General Anaesthesia

Safe general anaesthesia (GA) has developed in tandem with increasingly complex operations and procedures. Without advances in anaesthetic practice many surgical advances would have been impossible. GA has become more complex but has improved to become safer and more routine than ever before.

However, regional or spinal anaesthesia may be even safer and it is important that the safest and most appropriate forms of anaesthesia be selected. There is risk with even a brief anaesthetic because, for example, of risk during induction and recovery.

Skills in anaesthesia used to be quite common in general practice. However, the development of both disciplines has considerably reduced the scope for part-time anaesthesiology. The drive for safer anaesthetics means that GA is seldom administered outside hospitals which have 24-hour anaesthetic cover and an intensive care unit.

There are still parts of the world where skills in anaesthesia can be invaluable for doctors and others to acquire. The drugs and techniques used can be safely learned and used by non-medical personnel to allow simple operations to be performed in isolated communities where transfer of patients is impractical.

Pre-operative assessment

Pre-operative assessment by the anaesthetist is essential for safe anaesthesia. This involves assessing the fitness of the patient for operation but also assessment of which anaesthetic drugs and techniques can be used to complete the operation as safely as possible. A comprehensive assessment requires full understanding of the operation being undertaken, an assessment of the patient and full knowledge of the available drugs and techniques. It is usual practice to visit the patient before surgery and discuss the operation with the surgeon or someone from the surgical team.

The operation

The nature of the operation will greatly influence the type of anaesthetic administered. For example:

- Is it an emergency or an elective procedure? If the operation is being done as an emergency there will be several important factors to consider. For example, the patient will have a full stomach for a variety of reasons, including inadequate starvation (period of 'nil by mouth') and delayed gastric emptying (from pain and drugs administered). There may have been blood loss or other disturbances to normal homeostatic mechanisms which will compromise safe anaesthesia.
- Is GA necessary or can local or regional anaesthetic techniques be used to supplement or enhance the GA? Such techniques can be used with GA to reduce the amount of GA necessary and improve postoperative analgesia. They can be used in place of GA where it is safer to do so. There are many examples of using GA in combination with such techniques - for example, in cholecystectomy, circumcision, hernia repairs, etc.
- Will surgery require the patient to be in a position on the operating table which compromises the anaesthetic or maintenance of the airway? Is endotracheal intubation necessary?
- Is muscle relaxation necessary? For example, abdominal surgery will require use of muscle relaxants.
- Will hypotension or blood loss be a particular risk? What kind of venous access is required? Is a central line required?
- What sort of monitoring will be required? Will arterial access be required?

The patient

A multitude of factors can be present in an individual patient which will affect administration of safe GA. Consideration of these factors and the requirements of the particular operation requires a systematic approach to assessment of the patient. This is achieved through careful history, examination and, if necessary, further investigation.
History

- **Pre-existing conditions** affecting operation and anaesthesia. For example:
  - Heart disease (including recent myocardial infarction, heart failure and hypertension).
  - Liver disease.
  - Blood disorders (for example, anaemia and coagulopathy).
  - Diabetes mellitus
  - Respiratory disease (especially chronic obstructive pulmonary disease and asthma).
  - Neuromuscular disease.

See separate articles [Precautions with Patients with Diabetes Undergoing Surgery](#) and [Precautions for Patients on Steroids Undergoing Surgery](#).

- **Medication**, particularly that which can alter the response to an anaesthetic or surgery, should be considered. For example:
  - Steroids, neuroleptics, antihypertensives, antidepressants and barbiturates are all important. Even steroids taken in the fairly recent past are important if there is a risk that they have suppressed the adrenal-hypothalamic-pituitary axis.

- **Experience of previous anaesthetics** should be taken into account. For example:
  - Any adverse reactions to anaesthetic or other drugs.
  - Previous anaphylaxis or idiosyncratic reactions.
  - Particular fears or concerns about anaesthesia. There are many such fears (for example, of awareness, choking, vomiting, 'masks', 'needles', etc.). These can be addressed if identified beforehand and techniques tailored to the patient where possible.

Examination

This will be influenced by the history and the operation to be performed:

- Examine particularly cardiovascular and respiratory systems. Check heart rate, blood pressure, heart murmurs, carotid bruits and any pleural effusions or respiratory disease.
- Check for potential problems with the airway, such as a short neck or impaired mobility of the temporomandibular joint (TMJ). There are also problems of the neck in rheumatoid arthritis, as hyperextension may lead to snapping of the odontoid peg.
- Check mouth and dentition. Loose teeth or crowns can present problems.
- Check the veins for ease of intravenous (IV) access.

Investigations

These are only requested if there is an indication:

- Haemoglobin estimation is indicated if there is history of blood loss, anaemia, etc.
- U&E and creatinine if on diuretics or if there is history of previous abnormalities, renal impairment, etc.
- Further investigations such as LFTs may be indicated. A history of easy bleeding or bruising should lead to a coagulation screen being performed.
- Patients of Afro-Caribbean origin must have haemoglobin electrophoresis to exclude sickle cell trait unless this is already on record.
- ECG may be required in anyone with existing heart disease, or those with high risk of heart disease - including those with type 2 diabetes or in older patients.
- Existing lung disease or older age requires spirometry.
- CXR may be indicated from history and examination or routine for age.
- Blood may be taken for group and cross-match if this is thought necessary.

Premedication

- This is now only used in anxious patients, generally given 30 minutes to 2 hours before surgery. Temazepam is a commonly used anxiolytic, or midazolam is used in the anaesthetic room, both as an anxiolytic and to reduce the amount of induction agent used.
- Drugs may also be used to reduce gastric acidity - generally ranitidine but, for rapid sequence, sodium citrate may be given pre-induction. See separate [Mendelson's Syndrome](#) article.
Risk factors for postoperative nausea and vomiting are not well established but, if risk is considered to be high then additional components may be added to the premedication to help alleviate the problem. Postoperative nausea and vomiting are more common with procedures involving the middle ear and with gynaecological, bowel, gallbladder or ophthalmic surgery.

Induction

- The most common technique is now IV induction. The drugs used have changed over the years. Sodium thiopentone was commonly used until recently. Today propofol and fentanyl or alfentanil are often used. This is followed by use of a laryngeal mask airway (LMA) or an ordinary BOC mask (all sized appropriately). The patient can breathe spontaneously through this mask. Muscle relaxant is only given if the surgery cannot be undertaken without paralysis, such as open abdominal surgery. Muscle relaxants can still be given when an LMA is used. Endotracheal tubes (ETs) can also be used but generally require short-acting muscle relaxants and laryngoscopy for intubation.

- Alternatively, inhalational induction uses a volatile anaesthetic such as sevoflurane to induce anaesthesia over 3-5 minutes followed by either placement of an LMA or muscle relaxant and intubation. This can be preferred by those anxious about 'injections' but is slower and perhaps not as safe as IV induction. It should only be used when there are no concerns about the airway. Sevoflurane has superseded isoflurane, halothane and others as the agent of choice for inhalational induction of anaesthesia, as it has a more rapid onset of action. The patient maintains their own airway as anaesthesia progresses, such that, if there are difficult airway issues, laryngoscopy can be performed with the patient still breathing. This avoids any problems if the patient cannot be intubated. Fentanyl or alfentanil are normally given at induction to obtund the stress response from direct laryngoscopy. Suxamethonium is still the agent of choice for rapid paralysis. It is a depolarising muscle relaxant causing small contractions or fasciculations of muscles before short duration paralysis ensues prior to routine intubation. It is also used as a neuromuscular blocking agent during a rapid sequence induction. Rocuronium has a slower onset of action than suxamethonium. Most anaesthetists still use suxamethonium because it has predictable features of paralysis such as muscle fasciculations which precede the onset of paralysis (depolarising blockade). It is rapidly metabolised, unlike rocuronium, and there is spontaneous return of muscle power. Rarely, the patient is unable to metabolise suxamethonium (so-called 'scoline apnoea'). Suxamethonium can cause muscle aching postoperatively.

Airway management

- LMA is normally used to maintain the airway unless the particular surgery or the patient requires enhanced airway protection (for example, if the patient has hiatus hernia or reflux confirmed radiologically or by gastroscopy).
- A full stomach, as may be seen with trauma patients, will require intubation with a rapid sequence induction and cricoid pressure to protect the airway although in recent years there has been debate about the usefulness of using routine cricoid pressure.
- Protection of the airway by intubation may be necessary for ear, nose and throat (ENT) surgery, although a reinforced LMA and a throat pack are commonly used during day case nose procedures.

Maintenance of anaesthetic

Aims of GA are:

- Controlled unconsciousness.
- Pain relief.
- Muscle relaxation.
- Reducing the response of the autonomic nervous system.

These are achieved with a combination of anaesthetics (IV and inhaled), opioids and muscle relaxants. Volatile anaesthetics were usually combined with nitrous oxide and oxygen. Nitrous oxide can be used to spare the amount of volatile anaesthetic required to maintain anaesthesia. It has been associated with postoperative nausea and vomiting and there are some types of surgery in which nitrous oxide should not be used. Many anaesthetists now prefer mixing volatiles with oxygen and air, especially during the day case setting.
Monitoring

During induction and maintenance of anaesthesia - clinical observations, supplemented by the following equipment:

- Pulse oximeter.
- Non-invasive blood pressure monitor.
- Electrocardiograph.
- Airway gases: oxygen, carbon dioxide and vapour.
- Airway pressure.

The following must also be available

- A nerve stimulator (whenever a muscle relaxant is used).
- A means of measuring the patient's temperature.

During recovery - clinical observations, supplemented by:

- Pulse oximeter.
- Blood pressure monitor.

The following must also be immediately available:

- Electrocardiograph.
- Nerve stimulator.
- Means of measuring temperature.
- Capnograph.

Complications

Complications of GA are varied and can be fatal but, thankfully, are rare. Complications of anaesthesia remain an important contributor to the statistics on maternal mortality.

- Damage to the mouth or pharynx, including damage to teeth and artificial crowns during intubation (uncommon - those with pre-existing poor dentition are most at risk).
- Minor idiosyncratic/allergic reaction to agents, producing nausea and vomiting (uncommon).
- Major idiosyncratic/allergic reaction to agents, inciting cardiovascular collapse, respiratory depression and jaundice (uncommon).
- Slow recovery from anaesthetic due to poor cardiac, hepatic or renal function, drug interactions, incorrect drug or dosage and inadequate reversal (uncommon).
- Malignant hyperpyrexia caused by anaesthetic gas or suxamethonium (rare).
- Prolonged apnoea after suxamethonium caused by pseudocholinesterase deficiency (rare).
- 'Awareness' during surgery can occur when the patient is paralysed but without effective anaesthetic.

Because of the aim to give a fairly light anaesthetic, aided by muscular relaxation, it is easy to let the patient become aware but, being paralysed, unable to respond. Sometimes patients can accurately recount the conversation that the operating team was having. The paralysed patient must be closely monitored to detect any signs of awareness or pain. If there is a suggestion of intraoperative awareness, IV midazolam can induce amnesia. New methods for monitoring anaesthesia are being devised.

See also separate Important Complications of Anaesthesia article.

Recovery

The time of recovery is a time of risk. All patients are observed on a one-to-one basis by an anaesthetist or recovery nurse until they have regained airway control and cardiovascular stability and are able to communicate. Patients are kept under clinical observation at all times and all measurements recorded:

- Level of consciousness.
Oxygen saturation and oxygen administration.
Blood pressure, respiratory rate, heart rate and rhythm.
Pain intensity - eg, verbal rating scale (none, mild, moderate, severe).
IV infusions, drugs administered.
Other parameters (depending on circumstances) - eg, temperature, urinary output, central venous pressure, end-tidal CO₂, surgical drainage.

Patients are only discharged to the ward when:

- The patient is fully conscious, able to maintain a clear airway and exhibiting protective airway reflexes.
- Respiration and oxygenation are satisfactory.
- The cardiovascular system is stable with no unexplained cardiac irregularity or persistent bleeding, with a pulse and blood pressure at an acceptable level and adequate peripheral perfusion.
- Pain and nausea or vomiting should be controlled and suitable analgesic and anti-emetic regimens prescribed.
- Temperature should be within acceptable limits (ie not significantly hypothermic).

There is considerable pressure these days for day case surgery and so anaesthetics are often arranged for rapid recovery so that the patient may be discharged just a few hours later. However, effects will last and the patient must be discharged into the care of another who will drive home. A taxi can be used (but not a bus) and only if there is someone at home to receive the patient. Under no circumstances should a person drive on the same day as having received a GA. Driving should be avoided until 24 hours after the anaesthetic and even important decisions such as signing legal documents should be avoided for this time as judgment is impaired.

Safety

The potential dangers of general anaesthesia should not be underestimated, although serious problems are rare.

Historical perspective

Before GA, alcohol was often used as an analgesic and it was common practice in the armed forces to give the unfortunate patient strong alcoholic drink before surgery. Inadequate anaesthesia placed a big emphasis on the surgeon's speed.

Ether was administered by Robert Liston, a surgeon trained in the USA but working in London on a patient named Frederick Churchill, at the University College Hospital, on 21st December 1846. The operation was for a mid-thigh amputation.

The technical difficulties of ether were partly overcome by the substitution of chloroform, by James Young Simpson, professor of midwifery at Edinburgh University in 1847. He poured drops on to a gauze held near the face of the patient, avoiding the use of the inhalers used for ether. Chloroform tended to be used more in Scotland than in England. Despite the technical advantages, there were more accidents and deaths associated with chloroform during anaesthesia.

One of the early pioneers of anaesthesia was John Snow, renowned for removing the handle from the Broad Street pump and stopping the spread of cholera in London in 1854. He and J T Glover ascertained that anaesthesia remained in the hands of medical men and eventually specialists.

Nitrous oxide had been used in the USA but its disadvantages were difficulty in administration and evidence of asphyxia during its use. The latter was partly overcome by Edmund Andrews of Chicago, who, in 1868, gave it with 20% oxygen. Paul Bert of Paris gave it under pressure 10 years later in 1878. Induction was with 100% nitrous oxide and hypoxia was a major force in the establishment of unconsciousness.

The first major war in which anaesthetics were used was the Crimean War of 1854-1855. It was 25 years after ether had first been used during surgery but operations were still normally performed without any form of anaesthesia.
Simpson's open drop method was the most popular method until the first Boyle machine appeared in 1917. In the 1930s the appearance of bromethol (Avertin®), divinyl ether, cyclopropane and trichloroethylene, and the induction of anaesthesia by intravenous barbiturates, were innovations. Because of the difficulty of obtaining relaxation of the jaw and larynx with ether, blind naso-tracheal intubation became popular.

Controlled respiration was used with cyclopropane, so that when curare was first tried by Harold Griffith in Montreal in 1942, the way to deal with hypoventilation and apnoea was well established, and very soon intermittent positive pressure ventilation (IPPV) became common practice.

In the 1950s, anyone who entered a hospital would be struck by the pervasive smell of ether throughout the building. To many people in their 50s and beyond, this smell will always be associated with hospitals.

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Further reading & references

6. Immediate Post-anaesthesia Recovery; Association of Anaesthetists of Great Britain and Ireland, March 2013

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