm ball seen in the sky for part of a 24 hour cycle. Likewise, a person can have dreams (a state of subjective consciousness) during anesthetic or have consciousness of the procedure despite having no indication of it under anesthetic. It is estimated that 22% of people dream during general anesthesia and 1 or 2 cases per 1000 have some consciousness termed “awareness during general anesthesia”.

Techniques

Anesthesia is unique, in that it is not a direct means of treatment, rather it allows others to do things that may treat, diagnose, or cure an ailment which would otherwise be painful or complicated. The best anesthetic, therefore is the one with the lowest risk to the patient that still achieves the endpoints required to complete the procedure. The first stage of an anesthetic is the pre-operative risk assessment made up of the medical history, physical examination and lab tests. Diagnosing a person’s pre-operative physical status allows the clinician to minimize anesthetic risks. A well completed medical history will arrive at the correct diagnosis 56% of the time which increases to 73% with a physical examination. Lab tests help in diagnosis but only in 3% of cases, underscoring the need for a full history and physical examination prior to anesthetics. Incorrect pre-operative assessments or preparations are the root cause of 11% of all adverse anesthetic events.
Anesthesia

ASA physical status classification system

<table>
<thead>
<tr>
<th>ASA class</th>
<th>Physical status</th>
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<tr>
<td>ASA 1</td>
<td>Healthy person</td>
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<tr>
<td>ASA 2</td>
<td>Mild systemic disease</td>
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<tr>
<td>ASA 3</td>
<td>Severe systemic disease</td>
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<td>ASA 4</td>
<td>Severe systemic disease that is a constant threat to life</td>
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<tr>
<td>ASA 5</td>
<td>A moribund person who is not expected to survive without the operation</td>
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<td>ASA 6</td>
<td>A declared brain-dead person whose organs are being removed for donor purposes</td>
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<td>Suffix added for patients undergoing emergency procedure</td>
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One part of the risk assessment is based on the patients’ health. The American Society of Anesthesiologists have developed a six-tier scale which stratifies the pre-operative physical state of the patient called the ASA physical status. The scale assesses a high-order of risk as the patient’s general health relates to an anesthetic.

The more detailed pre-operative medical history aims to discover genetic disorders (such as malignant hyperthermia or pseudocholinesterase deficiency), habits (tobacco, drug and alcohol use), physical attributes (such as obesity or a difficult airway) and any coexisting diseases (especially cardiac and respiratory diseases) that might impact the anesthetic. The physical examination helps quantify the impact of anything found in the medical history in addition to lab tests.

Aside from the generalities of the patients health assessment, an evaluation of the specific factors as they relate to the surgery also need to be considered for anesthesia. For instance, anesthesia during childbirth must consider not only the mother but the baby. Cancers and tumors that occupy the lungs or throat create special challenges to general anesthesia. After determining the health of the person undergoing
anesthetic and the endpoints that are required to complete the procedure, the type of anesthetic can be selected. Choice of surgical method and anaesthetic technique aims to reduce risk of complications, shorten time needed for recovery and minimise the surgical stress response.

**General anesthesia**

Anesthesia is the combination of the endpoints (discussed above) which are reached by drugs acting on different but overlapping sites in the central nervous system.

General anesthesia (as opposed to sedation or regional anesthesia) has three main goals: lack of movement (paralysis), unconsciousness, and blunting of the stress response. In the early days of anesthesia, anesthetics could reliably achieve the first two, allowing surgeons to perform necessary procedures, but many patients died because the extremes of blood pressure and pulse caused by the surgical insult were ultimately harmful. Eventually, the need for blunting of the surgical stress response was identified by Harvey Cushing, who injected local anesthetic prior to hernia repairs. This led to the development of other drugs that could blunt the response leading to lower surgical mortality rates.

The most common approach to reach the endpoints of general anesthesia is through the use of inhaled general anesthetics. Each has its own potency which is correlated to its solubility in oil.

This relationship exists because the drugs bind directly to cavities in proteins of the central nervous system, although several theories of general anaesthetic action have been described. Inhalational anesthetics are thought to exact their effects on different parts of the central nervous system. For instance, the immobilizing effect of inhaled anesthetics results from an effect on the spinal cord whereas sedation, hypnosis and amnesia involve sites in the brain. The potency of an
An inhalational anesthetic is quantified by its minimum alveolar concentration or MAC.

The MAC is the percentage dose of anaesthetic that will prevent a response to painful stimulus in 50% of subjects. The higher the MAC, generally, the less potent the anesthetic.

Syringes prepared with medications that are expected to be used during an operation under general anesthesia maintained by sevoflurane gas:

- Propofol, an hypnotic
- Ephedrine, in case of hypotension
- Fentanyl, for analgesia
- Atracurium, for neuromuscular block
- Glycopyrronium bromide (here under trade name Robinul), reducing secretions
The ideal anesthetic drug would provide hypnosis, amnesia, analgesia, and muscle relaxation without undesirable changes in blood pressure, pulse or breathing. In the 1930s, physicians started to augment inhaled general anesthetics with intravenous general anesthetics. The drugs used in combination offered a better risk profile to the person under anesthetic and a quicker recovery.

A combination of drugs was later shown to result in lower odds of dying in the first 7 days after anesthetic. For instance, propofol (injection) might be used to start the anesthetic, fentanyl (injection) used to blunt the stress response, midazolam (injection) given to ensure amnesia and sevoflurane (inhaled) during the procedure to maintain the effects. More recently, several intravenous drugs have been developed which, if desired, allow inhaled general anesthetics to be avoided completely.

**Equipment**

The core instrument in an inhalational anesthetic delivery system is an anesthetic machine. It has vaporizers, ventilators, an anesthetic breathing circuit, waste gas scavenging system and pressure gauges.

The purpose of the anesthetic machine is to provide anesthetic gas at a constant pressure, oxygen for breathing and to remove carbon dioxide or other waste anesthetic gases. Since inhalational anaesthetics are inflammable, various checklists have been developed to confirm that the machine is ready for use, that the safety features are active and the electrical hazards are removed.

Intravenous anesthetic is delivered either by bolus doses or an infusion pump. There are also many smaller instruments used in airway management and monitoring the patient. The common thread to modern machinery in this field is the use of fail-safe systems that decrease the odds of catastrophic misuse of the machine.
Patients under general anesthesia must undergo continuous physiological monitoring to ensure safety. In the US, the American Society of Anesthesiologists (ASA) have established minimum monitoring guidelines for patients receiving general anesthesia, regional anesthesia, or sedation. This includes electrocardiography (ECG), heart rate, blood pressure, inspired
and expired gases, oxygen saturation of the blood (pulse oximetry), and temperature. In the UK the Association of Anaesthetists (AAGBI) have set minimum monitoring guidelines for general and regional anesthesia. For minor surgery, this generally includes monitoring of heart rate, oxygen saturation, blood pressure, and inspired and expired concentrations for oxygen, carbon dioxide, and inhalational anesthetic agents. For more invasive surgery, monitoring may also include temperature, urine output, blood pressure, central venous pressure, pulmonary artery pressure and pulmonary artery occlusion pressure, cardiac output, cerebral activity, and neuromuscular function. In addition, the operating room environment must be monitored for ambient temperature and humidity, as well as for accumulation of exhaled inhalational anesthetic agents, which might be deleterious to the health of operating room personnel.

Sedation

Sedation (also referred to as dissociative anesthesia or twilight anesthesia) creates hypnotic, sedative, anxiolytic, amnesic, anticonvulsant, and centrally produced muscle-relaxing properties. From the perspective of the person giving the sedation, the patient will appear sleepy, relaxed and forgetful, allowing unpleasant procedures to be more easily completed. Sedatives such as benzodiazepines are usually given with pain relievers (such as narcotics, or local anesthetics or both) because they don’t, by themselves, provide significant pain relief.

From the perspective of the person receiving sedative, the effect is a feeling of general relaxation, amnesia (loss of memory) and time passing quickly. Many drugs can produce a sedative effect including benzodiazepines, propofol, thiopental, ketamine and inhaled general anesthetics. The advantage of sedation over a general anesthetic is that it generally does not require support of the airway or breathing (no tracheal intubation or mechanical ventilation) and can have less of an
effect on the cardiovascular system which may add to a greater margin of safety in some patients.

Regional anesthesia

Sonography guided femoral nerve block

Backflow of cerebrospinal fluid through a spinal needle after puncture of the arachnoid mater during spinal anaesthesia
When pain is blocked from a part of the body using local anesthetics, it is generally referred to as regional anesthesia.

There are many types of regional anesthesia either by injecting into the tissue itself, a vein that feeds the area or around a nerve trunk that supplies sensation to the area.

The latter are called nerve blocks and are divided into peripheral or central nerve blocks.

The following are the types of regional anesthesia:

• **Infiltrative anesthesia**: a small amount of local anesthetic is injected in a small area to stop any sensation (such as during the closure of a laceration, as a continuous infusion or “freezing” a tooth). The effect is almost immediate.

• **Peripheral nerve block**: local anesthetic is injected near a nerve that provides sensation to particular portion of the body. There is significant variation in the speed of onset and duration of anesthesia depending on the potency of the drug (e.g. Mandibular block).

• **Intravenous regional anesthesia** (also called a Bier block): dilute local anesthetic is infused to a limb through a vein with a tourniquet placed to prevent the drug from diffusing out of the limb.

• **Central nerve blockade**: Local anesthetic is injected or infused in or around a portion of the central nervous system (discussed in more detail below in Spinal, epidural and caudal anesthesia).

• **Topical anesthesia**: local anesthetics that are specially formulated to diffuse through the mucous membranes or skin to give a thin layer of analgesia to an area (e.g. EMLA patches).

• **Tumescent anesthesia**: a large amount of very dilute local anesthetics are injected into the subcutaneous tissues during liposuction.
• **Systemic local anesthetics**: local anesthetics are given systemically (orally or intravenously) to relieve neuropathic pain

**Nerve blocks**

When local anesthetic is injected around a larger diameter nerve that transmits sensation from an entire region it is referred to as a nerve block. Nerve blocks are commonly used in dentistry, when the mandibular nerve is blocked for procedures on the lower teeth. With larger diameter nerves (such as the interscalene block for upper limbs or psoas compartment block for lower limbs) the nerve and position of the needle is localized with ultrasound or electrical stimulation. The use of ultrasound may reduce complication rates and improve quality, performance time, and time to onset of blocks. Because of the large amount of local anesthetic required to affect the nerve, the maximum dose of local anesthetic has to be considered. Nerve blocks are also used as a continuous infusion, following major surgery such as knee, hip and shoulder replacement surgery, and may be associated with lower complications. Nerve blocks are also associated with a lower risk of neurologic complications when compared to neuraxial blocks.

**SPINAL, EPIDURAL AND CAUDAL ANESTHESIA**

Central neuraxial anesthesia is the injection of local anesthetic around the spinal cord to provide analgesia in the abdomen, pelvis or lower extremities. It is divided into either spinal (injection into the subarachnoid space), epidural (injection outside of the subarachnoid space into the epidural space) and caudal (injection into the cauda equina or tail end of the spinal cord). Spinal and epidural are the most commonly used forms of central neuraxial blockade.

Spinal anesthesia is a “one-shot” injection that provides rapid onset and profound sensory anesthesia with lower doses of anesthetic, and is usually associated with neuromuscular
blockade (loss of muscle control). Epidural anesthesia uses larger doses of anesthetic infused through an indwelling catheter which allows the anesthetic to be augmented should the effects begin to dissipate. Epidural anesthesiа does not typically affect muscle control.

Because central neuraxial blockade causes arterial and vasodilation, a drop in blood pressure is common. This drop is largely dictated by the venous side of the circulatory system which holds 75% of the circulating blood volume. The physiologic effects are much greater when the block is placed above the 5th thoracic vertebra. An ineffective block is most often due to inadequate anxiolysis or sedation rather than a failure of the block itself.

Acute pain management

Pain that is well managed during and immediately after surgery improves the health of patients (by decreasing physiologic stress) and the potential for chronic pain. Nociception (pain sensation) is not hard-wired into the body. Instead, it is a dynamic process wherein persistent painful stimuli can sensitize the system and either make pain management difficult or promote the development of chronic pain. For this reason, preemptive acute pain management may reduce both acute and chronic pain and is tailored to the surgery, the environment in which it is given (in-patient/out-patient) and the individual patient.

Pain management is classified into either pre-emptive or on-demand. On-demand pain medications typically include either opioid or non-steroidal anti-inflammatory drugs but can also make use of novel approaches such as inhaled nitrous oxide or ketamine. On demand drugs can be administered by a clinician (“as needed drug orders”) or by the patient using patient-controlled analgesia (PCA). PCA has been shown to provide slightly better pain control and increased patient satisfaction when compared with conventional methods.
Common preemptive approaches include epidural neuraxial blockade or nerve blocks. One review which looked at pain control after abdominal aortic surgery found that epidural blockade provides better pain relief (especially during movement) in the period up to three postoperative days. It reduces the duration of postoperative tracheal intubation by roughly half. The occurrence of prolonged postoperative mechanical ventilation and myocardial infarction is also reduced by epidural analgesia.

**RISKS AND COMPLICATIONS**

Risks and complications as they relate to anesthesia are classified as either morbidity (a disease or disorder that results from anesthesia) or mortality (death that results from anesthesia). Attempting to quantify how anesthesia contributes to morbidity and mortality can be difficult because a person’s health prior to surgery and the complexity of the surgical procedure can also contribute to the risks.

Prior to anesthetic in the early 19th century, the physiologic stress from surgery caused significant complications and many deaths from shock. The faster the surgery was, the lower the rate of complications (leading to reports of very quick amputations). The advent of anesthesia allowed more complicated and life-saving surgery to be completed, decreased the physiologic stress of the surgery, but added an element of risk. It was two years after the introduction of ether anesthetics that the first death directly related to anesthetic was reported.

Morbidity can be major (myocardial infarction, pneumonia, pulmonary embolism, renal failure/insufficiency, postoperative cognitive dysfunction and allergy) or minor (minor nausea, vomiting, readmission). There is usually overlap in the contributing factors that lead to morbidity and mortality between the health of the patient, the surgery being performed and the anesthetic. To understand the relative risk of each
contributing factor, consider that the rate of deaths totally attributed to the patient’s health is 1:870.

Compare that to the rate of deaths totally attributed to surgical factors (1:2860) or anesthesia alone (1:185,056) illustrating that the single greatest factor in anesthetic mortality is the health of the patient.

These statistics can also be compared to the first such study on mortality in anesthesia from 1954, which reported a rate of death from all causes at 1:75 and a rate attributed to anesthesia alone at 1:2680.

Direct comparisons between mortality statistics cannot reliably be made over time and across countries because of differences in the stratification of risk factors, however, there is evidence that anesthetics have made a significant improvement in safety but to what degree is uncertain.

Rather than stating a flat rate of morbidity or mortality, many factors are reported as contributing to the relative risk of the procedure and anesthetic combined.

For instance, an operation on a person who is between the ages of 60–79 years old places the patient at 2.32 times greater risk than someone less than 60 years old. Having an ASA score of 3, 4 or 5 places the person at 10.65 times greater risk than someone with an ASA score of 1 or 2.

Other variables include age greater than 80 (3.29 times risk compared to those under 60), gender (females have a lower risk of 0.77), urgency of the procedure (emergencies have a 4.44 times greater risk), experience of the person completing the procedure (less than 8 years experience and/or less than 600 cases have a 1.06 times greater risk) and the type of anesthetic (regional anesthetics are lower risk than general anesthetics).

Obstetrical, the very young and the very old are all at greater risk of complication so extra precautions may need to be taken.
RECOVERY

The immediate time after anesthesia is called emergence. Emergence from general anesthesia or sedation requires careful monitoring because there is still a risk of complication. Nausea and vomiting are reported at 9.8% but will vary with the type of anesthetic and procedure. There is a need for airway support in 6.8%, there can be urinary retention (more common in those over 50 years of age) and hypotension in 2.7%. Hypothermia, shivering and confusion are also common in the immediate post-operative period because of the lack of muscle movement (and subsequent lack of heat production) during the procedure.

Postoperative cognitive dysfunction (also known as POCD and post-anesthetic confusion) is a disturbance in cognition after surgery. It may also be variably used to describe emergence delirium (immediate post-operative confusion) and early cognitive dysfunction (diminished cognitive function in the first post-operative week). Although the three entities (delirium, early POCD and long-term POCD) are separate, the presence of delirium post-operatively predicts the presence of early POCD. There does not appear to be an association between delirium or early POCD and long-term POCD. According to a recent study conducted at the David Geffen School of Medicine at UCLA, the brain navigates its way through a series of activity clusters, or “hubs” on its way back to consciousness. Dr. Andrew Hudson, an assistant professor in anesthesiology states, “Recovery from anesthesia is not simply the result of the anesthetic ‘wearing off,’ but also of the brain finding its way back through a maze of possible activity states to those that allow conscious experience. Put simply, the brain reboots itself.”

Long-term postoperative cognitive dysfunction is a subtle deterioration in cognitive function, that can last for weeks, months, or longer. Most commonly, relatives of the person report a lack of attention, memory and loss of interest in activities previously dear to the person (such as crosswords).
In a similar way, people in the workforce may report an inability to complete tasks at the same speed they could previously. There is good evidence that POCD occurs after cardiac surgery and the major reason for its occurrence is the formation of microemboli. POCD also appears to occur in non-cardiac surgery. Its causes in non-cardiac surgery are less clear but older age is a risk factor for its occurrence.

History

The first attempts at general anesthesia were probably herbal remedies administered in prehistory. Alcohol is one of the oldest known sedatives and it was used in ancient Mesopotamia thousands of years ago. The Sumerians are said to have cultivated and harvested the opium poppy (Papaver somniferum) in lower Mesopotamia as early as 3400 BC.

The ancient Egyptians had some surgical instruments, as well as crude analgesics and sedatives, including possibly an extract prepared from the mandrake fruit. Bian Que (Chinese: AbJž, Wade–Giles: Pien Ch’iao, c. 300 BC) was a legendary Chinese internist and surgeon who reportedly used general anesthesia for surgical procedures.

Throughout Europe, Asia, and the Americas a variety of Solanum species containing potent tropane alkaloids were used for anesthesia. In 13th century Italy, Theodoric Borgognoni used similar mixtures along with opiates to induce unconsciousness, and treatment with the combined alkaloids proved a mainstay of anesthesia until the nineteenth century. Local anesthetics were used in Inca civilization where shamans chewed coca leaves and performed operations on the skull while spitting into the wounds they had inflicted to anesthetize. Cocaine was later isolated and became the first effective local anesthetic. It was first used in 1859 by Karl Koller, at the suggestion of Sigmund Freud, in eye surgery in 1884. German surgeon August Bier (1861–1949) was the first to use cocaine for intrathecal anesthesia in 1898. Romanian surgeon Nicolae
Racoviceanu-Pitești (1860–1942) was the first to use opioids for intrathecal analgesia; he presented his experience in Paris in 1901.

Early Arab writings mention anesthesia by inhalation. This idea was the basis of the “soporific sponge” (“sleep sponge”), introduced by the Salerno school of medicine in the late twelfth century and by Ugo Borgognoni (1180–1258) in the thirteenth century. The sponge was promoted and described by Ugo’s son and fellow surgeon, Theodoric Borgognoni (1205–1298). In this anesthetic method, a sponge was soaked in a dissolved solution of opium, mandragora, hemlock juice, and other substances. The sponge was then dried and stored; just before surgery the sponge was moistened and then held under the patient’s nose. When all went well, the fumes rendered the patient unconscious.

The most famous anesthetic, ether, may have been synthesized as early as the 8th century, but it took many centuries for its anesthetic importance to be appreciated, even though the 16th century physician and polymath Paracelsus noted that chickens made to breathe it not only fell asleep but also felt no pain. By the early 19th century, ether was being used by humans, but only as a recreational drug.

Meanwhile, in 1772, English scientist Joseph Priestley discovered the gas nitrous oxide. Initially, people thought this gas to be lethal, even in small doses, like some other nitrogen oxides. However, in 1799, British chemist and inventor Humphry Davy decided to find out by experimenting on himself. To his astonishment he found that nitrous oxide made him laugh, so he nicknamed it laughing gas. Davy wrote about the potential anesthetic properties of nitrous oxide, but nobody at that time pursued the matter any further.

American physician Crawford W. Long noticed that his friends felt no pain when they injured themselves while staggering around under the influence of ether. He immediately
thought of its potential in surgery. Conveniently, a participant in one of those “ether frolics”, a student named James Venable, had two small tumors he wanted excised. But fearing the pain of surgery, Venable kept putting the operation off. Hence, Long suggested that he have his operation while under the influence of ether. Venable agreed, and on 30 March 1842 he underwent a painless operation. However, Long did not announce his discovery until 1849.

**Morton’s ether inhaler**

Horace Wells conducted the first public demonstration of the inhalational anesthetic at the Massachusetts General Hospital in Boston in 1845. However, the nitrous oxide was improperly administered and the patient cried out in pain. On October 16, 1846, Boston dentist William Thomas Green Morton gave a successful demonstration using diethyl ether to medical students at the same venue. Morton, who was unaware of Long’s previous work, was invited to the Massachusetts General Hospital to demonstrate his new technique for painless surgery. After Morton had induced anesthesia, surgeon John Collins Warren removed a tumor from the neck of Edward Gilbert Abbott. This occurred in the surgical amphitheater now called the Ether Dome. The previously skeptical Warren was impressed and stated, “Gentlemen, this is no humbug.” In a letter to Morton shortly thereafter, physician and writer Oliver Wendell Holmes, Sr. proposed naming the state produced “anesthesia”, and the procedure an “anesthetic”.

Morton at first attempted to hide the actual nature of his anesthetic substance, referring to it as Letheon. He received a US patent for his substance, but news of the successful anesthetic spread quickly by late 1846. Respected surgeons in Europe including Liston, Dieffenbach, Pirogov, and Syme quickly undertook numerous operations with ether. An American-born physician, Boott, encouraged London dentist James Robinson to perform a dental procedure on a Miss
Lonsdale. This was the first case of an operator-anesthetist. On the same day, 19 December 1846, in Dumfries Royal Infirmary, Scotland, a Dr. Scott used ether for a surgical procedure. The first use of anesthesia in the Southern Hemisphere took place in Launceston, Tasmania, that same year. Drawbacks with ether such as excessive vomiting and its explosive flammability led to its replacement in England with chloroform.

Discovered in 1831 by an American physician Samuel Guthrie (1782–1848), and independently a few months later by Frenchman Eugène Soubeiran (1797–1859) and Justus von Liebig (1803–73) in Germany, chloroform was named and chemically characterised in 1834 by Jean-Baptiste Dumas (1800–84). Its anaesthetic properties were noted early in 1847 by Marie-Jean-Pierre Flourens (1794–1867). The use of chloroform in anesthesia is linked to James Young Simpson, who, in a wide-ranging study of organic compounds, found chloroform’s efficacy on 4 November 1847. Its use spread quickly and gained royal approval in 1853 when John Snow gave it to Queen Victoria during the birth of Prince Leopold. Unfortunately, though free of ether’s flammability and consequent explosion hazard, chloroform is not as safe pharmacologically, especially when administered by an untrained practitioner (medical students, nurses, and occasionally members of the public were often pressed into giving anesthetics at this time). This led to many deaths from the use of chloroform that (with hindsight) might have been preventable. The first fatality directly attributed to chloroform anesthesia was recorded on 28 January 1848 after the death of Hannah Greener.

John Snow of London published articles from May 1848 onwards “On Narcotism by the Inhalation of Vapours” in the London Medical Gazette. Snow also involved himself in the production of equipment needed for the administration of inhalational anesthetics, the forerunner of today’s anesthesia machines.
Of these first famous anesthetics, only nitrous oxide is still widely used today, with chloroform and ether having been replaced by safer but sometimes more expensive general anesthetics, and cocaine by more effective local anesthetics with less abuse potential.

**Society and culture**

Almost all healthcare providers use anesthesia to some degree, however most health professions have their own field of specialists in the field including medicine, nursing and dentistry.

Doctors specializing in perioperative care, development of an anesthetic plan, and the administration of anesthetics are known in the US as **anesthesiologists** and in the UK, Canada, Australia, and NZ as **anaesthetists** or **anaesthesiologists**. All anesthetics in the UK, Australia, New Zealand, Hong Kong and Japan are administered by doctors.

Nurse anesthetists also administer anesthesia in 109 nations. In the US, 35% of anesthetics are provided by physicians in solo practice, about 55% are provided by anesthesia care teams (ACTs) with anesthesiologists medically directing anesthesiologist assistants or certified registered nurse anesthetists (CRNAs), and about 10% are provided by CRNAs in solo practice. There can also be anesthesiologist assistants (US) or physician assistant (anaesthesia) (UK) who assist with anesthesia.

**Special populations**

There are many circumstances when anesthesia needs to be altered for special circumstances due to the procedure (such as in cardiac surgery, cardiothoracic anesthesiology or neurosurgery), the patient (such as in pediatric anesthesia, geriatric, bariatric or obstetrical anesthesia) or special circumstances (such as in trauma, prehospital care, robotic surgery or extreme environments).
GENERAL ANAESTHESIA

General anaesthesia or general anesthesia is a medically induced state of unconsciousness with loss of protective reflexes, resulting from the administration of one or more general anaesthetic agents. It is carried out to allow medical procedures that would otherwise be intolerably painful for the patient; or where the nature of the procedure itself precludes the patient being awake.

A variety of medications may be administered, with the overall aim of ensuring unconsciousness, amnesia, analgesia, loss of reflexes of the autonomic nervous system, and in some cases paralysis of skeletal muscles. The optimal combination of drugs for any given patient and procedure is typically selected by an anaesthetist, or another provider such as a physician assistant or nurse anaesthetist (depending on local practice), in consultation with the patient and the surgeon, dentist or other practitioner performing the operative procedure.

History

Attempts at producing a state of general anaesthesia can be traced throughout recorded history in the writings of the ancient Sumerians, Babylonians, Assyrians, Egyptians, Greeks, Romans, Indians, and Chinese. During the Middle Ages, scientists and other scholars made significant advances in the Eastern world, while their European counterparts also made important advances.

The European Renaissance saw significant advances in anatomy and surgical technique. However, despite all this progress, surgery remained a treatment of last resort. Largely because of the associated pain, many patients chose certain death rather than undergo surgery. Although there has been a great deal of debate as to who deserves the most credit for the discovery of general anaesthesia, it is generally agreed that certain scientific discoveries in the late 18th and early 19th
centuries were critical to the eventual introduction and development of modern anaesthetic techniques.

Two enormous leaps occurred in the late 19th century, which together allowed the transition to modern surgery. An appreciation of the germ theory of disease led rapidly to the development and application of antiseptic techniques in surgery. Antisepsis, which soon gave way to asepsis, reduced the overall morbidity and mortality of surgery to a far more acceptable rate than in previous eras. Concurrent with these developments were the significant advances in pharmacology and physiology which led to the development of general anaesthesia and the control of pain. In 14 November 1804, Hanaoka Seishū, who was a Japanese doctor, succeeded the first to perform surgery using general anesthesia in the world.

In the 20th century, the safety and efficacy of general anaesthesia was improved by the routine use of tracheal intubation and other advanced airway management techniques. Significant advances in monitoring and new anaesthetic agents with improved pharmacokinetic and pharmacodynamic characteristics also contributed to this trend. Finally, standardized training programs for anaesthesiologists and nurse anaesthetists emerged during this period.

Purpose

General anaesthesia has many purposes, including:
1. Analgesia (loss of response to pain)
2. Amnesia (loss of memory)
3. Immobility (loss of motor reflexes)
4. Hypnosis (unconsciousness)
5. Paralysis (skeletal muscle relaxation)

Biochemical mechanism of action

The biochemical mechanism of action of general anaesthetics is not well understood. To induce unconsciousness,
Anaesthetics have myriad sites of action and affect the central nervous system (CNS) at multiple levels. Common areas of the central nervous system whose functions are interrupted or changed during general anesthesia include the cerebral cortex, thalamus, reticular activating system, and spinal cord. Current theories on the anaesthetized state identify not only target sites in the CNS but also neural networks and loops whose interruption is linked with unconsciousness. Potential pharmacologic targets of general anaesthetics are GABA, glutamate-activated ion channels, NMDA receptor families, voltage-gated ion channels, and glycine and serotonin receptors.

Halothane has been found to be a GABA agonist, and ketamine is an NMDA receptor antagonist.

Preanaesthetic evaluation

Prior to a planned procedure, the anaesthetist reviews medical records and/or interviews the patient to determine the best combination of drugs and dosages and the degree to which monitoring will be required to ensure a safe and effective procedure. Key factors in this evaluation are the patient’s age, body mass index, medical and surgical history, current medications, and fasting time. Thorough and accurate answering of the questions is important so that the anaesthetist can select the proper drugs and procedures. For example, a patient who consumes significant quantities of alcohol or illicit drugs could be undermedicated if s/he fails to disclose this fact, and this could lead to anaesthesia awareness or intraoperative hypertension. Commonly used medications can interact with anaesthetics, and failure to disclose such usage can increase the risk to the patient.

An important aspect of pre-anaesthetic evaluation is an assessment of the patient’s airway, involving inspection of the mouth opening and visualisation of the soft tissues of the pharynx. The condition of teeth and location of dental crowns
are checked, and neck flexibility and head extension are observed.

**Premedication**

Prior to administration of a general anaesthetic, the anaesthetist may administer one or more drugs that complement or improve the quality or safety of the anaesthetic.

One commonly used premedication is clonidine, an alpha-2 adrenergic agonist. Clonidine premedication reduces the need for anaesthetic induction agents, for volatile agents to maintain general anaesthesia, and for postoperative analgesics. It also reduces postoperative shivering, postoperative nausea and vomiting, and emergence delirium. In children, clonidine premedication is at least as effective as benzodiazepines and has less serious side effects. However, oral clonidine can take up to 45 minutes to take full effect, and drawbacks include hypotension and bradycardia.

Midazolam, a benzodiazepine characterized by a rapid onset and short duration, is effective in reducing preoperative anxiety, including separation anxiety in children. Dexmedetomidine and certain atypical antipsychotic agents may be used in uncooperative children.

Melatonin has been found to be effective as an anaesthetic premedication in both adults and children because of its hypnotic, anxiolytic, sedative, antinociceptive, and anticonvulsant properties. Unlike midazolam, melatonin does not impair psychomotor skills or hinder recovery. Recovery is more rapid after premedication with melatonin than with midazolam, and there is also a reduced incidence of postoperative agitation and delirium. Melatonin premedication also reduces the required induction dose of propofol and sodium thiopental.

Another example of anaesthetic premedication is the preoperative administration of beta adrenergic antagonists to
reduce the incidence of postoperative hypertension, cardiac
dysrhythmia, or myocardial infarction. Anaesthesiologists may
administer an antiemetic agent such as ondansetron,
droperidol, or dexamethasone to prevent postoperative nausea
and vomiting, or subcutaneous heparin or enoxaparin to reduce
the incidence of deep vein thrombosis. Other commonly used
premedication agents include opioids such as fentanyl or
sufentanil, gastrokinetic agents such as metoclopramide, and
histamine antagonists such as famotidine.

Non-pharmacologic preanaesthetic interventions include
playing relaxing music, massage, and reducing ambient light
and noise levels in order to maintain the sleep-wake cycle.
These techniques are particularly useful for children and
patients with intellectual disabilities. Other options for children
who refuse or cannot tolerate pharmacologic premedication
include interventions by clowns and child life specialists.
Minimizing sensory stimulation or distraction by video games
may also help to reduce anxiety prior to or during induction
of general anaesthesia.

STAGES OF ANAESTHESIA

Guedel’s classification, introduced by Arthur Ernest Guedel
in 1937, describes four stages of anaesthesia. Despite newer
anaesthetic agents and delivery techniques, which have led to
more rapid onset of – and recovery from – anaesthesia (in
some cases bypassing some of the stages entirely), the principles
remain.

Stage 1

Stage 1, also known as induction, is the period between the
administration of induction agents and loss of consciousness.
During this stage, the patient progresses from analgesia without
amnesia to analgesia with amnesia. Patients can carry on a
conversation at this time.
Stage 2

Stage 2, also known as the *excitement stage*, is the period following loss of consciousness and marked by excited and delirious activity. During this stage, the patient’s respiration and heart rate may become irregular. In addition, there may be uncontrolled movements, vomiting, suspension of breathing, and pupillary dilation. Because the combination of spastic movements, vomiting, and irregular respiration may compromise the patient’s airway, rapidly acting drugs are used to minimize time in this stage and reach Stage 3 as fast as possible.

Stage 3

In Stage 3, also known as *surgical anaesthesia*, the skeletal muscles relax, vomiting stops, respiratory depression occurs, and eye movements slow and then stop. The patient is unconscious and ready for surgery. This stage is divided into four planes:

1. The eyes roll, then become fixed;
2. Corneal and laryngeal reflexes are lost;
3. The pupils dilate and light reflex is lost;
4. Intercostal paralysis and shallow abdominal respiration occur.

Stage 4

Stage 4, also known as *overdose*, occurs when too much anaesthetic medication is given relative to the amount of surgical stimulation and the patient has severe brainstem or medullary depression, resulting in a cessation of respiration and potential cardiovascular collapse. This stage is lethal without cardiovascular and respiratory support.

Induction

General anaesthesia is usually induced in a medical facility, most commonly in an operating theatre or in a dedicated
anaesthetic room adjacent to the theatre. However, it may also be conducted in other locations, such as an endoscopy suite, radiology or cardiology department, emergency department, or ambulance, or at the site of a disaster where extrication of the patient may be impossible or impractical.

Anaesthetic agents may be administered by various routes, including inhalation, injection (intravenous, intramuscular, or subcutaneous), oral, and rectal. Once they enter the circulatory system, the agents are transported to their biochemical sites of action in the central and autonomic nervous systems.

Most general anaesthetics are induced either intravenously or by inhalation. Intravenous injection works faster than inhalation, taking about 10–20 seconds to induce total unconsciousness.

This minimizes the excitatory phase (Stage 2) and thus reduces complications related to the induction of anaesthesia. Commonly used intravenous induction agents include propofol, sodium thiopental, etomidate, and ketamine. Inhalational anaesthesia may be chosen when intravenous access is difficult to obtain (e.g., children), when difficulty maintaining the airway is anticipated, or when the patient prefers it. Sevoflurane is the most commonly used agent for inhalational induction, because it is less irritating to the tracheobronchial tree than other agents.

As an example sequence of induction drugs:
1. Pre-oxygenation to fill lungs with oxygen to permit a longer period of apnea during intubation without affecting blood oxygen levels
2. Lidocaine for sedation and systemic analgesia for intubation
3. Fentanyl for systemic analgesia for intubation
4. Propofol for sedation for intubation
5. Switching from oxygen to a mixture of oxygen and inhalational anesthetic
Laryngoscopy and intubation are both very stimulating and induction blunts the response to these maneuvers while simultaneously inducing a near-coma state to prevent awareness.

**Physiologic monitoring**

Several monitoring technologies allow for a controlled induction of, maintenance of, and emergence from general anaesthesia.

1. **Continuous electrocardiography (ECG or EKG):** Electrodes are placed on the patient’s skin to monitor heart rate and rhythm. This may also help the anaesthesiologist to identify early signs of heart ischaemia. Typically lead II and V5 are monitored for arrhythmias and ischemia, respectively.

2. **Continuous pulse oximetry (SpO2):** A device is placed, usually on a finger, to allow for early detection of a fall in a patient’s haemoglobin saturation with oxygen (hypoxaemia).

3. **Blood pressure monitoring:** There are two methods of measuring the patient’s blood pressure. The first, and most common, is non-invasive blood pressure (NIBP) monitoring. This involves placing a blood pressure cuff around the patient’s arm, forearm, or leg. A machine takes blood pressure readings at regular, preset intervals throughout the surgery. The second method is invasive blood pressure (IBP) monitoring. This method is reserved for patients with significant heart or lung disease, the critically ill, and those undergoing major procedures such as cardiac or transplant surgery, or when large blood loss is expected. It involves placing a special type of plastic cannula in an artery, usually in the wrist (radial artery) or groin (femoral artery).

4. **Agent concentration measurement:** Anaesthetic machines typically have monitors to measure the
percentage of inhalational anaesthetic agents used as well as exhalation concentrations. These monitors include measuring oxygen, carbon dioxide, and inhalational anaesthetics (e.g., nitrous oxide, isoflurane).

5. Oxygen measurement: Almost all circuits have an alarm in case oxygen delivery to the patient is compromised. The alarm goes off if the fraction of inspired oxygen drops below a set threshold.

6. A circuit disconnect alarm or low pressure alarm indicates failure of the circuit to achieve a given pressure during mechanical ventilation.

7. Capnography measures the amount of carbon dioxide exhaled by the patient in percent or mmHg, allowing the anaesthesiologist to assess the adequacy of ventilation. MmHg is usually used to allow the provider to see more subtle changes.

8. Temperature measurement to discern hypothermia or fever, and to allow early detection of malignant hyperthermia.

9. Electroencephalography, entropy monitoring, or other systems may be used to verify the depth of anaesthesia. This reduces the likelihood of anesthesia awareness and of overdose.

Airway management

Anaesthetized patients lose protective airway reflexes (such as coughing), airway patency, and sometimes a regular breathing pattern due to the effects of anaesthetics, opioids, or muscle relaxants. To maintain an open airway and regulate breathing, some form of breathing tube is inserted after the patient is unconscious. To enable mechanical ventilation, an endotracheal tube is often used, although there are alternative devices that can assist respiration, such as face masks or laryngeal mask airways. Generally, full mechanical ventilation is only used if a very deep state of general anesthesia is to be
induced for a major procedure, and/or with a profoundly ill or injured patient. That said, induction of general anesthesia results in apnea and requires ventilation until the drugs wear off and spontaneous breathing starts. In other words, ventilation may be required for both induction and maintenance of general anesthesia or just during the induction. However, mechanical ventilation can provide ventilatory support during spontaneous breathing to ensure adequate gas exchange.

**Eye management**

General anaesthesia reduces the tonic contraction of the orbicularis oculi muscle, causing lagophthalmos, or incomplete eye closure, in 59% of patients. In addition, tear production and tear-film stability are reduced, resulting in corneal epithelial drying and reduced lysosomal protection. The protection afforded by Bell’s phenomenon (in which the eyeball turns upward during sleep, protecting the cornea) is also lost. Careful management is required to reduce the likelihood of eye injuries during general anaesthesia.

**Neuromuscular blockade**

Paralysis, or temporary muscle relaxation with a neuromuscular blocker, is an integral part of modern anaesthesia. The first drug used for this purpose was curare, introduced in the 1940s, which has now been superseded by drugs with fewer side effects and, generally, shorter duration of action. Muscle relaxation allows surgery within major body cavities, such as the abdomen and thorax, without the need for very deep anaesthesia, and also facilitates endotracheal intubation.

Acetylcholine, the natural neurotransmitter at the neuromuscular junction, causes muscles to contract when it is released from nerve endings. Muscle relaxants work by preventing acetylcholine from attaching to its receptor. Paralysis of the muscles of respiration—the diaphragm and
intercostal muscles of the chest—requires that some form of artificial respiration be implemented. Because the muscles of the larynx are also paralysed, the airway usually needs to be protected by means of an endotracheal tube.

Paralysis is most easily monitored by means of a peripheral nerve stimulator. This device intermittently sends short electrical pulses through the skin over a peripheral nerve while the contraction of a muscle supplied by that nerve is observed. The effects of muscle relaxants are commonly reversed at the end of surgery by anticholinesterase drugs. Examples of skeletal muscle relaxants in use today are pancuronium, rocuronium, vecuronium, atracurium, mivacurium, and succinylcholine.

**MAINTENANCE**

The duration of action of intravenous induction agents is generally 5 to 10 minutes, after which time spontaneous recovery of consciousness will occur. In order to prolong unconsciousness for the required duration (usually the duration of surgery), anaesthesia must be maintained. This is achieved by allowing the patient to breathe a carefully controlled mixture of oxygen, nitrous oxide, and a volatile anaesthetic agent, or by administering medication, usually propofol, through an intravenous catheter. Inhaled agents are frequently supplemented by intravenous anaesthetics, such as opioids (usually fentanyl or a fentanyl derivative) and sedatives (usually propofol or midazolam), although with a propofol-based anaesthetic, supplementation by inhalation agents is not required.

At the end of surgery, the anaesthetic agents are discontinued. Recovery of consciousness occurs when the concentration of anaesthetic in the brain drops below a certain level (usually within 1 to 30 minutes, depending on the duration of surgery). In the 1990s, a novel method of maintaining anaesthesia was developed in Glasgow, Scotland. Called TCI (target controlled infusion), it involves using a computer-
controlled syringe driver (pump) to infuse propofol throughout the duration of surgery, removing the need for a volatile anaesthetic and allowing pharmacologic principles to more precisely guide the amount of the drug used by setting the desired drug concentration. Advantages include faster recovery from anaesthesia, reduced incidence of post-operative nausea and vomiting, and absence of a trigger for malignant hyperthermia. At present, TCI is not permitted in the United States, but a syringe pump delivering a specific rate of medication is commonly used instead.

Other medications are occasionally used to treat side effects or prevent complications. They include antihypertensives to treat high blood pressure; ephedrine or phenylephrine to treat low blood pressure; salbutamol to treat asthma, laryngospasm, or bronchospasm; and epinephrine or diphenhydramine to treat allergic reactions. Glucocorticoids or antibiotics are sometimes given to prevent inflammation and infection, respectively.

**Emergence**

Emergence is the return to baseline physiologic function of all organ systems after the cessation of general anaesthetics. This stage may be accompanied by temporary neurologic phenomena, such as agitated emergence (acute mental confusion), aphasia (impaired production or comprehension of speech), or focal impairment in sensory or motor function. Shivering is also fairly common and can be clinically significant because it causes an increase in oxygen consumption, carbon dioxide production, cardiac output, heart rate, and systemic blood pressure. The proposed mechanism is based on the observation that the spinal cord recovers at a faster rate than the brain. This results in uninhibited spinal reflexes manifested as clonic activity (shivering). This theory is supported by the fact that doxapram, a CNS stimulant, is somewhat effective in abolishing postoperative shivering. Cardiovascular events such
as increased or decreased blood pressure, rapid heart rate, or other cardiac dysrhythmias are also common during emergence from general anaesthesia, as are respiratory symptoms such as dyspnoea.

**Postoperative care**

Anaesthesia should conclude with a pain-free awakening and a management plan for postoperative pain relief. This may be in the form of regional analgesia or oral, transdermal, or parenteral medication. Minor surgical procedures are amenable to oral pain relief medications such as paracetamol and NSAIDs (e.g., ibuprofen). Moderate levels of pain require the addition of mild opiates such as tramadol. Major surgical procedures may require a combination of modalities to confer adequate pain relief. Parenteral methods include patient-controlled analgesia (PCA) involving a strong opiate such as morphine, fentanyl, or oxycodone. The patient presses a button to activate a syringe device and receive a preset dose or “bolus” of the drug (e.g., one milligram of morphine). The PCA device then “locks out” for a preset period to allow the drug to take effect. If the patient becomes too sleepy or sedated, he or she makes no more requests. This confers a fail-safe aspect that is lacking in continuous-infusion techniques.

Postanesthetic shivering is common. Apart from causing discomfort and exacerbating pain, shivering has been shown to increase oxygen consumption, catecholamine release, cardiac output, heart rate, blood pressure, and intraocular pressure. A number of techniques are used to reduce shivering, such as increased ambient temperature, conventional or forced warm air blankets, and warmed intravenous fluids.

In many cases, opioids used in general anaesthesia can cause postoperative ileus, even after non-abdominal surgery. Administration of a n-opioid antagonist such as alvimopan immediately after surgery can help reduce the severity and duration of ileus.
PERIOPERATIVE MORTALITY

Most perioperative mortality is attributable to complications from the operation, such as haemorrhage, sepsis, and failure of vital organs. Current estimates of perioperative mortality in procedures involving general anaesthesia range from one in 53 to one in 5,417. However, a 1997 Canadian retrospective review of 2,830,000 oral surgical procedures in Ontario between 1973 and 1995 reported only four deaths in cases in which an oral and maxillofacial surgeon or a dentist with specialized training in anaesthesia administered the general anaesthetic or deep sedation. The authors calculated an overall mortality rate of 1.4 per 1,000,000.

Mortality directly related to anaesthetic management is very uncommon but may be caused by pulmonary aspiration of gastric contents, asphyxiation, or anaphylaxis. These in turn may result from malfunction of anaesthesia-related equipment or, more commonly, human error. A 1978 study found that 82% of preventable anaesthesia mishaps were the result of human error. In a 1954 review of 599,548 surgical procedures at 10 hospitals in the United States between 1948 and 1952, 384 deaths were attributed to anaesthesia, for an overall mortality rate of 0.064%. In 1984, after a television programme highlighting anaesthesia mishaps aired in the United States, American anesthesiologist Ellison C. Pierce appointed the Anesthesia Patient Safety and Risk Management Committee within the American Society of Anesthesiologists. This committee was tasked with determining and reducing the causes of anaesthesia-related morbidity and mortality. An outgrowth of this committee, the Anesthesia Patient Safety Foundation, was created in 1985 as an independent, nonprofit corporation with the goal “that no patient shall be harmed by anesthesia”.

As with perioperative mortality rates in general, mortality attributable to the management of general anaesthesia is controversial. Estimates of the incidence of perioperative
Anesthesia

mortality directly attributable to anaesthesia range from one in 6,795 to one in 200,200.

SEDATION

Sedation is the reduction of irritability or agitation by administration of sedative drugs, generally to facilitate a medical procedure or diagnostic procedure. Examples of drugs which can be used for sedation include propofol, etomidate, ketamine, fentanyl, and midazolam.

Medical uses

Sedation is typically used in minor surgical procedures such as endoscopy, vasectomy, or dentistry and for reconstructive surgery, some cosmetic surgeries, removal of wisdom teeth, or for high-anxiety patients. Sedation methods in dentistry include inhalation sedation (using nitrous oxide), oral sedation, and intravenous (IV) sedation. Inhalation sedation is also sometimes referred to as relative analgesia.

Sedation is also used extensively in the intensive care unit so that patients who are being ventilated tolerate having an endotracheal tube in their trachea. Also can be used during a long term brain EEG to help patient relax.

Risks

Airway obstruction, apnea and hypotension are not uncommon during sedation and require the presence of health professionals who are suitably trained to detect and manage these problems.

Levels of sedation

Sedation scales are used in medical situations in conjunction with a medical history in assessing the applicable degree of sedation in patients in order to avoid under-sedation (the patient risks experiencing pain or distress) and over-sedation (the patient risks side effects such as suppression of breathing,
which might lead to death). Typically, levels are (i) agitation, (ii) calm, (iii) responsive to voice alone, (iv) responsive to tactile stimulation, (v) responsive to painful stimulation only, and (vi) unresponsive to painful stimulation.

Examples of sedation scales include MSAT (Minnesota Sedation Assessment Tool), UMSS (University of Michigan Sedation Scale), the Ramsay Scale (Ramsay, et al. 1974) and the RASS (Richmond Agitation-Sedation Scale).

The American Society of Anesthesiologists defines the continuum of sedation as follows:

- **Minimal Sedation** – Normal response to verbal stimuli.
- **Moderate Sedation** – Purposeful response to verbal/tactile stimulation. (This is usually referred to as “conscious sedation”)
- **Deep Sedation** – Purposeful response to repeated or painful stimulation.
- **General Anesthesia** – Unarousable even with painful stimulus.

In the United Kingdom, deep sedation is considered to be a part of the spectrum of general anesthesia, as opposed to conscious sedation.

**Patient screening**

Prior to any oral sedation methods being used on a patient, screening must be done to identify possible health concerns. Before using sedation, doctors try to identify any of the following that may apply:

1. known drug allergies and sensitivities,
2. hypertension
3. heart defects
4. kidney
5. other allergens, such as latex allergy
6. history of stroke or transient ischemic attack (TIA) (certain oral sedation methods may trigger a TIA)
7. neuromuscular disorders (such as muscular dystrophy)
8. a current list of medications and herbal supplements taken by the patient

A patient with any of these conditions must be evaluated for special procedures to minimize the risk of patient injury due to the sedation method.

In addition to the aforementioned precautions, patients should be interviewed to determine if they have any other condition that may lead to complications while undergoing treatment. Any head, neck, or spinal cord injuries should be noted as well as any diagnosis of osteoporosis.
Spinal Anaesthesia

Spinal anaesthesia (or spinal anesthesia), also called spinal block, subarachnoid block, intradural block and intrathecal block, is a form of regional anaesthesia involving the injection of a local anaesthetic into the subarachnoid space, generally through a fine needle, usually 9 cm (3.5 in) long. For obese patients longer needles are available (12.7 cm / 5 inches). The tip of the spinal needle has a point or small bevel. Recently, pencil point needles have been made available (Whitacre, Sprotte, Gertie Marx and others).

Medical uses

Spinal anaesthesia is a commonly used technique, either on its own or in combination with sedation or general anaesthesia. Examples of uses include:

- Orthopaedic surgery on the pelvis, hip, femur, knee, tibia, and ankle, including arthroplasty and joint replacement
- Vascular surgery on the legs
- Endovascular aortic aneurysm repair
- Hernia (inguinal or epigastric)
- Haemorrhoidectomy
- Nephrectomy and cystectomy in combination with general anaesthesia
Spinal Anaesthesia

- Transurethral resection of the prostate and transurethral resection of bladder tumours
- Hysterectomy in different techniques used
- Caesarean sections

Spinal anaesthesia is the technique of choice for Caesarean section as it avoids a general anaesthetic and the risk of failed intubation (which is approximately 1 in 250 in pregnant women). It also means the mother is conscious and the partner is able to be present at the birth of the child. The post operative analgesia from intrathecal opioids in addition to non-steroidal anti-inflammatory drugs is also good.

If surgery allows, spinal anaesthesia is very useful in patients with severe respiratory disease such as COPD as it avoids intubation and ventilation. It may also be useful in patients where anatomical abnormalities may make tracheal intubation very difficult.

Contraindications
- Non-availability of patient’s consent
- Local infection or sepsis at the site of lumbar puncture
- Bleeding disorders, thrombocytopaenia, or systemic anticoagulation (secondary to an increased risk of a spinal epidural hematoma)
- Space occupying lesions of the brain
- Anatomical disorders of the spine
- Hypovolaemia e.g. following massive haemorrhage, including in obstetric patients

Risks/Complications

Can be broadly classified as immediate (on the operating table) or late (in the post-anaesthesia care unit or ward):
- Hypotension (Neurogenic shock) - Due to sympathetic nervous system blockade. Common but usually easily treated with intravenous fluid and sympathomimetic
drugs such as Ephedrine, Phenylephrine or Metaraminol
• Post dural puncture head ache or post spinal head ache
  - Associated with the size and type of spinal needle used
• Cauda equina injury - very rare, due to the insertion site being too high
• Cardiac arrest - very rare, usually related to the underlying medical condition of the patient
• Spinal canal haematoma, with or without subsequent neurological sequelae due to compression of the spinal nerves. Urgent CT/MRI to confirm the diagnosis followed by urgent surgical decompression to avoid permanent neurological damage
• Epidural abscess, again with potential permanent neurological damage. May present as meningitis and abscess with back pain, fever, lower limb neurological impairment and loss of bladder/bowel function. Urgent CT/MRI confirms the diagnosis followed by antibiotics and urgent surgical drainage

Technique

Regardless of the anaesthetic agent (drug) used, the desired effect is to block the transmission of afferent nerve signals from peripheral nociceptors. Sensory signals from the site are blocked, thereby eliminating pain. The degree of neuronal blockade depends on the amount and concentration of local anaesthetic used and the properties of the axon. Thin unmyelinated C-fibres associated with pain are blocked first, while thick, heavily myelinated A-alpha motor neurons are blocked moderately. Heavily myelinated, small preganglionic sympathetic fibers are blocked first. The desired result is total numbness of the area. A pressure sensation is permissible and often occurs due to incomplete blockade of the thicker A-beta mechanoreceptors. This allows surgical procedures to be
performed with no painful sensation to the person undergoing the procedure.

Some sedation is sometimes provided to help the patient relax and pass the time during the procedure, but with a successful spinal anaesthetic the surgery can be performed with the patient wide awake.

Limitations

Spinal anaesthetics are typically limited to procedures involving most structures below the upper abdomen. To administer a spinal anaesthetic to higher levels may affect the ability to breathe by paralysing the intercostal respiratory muscles, or even the diaphragm in extreme cases (called a “high spinal”, or a “total spinal”, with which consciousness is lost), as well as the body’s ability to control the heart rate via the cardiac accelerator fibres. Also, injection of spinal anaesthesia higher than the level of L1 can cause damage to the spinal cord, and is therefore usually not done.

Difference from epidural anesthesia

Epidural anesthesia is a technique whereby a local anesthetic drug is injected through a catheter placed into the epidural space. This technique has some similarity to spinal anesthesia, both are neuraxial, and the two techniques may be easily confused with each other. Differences include:

- A spinal anaesthetic delivers drug to the intrathecal space (the CSF), and acts on the spinal cord directly. An epidural delivers drugs outside the dura (outside CSF), and has its main effect on nerve roots leaving the dura at the level of the epidural, rather than on the spinal cord itself.
- A spinal gives profound block of all motor and sensory function below the level of injection, whereas an epidural blocks a ‘band’ of nerve roots around the site of injection, with normal function above, and close-to-normal function below the levels blocked.
• The injected dose for an epidural is larger, being about 10–20 mL compared to 1.5–3.5 mL in a spinal.
• In an epidural, an indwelling catheter may be placed that serves for additional injections, while a spinal is almost always a one-shot only.
• The onset of analgesia is approximately 25–30 minutes in an epidural, while it is approximately 5 minutes in a spinal.
• An epidural often does not cause as significant a neuromuscular block as a spinal, unless specific local anesthetics are also used which block motor fibres as readily as sensory nerve fibres.
• An epidural may be given at a cervical, thoracic, or lumbar site, while a spinal must be injected below L2 to avoid piercing the spinal cord.

Injected substances

Bupivacaine (Marcaine) is the local anaesthetic most commonly used, although lidocaine (lignocaine), tetracaine, procaine, ropivacaine, levobupivacaine, prilocaine and cinchocaine may also be used. Commonly opioids are added to improve the block and provide post-operative pain relief, examples include morphine, fentanyl, diamorphine or buprenorphine. Non-opioids like clonidine may also be added to prolong the duration of analgesia (although Clonidine may cause hypotension). In the United Kingdom, since 2004 the National Institute for Health and Care Excellence recommends that spinal anaesthesia for Caesarean section is supplemented with intrathecal diamorphine and this combination is now the modal form of anaesthesia for this indication in that country. The peculiar legal status of diamorphine (heroin) means that this cannot easily occur elsewhere.

Baricity refers to the density of a substance compared to the density of human cerebrospinal fluid. Baricity is used in anaesthesia to determine the manner in which a particular
drug will spread in the intrathecal space. Usually, the
hyperbaric, (for example, hyperbaric bupivacaine) is chosen,
as its spread can be effectively and predictably controlled by
the Anaesthesiologist or Nurse Anesthetist, by tilting the
patient. Hyperbaric solutions are made more dense by adding
glucose to the mixture.

Baricity is one factor that determines the spread of a spinal
anaesthetic but the effect of adding a solute to a solvent, i.e.
solvation or dissolution, also has an effect on the spread of the
spinal anaesthetic.

In tetracaine spinal anaesthesia, it was discovered that the
rate of onset of analgesia was faster and the maximum level
of analgesia was higher with a 10% glucose solution than with
a 5% glucose spinal anaesthetic solution. Also, the amount of
ephedrine required was less in the patients who received the
5% glucose solution. In another study this time with 0.5%
bupivacaine the mean maximum extent of sensory block was
significantly higher with 8% glucose (T3.6) than with 0.83%
glucose (T7.2) or 0.33% glucose (T9.5). Also the rate of onset
of sensory block to T12 was fastest with solutions containing
8% glucose.

History

The first spinal analgesia was administered in 1885 by
James Leonard Corning (1855–1923), a neurologist in New
York. He was experimenting with cocaine on the spinal nerves
of a dog when he accidentally pierced the dura mater.

The first planned spinal anaesthesia for surgery in man
was administered by August Bier (1861–1949) on 16 August
1898, in Kiel, when he injected 3 ml of 0.5% cocaine solution
into a 34-year-old labourer. After using it on 6 patients, he and
his assistant each injected cocaine into the other’s spine. They
recommended it for surgeries of legs, but gave it up due to
the toxicity of cocaine.
Society and culture

Current usage of this technique is waning in the developed world, with epidural analgesia or combined spinal-epidural anaesthesia emerging as the techniques of choice where the cost of the disposable ‘kit’ is not an issue.

However spinal analgesia is the mainstay of anaesthesia in countries like India, Pakistan and parts of Africa, excluding the major centres. Thousands of spinal anaesthetics are administered daily in hospitals and nursing homes. At a low cost, a surgery of up to two hours duration can be performed below the umbilicus of the patient.

EPIDURAL ADMINISTRATION

Epidural administration is a medical route of administration in which a drug or contrast agent is injected into the epidural space of the spinal cord. Techniques such as epidural analgesia and epidural anaesthesia employ this route of administration. The epidural route is frequently employed by certain physicians and nurse anaesthetists to administer diagnostic (e.g. radiocontrast agents) and therapeutic (e.g., glucocorticoids) chemical substances, as well as certain analgesic and local anaesthetic agents. Epidural techniques frequently involve injection of drugs through a catheter placed into the epidural space. The injection can result in a loss of sensation—including the sensation of pain—by blocking the transmission of signals through nerve fibers in or near the spinal cord.

It was in 1921 when the Spanish military surgeon Fidel Pagés (1886–1923) developed, for the first time, the technique of “single-shot” lumbar epidural anaesthesia.

Difference from spinal anaesthesia

Spinal anaesthesia is a technique whereby a local anaesthetic drug is injected into the cerebrospinal fluid. This technique
has some similarity to epidural anaesthesia, and lay people often confuse the two techniques. Important differences include:

- To achieve epidural analgesia or anaesthesia, a larger dose of drug is typically necessary than with spinal analgesia or anaesthesia.
- The onset of analgesia is slower with epidural analgesia or anaesthesia than with spinal analgesia or anaesthesia.
- An epidural injection may be performed anywhere along the vertebral column (cervical, thoracic, lumbar, or sacral), while spinal injections are typically performed below the second lumbar vertebral body to avoid piercing and consequently damaging the spinal cord.
- It is easier to achieve segmental analgesia or anaesthesia using the epidural route than using the spinal route.
- An indwelling catheter is more commonly placed in the setting of epidural analgesia or anaesthesia than with spinal analgesia or anaesthesia.

**Indications**

Injecting medication into the epidural space is primarily performed for analgesia. This may be performed using a number of different techniques and for a variety of reasons. Additionally, some of the side-effects of epidural analgesia may be beneficial in some circumstances (e.g., vasodilation may be beneficial if the subject has peripheral vascular disease). When a catheter is placed into the epidural space a continuous infusion can be maintained for several days, if needed. Epidural analgesia may be used:

- For analgesia alone, where surgery is not contemplated. An epidural injection or infusion for pain relief (e.g. in childbirth) is less likely to cause loss of muscle power, but has to be augmented to be sufficient for surgery.
- As an adjunct to general anaesthesia. The anaesthetist may use epidural analgesia in addition to general anaesthesia. This may reduce the patient’s requirement
for opioid analgesics. This is suitable for a wide variety of surgery, for example gynaecological surgery (e.g. hysterectomy), orthopaedic surgery (e.g. hip replacement), general surgery (e.g. laparotomy) and vascular surgery (e.g. open aortic aneurysm repair).

• As a sole technique for surgical anaesthesia. Some operations, most frequently Caesarean section, may be performed using an epidural anaesthetic as the sole technique. This can allow the patient to remain awake during the operation. The dose required for anaesthesia is much higher than that required for analgesia.

• For post-operative analgesia, after an operation where the epidural technique is employed as the sole anaesthetic, or in conjunction with general anaesthesia. Analgesics are administered into the epidural space typically for a few days after surgery, provided a catheter has been inserted. Through the use of a patient-controlled epidural analgesia (PCEA) infusion pump, a person can supplement an epidural infusion with occasional doses of pain medication through an epidural catheter.

• For the treatment of back pain. Injection of analgesics and steroids into the epidural space may improve some forms of back pain.

• For the treatment of chronic pain or palliation of symptoms in terminal care, usually in the short- or medium-term.

The epidural space is more difficult and risky to access as one ascends the spine (because the spinal cord gains more nerves as it ascends and fills the epidural space leaving less room for error), so epidural techniques are most suitable for analgesia anywhere in the lower body and as high as the chest. They are (usually) much less suitable for analgesia for the neck, or arms and are not possible for the head (since sensory innervation for the head arises directly from the brain via
cranial nerves rather than from the spinal cord via the epidural space.)

**Anatomy**

The epidural space is the space inside the bony spinal canal but just outside the dura mater ("dura"). In contact with the inner surface of the dura is another membrane called the arachnoid mater ("arachnoid"). The cerebrospinal fluid that surrounds the spinal cord is contained by the arachnoid mater. In adults, the spinal cord terminates around the level of the disc between L1 and L2 (in neonates it extends to L3 but can reach as low as L4), below which lies a bundle of nerves known as the cauda equina ("horse's tail"). Hence, lumbar epidural injections carry a low risk of injuring the spinal cord.

Insertion of an epidural needle involves threading a needle between the bones, through the ligaments and into the epidural potential space taking great care to avoid puncturing the layer immediately below containing CSF under pressure.

**Technique**

Procedures involving injection of any substance into the epidural space require the operator to be technically proficient in order to avoid complications.

The subject may be in the seated, lateral or prone positions. The level of the spine at which the catheter is best placed depends mainly on the site and type of an intended operation or the anatomical origin of pain. The iliac crest is a commonly used anatomical landmark for lumbar epidural injections, as this level roughly corresponds with the fourth lumbar vertebra, which is usually well below the termination of the spinal cord. The Tuohy needle is usually inserted in the midline, between the spinous processes. When using a paramedian approach, the tip of the needle passes along a shelf of vertebral bone called the lamina until just before reaching the ligamentum flavum and the epidural space.
Along with a sudden loss of resistance to pressure on the plunger of the syringe, a slight clicking sensation may be felt by the operator as the tip of the needle breaches the ligamentum flavum and enters the epidural space.

Practitioners commonly use air or saline for identifying the epidural space. However, evidence is accumulating that saline is preferable to air, as it is associated with a better quality of analgesia and lower incidence of post-dural-puncture headache. In addition to the loss of resistance technique, realtime observation of the advancing needle is becoming more common. This may be done using a portable ultrasound scanner, or with fluoroscopy (moving X-ray pictures).

After placement of the tip of the needle into the epidural space, a catheter is often threaded through the needle. The needle is then withdrawn over the catheter. Generally the catheter is inserted 4–6 cm into the epidural space. The catheter is typically secured to the skin with adhesive tape or dressings to prevent it becoming dislodged.

The catheter is a fine plastic tube, through which anaesthetics may be injected into the epidural space. Many epidural catheters have a blind end but have three or more orifices along the shaft near the distal tip (far end) of the catheter. This not only disperses the injected agents more widely around the catheter, but also reduces the incidence of catheter blockage.

Choice of agents A person receiving an epidural for pain relief may receive local anaesthetic, an opioid, or both. Common local anaesthetics include lidocaine, mepivacaine, bupivacaine, ropivacaine, and chloroprocaine. Common opioids include hydromorphone, morphine, fentanyl, sufentanil, and pethidine (known as meperidine in the United States). These are injected in relatively small doses, compared to when they are injected intravenously. Other agents such as clonidine or ketamine are also sometimes used.
Bolus or infusion?

For a short procedure, the anaesthetist may introduce a single dose of medication (the “bolus” technique). This will eventually dissipate. Thereafter, the anaesthetist may repeat the bolus provided the catheter remains undisturbed. For a prolonged effect, a continuous infusion of drugs may be employed. There is some evidence that an automated intermittent bolus technique provides better analgesia than a continuous infusion technique, though the total doses are identical.

Level and intensity of block Typically, the effects of the epidural block are noted below a specific level on the body. This level may be determined by the anaesthetist. A high insertion level may result in sparing of nerve function in the lower spinal nerves. For example, a thoracic epidural may be performed for upper abdominal surgery, but may not have any effect on the perineum (area around the genitals) or pelvic organs. Nonetheless, giving very large volumes into the epidural space may spread the block both higher and lower.

The intensity of the block is determined by the concentration of local anaesthetic solution used. For example, 0.1% bupivacaine may provide adequate analgesia for a woman in labour, but would likely be insufficient for surgical anaesthesia. Conversely, 0.5% bupivacaine would provide a more intense block, likely sufficient for surgery.

Removing the catheter

The catheter is usually removed when the subject is able to take oral pain medications. Catheters can safely remain in place for several days with little risk of bacterial infection, particularly if the skin is prepared with a chlorhexidine solution. Subcutaneously tunneled epidural catheters may be left in place for longer periods, with a low risk of infection or other complications.
Special situations

_Epidural analgesia during childbirth_

Epidural analgesia provides rapid pain relief in most cases. It is more effective than nitrous oxide, opioids, TENS, and other common modalities of analgesia in childbirth. Epidurals during childbirth are the most commonly used anesthesia in this situation.

The medication levels are very low to decrease the side effects to both mother and baby. When in labor the mother does not usually feel pain after an epidural but they do still feel the pressure. Women are able to bear down and push with contractions. Epidural clonidine has been extensively studied for management of analgesia during labor. Epidural analgesia is a relatively safe method of relieving pain in labor. In a 2011 Cochrane review which included 38 randomized controlled studies involving 9658 women, wherein all but five studies compared epidural analgesia with opiates, epidural analgesia in childbirth was associated with the following advantages and disadvantages:

Advantages
• Better pain relief than other pain medication
• Fewer babies needing naloxone to counter opiate use by the mother
• Decreased maternal hyperventilation and increased oxygen supply to baby
• Decreased circulating adrenocorticotropic hormone and decreased fetal distress

Disadvantages
• More use of instruments to assist with the birth
• Increased risk of Caesarean section for fetal distress
• Longer delivery (second stage of labour)
• Increased need for oxytocin to stimulate uterine contractions
Spinal Anaesthesia

- Increased risk of very low blood pressure
- Increased risk of muscular weakness for a period of time after the birth
- Increased risk of fluid retention
- Increased risk of fever

However, the review found no difference in overall Caesarean delivery rates, nor were there effects on the baby soon after birth. Also, the occurrence of long-term backache was no different whether an epidural was or was not used.

Though complications are rare, some women and their babies will experience them. Some side effects for the mother include headaches, dizziness, difficulty breathing and seizures. The child may experience slowed heartbeat, temperature regulation issues and there could be high levels of drugs in the child’s system from the epidural.

Differing outcomes in frequency of Cesarean section may be explained by differing institutions or their practitioners: epidural anesthesia and analgesia administered at top-rated institutions does not generally result in a clinically significant increase in caesarean rates, whereas the risk of caesarean delivery at poorly ranked facilities seems to increase with the use of epidural.

Regarding early or late administration of epidural analgesia, there is no overall difference in outcomes for first-time moms in labor. Specifically, the rate of caesarean section, instrumental birth, or duration of labor is equal, as well as baby Apgar scores and cord pH.

Epidurals (other than low-dose ambulatory epidurals) preclude maternal movement, but “walking, movement, and changing positions during labor help labor progress, enhance comfort, and decrease the risk of complications.”

One study concluded that women whose epidural infusions contained fentanyl were less likely to fully breastfeed their infant in the few days after birth and more likely to stop
breastfeeding in the first 24 weeks. However, this study has been criticized for several reasons, one of which is that the original patient records were not examined in this study, and so many of the epidural infusions were assumed to contain fentanyl when almost certainly they would not have.

In addition, all those who had received epidural infusions in this study had also received systemic pethidine, which would be much more likely to be the cause of any effect on breastfeeding due to the higher amounts of medication used via that route.

If this were the case, then early epidural analgesia which avoided the need for pethidine would be expected to improve breastfeeding outcomes rather than worsen them. Traditional epidural for labor relieves pain reliably only during first stage of labor (uterine contractions till cervix is fully open). It does not relieve pain as reliably during the second stage of labor (passage of the fetus through the vagina).

**Epidural analgesia after surgery**

Epidural analgesia has been demonstrated to have several benefits after surgery, including:

- Effective analgesia without the need for systemic opioids.
- The incidence of postoperative respiratory problems and chest infections is reduced.
- The incidence of postoperative myocardial infarction (“heart attack”) is reduced.
- The stress response to surgery is reduced.
- Motility of the intestines is improved by blockade of the sympathetic nervous system.
- Use of epidural analgesia during surgery reduces blood transfusion requirements.

Despite these benefits, no survival benefit has been proven for high-risk individuals.
Caudal epidural analgesia

The caudal approach to the epidural space involves the use of a Tuohy needle, an intravenous catheter, or a hypodermic needle to puncture the sacrococcygeal membrane. Injecting local anaesthetic at this level can result in analgesia and/or anaesthesia of the perineum and groin areas.

The caudal epidural technique is often used in infants and children undergoing surgery involving the groin, pelvis or lower extremities. In this population, caudal epidural analgesia is usually combined with general anaesthesia since most children do not tolerate surgery when regional anaesthesia is employed as the sole modality.

Combined spinal-epidural techniques

For some procedures, the anaesthetist may choose to combine the rapid onset and reliable, dense block of a spinal anaesthetic with the post-operative analgesic effects of an epidural. This is called combined spinal and epidural anaesthesia (CSE).

The practitioner may insert the spinal anaesthetic at one level, and the epidural at an adjacent level. Alternatively, after locating the epidural space with the Tuohy needle, a spinal needle may be inserted through the Tuohy needle into the subarachnoid space. The spinal dose is then given, the spinal needle withdrawn, and the epidural catheter inserted as normal. This method, known as the “needle-through-needle” technique, may be associated with a slightly higher risk of placing the catheter into the subarachnoid space.

Epidural steroid injection

Epidural steroid injection may be used to treat radiculopathy, radicular pain and inflammation caused by such conditions as spinal disc herniation, degenerative disc disease, and spinal stenosis. Steroids may be injected at the cervical, thoracic, lumbar, or caudal/sacral levels, depending
on the specific area where the pathology (disease, condition, or injury) is located.

**Side effects**

In addition to blocking the nerves which carry pain, local anaesthetic drugs in the epidural space will block other types of nerves as well, in a dose-dependent manner. Depending on the drug and dose used, the effects may last only a few minutes or up to several hours. Epidural analgesia typically involves using the opiates fentanyl or sufentanil, with bupivacaine or one of its congeners. Fentanyl is a powerful opioid with a potency 80 times that of morphine and side effects common to the opiate class. Sufentanil is another opiate, 5 to 10 times more potent than Fentanyl. Bupivacaine is markedly toxic if inadvertently given intravenously, causing excitation, nervousness, tingling around the mouth, tinnitus, tremor, dizziness, blurred vision, or seizures, followed by depression: drowsiness, loss of consciousness, respiratory depression and apnea. Bupivacaine has caused several deaths by cardiac arrest when epidural anaesthetic has been accidentally inserted into a vein instead of the epidural space.

Sensory nerve fibers are more sensitive to the effects of the local anaesthetics than motor nerve fibers. This means that an epidural can provide analgesia while affecting muscle strength to a lesser extent. For example, a labouring woman may have a continuous epidural during labour that provides good analgesia without impairing her ability to move. If she requires a Caesarean section, she may be given a larger dose of epidural local anaesthetic.

The larger the dose used, the more likely it is that side effects will be evident. For example, very large doses of epidural anaesthetic can cause paralysis of the intercostal muscles and thoracic diaphragm (which are responsible for breathing), and loss of sympathetic nerve input to the heart, which may cause a significant decrease in heart rate and blood pressure. This
may require emergency intervention, which may include support of the airway and the cardiovascular system.

The sensation of needing to urinate is often significantly diminished or even abolished after administration of epidural local anaesthetics and/or opioids. Because of this, a urinary catheter is often placed for the duration of the epidural infusion. People with continuous epidural infusions of local anaesthetic solutions typically ambulate only with assistance, if at all, in order to reduce the likelihood of injury due to a fall.

Large doses of epidurally administered opioids may cause troublesome itching, and respiratory depression.

Complications

These include:

• failure to achieve analgesia or anaesthesia occurs in about 5% of cases, while another 15% experience only partial analgesia or anaesthesia. If analgesia is inadequate, another epidural may be attempted.
  - The following factors are associated with failure to achieve epidural analgesia/anaesthesia:
    - Obesity
    - Multiparity
    - History of a previous failure of epidural anaesthesia
    - History of regular opiate use
    - Cervical dilation of more than 7 cm at insertion
    - The use of air to find the epidural space while inserting the epidural instead of alternatives such as saline or lidocaine

• Accidental dural puncture with headache (common, about 1 in 100 insertions). The epidural space in the adult lumbar spine is only 3-5mm thick, which means it is comparatively easy to cross it and accidentally puncture the dura (and arachnoid) with the needle.
This may cause cerebrospinal fluid (CSF) to leak out into the epidural space, which may in turn cause a post dural puncture headache (PDPH). This can be severe and last several days, and in some rare cases weeks or months. It is caused by a reduction in CSF pressure and is characterised by postural exacerbation when the subject raises his/her head above the lying position. If severe it may be successfully treated with an epidural blood patch (a small amount of the subject’s own blood given into the epidural space via another epidural needle which clots and seals the leak). Most cases resolve spontaneously with time. A change in headache pattern (e.g., headache worse when the subject lies down) should alert the physician to the possibility of development of rare but dangerous complications, such as subdural hematoma or cerebral venous thrombosis.

• Delayed onset of breastfeeding and shorter duration of breastfeeding: In a study looking at breastfeeding 2 days after epidural anaesthesia, epidural analgesia in combination with oxytocin infusion caused women to have significantly lower oxytocin and prolactin levels in response to the baby breastfeeding on day 2 postpartum, which means less milk is produced. In many women undergoing epidural analgesia during labour oxytocin is used to augment uterine contractions.

• Bloody tap (occurs in about 1 in 30-50). Epidural veins can be inadvertently punctured with the needle during the procedure. This is a common occurrence and is not usually considered a complication. In people who have normal blood clotting, it is extremely rare (estimated less than 0.07%) for permanent neurological problems to develop. However, people who have a coagulopathy may be at risk of epidural hematoma.

• Catheter misplaced into a vein (uncommon, less than
Occasionally the catheter may be misplaced into an epidural vein, which results in all the anaesthetic being injected intravenously, where it can cause seizures or cardiac arrest in large doses (about 1 in 10,000 insertions). This also results in block failure.

- High block, as described above (uncommon, less than 1 in 500).
- Catheter misplaced into the subarachnoid space (rare, less than 1 in 1000). If the catheter is accidentally misplaced into the subarachnoid space (e.g. after an unrecognised accidental dural puncture), normally cerebrospinal fluid can be freely aspirated from the catheter (which would usually prompt the anaesthetist to withdraw the catheter and resite it elsewhere). If, however, this is not recognised, large doses of anaesthetic may be delivered directly into the cerebrospinal fluid. This may result in a high block, or, more rarely, a total spinal, where anaesthetic is delivered directly to the brainstem, causing unconsciousness and sometimes seizures.
- Neurological injury lasting less than 1 year (rare, about 1 in 6,700).
- Epidural abscess formation (very rare, about 1 in 145,000). Infection risk increases with the duration catheters are left in place, although infection was still uncommon after an average of 3 to 5 days’ duration.
- Epidural haematoma formation (very rare, about 1 in 168,000).
- Neurological injury lasting longer than 1 year (extremely rare, about 1 in 240,000).
- Paraplegia (1 in 250,000).
- Arachnoiditis (extremely rare, fewer than 1000 cases in the past 50 years)
- Death (extremely rare, less than 1 in 100,000).
To epidural anaesthesia and analgesia in healthy individuals.

Evidence to support the assertion that epidural analgesia increases the risk of anastomotic breakdown following bowel surgery is lacking.

Controversial claims:

• “epidural anaesthesia and analgesia significantly slows the second stage of labour”. The following are a few plausible hypotheses for this phenomenon:

  o The release of oxytocin, which stimulates the uterine contractions that are needed to move the child out through the vagina, may be decreased with epidural anaesthesia or analgesia due to factors involving the reduction of stress, such as:
    - Epidural analgesia may reduce the endocrine stress response to pain
    - Diminished release of epinephrine from the adrenal medulla slows the release of oxytocin
    - Diminished blood pressure, accommodated by both decreased stress and less adrenal release, may decrease the release of oxytocin as a natural mechanism to avoid hypotension. It may also affect the heart-rate of the fetus.

• Still plausible (though less studied without a documented reproduction in a laboratory setting) are the effects of the reclined position of the woman on the fetus, both immediately prior to and during delivery.

  o These hypotheses generally posit an interaction with the force of gravity on fetal position and movement, as demonstrated by the following examples:

    - Transverse or posterior fetal positioning may become more likely as a result of the shift in orientation to gravitational force.
Diminished gravitational assistance is present in building pressure for commencing delivery and for progressing the fetus along the vagina. It is important to note that the orientation of the fetus can be established by ultrasonic stenography prior to, during, and after the administration of an epidural block. This would seem a fine experiment for testing the first hypothesis. It should also be noted that the majority of fetal movement through the vagina is accomplished by cervical contractions, and so the role of gravity and its force relative to the position of the woman in labour (on delivery, not development) is difficult to establish.

There has been a good deal of concern, based on older observational studies, that women who have epidural analgesia during labour are more likely to require a cesarean delivery. However, the preponderance of evidence now supports the conclusion that the use of epidural analgesia during labour does not have a significant effect on rates of cesarean delivery. A Cochrane review of twenty trials involving a total of 6534 women estimated that women undergoing labour using epidural analgesia were only slightly more likely (1.07 times as likely) to undergo cesarean delivery than those in whom epidural analgesia was not used.

Epidural analgesia does increase the duration of the second stage of labour by 15 to 30 minutes and may increase the rate of instrument-assisted vaginal deliveries as well as that of oxytocin administration.

Some people have also been concerned about whether the use of epidural analgesia in early labour increases the risk of cesarean delivery.

Three randomized, controlled trials showed that early initiation of epidural analgesia (cervical dilatation, <4 cm) does
not increase the rate of cesarean delivery among women with spontaneous or induced labour, as compared with early initiation of analgesia with parenteral opioids.

**History**

In 1885, American neurologist James Leonard Corning (1855–1923), of Acorn Hall in Morristown, NJ, was the first to perform neuraxial blockade, when he injected 111 mg of cocaine into the epidural space of a healthy male volunteer (although at the time he believed he was injecting it into the subarachnoid space).

In 1921, Spanish military surgeon Fidel Pagés (1886–1923) developed the technique of “single-shot” lumbar epidural anaesthesia, which was later popularized by Italian surgeon Achille Mario Dogliotti (1897–1966).

In 1941, Robert Andrew Hingson (1913–1996) and Waldo B. Edwards developed the technique of continuous caudal anaesthesia using an indwelling needle. The first use of continuous caudal anaesthesia in a labouring woman was in 1942.

In 1947, Manuel Martínez Curbelo (1906–1962) was the first to describe placement of a lumbar epidural catheter.

**GENERAL ANAESTHETIC**

A general anaesthetic is a drug that can bring about a reversible loss of consciousness. Anaesthetists, physician assistants or nurse anaesthetists administer these drugs to induce or maintain general anaesthesia to facilitate surgery. Some of these drugs are also used in lower dosages for pain management. The biological mechanisms of the action of general anaesthetics are not well understood.

**Mode of administration**

Drugs given to induce general anaesthesia can be either as gases or vapours (inhalational anaesthetics), or as injections
(intravenous anaesthetics or even intramuscular). It is possible to deliver anaesthesia solely by inhalation or injection, but most commonly the two forms are combined, with an injection given to induce anaesthesia and a gas used to maintain it.

**Inhalation**

Inhalational anaesthetic substances are either volatile liquids or gases, and are usually delivered using an anaesthesia machine.

An anaesthesia machine allows composing a mixture of oxygen, anaesthetics and ambient air, delivering it to the patient and monitoring patient and machine parameters. Liquid anaesthetics are vapourised in the machine. All of these agents share the property of being quite hydrophobic (i.e., as liquids, they are not freely miscible—or mixable—in water, and as gases they dissolve in oils better than in water).

Many compounds have been used for inhalation anaesthesia, but only a few are still in widespread use. Desflurane, isoflurane and sevoflurane are the most widely used volatile anaesthetics today. They are often combined with nitrous oxide. Older, less popular, volatile anaesthetics, include halothane, enflurane, and methoxyflurane. Researchers are also actively exploring the use of xenon as an anaesthetic.

**Injection**

Injectable anaesthetics are used for the induction and maintenance of a state of unconsciousness. Anaesthetists prefer to use intravenous injections, as they are faster, generally less painful and more reliable than intramuscular or subcutaneous injections. Among the most widely used drugs are:

- Propofol
- Etomidate
- Barbiturates such as methohexital and thiopentone/thiopental
- Benzodiazepines such as midazolam
• Ketamine is used in the UK as “field anaesthesia”, for instance at a road traffic incidents or similar situations where an operation must be conducted at the scene or when there is not enough time to move to an operating room, while preferring other anaesthetics where conditions allow their use. It is more frequently used in the operative setting in the US.

Benzodiazepines are sedatives and are used in combinations with other general anaesthetics

**Method of action**

General anaesthetics are often defined as compounds that induce a reversible loss of consciousness in humans or loss of righting reflex in animals. Clinical definitions are also extended to include the lack of awareness to painful stimuli, sufficient to facilitate surgical applications in clinical and veterinary practice. General anaesthetics do not act as analgesics and should also not be confused with sedatives. General anaesthetics are a structurally diverse group of compounds whose mechanisms encompasses multiple biological targets involved in the control of neuronal pathways. The precise workings are the subject of some debate and ongoing research.

**Lipid theory**

At the start of the 20th century, it was postulated by Overton and Meyer that general anaesthetics exert their action by acting on the plasma membrane. This was supported by evidence that the potency of the drug has a direct, positive correlation with the lipid solubility of the blood. The mechanism of action was proposed to be increased fluidity of the membrane. The interpretation of the Overton and Meyer finding has been challenged and discredited.

**Ion channels**

It is postulated that general anaesthetics exert their action by the activation of inhibitory central nervous system (CNS)
receptors, and the inactivation of CNS excitatory receptors. The relative roles of different receptors is still under much debate, but evidence has emerged for some targets being involved with particular anaesthetics.

Multiple anaesthetics have been found to affect the inhibitory GABA$_A$ receptor, including propofol, thiopental and isoflurane. However, xenon and nitrous oxide are thought to have no effect here. Glycine receptors have been suggested as putative target for at least the analgesic effect of inhalational anaesthetics.

2-pore-domain potassium channels, with the subfamilies TREK and TASK, have recently emerged as a potential target. These channels regulate membrane excitability, and halothane has been found to reduce neuronal firing by hyperpolarising neurons by a current similar to TASK.

Knockout mouse models have provided support for TREK-1. NMDA receptors, HCN channels and some sodium channels.

**Pharmacokinetics**

**Induction**

Induction is a term that refers to the first stage of anaesthesia, Stage 1, prior to reaching a depth suitable for surgery, i.e. Stage 3.

The speed of induction depends on the time taken for the drug to reach an effective concentration in the brain. Different compounds partition to different compartments of the body, such as fatty tissue, at different rates.

Hence, different compounds have different rates of induction. Intravenous anaesthetics like Thiopental have been used for induction and it is common for anaesthesia to be maintained by inhalational anaesthetics such as Isoflurane. Propofol is now the most widely used intravenous general anaesthetic.
Elimination

Volatile anaesthetics are eliminated in the terminal phase via the lungs. A low blood:gas partition coefficient is therefore necessary for quick removal of the anaesthetic. When the oil:water coefficient is high, there will be little anaesthetic in the blood, so elimination will be slow, giving a prolonged hangover effect.

Intravenous and intramuscular drugs are eliminated by metabolic pathways in the liver. It is not uncommon to produce toxic metabolites (e.g. chloroform).

INHALATIONAL ANAESTHETIC

An inhalational anaesthetic is a chemical compound possessing general anaesthetic properties that can be delivered via inhalation. They are administered by anaesthetists (a term which includes anaesthesiologists, nurse anaesthetists, and anaesthesiologist assistants) through an anaesthesia mask, laryngeal mask airway or tracheal tube connected to an anaesthetic vaporiser and an anaesthetic delivery system. Agents of significant contemporary clinical interest include volatile anaesthetic agents such as isoflurane, sevoflurane and desflurane, as well as certain anaesthetic gases such as nitrous oxide and xenon.

List of inhalational anaesthetic agents

Currently-used agents

- Desflurane
- Isoflurane
- Nitrous oxide
- Sevoflurane
- Xenon

Previously-used agents

Although some of these are still used in clinical practice
and in research, the following anaesthetic agents are primarily of historical interest in developed countries:

- Chloroethane (ethyl chloride)
- Chloroform
- Cryofluorane
- Cyclopropane
- Diethyl ether
- Enflurane
- Ethylene
- Fluroxene
- Halothane
- Methoxyflurane (still used currently as an analgesic)
- Methoxypropane
- Trichloroethylene
- Vinyl ether

**Never-marketed agents**

- Aliflurane
- Halopropane
- Norflurane
- Roflurane
- Synthane
- Teflurane

**Volatile anaesthetics**

Volatile anaesthetic agents share the property of being liquid at room temperature, but evaporating easily for administration by inhalation. All of these agents share the property of being quite hydrophobic (i.e., as liquids, they are not freely miscible with water, and as gases they dissolve in oils better than in water). The ideal volatile anaesthetic agent offers smooth and reliable induction and maintenance of general anaesthesia with minimal effects on other organ systems. In addition it is odourless or pleasant to inhale; safe
for all ages and in pregnancy; not metabolised; rapid in onset and offset; potent; and safe for exposure to operating room staff. It is also cheap to manufacture; easy to transport and store, with a long shelf life; easy to administer and monitor with existing equipment; stable to light, plastics, metals, rubber and soda lime; non-flammable and environmentally safe.

None of the agents currently in use are ideal, although many have some of the desirable characteristics. For example, sevoflurane is pleasant to inhale and is rapid in onset and offset. It is also safe for all ages. However, it is expensive (approximately 3 to 5 times more expensive than isoflurane), and approximately half as potent as isoflurane.

**Gases**

Other gases or vapors which produce general anaesthesia by inhalation include nitrous oxide, cyclopropane and xenon. These are stored in gas cylinders and administered using flowmeters, rather than vaporisers.

Cyclopropane is explosive and is no longer used for safety reasons, although otherwise it was found to be an excellent anaesthetic. Xenon is odourless and rapid in onset, but is expensive and requires specialized equipment to administer and monitor. Nitrous oxide, even at 80% concentration, does not quite produce surgical level anaesthesia in most persons at standard atmospheric pressure, so it must be used as an adjunct anaesthetic, along with other agents.

**Hyperbaric anaesthesia**

Under hyperbaric conditions (pressures above normal atmospheric pressure), other gases such as nitrogen, and noble gases such as argon, krypton, and xenon become anaesthetics. When inhaled at high partial pressures (more than about 4 bar, encountered at depths below about 30 metres in scuba diving), nitrogen begins to act as an anaesthetic agent, causing nitrogen narcosis. However, the minimum alveolar concentration (MAC)
for nitrogen is not achieved until pressures of about 20 to 30 atm (bar) are attained. Argon is slightly more than twice as anaesthetic as nitrogen per unit of partial pressure. Xenon however is a usable anaesthetic at 80% concentration and normal atmospheric pressure.

**Neurological theories of action**

The full mechanism of action of volatile anaesthetic agents is unknown and has been the subject of intense debate. “Anesthetics have been used for 160 years, and how they work is one of the great mysteries of neuroscience,” says anaesthesiologist James Sonner of the University of California, San Francisco. Anaesthesia research “has been for a long time a science of untestable hypotheses,” notes Neil L. Harrison of Cornell University.

“Most of the injectable anesthetics appear to act on a single molecular target,” says Sonner. “It looks like inhaled anesthetics act on multiple molecular targets. That makes it a more difficult problem to pick apart.”

The possibility of anaesthesia by the inert gas argon in particular (even at 10 to 15 bar) suggests that the mechanism of action of volatile anaesthetics is an effect best described by physical chemistry, and not a chemical bonding action. However, the agent may bind to a receptor with a weak interaction.

A physical interaction such as swelling of nerve cell membranes from gas solution in the lipid bilayer may be operative. Notably, the gases hydrogen, helium, and neon have not been found to have anaesthetic properties at any pressure. Helium at high pressures produces nervous irritation (“anti-anaesthesia”), suggesting that the anaesthetic mechanism(s) may be operated in reverse by this gas (i.e., nerve membrane compression). Also, some halogenated ethers (such as flurothyl) also possess this “anti-anaesthetic” effect, providing further evidence for this theory.
History

The concept was first used by Paracelsus in 1540. He used sweet oil of vitriol (prepared by Valerius Cordus and named Aether by Frobenius): used to feed fowl: “it was taken even by chickens and they fall asleep from it for a while but awaken later without harm”. Subsequently, about 40 years later, in 1581, Giambattista Delia Porta demonstrated the use of ether on humans although it was not employed for any type of surgical anesthesia.

ANAESTHETIC MACHINE

The anaesthetic machine (UK English) or anesthesia machine (US English) or Boyle’s machine is used by anaesthesiologists, nurse anaesthetists, and anaesthesiologist assistants to support the administration of anaesthesia. The most common type of anaesthetic machine in use in the developed world is the continuous-flow anaesthetic machine, which is designed to provide an accurate and continuous supply of medical gases (such as oxygen and nitrous oxide), mixed with an accurate concentration of anaesthetic vapour (such as isoflurane), and deliver this to the patient at a safe pressure and flow. Modern machines incorporate a ventilator, suction unit, and patient monitoring devices.

The original concept of Boyle’s machine was invented by the British anaesthetist Henry Boyle (1875–1941) in 1917. Prior to this time, anaesthetists often carried all their equipment with them, but the development of heavy, bulky cylinder storage and increasingly elaborate airway equipment meant that this was no longer practical for most circumstances. The anaesthetic machine is usually mounted on anti-static wheels for convenient transportation.

Simpler anaesthetic apparatus may be used in special circumstances, such as the TriService Apparatus, a simplified anaesthesia delivery system invented for the British armed
forces, which is light and portable and may be used effectively even when no medical gases are available. This device has unidirectional valves which suck in ambient air which can be enriched with oxygen from a cylinder, with the help of a set of bellows. A large number of draw-over type of anaesthesia devices are still in use in India for administering an air-ether mixture to the patient, which can be enriched with oxygen. But the advent of the cautery has sounded the death knell for this device, due to the explosion hazard.

Many of the early innovations in U.S. anaesthetic equipment, including the closed circuit carbon-dioxide absorber (aka: the Guedel-Foregger Midget) and diffusion of such equipment to anaesthetists within the United States can be attributed to Richard von Foregger and The Foregger Company.

In dentistry a simplified version of the anaesthetic machine, without a ventilator or anaesthetic vaporiser, is referred to as a relative analgesia machine. By using this machine, the dentist can administer a mild inhalation sedation with nitrous oxide and oxygen, in order to keep his patient in a conscious state while depressing the feeling of pain.

**Components of a typical machine**

A modern anaesthesia machine includes the following components:

- Connections to piped hospital oxygen, medical air, and nitrous oxide.
- Reserve gas cylinders of oxygen, air, and nitrous oxide attached via a specific yoke with a Bodok seal.
- A high-flow oxygen flush which provides pure oxygen at 30-75 litres/minute
- Pressure gauges, regulators and ‘pop-off’ valves, to protect the machine components and patient from high-pressure gases
- Flow meters (rotameters) for oxygen, air, and nitrous oxide, low Flow meters oxygen nitrous oxide
• Updated vaporizers to provide accurate dosage control when using volatile anaesthetics such as isoflurane and sevoflurane
• An integrated ventilator to properly ventilate the patient during administration of anaesthesia
• A manual ventilation bag in combination with an Adjustable Pressure Limiting (APL) valve
• Systems for monitoring the gases being administered to, and exhaled by the patient
• Systems for monitoring the patient’s heart rate, ECG, blood pressure and oxygen saturation, in some cases with additional options for monitoring end-tidal carbon dioxide and temperature
• breathing circuits, circle attachment, or a Bain’s breathing system

Safety features of modern machines

Based on experience gained from analysis of mishaps, the modern anaesthetic machine incorporates several safety devices, including:

• an oxygen failure alarm (aka ‘Oxygen Failure Warning Device’ or OFWD). In older machines this was a pneumatic device called a Ritchie whistle which sounds when oxygen pressure is 38 psi descending. Newer machines have an electronic sensor.
• Nitrous cut-off or oxygen failure protection device, OFPD: the flow of medical nitrous-oxide is dependent on oxygen pressure. This is done at the regulator level. In essence, the nitrous-oxide regulator is a ‘slave’ of the oxygen regulator. i.e., if oxygen pressure is lost then the other gases can not flow past their regulators.
• hypoxic-mixture alarms (hypoxy guards or ratio controllers) to prevent gas mixtures which contain less than 21-25% oxygen being delivered to the patient. In modern machines it is impossible to deliver 100%
nitrous oxide (or any hypoxic mixture) to the patient to breathe. Oxygen is automatically added to the fresh gas flow even if the anaesthetist should attempt to deliver 100% nitrous oxide. Ratio controllers usually operate on the pneumatic principle or are chain linked (link 25 system). Both are located on the rotameter assembly, unless electronically controlled.

- ventilator alarms, which warn of low or high airway pressures.
- interlocks between the vaporizers preventing inadvertent administration of more than one volatile agent concurrently
- alarms on all the above physiological monitors
- the Pin Index Safety System prevents cylinders being accidentally connected to the wrong yoke
- the NIST (Non-Interchangeable Screw Thread) or Diameter Index Safety System, DISS system for pipeline gases, which prevents piped gases from the wall being accidentally connected to the wrong inlet on the machine
- pipeline gas hoses have non-interchangeable Schrader valve connectors, which prevents hoses being accidentally plugged into the wrong wall socket

The functions of the machine should be checked at the beginning of every operating list in a “cockpit-drill”. Machines and associated equipment must be maintained and serviced regularly.

Older machines may lack some of the safety features and refinements present on newer machines. However, they were designed to be operated without mains electricity, using compressed gas power for the ventilator and suction apparatus. Modern machines often have battery backup, but may fail when this becomes depleted.

The modern anaesthetic machine still retains all the key working principles of the Boyle’s machine (a British Oxygen
Company trade name) in honour of the British anaesthetist Henry Boyle. In India, however, the trade name ‘Boyle’ is registered with Boyle HealthCare Pvt. Ltd., Indore MP.

A two-person pre-use check (consisting of an anaesthetist and an operating department practitioner) of the anaesthetic machine is recommended before every single case and has been shown to decrease the risk of 24-hour severe postoperative morbidity and mortality. Various regulatory and professional bodies have formulated checklists for different countries. A free transparent reality simulation of the checklist recommended by the United States Food & Drug Administration is available from the Virtual Anesthesia Machine web site after registration which is also free. Machines should be cleaned between cases as they are at considerable risk of contamination with pathogens.

**Anesthesia machine vs anesthesia cart**

*Fig. An anaesthetic machine*
The Anesthesia machine contains mechanical respiratory support (ventilator) and O₂ support as well as being a means for administering anesthetic gases which may be used for sedation as well as total anesthesia. An anesthesia cart holds extra IV push meds for anesthesia, sedation and reversal, extra equipment that the person giving anesthesia/sedation might need, and the hardware for respiratory support and resuscitation.

LOCAL ANESTHESIA

Local anesthesia is any technique to induce the absence of sensation in a specific part of the body, generally for the aim of inducing local analgesia, that is, local insensitivity to pain, although other local senses may be affected as well. It allows patients to undergo surgical and dental procedures with reduced pain and distress. In many situations, such as cesarean section, it is safer and therefore superior to general anesthesia. It is also used for relief of non-surgical pain and to enable diagnosis of the cause of some chronic pain conditions. Anesthetists sometimes combine both general and local anesthesia techniques.

The following terms are often used interchangeably:
- *Local anesthesia*, in a strict sense, is anesthesia of a small part of the body such as a tooth or an area of skin.
- *Regional anesthesia* is aimed at anesthetizing a larger part of the body such as a leg or arm.
- *Conduction anesthesia* is a comprehensive term, which encompasses a great variety of local and regional anesthetic techniques.

Medical

A local anesthetic is a drug that causes reversible local anesthesia and a loss of nociception. When it is used on specific nerve pathways (nerve block), effects such as analgesia (loss of pain sensation) and paralysis (loss of muscle power) can be
achieved. Clinical local anesthetics belong to one of two classes: aminoamide and amineoester local anesthetics.

Synthetic local anesthetics are structurally related to cocaine. They differ from cocaine mainly in that they have no abuse potential and do not act on the sympathoadrenergic system, i.e. they do not produce hypertension or local vasoconstriction, with the exception of Ropivacaine and Mepivacaine that do produce weak vasoconstriction.

Local anesthetics vary in their pharmacological properties and they are used in various techniques of local anesthesia such as:

• Topical anesthesia (surface)
• Infiltration
• Plexus block
• Epidural (extradural) block
• Spinal anesthesia (subarachnoid block)

Adverse effects depend on the local anesthetic agent, method, and site of administration and is discussed in depth in the local anesthetic sub-article, but overall, adverse effects can be:

1. localized prolonged anesthesia or paresthesia due to infection, hematoma, excessive fluid pressure in a confined cavity, and severing of nerves & support tissue during injection.
2. systemic reactions such as depressed CNS syndrome, allergic reaction, vasovagal episode, and cyanosis due to local anesthetic toxicity.
3. lack of anesthetic effect due to infectious pus such as an abscess.

Non-medical local anesthetic techniques

Local pain management that uses other techniques than analgesic medication include:
• Transcutaneous electrical nerve stimulation, which has been found to be ineffective for lower back pain, however, it might help with diabetic neuropathy.
• Pulsed radiofrequency, neuromodulation, direct introduction of medication and nerve ablation may be used to target either the tissue structures and organ/systems responsible for persistent nociception or the nociceptors from the structures implicated as the source of chronic pain.

NURSE ANESTHETIST

A nurse anesthetist is a nurse who specializes in the administration of anesthesia. In the United States, a certified registered nurse anesthetist (CRNA) is an advanced practice registered nurse (APRN) who has acquired graduate-level education and board certification in anesthesia.

The American Association of Nurse Anesthetists’ (AANA) is the national association that represents more than 90% of the 45,000 nurse anesthetists in the United States. Certification is governed by the National Boards of Certification and Recertification of Nurse Anesthetists (NBCRANA). Education is governed by the Council on Accreditation (COA) of Nurse Anesthesia Educational Programs.

In the United States

History

Nurse anesthetists have been providing anesthesia care in the United States for 150 years. According to the American Association of Nurse Anesthetists, nurse anesthetists are the oldest nurse specialty group in the United States. Additionally, in testament to the profession’s roots, today’s nurse anesthetists remain the primary anesthesia providers to U.S. service men and women at home and abroad.
Among the first American nurses to provide anesthesia was Catherine S. Lawrence. Along with other nurses, Lawrence administered anesthesia during the American Civil War (1861–1865). The first “official” nurse anesthetist is recognized as Sister Mary Bernard, a Catholic nun who practiced in 1877 at St. Vincent’s Hospital in Erie, Pennsylvania.

There is evidence that up to 50 or more other Catholic sisters were called to practice anesthesia in various mid-west Catholic and Protestant hospitals throughout the last two decades of the 19th century. The first school of nurse anesthesia was formed in 1909 at St. Vincent Hospital, Portland, Oregon. Established by Agnes McGee, the course was seven months long, and included courses on anatomy and physiology, pharmacology, and administration of common anesthetic agents.

Within the next decade, approximately 19 schools opened. All consisted of post-graduate anesthesia training for nurses and were about six months in length. These included programs at Mayo Clinic, Johns Hopkins Hospital, Barnes Hospital, New York Post-Graduate Hospital, Charity Hospital in New Orleans, Grace Hospital in Detroit, among others. Early anesthesia training programs provided education for all levels of health providers. For example, in 1915, chief nurse anesthetist Agatha Hodgens established the Lakeside Hospital School of Anesthesia in Cleveland, Ohio. This program was open to nurses, physicians, and dentists. The training was six months and the tuition was $50. A diploma was awarded on completion. In its first year, it graduated six physicians, two dentists, and 11 nurses. Later, in 1918, it established a system of clinical affiliations with other Cleveland hospitals. Some nurse anesthetists were appointed to medical school faculties to train the medical students in anesthesia. For example, Agnes McGee also taught third year medical school students at the Oregon Health Science Center. Furthermore, nurse anesthetist Alice Hunt was appointed instructor in anesthesia with university
rank at the Yale University School of Medicine in 1922. She held this position for 26 years. In addition, she authored the 1949 book *Anesthesia, Principles and Practice*. This is most likely the first nurse anesthesia textbook.

Early nurse anesthetists were involved in publications. For example, in 1906, nurse anesthetist Alice Magaw (1860–1928) published a report on the use of ether anesthesia by drop method 14,000 times without a fatality (*Surg., Gynec. & Obst. 3:795, 1906*). Beginning in 1899, Magaw authored several publications with some published and many ignored because of her status as a non-physician. Ms. Magaw was the anesthetist at St. Mary’s Hospital in Rochester for the famous brothers, Dr. William James Mayo and Dr. Charles Horace Mayo. This became the Mayo Clinic in Rochester, Minnesota. Ms. Magaw set up a showcase for surgery and anesthesia that has attracted many students and visitors.

**Education pathway**

Nurse Anesthesiology is a graduate prepared profession. In the United States of America, nurse anesthetists must be licensed registered nurse and complete a master’s degree in anesthesia and/or nursing with a post-masters certification in anesthesia. In addition, candidates are required to have a minimum of one year of full-time nursing experience in a medical or surgical intensive care unit. Following this experience, applicants apply to a Council on Accreditation (COA) accredited program of nurse-anesthesia. Education is offered on a master’s degree or doctoral degree (in Nurse Anesthesia Practice). Program length is typically 28 months in duration, but can vary from 24 to 36 months. The didactic curricula of nurse-anesthesia programs are governed by the Council on Accreditation (COA) standards and provide students the scientific, clinical, and professional foundation upon which to build a sound and safe clinical practice. Accredited programs afford and ensure supervised experiences
for students during which time they are able to learn anesthesia techniques, test theory, and apply knowledge to clinical problems. Students gain experience with patients of all ages who require medical, surgical, obstetrical, dental, and pediatric interventions. In addition, many require study in methods of scientific inquiry and statistics, as well as active participation in student-generated and faculty-sponsored research. Among the oldest schools in the U.S., Ravenswood Hospital in Chicago, opened in 1925 by Mae Cameron, which in 2001 became the NorthShore University HealthSystem School of Nurse Anesthesia, was the first school to be accredited by the Council on Accreditation of Nurse Anesthesia Educational Programs in 1952.

**History of education**

CRNAs in the United States receive Master’s or Doctoral degrees in nurse anesthesia. The Council on Accreditation develops requirements for degree programs. In 1981, the Council on Accreditation developed guidelines for master’s degrees. In 1982, it was the official position of the AANA board of directors’ that registered nurses applying for a school of anesthesia shall be, at minimum, baccalaureate prepared and then complete a master’s level anesthesia program. At that time, many programs started phasing in advanced degree requirements. As early as 1978, the Kaiser Permanente California State University program had evolved to a master’s level program. All programs were required to transition to a master’s degree beginning in 1990 and complete the process by 1998. Currently, the American Association of Colleges of Nursing has endorsed a position statement that will move the current entry level of training and education of nurse anesthetists in the United States to the Doctor of Nursing Practice (DNP) or Doctor of Nurse Anesthesia Practice (DNAP). This move will affect all advance practice nurses, with a mandatory implementation by the year 2015. In August 2007, the AANA announced its support of this advanced clinical
degree as an entry level for practice of all nurse anesthetists with a target compliance date of 2025. In accordance with traditional grandfathering rules, all those in current practice will not be affected. Several nurse anesthesia programs have already transitioned to the DNP or DNAP entry level format. Because all programs will be converting to a doctorate level education, the length of the programs will continue to expand. Nurse anesthetists have always embraced the responsibility of helping meet America’s growing healthcare needs. As healthcare technologies continue to advance and the knowledge base of the human body continues to expand, the 2025 requirement of a doctoral level education for entry into nurse anesthesia practice will ensure that patients have continued access to the highest quality anesthesia care that is possible.

Certification

The certification and recertification process is governed by the National Board on Certification and Recertification of Nurse Anesthetists (NBCRNA). The NBCRNA exists as an autonomous not-for-profit incorporated organization so as to prevent any conflict of interest with the AANA. This provides assurance to the public that CRNA candidates have met unbiased certification requirements that have exceeded benchmark qualifications and knowledge of anesthesia. CRNAs also have continuing education requirements and recertification every two years thereafter, plus any additional requirements of the state in which they practice. Currently in revision, recertification in the future will included NBCRNA mandated course subjects in addition to board retesting, similar to physician requirements.

Legal challenges

In the United States, there have been three challenges brought against nurse anesthetists for illegally practicing medicine: *Frank v. South* in 1917, Hodgins and Crile in 1919, and *Chalmers-Francis v. Nelson* in 1936. All occurred before
1940 and all were found in favor of the nursing profession, relying on the premise that the surgeon in charge of the operating room was the person practicing medicine. Prior to World War II, the delivery of anesthesia was mainly a nursing function. There were limited anesthetic drug choices and less was known about the physiologic effects of anesthesia and surgery. In 1942, there were 17 nurse anesthetists for every one anesthesiologist. As knowledge grew and surgery became more complex, the numbers of physicians in this specialty expanded in the late 1960s. Therefore, it was legally established that when a nurse delivers anesthesia, it is the practice of nursing. When a physician delivers anesthesia, it is the practice of medicine. When a dentist delivers anesthesia, it is the practice of dentistry. There are great overlaps of tasks in the health care professions. Administration of anesthesia and its related tasks by one provider does not necessarily contravene the practice of other health care providers. For example, endotracheal intubation (placing a breathing tube into the windpipe) is performed by physicians, physician assistants, nurse anesthetists, anesthesiologist assistants, respiratory therapists, paramedics, EMT-Intermediates, and dental (maxillofacial) surgeons. In the United States, nurse anesthetists practice under the state’s nursing practice act (not medical practice acts), which outlines the scope of practice for anesthesia nursing.

**Scope of practice**

Today, nurse anesthetists practice in all 50 United States and administer approximately 34 million anesthetics each year (AANA). CRNA practice varies from state to state, and is also dependent on the institution in which CRNAs practice.

CRNAs practice in a wide variety of public and private settings including large academic medical centers, small community hospitals, outpatient surgery centers, pain clinics, or physician’s offices, either working together with anesthesiologists, other CRNAs, or in independent practice.
When practicing within the Anesthesia Care Team model, CRNAs most often fall under the medical direction, or supervision, of an anesthesiologist. CRNAs also have a substantial role in the military, the Veterans Administration (VA), and public health.

The degree of independence or supervision by a licensed provider (physician, dentist, or podiatrist) varies with state law. Some states use the term collaboration to define a relationship where the supervising physician is responsible for the patient and provides medical direction for the nurse anesthetist. Other states require the consent or order of a physician or other qualified licensed provider to administer the anesthetic. No state requires supervision specifically by an anesthesiologist.

The licensed CRNA is authorized to deliver comprehensive anesthesia care under the particular Nurse Practice Act of each state. Their anesthesia practice consists of all accepted anesthetic techniques including general, epidural, spinal, sedation, or local. Scope of CRNA practice is commonly further defined by the practice location’s clinical privilege and credentialing process, anesthesia department policies, or practitioner agreements. Clinical privileges are based on the scope and complexity of the expected clinical practice, CRNA qualifications, and CRNA experience. This allows the CRNA to provide core services and activities under defined conditions with or without supervision.

In 2001, the Centers for Medicare and Medicaid Services (CMS) published a rule in the Federal Register that allows a state to be exempt from Medicare’s physician supervision requirement for nurse anesthetists after appropriate approval by the state governor. To date, 17 states have opted out of the federal requirement, instituting their own individual requirements instead.

More than 40 percent of the CRNAs are men, a much greater percentage than in the nursing profession as a whole.
(ten percent of all nurses are men). Because many less-developed countries have few anesthesiologists, they rely mainly on nurse anesthetists for anesthesia services. In 1989, the International Federation of Nurse Anesthetists was established. The International Federation of Nurse Anesthetists has since increased in membership and has become a voice for nurse anesthetists worldwide. They have developed standards of education, practice, and a code of ethics. Delegates from 35 member countries participate in the World Congress every few years. Currently there are 107 countries where nurse anesthetists train and practice and nine countries where nurses assist in the administration of anesthesia.

**Armed forces**

In the United States armed forces, nurse anesthetists provide a critical peacetime and wartime skill. During peacetime and wartime, nurse anesthetists have been the principal providers of anesthesia services for active duty and retired service members and their dependents. Nurse anesthetists function as the only licensed independent anesthesia practitioners at many military treatment facilities, including U.S. Navy ships at sea. They are also the leading provider of anesthesia for the Veterans Administration and Public Health Service medical facilities.

During World War I, America’s nurse anesthetists played a vital role in the care of combat troops in France. From 1914 to 1915, three years prior to America entering the war, Dr. George Crile and nurse anesthetists Agatha Hodgins and Mabel Littleton served in the Lakeside Unit at the American Ambulance at Neuilly-sur-Seine in France. In addition, they helped train the French and British nurses and physicians in anesthesia care. After the war, France continued to use nurse anesthetists, however, Britain adopted a physician-only policy that continues today. In 1917, the American participation in the war resulted in the U.S. military training nurse anesthetists
Spinal Anaesthesia

for service. The Army and Navy sent nurses anesthesia trainees to various hospitals, including the Mayo Clinic at Rochester and the Lakeside Hospital in Cleveland before overseas service.

Among notable nurse anesthetists are Sophie Gran Winton. She served with the Red Cross at an army hospital in Château-Thierry, France, and earned the French Croix de Guerre in addition to other service awards. In addition, Anne Penland was the first nurse anesthetist to serve on the British Front and was decorated by the British government.

American nurse anesthetists also served in World War II and Korea, receiving numerous citations and awards. Second Lieutenant Mildred Irene Clark provided anesthesia for casualties from the Japanese attack on Pearl Harbor. During the Vietnam War, nurse anesthetists served as both CRNAs and flight nurses, and also developed new field equipment. Nurse anesthetists have been casualties of war. Lieutenants Kenneth R. Shoemaker, Jr. and Jerome E. Olmsted, were killed in an air evac mission en route to Qui Nhon, Vietnam.

At least one nurse anesthetist was a prisoner of war. Army Nurse anesthetist Annie Mealer endured a three-year imprisonment by the Japanese in the Philippines, and was released in 1945. During the Iraq War, nurse anesthetists comprise the largest group of anesthesia providers at forward positioned medical treatment facilities. In addition, they play a role in the continuing education and training of Department of Defense nurses and technicians in the care of wartime trauma patients.
Criteria for Referral to Specialist Paediatric Centre

REFERRAL TO A PEDIATRIC NEUROLOGIC SURGEON

A pediatric neurosurgeon is identified by board certification. The American Board of Pediatric Neurologic Surgery offers a subspecialty certificate in pediatric neurologic surgery that can be earned by those Diplomates of the American Board of Neurologic Surgery who have specialized in pediatric neurologic surgery by completing approved training programs.

This certificate recognizes training and experience in the care of children with neurologic surgical problems, as well as the care of congenital disorders throughout the life span, as demonstrated by a minimum of a 75% pediatric neurosurgical operative caseload. It is recognized that in an era of increasing neurosurgical subspecialization, children with particular disorders (eg, intracranial aneurysms) may be better served by a specialist experienced with that specific disorder.

The pediatric neurosurgeon is usually in the best position to determine the most appropriate balance of care for both the child and condition by virtue of access to other regional pediatric and neurosurgical specialists. With these comments
Criteria for Referral to Specialist Paediatric Centre

in mind, the following recommendations are suggested for referral of the infant (0–1 year), child (2–12 years), and adolescent (13–18 years) to a pediatric neurosurgical specialist.

• All infants and children requiring neurosurgical operative care should be cared for by a pediatric neurosurgeon if one is within reasonable proximity. However, it is recognized that under some circumstances, the distance to the nearest pediatric neurosurgeon is prohibitive, and it may be necessary for a general neurosurgeon to provide care; the benefits of each option should be considered on an individual basis.

• Infants and children with traumatic head, spine, spinal cord, and peripheral nerve injuries may be stabilized at a local hospital but should then be transferred to a center having both pediatric neurosurgical expertise and a system in place to care for the traumatically injured child. Infants and children with suspected abusive head trauma should also be evaluated by a pediatric neurosurgeon as part of a team of dedicated pediatric child abuse specialists.

• Infants, children, and adolescents with benign and malignant central nervous system tumors (including tumors involving the brain, spinal cord, meninges, spine, pituitary gland, and peripheral nerves) should be referred from the outset to a pediatric neurosurgeon and other dedicated pediatric cancer specialists.

• All infants, children, and adolescents with congenital brain and spinal cord malformations (including spina bifida) should be cared for by a pediatric neurosurgeon as part of a multidisciplinary medical-surgical team (such as a spina bifida clinic).

• All infants, children, and adolescents with disorders of the craniofacial skeleton (eg, craniosynostosis and
craniofacial disorders) should be cared for by a pediatric neurosurgeon as part of a craniofacial team.

- Infants with hydrocephalus, as well as children and adolescents with complex hydrocephalus, are preferably cared for by a pediatric neurosurgeon; those for whom neuroendoscopy is a surgical option should be evaluated by a pediatric neurosurgeon with neuroendoscopy experience.

- Infants, children, and adolescents with intractable epilepsy who are being considered for seizure surgery should be referred to a neurosurgeon having expertise in seizure surgery.

- Infants and children with infections of the central nervous system, including epidural abscess, subdural empyema, or brain abscess, are preferably cared for by a pediatric neurosurgeon in conjunction with specialists in pediatric infectious disease.

- Infants and children with medical conditions that increase operative risk, such as congenital heart disease, who must undergo a neurosurgical procedure should be cared for by a pediatric neurosurgeon with access to other pediatric specialists.

**REFERRAL TO A PEDIATRIC OPHTHALMOLOGY SPECIALIST**

A pediatric ophthalmologist has completed a residency in ophthalmology, is certified by the American Board of Ophthalmologic Surgery, and has completed additional training of at least 1 year in pediatric ophthalmology. For purposes of developing these recommendations, the following age group definitions are used: infant (0–1 year), child (2–12 years), and adolescent (13–18 years).

Pediatric patients with the following conditions should be referred to a pediatric ophthalmologist:
Criteria for Referral to Specialist Paediatric Centre

- children 7 years or younger who are nonverbal or unable to read letters and in whom there is reason to suspect eye disease;
- infants or children with retinoblastoma or other tumors of the eye and orbital area;
- infants or children with known or suspected cataracts, glaucoma, or blindness;
- infants or children with a diagnosis or at risk of retinopathy of prematurity;
- infants or children with congenital or genetic ocular anomalies or infections (eg, aniridia, toxoplasmosis);
- infants or children with systemic syndromes, metabolic disorders, or chromosomal abnormalities with possible ocular involvement (eg, juvenile idiopathic arthritis, galactosemia, diabetes mellitus, Marfan syndrome, Down syndrome); and
- infants or children suspected of being abused and in whom there is a possibility of eye injury.

Pediatric patients with the following conditions are preferably managed by a pediatric ophthalmologist:

- infants with congenital nystagmus and children with early-onset nystagmus;
- children with strabismus or amblyopia (ie, dimness of vision without detectable organic lesion of the eye) or risk factors for strabismus or amblyopia (eg, family history of amblyopia or orbital or eyelid hemangioma);
- children with a family history of congenital or genetic ocular anomalies (eg, aniridia), infections (eg, toxoplasmosis), tumors (eg, retinoblastoma), or a family history of systemic or metabolic syndromes (eg, juvenile idiopathic arthritis, galactosemia, diabetes mellitus), chromosomal abnormalities (eg, Down syndrome), or other disorders with possible ocular involvement;
• infants or children with exposure during gestation to certain specific drugs or other substances (such as alcohol) that are known to cause anomalies of the eyes;
• infants or children with poor vision or delayed attainment of vision-related developmental milestones and infants and children with severe refractive errors or a strong family history of severe refractive errors; and
• infants or children with ocular or periocular inflammation not responding to initial topical and/or systemic antibiotic therapy or not clearing within 3 weeks of treatment and children with suspected herpes simplex or zoster infections involving the eye or a history of these infections involving the eye.
Identification, Resuscitation, Stabilisation and Transport of the Critically Ill Child

Medical transport of high-risk and critically ill newborns requires skilled personnel and specialized equipment. Ideally, a neonatal transport team forms a single component associated with a larger system of perinatal care composed of a tertiary care neonatal intensive care unit (NICU), a perinatal care unit, cadres of medical and surgical pediatric subspecialists, and a neonatal outreach program.

The critically ill newborn population, including personnel, medical control, equipment, policy development, and transport administration.

A significant number of neonates require emergent transfer to a tertiary care center, often because of medical, surgical, or rapidly emerging postpartum problems. These are termed “outborn” neonates, because they have been born somewhere besides the facility to which they’ve been transferred.

Studies show that shortened interfacility transport time leads to improved outcomes for the smallest and most critically ill newborns. (Critically ill neonates who are born in the specialized center itself, perhaps because of prenatal detection of a problem or because the referral center routinely delivers
care to at-risk perinatal populations, are termed “inborn” neonates.)

Vehicles for ground transport of pediatric and neonatal patients in the United States are usually truck chassis-based and either large enough to transport a single patient, similar in size to most ambulances (on the right), or larger units designed to transport several critically ill infants in transport incubators (on the left). Note that children’s hospital units often may use custom, child-friendly designs. Note that despite the color schemes, the units must have mandatory safety features common to ambulances (eg, lights, lightbars, sirens, the “Star of Life,” highly reflective stripes).

Because the outcome of an outborn neonate with major medical or surgical problems (including extreme prematurity) remains worse than for an inborn infant, primary emphasis should always remain on prenatal diagnosis and subsequent in-utero (ie, maternal) transfer whenever possible. Despite advanced training and technology, mothers usually make the best transport incubators.

**Development of neonatal transport, perinatal regionalization, and NICUs**

The emergence of skills to care for ill or premature
newborns can be linked to exhibits of premature infant care at public expositions, such as the 1933 World’s Fair in Chicago. These exhibits preceded the emergence of NICUs and the transport of ill infants.

After establishment of centers to care for ill neonates, attention shifted to caring for infants who were either born at home or in inadequately equipped centers.

Transport of outborn neonates to specialty centers initially used clever adaptations of incubators otherwise carried in an automobile. Butterfield has written an excellent and personal review of these beginnings.

The next evolution in transport developed from the lessons in aeromedical transport of the wounded in World War II, Korea, and Vietnam. The need for rapid evacuation of trauma patients from the scene of accidents led to the development of a system of trauma centers and aeromedical transport services.

In 1976, the Committee on Perinatal Health, sponsored by the March of Dimes, proposed a system for regionalized perinatal care and defined three levels of hospital care, which served throughout the 1970s and 1980s as a national model for the rapid development of neonatal referral centers. This model required the development of a neonatal transport system, which was associated with a significant reduction in the US neonatal mortality rate.

Because neonatal transport was required for NICU referral centers, and because pediatric transports to pediatric ICUs (PICUs) were increasing, the American Academy of Pediatrics (AAP) formed a Task Force on Interhospital Transport and subsequently developed guidelines. The appearance of various commercial products for the care of neonatal patients in the transport environment paralleled the proliferation of neonatal transport programs.
ADMINISTRATIVE ASPECTS OF NEONATAL TRANSPORT SERVICES

Program director

As health care financing becomes increasingly problematic, pressure increases to achieve efficiency. However, transport scheduling is an intrinsically unpredictable and inefficient process, especially for a low-volume/high-acuity specialty team such as that required for the neonatal population.

A committed hospital administration should provide an experienced manager or program director for a transport service and encourage communication between the hospital administration, the transport team personnel, and the medical director.

Medical control physician

The on-call medical control physician is immediately available to provide advice before and during transport. The medical control physician has the appropriate knowledge to manage critically ill neonatal patients and must be familiar with the capabilities and procedures of the neonatal transport team.

Medical director

The neonatal transport team medical director, who should be a licensed physician and familiar with air and ground emergency medical services, supervises and evaluates the quality of medical care. Ideally, this physician is a board-certified subspecialist in neonatal/perinatal medicine, pediatric intensive care, or both. However, as an alternative, an adult-oriented medical director of a transport team may use subspecialty physicians as consultants.

The medical director should be actively involved in (1) the selection of appropriate personnel, (2) continuing team education and training, (3) the development and review of
policies, (4) the quality management program, and (5) the selection, orientation, and supervision of medical control physicians.

**Communications**

To initiate the transport process, a mechanism is needed for immediately contacting the appropriate medical control physician upon receiving a transport request. The medical control physician decides whether transfer is appropriate, discusses stabilization issues with the referring physician, and, if indicated, authorizes or recommends a mode of transport. Additional communication occurs between referring physicians, accepting physicians, medical control physicians, transport team members, and pilots or drivers.

Ideally, a dedicated communications center operates 24 hours a day, 7 days a week to allow for constant communication during the triage process and transport. A dedicated communications center is especially valuable for rotor-wing aircraft transport or for teams with multiple ground units.

Several viable models are available for communications; to increase efficiency, the trend is to share resources via consolidated communications centers. An alternative method of initial contact is for the referring physicians to call the neonatal intensive care unit (NICU) directly and have the unit personnel place them in contact with the appropriate transport team medical control physician. This mechanism of routing communications is more commonly used by smaller centers and transport teams.

Medical transport systems appropriately focus on rapid arrival of the transport team and medical direction of the team upon arrival at bedside. However, prior to the arrival of the transport team, medical direction and advice to the stabilizing personnel at the referring hospital may be invaluable.

Upon being informed of a transfer request, the medical control physician is put in contact with the referring physician
to discuss the case. Such discussion is essential to allow for adequate preparation of the accepting hospital and transport team and to provide direction on pretransport stabilization prior to the arrival of the transport team. Communication of vital signs, laboratory values, and previous therapies allows for effective comanagement of the patient.

**Procedures and protocols**

The Commission on Accreditation of Medical Transport Systems (CAMTS) develops standards that address patient care and safety in the transport environment and is an excellent resource for the transport industry. CAMTS strives to maintain accreditation standards in accordance with current medical research and transport industry developments and publishes these standards in order to define quality issues.

The medical director is responsible for the development and supervision of transport protocols. The process involves the input of the medical control physicians, transport team personnel, and any applicable subspecialty services (eg, surgery, cardiology), who are encouraged to create a wide spectrum of protocols that cover the most common clinical scenarios encountered in this neonatal population, especially those requiring immediate recognition and action.

Protocols usually include care guidelines for transport team configurations that require a physician. However, with the more common team configurations, the protocols may serve as standing orders to allow the transport team personnel to expedite the care of a critically ill neonate in the absence of direct physician input. The medical director should review protocols at least annually and distribute them to all medical personnel involved in the transport process.

**MANAGING THE CRITICALLY ILL CHILD**

In 2009 nearly 5000 UK children were admitted to 28 paediatric intensive care units (PICUs) from outlying hospitals,
accounting for 64% of their unplanned workload. A designated retrieval team performed the transfer to PICU in 80% of cases with a median time of arrival at the patient’s bedside of 2 hours.

Life-saving interventions required during the first few hours of stabilization remain the responsibility of the referring district general hospital (DGH) and cannot be deferred until the arrival of the retrieval team. The frequency with which referring teams perform interventions. Any hospital that potentially manages sick children should have a series of systems in place that anticipate and ease the process of managing a critically ill child.

Changing practice in district general hospitals (DGH)

Decreasing experience

Many UK hospitals have withdrawn surgical services for children younger than 2 years of age. This leaves many non-specialist anaesthetists with a duty of care to manage sick children out of normal working hours. Nevertheless, public expectation of standards of care has increased and DGH emergency departments (EDs) have maintained open access for all children.

The Tanner report

In 2006 the Department of Health published a report entitled ‘The acutely or critically sick or injured child in the district general hospital – a team response’. The working group established that concerns about deskillling in the management of critically ill children were shared by many specialties, including paediatrics and ED medicine.

The report recommended that services for the critically ill child should be planned within a network, with the local tertiary hospital acting as a source of advice and support while stabilization is performed in the local DGHs. It suggested six
generic skills which can be expected of all personnel involved in the care of critically sick or injured children in the DGH:

• to recognize the critically sick or injured child
• to initiate appropriate immediate treatment
• to work as part of a team
• to maintain and enhance skills
• to be aware of issues around safeguarding children
• to communicate effectively with children and carers.

There was also emphasis on the importance of considering the whole patient pathway.

**Pre-hospital**

The report commented that paramedic crews should transport sick children to the most appropriate paediatric facility, and make a clinical judgement to ‘drive-by’ a local DGH if the hospital does not have a team capable of stabilizing the critically ill child.

**Resuscitation/stabilization**

The report encouraged a team approach with shared responsibility. It emphasized that ‘following the initial stages of resuscitation of a critically ill D collapsed child, stabilization and further management should not be left solely to the anaesthetist’.

**Transfer**

The sickest children require transfer to the local tertiary paediatric centre and this transfer should be performed by a designated paediatric retrieval team. However, in certain cases, it may be necessary for the DGH team to facilitate transfer.

**Organizing a DGH to manage a critically ill child**

**Preparation**

Relative to adult practice, the resuscitation and stabilization of critically ill children is a rare event. This increases the need
for clear planning in order to ensure a smooth pathway for each patient. As a minimum each hospital should aim to have in place:

- clear communication pathways within and between departments
- easily available hospital protocols and guidelines for the management of common paediatric emergencies
- appropriate range of drugs and equipment
- adequate, ongoing training of staff in paediatric emergencies.

**Location**

Critically ill children usually present to the ED; however, they may also deteriorate in theatre, wards or other clinical areas. It is not practical to equip all clinical areas to stabilize a sick child. Local guidelines should be in place stating where resuscitation and stabilization should occur until the child’s condition improves or the retrieval team arrives.

Children should ideally not be managed directly alongside adults and the need to support the family should be remembered. Parents and, where possible, children should be consulted when designing areas of care.

**Equipment**

Studies show that DGHs continue to perform the vast majority of key stabilization procedures on critically ill children. Therefore it is essential that paediatric and neonatal emergency equipment be readily available, well maintained and organized in a systematic fashion. Staff should undergo regular updates on its use, especially if used infrequently. A robust system should be in place to ensure that every area has rapid access to this equipment in the event of a paediatric emergency. Formal checks of drugs and equipment should be performed daily.
When equipment is procured in the DGH, it is useful to ensure suitability for use with both adult and paediatric patients as this will allow adult practitioners to use equipment with which they are familiar, and minimize cost.

The emergency equipment should be arranged in a structured manner so that staff using it infrequently can find the necessary items quickly and easily. This can be achieved in different ways:

- system-based
  - airway equipment of all sizes in one drawer, circulation in another
- weight-based
  - one tray containing all the equipment for a child of a given weight.

**Team composition**

Stabilization of a critically ill child requires a team of competent individuals. As a minimum this should include:

- a paediatrician or ED consultant
- an anaesthetist or intensivist
- a paediatric trained nurse.

Clinicians from other services such as surgery or radiology may also need to be involved. All staff should be trained in the specific needs of children and their families, including child protection and consent.

It may sometimes be necessary for staff within the DGH to undertake transfer to the regional PICU if the condition is time-critical or if the retrieval team is unavailable. Suitable trained staff to facilitate the transfer must be available at all times.

**Support services**

Services such as haematology, chemical pathology, radiology and blood transfusion should meet the requirements
of children. Pharmacy staff with specialist paediatric knowledge should be available to ensure safe and effective drug management.

**Hospitals with no acute paediatric units**

Where a DGH with no on-site inpatient paediatric facilities offers children unrestricted access via the ED, the challenges of being able to manage the critically ill child are even greater. ‘Drive-by’ policies agreed with the ambulance service and close links to other hospitals with paediatric facilities are crucial.

**Teamwork and training**

A team approach is essential in order to utilize the skill-mix of different practitioners.

Local policies should define the members of the paediatric resuscitation team, the team leader (for example, emergency medicine consultant or paediatrician) and the roles expected to be performed by each member of the team.

Front-line medical staff should be trained in paediatric resuscitation and receive annual updates. The departments should aim to support staff as they improve their knowledge and skills through:

- practising skills such as intraosseous needle insertion on purpose-built equipment
- completion of an accredited paediatric life-support course
- repeated attendance at these courses for the purpose of recertification/revalidation
- secondment to a local paediatric centre
- locally organized training (involving all departments)
- regular audit
- interdepartmental morbidity/mortality meetings
- tutorials and e-learning modules.
Practice scenarios are a good opportunity to test equipment and review or develop local guidelines. Audit and morbidity/mortality meetings are an essential opportunity for the team to reflect on how actual cases are managed and identify areas of improvement.

**Relationship with the tertiary centre**

A good relationship between a DGH and the local tertiary paediatric centre is essential if care of the acutely ill or injured child is to be well organized and effective. Links and coordination need to exist on several different levels.

**Networks**

The creation of paediatric service networks has helped improve communication over the last decade. In many regions, paediatricians, surgeons and paediatric anaesthetists have formed groups that create regional guidelines, conduct peer reviews of services and organize study days. There is no substitute for face-to-face meetings between clinicians as a way of developing closer links between local and tertiary centres. Outreach education and feedback sessions in local units help to foster the feeling of partnerships between DGHs and regional PICUs.

**PREVENTION OF COMPLICATIONS IN THE AIR TRANSPORT OF THE CRITICALLY ILL PAEDIATRIC PATIENT BETWEEN HOSPITALS**

A large number of publications have demonstrated a direct relationship between the volume of admissions and the survival of patients in various highly specialised services. Centralisation of paediatric intensive care units has also been shown to improve results and optimise the cost–benefit ratio of hospitalising critically ill patients. Consequently, tertiary hospitals are centralised in major cities and seriously ill children admitted to local hospitals have to be transferred, making it necessary to establish specialist transport teams.
This entails a risk in addition to that of the patient’s actual illness. In 1975 Waddell described a rate of complications as high as 20% during transfer and a resulting increase in mortality; children who required transport were at double the risk of dying compared with those admitted to the Intensive Care Unit from the same hospital.

The American Academy of Pediatrics published its guidelines for air and ground transportation of paediatric patients in 1986, with the goal of standardising the transport of critically ill children. In 1990, it founded the Section on Transport Medicine, comprising experts in neonatology, intensive care and emergency medicine working in this area.

Since then it has coordinated research and teaching on paediatric transport in the United States. The guidelines were revised in 1993 and 1997. All of them agree that the quality of interhospital paediatric transport is determined by two factors: the level of training and specialisation of teams, and optimum stabilisation of patients before transfer.

The aim of this review is to analyse the rate of complications recorded during the transport of critically ill patients after applying the stabilisation standards in the sending hospital, as established by our air transport unit. For this purpose we defined the criteria for stabilisation prior to transport, the interventions resulting from them, the complications arising during transfer and the therapeutic procedures required to resolve them.

**Materials and methods**

This is a retrospective, descriptive study, which includes patients aged between 0 and 14 transferred by our air unit between January 2005 and December 2009 (5 years). The care team is made up of paediatricians and nurses who carry out air transport exclusively by helicopter. Three diagnostic groups were identified: patients with respiratory failure, patients with
haemodynamic instability and patients with neurological involvement.

We recorded the actions performed by staff of the sending hospital and those of the transfer team at the sending institution, dividing them into oxygen therapy, intubation, connection to invasive or non-invasive mechanical ventilation, pleural drainage, placement of peripheral or central lines, infusion of vasoactive drugs, administration of anticonvulsants and cardiopulmonary resuscitation procedures.

We recorded the complications that arose during transfer, dividing them into major and minor complications and classifying them as respiratory, haemodynamic or neurological. The following were defined as major complications: desaturation lasting more than a minute that was not corrected by increasing FiO2 or adjusting the ventilator, disconnection of catheters or chest tubes, accidental extubation, drop in arterial blood pressure requiring the administration of at least 10mL/kg of fluids, arrhythmias or cardiac arrest, and clinical signs of intracranial hypertension. Minor complications were desaturation corrected by increasing FiO2 or adjusting the ventilator, patient-ventilatory dyssynchrony, kinking of the endotracheal tube, drop in arterial blood pressure corrected by modifying the infusion of vasoactive drugs, and convulsions controlled by anticonvulsants.

**Results**

A total of 388 patients were transferred, 157 male and 231 female. Of these, 167 were neonates and the rest were children of up to 14 with an average age±standard deviation of 37±42 months.

Within the various diagnostic categories, the most prevalent item was acute respiratory failure (207/388), followed by neurological involvement (124/388) and (102/388) patients with haemodynamic alterations.
A patient with craneoencephalic trauma and a ruptured liver had to be operated on beforehand at the indication of the transport team on the grounds of haemodynamic instability. Two patients died in the sending hospital.

During the transfer of the 388 patients, 20 major complications (5.1%) and 69 minor ones (17.7%) were recorded. Of these, 27 were respiratory, 42 haemodynamic and 20

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**Table : Stabilisation procedures carried out by the professionals at the sending hospital.**

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<thead>
<tr>
<th>Stabilisation procedures sending hospital</th>
<th>Number</th>
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<tr>
<td>Supplementary administration of oxygen</td>
<td>144</td>
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<tr>
<td>Intubation and connection to invasive</td>
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<td>mechanical ventilation</td>
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<td>Non-invasive ventilation</td>
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<tr>
<td>Placement of chest tube</td>
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<td>Placement of central lines</td>
<td>80</td>
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<td>Infusion of vasoactive drugs</td>
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<tr>
<td>Administration of anticonvulsants</td>
<td>30</td>
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<td>Cardiopulmonary resuscitation procedures</td>
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**Table : Stabilisation procedures carried out by the transport team.**

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<tr>
<th>Stabilisation procedures transport team</th>
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<td>Placement of chest tube</td>
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<tr>
<td>Infusion of vasoactive drugs</td>
<td>43</td>
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<tr>
<td>Administration of anticonvulsants</td>
<td>11</td>
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<tr>
<td>Cardiopulmonary resuscitation procedures</td>
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neurological. We analysed each group separately and found the following:

- Of the total of 27 respiratory complications, 26 were minor: 24 cases of hypoxia, resolved by adjusting the ventilator, and 2 of kinking of the endotracheal tube (ETT) that required repositioning the tube. The major complication was a pneumothorax, for which a chest tube needed to be placed. All the respiratory complications occurred in intubated patients; none of the non-intubated patients had to be intubated during transport and none required adjustment of the oxygen concentration administered.

- Of the haemodynamic complications, 13 of the 42 were major: 11 cases of hypotension requiring treatment with fluids, one of cardiac arrest, and one of ventricular fibrillation requiring CPR prior to an emergency landing. The patient with cardiac arrest died. The remaining 29 complications were minor and involved hypotension resolved by adjusting the dose of vasoactive drugs that the patients were receiving. In no case was it necessary to place an intravenous line or initiate continuous infusion of vasoactive drugs during transport.

- As for neurological complications, 6 of the total of 20 were major, due to the appearance of clinical signs of intracranial hypertension (IH) which required infusion of hypertonic saline solutions and/or short-term hyperventilation. All the patients with IH had previously been intubated and ventilated. The 14 minor cases involved convulsions which were treated successfully with anticonvulsants.

Discussion

The efficiency of paediatric transport rests on three fundamental principles: specialisation of teams, appropriate stabilisation prior to transport and prevention of complications.
Specialisation of teams

Paediatric transport requires a high degree of specialisation. Macnab in 1991, and Edge et al. in 1994, each published papers showing that the transfer of critically ill children with paediatric teams reduced morbidity compared with non-paediatric teams. Another study by Macnab et al. in 2001 demonstrated that specialised teams achieved a better cost-benefit ratio, leading to lower hospitalisation costs, because fewer complications occurred during transfer. Our hospital’s paediatric transport unit, with 15 years’ experience, undertakes interhospital transfer of patients throughout Catalonia and is part of the Sistema de Emergencias Médicas (Medical Emergencies System). The care staff comprises doctors specialising in paediatrics, paediatricians and holders of university degrees in nursing, with expertise in paediatric and neonatal intensive care. All of them have taken courses in advanced paediatric cardiopulmonary resuscitation, neonatal cardiopulmonary resuscitation, advanced paediatric trauma life support, the course for health care crew in Helicopter Emergency Medical Services (HEMS), and an annual Crew Resource Management (CRM) refresher course. The pilots and co-pilots, for their part, have extensive experience in HEMS and training in advanced life support techniques.

Stabilisation standards

In 2010 Fanara et al. published a review of 66 bibliographical items on adverse events during transport of critically ill adult patients. They emphasised stabilisation prior to transport as a decisive factor in preventing them and distinguished between major and minor complications, categorising them as respiratory, cardiocirculatory or neurological.

They defined major complications as those that required urgent action and put the patient’s life at risk. In the case of children, and especially in helicopter transport, the level of stabilisation at the sending hospital must be optimal. Whether
complications arise or not during transfer largely depends on
this. One must bear in mind that if they do arise, they are
extremely difficult to treat on board a helicopter in flight. We
must therefore be very careful during this phase of transfer.
The stabilisation standards we have adopted in our case follow
the classic ABC pattern.

- The airway must be systematically isolated in patients
  with severe neurological, respiratory or haemodynamic
  involvement, as well as those in whom permeability
  cannot be permanently guaranteed because of trauma
  or severe burns to the facial bones, face or neck. The
  same procedure must be followed if the patient is
  agitated or requires high doses of sedatives or analgesics
  that could give rise to respiratory arrest. In most cases,
  in-flight intubation would necessitate a highly
  undesirable emergency landing.

- In critically ill patients, oxygen transport is
  compromised, and so, in many cases, is gas exchange
  in the lungs. Tissue oxygenation is a priority, and
  therefore, as an indispensable measure, we have to
  ensure that oxygen saturation is maintained close to
  100% through conventional or high-flow masks or in
  nasal cannulae if the patient is not intubated. In patients
  undergoing mechanical ventilation special attention
  must be paid to airway pressure. The risk of
  pneumothorax must be minimised, especially in patients
  with a pattern of obstruction. Peak pressure, and
  especially mean pressure, must be as low as possible.
  The greatest risk to a patient on ventilation, apart from
  pneumothorax, is accidental extubation; special
  attention must be paid to the fixing of the endotracheal
  tube and any moving of the patient must be done with
  extreme care.

- From the circulatory point of view, it is essential to
  have at least two intravenous lines and for at least one
of them to ensure high flow infusion. Otherwise, the placement of a central catheter will be indicated, allowing for rapid expansion of volume when the need arises. One must try to achieve the maximum possible haemodynamic stabilisation, depending on the condition from which the patient is suffering, optimising blood volume or using vasoactive drugs. Although the minimum level of haemoglobin in stable patients is 8g/dl, in critically ill patients it is advisable to set it at 10g/dl, especially in cases of craneoencephalic trauma; PRBC (packed red blood cells) must therefore be infused until this is achieved. The coagulopathy which tends to occur in these patients must also be stabilised as far as possible. Prothrombin time, partial thromboplastin time and platelet count are the values that must be monitored. The objective is to attain a prothrombin time >18s, an activated partial thromboplastin time >60s and a platelet count >100,000 with the administration of plasma and/or platelets. Finally, it must be borne in mind that we can never transfer a patient with ongoing internal haemorrhage. Damage control surgery is essential in such cases to control the bleeding and make it possible to achieve haemodynamic stabilisation that will ensure a sufficient degree of haemodynamic stability during the transfer. If necessary, definitive surgery will be performed at the receiving hospital in a second phase.

• With respect to neurological status, patients with a Glasgow Coma Scale score <10 must be intubated, avoiding as far as possible continuous infusion of curare, which would prevent us from detecting possible convulsions or clinical signs of herniation during transport. In cases of craneoencephalic trauma, appropriate cerebral oxygenation and perfusion pressure must be maintained. Reduction of cerebral
blood flow due to hyperventilation may aggravate post-traumatic ischaemia. For this reason we maintain a pCO2 of between 35 and 40 mm Hg and oxygen saturation close to 100%. Hyperventilation must not be induced nor must manitol or hypertonic saline solutions be used as a preventive measure. Arterial blood pressure shall be kept, as far as possible, at normal levels, helping to maintain appropriate cerebral perfusion pressure; permissive hypertension is not recommended in these patients. By obtaining a cranial CT scan prior to transfer we will be informed of possible lesions that may give rise to increases in intracranial pressure during transfer. Finally, patients who have presented with convulsive seizures must be treated.

Even though the hospital care staff largely stabilised the patients in the series under review, the transport team had to apply various techniques before beginning the transfer in order to achieve the desired stabilisation.

This explains the fact that on many occasions stabilisation took longer than the transport itself. The transport team carried out 24% of the intubations, 20% of the peripheral intravenous line placements, 17% of the central catheters and 71% of the pleural drains. This last point is particularly significant.

One must remember that atmospheric pressure during a helicopter flight is lower than at sea level. According to Boyle’s law, this leads gases to expand, and the higher the flight altitude the greater the expansion. Therefore any pneumothorax, even if not under tension, must be drained beforehand.

Another point to be highlighted is that haemodynamic stabilisation is more demanding, as evidenced by the high rate of use of vasoactive drugs by transport teams, 46% of the total. Finally, it is important to note that transport of an unstable patient with internal bleeding was refused until a surgical
operation had been performed. Specifically, a simple craneoencephalic trauma had been diagnosed. The transfer team observed a haemodynamic instability that was not attributable to the cranial trauma; a scan detected a ruptured liver, and an operation was therefore carried out prior to transport.

Checking the infusion pumps and the correct placement of drains, probes and intravenous drips before and after transport is crucial. Autonomy in medical gases and electricity must be tested beforehand, as well as the autonomous suction equipment. The transport ventilator parameters must be adjusted, on the basis of the prior ventilation settings in the hospital, according to blood gas values, just before beginning the transfer. It is advisable to take a chest X-ray to check the correct positioning of the endotracheal tube and the pleural drains once the patient has been placed on the trolley. Electrocardiogram, arterial oxygen saturation, respiratory frequency and arterial blood pressure must be continuously monitored.

The resuscitation medication, manual ventilation equipment and defibrillator, as well as the drugs that may potentially be needed according to the illness, must be kept to hand. Among the latter we would particularly emphasise sedatives, analgesics, neuromuscular blockers, anticonvulsants and vasoactive drugs. The most important thing, however, is to be constantly attentive to the patient being monitored: to keep a constant check on his or her state, level of consciousness, colour, symmetry of ventilation, pulse and possible presence of alarming clinical signs. We must detect any change in stability, anticipate events and treat complications as soon as they arise. We have to bear in mind that an emergency landing may be required, depending on the procedures that have to be performed. We must warn the pilots about these circumstances so that they keep the flight as stable as possible and stay on the lookout for potential landing sites.
Complications during transport

Any complication during medical transport, particularly by helicopter, is potentially serious. The difficulties of any transfer are increased by the limited space in the cabin. We want to emphasise, however, that although the overall rate of complications in transit was 22.9%, those that put the patient at grave risk and that we define as major represented only 5.1% of the total. As for minor complications, they amounted to 17.7%, in line with other articles published on adults. However, although we have defined them as complications that we were able to resolve with minimal intervention, if they had not been noticed and consequently treated they could have put the patient in serious danger. It must be emphasised that in order for such situations to be easily controllable, they have to have been anticipated and the necessary means provided to resolve them. The line separating minor from major complications is precisely their prevention, even if it entails a greater degree of intervention during prior stabilisation.

Specifically, with regard to the airway, ventilation and oxygenation, the greatest risk of complications is accidental extubation or an unforeseen need for intubation. It is important to stress that one must be especially careful in this area and very rigorous in prior stabilisation. In our case, 38.1% of patients were intubated before transfer and we would highlight the fact that none needed to be intubated in flight. It is also worth mentioning that only one pneumothorax occurred while flying. This point reinforces the importance of detecting and draining air leaks before transport, even if they are not under tension, and ventilating patients at the lowest possible pressures. From the point of view of circulation, it is vital to have permeable venous access points that enable large flows of liquids to be infused. In our series, no lines needed to be placed in transit. It should be remembered that this last technique, and also intubation, are particularly difficult procedures to perform in
flight and significantly compromise the patient. It is worth emphasising that an emergency landing had to be made on only two occasions, one for ventricular fibrillation and one because of a cardiac arrest. In the latter case, the patient died.

**Conclusion**

Transport of critically ill paediatric patients between hospitals entails a potential risk of complications. Their treatment, if they occur, is especially difficult during transfer by helicopter. In order for it to be carried out in optimum conditions, two conditions have to be fulfilled: a high degree of specialisation in the care team and an adequate level of stabilisation at the sending hospital. Ensuring permeability of the airway, providing appropriate ventilation and optimising the level of cardiocirculatory stability are particularly important. In our series, 38.1% of the patients were intubated (24.3% by the transport team) and no patient required intubation during transfer. A total of 14 chest tubes were placed (71.4% by the escorts) and only one patient had a pneumothorax during the flight. Of the total of 495 intravenous line placements, 19.8% were carried out by the transport team and none were needed in transit. Vasoactive drugs were administered to 23.7% of the patients, 46.7% being instituted by the escorts. In no case did administration have to be initiated during the transfer.

In total, only 5.1% of the patients suffered a serious complication. We attribute this low rate of complications to correct stabilisation based on the standards adopted by the team.
Day Case Anaesthesia and Pain Control

THE MANAGEMENT OF PAIN FOLLOWING DAY-CASE SURGERY

The object of this study was to assess patients’ experience of pain management following day surgery. One hundred and two patients agreed to take part in a telephone survey, 2 and 4 days following day surgery. The majority of patients (73%) were broadly satisfied with the quality of pain management they received, however, there was room for improvement. Despite modern anaesthesia and surgery, 17% of patients surveyed reported having severe pain immediately following day-case surgery.

The majority (82%) of patients left the day-case ward in pain and an even higher proportion (88%) had pain at some time between 2 and 4 days postoperatively. Severe levels of pain following discharge from hospital were a concern for 21% of patients. It was reported that day-case staff did not always ask patients whether they were in pain. Communication with patients is vital in the delivery of optimal care. More support and more information are needed to manage patients’ pain effectively, whilst in the day-case wards and also following discharge, at home.
The Royal College of Surgeons of England defines a surgical day case as: ‘a patient who is admitted for investigation or an operation on a planned nonresident basis and who nonetheless requires facilities for recovery’.

In 1990, the Audit Commission recommended an increase in the provision of day surgery, and the number of patients undergoing surgery as a day case has subsequently increased. This has largely been made possible by advances in surgical and anaesthetic techniques, for example, patients’ recovery following day surgery has improved with the use of new short-acting anaesthetic agents.

The cost of day-case surgery is generally seen as being lower than the cost of inpatient care. However, there is concern that this increase in day surgery has increased the workload of community staff.

The day surgery task force report advised that the expansion of day surgery would be strongly influenced by consumer’s attitudes, including patient and carer satisfaction with day surgery. Many day surgery units regularly audit their practices to try and improve patient care and patient satisfaction.

A number of approaches exists to determine patient satisfaction and preferences for healthcare treatments and services.

Many previous studies have investigated patients’ attitudes and satisfaction with their day-case experience, and these may have led to improvements in day-case surgery provision. For example, the study by Cripps & Bevan of patient experiences following day surgery found that 25% of patients reported ‘unacceptable’ levels of pain, resulting in changes in local practice relating to pain relief.

A national postal survey of day surgery units found that the management of postoperative pain was perceived as substandard in almost 70% of patients. It would seem that we
still do not know enough about managing patient’s pain following day-case surgery, or how to learn from patient’s experiences of their pain after discharge.

The purpose of this study was to investigate pain management, both within and out of hospital, in patients undergoing day surgery with general anaesthesia; with a particular focus on the day-case procedures known to be more painful.

Previous studies have followed patients for the first 24–48 h after discharge. Our study followed up the management of pain for up to 4 days postoperatively, and included the patient’s own rating of pain, contact with other services, and the requirements for further analgesia at discharge, and on days 2 and 4 postoperatively.

The study

This investigation formed part of a large national study reviewing pain services and standards for the Clinical Standards Advisory Group (CSAG). Patients attending each of 10 hospital sites for day-case surgery were surveyed during 1997.

Hospitals were selected randomly from a sampling frame of all UK acute hospitals, stratified to ensure a geographical spread of sites. Sequential adult patients attending for day-case surgery at the time of the local CSAG investigation were approached. The recruitment of patients continued until a predetermined number of patients was recruited from the 10 hospitals.

Methods

Patients undergoing a range of day-case procedures (including laparoscopy, dental extractions, vasectomy, hernia repair and arthroscopy) were approached by a research interviewer and asked whether they would be willing to take part in a telephone survey. Each patient was provided with
an information sheet about the study, and asked to sign a consent form and give telephone details for later contact. A structured questionnaire was used to interview patients by telephone on day 2 and day 4 following discharge.

**Results**

One hundred and ten patients were approached to be included in the study, three patients refused and five patients, even though they consented, could not be contacted on day 2 following discharge. Therefore, one hundred and two patients (93%) took part in the survey. Three of the 102 patients who took part in the questionnaire on day 2 could not be reached on day 4, so results from the telephone interview for day 4 are based on 99 respondents.

**Patient details**

The age range of the patients was 17–71 years with a median age of 34 years. More females (55% \( n = 56 \)) were interviewed than males (45% \( n = 46 \)). The types of day-case procedures were: laparoscopy (31%), dental extractions (23%), vasectomy (13%), hernia repair (10%), arthroscopy (8%), cyst removal (4%) and other (11%).

**Perceptions of pain after surgery**

The majority of patients (73% \( n = 74 \)) rated their overall pain management on the day-case ward as being good or excellent with only a small minority rating their care as being poor (4% \( n = 4 \)).

However, despite modern anaesthesia and surgery, 17% of patients reported having severe pain immediately following day-case surgery, and a significant number continued to experience pain at home for up to 4 days following discharge. Severe pain was still reported as a problem for 21% of patients 2 days following discharge although by day 4, only 7% still experienced severe pain.
Three of the patients who experienced severe pain on day 4 were not those who experienced severe pain on day 2. When patients were telephoned on day 4, 19% of the patients still stated that their pain had not improved.

Twenty-four of our 102 patients were experiencing pain prior to their operations. Five of the 24 patients having pain before surgery did not have pain following surgery.

**Assessment of pain and use of analgesics**

While patients were in the day surgery ward, staff asked 65% ($n = 66$) of patients whether they were in any pain, however, 29% ($n = 30$) of patients said they were not consulted and 6% ($n = 6$) could not remember being asked. The majority of day-case wards assessed patients’ pain using a verbal description of pain, whereas 4% ($n = 4$) of wards used a numeric
Day Case Anaesthesia and Pain Control

assessment. Just over half (57% \( n = 58 \)) of the respondents were asked whether they wanted any pain relief. Of those patients who received analgesia, the majority (77% \( n = 79 \)) received pain relief in < 10 min, but there were three patients who reported waiting ‘up to an hour’; and two patients surveyed reported waiting ‘over an hour’ for pain relief medication.

Information about the nature of surgery was reported to be available to 88% \( (n = 90) \) of patients, but in 29% \( (n = 26) \) of these, there was no reported advice on pain management or pain relief treatments. Of those patients receiving information, the majority (78%) referred to the information, 12% did not refer to it and 10% did not find it helpful.

Once patients returned home, the majority of patients felt confident at managing their own pain, with 71% rating their own management as being good or excellent, 24% rating it as average and only 5% rating it as poor.

Patients’ requirements for analgesia

Many patients (76% \( n = 74 \)) were sent home with analgesic medication. However, by day 2, 43% \( (n = 42) \) of patients had obtained further analgesics in addition to those originally given by day-case ward staff.

Table: Number of patients obtaining further analgesia (98 respondents; four non-responders).

<table>
<thead>
<tr>
<th></th>
<th>Further analgesia obtained</th>
<th>No further analgesia obtained</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sent home with analgesia</td>
<td>24</td>
<td>50</td>
<td>74 (76%)</td>
</tr>
<tr>
<td>Sent home without analgesia</td>
<td>18</td>
<td>6</td>
<td>24 (24%)</td>
</tr>
<tr>
<td></td>
<td>42 (43%)</td>
<td>56 (57%)</td>
<td>98 (100%)</td>
</tr>
</tbody>
</table>

Most (18) of the 24 patients who were sent home without analgesia reported having to seek analgesia postoperatively; A further 24 patients (24%) who were sent home with analgesia
also needed to obtain more analgesia. By the second telephone interview on day 4, about half had obtained additional analgesia.

Of the 42 patients who obtained further analgesia, advice was sought from the day-case ward in 48%, from a general practitioner (GP) in 11% and from a local pharmacy in 5%. Decisions to obtain additional analgesia were taken by 35% of patients without reference to any professional advice.

**Level of contact with the community services and primary care**

Most patients (89% \( n = 88 \)) had not contacted their GP by day 2. Of the 11 patients who did, five had visited their GP at the health centre, two had a home visit and four sought telephone advice. On day 4, our telephone interview identified 15 patients in total who had contacted their GP. Three of these individuals reported having severe pain, six reported mild pain and six reported moderate pain.

**Discussion**

Research in the area of patient satisfaction is difficult. Bowling stated that investigators rarely define patient satisfaction in their studies, so that it is difficult to know what dimension is actually being measured. It is common to find studies on patient satisfaction that report patients being ‘satisfied with care’, whereas more detailed investigation reveals a far greater degree of criticism by patients.

Previous studies have demonstrated that patients are mostly satisfied with the care they received in the day-case surgery unit. Despite inadequate pain management in some cases, the patients we surveyed were also broadly satisfied with the care that they had received.

Postoperative pain was still a problem on returning home for many patients and continued to be so for up to 4 days in > 10% of patients in our study. Despite effective pain relief
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Although practices of individual day-case units differ, most follow written postoperative pain relief regimens. Most provide analgesics for patients to take home, the details varying with the surgical procedure. Our study found that 76% of patients were given analgesics to take home, however, 24% of patients required additional analgesia.

Patients value adequate information about the possible pain that they might experience postoperatively. Our study demonstrated that 12% of patients were not provided with either written or verbal information about their surgery or treatment. Previous studies have shown that patients usually want more information concerning their care. Waterman et al. investigating patients’ perspectives on pain, nausea and vomiting following ophthalmic day-case procedures, revealed that patients usually require more information about pain.

Once patients had returned home, we found that 48% of patients contacted the day-case ward for further advice and support. If more information was provided to patients about their pain management prior to discharge, it is possible that the need to contact the day-case unit might be reduced.

In previous studies, between 4 and 6% of day-case patients sought advice from their GP during the post operative period. Our study showed rather more contact (11%) with GPs following discharge.

With increasing numbers of surgical operations being performed as day cases, good patient information, good management of pain and adequate support are important issues. Despite advances, there is still room to improve pain management and quality of care for patients undergoing day-case surgery.

Alternative ways to reduce prevalence of pain following discharge need to be examined. Some day-case units have only
one pain relief regimen for discharge, and this might not be adequate for more complicated or more painful operations. Day-case units that do not provide oral analgesia can be regarded as delivering substandard care. Communication with patients is vital in the delivery of optimal care, and provision of good quality information is one way to improve patient care.

RAPID EMERGENCE OF DAY-CARE ANAESTHESIA: A REVIEW

The boundaries of day-care surgery are redefined exponentially with time. The rapidly changing financial situation in the world has led to the increase in the incidence of ambulatory surgery.

The advances in surgery, anaesthesia and pain management have allowed huge expansion of this modality of care with a consequent reduction in the need for hospitalization. The target for day surgeries in the USA and UK are 80% and >75% of the total surgeries, respectively. Even though data are not available for India, there is huge potential in view of a massive population of 1.2 billion and recent huge expansion in the private sector has created an opportunity for expansion in day surgery in India.

The advantages of day case surgeries are to patient, hospital and insurance companies. They include minimal psychological disturbances for the patient, especially children, economical with reduced requirement of nursing and medical supervision and hospital services allowing more number of patients to be treated and finally consequent reduction in the risk of hospital-acquired infection and venous thromboembolism (VTE).

Few controversies related to day case surgery are under the following: patient selection, surgical procedures, preparation, anaesthetic management, recovery and organizational issues.
PATIENT SELECTION

Most of the patients are suitable for day surgery. With the current in-patient procedures, we should question ourselves if there are any ways with which they can be managed as day cases.

Age

It is now a routine to accept full-term infants of more than 1 month age and 60 weeks post-conception age in premature born for day case procedures. Post-operative apnoea is a serious complication in infants with recent episodes of apnoea, cardiac or respiratory disease, family history of sudden infant death syndrome and adverse social circumstances who should be admitted for overnight observation with close monitoring. Children are ideal for day surgery as there is minimal separation from parents and risk of hospital-acquired infection. Federation of ambulatory surgery association has observed that there is no significant relationship with pre-existing diseases and incidence of post-operative complications; elderly with multiple co-morbidities are also acceptable for day surgery.

Hypertension

The benefits of deferring surgery solely for the purpose of control of a possibly isolated high BP of up to 160/100 mmHg are not clear. Uncontrolled hypertension in itself is a minor risk factor for peri-operative outcomes. There is neither level 1 evidence to support the hypothesis that pre-operative control of arterial blood pressure is beneficial in reducing adverse events nor that moderate hypertension is a predictor of adverse outcomes. Even though cardiovascular complications are common in hypertensive patients, they are of limited consequence. Pre-operative blood pressure of more than 160/100 mmHg would require further investigation and treatment.

Intra-operative hypotension is more frequent in patients taking angiotensin-converting enzyme (ACI) inhibitors and
angiotensin II receptor antagonists. It is common for all antihypertensive agents to be continued except ACE inhibitors. As intra-operative hypotension is more frequent, whether ACE inhibitors and angiotensin blocking drugs should be continued as before or stopped is still controversial. The benefits of continuing medications include cardio protection, improved renal function and reduced sympathetic response and the fact that hypotensive consequences are generally mild and respond to usual corrective measures.

**Obesity**

It is defined as the body mass index (BMI) of more than 30 kg/m$^2$. Department of health in UK suggests that patients with BMI up to 40 kg/m$^2$ are also suitable for day surgery. There is little evidence to support the view that obese patients suffer clinically relevant increased morbidity after day surgery. The incidence of complications during the peri-operative period increases with increasing BMI. These problems occur in the first 3- to 4-hour post-operative period, can be easily resolved and later patient can be discharged. The day surgery with its short duration anaesthetics and early mobilization are especially suitable for obese patients.

**Obstructive sleep apnoea**

The main problems with obstructive sleep apnoea (OSA) patients are as follows: airway management – increased risk of difficult mask ventilation and intubation, there is increased risk of post-operative obstruction and hypoxia in airway surgery and residual sedation with increased risk of post-operative apnoea. Any anaesthetic techniques including local or regional anaesthesia, total intravenous anaesthesia or general anaesthesia with sevoflurane, using paracetamol, NSAIDS, remifentanil, are appropriate if used judiciously.

The type of surgery whether for correction of OSA or coincidental surgery, severity of OSA, presence of comorbidity,
availability of nasal continuous positive airway pressure device, adequacy of post-operative observation, ability to manage complications and patient’s support system at home determine suitability for day-care anaesthesia. An anaesthetist should individually assess patients with severe symptoms and comorbidities regarding suitability for day surgery depending on the surgery and the anaesthetic planned.

Patients on anti-platelet and anti-coagulant drugs

Patients with VTE in last 3 months, recurrent VTE and mechanical mitral valves are not suitable for day-care surgery. A discussion with cardiologist and haematologist is essential in patients with mechanical aortic valve, with atrial fibrillation and arterial thrombus within a month for their peri-operative care planning. Pre-operative assessment allows us to identify patients with anticoagulant drugs and advise them regarding drug management.

Patients with upper respiratory infection

What should be done with day case patients with colds?

The history of reactive airways, copious secretions, nasal congestion, smoking or productive cough favours postponement. The available evidence suggests that increased upper airway reactivity may lead to increase in intra-operative complications.

Consider postponing the procedure for 3 weeks in patients with upper respiratory infection (URI) based on the anaesthetic necessities and surgical factors. It is suggested to assess carefully for the presence of lower respiratory infections before going ahead with surgery for patients with URI.

Diabetes

Many patients with diabetes need surgical procedures that are suitable for day surgery. A recent consensus statement concludes ‘the usefulness of strict control of blood glucose
concentration (i.e. a blood glucose level of <8 mmol/l) during the peri-operative period is uncertain in patients with diabetes or acute hyperglycaemia who are undergoing surgery. Tight glycaemia control is not necessary in stable diabetics and in those requiring up to 8 hours of peri-operative fasting.

The combination of less invasive surgical techniques, modern anaesthetic agents with less post-operative nausea and vomiting and improved patient understanding of their diabetic control mean many patients can be safely managed as day case. Minor and intermediate procedures are suitable for day case surgery. Major procedures with increased risk of post-operative nausea and vomiting and delay in oral intake will increase the risk of unplanned admission. Choose anaesthetic techniques that reduce post-operative nausea and vomiting. Local or regional anaesthesia has the advantage of minimizing metabolic disturbance and enabling early return to oral intake. Type 1 diabetic patients have more variable blood sugar than type 2 patients peri-operatively. Diabetic patients should be the first on the list allowing sufficient time for glycaemic stability. Type 1 and 2 diabetic patients with glycosylated haemoglobin (HbA1C) less than 8.5% are acceptable. Diabetic patients with comorbidity should be assessed similar to any non-diabetic patient.

**Haematological disorders**

A coordinated planning and liaison with haematologist is required for better outcome. The recommendations for safe platelet counts in adults include

- dentistry procedures $e^{30 \times 10^9}/L$
- minor surgery $e^{50 \times 10^9}/L$
- major surgery/neuraxial blocks $e^{80 \times 10^9}/L$.

**Neuromuscular disorders**

There is an increased risk of peri-operative respiratory complications during day surgery in patients with
neuromuscular disorders. The patients with motor neuron disorders are at increased risk of aspiration and developing respiratory failure.

In patients with peripheral neuropathies, the pre-anaesthetic assessment allows for documentation of neurological impairment and enables comparison in the post-operative period when regional anaesthetic is planned. An overnight stay is necessary in the event of peri-operative severe respiratory problems for careful observation. Patients with Myasthenia gravis requiring general anaesthesia are not suitable candidates for day surgery as recurrent aspirations can occur. Similarly patients with muscular dystrophy requiring general anaesthesia have to stay overnight for observation of respiratory function.

But if day-care surgery is suggested, regional or local anaesthesia is a safer option in patients with respiratory or bulbar involvement. General anaesthesia with neuromuscular blockade may have prolonged or unpredictable effects.

**Alcohol abuse**

The post-operative alcohol consumption can increase the opioid-induced respiratory depression.

Few patients who abuse alcohol may pose problems to the day surgery unit including higher risk of peri-operative complication. Following alcohol abstinence, platelet function/bleeding time can recover in 1-2 weeks and improved wound healing after 8 weeks.

**American society of anaesthesiologists classification**

American Society of Anaesthesiologists (ASA) class 1 and 2 patients are to be considered for ambulatory care including uncomplicated obese and elderly patients. Few ASA 3 and 4 patients are also suitable for day surgery. Serious health problems, psychiatric disorders and mental/cognitive deficits are not necessarily contraindications.
Surgical factors

The procedure with risk of serious complications like haemorrhage and cardiovascular instability are unsuitable for day-care surgeries. Post-operative pain and nausea and vomiting must be easily controllable by the use of combination of oral medications and local anaesthetic techniques. The procedure should allow the patient to resume oral intake within few hours and be able to mobilize before discharge although full mobilization is not always necessary. The examples of advanced procedures successfully carried out in ambulatory setting are

- laparoscopic major gastrointestinal surgery such as cholecystectomy, fundoplication, gastric banding (obese)
- laparoscopic major gynaecology including hysterectomy
- breast cancer surgery
- cruciate ligament repair
- major plastic surgeries like breast reduction, liposuction.

Day surgery for urgent procedures

Patients presenting with acute conditions requiring urgent surgery also can be efficiently treated as day cases via a semi-elective pathway. This reduces the likelihood of repeated postponement in the main hospital (prioritization). Robust day surgery process is essential. These urgent procedures include manipulation of fractures, tendon repairs, laparoscopic ectopic pregnancy, evacuation of retained products of conception, laparoscopic appendicectomy or incision and drainage and similar procedures.

Pre-op investigations

The National Institute of Clinical Excellence (NICE) guidelines can be used to conduct pre-operative investigations.
However, one study has showed no difference in the outcomes of day surgery even when all investigations were omitted.

**One-stop clinic**

An early pre-operative assessment is necessary with shorter time between ‘decision to treat’ and surgery. At one-stop clinic, patients will have access for all consultations, investigations and other preparations. It eliminates the second hospital visit and gives more time for pre-op investigation or optimization. It also provides a pool of patients should a cancellation arise, early appointment to another patient is generally popular. The disadvantages include planning of resources (staff/facilities) to deal with unpredictable demand from outpatient clinics. Careful planning allows us to predict which slots should be available for one-stop patients and which can be reserved for scheduled appointments.

Pre-operative sedation, amnesic and anxiolytic drugs can be administered safely without clinically significant delays in recovery times even after short procedures. Ketamine can be safely used in mentally disabled patients without increase in side effects.

**Anaesthetic techniques**

The anaesthetic techniques chosen should have minimum stress and provide maximum comfort to patient in addition to minimal residual effects. A multimodal peri-operative analgesia with paracetamol, NSAIDS, opiates and local anaesthetics should be a part of anaesthesia.

**Total intravenous anaesthesia or inhalational anaesthesia**

Total intravenous anaesthesia (TIVA) in day surgery is advantageous because of rapid recovery without agitation and behavioural disorders. It is simple to use without the need for sophisticated gas delivery systems and scavenger equipment. It avoids the risks of failure of regional blocks,
residual paralysis and less chance of side effects like post-operative nausea and vomiting. It also avoids environmental pollution and also avoids the possibility of malignant hyperthermia. The disadvantages include pump failure, disconnection and awareness. The use of N\textsubscript{2}O is associated with increased risk of post-operative nausea and vomiting.

The inhalational agents sevoflurane, desflurane and isoflurane have advantages of amnesia and safety in multi-allergy patients. Monitoring their end-tidal concentration provides indication of depth of anaesthesia which has no equivalent in TIVA. Sevoflurane and desflurane are associated with rapid emergence than propofol. Desflurane emergence is faster than sevoflurane even in prolonged procedures especially in obese patients.

**Use of laryngeal mask airway**

The face mask is an alternative only if the patient is fasted, as it does not provide protection against aspiration. The laryngeal mask airway (LMA) is the most commonly used airway devices in day surgery. According to the UK National audit project 4 first generation LMAs carry higher incidence of aspiration. Second-generation LMAs like I-gel-, Proseal providing additional port for gastric emptying are more safer. The use of LMA may not need muscle relaxants and are less invasive to airway than intubation. Post-operative airway problems like coughing or laryngospasm are minimal. The main disadvantage is that the protection against aspiration is less compared to endotracheal tube. However, there is still some role for endotracheal intubation in patients with obesity, pregnancy, gastro-oesophageal reflux disease and surgery in prone position.

**Central neuraxial blocks**

Spinal or caudal anaesthesia are suitable in lower extremity, abdominal and gynaecological procedures. The use of sub-
clinical doses of local anaesthetics and opioid adjuncts has a superior recovery profile. Isobaric prilocaine may be well suited for day surgery. The advantages are rapid onset, offset and ease of administration. It is cheaper, have less side effects including fivefold reduction in post-operative nausea/vomiting compared with GA. The technique of selective spinal anaesthesia using low dose lidocaine 10 mg and sufentanil 10 mcg for gynaecological laparoscopic procedures has better results compared with desflurane and nitrous oxide. The disadvantage of post-dural puncture headache (0-2%) can be reduced with 25 or 27 G pencil point needles. Transient neurological symptoms are more common in lithotomy or knee arthroscopy position. These symptoms are more with lignocaine than procaine and mepivacaine. Post-operative pain is the most significant complaint among ASA-1, young adults, larger BMI, prolonged surgeries including orthopaedic, urologic and plastic surgeries and hence multimodal analgesia recommended.

QUALITY OF PAIN RELIEF AFTER AMBULATORY SURGERY

A considerable number of studies have looked at the quality of analgesia in the ambulatory surgery setting, and overall the results are rather disappointing and disenchanted.

Pain after discharge remains the most common complication after ambulatory surgery. This has been shown only a few years ago in two large Swedish surveys, as well as in a general pediatric population. Similar findings were reported in selected populations, eg, after urological surgery in Spain. A prospective study after day-case laparoscopic cholecystectomy identified that, after 24 hours, 65% of patients reported moderate and 23% severe pain. Even after operations usually considered as not very painful, such as laparoscopic gynecological surgery, only 60% of the patients were satisfied with their pain relief. And these disappointing data continue
through to cataract day-stay surgery, where 10% of patients reported ocular pain at 24 hours, 9% at 7 days, and 7% at 6 weeks.

As already alluded to above, these results are not limited to adults but also mirrored in pediatric studies. Here, ear-nose-throat (ENT) procedures have been looked at in detail; eg, after adenotonsillectomy, 52% of children had a pain score >5/10 on day 3 and 30% on day 7. It is of note here that in a comparison of day-stay versus overnight inpatient stay, pain scores during the first 24 hours were only slightly increased for day-stay patients, and that the maximum pain scores at 24 hours and 7 days were similar. This is contradicted by another audit, which found pain reports to be significantly higher at home than in the hospital. Pain relief needs to also be provided for an extended period of time at home; the majority of children after tonsillectomy required at least one analgesic medication for 7 days after surgery.

**Adverse effects of pain after ambulatory surgery**

Poor analgesia after any surgery is unacceptable and distressing to patients. This is even more so in an ambulatory setting, where patients have limited access to health care providers and analgesic medications. As a consequence, they may feel abandoned. Callbacks to the surgical center and/or family practitioners and/or emergency departments and readmissions are the result; the most common reason for unplanned hospital admission after ambulatory surgery is unrelieved pain. Poor analgesia at home may lead to sleep disturbance and limited early mobilization, thereby impairing early return to normal function and work.

Last, but not least, exposure to severe pain can cause adverse long-term effects in adults as well as in children. Up to 50% of adults develop chronic pain subsequent to surgery and trauma, with severity of acute pain a major predictive factor similar effects have been reported in children.
But the consequences of inadequate analgesia begin much earlier after the operation when this issue delays patient discharge; here again, pain was the most common cause of delayed recovery (24% of patients). While opioids can cause nausea and vomiting, uncontrolled pain is also a major cause, often leading to extended stay in the recovery room.

All these adverse effects of unrelieved pain have not only human consequences but also economic ones because delays in discharge and readmissions are costly. Finally, the medicolegal consequences of poor analgesia need to be recognized.

Therefore, the challenge of provision of analgesia after ambulatory surgery needs to be accepted and solutions need to be found.

Reasons for poor analgesia after ambulatory surgery

The failures to provide sufficient analgesia described above occur despite a wide body of evidence for the best approaches to management of acute pain and despite the clinical availability of a wide range of excellent analgesic drugs. One potential cause for the lack of improvement in this area has been identified by German surveys as poor adherence to such guidelines for acute pain therapy. This phenomenon has been described as being due to the “disconnect” between the significant scientific advances in the area of multimodal analgesia and the lack of implementation of these concepts into routine clinical practice, in an editorial by White. This editorial highlights a number of relevant issues in this setting, such as the extensive reliance on opioids leading to complications and the lack of continuation of analgesic therapies into the post-discharge period.

However, improving things is not always easy, as extensively shown in the pediatric literature. Here, barriers against good analgesia have been identified as parental, child, medication, and system factors. However, overcoming these
barriers is not easy because differences in parental attitudes, understanding and access to medications, nausea, or fear of side effects are relevant contributing factors. Attempts to address such problems by supplying a discharge medication package or telephone follow-up by nurses failed after ambulatory tonsillectomy.

**General strategies to improve analgesia**

In view of the above shortcomings, and to address current deficits in the management of acute pain after ambulatory surgery, a most recent review has suggested a practical three-step approach. The suggested steps are 1) identification of high-risk patients, 2) implementation of multimodal analgesic strategies, and 3) ready availability of rescue analgesic regimens.

With regard to identification of high-risk patients, a review recommends a number of issues to be considered in the preoperative assessment, as they will increase the risk of poor pain control postoperatively. These include a past history of increased preoperative pain (eg, patients with chronic pain) as well as the observation of increased preoperative anxiety. Younger patients and females are also at increased risk. These proposals are supported by data that show preoperative pain to be the best predictive factor of postoperative pain.

Finally, the type of surgery is important, as there are now data that certain operations including appendectomy, cholecystectomy, hemorrhoidectomy, and tonsillectomy as well as longer lasting operations lead to more postsurgical pain. The latter point is in line with increasing interest in procedure-specific pain management; such evidence-based, procedure-specific guidelines for a number of operations are available at the PROSPECT website (http://www.postoppain.org). An example from the ambulatory setting would be adenoidectomy and adenotonsillectomy, two common day-case procedures done in children, which frequently cause significant
postoperative pain. Following adenoidectomy, acetaminophen may suffice, whereas adenotonsillectomy causes significantly more pain requiring at least a combination of acetaminophen with a nonsteroidal anti-inflammatory drug (NSAID). Last, but not least, failure of a specific analgesic regimen requires rapid implementation of a rescue strategy.

The importance of evidence-based, multimodal analgesic regimens extending longer into the postoperative period has been highlighted in recent literature, and it is suggested that more future studies on this topic should be undertaken.

**Concept of multimodal analgesia**

Multimodal or balanced analgesia, a concept developed around 20 years ago, has become the something of a gold standard for postoperative pain management. Underpinning this concept has been the idea to use more than one analgesic compound or modality of pain control. Combinations of different medications with different mechanisms of action and/or working at different sites along the pain pathway are used to obtain additive (or even synergistic) pain relief, while leading to an opioid-sparing effect and thereby minimizing adverse effects.

The concept of multimodal analgesia is now widely supported by the literature and in recent guidelines. The new practice guidelines for acute pain management in the perioperative setting by the American Society of Anesthesiologists’ Task Force on Acute Pain Management state specifically that, whenever possible, anesthesiologists should use multimodal pain management therapy including regional blocks and an around-the-clock regimen of Cox-2 Inhibitors (coxibs) or nonselective NSAIDs and/or acetaminophen. Such multimodal analgesia with an emphasis on nonopioids and local anesthetics is a promising concept. This is true in particular after ambulatory surgery, where classical adverse effects of opioids such as nausea and vomiting can delay discharge and
increase readmission rates. In the setting of ambulatory surgery, after incomplete pain relief as discussed above, adverse effects of opioids are the second most common cause for readmission of patients. A good example of the benefits of even avoiding weak opioids such as codeine by combining nonopioids (acetaminophen and ibuprofen) is a trial in which patients in the nonopioid group were more satisfied with their analgesia and had fewer side effects.

Combinations for which benefits along the concept of multimodal analgesia have been identified include acetaminophen, NSAIDs and coxibs, alpha-2-delta modulators (gabapentin and pregabalin), N-methyl-D-aspartate (NMDA) receptor antagonists (ketamine), alpha-2 receptor agonists (such as clonidine and dexmedetomidine), and local anesthetics.

**Analgesics**

**Nonopioid analgesics**

Acetaminophen, nonselective NSAIDs, and COX-2 selective NSAIDs (coxibs) have become the mainstay of the background analgesia in a multimodal analgesia approach to postoperative pain in all surgical settings.

Acetaminophen is obviously the weakest of the nonopioid analgesics. However, it has also a very low rate of adverse effects, as long as used in therapeutic doses <4 g/day, and nearly no contraindications. It is therefore not surprising that it is the most commonly used background analgesic in multimodal approaches. In a survey of analgesia after ambulatory surgery in Sweden, it was used in 95% of cases. There are even minor surgical interventions performed in an ambulatory setting where acetaminophen may be a sufficient analgesic on its own; in a study, 82% of patients in such a setting were satisfied or very satisfied with acetaminophen as their only analgesic. This study used intravenous acetaminophen, which is more costly than oral administration,
but may be particularly useful for perioperative administration. In an interesting meta-analysis, perioperative intravenous acetaminophen (best given before surgery) resulted in significant reduction of PONV. Finally, acetaminophen can be combined with NSAIDs, and this combination provides analgesia superior to each single drug. This is the simplest form of multimodal analgesia and has been specifically demonstrated for the combination of acetaminophen with ibuprofen.

Nonselective NSAIDs and coxibs are significantly more effective than acetaminophen with much lower numbers-needed-to-treat (NNTs) in the range 1.7–2.7. There are no differences in efficacy between NSAIDs and coxibs here. The role of these nonopioids as a component of multimodal analgesia is well established, with clear demonstration of improved analgesia, reduced opioid requirements, and, thereby, reduced adverse effects such as nausea, vomiting, and sedation. The use of ibuprofen (120 mg/day) or celecoxib (400 mg/day) for 4 days after ambulatory surgery reduced the need for breakthrough analgesia in the early post-discharge period, leading to improved patient satisfaction and quality of recovery. Whenever they are not contraindicated, these drugs should be a component of any multimodal analgesic regimen in the ambulatory setting.

However, adverse effects limit the use of NSAIDs in particular. Coxibs with their reduced adverse event profile offer an advantage here; their benefits include reduced gastrointestinal ulceration, lack of platelet inhibition with reduced perioperative blood loss, and lack of induction of bronchospasm in patients with aspirin-exacerbated respiratory disease. The advantages of coxibs with regard to reduced gastrointestinal ulceration do not only become obvious in the chronic setting, but they are even superior to NSAIDs when combined with a proton pump inhibitor. Even in the acute setting of short-term use (5–7 days), NSAIDs such as ketorolac
and naproxen cause gastric ulcerations in 20%–40% of cases, while coxibs have a rate similar to placebo. While a number of studies and meta-analyses show an increased risk of postoperative bleeding with perioperative NSAIDs, coxibs show a reduced risk compared to NSAIDs and blood loss identical to placebo.

In countries where available, the intravenously injectable coxib, parecoxib, might be particularly useful, as it permits perioperative use. The cardiovascular safety of this compound in the perioperative setting has been confirmed in a meta-analysis with no increased risk of cardiovascular events compared to placebo. After ambulatory laparoscopic cholecystectomy, pre- or intraoperatively administered parecoxib was associated with less pain and analgesic requirements leading to shorter times to attain recovery room and hospital discharge criteria compared to placebo.

The most important safety consideration for the use of any NSAIDs is their effect on renal function. While their short-term use causes only transient reduction in renal function of no relevance in patients with normal renal function, use in patients with impaired renal function or risk factors such as hypotension/hypovolemia or concomitant use of other nephrotoxic agents increases the risk.

In countries where available, metamizol (dipyrone) is another valuable nonopioid for the ambulatory surgical setting. It is highly effective, has an additional spasmolytic effect, and has very little adverse effects with regard to the gastrointestinal, cardiovascular, and renal systems. There is ongoing debate on the extremely low risk of agranulocytosis, which has resulted in it being registered only in a limited number of countries worldwide. However, it is recommended and used widely in countries where available, such as The Netherlands, Austria, and Germany.

Overall, all nonopioids are a very useful component of multimodal analgesia after ambulatory surgery and can
contribute to improved analgesia and reduced opioid side effects through their opioid-sparing effects. The selection of the most suitable nonopioid for a specific patient should be governed by the severity of pain, comorbidities, and, thereby, contraindications and drug availability in the respective setting.

**Opioid analgesics**

Opioids play an important role as analgesics in the immediate perioperative period and as rescue analgesic in ambulatory anesthesia. As mentioned before, multimodal analgesia helps to minimize opioid requirements and thereby opioid related adverse effects such as sedation, nausea, vomiting, and constipation, which may have negative effects on early recovery (affecting discharge from recovery room and from hospital) and resumption of normal activities.

A specific recent concern has developed based on reports of death or opioid-induced ventilatory impairment (OIVI) after codeine use in children. The risk is linked to genetically predisposed ultrarapid metabolism of codeine to morphine (cytochrome P450 2D6-dependent) and in particular increased after tonsillectomy and/or adenoidectomy (most commonly performed in an ambulatory setting). The reason is obviously that children who need this operation often have sleep-disordered breathing; a boxed warning by the FDA on codeine in children after tonsillectomy and adenoidectomy is now in place.

**Co-analgesics**

*Alpha-2-delta modulators (gabapentin, pregabalin)*

In general, gabapentin and pregabalin have become important components of multimodal analgesia. Usually administered as a premedication, they do not only provide preoperative sedation and anxiolysis but have also beneficial effects with regard to improved analgesia, reduced opioid requirements, and thereby reduced adverse effects of opioids,
in particular PONV. The reduction of PONV might even be a specific effect of these compounds. While these benefits have been shown in some specific surgical settings such as after hysterectomy and lumbar spinal surgery, specific studies in the ambulatory setting are limited.

These limited studies have given some contradictory results. For minor gynecological surgery, 100 mg pregabalin had no benefit, suggesting that its role may be in more invasive settings. In contrast, after laparoscopic hysterectomy, 150 mg pregabalin improved analgesia. Similarly, after ambulatory laparoscopic cholecystectomy, 1200–1600 mg gabapentin resulted in better analgesia than 15 mg meloxicam. In this study, an interesting result was that a combination of gabapentin and meloxicam was not superior to the single medications, suggesting that it might not always be useful to combine multiple modalities. This seems also to be the case when 800 mg gabapentin did not improve analgesia provided by a brachial plexus block for arthroscopic shoulder surgery; possibly a nerve block results in such good analgesia that this cannot be improved by gabapentin.

In the day-care setting, there is understandably concern about the sedating effect of these drugs impairing recovery and discharge. In a study specifically looking at this, 300 mg pregabalin as a premedication prior to ambulatory orthopedic surgery reduced preoperative anxiety and opioid requirements without persisting sedation impairing discharge.

Overall, gabapentin and pregabalin may provide anxiolysis and improved analgesia in the ambulatory setting and are recommended here they might be of particular benefit after more than minor surgery and further studies in this setting are needed.

Corticosteroids

In general, there is increasing interest in the use of perioperative corticosteroids, most commonly dexamethasone,
to reduce PONV originally but now also with increasing evidence for an analgesic effect. The latter meta-analysis identified the following benefits from perioperative dexamethasone use: reduction of postoperative pain, opioid consumption, time to first analgesia, requirements for rescue analgesia, and stay in the post-anesthesia care unit.

As these advantages would be of significant benefit in an ambulatory surgery setting, it is not surprising that similar results were found in this setting, eg, after ambulatory gynecological surgery. In view of the low risk of adverse effects with a single perioperative dose of dexamethasone (4–10 mg), the use of this compound as a component of multimodal analgesia can be recommended in the ambulatory setting.

**Local and regional anesthesia techniques**

Local and regional anesthesia techniques are highly recommended as an integral part of multimodal analgesia, eg, in the recent US guidelines. These techniques are able to offer specific benefits to patients after ambulatory surgery. The techniques cover simple local anesthetic infiltration via single dose (“single-shot”) administration, often combined with adjuvants to continuous peripheral nerve blockade (CPNB), increasingly continued for a period after discharge.

**Local and peritoneal infiltration**

Simple infiltration and instillation techniques can be quite useful in providing analgesia with minimal adverse effects after ambulatory surgery. Settings where this has been shown to be effective include wound infiltration after hernia repair, mid-foot infiltration after hallux valgus repair, and infiltration of trocar sites with local anesthetic after laparoscopic cholecystectomy. Here, intraperitoneal local anesthetic instillation was also effective, and the combination of both techniques offered further benefits. Intraperitoneal use was also effective after laparoscopic gynecologic surgery. However,
the duration of these effects is limited; maybe this shortcoming can be overcome by use of new slow-release preparations of local anesthetics such as liposomal bupivacaine.

**Single-dose peripheral nerve blockade**

The benefits of peripheral nerve blocks after ambulatory surgery are not debatable, and many trials in many settings show excellent analgesia with minimal adverse events.

Classical uses here include ilioinguinal and iliohypogastric nerve blocks for hernia repair in adults and children, paravertebral blocks for breast surgery, transversus abdominis plane (TAP) blocks after laparoscopic cholecystectomy, femoral nerve blocks after anterior cruciate ligament repair, adductor canal block after arthroscopic meniscectomy, and a range of brachial plexus blocks for shoulder and hand surgery. Pelvic plexus block can be used for ambulatory transrectal ultrasound-guided prostate biopsy and paracervical block for cervical dilatation and uterine interventions.

To extend the duration and quality of analgesia, adjuvants are often added to single-bolus peripheral nerve blocks, as otherwise the limited duration of effect results in development of pain soon after discharge. This has been recommended in particular in the pediatric setting. In addition, as local anesthetics impair motor function while providing analgesia, this may impair early ambulation and initiation of physiotherapy. Here, addition of adjuvants such as clonidine, dexamethasone, buphrenorphine, and midazolam may be beneficial.

Such beneficial effects have been well demonstrated with dexamethasone as well, if added to caudal local anesthetic as local anesthetic for brachial plexus block. Similar data exist on buprenorphine as an adjuvant to intraoral nerve blocks. A meta-analysis of studies of ketamine added to caudal local anesthetics in children, of which many were performed in an outpatient setting, showed prolonged analgesia without
prolonged motor block; however, the practical usefulness of this finding is limited in view of concerns about the neurotoxicity of neuraxial ketamine. Similar findings of a meta-analysis exist for clonidine, and there is also a study of dexmedetomidine via the caudal route. However, the addition of clonidine to local anesthetics for intravenous regional anesthesia has shown no benefits.

Whenever patients are discharged after ambulatory surgery before local anesthetic effects have worn off, attention needs to be paid to potential injury to the numb area (knives, heat, cigarettes). However, such discharges are routine practice and should actually be encouraged in view of the excellent analgesia on transfer and in the first hours at home. In a large follow-up series, this practice was shown to be safe; however, patients need to be provided with appropriate information.

**Continuous peripheral nerve blockade**

Insertion of a catheter while blocking peripheral nerves permits extension of the analgesia by top-up doses or a continuous infusion. While this approach has already become standard practice in in-patient settings, it is now also used increasingly in an ambulatory setting. Patients are commonly sent home with portable pumps providing a continuous infusion via the peripheral nerve catheter, thereby extending the analgesic effect from the maximum 12–16 hours provided by a single bolus nerve block to a number of days postoperatively, if so desired. These techniques are most commonly used after orthopedic surgery and have been used for various blocks, including paravertebral, interscalene, intersternocleidomastoid, infraclavicular, axillary, psoas compartment, femoral, fascia iliaca, sciatic/Labat’s, sciatic/popliteal, and tibial techniques. Compared to patients discharged home with systemic analgesics, patients using these techniques reported significantly reduced opioid requirements leading to fewer opioid-related adverse effects, less sleep
disturbance, faster functional rehabilitation, and higher overall
satisfaction., Similar findings were made in the pediatric
setting. Enabling discharge earlier after more complex
orthopedic surgery, these techniques have also potential
economic advantages.

A few examples of such successful usage are a 2-day
interscalene infusion at home after shoulder surgery,
continuous popliteal sciatic nerve block for foot and ankle
surgery, and continuous paravertebral block after short-stay
mastectomy. A more detailed analysis of the routine use of
continuous interscalene infusions for shoulder surgery in 300
patients revealed a 4% rate of failure of the technique after
discharge from recovery room, one patient developing a site
infection requiring antibiotic treatment, and no permanent
neurological deficits. These results are in line with other large
case series. Care needs to be taken to reduce the risk of infection.

With regard to safety, the discharge of patients with
continuous peripheral nerve blocks requires certain
precautions, but are then described as safe. As always,
intravascular placement of the catheter needs to be avoided
and confirmed. While it is important that patients and carers
get detailed instructions about the technique, its potential
adverse effects, and the care for the catheter and the insertion
site, it is strongly recommended that patients have access by
phone to an anesthesiologist for advice 24 hours a day. This
requirement is confirmed by case series which show that
patients call such a service a considerable number of times to
get advice on issues such as equipment malfunction, inadequate
analgesia, or problems with catheter removal.

Overall, techniques of local and regional analgesia should
be used whenever possible; this is not only true in the in-
patient but even more so in the ambulatory surgery setting.
The combination of excellent analgesia with minimal systemic
adverse effects and significant reduction of opioid requirements
makes these techniques ideal after ambulatory surgery.
Nonpharmacological analgesic techniques

Nonpharmacological techniques are so commonly used in the setting of sports injuries, the home, and physiotherapy, but possibly underutilized after ambulatory surgery. One reason may also be that these techniques are not well studied. However, cryoanalgesia, transcutaneous electrical nerve stimulation (TENS), and acupuncture/acupressure, among others, have been used for acute pain management after ambulatory surgery.

Discharge analgesia after ambulatory surgery

As outlined above, a major problem with ambulatory surgery is that patients experience pain at home hours or days after discharge. This is not only unacceptable from the point of view of the patients’ well-being but has also unwanted consequences such as additional presentations at family practitioners, emergency departments, or even readmissions with significant cost and possibly even medicolegal implications.

Therefore, these patients require careful instruction and supply of sufficient amounts of appropriate analgesics to cover their pain at home, which may even increase when they become more active and start rehabilitation.

Such supply can be provided by prescription or as a discharge analgesia package.

On the other hand, there are increasing concerns that provision of discharge analgesics, in particular opioids, would lead to increased long-term use of such analgesics. Furthermore, opioids introduced acutely carry other increased risks such as impaired ventilation, in particular when used in obese patients and those with sleep-disordered breathing and/or when combined with benzodiazepines, and impaired driving ability. There are recent additional concerns in view of the high rate of prescription of opioid overdoses in many countries; opioid
provided to patients on discharge may be used by others or even sold on the black market. Therefore, such risks including the risk of abuse need to be identified, and prescriptions of discharge opioids need to be governed by some appropriate precautions.

These arguments are additional support for the use of multimodal analgesia as the preferred analgesic strategy after ambulatory surgery, with an emphasis on nonopioids and local and regional techniques.

DAY CASE SHOULDER SURGERY

Shoulder surgery has traditionally been considered a painful procedure and it had, until relatively recently only been carried out on an in-patient basis, requiring overnight hospital stay.

Patients are beginning to accept shoulder surgery as a day-case procedure due to improvements in pain relief. Increasingly it is becoming preferred.

The benefits of performing the surgery as a day-case procedure include shorter hospital stay, increased throughput of patients and increased patient satisfaction. The strategies used to improve pain relief and therefore increase acceptability include, most significantly, the use of an interscalene brachial plexus block, supplemented with oral analgesics. Supplementary therapies including cold compression can be used to reduce inflammation and promote early healing, allowing for early initiation of rehabilitation services, optimising outcome in the longer term.

Despite this progress there are still concerns about the management of post-operative pain in the community and reports suggest that pain remains a problem for a significant proportion of shoulder surgery patients. There have also been concerns about the ‘rebound pain’ which can occur once the interscalene block has worn off.
AIMS

The aims of this study were to assess the post-operative pain of all shoulder procedures in our practice undergoing day-case shoulder surgery (open and arthroscopic), with particular emphasis on the pain once the interscalene block had worn off.

METHODS

A prospective review of 187 patients who underwent shoulder surgery as a day case procedure by a single surgeon over a one year period (from the 10th of November 2008 until the 7th of December 2009) was performed. The analgesic regimen included:

1. Patient Education - pre-operative surgical booklets were provided and post-operatively patients were given written and verbal information and instruction on the analgesic regimen by the surgeon, anaesthetist and ward staff.
2. A single shot interscalene block with bupivacaine, given prior to surgery
3. Diclofenac, codeine phosphate and paracetamol (where tolerated) - patients were instructed to start taking these regularly from about 6 hours after surgery (whilst the block was still working)
4. Activewrap (Harvard Healthcare UK) cold compression wrap - commenced 3 hours after surgery and used 15 minutes at a time every two hours.
5. Tramadol to be taken for breakthrough pain, if required.

Patients were followed up with a telephone call from the practice surgical practitioner 24 hours post-operatively, allowing sufficient time for the interscalene block to wear off.

Pain was assessed using a standard visual analogue scale comparative to the Constant Shoulder Score, as shown in Table below.
Table: Visual analogue score for pain:
- 0 = Severe
- 5 = Moderate
- 10 = Mild
- 15 = None

The operations performed. Although most were arthroscopic procedures, there were 7 open Latarjet shoulder stabilisations (4%), 3 pectoralis major repairs (2%) and 2 shoulder replacements (2%) performed as day-case procedures.

Of the 187 patients, 129 were male and 58 were female. The average age was 43.6 ± 16.1 years, ranging from a minimum of 15 years old to a maximum of 80 years old.

RESULTS

Of the 187 patients 169 considered their pain to be well controlled 24 hours after the operation. This represents 90.4% of the cohort group. The interscalene block had worn off in all cases. None of the patients required an overnight stay or re-admission.

Table: Table showing numbers and percentage of patients with adequate pain control

<table>
<thead>
<tr>
<th>Pain controlled?</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>18</td>
<td>9.6</td>
</tr>
<tr>
<td>Yes</td>
<td>169</td>
<td>90.4</td>
</tr>
<tr>
<td>Total</td>
<td>187</td>
<td>100.0</td>
</tr>
</tbody>
</table>

A more detailed breakdown of pain reported post-operatively is demonstrated in table below. The pain was recorded as either absent, mild, moderate or severe and plotted. 85% of patients reported either no painful symptoms at all or only mild pain. Only 2.1%, 4 patients in total were experiencing severe pain 24 hours after the operation.
Table: Frequency and percentage of pain scores in each patient.

<table>
<thead>
<tr>
<th>Pain Score</th>
<th>Frequency</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>4</td>
<td>2.1</td>
</tr>
<tr>
<td>Moderate</td>
<td>24</td>
<td>12.8</td>
</tr>
<tr>
<td>Mild</td>
<td>81</td>
<td>43.3</td>
</tr>
<tr>
<td>None</td>
<td>78</td>
<td>41.7</td>
</tr>
</tbody>
</table>

Identifying factors for painful procedures

There was no age or gender discrepancy.

Table: Identifying factors for painful procedures

<table>
<thead>
<tr>
<th>Operation</th>
<th>Frequency of painful operations</th>
<th>Proportion of painful operations (28)</th>
<th>Proportion of total operations being this procedure (187)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD &amp; ACJ Excision</td>
<td>2</td>
<td>7.1%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Arthroscopic rotator cuff repair</td>
<td>9</td>
<td>32.1%</td>
<td>12.8%</td>
</tr>
<tr>
<td>Arthroscopic shoulder stabilisation</td>
<td>12</td>
<td>42.9%</td>
<td>20.3%</td>
</tr>
<tr>
<td>Arthroscopic SLAP repair</td>
<td>3</td>
<td>10.7%</td>
<td>6.4%</td>
</tr>
<tr>
<td>ASD</td>
<td>2</td>
<td>7.1%</td>
<td>26.7%</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td></td>
<td>100.0%</td>
</tr>
</tbody>
</table>

There were 28 (15%) cases that reported moderate or severe pain. These were limited to five common procedures only.
These were all arthroscopic procedures, with arthroscopic rotator cuff repair and arthroscopic stabilisation being the most common, making up 75% of the reported painful procedures.

Only four patients reported severe pain (2%). However, two of these four patients reporting severe pain took no medications at all. Three of the four patients had 360 degree arthroscopic shoulder stabilisation procedures and the other a massive, revision arthroscopic rotator cuff repair.

DISCUSSION

Developments in surgical technique and anaesthetic administration have allowed many shoulder surgeries to be safely and satisfactorily carried out as a day-case procedures. There is still some concern over levels of post-operative pain due to its more challenging management in the community and the after effects of regional anaesthesia.

The results of this cohort group demonstrate that 90.4% were pleased with their pain relief, even for open surgery and complex arthroscopic procedures. This level compares favourably with previously published results of shoulder surgery as a day-case procedure which range from 80 to 85% satisfaction 4,5. Our patient compliance was better than previous studies 5, with only two patients not following the post-operative regimen. The reasons for this are likely to be a combination of surgical and anaesthetic factors, as well as thorough patient education. All cases were given an interscalene brachial plexus block. This is a very effective method of reducing pain for the duration of the operation and for around 20-22 hours thereafter 4. There is little doubt that supplemental analgesia is required after the operation. This was anticipated and analgesics were adequately prescribed in the form of co-codamol and diclofenac. Alternative medications including tramadol and ibuprofen were used where codeine, paracetamol and diclofenac were not tolerated due to side effects or
contraindications. The anaesthetist performing the plexus blocks was also a specialist in pain management and experience from this field will have contributed to his appreciation of the importance of post and intra-operative pain management. All patients also received instruction on taking their oral medications before the block had worn off in both written and verbal formats from the surgeon, anaesthetist, ward nurses and ward physiotherapist.

This allowed patients to understand what they were going through. It empowered them to play their part in optimising their progress through the duration of the recovery period. They were also instructed to apply a cold compression wrap (Activewrap, Harvard Healthcare) for 15 minutes every 2 hours. This works on the principle of maintaining the joint at a lower temperature, decreasing its susceptibility to pain sensation and inflammation 3. Patients using this wrap reported enhanced pain relief and comfort with its application.
Anaesthetic Techniques

During general anaesthesia, carefully administered medicines bring about a temporary loss of consciousness and freedom from pain. These anaesthetic drugs are selected, dosed and administered continuously to allow you to wake up pleasantly and at the right time. Patients may experience phases of tiredness or drowsiness after receiving an anaesthetic if powerful pain-killers have to be administered repeatedly.

In regional anaesthesia, local anaesthetics are injected into specific parts of the body to make them insensitive to pain. In many cases modern ultrasound probes are used to visualize the pattern of nerves, enabling the anaesthetic to be administered even more efficiently. Regional anaesthesia of an arm or a leg can be achieved by blocking one or more nerves at the same time.

Techniques involving the spinal cord (spinal and peridural anaesthetic) achieve freedom from pain in the chest, abdomen or legs. Thin catheters are inserted so that the duration of the anaesthetic can be extended as required and/or to provide optimal post-operative pain control.

Patients who undergo surgery under regional anaesthesia may choose to stay awake, listen to music or take medication to make them sleep.
Combined anaesthesia means that regional and general anaesthetic techniques are used together. It is used routinely for major abdominal and chest surgery and leads to more rapid post-operative recovery.

**ANAESTHESIA - AN INTRODUCTION**

Conscious Sedation - sedation and anxiolysis with retention of consciousness at all times.

Unconscious (‘deep’) Sedation - sedation sufficient to induce sleep from which arousal to consciousness is easy

Neurolept Analgesia - analgesia, disinterest and psychomotor retardation typically induced by a combination of a major tranquiliser (e.g. droperidol) and a narcotic analgesic. Patient may appear calm but be anxious.

General Anaesthesia - unrousable unconsciousness, reversible, and usually drug induced.

Local anaesthesia - rendering a part of the body numb.

Topical anaesthesia - anaesthesia of skin or mucous membranes by topical application of local anaesthetics.

Infiltration anaesthesia - anaesthesia of tissues by direct injection of local anaesthetic where it is needed - i.e. for excision of skin lesions.

Regional anaesthesia (‘conduction blocks’ or ‘blocks’) - anaesthesia of a part of the body by injecting local anaesthetic into the nerves that go there. Simple blocks include finger blocks, ankle blocks, etc; more complex blocks include plexus blocks, and ‘major regionals’ mean epidural or spinal anaesthesia.

*What do Anaesthetists do?*

5-6 years medical school, 2 years in hospital (intern and resident), a further 6 years specialist training, focusing on physiology, pharmacology, intensive care, and technical aspects.
of anaesthetic practice. The College of Anaesthetists supervises registrar training, exams, post-Fellowship training, ongoing education and policy matters; the Australian Society of Anaesthetists assists more with practice management and political issues. Fees to these bodies are about $2,400 in total annually. Medical Defence is about $7,000 for Staff Specialists and $15,000 for VMO’s each year.

Patients are usually seen by an anaesthetist (or a trainee anaesthetist) preoperatively in a pre-admission clinic. This person may or may not actually do the case. The patient’s health, pre-operative tests, and any specific concerns are reviewed in the context of the planned procedure.

A discussion of the risks and benefits of the various approaches or techniques required should result in an agreed plan. Selecting the safest technique in the circumstances is important, and the details of that technique, including the management of post-operative pain, should be explained. Common risks (pain, nausea, sore throat, muscle aches, etc) and rare but serious risks (death, paraplegia, etc) should be discussed. The patient should be sufficiently well informed that they can make an informed decision as to whether or not they should proceed with the anaesthesia plan for the procedure.

Management of the anaesthetic is the responsibility of the anaesthetist, not the surgeon.

The anaesthetist stays with the patient from the time anaesthesia starts until care is passed on to recovery staff, however their responsibility legally covers to the entire period from premedication until full recovery from the anaesthetic.

Once the patient is asleep, the Anaesthetist continuously monitors the adequacy of breathing and the circulation; additional monitoring is used in special circumstances, ie brain monitoring in neurosurgery. Positioning is performed carefully so as to not cause nerve or skin damage.
Anaesthetists adjust the doses of the anaesthesia-inducing drugs individually on a patient by patient basis - they are generally titrated to a measurable end-point of some kind. Subconscious hearing is preserved during most anaesthetics. Fortunately memory is strongly impaired with small doses of anaesthetics, so most people don’t remember much from just before they go to sleep until some time after they actually wake up.

During most anaesthetics there is no way to be certain that the patient is asleep. Brain monitoring can be helpful especially if patients are at high risk of awareness, for example if the anaesthetic requires paralysis of the muscles, in which case the patient can’t move even if they want to, or if the patient had an episode of awareness in the past. Drug adminstration is part of the art of anaesthesia.

Anaesthesia practice is a combination of technical skill, experience, compassion and science; experience is far more important than knowledge alone.

At the end of the operation the anaesthetic drugs are turned off or reversed, and once the patient is awake they will be transported to recovery, or ICU. The anaesthetist will wait awhile to make sure the patient is OK. We arrange appropriate post-operative analgesia.

Anaesthetists run most acute pain services and often have substantial input to ICU and the ER.

Anaesthesia alone in healthy patients has a mortality (due to unexpected drug reactions, haste, device malfunction, etc) of 1:500,000. This contrasts with the 1:30 chance of being killed or maimed for drivers from the age of 17 to 25, and is far less than the risk of surgery. Overall the risk of death due to anaesthesia in all patients undergoing surgery is about 1:30,000. This is about the same risk of death and/or disablility as driving 10km to and from work in Sydney traffic for a few months.
History

Opium, alcohol etc were used in antiquity. Bromide first used 1853, and an account of Bromism in Evelyn Waugh’s “The Ordeal of Gilbert Pinfold”. Before 1900, Chloral Hydrate, Paraldehyde, Urethan, and Sulfonal were in use. Barbiturates were first synthesised in 1864 on St. Barabar’s Day (which celebrates the day long ago when the father of a 4th century virgin and martyr was struck dead by lightning after unjustifiably beheading same. St. Barabar is also the Patron Saint of Gunners and Arsenals). Phenobarbital first used in 1912. Thiopentone introduced in World War II - killed many in Pearl Harbour because too much was unknowingly given to patients in hypovolaemic shock. Benzodiazepines first synthesised 1933, Chlordiazepoxide first clinically used in 1960. Propofol is relatively recent - 1993.

Charpentier first synthesised and used Promethazine, the first major tranquiliser, in the 1930’s and Chlorpromazine in the 1950’s.

Nitrous Oxide was first ‘abused’ by travelling entertainers; then in 1890’s successfully used for dental extractions and anaesthesia.

Ether and Chloroform were the first drugs to make inhalational anaesthesia possible. Ether was used first, but Chloroform was easier to administer. Commenced in 1847. Simpson, for obstetrics; use ended in 1900’s due to cardiac irritability and hepatic damage (obligate hepatotoxin via phosgene). Ether then regained popularity. They were usually given by open drop onto wire frames, but machines not unlike those in use now were made by Boyle in the 1920’s. Halothane, the first potent volatile agent was first use in 1956; Isoflurane in the 1980’s.

Spinal anaesthesia became popular as an alternative to ether, but suffered in the late 1930’s when several patients became paraplegic. Now spinal and epidural anaesthesia are
Early anaesthetics were given by assistants to the surgeon, and in the USA it was more common for a non-medical person to do so under the supervision of the surgeon (these are now the CRNA’s of today). In England, doctors with a particular interest in anaesthesia became anaesthetists and the specialist practice of anaesthetics is the result.

The likelihood of death or injury attributable to anaesthesia have declined dramatically over the last 50 years not only because the drugs and equipment have improved greatly, but also because of a much more accurate and detailed understanding of how how the body works and a far greater level of training before a doctor can call themselves an Anaesthetist.

**DRUGS USED**

**Intravenously administered anaesthetic agents**

Used mostly as oral premeds (Temazepam 10-30 p.o. an hour pre-op) or parenteral sedatives, anxiolytics and induction agents. Diazepam is slow in offset and irritant to veins - cannot be given imi. Midazolam is relatively new agent that is not too irritant to veins and can be given orally, imi, or ivi; it is often used for sedation for blocks.

All benzodiazepines are protein bound moderately lipid soluble drugs; their duration of effect depends primarily on the rate of metabolism of the main active metabolite, except with IV use where relatively brief responses (after boluses) are due to redistribution. Metabolised mostly in the liver; long half-life in the elderly. Nor-Diazepam (N-desmethyldiazepam) is active with a half-life of 50 to 100 hours.

They act by polysynaptic pathway inhibition via interaction with specific receptors (GABA, BZ, Barbiturate modified Chloride channel) which enhance the inhibitory effect of GABA in the Reticular Activating System and Amygdala.
Benzodiazepines reduce the dose of other intravenous anaesthetic agents.

Main effects are:-
1) CNS Depression - decreased anxiety, tranquility, sedation, anterograde amnesia, ultimately unconsciousness and respiratory depression. Anxiety reduced more than apparent drowsiness. Sleep changes include delayed and reduced REM sleep and reduced stage 3 and 4 sleep, but increased overall sleep times.
2) Anticonvulsant effects - mostly with Diazepam.
3) Muscle relaxation - due to relaxation and reduced tone - do not enhance paralysing drugs.

**Barbiturates**

These are general anaesthetic agents (like alcohol, only stronger) with no specific receptor sites (except in low doses via weak interactions at the GABA receptor. When used as sleeping pills they cannot be safely used in conjunction with alcohol and have a very low therapeutic index, hence are frequently used orally for successful suicides. Anxiolysis is not clearly seen, and euphoria and antalgiesia may occur.

Thiopentone is the most commonly used induction agent in the world. It is a yellow powder that comes in 20ml ampoules (500mg) and has to be dissolved in water before it can be given. The dose required varies a lot - from 50 to 750mg. Patients wake up fairly quickly after ordinary doses (ie, 5-15 minutes), but may have a depressed, tired feeling afterwards. It can’t be given by infusion without accumulating so much in the body that the patient remains drowsy for ages.

Overdoses cause profound respiratory and cardiac depression and death from extreme hypotension; it is easy to overdoes little old ladies and people in shock.

**Propofol**

This is a recently introduced modified phenol (di-isopropyl
phenol to be exact) dissolved in a soya emulsion like intralipid. Kind of disinfectant in soy milk. 20ml in a glass ampoule or 50ml in a larger bottle. About twice as expensive as thiopentone. More rapid recovery, less hangover, clear sensorium make it appealing; tendency for euphoria on recovery and also tends to cause a lot of hypotension. Cautious use in the elderly is necessary. Laryngeal reflexes are suppressed more than thiopentone and much more than the volatile agents, so it is often used if a laryngeal mask is to be used.

Propofol can be used quite effectively as the sole anaesthetic drug by infusion and even after a long time patients wake up fairly well.

**Ketamine**

This agent maintains BP and muscle tone and can be used intramuscularly as the sole anaesthetic agent, especially in trauma. Unfortunately most patients wake up feeling very odd (dissociated, hallucinatory) so it is not used much for elective surgery.

Gaseous anaesthetics, eg N2O, Cyclopropane. Mode of action not clearly understood; probably cell membrane expansion (‘pressure reversal’ theory). Rapid onset and offset.

**Cyclopropane**

Virtually unused today - highly explosive when mixed with oxygen. Very rapid induction of anaesthesia is possible - just inhale one deep breath and away you go!

**Nitrous oxide - N2O or laughing gas**

Used in almost every anaesthetic these days as the main ‘background’ anaesthetic, typically at about 66% of the inspired gas, with the remainder oxygen. Comes in blue cylinders.

Once breathed in, the patient rapidly equilibrates (5-10 minutes) with the inspired concentration. Similarly rapid offset.
You need 105% N2O at sea level for full anaesthesia so some other drugs have to be given as well to make sure the patient will stay still and remain unconscious; usually volatile inhaled agents and narcotics are added.

**Volatile anaesthetics (ie, Sevoflurane, Isoflurane, Desflurane)**

These drugs are thought to act like the gaseous agents. They are pungent liquids at room temperature (smell like metho or cleaning fluid) and are breathed in from a calibrated device called a vapouriser, which is usually a shiny metal thing on the back bar of an anaesthetic machine. For isoflurane, 1% concentration in 66% N2O is enough, usually, to maintain anaesthesia. As increasing doses are inhaled, patients experience increasing disinhibition, numbness, drowsiness, excitement, disorientation, agitation, unconsciousness, reflex suppression, cardiovascular depression, respiratory depression, and ultimately death.

Ether is a very irritable, highly flammable volatile anaesthetic. Patients in whom ether is used to induce anaesthesia never forget it! They vividly remember being held down and gradually drowning and falling into some kind of terrible nightmare. It can be used (and often is in developing countries) for the maintenance of anaesthesia after an inhalational induction (6-7%).

Halothane was the first modern potent inhalational anaesthetic. It is not flammable and is not as pungent as ether, so it can be used for the inhalational induction and maintenance of anaesthesia. It has rare complications such as malignant hyperthermia and hepatic failure, and potentiates cardiac dysrhythmias, so it is used much less these days, except in children.

Isoflurane is now the most popular inhalational agent; patients wake up more quickly than with Halothane and it has fewer side-effects.
Neuromuscular Blockers (muscle relaxants)

These drugs cause nerve stimuli that would usually cause movement to not get conducted to the muscles - resulting in paralysis.

Suxamethonium is a very rapid acting 'depolarising' muscle relaxant and is used where it's rapid onset makes anaesthesia safer - for example when it is necessary to intubate a patient urgently or when the stopmach is full - and for brief procedures that need muscle relaxation. Sux cannot be reversed; you just have to wait for it to go away.

Pancuronium, Vecuronium and Atracurium are all slower onset longer duration drugs which can (an usually need to) be reversed with an anatagonist at the end of the operation.

COMMON ANAESTHETIC TECHNIQUES

Premedication

Mostly we tell the patient to fast from midnight but to continue all the their usual medications, and give a premed to relieve anxiety (a benzodiazepine, usually orally). Sometimes something to relieve pain (pethidine or morphine imi) and dry secretions (atropine) may be given, but this is less common now. The most important thing is to be sure that the patient’s general medical condition is as good as it could be and to make sure that appropriate tests have been done, checked, and, if necessary, acted on.

General Anaesthesia

In adults anaesthesia usually starts with the application of basic monitoring, an iv cannula, then an intravenous anaesthetic agent (thiopentone, propofol, or midazolam) in the right dose. Often multiple small doses titrated to effect. Small children are induced with N₂O and a volatile agent by mask.

Once the patient is asleep N₂O and some volatile anaesthetic is given by mask. The patient’s airway may be
managed by intubation, the laryngeal mask airway, or just a facemask with or without a guedel airway; intubation usually goes hand in hand with the need for muscle relaxants.

Towards the end, the inhalational agents are turned off and they gradually get breathed out; if you get it right the patient wakes up at the end rather than before or half an hour later! Often narcotics are given as well to reduce the amount of other agents that are needed and to help the patient be pain free at the end.

Continuous infusions of propofol are used sometimes in place of a volatile agent.

**Spinal Anaesthesia**

Here a small (25g by 3 inch) needle goes in the back and ends up in the CSF; where about 3 ml of 0.5% plain bupivacaine (Marcaine) is injected the patient finds that within 10-15 minutes they can’t feel or move their legs - or in fact anything from the waist down.

Recovery usually occurs 4 to 8 hours later.

Spinals are good for operations on the pelvis and lower limbs, particularly in the elderly. Unfortunately CSF leaks out of the hole in the dura and in young people and day surgery it is common to get quite a bad ‘post-spinal’ headache. Spinals are really much more common in the elderly - for fractured hips, TUR’s etc.

Basic monitoring only is used and the patient needs a drip.

**Epidural Anaesthesia**

This is similar to a spinal but the needle is bigger (14G) and the local (about 10-20ml) is injected into the epidural space (just outside the dura, and NOT into the CSF). Onset of the block is slower and a little less predictable.

Usually a fine plastic catheter is left in place and ‘top-ups’ of local can be injected to maintain the block for many hours
- this can’t be done with spinals. Dilute local anaesthetics can give good analgesia for labour while retaining a lot of movement and some sensation, though getting it right is an art.

Neurolept Analgesia

The “Neuroleptic” effects of the major tranquillisers was first noted by Charpentier. The patient loses interest in their surroundings, emotions are dulled and spontaneous and complex movements are reduced. There is no gross impairment of intelligence or the ability to perform tasks and unconditioned or reflex activity remains unimpaired (in contrast to the effects of benzodiazepines.

Neurolept Analgesia refers to the use of major tranquillisers, ie droperidol, in conjunction with narcotics such as morphine or fentanyl. Unfortunately one often gets a ‘locked-in’ state of ‘outer calm inner panic’ that patients recall vividly and unpleasantly, so this technique is not used much these days. It is not so bad if the patient has received a good dose of bezodiazepines - when it is quite good in small doses for restless fidgety old people who won’t stay still while having operations under local.

Conscious Sedation

Small doses of midazolam or infusions of propofol are commonly used to sedate patients who are undergoing unpleasant (ie, gastroscopy) or boring (ie, eye) procedures. Midazolam is associated with more sleepiness afterwards but more amnesia for what exactly happened. The trick is not to give so much that the person goes unconscious!

General Anaesthesia (GA)

As a novice trainee, General Anaesthesia is the most common type of anaesthetic that you will be required to provide and become competent with as part of the IAC.
General Anaesthesia consists of a triad of:

- Unconsciousness
- Analgesia
- +/- Muscle relaxation

A General Anaesthetic (GA) can be subdivided into 3 key stages:

- Induction - getting the patient to sleep
- Maintenance - keeping the patient asleep during the operation
- Emergence - waking the patient up at the end of the procedure

The most common techniques you will be exposed to are:

- Spontaneous ventilation with a laryngeal mask airway (GA LMA SV)
- Intermittent positive pressure ventilation with an endotracheal tube (GA ETT IPPV)
- Rapid Sequence Induction to protect the airway if there is a risk of soiling from gastric contents (RSI GA ETT IPPV)
Your choice of technique will be influenced by specific patient, surgical and anaesthetic factors, as well as the level of your experience in the specialty and its related subspecialties.

The chapter that follow will give you a broad overview and the basic principles underpinning these three techniques.

**General Anaesthesia: Spontaneous Ventilation with an LMA**

Generally used for elective or emergency surgery in patients who have been fasted and where there is no risk of aspiration of gastric contents. Common risk factors for aspiration include:

- History or reflux or hiatus hernia
- Intra-abdominal pathology
- Pregnancy
- Recent major trauma or administration of opiates
- Morbid obesity
- Autonomic dysfunction associated with diabetes

Suitable for most peripheral surgery in patients who are not obese and for some minor abdominal surgery where muscle
relaxation is not needed (i.e. elective inguinal hernia repair). Can be used for patients in the supine or lateral position. Not recommended for use in very long cases.

Experienced anaesthetists may use this technique in ENT and Maxillofacial surgery for short procedures.

Basic Principles in ASA 1/2 patient:
• Attach basic monitoring (SpO₂, ECG and NIBP)
• Pre-oxygenate the patient
• Induction - intravenous (propofol) or inhalational induction (sevoflurane) + small dose of fentanyl followed by insertion of LMA
• Maintenance - Oxygen/Air or Oxygen/Nitrous Oxide plus volatile or intravenous agent
• Emergence – 100% Oxygen and turn off volatile or intravenous agent. Remove LMA when patient wakes up

General Anaesthesia: Endotracheal Intubation and Positive Pressure Ventilation

Generally used for elective or emergency surgery in patients who have been fasted and where there is no risk of aspiration of gastric contents but where:
• Muscle relaxation is required to facilitate surgery
• Surgery will increase intra-abdominal pressure or the bowel will be manipulated
• Surgery could take a long time
• Airway is shared with the surgeon and may lead to airway soiling with blood or debris
• Prone patients or those where positioning require their head to be at the opposite end of the table

Basic Principles in ASA 1/2 patient:
• Attach basic monitoring (SpO₂, ECG and NIBP)
• Pre-oxygenate the patient

• Induction
  o Intravenous (propofol) or inhalational induction (sevoflurane) + small dose of fentanyl
  o Non-depolarizing muscle relaxant to facilitate intubation
  o Manual ventilation until relaxant effective
  o Oral or nasal endotracheal intubation and confirmation of tube placement by visualization, auscultation and capnography

• Maintenance
  o Oxygen/Air or Oxygen/Nitrous Oxide plus volatile agent
  o Top up doses of muscle relaxant guided by neuromuscular monitoring
  o Additional analgesia as required

• Emergence
  o 100% Oxygen
  o Turn off volatile or intravenous agent
Reverse neuromuscular block
Remove ETT when patient spontaneously breathing and wakes up

**General Anaesthesia: Rapid Sequence Induction**

Used for elective or emergency surgery in patients who are either not fasted or where there is a risk of aspiration of gastric contents. The airway is protected from aspiration by the application of cricoid pressure prior to rapid intubation using a depolarizing muscle relaxant. Thereafter, the anaesthetic technique is the same as an ETT with IPPV.

Basic Principles in ASA 1/2 patient:

- Attach basic monitoring (SpO₂, ECG and NIBP)
- Pre-oxygenate the patient for 3 minutes
- Proper preparation – tipping trolley, suction available, equipment checked
- Induction
  - Intravenous (thiopental or propofol)
  - Suxamethonium to facilitate intubation with cricoid
pressure applied by anaesthetic assistant to prevent aspiration
- Oral intubation and confirmation of tube placement by visualization, auscultation and capnography
- Release of cricoid pressure
- Non-depolarizing muscle relaxant to maintain muscle relaxation

- Maintenance
  - Oxygen/Air or Oxygen/Nitrous Oxide plus volatile agent
  - Top up doses of muscle relaxant guided by neuromuscular monitoring
  - Additional analgesia as required

- Emergence
  - 100% Oxygen
  - Turn off volatile or intravenous agent
  - Reverse neuromuscular block
  - Remove ETT when patient spontaneously breathing, regains airway reflexes and wakes up
  - It is recommended that this is performed with the patient in the left lateral position

OTHER TYPES OF ANAESTHESIA

Local Infiltration

Good choice for skin and soft-tissue surgery of limited size, depth and duration, e.g. ring block for a distal finger operation.

Regional Anaesthesia

Achieved by introducing a local anaesthetic agent near the nerves supplying that region. May be used as the sole mode of anaesthesia or combined with general anaesthesia or sedation.
Central (neuraxial) techniques for lower half of the body:
- Spinal - hip or knee surgery
- Epidural - below knee amputation

Plexus techniques:
- Interscalene - shoulder surgery
- Suprclavicular - elbow surgery

Single nerve techniques:
- Femoral and Sciatic - knee replacement surgery
- Popliteal - ankle surgery

Intravenous Regional Anaesthesia:
- Biers block - wrist fractures

DOES ANAESTHETIC TECHNIQUE REALLY MATTER FOR TOTAL KNEE ARTHROPLASTY?

Total knee arthroplasty (TKA) is a common, painful surgical procedure requiring good quality anaesthesia and postoperative analgesia to provide best patient care and facilitate effective rehabilitation. More than 70 000 knee
replacements are performed in the UK each year and this is projected to increase as the population ages and osteoarthritis, the most common reason for TKA, becomes more prevalent. Given ever increasing pressure on resource utilization the quality and the type of anaesthesia and postoperative pain relief can have a significant impact on ability to meet rehabilitation goals. Studies have also demonstrated that poor pain control after knee replacement is associated with development of chronic pain although our understanding of this area is only starting to develop.

The anaesthetic management of patients undergoing TKA has undergone several refinements and transitions. In the past, general anaesthesia (GA) with systemic opioid analgesia alone was commonly used. Spinal anaesthesia, uniquely suited to lower extremity orthopaedic procedures, has gained prominence with several landmark studies demonstrating the superiority of spinal anaesthesia over GA in terms of morbidity and mortality. Contemporary studies have continued to reinforce these data with recent epidemiological studies using large databases indicating a reduction in risk of morbidity and mortality with the use of neuraxial anaesthesia. The mechanisms underlying these benefits remain to be fully understood but may include improvements in blood flow, cardiorespiratory benefits and a possible reduction in surgical stress response. Outcomes such as pain relief, opioid consumption, and length of hospital stay (LOS) also favour spinal anaesthesia. However, neuraxial anaesthesia is not without risk, and although rare, does have potential for spinal haematoma, infection, or abscess in contemporary practice. Therefore, despite the perceived benefits of neuraxial anaesthesia, newer methods of providing anaesthesia for knee replacement need to be evaluated and existing techniques challenged.

A closer examination of the study reveals both strengths and limitations. A major strength of this study is the comparison
of a state-of-the-art general anaesthetic technique including multimodal analgesia with a basic spinal technique. Both of these relatively straightforward and common methods of anaesthesia would be feasible in all hospitals where total knee replacement procedures are currently performed. Many institutions across the world are unable to provide consistent, high-quality regional anaesthesia for their patients and in this regard demonstration of the effectiveness of a GA with multimodal analgesia technique is timely. The recovery time and time to reach discharge criteria are impressive in both groups and is currently faster than that achieved in many centres.

Some criticisms and observations with the techniques used in this study should be noted. First, the authors use a spinal anaesthetic technique without additional adjuvant and it is therefore not surprising that the spinal group had severe pain on block resolution. Most practitioners using spinal anaesthesia for TKA would institute adequate opioid-related analgesia before spinal resolution either by adding a dose of intrathecal hydrophilic opioid such as morphine, diamorphine, or hydromorphone, or by giving opioid analgesics by another effective route. Although the use of intrathecal opioids is associated with adverse effects such as pruritis, urinary retention, and respiratory depression, their addition will provide long-lasting analgesia after resolution of the local anaesthetic effect. The post-surgical pain that the patient experiences with the rapid regression of spinal anaesthesia can be intense, particularly when limited provisions for analgesia are made such as omitting peripheral nerve blocks, neuraxial opioids, or other systemic analgesia and this certainly contributed significantly to the poor pain control that the spinal group reported in this study.

Secondly, the duration of effectiveness of the local infiltration analgesia (LIA) technique was surprisingly short. Given the recent excitement for the potential of LIA as a
simple method of pain relief after knee replacement it was disappointing to see how poorly it performed in this study. Personal clinical experience of using LIA has given the impression of an effective but short-lasting effect. The study by Harsten and colleagues reinforces our impression because although the LIA appeared to provide good early analgesia in the GA group by the time the sensory block had resolved in the spinal group, the analgesic effectiveness of LIA appears to have disappeared.

It is also interesting to note that despite availability of rescue analgesia, the spinal group continued to experience significantly more pain for 2 days after surgery. The landmark editorial by Wall who coined the term preoperative pre-emptive analgesia and more recent work on preventive analgesia also note the ‘protective’ effect of opioids and other analgesics such as N-methyl D-aspartate receptor antagonists on pain control well beyond the clinically expected duration of these drugs. The seemingly prolonged analgesic effect of an intraoperative dose of oxycodone appears also to have provided some ‘preventive’ analgesic effect in the GA group. Conversely, there is no evidence of a hyperalgesic effect from remifentanil infusion that has previously been demonstrated. Finally, although a significant difference in LOS was demonstrated between the GA and spinal group, a 6 h differential may be of limited clinical or practical significance in most institutions and might not actually influence the day of discharge.

Several important messages can be taken from this chapter. First, despite current beliefs, it appears that a good quality GA technique such as the TCI method can in fact provide effective anaesthesia and transition to reasonable postoperative analgesia after knee replacement. This may be a very useful option in centres that are currently unable to provide consistent high-quality regional anaesthesia such as neuraxial anaesthesia, continuous peripheral nerve blocks, or both. Secondly, the importance of multimodal analgesia in facilitating good pain
control is underscored by the fact that all patients were given acetaminophen and celecoxib. The better pain control in the GA group reflects the important role that long-acting opioids continue to play in the context of multimodal postoperative analgesia especially when given before recovery of anaesthesia. Finally, the transient and disappointing effect of the LIA technique was especially evident in the spinal anaesthesia group and continues to call into question the overall utility of this method especially when used alone without systemic or spinal opioids.

TKA is a common and painful surgical procedure that requires effective, safe anaesthesia and good postoperative pain control to facilitate best outcomes including reduction in LOS and chronic pain after surgery. Harsten and colleagues demonstrate that the TCI GA technique used compares favourably with a very limited spinal anaesthesia technique. However, better regional anaesthesia methods are available in centres that have the expertise and resources to provide them. Regional anaesthesia including neuraxial techniques continue to provide short-, medium-, and long-term outcome benefits for patients having TKA.

Although Harsten and colleagues provide thought provoking data they do not really compare their GA technique with the standard of care for spinal anaesthesia not to mention peripheral nerve block techniques. Further studies are required to continue to investigate the best method of anaesthesia and postoperative analgesia for patients undergoing TKA (including GA techniques) before significant change in guidance can be advised.

LOCAL AND REGIONAL ANESTHESIA

Local anesthetics provide a reversible regional loss of sensation. Local anesthetics reduce pain, thereby facilitating surgical procedures. Delivery techniques broaden the clinical applicability of local anesthetics. These techniques include
topical anesthesia, infiltrative anesthesia, ring blocks, and peripheral nerve blocks.

Local anesthetics are safer than general or systemic anesthetics; therefore, they are used whenever possible. In addition, they are relatively easy to administer and readily available. Local anesthetics have been undergoing development for centuries, and, as this chapter illustrates, research continues to provide surgeons with pharmacologic variety and to provide patients with anesthetic agents that have superior safety and efficacy profiles.

Background

Although the medical world cannot cure every disease, the control of pain to ensure patient comfort should be a goal. In 1860, cocaine, the oldest anesthetic, was extracted from the leaves of the *Erythroxylon coca* bush. In 1884, Sigmund Freud and Karl Koller were the first to use it as an anesthetic agent during ophthalmologic procedures.

Procaine, a synthetic alternative to cocaine, was not developed until 1904. Procaine is an ester of para-aminobenzoic acid (PABA).

As procaine is metabolized, PABA, a known allergen, is released as a metabolic product. The potential for severe allergic reactions limits the use of procaine and other ester-type anesthetic agents. Tetracaine, another ester-type anesthetic, was introduced in 1930. Tetracaine is more potent than procaine, and it causes similar allergic reactions.

In 1943, an alternative class of anesthetics was discovered when Lofgren developed lidocaine. This agent is an amide derivative of diethylaminoacetic acid, not PABA; therefore, it has the benefit of a low allergic potential. Since then, multiple amide-type anesthetics have been introduced into clinical use. Slight chemical alterations to the compounds have imparted beneficial characteristics, including increased duration and potency, to each. These compounds offer the surgeon more
choices, and anesthetics can be appropriately matched to
different procedures.

Pathophysiology

Reviewing the physiology of nerve conduction is important
before any discussion of local anesthetics. Nerves transmit
sensation as a result of the propagation of electrical impulses;
this propagation is accomplished by alternating the ion gradient
across the nerve cell wall, or axolemma.

In the normal resting state, the nerve has a negative
membrane potential of -70 mV. This resting potential is
determined by the concentration gradients of 2 major ions,
Na\(^+\) and K\(^+\), and the relative membrane permeability to these
ions (also known as leak currents). The concentration gradients
are maintained by the sodium/potassium ATP pump (in an
energy-dependent process) that transports sodium ions out of
the cell and potassium ions into the cell. This active transport
creates a concentration gradient that favors the extracellular
diffusion of potassium ions. In addition, because the nerve
membrane is permeable to potassium ions and impermeable
to sodium ions, 95% of the ionic leak in excitable cells is caused
by K\(^+\) ions in the form of an outward flux, accounting for the
negative resting potential. The recently identified 2-pore
domain potassium (K2P) channels are believed to be responsible
for leak K\(^+\) currents.

When a nerve is stimulated, depolarization of the nerve
occurs, and impulse propagation progresses. Initially, sodium
ions gradually enter the cell through the nerve cell membrane.
The entry of sodium ions causes the transmembrane electric
potential to increase from the resting potential. Once the
potential reaches a threshold level of approximately -55 mV,
a rapid influx of sodium ions ensues. Sodium channels in the
membrane become activated, and sodium ion permeability
increases; the nerve membrane is depolarized to a level of +35
mV or more.
Once membrane depolarization is complete, the membrane becomes impermeable to sodium ions again, and the conductance of potassium ions into the cell increases. The process restores the excess of intracellular potassium and extracellular sodium and reinstates the negative resting membrane potential. Alterations in the nerve cell membrane potential are termed the action potential. Leak currents are present through all the phases of the action potential, including setting of the resting membrane potential and repolarization.

**Mechanism of action**

Local anesthetics inhibit depolarization of the nerve membrane by interfering with both Na\(^+\) and K\(^+\) currents. The action potential is not propagated because the threshold level is never attained.

Although the exact mechanism by which local anesthetics retard the influx of sodium ions into the cell is unknown, 2 theories have been proposed. The membrane expansion theory postulates that the local anesthetic is absorbed into the cell membrane, expanding the membrane and leading to narrowing of the sodium channels. This hypothesis has largely given way to the specific receptor theory. This theory proposes that the local anesthetic diffuses across the cell membrane and binds to a specific receptor at the opening of the voltage-gated sodium channel. The local anesthetic affinity to the voltage-gated Na\(^+\) channel increases markedly with the excitation rate of the neuron. This binding leads to alterations in the structure or function of the channel and inhibits sodium ion movement. Blockade of leak K\(^+\) currents by local anesthetics is now also believed to contribute to conduction block by reducing the ability of the channels to set the membrane potential.

On the basis of their diameter, nerve fibers are categorized into 3 types. Type A fibers are the largest and are responsible for conducting pressure and motor sensations. Type B fibers are myelinated and moderate in size. Type C fibers, which
transmit pain and temperature sensations, are small and unmyelinated. As a result, anesthetics block type C fibers more easily than they do type A fibers. Therefore, patients who have blocked pain sensation still feel pressure and have mobility because of the unblocked type A fibers.

All local anesthetics have a similar chemical structure, which consists of 3 components: an aromatic portion, an intermediate chain, and an amine group. The aromatic portion, usually composed of a benzene ring, is lipophilic, whereas the amine portion of the anesthetic is responsible for its hydrophilic properties. The degree of lipid solubility of each anesthetic is an important property because its lipid solubility enables its diffusion through the highly lipophilic nerve membrane. The extent of an anesthetic’s lipophilicity is directly related to its potency.

Local anesthetics are weak bases that require the addition of hydrochloride salt to be water soluble and therefore injectable. Salt equilibrates between an ionized form and a nonionized form in aqueous solution. Equilibration is crucial because, although the ionized form is injectable, the nonionized base has the lipophilic properties responsible for its diffusion...
into the nerve cell membrane. The duration of action of an anesthetic or the period during which it remains effective is determined by its protein-binding activity, because the anesthetic receptors along the nerve cell membrane are proteins.

The intermediate chain, which connects the aromatic and amine portions, is composed of either an ester or an amide linkage. This intermediate chain can be used in classifying local anesthetics.

**ANAESTHETIC TECHNIQUE AND CANCER RECURRENCE: CURRENT UNDERSTANDING**

Despite advancements in the field of oncology, cancer remains the second most common cause of death in the United States. Cancer accounts for one out of every four deaths with more than 1500 cancer-related deaths occurring each day. In 2012, over 1.6 million new cancer cases were diagnosed in the United States. This estimate does not include skin cancers and patients with carcinoma in situ, which are not reported to national cancer registries. Although cancer can develop at any age, the risk of being diagnosed with cancer increases with age. Projections suggest that well over 75% of cancers are diagnosed in persons aged 55 and older. With the growing geriatric population and the rising incidence of cancer diagnoses, anaesthesiologists have greater opportunities to manage oncology patients in their daily practice.

**Pathogenesis of tumour metastasis**

Cancer begins with the unregulated cell growth of a primary tumour. The mechanism of tumour metastasis encompasses a series of steps that is dependent on the intrinsic properties of tumour cells as well as the response of the host. The process of tumour metastasis includes the initial transformation and proliferation of neoplastic cells. Angiogenesis then ensues secondary to angiogenic factors, including vascular endothelial growth factor (VEGF) and
prostaglandin E\textsubscript{1}, both released from tumour cells. The neovascularisation occurring from host tissue allows nutrients to flow via these new capillaries, supporting their growth and ensuing proliferation. These tumour cells then penetrate neighbouring normal tissue, entering host circulation via lymphatics and blood vessels. Once in circulation, the aggregate of tumour cells are transported to distant sites, become trapped in capillary beds of distant organs, extravasate into the parenchyma of the organ and the metastatic cells then repeat the proliferative cell cycle.

**Immune system response to cancer**

It is well recognised that cell-mediated immunity is the initial defence mechanism against invading cancer cells. Cell-mediated immunity is comprised of two types of immune response: the innate and the adaptive immune responses. The former is a nonspecific system that does not require prior sensitisation and the latter is antigen-specific immune cell mediated. Both work in conjunction to detect and destroy the presence of tumour cells before it is clinically evident. The major cell components include natural killer (NK) cells, cytotoxic T cells (CTLs), mononuclear cells and dendritic cells. There has been a higher incidence of developing cancer reported in patients with decreased NK cell activity as well as an association between stress-induced attenuation of NK cell activity and the accentuation of breast tumour growth in rat models. Although some studies have shown a positive association between NK cell activity and a reduced incidence of cancer, a meta-analysis from 2012 suggested that the anaesthetic technique has no clinically significant effect on NK cell function.

Cytotoxic T lymphocytes have also demonstrated an importance in anti-tumour activity. Several studies have reported an association between improved patient morbidity and overall survival in a variety of cancers with accumulation of CTLs within the tumour mass.
TUMOUR RESPONSE TO SURGERY

Surgery remains the ‘gold standard’ and primary treatment for patients with solid tumours in conjunction with chemotherapy, radiotherapy and endocrine therapy. Despite optimal surgical debulking, excision of the tumour may not adequately remove the ‘minimal residual disease’ (MRD). MRD is defined as clinically undetectable cancer cells that remain despite the surgical removal of macroscopic tumour. Several studies have demonstrated that the mechanical act of surgery promotes tumour metastasis through various mechanisms: it disperses tumour cells into circulation; surgical stress response leads to depression of cell-mediated immunity and surgery promotes angiogenesis while attenuating the release of anti-angiogenic factors.

It is believed that the interval between the immediate postoperative period and the initiation of supplemental therapeutic treatment coincides with the MRD metastasis. The balance between the metastatic potential of MRD and the stability of the host immune system potentially determines the metastatic recurrence of tumour following surgery. Consequently, the perioperative period represents the highest risk for neoplastic metastasis during the course of a patient’s cancer treatment.

Effects of general anaesthesia on immune function and cancer

Although great strides have been made in the areas of endocrine therapy, radiation therapy and chemotherapy, surgical excision of a solid tumour offers the best opportunity for disease-free prognosis. Recent evidence suggest, however, that certain anaesthetic agents used during surgery may contribute to the immunosuppression that can negatively affect postoperative cancer recurrence.

Our knowledge regarding the potential effects of anaesthetic agents on immune function stems from in vitro
testing and studies on animal models, as well as some human studies.

**Intravenous anaesthetic agents**

Experiments on rats inoculated with mammary adenocarcinoma suggest that certain intravenous agents may suppress NK cell activity and promote tumour cell metastasis. Both ketamine and thiopental significantly reduced NK cell activity and increased the number of retained tumour cells found at autopsy. Ketamine had the strongest impact, promoting tumour retention and metastasis more than 2.5-fold. Similar inhibitory effects on NK cell activity were seen in rats given 10 mg/kg ketamine 1 h prior to surgery. Unlike other anaesthetics, propofol was not found to reduce NK cell activity or increase tumour retention. Kushida et al. found a beneficial effect on immunity via enhanced cytotoxic T lymphocyte activity and reduced tumour growth in mice that received propofol. Propofol’s ability to reduce tumour proliferation, invasion and angiogenesis may be related to its ability to modulate matrix metalloproteinases (MMPs). MMPs are proteinase enzymes that enable tumour cells to penetrate the basement membrane layer by degrading the extracellular matrix, which serves as a biological and mechanical barrier to cell movement. Furthermore, MMPs contribute to extracellular matrix remodelling through the release bioactive substances such as growth factors. Exposure to propofol in clinically relevant concentrations significantly decreased production and activity of MMPs and impaired invasive ability of human colon carcinoma cells.

**Inhaled anaesthetic agents**

Similar to intravenous anaesthetics, impaired lymphocyte function may be responsible for the immunosuppressive effects of volatile anaesthetic agents. In a mice model, both isoflurane and halothane were found to inhibit interferon-induced NK cell induction (>90% and 67%, respectively). Isoflurane and
sevoflurane have also been shown to induce apoptosis in human T-lymphocytes in vitro in a dose-dependent manner. In vivo studies on humans can be more difficult to interpret, mainly because of confounding variables and the medications patients are exposed to which may also affect tumour recurrence.

Brand et al. looked at patients undergoing general anaesthesia (GA) with fentanyl, thiopental and isoflurane for elective orthopaedic surgery and found a significant decrease of circulating NK cells in peripheral blood. One large retrospective study on over 4000 patients found that GA for primary excision of melanoma was associated with a decrease in survival rate (relative risk 1.46, $P < 0.0001$).

Additionally, volatile anaesthetics may influence cancer progression via effects on tumour cell gene expression. Gene expression profiles can be used for risk stratification, disease classification and prognosis prediction in cancer patients.

Gene expression profiling has been shown to predict disease outcome in patients with breast cancer based on clinical and histological criteria. A pilot study in 2010 showed that volatile anaesthetic agents could pave profound time-dependent effects on gene expression in ex-vivo breast and brain tumour cell cultures.

Nitrous oxide remains one of the most commonly used agents during GA. However, it is well documented that nitrous oxide exerts numerous immune modulating effects. Via its interaction with vitamin B12 and inactivation of methionine synthase, nitrous oxide impairs DNA and purine synthesis. Impaired DNA synthesis limits cell production and may cause bone-marrow depression. Reanalysis of data from a previous randomised, controlled trial initially designed to assess the effect of nitrous oxide on surgical site infection in patients undergoing colectomy showed that patients who received nitrous oxide had no significant difference in cancer recurrence compared with those receiving nitrogen and oxygen ($P = 0.72$).
Opioids

Opioids are frequently used in the treatment of oncology patients for both acute postoperative pain and chronic pain conditions. Opioid therapy, both acute and chronic, has been shown to have immunomodulating effects. Opioid administration suppresses immune function including NK cell activity, phagocyte function, as well as cytokine and antibody production. The published literature, however, is conflicting; with some reports suggesting that opioids may either promote or inhibit cancer metastasis. Similar to other anaesthetic agents, opioids have been found to suppress NK cell cytotoxicity in both rat and human models. It has also been proposed that opioids affect tumour growth by activation of VEGF receptors. Singleton et al. showed that morphine promoted tumour cell migration and proliferation in vitro in association with VEGF receptor activation and enhanced angiogenesis. Proposed mechanisms to explain the effect of opioids on angiogenesis include upregulation of COX-2 and increased prostaglandin production.

In contrast to the above results, a beneficial effect for perioperative opioids has been demonstrated in a few studies. In an experimental model of colon cancer, morphine inhibited cancer-promoting MMP production and decreased adhesion and migration of colon cancer cells to extracellular matrix components. Page et al. was able to show a reduction in surgery-induced tumour retention in all rats who received morphine; the effect was more pronounced if morphine was administered prior to laparotomy. This may suggest a role for the preoperative use of opioids to attenuate surgery-induced increase in tumour metastasis.

EFFECTS OF REGIONAL ANAESTHESIA ON IMMUNE FUNCTION AND CANCER

There are many conflicting studies regarding regional anaesthesia and its impact on cancer recurrence. It has been
reported that regional anaesthesia decreases some of the risk factors that promote cancer metastasis by attenuating the neuroendocrine stress response to surgery, reducing pain, the need for GA, minimising opioid use and decreasing pro-inflammatory cytokines. The theory is that regional anaesthesia may leave an intact immune system which could potentially decrease cancer recurrence via endogenous removal of tumour cell microemboli.

A small retrospective study of patients undergoing mastectomy compared cancer and metastasis-free survival in patients who received GA with paravertebral anaesthesia and analgesia (PVA) or GA with postoperative continuous morphine patient-controlled analgesia (PCA). Patients receiving GA + PVA demonstrated a higher rate ($P = 0.012$) of cancer and metastasis-free survival than GA + morphine PCA. An animal study of rats undergoing laparotomy demonstrated that the addition of spinal analgesia to GA decreased the incidence of lung metastasis when compared with GA alone. Another study of patients having prostate cancer surgery showed that patients who had GA + epidural analgesia had a lower risk of biochemical cancer recurrence than patients with GA + intravenous opioids.

On the other hand, a small retrospective study observed that men undergoing radical prostatectomy demonstrated no difference in disease-free survival between GA and combined general and epidural anaesthesia. A large analysis of 42,000 patients with colon cancer who underwent colon resection demonstrated that epidural use was associated with 5-year improved overall survival, but not actual cancer recurrence. Another retrospective study of patients with colorectal cancer who had laparoscopic surgery illustrated no effect of spinal or epidural analgesia compared with intravenous opioid analgesia.

As of 2013, the only long-term study published was the multicentre prospective randomised-control clinical trial,
known as the MASTER trial. This prospective clinical analysis compared patients who underwent major abdominal surgery. They were randomised to receive GA with either opioid or epidural analgesia and no significant difference was found in cancer-free survival between the groups. A potential variable that may represent a confounding factor in this study is that the amount of volatile anaesthetic used was not recorded during data collection. There are other smaller prospective studies but they also suffer from various confounders such as the use of multimodal anaesthesia and the inability to determine whether regional anaesthesia impacts cancer recurrence. To date, many of the common cancers offer potential areas for future research.

Conclusion

The role of endogenous cellular immunity in the defence against cancer metastasis and recurrence is well established. Both animal and human studies suggest that NK cell activity may play a critical role in determining disease-free survival after oncologic surgery. Other components of our immune system also contribute to host protection. The possible interaction between anaesthetic technique, cellular immunity and cancer recurrence has been studied over the years. Some, but not all, evidence suggest that anaesthetic technique may impact cancer recurrence rates. However, more prospective randomised controlled clinical trials are necessary to statistically demonstrate a causal relationship. There are several ongoing clinical trials by Outcomes Research Consortium in Cleveland, Ohio comparing an ‘anti-cancer’ anaesthetic technique utilising a propofol-based anaesthetic with regional anaesthesia on primary cancer patients versus standard GA with opioid analgesia; these investigations will require several more years until completion. While we anxiously await the results, we may have to consider the conflicting evidence presented before us and adjust our current clinical practice in
those oncologic patients where there are sufficient data to support an ‘anti-cancer’ anaesthetic.

**ANAESTHETIC TECHNIQUES IN PRE-ECLAMPSIA**

**Regional Anesthesia**

Regional techniques are superior to general anaesthesia in pre-eclamptic patients without cerebral symptoms for the following reasons:

- Avoids difficult/failed intubation. Patients with pre-eclampsia have increased oedema of the airway.
- They provide maximum analgesia, eliminating the risk of pain, apprehension and so on, which can raise the blood pressure and precipitate a convulsion.
- They have no direct effect on the patient’s heart, lungs, kidneys or liver (if the spinal is given carefully). However, coagulation tests may be necessary before a spinal.

**Pre-operative care**

- Give IV fluids until the patient is considered to be in fluid balance, as evidenced by the vital signs of pulse, blood pressure and urine output. (However, in the eclamptic patient these vital signs may be affected by the underlying pathology and may not be as useful). A large bore cannula must be inserted.
- Monitor vital signs until the patient is brought to the operating room. Intra-arterial monitoring is very useful in severe pre-eclampsia.
- Check the following:
  - The drugs given pre-operatively, especially the central depressants like pethidine
  - The time these drugs were given
  - The dose
The availability of naloxone for the mother and baby.

- Premedicate with ranitidine, metoclopramide and sodium citrate if available. Avoid prophylactic ephedrine.
- Make sure all the equipment necessary for a general anaesthetic is available, especially suction, oxygen, airways, endotracheal tubes, laryngoscopes.
- Follow the routine for a spinal anaesthetic for an obstetric patient, taking the usual precautions. Following spinal anaesthesia there may be a large drop in the patient’s blood pressure which must be treated with small doses of ephedrine (3-6mg) and 250-500 ml boluses of Hartmann’s solution.
- Be ready to resuscitate the baby.

General anaesthesia

General anaesthesia is the anaesthetic of choice in all patients with diminished level of consciousness e.g. those who have had eclamptic convulsions or are showing signs of increased cerebral irritability.

General anaesthesia may also be necessary in pre-eclamptic patients because of coagulation problems, maternal haemorrhage, or severe foetal distress.

General anaesthesia technique in pre-eclamptic and eclamptic patients

- Assess airway as there may be damage or swelling as a result of convulsions.
- Prepare all equipment for difficult intubation.
- Preoxygenate as for any emergency case.
- Induce anaesthesia with thiopentone (4-5mg/kg) or propofol 2-3mg/kg followed by suxamethonium (1-1.5mg/kg) as per rapid sequence induction with cricoid pressure. Ketamine is contra-indicated because it causes hypertension.
Anaesthetic Techniques

• To prevent the hypertensive response during laryngoscopy and intubation in severe pre-eclampsia give a generous dose of induction agent and use another agent, such as esmolol (0.5mg/kg over 15-30 secs) magnesium (loading dose as above), lignocaine (1.5mg/kg), fentanyl (1.5 micrograms/kg) or alfentanil (10 micrograms/kg). The neonate may need naloxone if opioids are used. Esmolol can also be used to prevent a hypertensive response at extubation.
• Maintain anaesthesia with small doses of a non-depolarising relaxant or suxamethonium infusion and a low concentration of volatile agent. An opioid can be given as soon as the baby is delivered.

REGIONAL ANESTHESIA FOR SURGERY

With regional anesthesia, your anesthesiologist injects medication near a cluster of nerves to numb only the area of your body that requires surgery. You may remain awake or you may be given a sedative. Spinal and epidural blocks involve interrupting sensation from the legs or abdomen by injecting local anesthetic medication in or near the spinal canal. Other blocks can be performed for surgery on your extremities, or limbs, blocking sensations from the arm or leg.

How is regional anesthesia different from general anesthesia?

In general anesthesia, you are unconscious and have no awareness or other sensations. In regional anesthesia, your anesthesiologist makes an injection near a cluster of nerves to numb the area of your body that requires surgery.

If I choose regional anesthesia, does that mean I am awake during the surgery?

You may remain awake, or you may be given a sedative. You do not see or feel the actual surgery take place. Your
anesthesiologist, after reviewing your individual situation, will discuss the appropriate amount of sedation for you. Although this sedation analgesia was once referred to as “twilight sleep”, the term “conscious sedation” has become more popular to describe a semi-conscious state that allows patients to be comfortable during certain surgical procedures.

During minimal sedation, you will feel relaxed, and you may be awake. You can understand and answer questions and will be able to follow your physician’s instructions. When receiving moderate sedation, you will feel drowsy and may even sleep through much of the procedure, but will be easily awakened when spoken to. You may or may not remember being in the operating room. During deep sedation, you will sleep through the procedure with little or no memory of the procedure room. Your breathing can slow, and you might be sleeping until the medications wear off.

While you receive sedation during surgery, your vital signs, including heart rate, blood pressure and oxygen level, will be watched closely in order to avoid sudden changes or complications. You may also receive supplemental oxygen during the surgery.

What are the different types of blocks performed for regional anesthesia?

In regional anesthesia, your anesthesiologist makes an injection near a cluster of nerves to numb the area of your body that requires surgery. There are several kinds of regional anesthesia. Two of the most frequently used are spinal anesthesia and epidural anesthesia, which are produced by injections made with great exactness in the appropriate areas of the back. They are frequently preferred for childbirth and prostate surgery. Another common type of regional anesthesia is a peripheral nerve block, which is produced by injections made with great exactness near a cluster of nerves to numb the appropriate area of your body extremity (arm, leg, head)
that requires surgery. Two of the most frequently used are femoral nerve block, which is produced by injection in the leg region, and brachial plexus block, which is produced by injection in the arm and shoulder region. These blocks are frequently performed for surgery in the knee, shoulder, or arm.

May I request what type of anesthesia I will receive?

Yes, in certain situations. Some operations can be performed using different anesthetic procedures. Your anesthesiologist, after reviewing your individual situation, will discuss any available options with you. If there is more than one type of anesthetic procedure available, your preference should be discussed with your anesthesiologist in order for the most appropriate anesthetic plan to be made.

What types of surgical procedures would be amenable for regional anesthesia?

If there are no medical contraindications, anesthesiologists are able to perform regional anesthesia techniques (with either sedation or general anesthesia) for a wide variety of surgical procedures. Some examples of surgeries utilizing regional techniques are:

- Gastrointestinal (stomach)/hepatic (liver): epidural, spinal or paravertebral nerve blocks and catheters may provide effective anesthesia and analgesia for colon resections and surgeries of the stomach, intestines, or liver.
- Gynecology (female reproductive organ): epidural, spinal or paravertebral nerve blocks and catheters may provide effective anesthesia and analgesia for hysterectomy, pelvic procedures, Cesarean sections, and other gynecologic procedures.
- Ophthalmology (eye): injection of local anesthetics may provide anesthesia and analgesia for many types of eye procedures.
• Orthopedics (bone and joint): epidural, spinal, and many types of peripheral nerve blocks and catheters may be used depending on the limb/joint being operated upon.

• Thoracic surgery (chest): epidural, paravertebral or intercostal nerve blocks and catheters may be especially useful in controlling pain following procedures of the chest or esophagus.

• Urology (kidney, prostate, and bladder): epidural, spinal or paravertebral nerve blocks and catheters may provide effective anesthesia and analgesia for radical prostatectomy, nephrectomy, and other procedures involving the kidneys, prostate, or bladder.

• Vascular surgery (blood vessel): cervical (neck) blocks may be used for incisional pain for carotid surgeries; epidural or paravertebral nerve blocks may be used for abdominal aortic endovascular procedures or lower extremity graft bypass procedures.

As with any other medical procedure, each type of regional/local block carries with it its own risks and benefits, which should be carefully considered and discussed with your anesthesiologist each time an anesthetic plan is chosen for a particular procedure.

**How is the epidural or spinal block performed?**

An epidural or spinal block is given in the back. You will either be sitting up or lying on your side. Before the block is performed, your skin will be cleansed with an antiseptic solution. The anesthesiologist will use local anesthesia to numb an area of your back.

For the epidural block, a special needle is placed in the epidural space just outside the spinal sac. A tiny flexible tube called an epidural catheter is inserted through this needle. Occasionally, the catheter will touch a nerve, causing a brief tingling sensation down one leg. Once the catheter is positioned...
properly, the needle is removed and the catheter is taped in place. Additional medications are given as needed through the epidural catheter without another needle being inserted. The medication bathes the nerves and blocks out the pain. This produces epidural anesthesia and analgesia.

For the spinal block, a small needle is placed in spinal sac. Occasionally, the needle will touch a nerve, causing a brief tingling sensation down one leg. Once the needle is positioned properly, medication is administered. The medication bathes the nerves and blocks out the pain. This produces spinal anesthesia and analgesia.

**How is a peripheral nerve block performed?**

Depending on the location of surgery, a peripheral nerve block can be given in the shoulder-arm, back or leg regions. Typically, you will either be lying flat on your back (supine) or lying on your side (lateral) but occasionally may even be on your stomach (prone). The block is administered at an appropriate location to provide anesthesia for the surgery. Before the block is performed, your skin will be cleansed with an antiseptic solution. The anesthesiologist will use local anesthesia to numb an area of where the peripheral nerve block will be administered.

For peripheral nerve blocks, a special needle or catheter is placed near the cluster of nerves that need to be numbed for surgery. Occasionally, the needle will touch a nerve, causing a brief tingling sensation down the extremity where the regional block is being performed. The needle may also be used to temporarily obtain muscle twitches in the extremity where surgery will occur.

**SPECIFIC NERVE BLOCKS**

This chapter will provide you with more detail on specific nerve blocks that can be used for anesthesia and analgesia.
Spinal and Epidural Anesthesia

Spinal and epidural blocks are forms of anesthesia that temporarily interrupt sensation from the trunk (chest and abdomen) and legs by injection of local anesthetic medication in the vertebral canal, which contains the spinal cord and spinal nerves. The spinal cord and spinal nerves are contained within a fluid-filled sac. The fluid-filled sac is called the dural sac and the fluid is known as cerebrospinal or spinal fluid.

Prior to performing a spinal or epidural block, your anesthesiologist may place monitors to watch your vitals signs. You will be placed either on your side with your knees and chin pulled as close to your chest as possible or sit with your arms and head resting on a small table. At this time, your anesthesiologist may choose to inject a small amount of relaxing medicine into your intravenous line if you require sedation. The anesthesiologist will feel your back, clean your skin with an antiseptic (bacteria-killing) solution, and place a sterile drape around the area. Your anesthesiologist may first inject some local anesthesia into the skin and then into the deeper tissues of the lower back - this may cause a slight burning or pressure sensation. Your anesthesiologist will then carefully insert the needle and advance it into the space between your vertebrae (backbones). Occasionally, you may feel a brief tingling sensation (paresthesia) during the procedure.

For spinal anesthesia, the anesthesiologist advances the needle until he or she is able to inject some local anesthesia into the spinal fluid. Since a spinal block typically involves a one-time injection, the duration of your spinal anesthesia will depend on the type and amount of local anesthetic medication administered by your anesthesiologist.

For epidural anesthesia, the anesthesiologist advances the needle into the epidural space which is located just outside of the dural sac containing the spinal fluid. Your anesthesiologist may insert a small flexible catheter to allow for continuous...
injections or infusions of local anesthesia. The needle is removed and only the catheter remains at the end of the procedure. Epidural analgesia is most commonly used to provide pain relief during childbirth or after painful surgical procedures of the chest, abdomen, and lower extremities.

After your anesthesiologist has performed the spinal or epidural block, you will generally feel numbness and may notice that your legs will become weak to the point where you may not be able to move them. This is normal. The surgery will be allowed to start only when your anesthesiologist is certain that the site of surgery is completely numb. During the surgery, you will have the option of being awake or sedated. If you choose to be sedated, the anesthesiologist will administer sedatives through your intravenous line to help you sleep lightly during the operation.

After surgery, you will be taken to the recovery room and monitored closely by recovery room nurse until your spinal or epidural block wears off. Typically, a spinal block lasts 2-6 hours depending the type and amount of local anesthetic given by the anesthesiologist. If you received an epidural catheter, it can be left in place for several days after surgery to allow a continuous infusion of pain relieving medications. Your epidural catheter is generally removed once you are able to keep down oral pain-relieving medications.

**Brachial Plexus Block**

The brachial plexus is the major nerve bundle going to the shoulder and arm. Depending on the level of surgery, your anesthesiologist will decide at what level he wants to block the brachial plexus. For example if you have surgery at the shoulder, your anesthesiologist may choose a nerve block (interscalene or cervical paravertebral block) performed at a location above the clavicle. For surgeries below the shoulder joint or clavicle, an infraclavicular or axillary technique may be used. Your anesthesiologist may use ultrasound, a nerve
stimulator or other techniques to help identify the appropriate location along the brachial plexus to inject the local anesthetic. If a nerve stimulator is used, you may feel the muscles in your shoulder or arm twitch. This is normal. If you experience any sharp pain or any type of paresthesia (“shock-like” sensation similar to if you were to hit your “funny-bone” in your elbow) shortly before or during the injection you should notify your anesthesiologist immediately. You should also notify your anesthesiologist before performing any brachial plexus block if you have any type of pain below the elbow, preexisting pain, or preexisting nerve injury. If you have serious respiratory (lung, breathing) problems you should notify your anesthesiologist before proceeding with the block. Your anesthesiologist will then decide whether a brachial plexus block is safe for you and will provide adequate analgesia for the surgery.

Paravertebral Block

Paravertebral blocks can be utilized to numb a specific area in one part of the body depending on where the block is performed. For example, paravertebral blocks at the level of the neck can be used for thyroid gland or carotid artery surgery. Paravertebral blocks at the level of the chest and abdomen can be used for many types of breast, thoracic, and abdominal surgery. Paravertebral blocks at the level of the hip can be used for surgeries involving the hip, knee, and the front of the thigh.

In general, all paravertebral blocks are performed with a similar technique. Your anesthesiologist will feel your back, clean your skin with an antiseptic (bacteria-killing) solution, and may inject some local anesthesia into the skin and then into the deeper tissues of the back - this may cause a slight burning or pressure sensation. Your anesthesiologist will then carefully insert and advance a needle and inject local anesthesia to numb the nerves. If a nerve stimulator is used to help locate
the nerves, you may feel the muscles in your chest, abdomen, or legs twitch. This is normal. If paravertebral blocks are utilized for thoracic and abdominal surgery, more than one injection may be needed to provide achieve adequate anesthesia. Your anesthesiologist may insert a small flexible catheter to allow for continuous injections or infusions of local anesthesia. The needle is removed and only the catheter remains at the end of the procedure if this is the case. As with other blocks, always let your anesthesiologist know if you experience any sharp or radiating pain during the procedure or injecting of the local anesthetic. Always notify your anesthesiologist if you experience sudden numbness, bilateral numbness or warmth with the injection of your local anesthetic

**Femoral Nerve Block**

The femoral nerve provides sensation and motor function to the front of the thigh and knee. This block is commonly used for procedures that cover the knee. If you receive a femoral nerve block, you will be positioned on lying on your back. Your anesthesiologist will clean your groin area with an antiseptic (bacteria-killing) solution. If using an ultrasound, the anesthesiologist will place the ultrasound probe on your skin. An image of the femoral nerve will be obtained by scanning the area. Once the nerve is identified, the anesthesiologist will inject local anesthesia ("numbing medicine") into the skin—this may cause a slight burning or pressure sensation. Your anesthesiologist will then carefully insert and advance a needle toward the femoral nerve. The ultrasound is used to visualize the needle as it approaches the nerve. The needle does not touch the nerve; it is stopped when it is near the nerve. Once the needle is in proper position relative to the nerve, local anesthetic is injected through the needle to numb the nerve. The local anesthetic can be seen surrounding the nerve with ultrasound. Sometimes a nerve stimulator is also used to help your anesthesiologist determine
the appropriate location to inject the local anesthetic. If a nerve stimulator is used, you may feel the muscles in your leg twitch—this is normal. Your anesthesiologist may insert a small flexible catheter to allow for continuous injections or infusions of local anesthesia. The needle is removed and only the catheter remains at the end of the procedure if this is the case. As with other blocks, always let your anesthesiologist know if you experience any sharp or radiating pain during the procedure or injecting of the local anesthetic. You may have difficulty with weight bearing on the blocked leg, and you should have help in attempting to get up. Care should be taken to prevent falls.

**Sciatic and Popliteal Nerve Block**

This sciatic nerve provides sensation and motor function to the back of the thigh and most of the leg below the knee. This block is commonly used for surgery on the knee, calf, Achilles tendon, ankle, and foot. If you receive a sciatic nerve block, you generally will be placed on your belly or side but occasionally you may be lying on your back. Your anesthesiologist will clean your skin with an antiseptic (bacteria-killing) solution. If using an ultrasound, the anesthesiologist will place the ultrasound probe on your skin.

An image of the sciatic nerve will be obtained by scanning the area. Once the nerve is identified, the anesthesiologist will inject local anesthesia (“numbing medicine”) into the skin—this may cause a slight burning or pressure sensation. Your anesthesiologist will then carefully insert and advance a needle toward the sciatic nerve. The ultrasound is used to visualize the needle as it approaches the nerve. The needle does not touch the nerve; it is stopped when it is near the nerve. Once the needle is in proper position relative to the nerve, local anesthetic is injected through the needle to numb the nerve. The local anesthetic can be seen surrounding the nerve with ultrasound. A nerve stimulator is sometimes used as well to help your anesthesiologist determine the appropriate location
to inject the local anesthetic. You may feel the muscles in your leg twitch—this is normal. As with other blocks, always let your anesthesiologist know if you experience any sharp or radiating pain during the procedure or injecting of the local anesthetic.

As with other blocks, always let your anesthesiologist know if you experience any sharp or radiating pain during the procedure or injecting of the local anesthetic. You may have difficulty with weight bearing on the blocked leg, and you should have help in attempting to get up. Care should be taken to prevent falls.
PAIN MANAGEMENT

Pain management, pain medicine, pain control or algatry, is a branch of medicine employing an interdisciplinary approach for easing the suffering and improving the quality of life of those living with chronic pain. The typical pain management team includes medical practitioners, pharmacists, clinical psychologists, physiotherapists, occupational therapists, physician assistants, nurse practitioners, and clinical nurse specialists. The team may also include other mental health specialists and massage therapists. Pain sometimes resolves promptly once the underlying trauma or pathology has healed, and is treated by one practitioner, with drugs such as analgesics and (occasionally) anxiolytics. Effective management of chronic (long-term) pain, however, frequently requires the coordinated efforts of the management team.

Medicine treats injury and pathology to support and speed healing; and treats distressing symptoms such as pain to relieve suffering during treatment and healing. When a painful injury or pathology is resistant to treatment and persists, when pain persists after the injury or pathology has healed, and when
medical science cannot identify the cause of pain, the task of medicine is to relieve suffering. Treatment approaches to chronic pain include pharmacological measures, such as analgesics, antidepressants and anticonvulsants, interventional procedures, physical therapy, physical exercise, application of ice and/or heat, and psychological measures, such as biofeedback and cognitive behavioral therapy.

**Uses**

Pain can have many causes and there are many possible treatments for it. In the nursing profession, one common definition of pain is any problem that is “whatever the experiencing person says it is, existing whenever the experiencing person says it does”. Different sorts of pain management address different sorts of pain.

Pain management includes patient communication about the pain problem. To define the pain problem, a health care provider will likely ask questions such as these:

- How intense is the pain?
- How does the pain feel?
- Where is the pain?
- What, if anything, makes the pain lessen?
- When did the pain start?

After asking questions such as these, the health care provider will have a description of the pain. Pain management will then be used to address that pain.

**Adverse effects**

There are many types of pain management, and each of them have their own benefits, drawbacks, and limits.

A common difficulty in pain management is communication. People experiencing pain may have difficulty recognizing or describing what they feel and how intense it is. Health care providers and patients may have difficulty
communicating with each other about how pain responds to treatments. There is a continuing risk in many types of pain management for the patient to take treatment which is less effective than needed or which causes other difficulty and side effects. Some treatments for pain can be harmful if overused. A goal of pain management for the patient and their health care provider to identify the amount of treatment which addresses the pain but which is not too much treatment.

Another problem with pain management is that pain is the body’s natural way of communicating a problem. Pain is supposed to resolve as the body heals itself with time and pain management. Sometimes pain management covers a problem, and the patient might be less aware that they need treatment for a deeper problem.

**Physical approach**

**Physical medicine and rehabilitation**

Physical medicine and rehabilitation (physiatry/physiotherapy) employs diverse physical techniques such as thermal agents and electrotherapy, as well as therapeutic exercise and behavioral therapy, alone or in tandem with interventional techniques and conventional pharmacotherapy to treat pain, usually as part of an interdisciplinary or multidisciplinary program.

**TENS**

Transcutaneous electrical nerve stimulation has been found to be ineffective for lower back pain, however, it might help with diabetic neuropathy. Although there has not been adequate evidence based research on acute sensory TENS, chronic conditions are efficacious in relieving pain. TENS is indicated for any chronic musculoskeletal condition under the gate control theory of pain. Essentially, the gate control theory states that sensory fibers carry their signal faster than pain fibers, and thus make their way to the dorsal root ganglion
of the spine (the gate) much faster. This in turn causes the pain signal to be blocked by the sensory TENS signal. This theory explains why rubbing a stubbed toe relieves pain. A study conducted by Oncel M and team compared the efficacy of TENS with a non-steroidal anti-inflammatory drug (NSAID, Naproxen sodium) in patients who had uncomplicated minor rib fractures. The researchers found that TENS therapy given twice a day for 3 days resulted in significant pain reduction and was found to be more effective than NSAID or placebo.

**Acupuncture**

Acupuncture involves the insertion and manipulation of needles into specific points on the body to relieve pain or for therapeutic purposes. An analysis of the 13 highest quality studies of pain treatment with acupuncture, published in January 2009 in the *British Medical Journal*, was unable to quantify the difference in the effect on pain of real, sham and no acupuncture.

Acupuncture is believed to restore the energy balance in the body through stimulation of energy channels called the meridians. It is believed acupuncture therapy reduces pain signals through production of endorphins that are known to be the natural painkillers. Clinical studies suggest that acupuncture can reduce joint pain and so the therapy can be effective in reducing pain caused by knee osteoarthritis.

**Light therapy**

Research has not found evidence that light therapy such as low level laser therapy is an effective therapy for relieving low back pain.

**Interventional procedures**

Interventional procedures - typically used for chronic back pain - include epidural steroid injections, facet joint injections, neurolytic blocks, spinal cord stimulators and intrathecal drug
delivery system implants. Pulsed radiofrequency, neuromodulation, direct introduction of medication and nerve ablation may be used to target either the tissue structures and organ/systems responsible for persistent nociception or the nociceptors from the structures implicated as the source of chronic pain.

An intrathecal pump used to deliver very small quantities of medications directly to the spinal fluid. This is similar to epidural infusions used in labour and postoperatively. The major differences are that it is much more common for the drug to be delivered into the spinal fluid (intrathecal) rather than epidurally, and the pump can be fully implanted under the skin. Interestingly, it is suggested this approach allows a smaller dose of the drug to be delivered directly to the site of action, with fewer systemic side effects, which is thus therapeutically questionable due to the fact that the three main opioid receptors; chiefly the [i-,ś-,and ä (Mu-,Kappa-, and Delta- respectively] are limited in their anatomical locations. The 3 main receptors are found dominantly within the brain, CNS and Digestive tract.

A spinal cord stimulator is an implantable medical device that creates electric impulses and applies them near the dorsal surface of the spinal cord provides a paresthesia (“tingling”) sensation that alters the perception of pain by the patient.

A small number of patients, especially those with severe pain from untreatable cancer, may benefit surgical treatment such as cordotomy.

Psychological approach

Cognitive behavioral therapy

Cognitive behavioral therapy (CBT) for pain helps patients with pain to understand the relationship between one’s physiology (e.g., pain and muscle tension), thoughts, emotions, and behaviors. A main goal in treatment is cognitive
restructuring to encourage helpful thought patterns, targeting a behavioral activation of healthy activities such as regular exercise and pacing. Lifestyle changes are also trained to improve sleep patterns and to develop better coping skills for pain and other stressors using various techniques (e.g., relaxation, diaphragmatic breathing, and even biofeedback).

Studies have demonstrated the usefulness of cognitive behavioral therapy in the management of chronic low back pain, producing significant decreases in physical and psychosocial disability. A study published in the January 2012 issue of the *Archives of Internal Medicine* found CBT is significantly more effective than standard care in treatment of people with body-wide pain, like fibromyalgia. Evidence for the usefulness of CBT in the management of adult chronic pain is generally poorly understood, due partly to the proliferation of techniques of doubtful quality, and the poor quality of reporting in clinical trials. The crucial content of individual interventions has not been isolated and the important contextual elements, such as therapist training and development of treatment manuals, have not been determined. The widely varying nature of the resulting data makes useful systematic review and meta-analysis within the field very difficult.

In 2009 a systematic review of randomized controlled trials (RCTs) of psychological therapies for the management of adult chronic pain (excluding headache) found that “CBT and BT have weak effects in improving pain. CBT and BT [behavior therapy] have minimal effects on disability associated with chronic pain. CBT and BT are effective in altering mood outcomes, and there is some evidence that these changes are maintained at six months;” and a review of RCTs of psychological therapies for the management of chronic and recurrent pain in children and adolescents, by the same authors, found “Psychological treatments are effective in pain control for children with headache and benefits appear to be
maintained. Psychological treatments may also improve pain control for children with musculoskeletal and recurrent abdominal pain. There is some evidence available to estimate effects on disability or mood."

**Hypnosis**

A 2007 review of 13 studies found evidence for the efficacy of hypnosis in the reduction of pain in some conditions, though the number of patients enrolled in the studies was small, bringing up issues of power to detect group differences, and most lacked credible controls for placebo and/or expectation. The authors concluded that “although the findings provide support for the general applicability of hypnosis in the treatment of chronic pain, considerably more research will be needed to fully determine the effects of hypnosis for different chronic-pain conditions.”

Hypnosis has reduced the pain of some noxious medical procedures in children and adolescents, and in clinical trials addressing other patient groups it has significantly reduced pain compared to no treatment or some other non-hypnotic interventions. However, no studies have compared hypnosis to a convincing placebo, so the pain reduction may be due to patient expectation (the “placebo effect”). The effects of self hypnosis on chronic pain are roughly comparable to those of progressive muscle relaxation.

**Mindfulness meditation**

A meta-analysis of studies that used techniques centered around the concept of mindfulness, concluded, “Findings suggest that MBIs decrease the intensity of pain for chronic pain patients.”

**Medications**

The World Health Organization (WHO) recommends a *pain ladder* for managing analgesia. It was first described for use in cancer pain, but it can be used by medical professionals
as a general principle when dealing with analgesia for any type of pain. In the treatment of chronic pain, whether due to malignant or benign processes, the three-step WHO Analgesic Ladder provides guidelines for selecting the kind and stepping up the amount of analgesia. The exact medications recommended will vary with the country and the individual treatment center, but the following gives an example of the WHO approach to treating chronic pain with medications. If, at any point, treatment fails to provide adequate pain relief, then the doctor and patient move onto the next step.

**Mild to moderate pain**

Paracetamol, an NSAID and/or paracetamol in a combination product with a weak opioid such as tramadol, may provide greater relief than their separate use. Also a combination of opioid with acetaminophen can be frequently used such as Percocet, Vicodin, or Norco.

**Moderate to severe pain**

When treating moderate to severe pain, the type of the pain, acute or chronic, needs to be considered. The type of pain can result in different medications being prescribed. Certain medications may work better for acute pain, others for chronic pain, and some may work equally well on both. Acute pain medication is for rapid onset of pain such as from an inflicted trauma or to treat post-operative pain. Chronic pain medication is for alleviating long-lasting, ongoing pain.

Morphine is the gold standard to which all narcotics are compared. Semi-synthetic derivatives of morphine such as hydromorphone (Dilaudid), oxymorphone (Numorphan, Opana), nicomorphine (Vilan), hydromorphinol and others vary in such ways as duration of action, side effect profile and milligramme potency. Fentanyl has the benefit of less histamine release and thus fewer side effects. It can also be administered via transdermal patch which is convenient for chronic pain management. In addition to the intrathecal patch and injectable
Sublimaze, the FDA has approved various immediate release fentanyl products for breakthrough cancer pain (Actiq/OTFC/Fentora/Onsolis/Subsys/Lazanda/Abstral). Oxycodone is used across the Americas and Europe for relief of serious chronic pain; its main slow-release formula is known as OxyContin, and short-acting tablets, capsules, syrups and ampules are available making it suitable for acute intractable pain or breakthrough pain. Diamorphine, methadone and buprenorphine are used less frequently. Pethidine, known in North America as meperidine, is not recommended for pain management due to its low potency, short duration of action, and toxicity associated with repeated use. Pentazocine, dextromoramide and dipipanone are also not recommended in new patients except for acute pain where other analgesics are not tolerated or are inappropriate, for pharmacological and misuse-related reasons. In some countries potent synthetics such as piritramide and ketobemidone are used for severe pain, and tapentadol is a newer agent introduced in the last decade.

For moderate pain, tramadol, codeine, dihydrocodeine, and hydrocodone are used, with nicocodeine, ethylmorphine and propoxyphene and dextropropoxyphene less commonly.

Drugs of other types can be used to help opioids combat certain types of pain, for example, amitriptyline is prescribed for chronic muscular pain in the arms, legs, neck and lower back with an opiate, or sometimes without it and/or with an NSAID.

While opiates are often used in the management of chronic pain, high doses are associated with an increased risk of opioid overdose.

**Opioids**

From the Food and Drug Administration’s website: “According to the National Institutes of Health, studies have shown that properly managed medical use of opioid analgesic
compounds (taken exactly as prescribed) is safe, can manage pain effectively, and rarely causes addiction.”

Opioid medications can provide short, intermediate or long acting analgesia depending upon the specific properties of the medication and whether it is formulated as an extended release drug. Opioid medications may be administered orally, by injection, via nasal mucosa or oral mucosa, rectally, transdermally, intravenously, epidurally and intrathecally. In chronic pain conditions that are opioid responsive a combination of a long-acting (OxyContin, MS Contin, Opana ER, Exalgo and Methadone) or extended release medication is often prescribed in conjunction with a shorter-acting medication (oxycodone, morphine or hydromorphone) for breakthrough pain, or exacerbations.

Most opioid treatment used by patients outside of healthcare settings is oral (tablet, capsule or liquid), but suppositories and skin patches can be prescribed. An opioid injection is rarely needed for patients with chronic pain.

Although opioids are strong analgesics, they do not provide complete analgesia regardless of whether the pain is acute or chronic in origin. Opioids are efficacious analgesics in chronic malignant pain and modestly effective in nonmalignant pain management. However, there are associated adverse effects, especially during the commencement or change in dose. When opioids are used for prolonged periods drug tolerance, chemical dependency, diversion and addiction may occur.

Clinical guidelines for prescribing opioids for chronic pain have been issued by the American Pain Society and the American Academy of Pain Medicine. Included in these guidelines is the importance of assessing the patient for the risk of substance abuse, misuse, or addiction; a personal or family history of substance abuse is the strongest predictor of aberrant drug-taking behavior. Physicians who prescribe opioids should integrate this treatment with any
psychotherapeutic intervention the patient may be receiving. The guidelines also recommend monitoring not only the pain but also the level of functioning and the achievement of therapeutic goals. The prescribing physician should be suspicious of abuse when a patient reports a reduction in pain but has no accompanying improvement in function or progress in achieving identified goals.

Commonly-used long-acting opioids and their parent compound:
- OxyContin (oxycodone)
- Hydromorph Contin (hydromorphone)
- MS Contin (morphine)
- M-Eslon (morphine)
- Exalgo (hydromorphone)
- Opana ER (oxymorphone)
- Duragesic (fentanyl)
- Nucynta ER (tapentadol)
- Metadol/Methadose (methadone)*
- Hysingla ER (hydrocodone bitartrate)
- Zohydro ER (hydrocodone bicarbonate)

*Methadone can be used for either treatment of opioid addiction/detoxification when taken once daily or as a pain medication usually administered on an every 12-hour or 8-hour dosing interval.

Non-steroidal anti-inflammatory drugs

The other major group of analgesics are non-steroidal anti-inflammatory drugs (NSAID). Acetaminophen/paracetamol is not always included in this class of medications. However, acetaminophen may be administered as a single medication or in combination with other analgesics (both NSAIDs and opioids). The alternatively prescribed NSAIDs such as ketoprofen and piroxicam have limited benefit in chronic pain disorders and with long-term use are associated with significant
Pain Management Techniques

adverse effects. The use of selective NSAIDs designated as selective COX-2 inhibitors have significant cardiovascular and cerebrovascular risks which have limited their utilization.

**Antidepressants and antiepileptic drugs**

Some antidepressant and antiepileptic drugs are used in chronic pain management and act primarily within the pain pathways of the central nervous system, though peripheral mechanisms have been attributed as well. These mechanisms vary and in general are more effective in neuropathic pain disorders as well as complex regional pain syndrome. Drugs such as gabapentin have been widely prescribed for the off-label use of pain control. The list of side effects for these classes of drugs are typically much longer than opiate or NSAID treatments for chronic pain, and many antiepileptics cannot be suddenly stopped without the risk of seizure.

**Cannabinoids**

Chronic pain is one of the most commonly cited reasons for the use of medical marijuana. A 2012 Canadian survey of participants in their medical marijuana program found that 84% of respondents reported using medical marijuana for the management of pain.

Evidence of medical marijuana’s pain mitigating effects is generally conclusive. Detailed in a 1999 report by The Institute of Medicine, “the available evidence from animal and human studies indicates that cannabinoids can have a substantial analgesic effect.” In a 2013 review study published in Fundamental & Clinical Pharmacology, various studies were cited in demonstrating that cannabinoids exhibit comparable effectiveness to opioids in models of acute pain and even greater effectiveness in models of chronic pain.

**Other analgesics**

Other drugs are often used to help analgesics combat various types of pain, and parts of the overall pain experience,
and are hence called adjuvant medications. Gabapentin — an anti-epileptic — not only exerts effects alone on neuropathic pain, but can potentiate opiates. While perhaps not prescribed as such, other drugs such as Tagamet (cimetidine) and even simple grapefruit juice may also potentiate opiates, by inhibiting CYP450 enzymes in the liver, thereby slowing metabolism of the drug. In addition, orphenadrine, cyclobenzaprine, trazodone and other drugs with anticholinergic properties are useful in conjunction with opioids for neuropathic pain. Orphenadrine and cyclobenzaprine are also muscle relaxants, and therefore particularly useful in painful musculoskeletal conditions. Clonidine has found use as an analgesic for this same purpose, and all of the mentioned drugs potentiate the effects of opioids overall.

**Society and culture**

**Undertreatment**

Undertreatment of pain is the absence of pain management therapy for a person in pain when treatment is indicated.

Consensus in evidence-based medicine and the recommendations of medical specialty organizations establish the guidelines which determine the treatment for pain which health care providers ought to offer. For various social reasons, persons in pain may not seek or may not be able to access treatment for their pain. At the same time, health care providers may not provide the treatment which authorities recommend.

**In children**

Acute pain is common in children and adolescents as a result of injury, illness, or necessary medical procedures. Chronic pain is present in approximately 15–25% of children and adolescents, and may be caused by an underlying disease, such as sickle cell anemia, cystic fibrosis, rheumatoid arthritis, or cancer or by functional disorders such as migraines, fibromyalgia, or complex regional pain.
Assessment

Pain assessment in children is often challenging due to limitations in developmental level, cognitive ability, or their previous pain experiences. Clinicians must observe physiological and behavioral cues exhibited by the child to make an assessment. Self-report, if possible, is the most accurate measure of pain; self-report pain scales developed for young children involve matching their pain intensity to photographs of other children’s faces, such as the Oucher Scale, pointing to schematics of faces showing different pain levels, or pointing out the location of pain on a body outline. Questionnaires for older children and adolescents include the Varni-Thompson Pediatric Pain Questionnaire (PPQ) and the Children’s Comprehensive Pain Questionnaire, which are often utilized for individuals with chronic or persistent pain.

Nonpharmacologic

Caregivers may provide nonpharmacological treatment for children and adolescents because it carries minimal risk and is cost effective compared to pharmacological treatment. Nonpharmacologic interventions vary by age and developmental factors. Physical interventions to ease pain in infants include swaddling, rocking, or sucrose via a pacifier, whereas those for children and adolescents include hot or cold application, massage, or acupuncture. Cognitive behavioral therapy (CBT) aims to reduce the emotional distress and improve the daily functioning of school-aged children and adolescents with pain through focus on changing the relationship between their thoughts and emotions in addition to teaching them adaptive coping strategies. Integrated interventions in CBT include relaxation technique, mindfulness, biofeedback, and acceptance (in the case of chronic pain). Many therapists will hold sessions for caregivers to provide them with effective management strategies.
Pharmacologic

Acetaminophen, nonsteroidal anti-inflammatory agents, and opioid analgesics are commonly used to treat acute or chronic pain symptoms in children and adolescents, but a pediatrician should be consulted before administering any medication.

Professional certification

Pain management practitioners come from all fields of medicine.

In addition to medical practitioners, a pain management team may often benefit from the input of pharmacists, physiotherapists, clinical psychologists and occupational therapists, among others. Together the multidisciplinary team can help create a package of care suitable to the patient.

Pain physicians are often fellowship-trained board-certified anesthesiologists, neurologists, psychiatrists or psychologists. Palliative care doctors are also specialists in pain management. The American Board of Anesthesiology, the American Osteopathic Board of Anesthesiology (recognized by the AOABOS), the American Board of Physical Medicine and Rehabilitation, and the American Board of Psychiatry and Neurology each provide certification for a subspecialty in pain management following fellowship training which is recognized by the American Board of Medical Specialties (ABMS) or the American Osteopathic Association Bureau of Osteopathic Specialists (AOABOS).

As the field of pain medicine has grown rapidly, many practitioners have entered the field, some none-ACGME board-certified.

PAIN LADDER

“Pain ladder”, or analgesic ladder, was created by the World Health Organization (WHO) as a guideline for the use
Pain Management Techniques

of drugs in the management of pain. Originally published in 1986 for the management of cancer pain, it is now widely used by medical professionals for the management of all types of pain.

The general principle is to start with first step drugs, and then to climb the ladder if pain is still present. The medications range from common, over-the-counter drugs at the lowest rung, to strong opioids.

The ladder

The WHO guidelines recommend prompt oral administration of drugs (“by the mouth”) when pain occurs, starting, if the patient is not in severe pain, with non-opioid drugs such as paracetamol (acetaminophen) or non-steroidal anti-inflammatory drugs (NSAIDs) including COX-2 inhibitors. Then, if complete pain relief is not achieved or disease progression necessitates more aggressive treatment, a weak opioid such as codeine, dihydrocodeine or tramadol is added to the existing non-opioid regime.

If this is or becomes insufficient, a weak opioid is replaced by a strong opioid, such as morphine, diamorphine, fentanyl, buprenorphine, oxymorphone, oxycodone, or hydromorphone, while continuing the non-opioid therapy, escalating opioid dose until the patient is pain free or at the maximum possible relief without intolerable side effects. If the initial presentation is severe pain, this stepping process should be skipped and a strong opioid should be started immediately in combination with a non-opioid analgesic.

The guideline directs that medications should be given at regular intervals (“by the clock”) so that continuous pain relief occurs, and (“by the individual”) dosing by actual relief of pain rather than fixed dosing guidelines. It recognizes that breakthrough pain may occur and directs immediate rescue doses be provided.
# WHO Pain Ladder

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Mild pain:</th>
<th>Non-opioid</th>
<th>Optional adjuvant</th>
<th>If pain persists or increases, go to step 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 2</td>
<td>Moderate pain:</td>
<td>Weak opioid</td>
<td>Non-opioid</td>
<td>Optional adjuvant</td>
</tr>
<tr>
<td>Step 3</td>
<td>Severe pain:</td>
<td>Strong opioid</td>
<td>Non-opioid</td>
<td>Optional adjuvant</td>
</tr>
</tbody>
</table>

The usefulness of the second step (weak opioid) is being debated in the clinical and research communities. Some authors challenge the pharmacological validity of the step and, pointing to their higher toxicity and low efficacy, argue that a weak opioid, with the possible exception of tramadol due to its unique action, could be replaced by smaller doses of a strong opioid.

Not all pain yields completely to classic analgesics, and drugs that are not traditionally considered analgesics, but which reduce pain in some cases, such as steroids or bisphosphonates, may be employed concurrently with analgesics at any stage. Tricyclic antidepressants, class I antiarrhythmics, or anticonvulsants are the drugs of choice for neuropathic pain. Up to 90 percent of cancer patients, immediately preceding death, use such adjuvants. Many adjuvants carry a significant risk of serious complications.

## INTERVENTIONAL PAIN MANAGEMENT

Interventional pain management or interventional pain medicine is a subspecialty of the medical specialty, pain
management, devoted to the use of invasive techniques such as facet joint injections, nerve blocks (interrupting the flow of pain signals along specific nervous system pathways), neuroaugmentation (including spinal cord stimulation and peripheral nerve stimulation), vertebroplasty, kyphoplasty, nucleoplasty, endoscopic discectomy, percutaneous spine fusion and implantable drug delivery systems.

History

Early efforts at interventional pain date back to the origins of regional analgesia and neural blockade, and gradually evolved into a distinct specialty. Tuffer described the first therapeutic nerve block for pain management in 1899. Von Gaza developed diagnostic blockade in pain management, using procaine for determining the pain’s pathways. Modern day contributors include Bonica, Winnie, Raj, Racz, Bogduk, and others. The term “interventional pain management” was first used by pain management specialist Steven D. Waldman in 1996 to define the emerging specialty. The subspecialty of interventional pain management has received a specific specialty designation by the United States National Uniform Billing Committee to allow its practitioners to bill Federal healthcare programs including Medicare and Medicaid. Physicians who practice interventional pain management are represented by a variety of pain management organizations including the Society For Pain Practice Management and the American Society of Interventional Pain Physicians.

Radiation

Radiotherapy is used when drug treatment is failing to control the pain of a growing tumor, such as in bone metastasis (most commonly), penetration of soft tissue, or compression of sensory nerves. Often, low doses are adequate to produce analgesia, thought to be due to reduction in pressure or, possibly, interference with the tumor’s production of pain-promoting chemicals. Radiopharmaceuticals that target specific
tumors have been used to treat the pain of metastatic illnesses. Relief may occur within a week of treatment and may last from two to four months.

**Neurolytic block**

A neurolytic block is the deliberate injury of a nerve by the application of chemicals (in which case the procedure is called “neurolysis”) or physical agents such as freezing or heating ("neurotomy"). These interventions cause degeneration of the nerve’s fibers and temporary interference with the transmission of pain signals. In these procedures, the thin protective layer around the nerve fiber, the basal lamina, is preserved so that, as a damaged fiber regrows, it travels within its basal lamina tube and connects with the correct loose end, and function may be restored. Surgically cutting a nerve severs these basal lamina tubes, and without them to channel the regrowing fibers to their lost connections, a painful neuroma or deafferentation pain may develop. This is why the neurolytic is preferred over the surgical block.

**Cutting or destruction of nervous tissue**

Surgical cutting or destruction of peripheral or central nervous tissue is now rarely used in the treatment of pain. Procedures include neurectomy, cordotomy, dorsal root entry zone lesioning, and cingulotomy.

Neurectomy involves cutting a nerve, and is (rarely) used in patients with short life expectancy who are unsuitable for drug therapy due to ineffectiveness or intolerance. The dorsal root or dorsal root ganglion (that carry mostly sensory signals) may be usefully targeted (called rhizotomy); with the dorsal root ganglion possibly the more effective target because some sensory fibers enter the spinal cord from the dorsal root ganglion via the **ventral** (motor) root, and these would not be interrupted by dorsal root neurectomy. Because nerves often carry both sensory and motor fibers, motor impairment is a
possible side effect of neurectomy. A common result of this procedure is “deafferentation pain” where, 6–9 months after surgery, pain returns at greater intensity.

Cordotomy involves cutting into the spinothalamic tracts, which run up the front/side (anterolateral) quadrant of the spinal cord, carrying heat and pain signals to the brain. Pancoast tumor pain has been effectively treated with dorsal root entry zone (DREZ) lesioning – damaging a region of the spinal cord where peripheral pain signals cross to spinal cord fibers. This is major surgery, carrying the risk of significant neurological side effects. Cingulotomy involves cutting the fibers that carry signals directly from the cingulate gyrus to the entorhinal cortex in the brain. It reduces the unpleasantness of pain (without affecting its intensity), but may have cognitive side effects.

Intrathecal infusion

Delivery of an opioid such as morphine, hydromorphone, fentanyl, sufentanil or meperidine directly into the subarachnoid cavity provides enhanced analgesia with reduced systemic side effects, and has reduced the level of pain in otherwise intractable cases. The anxiolytic clonidine, or the nonopioid analgesic ziconotide, and local anesthetics such as bupivacaine, ropivacaine or tetracaine may also be infused along with the opioid.

Epidural infusion

The outer layer of the sheath surrounding the spinal cord is called the dura mater. Between this and the surrounding vertebrae is the epidural space, filled with connective tissue, fat and blood vessels, and crossed by the spinal nerve roots. A catheter may be inserted into this space for three to six months, to deliver anesthetics or analgesics. The line carrying the drug may be threaded under the skin to emerge at the front of the patient, a process called tunneling. This is
recommended with long term use so as to reduce the chance of any infection at the exit site reaching the epidural space.

**Spinal cord stimulation**

Electrical stimulation of the dorsal columns of the spinal cord can produce analgesia. First, the leads are implanted, guided by the patient’s report and fluoroscopy, and the generator is worn externally for several days to assess efficacy. If pain is reduced by more than half, the therapy is deemed to be suitable. A small pocket is cut into the tissue beneath the skin of the upper buttocks, chest wall or abdomen and the leads are threaded under the skin from the stimulation site to the pocket, where they are attached to the snugly-fitting generator. It seems to be more helpful with neuropathic and ischemic pain than nociceptive pain, and is not often used in the treatment of cancer pain.

**Deep brain stimulation**

Ongoing electrical stimulation of structures deep within the brain – the periaqueductal gray and periventricular gray for nociceptive pain, and the internal capsule, ventral posterolateral nucleus and ventral posteromedial nucleus for neuropathic pain – has produced impressive results with some patients but results vary and appropriate patient selection is important.

One study of seventeen patients with intractable cancer pain found that thirteen were virtually painless and only four required opioid analgesics on release from hospital after the intervention. Most ultimately did resort to opioids, usually in the last few weeks of life.

**Hypophysectomy**

Hypophysectomy is the destruction of the pituitary gland, and has been used successfully on metastatic breast and prostate cancer pain.
UNDERTREATMENT OF PAIN

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Classification

When pain is a symptom of a disease, then treatment may focus on addressing the cause of the disease. Because of the hope that treatment which ends the disease would eliminate the pain, sometimes pain management is not recognized as a priority in favor of efforts to address an underlying cause of the pain.

In other cases, the pain itself might need its own treatment plan. Palliative care could be used to address the pain as its own priority. Palliative care might be used either with or alongside any treatment for an underlying condition.

Signs

Some organizations advise that health care providers treat pain whenever it is present. The perspective is that when a person complains of serious pain, then that person is in need of treatment.

Various publications offer guidance on recognizing pain and advising when a person with pain needs additional treatment.

Causes

Reasons for deficiencies in pain management include cultural, societal, religious, and political attitudes. Moreover,
the biomedical model of disease, focused on pathophysiology rather than quality of life, reinforces entrenched attitudes that marginalize pain management as a priority. Other reasons may have to do with inadequate training, personal biases or fear of prescription drug abuse.

**Prevention and screening**

Current strategies for improvement in pain management include framing it as an ethical issue; promoting pain management as a legal right; providing constitutional guarantees and statutory regulations that span negligence law, criminal law, and elder abuse; defining pain management as a fundamental human right; categorizing failure to provide pain management as professional misconduct, and issuing guidelines and standards of practice by professional bodies.

**Epidemiology**

Undertreatment of pain is common, and is experienced by all age groups from neonates to the elderly.

**Global incidence**

In September 2008, the World Health Organization (WHO) estimated that approximately 80 percent of the world population has either no or insufficient access to treatment for moderate to severe pain. Every year tens of millions of people around the world, including around four million cancer patients and 0.8 million HIV/AIDS patients at the end of their lives suffer from such pain without treatment. Yet the medications to treat pain are cheap, safe, effective, generally straightforward to administer, and international law obliges countries to make adequate pain medications available.

**United States**

In the United States, women and Hispanic and African Americans are more likely to be undertreated.
History

In 1961 the Single Convention on Narcotic Drugs established that certain drugs are “indispensable for the relief of pain and suffering” and that states should make them available to people who need them.

In 2009, a World Health Organization report noted that accessing treatment for pain was difficult for many people in many places in the world for a range of reasons.

In 2010 the Commission on Narcotic Drugs adopted a resolution on access to pain treatments. Also in 2010 the United Nations Office on Drugs and Crime published a feature explaining the problem of lack of access to pain treatment and expressing interest in the topic. In 2011 the International Narcotics Control Board published a supplement to its annual report which highlighted the issue as a concern to be addressed.

Society and culture

There is a complicated history of politics which influences practice in the treatment of pain.

Undertreatment may be due to physicians’ fear of being accused of over-prescribing, despite the relative rarity of prosecutions, or physicians’ poor understanding of the health risks attached to opioid prescription. As a result of two recent cases in California though, where physicians who failed to provide adequate pain relief were successfully sued for elder abuse, the North American medical and health care communities appear to be undergoing a shift in perspective. The California Medical Board publicly reprimanded the physician in the second case; the federal Center for Medicare and Medicaid Services has declared a willingness to charge with fraud health care providers who accept payment for providing adequate pain relief while failing to do so; and clinical practice guidelines and standards are evolving into clear, unambiguous statements on acceptable pain
management, so health care providers, in California at least, can no longer avoid culpability by claiming that poor or no pain relief meets community standards.

Special populations

Undertreatment in the elderly can be due to a variety of reasons including the misconception that pain is a normal part of aging, therefore it is unrealistic to expect older adults to be pain free. Other misconceptions surrounding pain and older adults are that older adults have decreased pain sensitivity, especially if they have a cognitive dysfunction such as dementia and that opioids should not be administered to older adults as they are too dangerous. However, with appropriate assessment and careful administration and monitoring older adults can have to same level of pain management as any other population of care.

PSYCHOLOGICAL APPROACHES TO PAIN MANAGEMENT

Psychology and psychological approaches to pain are an important and accepted part of the holistic pain management model. Research has shown that psychological approaches such as cognitive behaviour therapy (CBT), mindfulness and hypnotherapy can be important components in improving pain management and indeed for warding off or being of benefit if anxiety or depression develop.

There are a variety of psychological approaches needed to deal with chronic pain because not all treatments work the same way for everyone, hence the therapist will work with the patient to try alternative approaches to lessening the stress that pain causes on brain function and emotional responses.

Cognitive behaviour therapy

CBT has been researched intensely and shown to be effective in reducing the psychological distress that is associated
with long-term pain. Through the use of learning adaptive coping skills such as: relaxation, distraction, planning and routine, and problem solving, people are able to reduce the pain experience, improve positive social function and generally cope better with chronic pain. All of these techniques are used in order to replace the negative and catastrophic thoughts common to unmanaged chronic pain with more positive and calming thought processes.

MoodGYM, an Australian innovation, is a web based CBT program designed to prevent and manage anxiety and depression. MoodGYM has been shown to reduce depression and anxiety in research studies.

**Mindfulness**

Jon Kabat-Zinn has been the leading figure in bringing mindfulness to the fore in recent decades. His approach to mindfulness involves: deliberately paying attention to everything, using all the senses, to be in the present moment, and to let each experience happen moment by moment without judgement.

The mindfulness technique is about recognising that the person with pain’s mood, thoughts and emotions can play a huge role in an individual’s quality of life. Therefore, this approach is about separating the person’s emotions, thoughts and mood from the pain sensation itself.

The thoughts, emotions and mood associated with the chronic pain experience may seem attached to the pain experience. However, a mindful approach involves noticing when an individual is preoccupied with thoughts about the future or the past, recognising whether these are helpful or not, and developing the ability to free yourself from them.

A growing awareness of mindfulness allows an individual to differentiate between the unpleasant experience that is pain, from thoughts about it, for example “I’m going to become
disabled by it” or the emotions sparked by it, such as fear.

The ‘acceptance’ element of mindfulness is about modifying the unnecessary distress caused in fighting (or ignoring) the fact that something unwanted has happened. It is not about “giving into the pain” but rather it is about finding that an individual doesn’t have to pin an unpleasant value to it – it can just exist or to ‘be there’. It is not surprising that people with pain are often relieved to find that they can gradually let go of their unpleasant reactions to pain and in turn, can learn that the pain itself becomes more tolerable as the mindfulness begins to retrain the brain’s response to pain.

Biofeedback therapy

Antidepressants are often effective in treating anxiety and depression, and neuropathic pain in some people. However, if people with chronic pain can lessen the amount of medication used or boost the drug’s effectiveness by employing psychological techniques as well, then this is likely to benefit long term health as well as pain management.

Biofeedback is the process of gaining a greater understanding of how to notice and control body processes eg tension. This can be gained using an instrument to measure the tension or be taught without mechanical support.

Biofeedback has been found to be effective in the treatment of adult migraines and headaches. Paediatric studies have also found that chronic migraines and episodic headaches can be improved by using biofeedback therapy.

Biofeedback therapy comprises learning and performing relaxation and visualising exercises with the aim of lessening muscle tension and gaining some influence over autonomic nervous system functions such as heart rate and skin temperature. These techniques are then used to stimulate relaxation, lessen muscle tension, prevent worsening of headaches, and reduce the frequency of headaches and pain.
Trials have found that biofeedback has produced similar effectiveness to that of meditation and relaxation in treating anxiety.

Biofeedback is also gaining legitimacy in the rehabilitation for stroke victims after being subjected to scientific scrutiny.

Another quick note is on relaxation. This technique may be recommended for anyone dealing with chronic pain which could lead to ways to control and cope with chronic pain on a daily basis. Some activities linked to relaxation include meditation or yoga or simply just activities that you find relaxing and that reduce your stress levels overall.

PAIN-RELIEF AND COPING TECHNIQUES FOR SEVERE PAIN

Relaxing your body and calming your mind always helps decrease and help you cope with your pain, whether you’re flared-up or in need of ongoing pain management techniques. These range from those that can be done even when the pain is fierce to tools that you can utilise throughout your day and night, offering on-the-spot calm, release from anxiety, and a reduction in pain. It’s crucial to have techniques that you will still be able to enact even if the pain is so high you can scarcely think, let alone attempt anything complicated.

The many different forms of meditation to body-scan relaxation, autogenic training, progressive muscle relaxation, diaphragmatic breathing (and other breathing techniques), self-hypnosis or guided hypnosis, visualisation and creative imagery. There are many different techniques you can learn; experiment with the above list and find something that works for you.

Breathing to Calm the Body and Mind

Deep breathing is the cornerstone of relaxation practices and becomes all the more vital when living with pain. It can
be combined with other relaxing practices including everything from meditation to aromatherapy to listening to your favourite music.

The key in reducing pain through deep breathing is to breathe deeply from the abdomen, maximising the amount of oxygen in your lungs. Taking deep breaths from the abdomen rather than shallow breaths from your upper chest, means you absorb more oxygen. This results in your body being less tense, short of breath, more relaxed and calm, and less anxious.

- If possible, sit with your back straight, or if that is too painful for you, lying down and putting one hand on your chest and the other on your stomach is fine.
- Breathe in through your nose. The hand on your stomach should rise. The hand on your chest should move very little.
- Exhale through your mouth, pushing out as much air as you can while contracting your abdominal muscles. The hand on your stomach should move in as you exhale, but your other hand should move very little.
- Continue to breathe in through your nose and out through your mouth. Try to inhale enough so that your lower abdomen rises and falls. Count slowly as you exhale.

**Visualisation Meditation for Relaxation and Pain Relief**

Visualisation, or guided imagery, is a variation on traditional meditation that requires you to employ not only your visual sense, but also your sense of taste, touch, smell, and sound. When used as a relaxation technique, visualisation involves imagining a scene in which you feel at peace, free to let go of all tension and anxiety, thus reducing your pain, or at least your reaction to it. It’s also a wonderful escape from the tough reality of living with severe chronic pain. Choose whatever setting is most calming to you, whether it’s a tropical
beach, a favourite childhood spot, or a quiet wooded glen. You can do this visualisation exercise on your own in silence, while listening to soothing music, with a therapist or an audio recording guiding you through the imagery. To help you employ your sense of hearing you can use a sound machine or download sounds that match your chosen setting; the sound of ocean waves if you’ve chosen a beach, for example. However, to begin with, guided meditations are perhaps the easiest to learn from, alternatively, try the simple guidelines below:

- Find a quiet, relaxed place. Beginners sometimes fall asleep during a visualisation meditation, so you might try sitting up or standing.
- Close your eyes and let your worries drift away. Imagine your restful place. Picture it as vividly as you can—everything you can see, hear, smell, and feel. Visualisation works best if you incorporate as many sensory details as possible, using at least three of your senses. When visualising, choose imagery that appeals to you; don’t select images because someone else suggests them, or because you think they should be appealing. Let your own images come up and work for you.
- If you are thinking about a beach on a tropical island, for instance:
  - Walk slowly around the beach and notice the colours and textures around you.
  - Spend some time exploring each of your senses.
  - Feel the warm sand between your toes, the sun on your back, the waves tickling your ankles etc.
  - See the sun setting over the water and all the colours of the skies.
  - Hear the birds singing, palms swaying, sea lapping…
  - Smell the flora and fauna.
• Taste the fresh, clean air.
• Enjoy the feeling of deep relaxation that envelopes you as you slowly explore your restful place. When you are ready, gently open your eyes and come back to the present. Don’t worry if you sometimes zone out or lose track of where you are during a guided imagery session, just simply bring yourself back to the moment.

 Become Focused by Visualising Feelings and Colours

Another technique when experiencing excruciating pain is to focus on something that soothes your soul. It could be the feeling of a soft and fuzzy blanket or a place that quiets your spirit, even just play with colours – visualise the colours of a rainbow flowing through you, from red to orange to yellow to green to turquoise to indigo to violet to white to silver to gold. Anything that will keep your mind focused instead of constantly being drawn back to the pain. Think about the feeling, the smell, the taste (if applicable) and the sounds of this colour, object or place. Focus on what it looks like. Use all your senses to “innerly describe” your focus point, while distracting yourself from the pain. Recognise the pain, but don’t give into it. Feel it like you were not in your own body. Put your mind and body in separate places.

 Channelling Your Chi

It may sound like hocus-pocus, but this technique – a combination of that of the kung fu traditions and that of the more modern JudoKai – can really help you when the pain is so severe, you can do little else. All of this is may be familiar if you do, or once enjoyed, martial arts. To begin, meditate. Visualise your body as a translucent 3D figure. You can visualise your energy. Try using thousands of white dots to represent your energy or Chi (Ki). Now visualise a strength. It isn’t contained in your translucent figure but it flows through you. Now take your energy and focus it on the spot of your
pain and force the strength to the same spot. Visualise as well as actually forcing the ki and strength to that spot. Imagine even another force that forms a protective bubble around that spot. Nothing can go through it.

**Chi Kung Breathing**

Similar to the above technique in origin, this technique involves Chi Kung breathing where you breath into your body at the source of the pain, up to you Tan Tien, which is the centre of your energy and about three finger-widths below your navel, then exhale the pain back out. So for example, if your have CRPS in your right foot, you breath into a point on the sole of your foot, up to your Tan Tien and exhale pushing out the pain with your breath and getting the Chi or energy moving in the stagnant area where the CRPS is. You can add colour, deep blue is always soothing to pain patients in colour therapy but go with whatever feels right for you.

**Try to Relax with a Warm Salt Bath**

If you are able to prepare or blessed with someone to help you prepare a warm bath with Himalayan, Epsom or Dead Sea Salts (for their minerals to help soothe your muscles), during a severe flare-up or episode of increased pain, it may be the best thing for you. The water is healing on so many levels.

Ensure that the lighting is low and room as peaceful as possible – it’s about taking time out to cope and heal from this excruciating aspect of chronic pain conditions such as CRPS or a flare of fibromyalgia, though this advice extends to all of you who suffer with severe pain.

If you do not have a bath available, using heat mats can help soothe your pains, depending on what your body responds best to; some people prefer ice but never use ice if you have CRPS/RSD as this damages already weak ligaments and worsens the CRPS.
Use Psychology to Help You Cope

When your pain is increased the most important coping tool is in how you think about the pain. If you start thinking either this flare episode or our condition in general will always be terrible, horrible, debilitating, etc. then you are setting yourself up for an even harder time. Be kind to yourself, speak gently. Learning to handle yourself psychologically is no easy feat with pain but it is possible and you can improve your relationship to your pain condition and symptoms.

When pain is worse than ‘normal’ pain, it is so easy to have negative and unhelpful thoughts, or dwell on unpleasant things but never berate yourself for feeling how you do. You are in pain, you can be forgiven for not being spritely or joyful right now.

Some examples of negative and unhelpful thinking are:

“I cannot stand this pain any longer”

“Why can’t doctors do something for me?”

“What I do I have pain so what’s the point?”

“It’s terrible and I’m never going to get any better”

“Life isn’t worth living like this”

Thoughts can focus on a number of areas: how pain has affected your life, concerns about the future and getting worse, ‘if only’ thoughts, going over the circumstances which brought about the pain problem (for example accidents or injuries), your medical care, a sense of unfairness of having pain and of your life being changed in ways that you do not want.

It is common and natural to have such thoughts when pain is at its worst and most debilitating. Such thoughts can, however, be negative, destructive and self-defeating on your pain experience. Although these types of thoughts are common, they do not have a good effect on you nor do they help you cope with pain. However, if negativity becomes your new normal, it’s time to bring out the big guns.
One beneficial technique is using cognitive behavioural therapy or CBT, see the post on pain psychology for a table of thoughts and more information. It is important that you develop the skill of maintaining a positive attitude and keep your morale high.

Remind yourself repeatedly that you are strong enough to pull through this and that such episodes are mostly short-lived. Most of the patients who suffer from such acute flare-ups of chronic pain also find relief in prayers, mantras and meditation.

**Try Heat, Ice and Repositioning**

Use heat pads or cold compresses over painful areas to help relieve pain by reducing inflammation and relaxing muscle tension but NEVER USE ICE WITH CRPS, it weakens ligaments and worsens the condition. Keep altering your position and gently stretch and rotate your limbs and joints to prevent becoming too stiff and more painful.

**Distract Yourself [and Have a Giggle]**

Although mindfulness has its place, sometimes all you want to do is escape the pain. It’s possible to increase your pain tolerance by finding a way to take your mind off it. Distraction can take any form, though obviously brain fog is high during flare-ups so reading is not always possible. However, watching an amusing film or some comedy stand-up has the benefit of distracting you and making you laugh, which can only help reduce your pain.

Laughter stimulates the brain’s production of endorphins, which decrease the body’s perception of pain. Laughter is relaxing, too. It’s impossible to be tense and laugh. Also, laughter has a carry-over effect. Pain relief continues even after you stop laughing. Focusing your attention on something other than your pain doesn’t take the pain away, but it can make it more bearable.
Look Positively at the Pain [and Get Support]

When your pain increases or you have a pain flare-up, it may be an indication that you exceeded your limitations and pushed yourself too hard so see if there are any positive lessons that can be learned to reduce it happening again. You may feel that the pain is defeating you and there is nothing that you can do to stop it. This will only defeat you if you allow it to isolate you from other people, destroy your relationships with family and friends and make you bitter and angry.

During this period of pain look at what positive lessons you can learn, both about avoid it reoccurring again and about how you need to build up and nurture your friendships, relationships and the things that are important to you, so that you can try to enjoy life in spite of the pain. Having a good support network – online or in person – is vital. Reach out, post something on our Facebook page or Guest Book or Google support groups in your area.

Try Breathing into the Body with the Body-Scan

The body-scan practice, as taught in Jon Kabat-Zinn’s mindfulness-based stress reduction program for people with chronic pain, seems to have a cumulative effect on reducing pain levels and also helps heal the disassociation patients with chronic pain so often have with their painful bodies. This is a slightly adapted version, where you ‘breathe into the body’ reducing the pain by increasing the flow of chi or prana (energy). Follow these simple instructions daily if possible:

• Start in any comfortable relaxation pose such as the yoga asana, shavasana (corpse pose), lying down flat with arms out to the sides, breathing slowly and deeply.
• Place your hands on your belly and feel the movement of the breath.
• Notice the belly rising and falling, and notice the breath moving in and out of your body. In this practice, you
will imagine that you can inhale and exhale through different parts of your body, as if your nostrils were moved to that part of the body.

- Start with your feet. Imagine the breath entering your body through the soles of your feet, and exiting your body through the soles of your feet. Notice any sensations there.

- Feel, or imagine, that flow of energy in the feet as you breathe.

- Now repeat this visualization for other parts of your body: Your lower legs, knees, and upper legs. Your hips, lower back, middle back, and upper back. Your belly and chest. Your shoulders, upper arms, elbows, lower arms, hands. Your neck. Your forehead and the crown of your head. When you get to an area that feels tense, uncomfortable, or painful, don’t skip it.

- There are several things you can try that may make you feel more comfortable.

- First, stay with the visualization and direct the breath right at the sensations of discomfort or pain.

- Imagine that the breath is dissolving or massaging the tension and pain. Imagine the solidity of the tension or pain softening. Find the space inside the pain.

- Second, try moving your attention back and forth between the uncomfortable area and a more comfortable area. For a few breaths, breathe into the painful area; for the next few breaths, breathe into another area. Switching back and forth like this can teach the mind how to give the uncomfortable sensations less priority.

- You are practicing a healthy kind of distraction: intentionally shifting your focus while still being present in your body.

- When you have worked your way through the whole body, let yourself feel the breath enter the body through
your nose, mouth, and throat. Imagine the sensation of breathing through your whole body, as if the body were gently expanding as you inhale and contracting as you exhale. Feel, or imagine, the flow of energy through your whole body.

Read more about the body scan here: "Using the Body Scan to Help with Chronic Pain and Illness" By Toni Bernhard.

**Mindfulness to Reduce Chronic Pain**

A curious thing happens when you practice it as seems to help you not only focus on the present moment but accept it, to notice your body and your surroundings in a way that is non-judgmental and non-reactive. Mindfulness appears to assist in the process of living with pain without responding to it in a way that may make you feel more distressed, more worried, and more hopeless.

Mindfulness meditation has been successfully used in pain clinics to reduce stress as well as chronic pain and is worth trying on account of the sheer amount of people it has helped. One reason mindfulness is thought to help people with chronic pain is that it keeps you in the present moment, instead of having anticipatory pain. You no longer agonise about the past – and what has been lost – because you’re living in the present.

Perhaps more importantly, mindfulness helps you cope with the emotions that spring up in association with having chronic pain, such as anger, resentment and sadness. This is important as while pain may be permanent for some of us, the additional suffering of reacting to our suffering is optional. Obviously we’re human, and have wobbles from time to time, and it’s natural to be sad that you’re not only missing out on life but in constant pain too but mindfulness is a key to a more fulfilling life.

Using simplicity itself, mindful breathing, and having a non-judgmental awareness softens your world, in turn
allowing your spirit a little release of the drudgery and challenges. Taking a step back to simply be is powerful medicine indeed.

With practice, you may be better able to live beside your pain, noticing it, but living your life anyway. It also seems to help people to feel more relaxed; less tension helps to reduce pain. Another useful technique is the body scan, which is a mindfulness technique.

ACUTE PAIN MANAGEMENT TECHNIQUES

No one wants to experience pain, especially chronic pain. We understand that. Pain doesn’t have to get in the way of your daily life. Once you know how to treat acute pain before it becomes chronic, you’ll enjoy less painful days.

But how do you treat pain before it becomes chronic? That’s what we are here to talk to you about. In this chapter, National Pain Institute will talk about acute pain and chronic pain, how acute pain becomes chronic pain, and best of all, 7 ideas to treat acute pain before it turns into a chronic circumstance.

Here at National Pain Institute in Florida, our specialists believe in a multidisciplinary approach, including pain management, neurosurgery, and integrated therapy. We help our patients understand that pain management doesn’t solely involve narcotics and surgery. No, we have better ways to treat pain. Our model helps patients to prevent and minimize pain before it becomes chronic. Moreover, we help our patients to adapt to a healthier lifestyle to minimize the need for addictive pain medications or intensive surgery.

What is acute pain? What is chronic pain?

Acute Pain

Acute pain is pain that lasts less than 3-6 months. Or it can be pain that is directly related to tissue damage—in this
instance, pain is a symptom of an injury or diseased tissue. Have you ever had a paper cut? Have you ever touched a stove that was really hot? Those are examples of acute pain.

Other examples of events that can cause acute pain include:
- burns
- cuts
- labor pains
- childbirth
- dental work
- broken bones
- surgery

There are many ways to describe pain. When at the doctor’s office, he or she will most likely ask you to describe your pain as best as possible. The following adjectives are commonly used to describe acute pain:
- throbbing
- stabbing
- aching
- burning
- tingly
- hot
- sharp
- stinging
- cramping
- dull
- numb

Not all types of acute pain will turn into chronic pain. Acute pain typically disappears when the underlying cause of the pain has been successfully treated, or when it has healed. However, it is very important to treat acute pain before it becomes chronic.
Chronic Pain

So what is chronic pain? Chronic pain is pain that lasts longer than 6 months. There are two types of chronic pain problems—pain due to an identifiable generator (i.e. an injury); or pain without an identifiable generator (i.e. pain that occurs after the injury has healed).

Physical and emotional effects due to chronic pain include:

- limited mobility
- lack of energy
- changes in appetite and diet
- tense muscles
- headaches
- cancer pain
- arthritis pain
- lower back pain
- neurogenic pain (pain caused by damaged nerves)
psychogenic pain (pain that is not due to past injury, damage, or disease)
• anxiety
• anger
• fear of re-injury
• depression

Chronic pain can disrupt one’s daily life. When someone experiences chronic pain, it is very difficult to enjoy simple activities, let alone staying healthy through routine exercise.

Unfortunately, there is no medical test to measure the level of chronic pain that someone is experiencing. As you may have noticed in your experiences when you’re at the doctor’s office, he or she will tell you to choose one of the following levels of pain: no pain, mild pain, moderate pain, or severe pain. You may have also been asked to choose which facial expression (drawn with a paper and pen) best indicates your pain.

Pain is a subjective matter. It is very unfortunate that some doctors tell patients that chronic pain is “all in your head,” or that “it can’t be that bad.” Our pain management specialists understand chronic pain, so we’d never say that to our patients.

7 ideas to treat acute pain before it becomes chronic

Treatments for chronic and acute pain will differ depending on the underlying cause(s) of the pain. Furthermore, certain pain treatments will work for some people, but not for others. It is very important to be aware of the level of pain you are feeling and discuss this with your doctor. You may need to try different pain management techniques before finding one (or more) that work the best for you.

Here are some ways, including complementary and homeopathic techniques, to treat acute pain so it doesn’t become chronic:
1. nerve blockers: Local anesthetics can be used to block the group of nerves associated with pain.

2. non-prescription, non-habit forming drug treatments: Some examples include Aleve, Tylenol, or Motrin.

3. physical therapy: Some examples of passive physical therapy include hot packs, cold packs, TENS units, and ultrasound. Some examples of active physical therapy include stretching, pain relief exercises, strengthening exercises, and low impact aerobic conditioning.

4. psychological counseling: Some examples include talk therapy, relaxation training, stress management, and pain coping skills training.

5. behavior modification techniques: One example of this is cognitive behavioral therapy.

6. transcutaneous electrical nerve stimulation (TENS): Developed in the late 1960s, this technique uses electricity to help alleviate pain. The low electrical impulses block certain pain receptors so that the brain does not receive the messages that you are in pain. A session is typically 15 minutes, but may require multiple sessions for successful pain relief.

7. alternative pain management treatments: Some examples may include relaxation, acupuncture, hypnosis, and biofeedback.

It may be necessary to try a few different pain management techniques to determine which is the best for you. Treating acute pain is the goal.

It is not recommend to “tough it out.” Take care of acute pain right away because it can become chronic later down the road. Take pain seriously. Don’t just shrug it off and expect it to go away by itself. Take action.

When does acute pain become chronic pain?

It is not absolutely clear why some people develop chronic
pain but others do not. One patient may develop chronic pain, but another patient who has a similar condition will not develop chronic pain. The reasons are still unclear.

As acute pain advances into the chronic phase, the influence of other factors (in addition to tissue damage and injury) come into play. In such cases, the influences must be discussed and studied by your doctor in order to develop an effective pain management plan.

Ways to treat pain if it becomes chronic

If acute pain becomes chronic, your doctor will need to overcome some unique challenges.

It is very important to communicate your pain and symptoms with your doctor. National Pain Institute treats chronic pain by using a multidisciplinary approach.

Your treatment plan can include any of the following techniques:

• physical therapy
• chiropractic care
• pain medications (non-addictive)
• injections
• surgery as a last resort
In order to be truly successful, chronic pain treatment should address the whole person. This includes the treatment of mental health issues, when applicable, such as depression.

The specialists at National Pain Institute in Florida are dedicated to provide a multidisciplinary approach to relieve chronic, acute, and intractable pain. We are trained to determine the underlying root cause of pain and to treat it successfully.

What should you do now?

If you are suffering from acute pain or chronic pain, we can help. The first step is contacting one of our pain clinics located nearest to you. We have several locations in Florida (Deerfield Beach, Delray Beach, Ft. Pierce, Lake Mary, New Port Richey, Port St. Lucie, Turkey Lake, Lady Lake, and Winter Park).

Our pain management specialists will speak with you about your condition and symptoms to determine the best treatment options for you. So whether you are experiencing acute, chronic, or intractable pain, give us a call today to take advantage of our conservative pain care techniques.

CHRONIC PAIN CONTROL TECHNIQUES

To prepare for any chronic pain coping technique, it is important to learn how to use focus and deep breathing to relax the body. Learning to relax takes practice, especially when you are in pain, but it is definitely worth it to be able to release muscle tension throughout the body and start to remove attention from the pain.

Coping techniques for chronic pain begin with controlled deep breathing, as follows:

- Try putting yourself in a relaxed, reclining position in a dark room. Either shut your eyes or focus on a point.
- Then begin to slow down your breathing. Breathe deeply, using your chest. If you find your mind
wandering or you are distracted, then think of a word, such as the word “Relax,” and think it in time with your breathing...the syllable “re” as you breathe in and “lax” as you breathe out.

- Continue with about 2 to 3 minutes of controlled breathing.
- Once you feel yourself slowing down, you can begin to use imagery techniques.

Eleven specific imagery and chronic pain control techniques that are effective for pain control include:

1. Altered focus: This is a favorite technique for demonstrating how powerfully the mind can alter sensations in the body. Focus your attention on any specific non-painful part of the body (hand, foot, etc.) and alter sensation in that part of the body. For example, imagine your hand warming up. This will take the mind away from focusing on the source of your pain, such as your back pain.

2. Dissociation: As the name implies, this chronic pain technique involves mentally separating the painful body part from the rest of the body, or imagining the body and mind as separate, with the chronic pain distant from one’s mind. For example, imagine your painful lower back sitting on a chair across the room and tell it to stay sitting there, far away from your mind.

3. Sensory splitting: This technique involves dividing the sensation (pain, burning, pins and needles) into separate parts. For example, if the leg pain or back pain feels hot to you, focus just on the sensation of the heat and not on the hurting.

4. Mental anesthesia: This involves imagining an injection of numbing anesthetic (like Novocain) into the painful area, such as imagining a numbing solution being injected into your low back. Similarly, you may then
wish to imagine a soothing and cooling ice pack being placed onto the area of pain.

5. Mental analgesia: Building on the mental anesthesia concept, this technique involves imagining an injection of a strong pain killer, such as morphine, into the painful area. Alternatively, you can imagine your brain producing massive amount of endorphins, the natural pain relieving substance of the body, and having them flow to the painful parts of your body.

6. Transfer: Use your mind to produce altered sensations, such as heat, cold, anesthetic, in a non-painful hand, and then place the hand on the painful area. Envision transferring this pleasant, altered sensation into the painful area.

7. Age progression/regression: Use your mind’s eye to project yourself forward or backward in time to when you are pain-free or experiencing much less pain. Then instruct yourself to act “as if” this image were true.

8. Symbolic imagery: Envision a symbol that represents your chronic pain, such as a loud, irritating noise or a painfully bright light bulb. Gradually reduce the irritating qualities of this symbol, for example dim the light or reduce the volume of the noise, thereby reducing the pain.

9. Positive imagery: Focus your attention on a pleasant place that you could imagine going - the beach, mountains, etc. - where you feel carefree, safe and relaxed.

10. Counting: Silent counting is a good way to deal with painful episodes. You might count breaths, count holes in an acoustic ceiling, count floor tiles, or simply conjure up mental images and count them.

11. Pain movement: Move chronic back pain from one area of your body to another, where the pain is easier to
cope with. For example, mentally move your chronic back pain slowly into your hand, or even out of your hand into the air.

Some of these techniques are probably best learned with the help of a professional, and it usually takes practice for these techniques to become effective in helping alleviate chronic pain. It is often advisable to work on pain coping strategies for about 30 minutes 3 times a week. With practice, you will find that the relaxation and chronic pain control become stronger and last longer after you are done.

Sometimes, after you are good at using the techniques, you can produce chronic pain relief and relaxation with just a few deep breaths. You can then start to use these techniques while you are engaged in any activity, working, talking, etc. With enough experience you will begin to feel a greater sense of control over the chronic pain and its effects on your life.

CHRONIC PAIN COPING TECHNIQUES - PAIN MANAGEMENT

Clinicians who specialize in treating chronic pain now recognize that it is not merely a sensation, like vision or touch, but rather chronic pain is strongly influenced by the ways in which the brain processes the pain signals.

Chronic pain can provoke emotional reactions, such as fear or even terror, depending on what we believe about the pain signals. In other cases (such as in sports or another engaging, rewarding activity), chronic pain may be perceived by the individual as merely a nuisance, a feeling to be overcome in order to be able to continue in the activity.

The important role the mind plays in chronic pain is clearly recognized in the medical literature, as well as in the International Association for the Study of Pain’s definition of pain, which states that pain is always subjective and is defined by the person who experiences it.
The corollary is that the brain can also learn how to manage the sensation of pain. Using the mind to control chronic pain, or coping strategies, for managing persistent pain, may be used alone or in tandem with other pain management therapies.

Ideally, use of the chronic pain management techniques outlined in this chapter can help patients feel less dependent on pain killers and feel more empowered to be able to control their pain.

Managing Chronic Pain

Of course, the first step in coping with chronic back pain or other types of persistent pain is to receive a thorough medical evaluation to determine the cause of the pain.

- In some situations, such as a herniated disc in the spine, it may be important to pay attention to the level and type of pain so that it can serve as a warning signal of impending damage.

- In other cases, especially when the back pain is chronic and the health condition unchangeable, one goal can be to try and keep the chronic pain from being the entire focus of one’s life.

Whatever the medical condition, there are a number of effective strategies for coping with chronic back pain. These techniques generally include:

- Relaxation training: Relaxation involves concentration and slow, deep breathing to release tension from muscles and relieve pain. Learning to relax takes practice, but relaxation training can focus attention away from pain and release tension from all muscles. Relaxation tapes are widely available to help you learn these skills.

- Biofeedback: Biofeedback is taught by a professional who uses special machines to help you learn to control bodily functions, such as heart rate and muscle tension.
As you learn to release muscle tension, the machine immediately indicates success. Biofeedback can be used to reinforce relaxation training. Once the technique is mastered, it can be practiced without the use of the machine.

- **Visual imagery and distraction**: Imagery involves concentrating on mental pictures of pleasant scenes or events or mentally repeating positive words or phrases to reduce pain. Tapes are also available to help you learn visual imagery skills.

  *Distraction techniques* focus your attention away from negative or painful images to positive mental thoughts. This may include activities as simple as watching television or a favorite movie, reading a book or listening to a book on tape, listening to music, or talking to a friend.

- **Hypnosis**: Hypnosis can be used in two ways to reduce your perception of pain. Some people are hypnotized by a therapist and given a post-hypnotic suggestion that reduces the pain they feel. Others are taught self-hypnosis and can hypnotize themselves when pain interrupts their ability to function. Self-hypnosis is a form of relaxation training.

**RELAXATION TECHNIQUES**

Relaxation calms the mind and recharges the body. It is particularly important for people who live with pain. Pain increases muscle tension which in turn, creates more pain. When muscles are tense, they tighten and increase pressure on our nerves and other tissues and our pain sites, which can make the pain worse. Relaxation can help break the pain-tension cycle.

There are many forms of relaxation techniques so find one that works best for you.

Ideally, begin with deep breathing. Shallow, rapid
breathing results from tension. Deep breathing helps relax you. Learning deep breathing reduces muscle tension thereby lessening pain. To begin, find a quiet warm place, where you won’t be disturbed. Once this technique is learnt it can follow you into any situation you are in.

Deep breathing
1. Make yourself comfortable
2. Loosen any tight clothing
3. Begin by listening to your breathing without changing its natural pattern
4. Breathe through your nose (or mouth if your nose is blocked)
5. Put your hands over your stomach area and feel your hands rise and fall.
6. Imagine you are breathing into your hands. Relax your stomach muscles. Take deep, slow breaths. Remember to breathe at your own pace
7. As you breathe out, imagine your tensions are being breathed away. Every time you breathe in, imagine you are breathing in peace

Progressive Muscle Relaxation

Tense and relax each muscle in turn unless it hurts, in which case, leave that one out.
1. Sit or lie down quietly in a comfortable position
2. Close your eyes and take slow, deep breaths. Breathe easily and naturally
3. Slowly tense each muscle in your body. Begin with your right hand. Squeeze your right hand into a tight fist. Feel the tension in your right hand. Hold this position for a few seconds. Now release the tension slowly. As the tension disappears, your hand feels relaxed.
4. Repeat this for your left hand.
5. Arms – tense both arms. Make your arms rigid and tense. Hold and release
7. Toes – curl your toes up. Hold and release.
8. Feet – pull your toes up towards your face. Feel the muscles working in your shins. Hold and release. Then point your toes away from your face. Feel the muscles tensing in your calves. Hold and release.
10. Eyebrows – raise your eyebrows as high as they can go. Hold and release.
12. Eyes – screw up your eyes tightly. Hold and release
Now your muscles are relaxed. You feel calm and still.

Relaxation Imagery

Using imagery with relaxation helps to distract your mind from stressful thoughts
1. Make yourself comfortable i.e. lie down on your back, turn on your side or sit up straight, balanced on your chair with feet at shoulder width.
2. Close your eyes and concentrate on your breathing. Take deep, slow, full breaths
3. Think of your own special place - your favourite place in the whole world. A place you can go to escape everything. It can be a real place, or a made up spot.
4. Imagine yourself lying comfortably in your own special spot. You feel completely at home there
5. Become aware of your senses. Look around you. What colours do you see?
6. What sounds do you hear? What smells are in the air? Feel the ground beneath you. What textures can you feel? Imagine the temperature is nice and warm. You are feeling content.

7. Look around you. Gently focus on something that catches your eye. Spend a few moments thinking about your special spot.

8. When you are ready, end your visualization and gently bring your attention back to the room and your breathing.

Muscle tension is related to the stress response. By creating and releasing muscle tension, you will feel calmer and more relaxed. It raises the threshold of tolerance to pain and is an effective way of coping with the stress and anxiety associated with chronic pain.

PAIN MANAGEMENT TECHNIQUES TO HELP CONQUER BACK AND NECK PAIN

Types of Pain - Treatments and Therapies

Back and neck pain is one of the leading causes of lost work time, second only to the common cold. It affects 65-85% of the population of the United States at some point in their lives. The most common cause is sprain, strain, or spasm usually brought on by poor lifting techniques, improper posture, or an unhealthy ergonomic environment. Another common cause is disc problems brought on by injury, wear and tear, or age. Other causes include spinal stenosis (spinal sten-oh-sis), osteoarthritis (os-t-o-ar-th-rye-tis), osteoporosis (os-t-o-pour-o-sis), and other conditions.

Pain management often takes a multidisciplinary approach to minimize or eliminate pain. The goals include increasing physical activity, eliminating unsafe medication use, and learning lifestyle behaviors that work toward wellness. The purpose of this chapter is to help you to understand pain
management. Included is an explanation of the different types of pain and treatments pain management specialists use to fight pain.

Also, you may take a Chronic Pain Treatments Quiz to test your knowledge and learn about the most effective ways to treat chronic back and neck pain.

Types of Back and Neck Pain

Acute Pain (ah-cute pain) can be defined as severe short-term pain. Post-operative pain is an example. Acute pain is self-limiting, which means the pain acts to warn you to cease or limit activity that could cause additional tissue damage. The more intense and prolonged an acute pain episode is, the more likely it will lead to chronic pain. This makes sense given the information that we are beginning to learn about how the central nervous system changes in response to intense pain. As a result of intense pain, neurons in the spinal cord that help to prevent pain transmissions actually die. At the same time, pain-transmitting neurons grow more connections to other nerves, become more sensitive, and react more strongly to painful stimulus.

The study of neuroplasticity (nu-row-plaz-te-city), or how the nervous system changes and molds itself, is one of the hottest new areas in neuroscience. It seems to be the basis for the processes of learning and memory. It appears however, that the nervous system not only learns useful information but also ‘learns’ or remembers pain leading to the development of chronic pain.

Chronic Pain. Rather than being the symptom of a disease process, chronic pain is itself a disease process. Chronic pain is unrelenting and not self-limiting. It can persist for years and even decades after the initial injury. There are many factors that affect the development of chronic pain such as age, level of disability, depression, or the presence of nerve damage.
Neuropathic Pain (nu-row-path-eck pain) is usually described by patients as burning, electric, tingling, and shooting in nature. Often this type of pain cannot be controlled using traditional pain killing oral drugs. Management of neuropathic pain may include other medications (that are often not thought of as pain medicines) and multiple treatment modalities such as physical therapy, physical rehabilitation, relaxation training, trigger point injections, epidural steroid injections, sympathetic blocks, spinal cord stimulators, intrathecal morphine pump systems, and various surgical techniques.

Nociceptive Pain (no-si-sep-tive pain) is localized pain, which is usually described by patients as sharp, aching, or throbbing. Post-operative pain, pain associated with trauma, and arthritic pain are examples of nociceptive pain. Nociceptive pain usually responds to non-steroidal anti-inflammatory drugs (NSAIDs) and opioids (oh-pe-oids, strong prescription pain killers).

**Pain Management Treatments and Therapies**

Anti-Depressant Medications. There is considerable evidence that tricyclic anti-depressants are effective for the treatment of a variety of pain conditions such as migraine headache and neuropathic pain.

Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) are valuable analgesics (pain relieving medications). These drugs do not alter the patient’s cognitive functions, cause respiratory depression, or nausea. However, NSAIDs are associated with significant side effects especially with long-term use.

Epidural Steroid Injections (ESI). The traditional epidural (ep-e-do-ral) steroid injection technique involves the physician feeling the patient’s spine in order to guide the placement of the needle between the spinal vertebrae. A newer technique involves using x-ray fluoroscopy to guide the needle directly into the neural foramen; the point where the affected nerve root exits the spinal canal.
Injections of steroids into the lumbar epidural space are particularly useful to alleviate pain that radiates from the lower back into a leg. This pain may be caused by disc herniation or spinal stenosis, which triggers nerve root irritation, inflammation, and pain. Similarly, ESIs are used to treat neck pain that extends into the arms.

Facet Joint Injections involve the injection of steroid medication into the affected spinal facet joint (fah-set joint) to reduce inflammation and pain. Injections into these joints or blocks of the nerves that feed the facet joints can often be very helpful to relieve pain. This problem is more common in the lumbar spine, but does occur in the cervical spine too.

Trigger Point Injections are muscle blocks. Muscles chronically tense or in spasm become tender and painful. The pain triggers more spasm that can develop into a vicious cycle. Injections into the muscle can help to break the cycle.

Nerve Blocks are injections of medication onto or near nerves. The medications that are injected include local anesthetics, steroids, and opioids. Blocks are used to control acute pain (e.g. shot at the dentist or an epidural block for the surgical delivery of a baby). X-ray fluoroscopic guidance is sometimes used for accurate needle placement. Blocks can provide periods of dramatic pain relief, which promotes the desensitization of sensory pathways. Steroids can help reduce nerve and joint inflammation, and the abnormal triggering of signals from injured nerves. Further, blocks are used to provide diagnostic information such as helping to determine the pain source.

Peripheral Nerve Blocks affect the peripheral nerves; nerves beyond the brain and spinal cord. These nerves transmit sensation and motor (movement) signals.

Sympathetic Nerve Blocks. Chronic pain conditions often involve sympathetic nerve malfunctions. These nerves regulate blood flow, sweating, and glandular function. For example,
blocks administered in different areas of the spine help to reduce pain that involves the face, arm, hands, legs, and feet.

Physical Therapy (PT) addresses body mechanics (posture), building strength and flexibility through exercise, injury prevention, and utilizes many modalities. Modalities include electrical stimulation, heat and ice therapy, hydrotherapy, ultrasound, and massage.

Biofeedback is used to treat many types of conditions including chronic pain, migraine headache, spinal cord injury, and movement disorders. It is a type of relaxation training and behavior modification. Biofeedback works to control physiological reactions such as muscle tension, body temperature, heart rate, brain wave activity, and other life responses. The therapy requires the patient’s intense participation to learn how to control these functions. Biofeedback does not work for all patients. Electrical sensors, attached to monitoring equipment, are applied to special points on the patient’s body. The monitoring equipment feeds back the patient’s progress. The biofeedback therapist teaches the patient mental and physical exercises, visualization, and deep breathing to treat their specific disorder (e.g. low back muscle spasms).
Twelve anesthesiologists/intensivists provide Critical Care Anesthesia services at three main intensive care units at Brigham and Women’s Hospital: the general ICU, thoracic ICU and surgical ICU. These units are codirected by the Department of Anesthesiology, Perioperative and Pain Medicine and the Department of Surgery.

In this multidisciplinary model, anesthesiologists/intensivists are joined by burn/trauma surgeons, thoracic surgeons and pulmonary medicine physicians who participate in the staff coverage of these ICUs. This provides our staff and trainees an unusually broad perspective on the care of critically ill surgical patients.

To serve these ICUs, fully trained intensivists are in house and available at all times, with a 24/7/365 physician presence. They are accustomed to caring for the most challenging patients.

**Focus on Research**

The Brigham and Women’s Hospital Surgical ICU Translational Research (STAR) Center is a collaborative research
center focusing on translational, clinical and outcomes research in the surgical ICU. The main focus of the STAR Center is to build lasting, collaborative projects based on key issues in critical care.

The STAR Center mirrors the multidisciplinary clinical paradigm of the SICU, and facilitates clinical research projects from providers from the departments of surgery, anesthesia, emergency medicine, and medicine.

The Center is an international leader in critical care research, personalized critical care medicine, and complement the clinical practice of the ICUs through innovation and collaboration.

**Fellowship Program**

The mission of the Critical Care Medicine Fellowship program is to provide advanced, evidence-based care to critically ill patients, to advance knowledge through biomedical research, and to educate future practitioners, researchers, and leaders in critical care.

**OBSTETRIC ANESTHESIASKIP NAVIGATION**

The Obstetric Anesthesia Service at Brigham and Women’s Hospital is one of the foremost programs of its kind in the world. Our labor unit is the largest in New England and the third largest in the nation, with more than 9,000 births annually.

As a tertiary referral center, more than 25 percent of deliveries are high risk, including patients with preeclampsia as well as cardiac, pulmonary, and neurologic disease. More than 75 percent of patients receive anesthetic care.

**Supporting Pain-Free Childbirth**

The Division of Obstetric Anesthesia supports any decisions made by a patient regarding pain relief during labor and provides the information needed to answer any questions. The goal is to make the labor and delivery experience a safe and pleasant experience.
Led by William Camann, MD, a renowned leader in obstetric anesthesia, the Service has produced hundreds of research articles and features ongoing laboratory and clinical research efforts in every aspect of the discipline. Faculty serve in leadership roles in international societies and editorial boards, and have been honored with national research and teaching awards.

OUT-OF-OR ANESTHESIA

Out-of-OR Anesthesia – the most rapidly growing area within our Department – provides services to angiography, the cath lab, CT, MRI, endoscopy, the family planning clinic, and various others. Our staff specializes in providing anesthesia and sedation services for less-invasive procedures.

With today’s advances in short-acting anesthetics and patient monitoring, our anesthesiologists provide safe and effective care to coincide with an enormous increase in the use of outpatient facilities and procedures. Administering anesthesia in this setting requires expertise in patient assessment, choice of appropriate anesthetic agents, sophisticated monitoring and appropriate recovery protocols.

REGIONAL ANESTHESIA

Born of a tradition boasting world-class expertise in orthopedics and rheumatology, Brigham and Women’s Hospital is a world leader in the field of regional anesthesia.

The regional anesthesia program was developed in response to the challenges of caring for a huge number of orthopedic patients with extremely complex medical conditions. The Regional Anesthesia Service has flourished under the leadership of pioneers in the field who developed regional anesthetic techniques and agents.

The strong tradition of excellence in regional anesthesia has led to widespread use of these techniques by all services.
It has also encouraged development of innovative applications of regional anesthesia, such as thoracic epidural anesthesia for breast surgery and spinal anesthesia for back surgery.

**Variety of Options**

Our Department offers a variety of regional anesthesia options for appropriate cases. The most common regional techniques are spinal and epidural anesthetic (neuraxial blocks):

- Spinal anesthesia is often the choice for urologic and gynecologic procedures
- Epidural anesthesia is routinely used in obstetrics to alleviate labor pain. They may also be placed for postoperative pain relief, reducing the risk of pneumonia and respiratory complications.

We also offer peripheral nerve blocks for many inpatient and outpatient procedures. An injection along a nerve in order to numb a surgical site can avoid the need for general anesthesia. In addition, because most blocks last up to 24 hours after placement, they can provide pain relief after surgery as well.

**CRITICAL CARE ANESTHESIOLOGY FELLOWSHIP**

Vanderbilt’s Anesthesiology Critical Care Medicine fellowship is an ACGME-accredited one-year program which provides an unparalleled innovative and in-depth critical care training opportunity in one of the country’s best medical centers. The fellowship is designed to meet the individual needs of each fellow in preparation for board certification and evidence based critical care practice. Vanderbilt University Hospital (VUH) is the tertiary referral and Level I trauma center for Middle Tennessee and parts of four surrounding states. The facility is designed for advanced remote patient monitoring to improve the timeliness and efficiency of patient care. Currently, the critical care units at VUH include a 23-bed Surgical Intensive Care Unit (SICU), a 26-bed Cardiovascular Intensive Care Unit (CVICU), a 24-bed Neuro-Care ICU (NCU),
and a 10-bed, expandable Regional Burn Center ICU. Our faculty and fellows also staff the 13-bed Nashville VA SICU. The NCU, CVICU and Burn ICU are staffed exclusively by CCA faculty, while the SICU has both anesthesia and surgical attending staffing.

**CORE ROTATIONS**

Core rotations are in the Burn ICU, CV ICU, Neuro ICU, Trauma, SICU, VA-ICU, and ECHO/Ultrasound rotation with additional elective months. The fellowship program offers a diverse array of electives such as Trauma, MICU, PICU or a medical subspecialty (e.g., nephrology, ID or cardiology). Other popular rotations include ICU nutrition, TEE, and the Medical Examiner’s Office. Fellows who have research interests are strongly encouraged to use elective time to develop and pursue clinical or basic science investigations and are expected to present their work at national conferences.

Additionally, the Vanderbilt International Anesthesiology (VIA) program provides anesthetic and medical services to poorly-served countries in Africa. CCA fellows may take one elective month to participate in VIA. This program presents a singular opportunity for trainees to experience the challenges and rewards of practicing medicine in the developing world.

CCA fellows also organize teaching/work rounds, formulate care plans, and facilitate communication between the ICU team and surgical services, consultative services, and family members. Fellows also serve as instructors for Fundamentals of Critical Care Support (FCCS), Advanced Trauma Life Support (ATLS), and organize a monthly journal club. Additionally, they co-direct and teach portions of the Division of Critical Care Medicine’s nationally-recognized Critical Care Skills Week which exposes junior medical students to topics in anesthesiology and critical care and includes much simulation-based content.
The teaching curriculum includes weekly learning modules consisting of a didactic session and customized, web-based learning activities. In addition, fellows participate in monthly simulation training at Vanderbilt’s cutting-edge Center for Experiential Learning and Assessment (CELA). Fellow simulation sessions are designed to be integrated with the monthly curriculum. The sessions are unique in that they do not only focus on a single event or crisis, but also simulate the progression of a disease process, such as sepsis or stroke.

We participate in the San Francisco Match and require the following when applying to the program: SOCCA Application, Curriculum Vitae, 3 Letters of Support (Program Director, ICU Attending, and your choice), In-service Training Exam Scores, USMLE Scores, Med School Transcript/Dean’s Letter (can be copies), and Current Photo and send electronically to the fellowship coordinator.

CRITICAL CARE MEDICINE

Anesthesiology Critical Care Medicine service takes primary responsibility for the Surgical Intensive Care unit at the Veterans Administration Medical Center and for the Cardiac Surgery Intensive Care Unit at Jackson Memorial Hospital. In addition our attendings share the staffing needs of the Trauma Intensive Care Unit for Ryder Trauma Center of Jackson Memorial Hospital. Our patient populations are diverse with an array of co-morbidities.

Our staff provides not only excellent patient care and relevant clinical research but personalized teaching in a supportive environment to medical students, advanced registered practitioner students, residents and fellows. We maintain a fully accredited fellowship in Critical Care Medicine for those interested in extensive training in that area.

Our goal is to provide the most effective and immediate care possible to patients who become critically ill. We endeavor to care not only for the patient but the family.
Bibliography

Peter Staats; Mark Wallace: Pain Medicine and Management: Just the Facts. Mcgraw Hill. 2015.
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Pediatric Anesthesia and Critical Care in Hospital
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Preface

The pediatric anesthesiology discipline includes the evaluation, preparation and management of pediatric patients undergoing diagnostic and therapeutic procedures in operative and critical care settings. In addition, this discipline also entails the evaluation and treatment of children with acute and chronic painful disorders.

Anesthesia is unique, in that it is not a direct means of treatment, rather it allows others to do things that may treat, diagnose, or cure an ailment which would otherwise be painful or complicated. The best anesthetic, therefore is the one with the lowest risk to the patient that still achieves the endpoints required to complete the procedure. The first stage of an anesthetic is the pre-operative risk assessment made up of the medical history, physical examination and lab tests. Diagnosing a person's pre-operative physical status allows the clinician to minimize anesthetic risks. A well completed medical history will arrive at the correct diagnosis 56% of the time which increases to 73% with a physical examination. Lab tests help in diagnosis but only in 3% of cases, underscoring the need for a full history and physical examination prior to anesthetics. Incorrect pre-operative assessments or preparations are the root cause of 11% of all adverse anesthetic events.

The number of day-care surgeries is increasing every day. The boundaries of day-care surgeries are being redefined on a continual basis. Multi-dimensional benefits to the patient, hospital and national economy are the driving forces behind the changing scenario on the horizon of day surgery.

An attempt is also made to look at suitable surgical procedures, a pathway of introducing procedures, which are still complex and specialist procedures in challenging environment. The techniques of general anaesthesia, central neuraxial blocks, regional nerve
blocks with indwelling catheters and monitoring techniques are deliberated upon. Finally the most important post-operative issues of discharge criteria, including recovery after spinal anaesthetic, oral fluid intake, voiding and travel after day surgery, are considered.

The role of endogenous cellular immunity in the defence against cancer metastasis and recurrence is well established. Both animal and human studies suggest that NK cell activity may play a critical role in determining disease-free survival after oncologic surgery. Other components of our immune system also contribute to host protection. The possible interaction between anaesthetic technique, cellular immunity and cancer recurrence has been studied over the years. Some, but not all, evidence suggest that anaesthetic technique may impact cancer recurrence rates. However, more prospective randomised controlled clinical trials are necessary to statistically demonstrate a causal relationship.

There are several ongoing clinical trials by Outcomes Research Consortium in Cleveland, Ohio comparing an ‘anti-cancer’ anaesthetic technique utilising a propofol-based anaesthetic with regional anaesthesia on primary cancer patients versus standard GA with opioid analgesia; these investigations will require several more years until completion. While we anxiously await the results, we may have to consider the conflicting evidence presented before us and adjust our current clinical practice in those oncologic patients where there are sufficient data to support an ‘anti-cancer’ anaesthetic. 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

The pediatric anesthesiology discipline includes the evaluation, preparation and management of pediatric patients undergoing diagnostic and therapeutic procedures in operative and critical care settings. In addition, this discipline also entails the evaluation and treatment of children with acute and chronic painful disorders. In the practice of medicine (especially surgery) and dentistry, anesthesia or anaesthesia is a temporary induced state with one or more of analgesia (relief from or prevention of pain), paralysis (muscle relaxation), amnesia (loss of memory), and unconsciousness. A patient under the effects of anesthetic drugs is referred to as being anesthetized. More surgery on children is being carried out on a day-case basis and we review the anaesthetic management. Selection of appropriate patients and procedures is vital and careful preparation of children and families minimizes fear and anxiety and streamlines the organizational aspects of care. Simple, noninvasive general-anaesthetic techniques with modern agents are recommended. Good analgesia is important and is based upon local or regional blockade, nonsteroidal antiinflammatory drugs and paracetamol, with opioids being reserved for rescue analgesia. Omission of opioids helps to minimize postoperative emesis. Discharge home is facilitated by clear instructions about activities, dressings, wound care and continuing pain control. 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.

CONTENTS

Anesthesia; Spinal Anaesthesia; Criteria for Referral to Specialist Paediatric Centre; Identification, Resuscitation, Stabilisation and Transport of the Critically Ill Child; Day Case Anaesthesia and Pain Control; Anaesthetic Techniques; Pain Management Techniques; Anesthesia Critical Care in Hospital