UPDATE IN ANAESTHESIA

A journal for anaesthetists in developing countries

WORLD ANAESTHESIA

EDITORIAL

No 7 1997

ISSN 1353-4882

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Much of this issue of Update is devoted to the important, although sometimes neglected, subject of postoperative pain relief. There has been a welcome upsurge of interest in this aspect of patient care in recent years during which time great advances have been made. These include the introduction of patient controlled analgesia, continuous epidural infusions and the concept of acute pain services managed by fully trained staff.

Such innovations are however expensive, not only in the purchase and maintenance of equipment such as infusion pumps, but also in the need for increased staff vigilance to ensure safety. Additional funds are unlikely to be available in developing countries, many of which are currently finding it difficult to provide even the most basic of anaesthesia services.

However, by focusing attention on this subject it is hoped that a greater understanding and increased awareness of patient's needs can result in improved patient comfort and safety in the postoperative period without the need for expensive innovations.

This review demonstrates how significant improvements are possible at minimal cost, for example the wider use of local anaesthetic solutions for wound infiltration or regional blockade and the regular assessment of patients in the post-operative period leading to the prompt administration of adequate analgesia.

The review provides valuable information on the range of therapies currently available and their appropriate use, not only in healthy adults but also in a wide variety of situations, such as the extremes of age and patients with concurrent medical conditions, where extra precautions are needed.

In many parts of the world the care of the patient in the post-operative period is felt to be the province of the surgeon. However, the conscientious anaesthetist has much to contribute to the well being of patients during this critical time. It is hoped that all clinicians, whatever their circumstances, will find something of value in this time review.

The two logos at the top of this editorial mark the beginning of a new era of co-operation between the World Federation of Societies of Anaesthesiologists and the International Association for the Study of Pain (IASP). Both bodies are keen to improve the management of pain, either acute or chronic, throughout the world. World Anaesthesia will publish regular articles on the management of pain drawn from IASP resources. The subject of these articles is up to you. Let us know what aspects of pain management would interest you most and we will respond.

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THE MANAGEMENT OF POSTOPERATIVE PAIN

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The purpose of this review is to suggest methods of relieving acute postoperative pain. It will discuss how the use of peripherally-acting drugs (such as the non-steroidal anti-inflammatory drugs, centrally-acting agents (such as opioids) and local anaesthetics can achieve this. Guidelines are offered for pain relief in children and the elderly. Further suggestions are made about the route of administration of analgesic drugs and factors which may alter the complaint of pain following surgery. This review is not comprehensive but is intended to summarise current thought about the practical management of postoperative pain in an understandable and accessible fashion.

The effective relief of pain is of paramount importance to anyone treating patients undergoing surgery. This should be achieved for humanitarian reasons, but there is now evidence that pain relief has significant physiological benefit. Not only does effective pain relief mean a smoother postoperative course with earlier discharge from hospital, but it may also reduce the onset of chronic pain syndromes.

Pain serves a biological function. It signals the presence of damage or disease within the body. In the case of postoperative pain it is the result of the surgery, but the principles outlined in this article apply also to the management of other acute pains such as those following burns or injury. The goal for postoperative pain management is to reduce or eliminate pain and discomfort with a minimum of side effects as cheaply as possible. Postoperative pain relief must reflect the needs of each patient and this can be achieved only if many factors are taken into account. These may be summarised as clinical factors, patient-related factors and local factors. In the final analysis the ultimate determinant of the adequacy of pain relief will be the patient's own perception of pain.

Clinical factors

The site of the surgery has a profound effect upon the degree of postoperative pain a patient may suffer. Operations on the thorax and upper abdomen are more painful than operations on the lower abdomen which, in turn, are more painful than peripheral operations on the limbs. However, any operation involving a body cavity, large joint surfaces or deep tissues should be regarded as painful. In particular, operations on the thorax or upper abdomen may produce widespread changes in pulmonary function, an increase in abdominal muscle tone and an associated decrease in diaphragmatic function. The result will be an inability to cough and clear secretions which may lead to lung atelectasis (collapse of lung tissue) and pneumonia. Matters are made worse by postoperative bowel distension or tight dressings.

Pain causes an increase in the sympathetic response of the body with subsequent rises in heart rate, cardiac work and oxygen consumption. Prolonged pain can reduce physical activity and lead to venous stasis and an increased risk of deep vein thrombosis and consequent pulmonary embolism. In addition, there can be widespread effects on gut and urinary tract motility which may lead, in turn, to postoperative ileus, nausea, vomiting and urinary retention. These problems are unpleasant for the patient and may prolong hospital stay.

The choice of pain-relieving techniques may be influenced by the site of surgery. Equally, it may be influenced by drug availability and familiarity with different methods of analgesia. For example, although patient-controlled analgesia (PCA), has often been shown to be better than the intermittent delivery of intramuscular opioids it does not produce as much pain relief as epidural opioid analgesia. Equally, a local anaesthetic block can effectively relieve pain, but only for the duration of the particular agent used. Choice of technique will also be influenced by the degree of training and expertise of the staff.

For many years, the standard method of treating postoperative pain in the developed world has been intramuscular opioid (usually morphine). The effects of opioid drugs vary greatly among patients and thus individual responses cannot be predicted. Many studies have shown that under-treatment of acute postoperative pain occurs because doctors and nurses overestimate the length of action and the strength of the drugs and that they have fears about respiratory depression, vomiting, sedation and dependency.

Improvement can be achieved by better education for all staff concerned with the delivery of postoperative pain relief and by making the assessment and recording of pain levels part of the routine management of each patient. Ideally, a named individual should be responsible in each hospital for the delivery and teaching of acute pain management.

Patient-related factors

Although it may be possible to predict, to a degree, the amount of postoperative pain knowing the site and nature of the surgery, other factors may alter the amount of pain suffered by the individual patient. The nature and intended purpose of the surgery may be important. If the proposed operation will lead to a restoration of normal function, for example, a hernia repair or fixation of a fracture, it is likely to be seen in a positive way by the patient. Where the outcome is not clear, for example, an operation for cancer or to investigate an unknown pain, the patients' fear and anxiety may lead to high levels of postoperative pain being reported. Patients who are afraid of anaesthesia or surgery may report more pain and this can be very difficult to treat.

Adequate time must be allowed to explain the intended operation and the steps that will be taken to ensure pain relief afterwards. It is important to establish the expectations of the patient before surgery. Some may fear the unknown and others may have previous experience of surgery or have heard stories from friends and relatives that present the postoperative period in an unfavourable way. An adequate and friendly explanation in simple terms will often reduce anxiety and minimise misunderstandings about the nature and purpose of the proposed surgery.

Local factors

A major problem in some parts of the world is that certain drugs, such as morphine, which are the mainstay of postoperative pain relief in many places, are not available. In addition, economic factors may mean that techniques of pain relief such as patient-controlled analgesia (P.C.A.) are unavailable and that techniques of regional anaesthesia which employ continuous infusions through disposable catheters are impossible. It is no use advocating techniques such as these if they are beyond local resources. It is better to maximise the effective use of local anaesthetic techniques and intermittent delivery of such analgesic drugs as are available. This review will discuss the use of the more advanced techniques in broad terms with the hope that the availability of both drugs and equipment can be improved in the longer term.

In general, the introduction of new and potentially expensive techniques is resisted by administration and professions alike. However, the introduction of such techniques may yield increased benefits in the form of improved recovery and faster discharge from hospital with consequent reductions in the cost of health care. Effective postoperative pain management may be encouraged by education of politicians, administrators, professional colleagues and patients.

Assessment of pain severity

Assessment of pain is in two parts; before the operation to make a pain management plan and afterwards to see whether the plan is working. The preoperative assessment includes the factors mentioned previously, as well as variables such as age, sex, weight, degree of obesity, current drug intake or past history of drug-related problems. Potential difficulties caused by language or culture are also assessed. There may be problems related to age, and relief of pain in children and the elderly are considered under separate headings.

There is some evidence to suggest that the use of opioid premedication establishes a level of analgesic control from the outset. There is however no evidence to support the use of local anaesthetic blocks or peripherally acting drugs in this pre-emptive fashion.

Rating scales are the most commonly used method of assessing acute pain and its relief. In practice, these are either words or numbers. In addition, a numerical value can be derived from a visual analogue scale. All these methods are simple, can be readily understood and require little in the way of technology or resources.

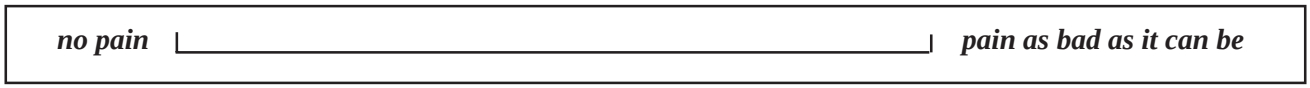
Words can be translated into any language and a simple five point scale is normally used. An example is shown on the next page.

Numbers can be assigned to each of the words for recording purposes (0-4). A simple numerical rating scale would require the patient to choose a number

no pain	*mild*	*moderate*	*severe*	*excruciating*

between 0 and 10 to represent their pain. Zero indicates that the patient has no pain and 10 means that the pain is as bad as can be imagined.

Visual analogue scales have a 10cm line which is marked as shown below. The patient is asked to make a vertical mark on the line to indicate the intensity of their pain.



There should be no other markings, numbers or words along the line as this tends to influence the results. It is most important to ensure that the patient understands the two end points. A small percentage of patients including the elderly and those with limited education have difficulty with visual analogue scales. Most can be trained by giving examples of familiar pain problems and relating these to positions along the line. If pain is being assessed regularly, then at the time of assessment the patient should not be able to see any other score as this may affect his decision. A visual analogue can be scored by measuring from the left side how far the patient marked towards the maximum pain end. This number can then be used to compare changes in the pain level.

Assessment of pain in infants or patients who cannot communicate can be difficult. Pain can be assessed with picture scales using varied facial expressions or by clinical observation (for example: sighing, groaning, sweating, ability to move). The latter method has the advantage that it does not rely on the patient to any great degree and can be carried out when other vital signs such as heart rate and blood pressure are being assessed. Asking the patient to take a deep breath or to cough or move will also provide useful information and it is important to emphasise that measurement of pain while the patient is at rest is unlikely to indicate the need for analgesia. Pain relief should be assessed when the patient is active.

Simple questions like "*where does it hurt?*" and "*what does it feel like?*" may allow a qualitative evaluation of pain after surgery. Pain distant from the operative site may indicate complications not associated with the procedure which may require separate treatment. Complaints of generalised pain all over the body may represent stress, anxiety, or in some cases fever. The description of the pain may indicate the cause. For example sharp, stabbing pain is associated with surgery, whereas numbness or tingling may mean nerve compression or ischaemia. Unusual or vague descriptions are more likely to be due to non-organic causes.

It may be difficult to assess pain in the early post-operative period by any of the methods described. It should be stressed that the assessment must be made at regular intervals and should form part of the routine postoperative observations. The progress of the patient is more easily assessed if results are charted in graphical form rather than as a number. Nursing, auxiliary and trainee medical staff should be encouraged to use assessment of pain routinely. Furthermore, they should be given training in the use of all forms of analgesic technique so they become confident in their use. Experience suggests that frequent assessment and delivery of analgesia whenever needed become a routine once the benefit to the patient is recognised.

PHARMACOLOGY

The World Health Organisation Analgesic Ladder was introduced to improve pain control in patients with cancer pain. However, it has lessons for the management of acute pain as it employs a logical strategy to pain management. As originally described, the ladder has three rungs. In the first instance peripherally acting drugs such as aspirin, paracetamol or non-steroidal anti-inflammatory drugs (NSAIDs) are given. If pain control is not achieved, the second part of the ladder is to introduce weak opioid drugs such as codeine or dextropropoxyphene together with appropriate agents to control and minimise side effects. If effective control is not achieved by this change, the final rung of the ladder is to introduce strong opioid drugs such as morphine. Analgesia from peripherally acting drugs may be additive to that from centrally-acting opioids and thus, the two are given together.

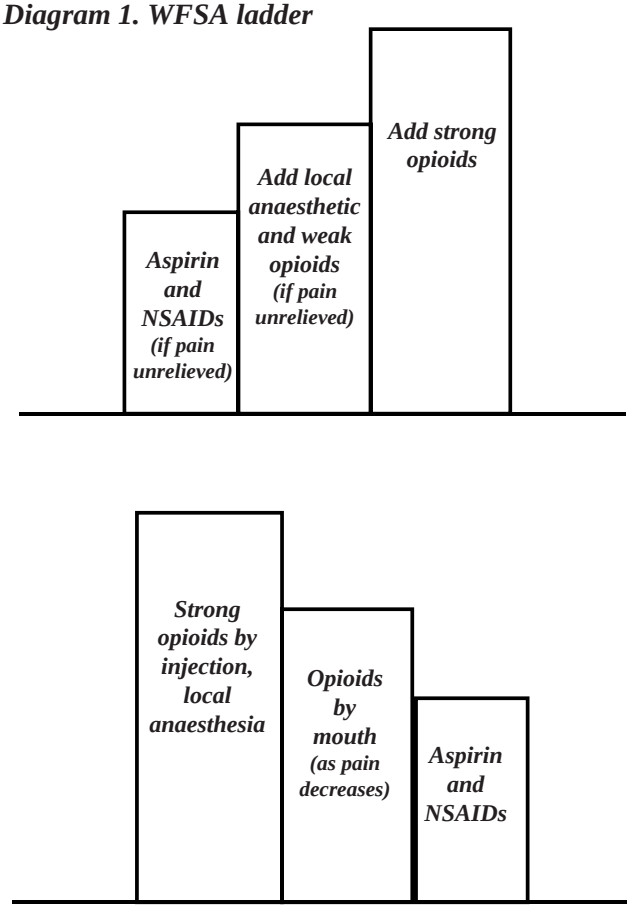
The World Federation of Societies of Anaesthesiologists (WFSA) Analgesic Ladder has been developed to treat acute pain. Initially, the pain can be expected to be severe and may need controlling with strong analgesics in combination with local anaesthetic blocks and peripherally acting drugs. The oral route for the administration of drugs may be denied because of the nature of the surgery and drugs may have to be given by injection. Normally, postoperative pain should decrease with time and the need for drugs to be given by injection should cease. The second rung on the postoperative pain ladder is the restoration of the use of the oral route to deliver analgesia. Strong opioids may no longer be required and adequate analgesia can be obtained by using combinations of peripherally acting agents and weak opioids. The final step is when the pain can be controlled by peripherally acting agents alone.

Local Anaesthetics

Regional anaesthetic techniques used for surgery may have positive respiratory and cardiovascular effects associated with reduced blood loss and excellent pain relief which can improve convalescence. Clearly, any technique that can be used for the surgical procedure will provide near perfect postoperative pain relief if it can be prolonged beyond the time of the surgery. There are many straightforward local anaesthetic techniques which can be continued into the postoperative period to provide effective pain relief. Most of these can be carried out with minimal risk to the patient and include local infiltration of incisions with long-acting local anaesthetics, blockade of peripheral nerves or plexuses and continuous block techniques peripherally or centrally. It is a mistake to expect 100% analgesia in every patient using a local anaesthetic technique alone as postoperative pain has many sources. The true place of local anaesthetic techniques is as part of a prepared plan for overall management that employs these techniques in conjunction with appropriate analgesic drugs. As pain is multifactorial in origin it is logical that management should consist of a combination of approaches in order to achieve the best results.

Infiltration of a wound with a long-acting local anaesthetic such as bupivacaine can provide effective analgesia for several hours. Further pain relief can be obtained with repeat injections or by infusions via a thin catheter. Blockade of plexuses or peripheral nerves will provide selective analgesia in those parts of the body supplied by the plexus or nerves. These techniques can either be used to provide anaesthesia for the surgery or specifically for postoperative pain relief. Depending upon the availability of drugs and equipment either single shot or continuous infusion techniques can be used to block brachial plexus, lumbar plexus, intercostal, sciatic, femoral or any nerves supplying the specific area of the surgery. These techniques may be especially useful where a sympathetic block is needed to improve postoperative blood supply or where central blockade such as spinal or epidural blockade is contraindicated.

Diagram 1. WFSA ladder



Spinal anaesthesia provides excellent analgesia for surgery in the lower half of the body and pain relief can last many hours after completion of the operation if long-acting drugs containing vasoconstrictors are used. Continuous analgesia using the spinal route has been tried but epidural analgesia is used more widely. The use of the epidural technique

requires experienced practitioners and specific training for nursing staff in the postoperative management of patients. In addition, great care must be taken to maintain sterility if a continuous technique is to be used. Epidural catheters can be placed in either the cervical, thoracic or lumbar regions but lumbar epidural blockade is the most commonly used. Although continuous infusions of

Fig 1. ***Local Anaesthetics for the Treatment of Acute Pain***

Agent	% solution for analgesic blocks	Duration (hours)	Max. single dose mg/kg. (Total mg in adults)*	% solution for infusion	Comments
Lignocaine					
Infiltration	0.5-1	1-2	7	——	Rapid onset
Epidural	1-2	1-2	(500)	0.3-0.7	Dense motor block
Plexus or nerve	0.75-1.5	1-3		0.5-1	
Mepivacaine					
Infiltration	0.5-1	1.5-3	7	——	Rapid onset
Epidural	1-2	1.5-3	(500)	0.3-0.7	Dense motor block
Plexus or nerve	0.75-1.5	2-4		0.5-1	Longer action than lignocaine
Prilocaine					
Infiltration	0.5-1	1-2	8.5	——	Rapid onset
Epidural	2-3	1-3	(600)	0.5-1	Dense motor block
Plexus or nerve	1.5-2	1.5-3		0.75-1.25	Least toxic amide agent Methaema-globinaemia >600 mg.
Bupivacaine					
Infiltration	0.125-0.25	1.5-6	3.5	——	Avoid 0.75% in obstetrics
Epidural	0.25-0.75	1.5-5	(225)	0.0625-0.125	
Plexus or nerve	0.25-0.5	8-24+	0.125-0.25		Mainly sensory block at low concen-trations. Cardiotoxic after rapid IV injection
Chloroprocaine					
Infiltration	1	0.5-1	14	——	Lowest systemic toxicity
Epidural	1.5-3	0.5-1	(1000)	0.5-1	of all agents Motor/sensory deficits may follow intrathecal injection

**for healthy patients with 1:200,000 adrenaline added to solutions. Maximum doses quoted should be reduced by 40% if solutions do not contain adrenaline. Much lower doses can be lethal if injected directly into a blood vessel*

local anaesthetic may produce very effective analgesia, they may also produce undesirable side effects such as hypotension, sensory and motor block, nausea and urinary retention. Combination of local anaesthetic drugs with opioids given centrally may reduce some of these problems (*see intrathecal and epidural opioids*)

The following table lists suggested concentrations, "safe" maximum doses and block characteristics of the most widely available local anaesthetics. All doses assume healthy adult patients and maximum permissible dosage should be calculated on the basis of body weight, particularly in the case of children (*see section on paediatric pain*).

Intravascular injection of local anaesthetic drugs can produce serious or life-threatening effects at much smaller doses than the maxima quoted.

Local anaesthetic injections at any site can form part of balanced analgesia where a mixture of techniques provides pain relief. This has the advantage of decreasing the dosage of each drug needed and diminishing the likelihood of side effects. The small delay that results from performance of the blocks is outweighed by the benefit to the patient.

Toxicity

The most important factor in the prevention of local anaesthetic toxicity is the avoidance of intravascular injection. Careful aspiration is vital especially if the needle is moved. However, a negative aspiration test is not an absolute guarantee of correct needle placement. Inject slowly and watch carefully for signs of toxicity such as buzzing in the ears, a feeling of numbness in the face and lips and a feeling of muscle twitching. If toxicity is suspected the injection should be stopped and the patient's respiration and circulation assessed. Provided hypoxia is avoided little other treatment is needed. Cardiovascular depression should be treated by raising the legs, giving intravenous fluids and administering a vasopressor such as ephedrine. Major collapse requires full resuscitation. Convulsions may occur and need management of airway, breathing and circulation as well as control of the fitting with diazepam or thiopentone.

Non-opioid analgesics

The most commonly used analgesic agents throughout the world are drugs in this group such as aspirin, paracetamol and the non-steroidal anti-inflammatory drugs (NSAIDs). These are the main analgesic treatment for mild to moderate pain.

Aspirin is an effective analgesic and is widely available throughout the world. It is active orally within a short period as it is rapidly metabolised into salicylic acid which has analgesic and, probably, anti-inflammatory activity. Salicylic acid has a half life of about four hours at therapeutic doses. Excretion is dose dependent and high doses will be excreted more slowly. The length of action may be reduced if aspirin is given with antacids.

Aspirin has major gastrointestinal side effects and may cause nausea, sickness or gastrointestinal bleeding because of antiplatelet effects which are irreversible. For this latter reason the use of aspirin after surgery should be withheld if alternatives are available. Diflunisal and Choline salicylate are related compounds without this latter problem.

Aspirin has an epidemiological association with Reye's syndrome and should not normally be used to provide analgesia in children under the age of 12 years.

Doses range from a minimum of 300mg orally, 4 hourly, to a maximum of 8g, orally daily.

Paracetamol has analgesic and antipyretic properties but little anti-inflammatory effect. It is well absorbed orally and is metabolised almost entirely in the liver. It has few side effects in normal dosage and is widely used for the treatment of minor pain. It causes hepatotoxicity in overdosage by overloading the normal metabolic pathways with the formation of a toxic metabolite.

Doses range from a minimum of 500mg, orally, 4 hourly to a maximum of 4g, orally daily.

NSAIDs have both analgesic and anti-inflammatory actions. Their mechanism of action is predominantly by inhibition of prostaglandin synthesis by the enzyme cyclo-oxygenase which catalyses the conversion of arachidonic acid to the various prostaglandins that are the chief mediators of inflammation. All NSAIDs work in the same way and thus there is no point in giving more than one at a time. In addition, there is a widespread individual variation in response to these agents and thus there is no drug of choice. NSAIDs are, in general, more useful for superficial pain arising from the skin,

buccal mucosa, joint surfaces and bone. They may be usefully combined with opioids due to their different modes of action.

The choice of a NSAID should be made on the basis of availability, cost and length of action. If pain is likely to be persistent over a long period of time it may be logical to choose an agent with a long half life and prolonged clinical effect. However, this group of drugs has a high incidence of side effects with prolonged use and caution should be exercised. All NSAIDs have antiplatelet activity leading to increased bleeding time. These drugs also inhibit prostaglandin synthesis in the gastric mucosa and may thus produce gastric bleeding as a side effect. Care should be exercised when using these drugs in patients with asthma or impaired renal function.

The following should be regarded as relative contraindications to the use of NSAIDs: Any history of peptic ulceration, gastrointestinal bleeding or bleeding diathesis; operations associated with high blood loss, asthma, moderate to severe renal impairment, dehydration and any history of hypersensitivity to NSAIDs or aspirin.

NSAIDs are available in a variety of formulations: tablet, injection, topical cream and suppository. The incidence of side effects and adverse reactions with an individual drug is similar regardless of the route of delivery.

Ibuprofen is the drug of choice if the oral route is available. It is clinically effective, cheap and has a lower side effects profile than other NSAIDs. Alternatives are diclofenac, naproxen, piroxicam, ketorolac, indomethacin and mefenamic acid. Where the oral route is not available the drug may be given by another route such as suppository, injection or topically. Aspirin and most of the NSAIDs are available as suppositories and are well absorbed.

NSAIDs

Drug Name	Forms Available	Daily Dose Range	Half Life (h)
Ibuprofen	tablet, syrup	600-1200 mg.	1-2
Diclofenac	tablet, suppository, injection, cream	75-150 mg.	1-2
Naproxen	tablet, suspension, suppository	500-1000 mg.	14
Piroxicam	capsule, suppository, cream, injection	10-30 mg.	35+
Ketorolac	tablet, injection	10-30 mg.	4
Indomethacin	capsule, suspension, suppository	50-200 mg.	4
Mefenamic Acid	tablet, capsule	1500 mg.	4

Weak opioids

Codeine is a weak opioid analgesic which is derived from opium alkaloids (as is morphine). Codeine is markedly less active than morphine, has predictable effects when given orally and is effective against mild to moderate pain. It may be combined with paracetamol but care should be taken not to exceed the maximum recommended dose of paracetamol when using combination tablets.

Doses range from 15 mg to 60mg 4 hourly with a maximum of 300mg daily. (If pain is not responding to maximum doses a stronger drug should be used if available)

Dextropropoxyphene is structurally related to methadone but is a relatively poor analgesic. It is often marketed in combination with paracetamol. and the same precautions should be observed. It offers few, if any, advantages over codeine.

Doses range from 32.5mg (in combination with paracetamol) to 60mg 4 hourly with a maximum of 300mg daily. (If pain is not responding to maximum doses a stronger drug should be used)

Combinations of weak opioids and peripherally acting drugs are useful in minor surgical procedures where excessive pain is not anticipated or for outpatient use:

Paracetamol 500mg/codeine 8mg tablets. 2 tablets 4 hourly to a maximum of 8 tablets daily.

If analgesia is insufficient - *Paracetamol 1g orally with Codeine 30 to 60mg 4 to 6 hourly to a maximum of 4 doses.*

Strong opioids

Severe pain arising from deep or visceral structures requires the use of strong opioids. Appropriate treatment begins with an understanding of the correct drug, route of administration and the mode of action. Early administration will achieve effective analgesic concentrations and make it easier to maintain the therapeutic level of the drug in the blood. Once a satisfactory level of pain relief has been achieved this can be sustained by regular administration of opioid regardless of whether the intramuscular, subcutaneous, intravenous, oral, sublingual or rectal route is chosen. Administration of adequate doses of analgesic may be inhibited because of side effects, notably nausea and vomiting.

The oral route of administration may not be available immediately after surgery. If gastrointestinal function is normal following surgery that has been superficial or minor in nature strong analgesia is not required. However, the oral route may be available as the patient recovers from major surgery and strong analgesics such as morphine are effective when taken by mouth. When the patient is unable to take drugs by mouth other routes of administration should be used. In general, effective analgesia can be provided by intramuscular injection despite the recognised drawbacks of this method. Conventional intramuscular delivery of opioid analgesics has the advantage of representing familiar practice and has inherent safety for this reason. The technique is inexpensive and the gradual onset of pain relief permits easy assessment of possible overdose. A disadvantage of the method may be that the dose is too large (side effects) or too small (no pain relief). In addition, the injections are painful and the onset of pain relief is delayed while the drug is absorbed.

Other factors affecting drug absorption. There may be enormous variations in the blood levels and rates of absorption of opioids after intramuscular injection. These may be influenced by the presence of hepatic or renal disease, the extremes of age and the presence of other drug therapy. Any condition that reduces peripheral blood flow can impair drug uptake and thus, reduced body temperature, hypovolaemia and hypotension will all result in lowered uptake from injection sites. Hypothermia and hypothyroidism may both lead to a reduction in metabolism causing an increased sensitivity to drugs.

Minimum effective analgesic concentration (MEAC) is the minimum plasma concentration at which analgesia occurs when a drug is given by constant infusion. The variation of MEAC level between different patients accounts for the vast difference in analgesic requirements that may be encountered. This can be illustrated by the large variations in drug demand seen when Patient Controlled Analgesia (PCA) systems are used. This varies between 13 and 44mg/h for pethidine (meperidine), 30 and 100mcg/h for fentanyl and 0.3 and 9mg/h for morphine in different patients.

Methods of using opioid drugs

The **oral** route of administration is the most widely used route and most acceptable for the patient. Disadvantages of the oral route to treat acute pain are that absorption of opioids may be reduced by the delay in gastric emptying that follows surgery. This has the dual disadvantage of non-absorption initially, followed by the possibility of a large dose being absorbed when gastrointestinal function resumes. Nausea and vomiting may prevent absorption of drugs administered orally and in addition, there is a reduced bioavailability after metabolism in the gut wall and the liver as the drug is absorbed (first pass metabolism). Thus the oral route may be unsuitable in many instances.

The **sublingual** route offers some theoretical advantages for drug administration. Absorption

occurs directly into the systemic circulation as there is no first pass metabolism. Tablets can be removed in the event of overdosage and, because of metabolism, they are unlikely to cause toxicity if they are swallowed. The drug that has been most commonly used by this route is buprenorphine which is rapidly absorped and has a long duration of action (6 h). It is associated with a high incidence of nausea, vomiting and sedation.

Rectal administration. Most opioid analgesics are subject to extensive metabolism if given by mouth. The rectal route is a useful alternative, particularly if severe pain is accompanied by nausea and vomiting. Opioids can be delivered successfully by suppository but it is not ideal for the immediate relief of acute pain because of the slow and sometimes erratic absorption, although it is ideally suited for the maintenance of analgesia. Rectal doses for most strong opioids are about half those needed by the oral route. Availability of preparations of opioids for rectal use is very variable throughout the world.

Strong analgesics

Drug Name	Route of Delivery	Dose (mg)	Length of Action (h)
Morphine	intramuscular/ subcutaneous	10-15	2-4
Methadone	intramuscular	7.5-10	4-6
Pethidine/meperidine	intramuscular	100-150	1-2
Buprenorphine	sublingual	0.2-0.4	6-8

(Intravenous - half the IM dose slowly over 5 minutes)

Intramuscular administration represents the optimum technique for the developing world where strong opioids are available. As stated previously, this method of analgesia may be associated with peaks and troughs in effect. A simple way of overcoming this problem is to administer the analgesic on a regular 4-hourly basis. In fact, it has been demonstrated that pain relief from intermittent intramuscular injection of opioids can be as good as that from PCA. To achieve this level of analgesia requires regular assessment and recording of pain scores and the development of treatment algorithms for automatic delivery of analgesia depending upon the level of pain recorded.

Intravenous administration. For many years it has been common practice to deliver small boluses of opioid both in theatre and the postoperative recovery area to produce immediate analgesia. This has the disadvantage of producing fluctuations in plasma concentrations of the injected drug, although when performed carefully intravenous injection brings more rapid pain relief than other methods. In general however intravenous techniques, by either intermittent injection or by infusion, are unsuitable except in high dependency and intensive therapy units as they are inherently dangerous if the patient is left unsupervised for even a short period.

Patient Controlled Analgesia (PCA) became popular when it was realised that individual requirements for opioids varied considerably. Therefore a system was devised whereby patients could administer their own intravenous analgesia and so titrate the dose to their own end-point of pain relief using a small microprocessor - controlled pump. A variety of commercial devices are now available for this purpose. When pain is experienced, the patient self-administers a small bolus dose of opioid and experiences the benefit of this action. Thus they can adjust the level of analgesia required, according to the severity of the pain. In theory, the plasma level of the analgesic will be relatively constant and side effects caused by fluctuations in plasma level will be eliminated.

To achieve successful and safe analgesia with PCA requires that the patient understands what is required and this should be explained in detail before the

operation. Almost every opioid drug has been used for PCA. In theory, the ideal drug should have rapid onset, moderate duration of action (to prevent the need for frequent demands) and have a high margin of safety between effectiveness and troublesome side effects. Choice usually depends upon availability, personal preference and experience. Once a selection has been made other parameters need to be set including the size of the bolus dose, the minimum time period between doses (the lock-out period) and the maximum dose allowed. Some devices permit the use of a continuous background infusion but for the reasons stated in the section on intravenous administration it will not be considered here.

Morphine is the most popular drug and will be used as an example. The ideal dose of morphine has been found to be 1mg. However, regular review is needed in every case to ensure that pain relief is adequate. The aim of the lock-out period is to prevent overdosage occurring because of over-enthusiastic demands for more analgesia. The lock-out time should be long enough for the previous dose to have an effect. In practice, lockout times of between 5 and 10 minutes are enough for most opioids. A maximum dose can be programmed into most PCA devices to prevent overdose. In practice, it is more logical to accept that the analgesic requirements of patients will vary considerably and some patients may require very large amounts to achieve adequate pain relief.

Guidelines for patient controlled intravenous opioid administration

Drug (concentration)	**Size of bolus (mg.)**	**Lockout interval (min)**
Morphine *(1mg/ml)*	0.5-2.5	5-10
Pethidine *(10mg/ml)*	5-25	5-1
Methadone *(1mg/ml)*	0.5-2.5	8-20
Fentanyl *(0.01mg/ml)*	0.01-0.02	3-10

PCA need not be administered intravenously and intramuscular, subcutaneous and epidural routes have all been employed. Patients using PCA usually titrate their analgesia to a point where they are comfortable rather than pain free. The reasons for this are not clear but are probably related to fears of overdosage, the need for contact with members of the hospital staff and the expectation of some pain after surgery. The normal pattern of use is for frequent demands to be made in the initial postoperative period and for these to decrease with time. The total amount of opioid used is less with PCA than with intramuscular delivery. The overall incidence of side effects is about the same with the two techniques but the incidence of respiratory depression is less with P.C.A. Where this has occurred it has usually been due to incorrect programming, device malfunction or inappropriate use by third parties. Because of this, devices should be tamperproof and activated only by the patient. The pump should normally be attached to a dedicated intravenous cannula. If it is attached to an existing intravenous infusion it must be through a one way valve to prevent increments of opioid collecting in the giving set which may be delivered later as a large bolus if the infusion rate is increased.

Intrathecal and epidural opioids have been used following a wide variety of surgical procedures and other acutely painful conditions. Intrathecal opioids are easy to administer either to provide surgical anaesthesia or as an additional technique when general anaesthesia is given. Many patients will remain comfortable for 24 hours or more after a single injection of intrathecal morphine. The epidural route has been used even more extensively although the reason for this is not clear. It may be that anaesthetists are more familiar with the epidural route for the delivery of long term analgesia and because of the potential advantages in terms of long term catheter use and freedom from post-spinal puncture headache.

Side effects are common using these routes of delivery. They include nausea, vomiting, itching (which is much more common with morphine than other drugs) and urinary retention. Of most concern however, as with any opioid, is the possibility of respiratory depression. Early respiratory depression may be caused by systemic drug absorption. Late respiratory depression is from rostral (towards the head) spread in the cerebrospinal fluid and the incidence is increased by factors such as dose, age, posture, aqueous solubility of the drug administered, positive pressure ventilation and increased intra-abdominal pressure

It should be assumed that all patients are at risk of this occasional complication and a high level of care and vigilance should be maintained. Many centres recommend that patients receiving analgesia by these methods should be in a high dependency or intensive therapy unit. Trained personnel should be present at all times to check on the rate and depth of respiration and level of consciousness of the patient at regular intervals, protocols should be available for immediate treatment of complications and

epidural catheter. These mixtures appear to produce a synergistic effect. Bupivacaine appears to be most suitable for this purpose as dilute solutions produce a very limited motor block. A mixture of bupivacaine 0.1% and morphine 0.01% infused at 3/4ml/h gives good pain relief and permits the patient to walk without the risk of hypotension.

Other routes of delivery Transdermal, inhaled and intranasal opioids are among the routes of drug delivery currently under development.

Intrathecal and epidural opioids for treatment of acute pain

Drug	Single dose (mg)	Onset(min)	Duration of single dose (h)
Epidural			
Morphine	1-6	30	6-24
Pethidine	20-150	5	4-8
Methadone	1-10	10	6-10
Fentanyl	0.025-0.1	5	2-4
Subarachnoid			
Morphine	0.1-0.3	15	8-24+
Pethidine	10-30	?	10-24+
Fentanyl	0.005-0.025	5	3-6

Note: lower dose levels may be effective in the elderly or when injected in cervical or thoracic regions. The duration of analgesia may be very varied. Higher doses tend to extend duration. Pethidine has local anaesthetic as well as analgesic actions.

medical staff have received appropriate training. Respiratory rate alone is insufficient to measure the status of respiration. A more global assessment is necessary particularly during the first 24 hours of treatment. Any patient receiving intrathecal or epidural opioids whose level of consciousness drops must be assumed to have respiratory depression until proved otherwise. Where available, the use of supple-mentary oxygen has been recommended.

It is particularly dangerous to prescribe other opioids to patients receiving intrathecal or epidural opioids as this increases the likelihood of clinically significant respiratory depression.

Opioid/local anaesthetic mixtures have been adopted in some centres in an attempt to reduce the frequency and severity of side effects seen with infusions of pure local anaesthetics. Dilute concentrations of these agents have been combined with opioids and delivered by infusion through an

Opioid analgesic agents (narcotics)

Opioid analgesic drugs act at receptors within the central nervous system. Initially three distinct receptor groups were described (mu, kappa and sigma) on the basis of their binding characteristics. The opioid drugs have differing affinities for these receptors and are described by their receptor affinities. Thus morphine and related compounds are known as mu agonists. Other analgesic agents have differing receptor affinities giving them different clinical properties.

Morphine remains the gold standard by which other analgesics are judged. Morphine has a short half life and poor bioavailability. It is metabolised in the liver and clearance is reduced in patients with liver disease, in the elderly and the debilitated. Major side effects include nausea, vomiting, constipation and respiratory depression. Tolerance may occur with repeated dosage but this is highly

unlikely to become apparent during the first week of continuous treatment.

Parenteral doses range from 2.5mg to a maximum of 20mg. Morphine may need to be prescribed as frequently as 2 hourly.

Pethidine is a synthetic opioid which is structurally different from morphine but which has similar actions. It has a short half life and similar bioavailability and clearance to morphine. Pethidine has a short duration of action and may need to be given hourly. Pethidine has a toxic metabolite (norpethidine) which is cleared by the kidney, but which accumulates in renal failure or following frequent and prolonged doses and may lead to muscle twitching and convulsions. Extreme caution is advised if pethidine is used over a prolonged period or in patients with renal failure.

Parenteral doses range from 25mg to a maximum of 150mg. Frequency of administration 1 to 4 hourly.

Methadone is different from morphine and pethidine but has the same actions. It differs from the other agents in that it is well absorbed by mouth and undergoes little metabolism. It is slowly metabolised in the liver and has a very long half life. The resultant prolonged duration of action makes it more suitable for use in chronic pain rather than acute postoperative pain although it has been used successfully for this purpose.

Oral doses range from 2.5mg to 25mg given 6 to 12 hourly.

Fentanyl is used chiefly for intraoperative analgesia because of its relatively short duration of action. It has similar actions and side effects to morphine and is metabolised in the liver. Postoperatively it has been used intrathecally or epidurally as described earlier.

Buprenorphine is described as a partial agonist, which, in practical terms, means that it has different properties from drugs which work mainly at the mu receptor. Buprenorphine appears to have some action at all the major opioid receptors. Its most useful attribute is that it can be delivered by the sublingual route. It is rapdly absorbed and has a prolonged duratiuon of action (6 h) but is associated with a high incidence of nausea, vomiting and sedation. Of the opioids, buprenorphine poses the least risk to patients with renal failure as the metabolites are virtually inactive and if accumulation does occur it is of no significance.

Sublingual doses range from 200-400mcg 8 hourly

Nalbuphine and Butorphanol are known as agonist/antagonists as unlike conventional opioids, they act at the kappa receptor rather than the mu receptor. Both have been used to provide postoperative analgesia by intermittent, continuous and PCA techniques. They exhibit a ceiling effect for analgesic activity (which has limited their popularity) and also for respiratory depression which should make clinical use safer. They are alleged to have a lower abuse potential than conventional opioid agents.

Side effects and toxicity

Opioid analgesics share many side effects though the degree may vary between agents. The most common include nausea, vomiting, constipation and drowsiness. Larger doses produce respiratory depression and hypotension. The specific antidote naloxone is indicated if there is coma or very slow respiration. Because of its short action, repeated injections of 200 - 400mcg intravenously may be necessary. Alternatively, it may be given by continuous intravenous infusion, the rate of administration being adjusted according to response.

Pain Relief In Children

Management of pain in children is often inadequate and there is no evidence to support the idea that pain is less intense in neonates and young children due to their developing nervous system. Children tend to receive less analgesia than adults and the drugs are often discontinued sooner. Furthermore, it is simply not true that potent analgesics are dangerous when used in children because of the risks of side effects and addiction. As with all pain, successful management depends upon the identification and treatment of all the factors which contribute, in particular fear and anxiety. In this context, careful explanations to child and parents can be helpful. A major problem in treating pain in children is associated with the difficulty in assessment

Assessment presents a major challenge, especially in those patients who cannot explain how they feel and who cannot understand the relationship between the treatment and the pain. The worst response is to

ignore the presence of pain and the best is to assess the pain and the patients response to treatment as thoroughly as possible. In very young children observational measures may be helpful, but absence of these signs does not rule out the existence of pain. Assessing simple factors such as whether or not the child is asleep, crying, relaxed, tense or are responding to their parents may be used to create a cumulative pain score.

Pain assessment for children under four years If the patient is asleep, no further assessment is needed. If the patient is awake check the following:

		Score
1. Cry	not crying	0
	crying	1
2. Posture	relaxed	0
	tense	1
3. Expression	relaxed or happy	0
	distressed	1
4. Response	responds when spoken to	0
	no response	1

Score 1 as slight pain, 2 as moderate pain, 3 as severe pain and 4 as the worst pain possible.

Children over four are better able to report pain and are able to use colour scales, pictures of varying facial expression and often visual analogue scales.

Management of pain in children needs to be handled more actively than in adults. Greater effort should be made to anticipate pain as children cannot be relied upon to ask for analgesia as might an adult. It may be better to establish a schedule of regular analgesia. The route of administration will depend on the drug to be used, the severity of the pain and the likely side effects. Drugs are best given by mouth if possible but the rectal route may be tolerated better if vomiting is a problem. The parenteral route (by injection) should only be used if the drug selected can only be given by that method or where other methods have failed. Intramuscular injections should be avoided as they may be very painful themselves and subcutaneous or intravenous routes are to be preferred.

Local anaesthetic creams are available that can be applied under an occlusive dressing to produce anaesthesia of the underlying skin for up to an hour. These may enable painless placement of venous catheters or allow infiltration of the area with local anaesthetic. These creams should not be used rectally, directly on the wound or on mucous membranes.

Many procedures associated with the relief of pain can themselves be painful. The performance of regional blockade, wound infiltration and the placement of intravenous or subcutaneous lines and catheters may be carried out without discomfort or resistance whilst the patient is anaesthetised.

Infiltration of local anaesthetic agent into the wound before wakening can reduce postoperative pain for long periods. Equally, regional anaesthesia undertaken while the child is under general anaesthesia can give prolonged control of pain and avoid the use of opioids. It is particularly suitable where early discharge from hospital is required. Extradural anaesthesia by the caudal route will provide excellent analgesia for any surgery below the waist such as herniorrhaphy, orchidopexy or circumcision. Children and their parents should be warned of the possibility of urinary retention and of transient weakness or numbness. Hypotension does not seem to be a problem in children under the age of six, but can be anticipated in older children and adults.

Dose schedule for caudal block with bupivacaine in children. 0.25% solution is satisfactory for blocks requiring a volume of 20ml or less. **A more dilute solution (0.2% bupivacaine) should be used where volumes of 20ml or more are required.**

For short cases 1% lignocaine will be effective and the required volume can be calculated in a similar fashion.

Type of block	Volume (ml/kg)
Lumbosacral	0.5
Thoracolumbar	1.0
Mid-thoracic	1.25

Maximum doses of bupivacaine in any four hour period are 2-3mg/kg and for lignocaine 3mg/kg (without adrenaline), 6mg/kg (with 1:200,000 adrenaline)

Non-opioid analgesics

Paracetamol is effective for mild to moderate pain. It can be given as an oral suspension in a dose of 15mg/kg to a maximum of 60mg/kg in 24 hours. Slightly higher doses (20mg/kg) are needed if this drug is used rectally as absorption is less reliable.

NSAIDs

Aspirin should not be given to children under 12 years old because of the association with Reye's syndrome. There is little experience with the use of NSAIDs in children except in the case of ibuprofen. This is available as a suspension or a syrup and should be given up to a dose of 20mg/kg/day. Diclofenac is available as a suppository (12.5mg or 25mg) for paediatric use and can be used as a premedicant or administered at induction of anaesthesia. Dosage can be up to 3mg/kg/day.

Opioids

Opioids can be used in the same way for children as for adults. The chief concern is that of respiratory depression when larger doses are being used. Suggested dose guidelines given here will minimise the possibility of this and yet still give effective pain relief.

Codeine is effective by mouth for mild to moderate pain and is usually taken in combination with paracetamol. Caution is needed when using this drug with neonates who may be more liable to respiratory depression. Codeine can be given by subcutaneous or intramuscular injection to provide pain relief for babies or children who are outpatients. Doses are similar whichever route is chosen. Codeine is effective when given by suppository. However, children between the ages of 2 and 12 may not always appreciate the virtues of giving the drug by this method.

Codeine is not suitable for intravenous use as it can produce severe falls in blood pressure and apnoea.

Doses of codeine syrup range from 0.5-1mg/kg 4 hourly given orally or by intramuscular injection. Codeine given as a suppository: 1mg/kg 4 hourly.

Morphine is the drug of choice for children who are inpatients. The preferred route of injection is intravenous but other routes can be used. Intramuscular injection is painful and unpopular with patients and nurses, however, this route may be used during the operation to provide analgesia at the time the child awakens from anaesthesia. The subcutaneous route can be useful when venous access is difficult. Intravenous morphine is painless once access has been established and if an infusion is to be used the same precautions must be taken to prevent accumulation as were outlined earlier. Normally a loading dose is infused over 30 minutes followed by a background infusion, titrated against the child's pain and the presence of side effects. If staff are experienced in looking after children postoperatively, there is no need for high dependency or intensive care facilities whilst these techniques are employed.

Doses of morphine orally are 200-400mcg/kg 4 hourly.

Subcutaneous or intramuscular routes 100-150mcg/kg 4 hourly. Intravenous doses 50-100mcg/kg over 30 minutes as a loading dose and then 5-40mcg/kg hourly.

Children as young as five years can use PCA satisfactorily. This is one of the rare circumstances where a background infusion may be of some benefit, as children rarely remember preoperative instructions immediately upon waking. Great care must be taken to ensure that parents do not use the device on behalf of the child. PCA may be of value when dealing with other acute pains such as may accompany sickle cell crisis or the mucositis associated with chemotherapy.

PCA Doses; background infusion 4mcg/kg/h. Additional doses 10-20mcg/kg and a 5-15 minute lock-out. A four hour dose limit is advisable and should be calculated after the patient's response is assessed (usually around 400mcg/kg).

Intrathecal and epidural opioids have been used in children. There is a very high incidence of nausea and vomiting, itching, urinary retention and late (up to 24 hours) respiratory depression. Although analgesia is good, the potential for unpleasant and serious side effects limits the use of these approaches in children.

Pain Relief in the Elderly

The elderly also present special problems in the provision of analgesia. There may be great difficulty in communication and assessment and the choice of analgesic techniques should reflect this. As a general rule the elderly report pain less frequently and require smaller doses of analgesic drugs to achieve adequate pain relief. Many patients are anxious, however, and this may correlate with increased pain postoperatively.

Assessment of pain may be carried out by normal methods and conventional numerical or graphical methods work well. However, impairment of higher intellectual functions may mean that observational techniques similar to those described earlier be needed. When analgesic drugs are given they may not be absorbed as well or metabolised as efficiently. In practical terms, doses of drugs such as NSAIDs and opioids should be reduced because of a decrease in liver metabolism. In addition, since the metabolites of drugs such as morphine and pethidine are excreted by the kidneys, any decrease in renal function may lead to accumulation with repeated doses. The elderly are more likely to be receiving more than one drug for underlying medical conditions and the possibility of drug interaction is greater.

Local anaesthetics. Nerve blocks are a most effective way of giving postoperative pain relief. Intercostal nerve block can aid pulmonary function after chest or upper abdominal surgery and pain below the waist can be abolished by epidural blockade aiding the return of gastrointestinal function after surgery. However, blocks spread more widely in the elderly and there may be compromise of respiratory function due to intercostal paralysis. In addition, a greater sympathetic block may occur with a consequent fall in blood pressure. With care, local anaesthetic blocks can be very useful in the elderly and give excellent pain relief whilst permitting mobilisation and rehabilitation.

NSAIDs are often undervalued. However, gastrointestinal disorders are more common and care should be taken in patients with compromised hepatic or renal function.

Opioids. Self-medication with opioids is not always wise in elderly patients and thus the role of PCA may be limited. It is probably better to use conventional intravenous and intramuscular methods of delivery which will give an immediate effect which can be assessed by those caring for the patient. The elderly may be particularly sensitive to opioids and side effects such as confusion, sedation and respiratory depression assume greater importance. Because of changes in hepatic and renal function lower doses of opioids are needed and the expected length of action may be longer.

Only one drug should be used at a time. In general about half the normal adult dose should be given at first, especially if the drug is being given intravenously. Small doses should be given regularly to anticipate pain where appropriate.

Pain from other Acute Causes

Many of the principles of pain relief contained in this survey apply to the management of other pain conditions; burns and trauma are obvious examples. A difference is that pain as a symptom may last longer than when seen in association with surgery. The initial pain of the injury will require treatment in the normal fashion, but there are subsequent

Drug interactions with local anaesthetics (drugs competing for plasma cholinesterases, phenobarbitone, (β–blockers, calcium channel blockers, cimetidine, tricyclic antidepressives and antiarrhythmic agents)

Drug interactions with NSAIDs (Most relate to the antiplatelet and gastrointestinal effects. Oral anticoagulants, tricyclic antidepressives, phenytoin, (β–blockers, and the ACE inhibitor captopril)

Drug interactions with opioids (Morphine: tricyclic antidepressives, metoclopramide, H2-blockers. Pethidine/meperidine: H2-blockers, barbiturates, phenothiazines, MAOIs, phenytoin. Methadone: tricyclic antidepressives, diazepam, anticonvulsants.

phases of healing and rehabilitation which may be long and painful.

The healing phase may take many weeks depending upon the nature of the injury and the length of the rehabilitation phase. It is important to provide adequate analgesia for the performance of procedures such as dressings, physiotherapy and skin grafts. Emotional consequences and tissue damage from the burn or injury, such as nerve damage, may require additional treatment. In these circumstance use of short-acting drugs is inappropriate. In addition, it is better to establish regimens of regular pain relief. Combined techniques to address all aspects of the pain problem are best carried out by a multidisciplinary team.

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PREOPERATIVE PREPARATION

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Introduction

The preoperative preparation and assessment is a vital part of the anaesthetic care given to patients scheduled for both routine and emergency surgery. All patients should be seen and assessed by the anaesthetist who is responsible for the administration of their anaesthetic. This practice not only avoids the chance of mistakes during "hand overs" but ensures continuity and rapport for both the anaesthetist and the patient.

The preoperative preparation of an individual patient will depend on the results of a thorough clinical assessment and on the particular operation to be undertaken. This will allow specific measures to be taken so that the patient is in the best possible condition for both anaesthesia and surgery.

The clinical assessment is best conducted using the standard format of history, examination and then further investigations. The latter will, in the majority of cases, serve to confirm the impression gained from an accurate history and examination, and should not be used to replace a thorough clinical assessment.

History and examination

The history should concentrate on the symptoms that alert the anaesthetist to potential problems during anaesthesia as well as those involving the general condition of the patient. In the majority of cases these will relate to the respiratory and cardiovascular systems.

Respiratory system

Symptoms of respiratory disease that should be sought are cough, shortness of breath and haemoptysis (blood in the sputum). The production of purulent sputum and the presence of wheeze may also indicate underlying lung disease. The functional ability of the patient can be assessed by questions such as "*how far can you walk before you get short of breath?*" or "*what activities make you short of breath?*". Valuable information may be revealed about a patient's cardio-respiratory reserve.

The presence of a productive cough is associated with an increase in postoperative chest complications and if it is of recent onset then consideration should be given to postponement of surgery and the commencement of appropriate treatment with antibiotics and chest physiotherapy. If the patient has a chronic productive cough then elective surgery should be postponed only if the patient has additional signs suggesting an infection. On examination of the chest the presence of altered breath sounds may indicate underlying lung disease. Bronchospasm and increased airway sensitivity are detected by the presence of expiratory rhonchi (wheeze). Fine inspiratory crepitations which do not clear after one or two deep breaths are caused by pulmonary congestion from left ventricular failure; while coarse crepitations indicate excess bronchial secretions. The presence of pleural effusions are indicated by a dull percussion note and reduced or absent breath sounds.

Cardiovascular system

When assessing the cardiovascular system it must be remembered that patients can have heart disease without symptoms or signs. In the developing world valvular heart disease is more common than ischaemic diease and a history of rheumatic fever must always be sought. Mitral stenosis occurs in 60% of patients who have had rheumatic fever but

30% of patients with mitral stenosis give no history of rheumatic fever. Symptoms of valvular heart disease include breathlessness on exertion, paroxysmal nocturnal dyspnoea, palpitations, haemoptysis and dizziness, fainting and angina. With a thorough history and clinical examination the cardiovascular reserve and the degree of stenosis, regurgitation and mobility of the valves can be estimated. The most accurate method of diagnosing the cause of a cardiac murmur is Echocardiography (an ultrasound examination of the heart) if this is available. In general all diastolic murmurs and loud systolic murmurs which are accompanied by a thrill are abnormal and indicate underlying structural heart disease. When the cardiac function is seriously compromised then symptoms and signs of cardiac failure will become apparant.

Signs of left ventricular failure include tachycardia, gallop rhythm, fine basal inspiratory crepitations, evidence of an enlarged heart and displaced apex beat. Right heart failure produces a raised jugular venous pressure wave, hepatic enlargement and peripheral oedema.

Ischaemic heart disease may be silent but is indicated by a history of angina or myocardial infarction. Precipitating factors such as anaemia or valvular heart disease should be sought. Angina associated with breathlessness is indicative of left ventricular dysfunction and a recent history of myocardial infarction (heart attack or coronary thrombosis) is of particular importance, as it increases the risk of perioperative myocardial infarction (MI). See Table 1.

Table 1.

Time since MI	Incidence of perioperative MI
< 3 months	36%
3-6 months	16%
> 6 months	6%

The degree of risk of cardiovascular disease can be assessed by using the Goldman Index (Table 2).

A total over 13 gives a poor prognosis (11% life threatening complications) and above 26 has a mortality of 50% and only life- saving operations should be considered. Note that it is almost entirely based upon clinical findings.

Past medical history

Table 2

Risk factor	*Score*
Third heart sound/gallop rhythm	11
MI within 6 months	10
>5 ventricular ectopics/ min	7
Rhythm other than sinus	7
Age > 70 years	5
Emergency surgery	5
Aortic stenosis	3
Abdominal or thoracic operation	3
Poor general condition	3

Enquiries should be made about previous operations and anaesthetics and any other known diseases should be noted. A history of diabetes, rheumatic fever or sickle cell disease is of particular importance as is epilepsy. A full drug history and details of any allergies should be sought. Particular importance should be paid to drugs that may interfere with anaesthetic agents such as beta blockers (which may cause bradycardias), anti-hypertensive agents, diuretics (hypokalaemia may prolong neuro-muscular blockade as well as induce arrhythmias) as well as those such as warfarin that may need dose alteration prior to surgery. Monoamine oxidase inhibitors should be stopped at least two weeks before surgery if at all possible. However the majority of drugs should be continued perioperatively to maintain stability of underlying medical conditions as much as possible.

Airway assessment

The anaesthetist must assess the airway in every patient prior to anaesthesia. There are various methods of assessing the likelihood of a difficult intubation at the bedside. The airway should be examined with the patient sitting upright with the mouth open as wide as possible. Neck mobility, jaw position, the presence and condition of teeth will all help predict a possible difficult airway or intubation. This topic is to be covered fully in the next edition. If there is a potentially difficult airway it is wise to make a contingency plan in case the airway cannot be secured.

Further Investigations

It should be remembered that most investigations will merely confirm the clinical impression gained

from a thorough history and examination. The availability of investigations varies widely and they should rarely be performed as primary diagnostic methods. It makes both clinical and economic sense to tailor the number of tests to the individual patient's needs. The value of preoperative investigations as screening tests is debatable. Some suggestions can however be made. Patients over fifty years of age and those scheduled for major surgery should have a haemoglobin estimation and, those at risk, a sickle cell screen. Urea and electrolyte estimations are useful in patients who have been vomiting and/or are clinically dehydrated and in those taking diuretics. The urine should always be tested for blood, protein and glucose and, if positive, further tests of renal function may be necessary. Routine chest radiography is not indicated on clinical or economic grounds. If the patient is short of breath at rest or has overt clinical signs of chest disease, then a chest X-ray may be helpful. Exercise tolerance and simple bedside spirometry are valuable methods of assessing respiratory function. Electrocardiograms are not indicated routinely but should be obtained if possible when there is a recent history of cardiac problems, an irregular pulse or clinical signs of heart failure. They are useful as screening tests in areas, such as Western Europe, where the incidence of ischaemic heart disease is known to be high.

Once the patient has been assessed, the anaesthetist must formulate a plan for the anaesthetic management which involves ensuring that the patient is in the best condition possible. This will include guidelines about fasting times accompanied by an adequate explanation to the patient. When possible correction of anaemia, dehydration and control of heart failure should all be achieved preoperatively as should optimisation of lung function with physiotherapy, bronchodilators and antibiotics. Advice from physicians may be helpful in difficult cases. In emergency cases it is vital to have replaced blood loss with appropriate fluids prior to induction of anaesthesia (*see Update 6*).

The final area of patient preparation is premedication. The aims of premedication are to decrease patients' anxiety and fear prior to surgery and to facilitate anaesthesia by reducing some of the side effects of the commonly used agents. Benzodiazepines and opioids are the most frequently used premedicant drugs but ultimately the choice will depend on the individual patients' needs and the type of anaesthetic to be administered.

Finally the anaesthetist should assess the risk to the patient. The American Society of Anesthesiologists (ASA) classification groups patients according to their current disease status so that the risk can be standardised. It also allows comparisons between different groups of patients to be made.

Class*	**Physical Status**
1	Normal, healthy
2	Mild systemic disease
3	Severe systemic disease that limits activity but is not life threatening
4	Severe systemic disease that is a constant threat to life
5	Moribund; Not expected to survive but is submitted to operation in desperation

*For an emergency operation an E is added to the class number

Summary

The preoperative preparation of patients should be based on a thorough clinical history and examination. Further investigations, if available, will confirm the clinical findings but should not be used as primary diagnostic methods. A plan of management should be formed before the start of every anaesthetic and the anaesthetist must be satisfied that the patient is in the best condition possible. The decision that the patient is "*fit for anaesthesia*" is the sole responsibility of the anaesthetist.

ANAESTHETIC BREATHING SYSTEMS

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The delivery systems which conduct anaesthetic gases from an anaesthetic machine to the patient are known as the breathing systems or circuits. They are designed to allow either spontaneous respiration or intermittent positive pressure ventilation (IPPV) and consist of a reservoir bag, anaesthetic tubing, and a pressure relief valve. A number of mechanical ventilators include a specific breathing system eg the Manley series. Other ventilators have been designed to operate with existing breathing systems e.g. the Penlon Nuffield 200.

The function of breathing is to maintain a supply of oxygen to the lungs for the blood to transport to the tissues and to remove carbon dioxide from the body. A breathing circuit must enable a patient to breathe satisfactorily without significantly increasing the work of breathing or the physiological deadspace. It must also conduct inhalational anaesthetic agents to the patient. The volume of gas inspired and expired with each breath is the tidal volume (normally 6-10mls/kg), the total volume breathed in a minute is the minute volume and the volume of gas in the lungs at the end of normal expiration is the Functional Residual Capacity (FRC).

The concentration of carbon dioxide in an exhaled breath varies with time; the first portion contains no carbon dioxide and comes from the upper respiratory tract where no gas exchange takes place (the anatomical dead space - 2mls/kg). The concentration of carbon dioxide then rises rapidly to a plateau of about 5% as alveolar gas is breathed out. The volume of alveolar gas expired per minute is called the alveolar minute ventilation. The anatomical dead space is 25-35% of each tidal volume. Any areas of lung that are ventilated with gas but are not perfused by blood cannot take part in gas exchange and represent the alveolar dead space. The total dead space in the patient is the physiological dead space.

The term rebreathing implies that expired alveolar gas containing 5% carbon dioxide (and less oxygen than normal) is inspired as part of the next tidal volume. Anaesthetic circuits are designed to minimise this occuring as it may lead to serious elevations in blood CO_2 levels. The amount of rebreathing that occurs with any particular anaesthetic breathing system depends on four factors; the design of the individual breathing circuit, the mode of ventilation (spontaneous or controlled), the fresh gas flow rate and the patient's respiratory pattern. Circuits may eliminate rebreathing either by ensuring an adequate flow of fresh gas which flushes the circuit clear of alveolar gas, or, in the case of a circle system by the use of sodalime which absorbs the CO_2 so that low fresh gas flows may be used. For each of the circuits described below, fresh gas flow rates that will ensure minimal rebreathing will be suggested.

Classification of breathing systems

A number of classifications exist and the one introduced in 1954 by Professor W W Mapleson is most commonly used in the UK (Figure 1). It does not however, include systems with carbon dioxide absorption.

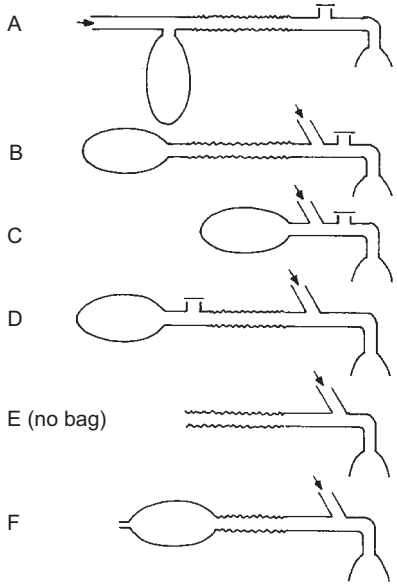

Figure 1. Mapleson classification of anaesthetic breathing systems. The arrow indicates entry of fresh gas to the system.

The Mapleson A (Magill) system was designed by Sir Ivan Magill in the 1930's and remains an excellent system for spontaneous ventilation (Figure 2). Fresh gas enters the system at the fresh gas outlet of the anaesthesia machine. The expiratory valve (Heidbrink valve) is very close to the patient to reduce the dead space. The respiratory cycle has three phases during spontaneous breathing; inspiration, expiration and the expiratory pause. During inspiration gas is inhaled from the 2 litre reservoir (breathing) bag which partially collapses giving a visual confirmation that breathing is occurring.

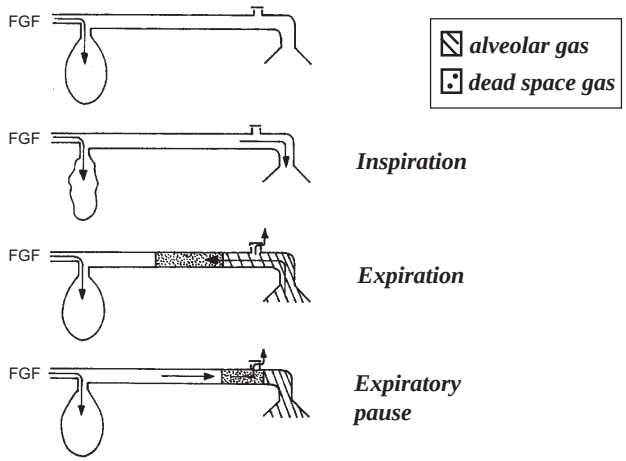

Figure 2. Mode of action of Magill attachment during spontaneous ventilation

During expiration the bag and tubing are initially refilled with a combination of exhaled dead space gas (containing no carbon dioxide) and fresh gas flowing from the anaesthetic machine. Once the bag is full the pressure within the breathing system rises and the expiratory valve near the patient opens allowing the alveolar gas (containing carbon dioxide) to be vented from the system. During the expiratory pause more fresh gas enters the system driving any remaining alveolar gas back along the corrugated tubing and out through the valve. If the fresh gas flow is sufficiently high all the alveolar gas is vented from the circuit before the next inspiration and no rebreathing will take place. With careful adjustment the fresh gas flow can be reduced until there is only fresh gas and dead space gas in the breathing system at the start of inspiration. When the system is functioning correctly, without any leaks, a fresh gas flow (FGF) equal to the patients alveolar minute ventilation is sufficient to prevent rebreathing. In practice however, a FGF closer to the patients total minute ventilation (including dead space) is usually selected to provide a margin of safety. An adult's minute volume is approximately 80mls/kg /min and thus for a 75kg man a FGF of 6 litres per minute will prevent rebreathing. This is an efficient system for spontaneously breathing patients if carbon dioxide absorption is not available.

During controlled ventilation the Magill circuit works in a different way and becomes wasteful and inefficient, requiring high fresh gas flows to prevent rebreathing. The inspiratory force is provided by the anaesthetist squeezing the reservoir bag after partly closing the expiratory valve next to the patient. During lung inflation some of the gas is vented from the circuit and at the end of inspiration the reservoir bag is less than half full. During expiration, dead space and alveolar gas pass down the corrugated tubing and may reach the bag which will then contain some carbon dioxide. During the next inspiration when the bag is compressed alveolar gas re-enters the patients lungs followed by a mixture of fresh, dead space and alveolar gas. A FGF of two and a half times the patient's minute volume is required to vent enough alveolar gas to minimise rebreathing (FGF of about 12-15 litres/min) which is obviously very inefficient. In practice the Magill circuit should not be used for positive pressure ventilation except for short periods of a few minutes at a time.

Modifications of the Mapleson A system

A simple modification of the Mapleson A circuit is required to make it more efficient for controlled ventilation. This is achieved by substituting a non-rebreathing valve (such as an Ambu E valve) for the Heidbrink valve at the patient end of the circuit. Not only does this arrangement prevent rebreathing, but during manual ventilation the delivered minute volume will be the same as the desired FGF which should be set at the rotameters. It is, however, a dangerous arrangement for spontaneous respiration because the valve may jam if the fresh gas flow is greater that the patient's minute volume.

The Lack circuit. A disadvantage of the Magill system is that the expiratory valve is attached close to the patient making it awkward to use (particularly when a scavenging circuit is added). The Lack circuit (Figure 3) is a Mapleson A system in which the exhaled gases travel down a central tube located within an outer corrugated tube towards the expiratory valve (co-axial system).

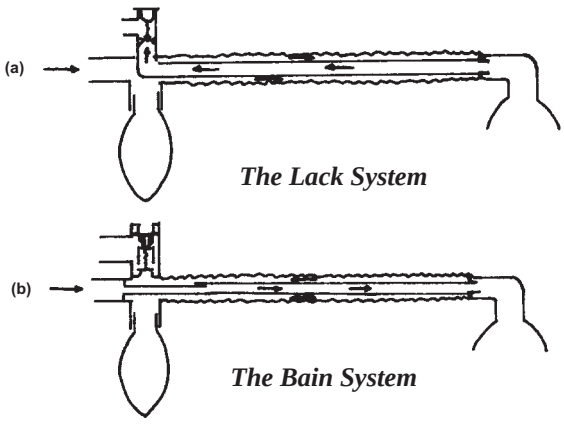

Figure 3. Coaxial anaesthetic breathing systems. (a) Lack system (Mapleson A). (b) Bain system (Mapleson D).

The inner tubing is wide enough to prevent an increase in the work of breathing and the expiratory valve is placed next to the reservoir bag, by the common gas outlet. The fresh gas flows required for both spontaneous and controlled ventilation are as described for the standard Mapleson A system.

The Mapleson B and C breathing systems (Figure 1) are similar in construction, with the fresh gas flow entry and the expiratory valves located at the patient end of the circuit. They are not commonly used in anaesthetic practice, although the C system is used on intensive care units. High flows of gases are needed to prevent rebreathing of CO_2 and this system was at one time combined with a canister of sodalime to absorb CO_2 (Waters' "To and Fro" Circuit). However the cannister proved too bulky for practical use and there was a risk of the patient inhaling soda lime dust.

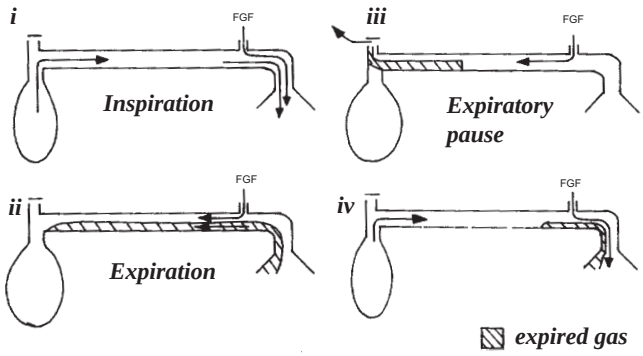

Figure 4. Mode of action of Mapleson D breathing system during spontaneous ventilation.

The Mapleson D, E and F systems are all functionally similar (Figure 1). They act as T pieces with the FGF delivered to the patient end of the circuit and differ only in the presence of valves or breathing bags at the expiratory end of the circuit. These systems are all inefficient for spontaneous respiration (Figure 4). During expiration exhaled gas and fresh gas mix in the corrugated tubing and travel towards the reservoir bag. When the bag is full the pressure in the system rises and the expiratory valve opens venting to the atmosphere a mixture of fresh and exhaled gas. During the expiratory pause fresh gas continues to push exhaled alveolar gas down the tubing towards the valve. However, unless the FGF is at least twice the patient's minute volume, rebreathing of alveolar gas will occur. A FGF of at least 8-10 litres/min (150mls/kg/min) is required to prevent rebreathing in an adult.

When used for controlled ventilation the Mapleson D system functions more efficiently. During expiration the corrugated tubing and reservoir bag fill with a mixture of fresh and exhaled gas. Fresh gas fills the distal part of the corrugated tube during the expiratory pause prior to inspiration. When the bag is compressed this fresh gas enters the lungs and when the expiratory valve opens a mixture of fresh and exhaled gas is vented. The degree of rebreathing that occurs depends on the FGF. A FGF of 70ml/kg/min is usually adequate for controlled ventilation; 100mls/kg/min will result in a degree of hypocapnia (lowered CO_2 level in the blood).

Modifications of the Mapleson D system

The Bain Circuit (Figure 3) is the most commonly used form of the Mapleson D system. It is a co-axial circuit which was introduced in 1972 by Bain and Spoerel. Unlike the Lack co-axial circuit described above, fresh gas flows down the central narrow bore tubing (7mm i.d.) to the patient and exhaled gases travel in the outer corrugated tubing (22mm i.d.). The reservoir bag may be removed and replaced by a ventilator such as the Nuffield Penlon 200 for mechanical ventilation. Before use the Bain circuit should be carefully checked by the anaesthetist. The outer tubing of a Bain circuit is made of clear plastic and the inner green or black. If a leak develops in the inner tubing or it becomes detached from the fresh gas port, a huge increase in apparatus dead space occurs. In order to check for this, the lumen of the green tubing should be occluded with a finger or the plunger of a 2ml syringe when a rise in gas pressure within the anaesthetic circuit should be observed.

The degree of rebreathing that occurs suring IPPVwill depend on the FGF. In an adult, fresh gas flows of 70-80mls/kg/min (6-7litres/min) will maintain a normal arterial carbon dioxide tension (normocapnia) and a flow of 100mls/kg/min will result in mild hypocapnia.

The Mapleson E system performs in a similar way to the Mapleson D, but because there are no valves and there is very little resistance to breathing it has proved very suitable for use with children. It was originally introduced in 1937 by P Ayre and is known as the Ayre's T-piece. The version most commonly used is the Jackson-Rees modification which has an open bag attached to the expiratory

limb (classified as a Mapleson F system although it was not included in the original description by Professor Mapleson). Movement of the bag can be seen during spontaneous breathing, and the bag can be compressed to provide manual ventilation. As in the Bain circuit, the bag may be replaced by a mechanical ventilator designed for use with children. This system is suitable for children under 20kg. Fresh gas flows of 2 - 3 times minute volume should be used to prevent rebreathing during spontaneous ventilation, with a minimum flow of 3 litres/minute, eg a 4 year old child weighing 20kg has a normal minute volume of 3 litres/min and would required a FGF of 6-9litres/min. During controlled ventilation in children normocapnia can be maintained with a fresh gas flow of 1000mls + 100mls/kg. e.g. a 4 year old weighing 20kg would need a total FGF of around 3litres/min.

Combination of the Mapleson A, D and E Systems - The Humphrey A D E Circuit. The Mapleson A circuit is inefficient for controlled ventilation as is the Mapleson D circuit for spontaneous ventilation. David Humphrey has designed a single circuit (Figure 5) that can be changed from a Mapleson A system to a Mapleson D by moving a lever on the metallic block which connects the circuit to the fresh gas outlet on the anaesthetic machine. The reservoir bag is situated at the fresh gas inlet end of the circuit, and gas is conducted to and from the patient down the inspiratory and expiratory limbs of the circuit. Depending on the position of the control lever at the Humphrey block, gases either pass through the expiratory valve or the ventilator port. When the lever is "up" the reservoir bag and the expiratory valve are used, creating a Mapleson A type circuit. When the lever is in the "down" position the bag and valve are by-passed and the ventilator port is opened creating a Mapleson D system for controlled ventilation. If no ventilator is attached and the port is left open the system will function like an Ayre's T piece (Mapleson E).

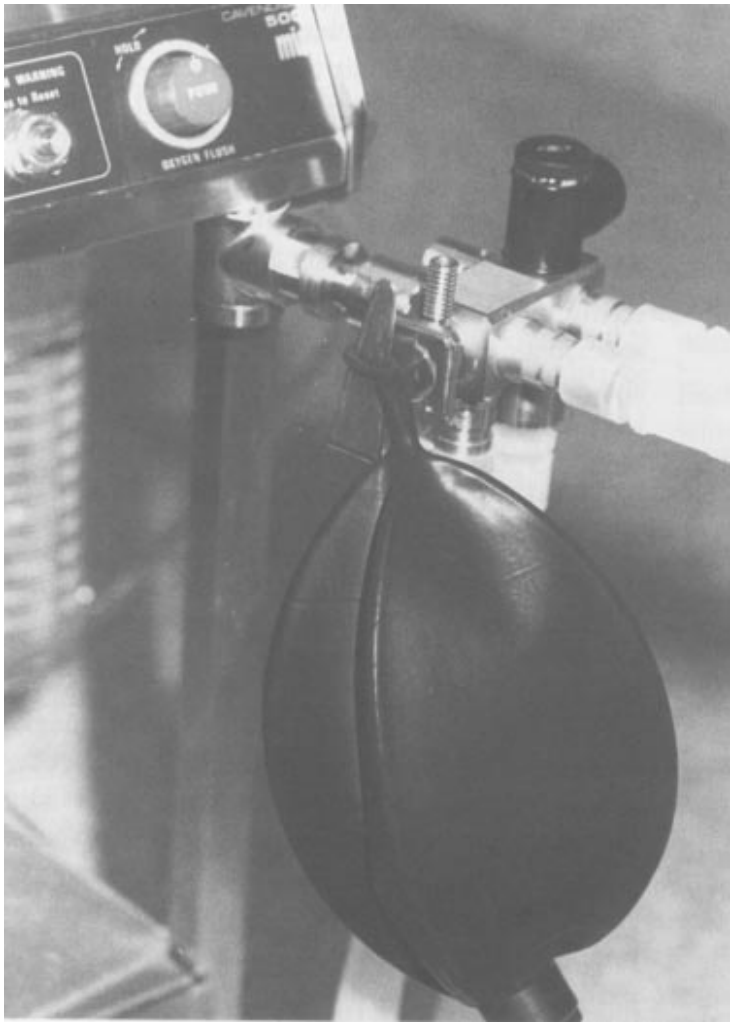

Figure 5.

Like all pieces of equipment, it is essential that the anaesthetist fully understands the function of a particular circuit. If the lever on the Humphrey block is moved from "up" to "down" whilst gases are flowing the breathing bag will remain full of gas but manual ventilation of the patient`s lungs by compressing the bag will be impossible and may resemble complete obstruction of the breathing circuit. This has led to anaesthetists ocasionally concluding that their endotracheal tube required changing.

Circle Systems. An alternative to using high flow circuits is to absorb CO_2 from the expired gases which are then recirculated to the patient. These circuits are known as circle systems, were first devised by Brian Sword in 1926 and require smaller amounts of fresh gas each minute.

Carbon dioxide is removed from the expired gas by passage through soda lime, a mixture of 94% calcium hydroxide and 5% sodium hydroxide, and 1% potassium hydroxide which reacts with CO_2 to form calcium carbonate. Soda lime also contains small amounts of silica to make the granules less likely to disintegrate into powder and a chemical dye which changes colour with pH. As more carbon dioxide is absorbed the

pH decreases and the colour of the dye changes from pink to yellow/white. When around 75% of the soda lime has changed colour it should be replaced . The soda lime canister should be mounted vertically on the anaesthetic machine to prevent the gases passing only through a part of the soda lime (streaming).

Fresh soda lime contains 35% water by weight which is necessary for the reaction between carbon dioxide and soda lime to take place. This generates considerable heat. The soda lime may rise in temperature to 40° centigrade. There are therefore additional advantages of using circle systems in that the gases within the circle are warmed and humidified prior to inspiration. (Baralyme is a commercially available CO_2 absorber which contains 5% barium hydroxide instead of sodium hydroxide.)

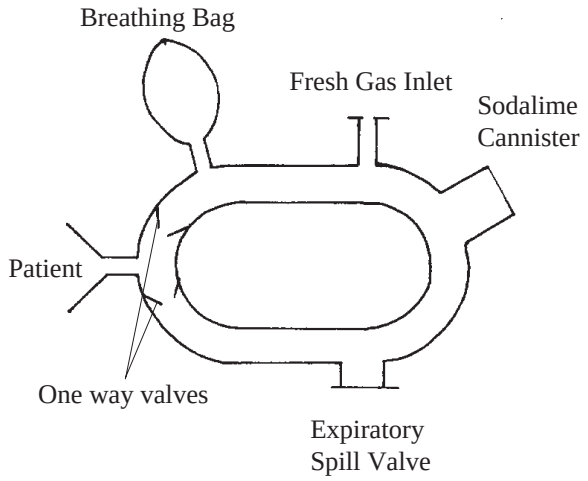

Figure 6. Arrangement of circle system.

Design of Circle Systems. A circle system (Figure 6) is composed of two one way valves (one inspiratory and one expiratory), a reservoir bag, a fresh gas inlet, a canister of soda lime and an expiratory spill valve. Although there may be slight differences in the positioning of these components, all the systems function in the same way.

Vaporiser Position. The vaporiser may be placed either outside the circle (VOC) on the anaesthetic machine in its conventional position, or rarely within the circle itself (VIC). Normal plenum vaporisers, with high internal resistance, cannot be used within the circle and a low internal resistance type vaporiser (such as the Goldman) is required. Drawover vaporisers such as the OMV are not recommended for use within the circle because of the risk of over-dosage. Since the gases are recirculated, if the vaporiser is placed in the circle, gas already containing volatile anaesthetic agent will re-enter the vaporiser and the resulting output will exceed the vaporiser setting. This is a particular danger during controlled ventilation when dangerously high concentrations can build up. Vaporisers should only be placed inside the circle (VIC) when inspired volatile anaesthetic agent monitoring is available. It is safer to use conventional plenum vaporisers mounted on the anaesthetic machine outside the circle. In this case the maximum volatile anaesthetic agent concentration achievable within the circle cannot exceed that set on the vaporiser.

Practical Use of Circle Systems. During the first 5 - 10 minutes of an inhalational anaesthetic using a volatile anaesthetic agent in oxygen and nitrous oxide, large amounts of the anaesthetic agent and nitrous oxide will be taken up by the patient, and the nitrogen contained in the patient's lungs and dissolved in their body will be washed out. If low fresh gas flows are used immediately the patient is connected to the circuit the nitrogen will not be flushed out of the circle system and will dilute the anaesthetic agent concentration. This may be prevented by using conventional fresh gas flows of 6litres/min for the first 5-10 minutes of each anaesthetic before reducing the flow rates.

Reducing the fresh gas flow rates. Inspired anaesthetic gases should contain no carbon dioxide and a minimum of 30% oxygen. Exhaled alveolar gas contains a lower concentration of oxygen and around 5% carbon dioxide which is removed from the exhaled gas on passage through the soda lime. A small amount of fresh gas is added before the next breath. At low fresh gas flow rates (<1000mls/min) unless 40 - 50% oxygen is supplied to the circle, the oxygen concentration within the circle can fall to unacceptably low levels due to the greater uptake of oxygen compared with nitrous oxide. Circle systems should preferably not be used at low flow rates without an oxygen analyser in the inspiratory limb. The lowest fresh gas flow rate of oxygen and nitrous oxide which can be used to ensure that the inspired oxygen concentration remains at a safe level is 1500mls/min (nitrous oxide 900mls/min and oxygen 600mls/min). Conventional flow meters and vaporisers become

unreliable if flows are set lower than these levels.

These comments are less important if only oxygen and a volatile agent is being used in the circle. Under these circumstances there is no risk of oxygen dilution and the flows may be reduced to 1000mls/min.

With flows of >1500mls/min the inspired concentration of volatile agent will be similar to that set on the vaporisers. With flows <1500mls/min the volatile agent concentration may fall within the circuit and the setting on the vaporiser may need to be increased.

Halothane, isoflurane and enflurane are all safe to use in circle systems with soda lime, however trichloroethylene (no longer used in the USA or UK) produces a toxic metabolite and must not be used. When the circle system is not in use all fresh gas flows should be turned off to avoid wastage and to prevent the soda lime from drying out.

Several paediatric circle systems have been developed using smaller bore tubing and a one litre reservoir bag. The work involved in breathing through these systems is no greater than with a conventional Mapleson F system.

Conclusion

There are many different breathing systems available, and this review has concentrated on the most commonly used ones. It is essential for the safety of patients that an anaesthetist routinely checks the anaesthetic circuit before use and has a thorough understanding of the function and pitfalls of a particular system before using it.

DECONTAMINATION PROCEDURES FOR MEDICAL EQUIPMENT

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Decontamination of medical equipment involves the destruction or removal of any organisms present in order to prevent them infecting other patients or hospital staff.

Microbes (bacteria & viruses) can be carried from one person to another on the surface of any equipment that is shared between them unless it is decontaminated between use. They can also be carried on the skin surface which is why handwashing between examining patients is important. Microbes gain access to the body, through open wounds, inhalation of infected secretions or by close contact with mucous membranes. The process by which microbes are passed from one infected person, to cause infection in another, is known as 'cross-infection'.

Cleaning, disinfection and sterilisation are all procedures that are used in the decontamination process. Decontamination reduces the risks of cross infection and helps to maintain the useful life of equipment. It is important in the overall control of hospital acquired infection.

Definitions

Cleaning is the process that removes contaminants including dust, soil, large numbers of micro-organisms and organic matter (e.g. blood, vomit). It is an essential prerequisite to disinfection and sterilisation. It also removes the organic matter on which micro-organisms might subsequently thrive.

Disinfection is a process used to reduce the number of micro-organisms but not usually bacterial spores. The process does not necessarily kill or remove all micro-organisms, but reduces their number to a level which is not harmful to health.

Sterilisation removes or destroys all forms of microbial life including bacterial spores.

Each instrument or piece of medical equipment which comes into contact with a patient is a potential source of infection. These are divided into 3 groups of risk:

- high risk
- intermediate risk
- low risk

High risk items come into close contact with a break in the skin or mucous membranes or are introduced into a normally sterile body area. e.g. surgical instruments, needles, urinary and other catheters. Sterilisation is required for this group.

Intermediate risk items come into close contact with mucous membrane or are items contaminated with particularly virulent or readily transmissible organisms. e.g. Items of respiratory equipment including laryngoscope blades, endotracheal and

tracheostomy tubes, oropharyngeal and nasal airways. Disinfection is required for this group.

Low risk items only come into contact with normal intact skin. e.g. stethoscopes or washing bowls. Cleaning and drying is usually adequate for this group.

Techniques of disinfection and sterilisation
Before equipment is to be disinfected or sterilised, it should be thoroughly cleaned to remove any visible dirt or secretions. This involves washing with water and detergent (soap). Protective clothing (an apron, gloves and a facemask) should be worn.

Disinfection is best achieved by moist heat such as boiling in water (100°C for 10 minutes at sea level) which kills all organisms except for a few bacterial spores. It is important to remember that the temperature at which water boils decreases with altitude and a longer boiling time will be required. e.g. at 4000m above sea level where boiling occurs at 86°C a minimum of 20 minutes is required for disinfection. It is important to note that boiling equipment items in water will not achieve sterilisation.

Disinfection can also be achieved by using chemicals which however may themselves be toxic when allowed contact with skin or are inhaled. They can also be corrosive and flammable so that protective clothing (gloves, apron and a facemask) should be worn. Chemical disinfectants may be supplied ready to use or may need accurate dilution to provide an appropriate solution. It must be remembered that disinfectants can decay and lose activity. Decay is more rapid at high temperatures and can be accelerated by the presence of impurities. All disinfectants take time to work.

Range of activity of disinfectants
Gram positive bacteria e.g. Staphylococci, are more sensitive than gram negative bacteria e.g. Pseudomonas. Mycobacteria and spores are relatively resistant. Enveloped viruses e.g. HIV are killed by most disinfectants but non-enveloped viruses e.g. Coxsackie tend to be more resistant.

Spores. Fungal spores are easily killed by disinfectants. Other bacterial spores e.g. Clostridia are resistant to most disinfectants in common use. Tubercle bacteria are more resistant to chemical disinfectants than other bacteria. They can be killed by exposure to 2% alkaline Glutaraldehyde solution (Cidex) for 60 minutes.

Viruses. Hepatitis B virus (HBV) and Human Immunodeficiency Virus (HIV) are inactivated by Cidex in 1 - 2 minutes, although to ensure adequate penetration, soiled items should be placed in a 2% glutaraldehyde solution for 30 minutes. Exposure to 70% alcohol solution for 10 minutes is also effective. Viruses causing Rabies, Lassa fever and other haemorrhagic fevers are also killed by Cidex.

Chemical disinfectant solutions
Clear Soluble Phenolics (e.g. Stercol & Hycolin) are good for killing most bacteria including TB.

They have limitied activity against viruses.

Hypochlorites (e.g. Presept & Milton) have a wide range of activity against bacteria, fungi, viruses and bacterial spores. They may be used for decontaminating any area with blood spillage. They are corrosive to metals and must be applied at the correct concentration. They are inactivated by organic matter and decay on storage.

Alcohols (eg methanol, ethanol & isopropanolol) have good activity against bacteria & viruses. They should only be used after all the visible surface dirt has been removed from the area to be disinfected.

Aldehydes (e.g. glutaraldehyde & formaldehyde) are active against bacteria, viruses and fungi. They have a slow action against tubercle bacilli and are irritant to skin and eyes.

Sterilisation
This can be achieved by steam, steam & formaldehyde, hot air, ethylene oxide or irradiation. Autoclaving is the commonest method. It uses steam under pressure and is the most reliable way to sterilise instruments. A temperature of 134°C for 3 minutes or 121°C for 15 minutes is recommended.

Formaldehyde is irritant to the eyes, respiratory tract and skin. It can also be absorbed by some materials and subsequently slowly released with potentially hazardous results. Hot air sterilisation takes a long time and items must be able to withstand temperatures of at least 160°C for periods of 2 hours or more.

Ethylene oxide is a colourless gas which is toxic to inhale. It is effective against all organisms and does not damage equipment. The operating cycle ranges

from 2 - 24 hours so the turnaround time is prolonged and it is a relatively expensive process.

Sterilisation by irradiation is an industrial process and particularly suited to the sterilisation of large batches of products. Irradiation can cause serious deterioration of materials and is therefore not a suitable method for the resterilisation of equipment items.

Summary of Decontamination Procedures

Respiratory equipment. Sterilisation is unnecessary since spore-bearing organisms are not a cause of respiratory infection. Infection hazards can be reduced by lowering the amount of condensation in a circuit by means of heat-moisture exchangers, moisture traps and by the regular cleaning and drying of valves and circuits.

Many hospitals do not have access to disposable ventilator circuits and therefore with mechanical ventilators the internal circuit can often be autoclaved. The external (or patient) circuit and humidifiers may be disinfected in a washing machine at a temperature of at least 71°C for 3 minutes. The external circuit should be changed every 48hr or between patients. Heated water humidifiers should be cleaned, dried and refilled with sterile water every 48-72hr. If nebulisers are used they should be rinsed in alcohol after cleaning every 48 hours.

Anaesthetic face masks should be washed and cleaned after each use.

Laryngoscope blades should be washed after use and disinfected either chemically by soaking in 70% alcohol for 10 minutes, or by thermal means such as boiling in water at 100°C for 5 mins.

Endotracheal tubes intended for single use can be re-used if they are cleaned and disinfected. Thermal methods are likely to cause material damage but following cleaning, chemical disinfection can be provided by immersing tubes in a solution of 70% alcohol for 10min. The tubes should then be allowed to dry before use. 2% glutaraldehyde is not suitable as it may be absorbed by the plastic and is too irritant.

Suction catheters are not easy to clean but provided they are free of visible soiling they may be disinfected using 70% alcohol as descibed earlier and allowed to dry before use.

Instruments

Needles and cannulae (including spinal and epidural needles).

After thorough cleaning these must be sterilised. In many situations autoclaving is the most practical technique.

Further Reading:

Ayliffe GAJ, Coates D, Hoffman PN Chemical Disinfection in Hospitals. PHLS 1993.

OESOPHAGEAL DETECTOR DEVICES

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INTRODUCTION

Oesophageal intubation may occur with a difficult laryngoscopy, inexperience, an emergency situation, accidental extubation with movement of the patient's head, or distraction of the person intubating. An unrecognized oesophageal intubation may result in gastric distension, regurgitation, and hypoxic damage to the brain. Early detection of oesophageal intubation will prevent or reduce the morbidity and mortality of this life threatening situation. There are both clinical and technical tests that can be used to assess tracheal tube position [(1)]. Occasionally clinical tests prove unreliable and confirmation of the correct placement of the endotracheal tube by technical means is useful. One of the simplest and most reliable methods involves the use of an oesophageal detector device (ODD), the best alternative to capnography in differentiating oesophageal from tracheal intubation.

Although usually referred to as an ODD, both oesophageal and tracheal intubations are detected and due to its method of operation it has also been termed the negative pressure device.

Oesophageal detector devices (ODD) are designed to aspirate air via the endotracheal tube and depend on the structural differences between the trachea and oesophagus to indicate ETT position. The ability to aspirate air easily when connected to an ETT indicates tracheal intubation as the trachea and main bronchi have a rigid structure and do not collapse when a negative pressure is applied. Failure to aspirate air indicates oesophageal intubation as the oesophagus collapses around the end of the ETT.

Types of oesophageal detector devices

There are two major types of ODD (Figure 1). The first ODD was described in 1980[2], but Wee (1988) was the first to use the term oesophageal detector device, and also the first to publish a study on it[3]. The ODD is made by connecting a 60 ml catheter-tip syringe to a right-angled endotracheal tube connector by a short length of rubber tubing (Figure 1). The device is attached to an ETT and the syringe aspirated. If resistance is encountered when the syringe is aspirated i.e. with an oesophageal intubation, when the plunger is released it usually rebounds to its original position. O'Leary[4] regarded the aspiration of 30mls of air as indicating tracheal intubation.

Nunn described an adaptation using an Ellick's evacuator (a rubber bulb) and a connector [5]. The bulb is squeezed and attached to the ETT. Passive re-inflation indicates a tracheal intubation, while a failure to reinflate occurs with an oesophageal intubation. The bulb from a disposable bulb syringe may also be used.

The advantages of the ODD are listed in table 1.

1. ODDs can be easily assembled using inexpensive and readily available equipment. They are easy to use (even by non-anaesthetists), portable, non-electronic, and provide a highly reliable assessment of ETT position. They are ideal for use in countries where capnography is not routinely available. They may also be useful for intubations performed outside the operating room (e.g., in the recovery room, emergency room, intensive care unit, and out in the field).

2. ODDs provide a rapid assessment of ETT position. In Wee's original study[3], the average time to perform the test was 6.9 seconds (range 5 - 16 seconds). Nunn[5] obtained a result with the Ellick's bulb in 3 - 5 seconds. When the bulb from a disposable bulb syringe was used, full re-inflation of the bulb took up to 30 seconds in only 6% of tracheal intubations[6]. The result of the ODD test is obtained more rapidly than that from capno-graphy, and relies solely on observation.

3. ODDs are useful in patients in cardiac arrest as the test result does not depend on carbon dioxide being present in exhaled gas.

4. ODDs are useful when a Combitube (an emergency device that can be inserted into the airway blindly and used to ventilate patients) has

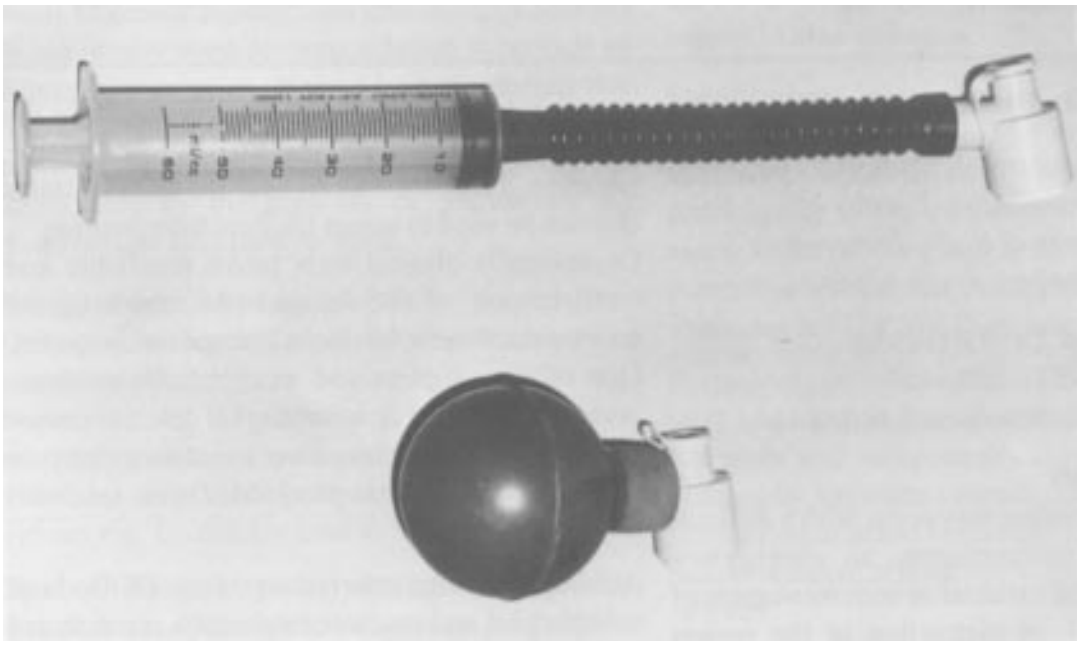

Figure 1. The two major types of oesophageal detector devices : Wee device (above), self-inflating bulb (below) as originally described. Subsequently, similar devices made with slightly different components have been described. See text for a description of the components used to assemble the devices.

been used. They can indicate whether the Combitube is positioned in the trachea or oesophagus, and whether or not the airway is patent.

5. ODDs can be re-used after cleaning or sterilisation.

The disadvantages of the ODD include:

1. Some false results may occur (Table 2). However, the incidence of this is low.

2. Regurgitation of gastric air, distension of the oesophagus with air, or an ODD that is not airtight may give a false impression of tracheal intubation when the tube is in fact in the oesophagus.

3. Thick secretions may occlude a tracheal tube[3] and give a false impression of oesophageal intubation. Occlusion of the bevel of a reinforced ETT by the wall of the trachea has been described to cause failure of bulb refill. Bronchial intubation, bronchospasm, tracheal compression, obesity, chronic obstructive pulmonary disease, may also cause resistance to aspiration or delayed refill of the bulb-type ODD.

4. Wee [3] had no problem in identifying tracheal intubation in two patients with moderate bronchospasm (peak airway pressures of 3.0 - 4.2kPa). However, delayed refill of the bulb-type ODD has been observed in an asthmatic patient. The slow re-inflation of the bulb seen in the presence of bronchospasm represents the slow exhalation that is characteristic of acute asthma.

Conclusions: role of the ODD

The ODD is a simple device, and its underlying principle is easy to explain, even to non-anaesthetists. Wee stated that instruction on the use of his device took five minutes. The ODDs have been reliably used by paramedics and by doctors not trained in anaesthesia.

ODDs are inexpensive, easily assembled, and generally very reliable. Although the required components may be found in many operating rooms it will take several minutes, at the very least, to collect and assemble them. The ODD should, therefore, be preassembled.

ODDs are ideal for use where capnography is unavailable. They are useful in hospitals which have capnography in the operating theatres, but not in the recovery rooms, wards and emergency rooms, and in hospitals where capnography is not yet available or affordable. It must be stressed that ODDs do not replace capnography, but they are the best alternative method to capnography in differentiating oesophageal from tracheal intubation. The ODDs must not be used on their own, but always in conjunction with clinical methods to assess endotracheal tube position.

Table 1

Advantages of the Oesophageal Detector Devices

1. Easy to use : Can be reliably used by paramedical staff and doctors not trained in anaesthesia.
2. Short instruction period required.
3. Can be assembled with readily available equipment.
4. Inexpensive.
5. Portable.
6. Non-electronic : No electricity supply is required.
7. The test result is rapidly obtained.
8. Highly reliable.
9. Reliable during cardiac arrests.
10. Reusable.

Table 2

Causes of False Results with the Oesophageal Detector Devices

False positive result (a)

1. Regurgitation of gas from the stomach.
2. Oesophageal distension with gas.
3. Oesophageal detector device not airtight.

False negative result (b)

1. Thick secretions occluding the ETT.
2. Occlusion of the end of an ETT (with no Murphy eye) by the tracheal wall.
3. Bronchial intubation.
4. Bronchospasm.
5. Tracheal compression.
6. Obese patient.
7. Chronic obstructive pulmonary disease.

ETT = endotracheal tube.

(a) ETT in oesophagus, and able to aspirate air with the syringe or the bulb refills (suggesting tracheal intubation).

(b) ETT in trachea, and unable to aspirate air with the syringe, or the bulb does not refill (suggesting oesophageal intubation).

A copy of this article with a full set of references can be obtained by writing or sending e-mail to Dr. R.P. Haridas:

References:

1. Clyburn P, Rosen M. Accidental oesophageal intubation. (Review) British Journal of Anaesthesia 1994; 73: 55-63.
2. Pollard B. Oesophageal detector device. (Letter) Anaesthesia 1988; 43: 713-4.
3. Wee MYK. The oesophageal detector device. Assessment of a new method to distinguish oesophageal from tracheal intubation. Anaesthesia 1988; 43: 27-29.
4. O'Leary JJ, Pollard BJ, Ryan MJ. A method of detecting oesophageal intubation or confirming tracheal intubation. Anaesthesia and Intensive Care 1988; 16: 299-301.
5. Nunn JF. The oesophageal detector device. (Letter) Anaesthesia 1988; 43: 804.
6. Zaleski L, Abello D, Gold MI. The esophageal detector device. Does it work? Anesthesiology 1993; 79: 244-7.

LETTERS TO THE EDITOR

Spinal Anaesthesia for Caesarean Section

Sir,

I read with interest D. Wilkinson's letter *"Low Spinal Anaesthesia for Caesarean Section"*[1] and although I agree with some of his points I have some queries about others.

Although not specified, one may guess that the heavy bupivacaine used is the common 0.5% solution. This should be mentioned as higher concentrations of 0.75% are used in some countries. I share the view that 1.5ml of anaesthetic solution (7.5mg) provides adequate levels of anaesthesia. The same amount is used successfully in Durban[2]. This is in contrast with other South African data[3] of a standard dose of 2.5ml (12.5mg). The latter amount is widely used in developed countries, where it is considered by some[4] that volumes of 2ml or less of heavy bupivacaine 0.5% are followed by an excessive number of inadequate blocks.

It would have been interesting to know the levels of upper sensory block in Wilkinson's experience. Working in similar conditions and with the same population of Zulu women, and using the same amount of anaesthetic solution, our average level of sensory blockade was T4.6 ($\pm$3.2 (median : T4; range : C5-T8, using Keegan and Garrett's non-overlapping dermatome map).

In contrast with Wilkinson, I did not keep the patients sitting after the subarachnoid injection, since other studies[5-6] have reported no effects of posture on the spread of hyperbaric as opposed to plain solutions. Since the main thrust of the letter was a "*low*" spinal obtained by keeping the patients sitting for 5 minutes, it would have been interesting to report the level of blockade to substantiate the relevance of the method. It is also not stated whether the patients were in labour or not. It is generally considered that hypotension is more prevalent and of greater magnitude in elective cases. Only 59 patients had a systolic blood pressure fall by an average of 16%, which is not hypotension by international criteria. Only 5% had a decrease of $\geq$39mmHg. This is surprising and exceptional! In a mixed population of 175 cases (20% elective cases; 14% hypertensive disease of pregnancy) I experienced hypotension <30% or more from baseline and (<90mm Hg) in 37.7%.

References:

1. Wilkinson D. Low spinal anaesthesia for Caesarean section. Update in Anaesthesia. 1996; 6:28
2. Bhagwanjee S, Rocke DA, Rout CC, Koovarjee RV, Brijball R. Prevention of hypotension following spinal anaesthesia for elective Caesarean section by wrapping of the legs. Br J Anaes 1990;65:819-822
3. Braithwaite H. Comparative study of time to produce surgical readiness between spinal anaesthesia and general anaesthesia for emergency Caesarean section. S Afr Fam Pract 1993; 14:46-49.
4. Kestin IG. Spinal anaesthesia in obstetrics. Br J Anaes 1991;66:596-607
5. Wildsmith JAW, McClure JH, Brown DT, Scott DB. Effects of posture on the spread of isobaric and hyperbaric amethocaine. Br J Anaesthes 1981;53:273-278
6. Stienstra R, Van Poorten JB. Plain or hyperbaric bupivacaine for spinal anaesthesia. Anesth Analg 1987;66:171-176

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Dear Sir,
In favour of an extra half ml.

We write regarding Dr Wilkinson's description of a low spinal blockade for Caesarean section (Update in Anaesthesia 1996;6:28). This is a technique which we have both used frequently and the comments below partly stem from personal observation. We believe that there are several important caveats that one should be aware of before recommending this technique widely.

1.5mls of 0.5% heavy bupivacaine given in the method described will only give a block to approximately the level of T10. The consequences of this are firstly that a vertical incision may not be anaesthetised at the upper margin and secondly that visceral peritoneal nerve fibres are not anaesthetised: this requires blockade up to the level approximately T-6, as described previously in this journal. Surgery, in particular peritoneal and uterine traction has to be very skilful and gentle if this method is to be effective.

In addition the small volume of local anaesthetic injectate correlates with a shorter duration of surgical anaesthesia and there can sometimes be a regression of block which leads to difficulties towards the end of the procedure; in particular patient discomfort along with significant abdominal muscle tone making wound closure troublesome. Incomplete surgical anaesthesia occurring when surgery is underway can be difficult to manage and potentially disastrous, especially for the sole operator-anaesthetist. This is a real possibility when using such a small amount of local anaesthetic and could easily occur, especially if surgery lasts longer than 30 - 40 minutes, as may be the case with an inexperienced surgeon, or with unexpected surgical difficulties. It is possible that Dr Wilkinson's excellent results are partly due to his speed and skill as a surgeon, although it is interesting to note that 13% of his patients required further agent to supplement the anaesthesia.

Using a larger volume of bupivacaine, for example 2.0 - 2.5mls of 0.5% solution would avoid some of the potential problems outlined above. It must be emphasised however that any spinal anaesthesia, and especially when using larger amounts of local anaesthetic that the usual rules apply. Included in these are that the patient must be fully fluid resuscitated with intravenous fluids and that they should be free of significant cardiac disease. In these situations spinal anaesthesia with a larger amount of local anaesthetic may be dangerous or even fatal.

Although he is rightly worried about the risks of a higher spinal block including hypotension, the level of spread of a heavy solution is limited somewhat by the natural thoracic kyphosis, especially if a pillow is placed beneath the upper body to exaggerate this.

Hypotension can be a problem but is easily treated with appropriate fluid. If necessary a vasopressor such as ephedrine may be used. One ampoule of 30mg can be diluted into a 10 ml syringe with saline and the anaesthetic assistant or nurse can inject boluses of 1 - 2mls as required to elevate the blood pressure. Alternatively one or two ampoules of ephedrine can be added to a bag of intravenous fluid and the rate of infusion adjusted in accordance with the blood pressure.

There can be little doubt that using a smaller dose of local anaesthetic lessens the cardiovascular effects of spinal anaesthesia. We are aware that vasopressors can sometimes be unavailable and that fluid resuscitation is sometimes limited. In these situations Dr Wilkinson's technique may well represent an appropriate compromise.

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Sir,

I feel I must comment on the letter entitled '*Low Spinal Anaesthesia for Caesarean Sections*' in your edition No. 6 of 1996.

The title obviously implies that a low segmental block was being administered yet the level of block is nowhere mentioned, a pity, as such is so easily ascertained by the judicious use of a needle or other methods.

Secondly, a caesarean section, because of the innervation of the peritoneum, to a large extent, by the Great Splanchnic Nerve with a root level of T5-9 needs a block to approximately T5 and even in the most stoical patients there will be evidence of discomfort if the block is much below this level. Therefore, I must conclude that the technique used by the author produced a block to this level and that therefore could under no circumstances be considered a low spinal.

However my main criticism is in the author's belief in the apparent novelty of his dosage of 1.5 mls of either hyperbaric or '*plain*' Bupivacaine. My personal experience in the UK of over 2000 Caesarean Sections under spinal anaesthesia was that a dosage of 1.6 mls of isobaric (hypobaric) bupivacaine was consistently adequate[1]. These patients were mainly of UK origin and therefore probably taller and heavier, on the average,

than those in Dr Wilkinson's series. However, in Rwanda in 1995 and in Burundi in 1996 working mainly with Hutu patients who are, on the whole, smaller, my normal dosage has always been 1.5 mls of hyperbaric Lignocaine and I have seen total spinals with dosages in the region of 1.8 mls. I certainly would not consider giving a larger dose than 1.5 mls and would not expect a low block, in the commonly used definition of the term, with this dosage. It could be said that comparing Lignocaine with Bupivacaine is not valid but my experience would tend to suggest that in the case of LSCS one can do so. I may add that I have had similar experiences with Cambodian and Afghan patients.

I conclusion, I do not believe that Dr Wilkinson has been using a '*low spinal*' technique, but merely a well tried procedure with a block to the correct level for the procedure in question.

Yours faithfully
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References

1. Dennison B. Combined spinal epidural techniques for caesarean sections. Canadian Journal of Anaesthesia 1987;34:105-6

Dear Sir,

I read the responses to my description of low spinal anaesthesia for caesarean section with interest, especially as Dr's Longmate and Hair both gained initial experience with this technique as colleagues of mine at Hlabisa hospital. Their letter suggests that the anaesthesia provided by a low spinal is inadequate at times, but that it is safe. They suggest using a higher dose but recognise the potential risks and advocate use of ephedrine more frequently, to control any hypotension. I see no real conflict in opinion here. My own preference however, is for a safe and simple anaesthetic that works for almost all people almost all the time. Their concerns are based on personal observation and not on systematically collected data and as such should be considered with caution, until they are able to publish prospective observations to back them up. Most medical officers in this hospital now use 1.8 - 2ml heavy 0.5% bupivacaine in the (untested) belief that it provides a better anaesthetic - it also seems clear, discussing this with them, that the incidence of hypotension is now higher. I find it difficult to reconcile this potential increase in risk without any documented increase in benefit.

I can advise Dr Dennison that the block achieved by 1.5ml heavy bupivacaine in our patients is consistently around the T10 dermatome, so it seems that this does produce a low spinal in our patients. I did not suggest that the technique is novel. I think that he is probably correct that it would be unwise to compare lignocaine directly with bupivacaine. I would however, disagree that a block to T5 is necessary for a caesarean section. I was taught to do this operation by a nurse in a rural hospital in Africa using local anaesthetic only. In several hundred patients, gentle surgery and local anaesthetic was more than adequate.

I think that we would all agree that anaesthesia for caesarean section in district hospitals in developing countries needs to be safe, simple and effective. Whatever technique is used, we should all regularly - and prospectively - audit our work so we can document how safe and how effective it is.

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Sponsored by: Overseas Development Administration
Typset by: Clinical Graphics, Royal Devon & Exeter Healthcare NHS Trust, Exeter, UK.
Printed in Great Britain by: BPC Wheatons Ltd, Exeter, UK.
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