

## WHAT'S NEW IN...

### Anaesthetics

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#### ABSTRACT

**Anaesthesia, like all other medical specialities continues to advance, with improvements in the agents used and techniques employed in order to minimise adverse effects to the patient. This review examines some of these advances and looks forward to what the future might hold in other areas. As well as purely technical advances, other facets of anaesthetic service provision are reviewed, paying particular attention to how to provide a high quality service within the constraints of current working time legislation and revalidation.**

#### Introduction

Anaesthesia is defined by the American Board of Anaesthesiology (1) as the practice of medicine providing insensibility to pain during surgical, obstetric, therapeutic and diagnostic procedures; it also monitors and restores homeostasis during the peri-operative period ensuring that the patient suffers no harm during the operation. General anaesthesia has become increasingly safe since William Morton's successful demonstration of its use over 150 years ago, such that the risk associated with it has become almost immeasurably small: the mortality rate attributable solely to anaesthesia is less than one death in 200,000 procedures (2). New developments in anaesthetic practice therefore, are focussed on the reduction of anaesthetic-associated morbidity and increasing the quality of peri-operative management.

Anaesthesia as a speciality is constantly growing, not only due to the increase in the number of patients undergoing surgery, but because its practice is extending into many diverse areas within health care, such as chronic pain management and intensive care. This review however limits itself to the practice of anaesthesia for surgery and obstetric care, including the peri- and post-operative period.

#### ANAESTHETIC AGENTS Volatile anaesthetics

The discovery of ether anaesthesia made modern surgery possible. Successive improvements have produced today's inhaled anaesthetics, compounds that allow precise control over the anaesthetic state without

compromising safety. This control continues throughout the induction, maintenance and recovery from anaesthesia, some of the features required of the "ideal anaesthetic agent" (3). The characteristics of the various inhalational agents are dependant on the agent's chemical structure, for example, its molecular stability will permit elimination of the unmetabolised anaesthetic molecule in expired air and show resistance to degradation by carbon dioxide absorbents. The greatest emphasis however is placed on the rapidity of onset and offset of volatile agents. This characteristic is dependent on both the blood and tissue solubility of the agent; the lower the solubility, the faster the blood and brain tissue levels change either up or down. In the past, halogenation of ether has produced agents such as halothane, enflurane and isoflurane and has led to a decrease in ether's solubility, improving its profile as a volatile agent. Manipulation of the chemical structures of present agents will lead to further improvements (Figure 1).



Fig 1. Three types (Halothane, Isoflurane and Sevoflurane) of volatile anaesthetic agents all derived from ether. Over time, changes in their chemical structure has led to improvement in their pharmacokinetics and pharmacodynamics.

#### Sevoflurane

Sevoflurane is a methylpropyl ether. First synthesised in the late 1960's it has only recently become a mainstream volatile anaesthetic agent in the UK. Due to its low blood solubility (three times less than halothane) it produces rapid induction and recovery with good control of depth of anaesthesia (4). It does not irritate the airways and allows a smooth and pleasant gaseous induction; consequently it has become popular when anaesthetising children. Concerns over a potentially nephrotoxic metabolite, compound A, which may

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accumulate during low flow anaesthesia initially limited its use (5), but evidence is accruing that this is less of a problem than first thought.

### **Desflurane**

Desflurane is another volatile anaesthetic relatively new to UK practice despite development in the late 1960's (6). It has similar physical properties to Sevoflurane but an even lower blood gas solubility giving even faster onset and offset times. However desflurane is an airway irritant producing coughing, breath holding and even laryngospasm when used for gaseous induction (7). Desflurane is suited to low flow circuits where the amount of volatile agent is reduced and costs minimised (8). The availability of both sevoflurane and desflurane brings the goal of finding the ideal volatile anaesthetic agent nearer, and as the demands for early return of cognitive function and same day anaesthetic discharge increase in parallel with the rise in day case surgery, the use of both agents will increase.

### **Future Agents**

Nitrous oxide has been used as an adjunct to general anaesthesia for more than 150 years (9), but its use in the future is likely to decline. The introduction of new and more efficacious anaesthetic agents, anaesthetic machines which incorporate air as a choice of fresh gas flow and the introduction of statutory controls on the safe levels of environmental pollution are all contributory factors to this likely decrease. A potential replacement is the inert gas Xenon, which has anaesthetic and analgesic properties similar to those of nitrous oxide. It's extremely low blood solubility gives Xenon faster onset and offset times than either sevoflurane or desflurane (10). It does not appear potent enough to be used as a sole agent but could replace nitrous oxide as an adjunct to the general anaesthetic as it presents no environmental pollution problems (11).

### **Intravenous agents**

Since the introduction of sodium thio-pentone, intravenous agents have been used for the smooth and rapid induction of anaesthesia, but no new intravenous agent has become available since the introduction of propofol in 1984. Improvements in the delivery of propofol and other agents however, have encouraged the use of total intravenous anaesthesia (TIVA), which proponents claim has a lower incidence of nausea and vomiting, less environmental pollution (12) and a smoother, quicker return of cognitive function. Target Controlled Infusion (TCI) systems allow the anaesthetist to select a desired plasma concentration of the drug, which the software in the infusion pump produces rapidly using inbuilt pharmacokinetic

equations (13). Changes to the desired plasma concentration i.e. the rate of infusion, can occur rapidly and safely. One longstanding criticism of TIVA has been its expense compared to traditional anaesthetics, but the introduction of a new 2% concentration of propofol and reductions in the price of propofol itself have meant that the costs of this type of anaesthetic now mirror those of using the newer volatile agents for maintenance. The popularity of TIVA is growing.

### **Remifentanyl**

Remifentanyl is a potent synthetic opioid that is becoming increasingly popular as it is pharmacokinetically suited for infusion. It is derived from fentanyl, but due to its chemical structure undergoes rapid extra-hepatic metabolism via non-specific esterases in the blood and tissue (14). This process cannot be saturated, producing a terminal half-life for remifentanyl of 10 minutes which is unaffected by the duration of the infusion (15). It's initial use was restricted to certain specialities such as neuro- and cardiac anaesthesia, but the cardiovascular stability it produces, coupled with its pharmacokinetics has made it more widely used, particularly when used with propofol in TIVA.

### **Local Anaesthetics**

The most recent developments in local anaesthetics are a direct result of the acute, life-threatening cardiotoxicity of bupivacaine (16). All local anaesthetics produce a dose dependent delay in the impulse transmission through the cardiac conduction system by their action on the sodium and potassium channels. Cardiotoxicity usually only becomes apparent as the last event in a reasonably predictable sequence of changes (17). The worrying feature of bupivacaine is that clinical evidence of drug accumulation in plasma may be diminished until a late stage, because of its high affinity for plasma protein binding sites (18). Ropivacaine and levobupivacaine are two new amide local anaesthetic agents that have been produced in order to address the issue of bupivacaine cardiotoxicity. Levobupivacaine is the 'S' isomer of bupivacaine. Ropivacaine is the propyl analogue of bupivacaine having a butyl group in the same position (19).

Ropivacaine (N-*n*-propyl 2',6'-pipercoloxylidide) is an amino-amide local anaesthetic, which is a pure 's' isomer propyl analogue of bupivacaine (19). It was first registered for clinical use in 1996 and a full review of its clinical pharmacology was published at that time (20). Ropivacaine is less cardiotoxic than bupivacaine and such effects are also probably more easily reversed after inadvertent intravascular injection (21). The physico-chemical properties of ropivacaine suggest that its effects are comparable to bupivacaine with a rate of

onset (related to pKa) similar to that of bupivacaine, and that its absolute potency (lipid solubility) and duration of effect (protein binding) are slightly less. In addition, lower lipid solubility explains the greater differential block of sensory and motor function produced by ropivacaine than bupivacaine (22). Thus, ropivacaine has other potential advantages besides that of reduced cardiotoxicity, although unfortunately it is not currently licensed for intrathecal use.

Once it was appreciated that the cardiotoxicity of bupivacaine exhibited enantioselectivity (23), the S(-) enantiomer (levobupivacaine) was developed as an alternative long-acting local anaesthetic. Human volunteer studies have demonstrated that S(-) bupivacaine is better tolerated than racemic bupivacaine (24), although it produces a greater prolongation of the QRS complex than ropivacaine in conscious rats (25). The pharmacology of levobupivacaine has been reviewed extensively elsewhere (26). An overview of the relatively small amount of published information on the clinical use of levobupivacaine seems to show that its clinical effects are, as might be expected, identical to those of bupivacaine, thus, its only advantage is one of safety when large doses are required. There are no definitive published comparisons with ropivacaine; some work suggests that the risk of clinical toxicity is less with ropivacaine, but the key to safe practice remains the avoidance of accidental intravascular injection. Only time will tell whether either drug will displace bupivacaine as the standard long-acting local anaesthetic

### Awareness

Awareness under general anaesthesia is as old as general anaesthesia itself; William Morton's first patient described feelings of pain and being half-awake during the surgery, and both its prevalence and morbidity are underestimated. Sandin *et al* (27) reported a prospective study of approximately 12,000 patients and found a prevalence of awareness of 1/1000 in non-paralysed patients and 1/500 in paralysed patients. Other studies from around the world have shown similar figures. Up until recently the main predictors of depth or sufficiency of anaesthesia were clinical parameters such as heart rate, blood pressure, sweating or other signs of autonomic arousal. Parameters such as the minimum alveolar concentration and the introduction of gas analysers have also been a main stay of preventing awareness. Measuring the end tidal concentration of volatile agents can be used to give an indication of the blood concentration of the volatile agent and hence likely depth of anaesthesia. All these methods are less than ideal and there is an increasing need for a

means of accurately measuring the depth of anaesthesia (28). The ideal monitoring should be able to differentiate between the awake, sedated and anaesthetised patient, it should be able to be used on both intravenous and volatile anaesthetic techniques during all surgical procedures and be economically viable.

Of the various techniques and equipment trialled as potential 'awareness monitors' the most promising is the measurement of the electroencephalogram (EEG) under anaesthesia. It is not practical to use a standard EEG, however monitors have been developed to measure evoked potentials from somatosensory, auditory and visual modalities (29) as well as a Bispectral Index Monitor (BIS) (28). BIS is an empirically derived, multifactorial EEG measurement (30) giving a dimensionless number between 0 and 100 that correlates with hypnosis. In the awake patient BIS is between 90 and 100, whilst a BIS of 0 represents complete suppression of cortical electrical activity (Figure 2). BIS values below 60 are associated with a low probability of consciousness (31).

Although BIS Monitors and auditory evoked potential (AEP) monitors (32) have been commercially available for a few years



Fig 2. Bispectral index awareness monitor. It is easy to use (A) and produces a Bispectral index number on the monitor screen (middle trace). This may become a minimum monitoring standard alongside ECG, non invasive blood pressure monitoring and pulse oximetry which are also displayed.

their use is not widespread at present and is confined to centres with a specific interest (Figure 2).

### The Potential for Closed Loop Control of Anaesthesia

The principles of closed loop anaesthesia are that an automated anaesthetic delivery system is controlled by a patient monitoring system which responds to patient parameters producing both negative and positive feedback mechanisms to the delivery system controlling the depth of anaesthesia. Currently this role is fulfilled by the anaesthetist titrating the anaesthetic to the patient's needs. With the introduction of Target Controlled Infusions (Figure 3) of propofol and newer, more responsive agents such as remifentanyl and sevoflurane, the first part of the loop, the delivery system, is potentially in place. With the advent of 'awareness monitoring' using BIS and AEP technology it may in the near future be possible to "close the loop" and in certain circumstances fully automate the delivery of anaesthesia (33-35).



Fig 3. Two delivery devices for target controlled infusions with pre filled syringes of 1 and 2% propofol, the commonest agent used with these devices.

## PERI-OPERATIVE MANAGEMENT

With the reduction of mortality and serious morbidity associated with anaesthesia to very low levels, the emphasis has shifted to improving the quality of care particularly, in the post-operative period. The two commonest problems encountered post-operatively are pain and nausea and vomiting.

### Post operative pain control

Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage (36) and its relief should be the fundamental objective of any health care system (37). Acute pain in hospital is common and occurs most frequently in the postoperative period. The

deleterious effects of untreated acute pain, psychological, physiological and socio-economic, are well recognised (38) and if not relieved may develop into a chronic pain syndrome (39). Effective acute pain relief helps reduce length of stay in hospital, promotes recovery and reduces the development of chronic pain states. The massive increase in day case and fast track surgery necessitates the provision of safe effective pain management to reduce delayed discharge or unplanned admissions (40).

Since its isolation from opium approximately 200 years ago morphine has remained the most widely used analgesic for post-operative pain control and is the standard by which all others are judged (41). Over the last twenty years it has been the method of delivery that has changed, from 'nurse-controlled' intramuscular injections to the now ubiquitous patient controlled analgesia devices. Patient controlled analgesia simply refers to a process where patients can determine when and how much medication they receive, regardless of the analgesic technique (42).

### Mobile Epidurals

The most recent advance in obstetric anaesthesia has been the introduction of mobile epidurals (43), which use a mixture of very low concentrations of local anaesthetics together with an opioid such as fentanyl, acting synergistically to produce analgesia without the motor blockade traditionally associated with epidural use. The increase in mobility allows patients to walk around free of pain during labour (44). Similar low concentrations of local anaesthetic-opioid mixtures are also being used in epidurals for post-operative pain management allowing improved mobilisation and greater patient satisfaction.

### Patient Controlled Epidural Analgesia (PCEA)

Empowering patients with control of their analgesia has become an important principle in acute pain management. Although the role and optimal regimen of PCEA after major surgery has not yet been fully clarified, the technique has a practical safety advantage of permitting bolus doses which do not require to be mixed on the ward. The importance of a background infusion when using an LA-opioid combination was emphasized in a recent study in patients recovering from gastrectomy, when PCEA alone was shown to be less effective in reducing pain on coughing than PCEA with a background infusion (45).

Effective pain relief after major surgery with epidural administration of local anaesthetic and opioid drugs has been a practical proposition since the early 1980s. Although epidural administration is perceived by 80% of UK anaesthetists as the

ideal analgesic technique for upper abdominal surgery (46), there are many patients undergoing major surgery who do not receive this form of analgesia. In a recent survey of UK practice, only 15% of patients undergoing abdominal surgery had epidural analgesia in the 12 hospitals sampled. The main factor which has limited the use of epidural analgesia has been the difficulty in making a reasonable risk/benefit analysis about the technique, which has resulted in clinicians constantly asking whether epidurals are effective for postoperative pain relief and whether the technique is safe. Recently publications are starting to answer some of these questions as well as the type of infusions being used and their efficacy.

Epidural infusions of local anaesthetic and opioid combinations are the most commonly used technique in the UK and Australia; approximately 97% of anaesthetists use this type of epidural infusion. There is now evidence from several studies that a mixture of local anaesthetic and opioid is associated with significantly better dynamic pain relief after lower or upper abdominal, orthopaedic or thoracic surgery than are the components used individually (47-49). Furthermore epidural anaesthesia with local anaesthetic and opioid infusion has been shown to be significantly better than intravenous PCA morphine in providing dynamic pain relief after major abdominal surgical (50-53). In the future it is likely that the newer local anaesthetic agents, levobupivacaine and ropivacaine will be used more commonly via the epidural route - partly due to their improved safety profile but also because of their decreased motor blockade.

### **Post-operative nausea and vomiting**

The causes of post-operative nausea and vomiting (PONV) are multiple, complex and not completely understood and include patient, surgical and anaesthetic factors. Currently the incidence of PONV is estimated at 25-30% of all patients undergoing general anaesthesia, whilst the rate of severe, intractable PONV is 0.18% (54). PONV can lead to delayed discharge from the post anaesthesia care unit and unanticipated admission. In certain circumstances it can lead to serious complications and in nearly all others will cause patient discomfort (55).

The older more commonly used anti emetics including anticholinergics, phenothiazines, antihistamines and butyrophenones have many adverse effects such as dry mouth, sedation, hypotension, and extra pyramidal effects. The newest class of anti emetics used for the prevention and treatment of PONV are the serotonin receptor antagonists, such as Ondansetron, which have a better side effect profile than the older drugs. The serotonin receptor antagonists

have improved anti emetic effectiveness compared to the traditional agents, but are not as efficacious against PONV as they are for chemotherapy induced nausea and vomiting (55).

In resistant PONV, current evidence suggests suppression of emetogenic stimuli, including multiple different anti emetic medications, using less emetogenic anaesthetic agents, adequate rehydration and adequate pain control (54) are the most effective means of controlling the patient's symptoms. There is also some evidence that physiological doses of intravenous steroids act synergistically with anti emetics to improve their effects.

### **BLOOD TRANSFUSION**

Transfusion medicine is changing in response to a number of developments including the increasing incidence of blood borne diseases, some only recently identified, which requires the anaesthetist to be fully informed of the risks and benefits to the patient of red cell transfusion. The transfusion of allogenic blood can be life-saving, but unfortunately, despite the best efforts of the Blood Transfusion Service which prepares all transfusion products in UK, serious clinical consequences still occur, as highlighted in the annual Serious Hazards Of Transfusion (SHOT) report (56), often as a result of mistakes in the actual administration of the blood.

Half of the one million transfused units of allogenic blood given in UK each year are to surgical patients and are mostly prescribed and administered by anaesthetists in an attempt to improve or maintain the oxygen carrying capacity of the circulation, often in the face of rapid changes in intravascular volume and haemoglobin concentrations peri-operatively. The traditional approach of transfusion to achieve a specific (arbitrary) haemoglobin concentration, is being questioned in the light of both continuing risks from allogenic blood and the increasing evidence that such an approach is flawed.

### **Evidence for a changing transfusion policy**

Large amounts of evidence now challenge the traditional views that the haemoglobin concentration must be kept above 10g.dl<sup>-1</sup> for both safe anaesthesia and good post-operative recovery.

- Clinical experience in trauma demonstrates that blood losses of up to 30% can be treated with crystalloid or colloid replacement. A large retrospective observational study reported no increase in mortality provided the haemoglobin concentration was kept above 8g.dl<sup>-1</sup>, even in the elderly population (57).
- Haemoglobin levels above 8g.dl<sup>-1</sup> are sufficient even in patients with severe cardio respiratory disease (58).

- Post-operative patients who are limited in their activity are unlikely to have oxygen demands that exceed their supply. It is only in the most critically ill patients that oxygen demand exceeds supply. Studies in healthy volunteers have shown oxygen delivery is not compromised with haemoglobin levels as low as  $5\text{g}\cdot\text{dl}^{-1}$  (59).
- Wound healing occurs normally above haematocrit levels of 18 % (60).
- Transfusion of allogenic blood may lead to an increase in postoperative infections due to an immunosuppressive effect (61).
- In a large randomised controlled trial of intensive care patients there was no detriment in restricting transfusions (at haemoglobin concentrations of  $7\text{-}9\text{g}\cdot\text{dl}^{-1}$ ) compared to a liberal transfusion policy (62).

With these changes of attitude, alternative techniques are being used to reduce the number of allogenic transfusions.

## Alternatives to Allogenic Transfusion

### Autologous transfusions

Autologous blood transfusion can be accomplished by three different methods. In a pre-deposit programme, patients donate their own blood over the weeks preceding surgery, which is stored and then made available at operation. Acute normovolaemic haemodilution removes up to 500mls of the patient's blood prior to the actual commencement of surgery with maintenance of circulating volume by replacement with crystalloid. This fresh blood, which has the benefit of containing platelets and clotting factors, may later be returned to the patient once operative blood loss has been controlled. The main advantage of both these techniques is a reduction in allogenic blood transfusion requirements. Unfortunately the pre-deposit program is still dependant on adequate storage of the donated blood and administration errors are still possible, whilst normovolaemic haemodilution is dependant on adequate pre-operative haemoglobin levels and is limited to relatively small volumes of blood.

The third technique is red cell salvage autotransfusion, whereby shed blood is collected either by suction during surgery or closed vacuum drains afterwards, is processed and returned to the patient. This currently seems the easiest and most widely available method of avoiding allogenic transfusion.

### Pharmacological Agents

Aprotinin is a proteolytic enzyme inhibitor which at low doses inhibits plasmin, a natural occurring fibrinolytic agent, thereby reducing fibrinolysis and stabilising clot formation. It can help reduce allogenic blood

requirements particularly, in cardiothoracic surgery (63).

Erythropoietin is a glycoprotein secreted mainly by the kidneys which stimulates the synthesis of haemoglobin and the production of reticulocytes from bone marrow stem cells and thus erythropoiesis. Secretion is normally stimulated by haemorrhage or hypoxia. The use of recombinant erythropoietin in the perioperative period is still under investigation but has been used successfully in the treatment of anaemia associated with renal failure. It has also been used to increase the yield of blood collected for autologous blood transfusions.

Recombinant Factor VIIa is a potent but expensive addition to the tools available to reduce blood loss, and hence transfusion requirements. It has been used successfully around the world in the management of severe haemorrhagic trauma (64), and was used by Allied Medical Services in the recent Gulf War. Its exact place in clinical management of the haemorrhaging patient is still being evaluated. The ideal solution to depletion of both intravascular volume and haemoglobin carrying capacity would seem to be artificial oxygen carrying solutions (OCS's), manufactured free of infectious agents. Several have been tested and fallen short of the mark over the years due to unacceptable side effect profiles and an apparent poor ability to release oxygen to the tissues, but it is likely that the first two OCS's – a perfluorocarbon emulsion and an artificial haemoglobin solution - will soon be available in the UK. Despite these advances it is unlikely that these products will be widely available or applicable, so allogenic blood transfusions will still be required for the foreseeable future.

### Current Guidelines

In the face of the mounting evidence to limit allogenic transfusion, the Royal College of Anaesthetists has issued guidelines regarding the current indications for allogenic transfusion which many hospitals have incorporated into their own hospital transfusion policies. The guidelines suggest that:

- Patients should not be transfused if the haemoglobin concentration is above  $10\text{g}\cdot\text{dl}^{-1}$ .
- A haemoglobin concentration below  $7\text{g}\cdot\text{dl}^{-1}$  is a strong indication for transfusion.
- Transfusion becomes essential when the haemoglobin level concentration decreases to  $5\text{g}\cdot\text{dl}^{-1}$ .
- A haemoglobin level concentration between 8 and  $10\text{g}\cdot\text{dl}^{-1}$  is a safe level even for those patients with significant cardio respiratory disease
- Symptomatic patients should be transfused.

## PROVISION OF ANAESTHETIC SERVICES

### Fast track surgery

Over the last decade escalating health care costs, particularly in the United States, coupled with advances in both anaesthetic and surgical techniques have increased the number of surgical procedures being performed on a day case basis - 60% of all surgery in North America in the 1990's (65). As outcome data becomes available it is anticipated that day case surgery will increase, and its success has led to the emergence of fast track surgical units for a variety of surgical specialties (66), which utilise many of the successful anaesthetic techniques employed in day case anaesthesia.

Advances in the understanding of peri-operative pathophysiology have shown that multiple factors are responsible for post-operative morbidity, length of stay in hospital and convalescence. These include pain, the stress response, nausea and vomiting or ileus, hypoxiaemia and sleep disturbances, fatigue and immobilisation - knowledge of these factors allows anaesthetic and surgical techniques to be tailored to pre-empt these potential problems. Rapid, short acting volatile anaesthetic agents such as sevoflurane and desflurane, opioids such as remifentanyl and short acting muscle relaxants have facilitated the expansion of ambulatory surgery, epidural or regional anaesthesia may help to optimise pain control, multi-drug antiemetic regimens to eliminate PONV and aggressive post-operative rehabilitation including early enteral feeding and ambulation. The benefits of this approach may also be extended to facilitate early recovery and a decreased need for prolonged monitoring or stay in high dependency units after major procedures (67).

### Acute Pain Teams

Whichever technique is used to control post-operative pain, from simple medication to interventions such as neural blockade and PCA, increasing the complexity requires greater staff and resources. It has been recognised that the presence of a specialist acute pain team reduces the numbers of patients in pain post-operatively, whichever analgesic technique is employed.

The Royal College of Anaesthetists and the Pain Society have published joint guidelines outlining the minimum requirements of an acute pain team (36). These recommendations describe a multi disciplinary service with a named consultant anaesthetist as its lead. Clinical nurse specialists should be on site advising on pain management and undertaking regular patient reviews. Education, training and staffing arrangements must ensure safe practice continues when core staff are not on duty.

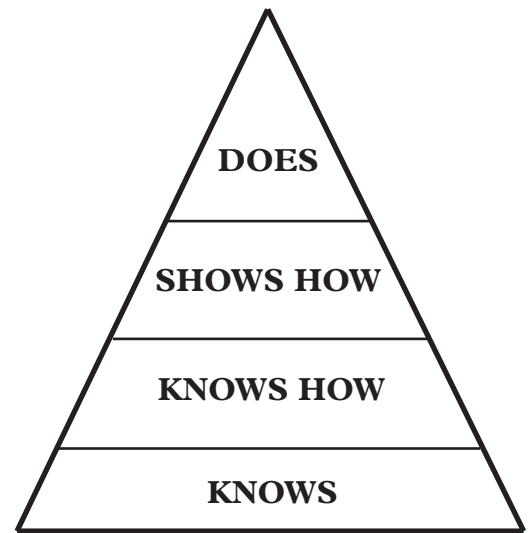


Fig 5. The Miller Pyramid. The bottom two stages of the pyramid compare with traditional assessment tools of written and oral examination. These do not extrapolate to the application of knowledge in the clinical work place. To assess clinical competence the top two stages become relevant. The 'shows how' stage is currently assessed by practical examinations such as the OSCE and clinical viva. The only way to assess the 'Does' stage is to assess the anaesthetist in the clinical environment.

Few hospitals can boast of an acute pain service that fulfils all of these requirements, but other advances in pharmacology and equipment for the relief of pain or the accrual of evidence as to the most effective analgesic strategies are likely to have less clinical impact without the input of an effective acute pain team.

### Anaesthetic Simulators.

In the current climate of assessment of clinical competency, consultant revalidation and appraisal systems, how clinicians perform their duties will be repeatedly scrutinised. The assessment of clinical competence is difficult as there are many different parameters to be assessed. A useful model of the skills to be assessed is demonstrated by the Miller pyramid (68) (Figure 5). It is this assessment of the anaesthetist in working environment that is potentially amenable to the use of simulators, as their current 'teaching' role emphasises some of the key non-technical skills which underpin performance such as task management, team work, situation awareness and decision making.

Anaesthetic simulators are of two types (69). One is computer based where clinical scenarios are played out on a virtual reality basis. The other is a full-scale simulator in which the anaesthetist is placed within a mock theatre with a manikin and anaesthetic machine (Figure 6). Scenarios are played out involving various clinical situations involving other personnel. Screen-based simulators are good devices to help acquire the skills of crisis management while mannequin-based simulators provide better training and assessment for behavioural aspects of crisis



Fig 6. Full scale anaesthetic simulator incorporating a mannequin, anaesthetic machine and functioning theatre suite. This type of simulator can assess not only clinical skills but also behaviour and team dynamics.

management, communication, and leadership. It is likely that simulators such as these will be an integral part of competency assessment for trainees and revalidation for consultants.

### Non-medical anaesthetists

At present only medically qualified personnel administer anaesthetics in the UK; additionally, anaesthetists account for 85% of the doctors in critical care and 75% of doctors in pain management. An anaesthetist is involved in the care of approximately two thirds of patients treated in a NHS hospital-anaesthetic manpower requirements are therefore very sensitive to service developments (70). Increases in the volume and complexity of work, expansion of the role of the anaesthetist into areas such as critical care outreach teams, the impact of the European Working Time Directive and a consultant led service mean that the NHS faces a huge shortfall of consultant anaesthetists. One suggestion of a RCA report on potential manpower shortages has highlighted the role of non-medical anaesthetists in other countries, including the Netherlands, Sweden and the USA.

In Sweden, Anaesthetic Nurses (AN's) are drawn from nursing backgrounds and can enter the one year AN training directly upon graduation, although most have at least two years nursing experience. Physician anaesthetists supervise several theatres and should be present for induction and reversal of each anaesthetic. Two AN's working together can practice semi-independently with patients graded as ASA 1 or 2, undergoing certain types of surgery. AN's are not involved in preoperative assessments or the performance of any regional anaesthesia. Dutch AN's are drawn from either a nursing background (2 year AN training) or as direct entrants from school with good academic achievement (3 year AN training). Physician anaesthetists supervise no more than two theatres and must be present at induction and reversal of anaesthesia. An anaesthetic

nurse must be present at every anaesthetic, but like their Swedish counterparts are not involved in preoperative assessment or regional anaesthetic techniques.

In the USA there are two types of non-physician assistants: certified registered nurse anaesthetists (CRNA's) who are entirely recruited from intensive care nurses and anaesthetic assistants (AA's) who have degrees in biological sciences - both undertake a three year training course. They are supervised in theatres on a one to two basis and a physician must be present at both induction and reversal of anaesthesia. In rural areas CRNA's, but not AA's, may undertake relatively independent anaesthetic practice under the supervision of a non-anaesthetist physician, for example, a surgeon or general practitioner, and in these circumstances CRNA's can undertake spinal and epidural anaesthesia. It is interesting to note that the deployment of CRNA's and AA's has not reduced the cost of anaesthesia, probably due to the low salaries of the medically qualified anaesthetic trainees.

Reports concerning the expected imminent shortfall in anaesthetists and a potential role for non-medical anaesthetists have been submitted to the Board of the Modernising Agency but a decision from the Department of Health is still awaited. Several NHS trusts have however expressed interest in the idea of employing non-medically qualified anaesthetists. If this were to go ahead it would be the greatest change in the practice of anaesthesia in the UK for over one hundred years with a substantial impact on both the working practice of anaesthetists and the wider delivery of anaesthetic services.

### Summary

Anaesthesia has become increasingly safe over the last one hundred years so current research aims to improve the associated morbidity. The use of new inhalational agents allows smoother and more rapid induction with quicker return of cognition afterwards, which can facilitate same day discharge from hospital. Coupled with potent, short acting analgesics like remifentanyl a wider range of procedures could become amenable to day case or limited stay surgery with benefits to both patient and Health Service. Blood transfusion remains a powerful tool in the anaesthetist's peri-operative armamentarium, but the risks of allogenic transfusion should never be taken lightly. Modification of transfusion guidelines in view of current evidence and the use of new pharmacological adjuncts should help to reduce the use of allogenic blood with its attendant risks. Continuing professional education and revalidation alongside the constraints of reduced working hours are a challenge to all medical specialities, but anaesthesia is at the forefront of investigating innovative methods to meet both these

challenges. Computer-based simulations are a useful method of assessing professional competence in key areas whilst the Royal College of Anaesthetists's willingness to look at the role of non-medical anaesthetists could herald the greatest change in anaesthetic practice in UK since the introduction of ether.

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