Intraoperative care

Prior planning and preparation protects patients

World Health Organization ‘Safe Surgery Saves Lives’

In 2008, the World Health Organization (WHO) established the ‘Safe Surgery Saves Lives’ initiative to reduce the number of unnecessary surgical deaths and complications. The initiative aims to address important safety issues including inadequate safety practices, avoidable surgical site infections, and poor communication among team members. WHO established ten essential objectives for safe surgery:

1. The team will operate on the correct patient at the correct site.
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2. The team will use methods known to prevent harm from administration of anaesthetics, while protecting the patient from pain.
3. The team will recognize and effectively prepare for life threatening loss of airway or respiratory function.
4. The team will recognize and effectively prepare for risk of high blood loss.
5. The team will avoid inducing an allergic or adverse drug reaction for which the patient is known to be at significant risk.
6. The team will consistently use methods known to minimize the risk for surgical site infection.
7. The team will prevent inadvertent retention of instruments and sponges in surgical wounds.
8. The team will secure and accurately identify all surgical specimens.
9. The team will effectively communicate and exchange critical information for the safe conduct of the operation.
10. Hospitals and public health systems will establish routine surveillance of surgical capacity, volume and results.


The WHO surgical checklist and local adaptations of it is a recommended set of standard procedures to follow for every patient undergoing surgery.

This includes the ‘sign-in’ before induction of anaesthesia, which confirms the correct patient is present and has consented for the agreed procedure, and that the surgical site is correctly marked and allergies and risks of bleeding or difficult intubation have been identified.

The ‘time-out’ before the start of surgical intervention is a further check that the correct patient is present on the operating table and that all necessary staff are present and equipment available. Any significant surgical or anaesthetic risks are identified at this point and consideration given to aseptic technique, antibiotic, and venous thromboembolism prophylaxis.

The ‘sign-out’ is for confirmation of an adequate record of the procedure, that all equipment used is accounted for, specimens labelled, and that any concerns for postoperative care have been identified.

**Five steps to safer surgery**

In December 2010, along with the three steps of the WHO Surgical Check list, the National Patient Safety Agency (NPSA) supported the addition of team brief and debriefing sessions at the beginning and the end of
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Theatre lists to make ‘five steps to safer surgery’. These steps aim to promote team performance and safety, with additional benefits of reducing delays, improving communication, and creating a safety climate.²

**Patient positioning**

Another key aspect of intraoperative care is the protection of the patient from inadvertent injury while under anaesthesia. Safe transfer of the patient and positioning on the operating table are vital. Knight and Mahajan have published a concise summary of this aspect of care.³

All patients are at risk of injury if attention to positioning is not ensured, but certain patient groups (extremes of age, particularly the older patient, morbid obesity or marked cachexia, those with skin fragility [long-term steroid use]) and certain procedures that require specific patient positioning (e.g. lithotomy) will carry extra risks of inadvertent injury.

The types of potential injury include pressure sores (increased risk in longer operations) and skin injury from adhesive dressings, nerve injury (direct pressure or stretch on susceptible nerves), thermal injury (both hypothermia and burns), corneal abrasions, vascular compromise, and electrical injury associated with diathermy use. Faulty equipment or misuse of equipment pose significant risks.

**Pressure sores**

Pressure sores are a major source of pain and distress, increasing the length of stay and costs. The process of skin necrosis may begin in the operating theatre. Simple measures, such as pressure relieving mattresses, gel pads for heels or occiput may reduce if not remove the risk.

Extra care when applying and removing adhesive drapes or dressings (electrocardiograph dots and eye tapes included) may reduce the risk of skin loss. Those patients on long-term steroids or those with thin and fragile skin are at increased risk.

**Nerve injury**

Nerve injury can be profoundly debilitating for the patient and is the second most common class of injury associated with claims in the USA (American Society of Anesthesiologists [ASA] Closed Claims Project database). Likely mechanisms include stretch, compression, and ischaemia of the nerve, although a clear-cut cause is often not identified. Certain co-morbidities such as diabetes (microvascular complications affect nerves) or pre-existing neuropathy may increase incidence, but all patients should be assumed to be at risk of nerve injury.
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Brachial plexus injury is most likely to occur if the arm is abducted by more than 90° while the head is rotated away from the abducted arm causing compression against first rib, clavicle, and humerus. In the prone position care must be taken to ensure the chest support does not impinge on and cause compression of the plexus in the axilla.

More than 25% of all intraoperative nerve injuries involve the ulnar nerve. It is vulnerable to stretch and external compression in the ulnar groove at the elbow. Appropriate padding should be applied, especially in the prone position.

In the Lloyd-Davies and lithotomy positions, sciatic and obturator nerve injury can be caused by extreme flexion of the hip joints causing stretch. This may also lead to compression of the femoral nerve under the inguinal ligament. The common peroneal nerve (as it passes the neck of the fibula) and saphenous nerve (as it passes the medial condyle) are also at risk of compression injury. In the lateral position a pillow should be placed between the knees to prevent damage to these nerves.

The lithotomy position can lead to calf compression. The resulting reduction in perfusion pressure may increase the risk of venous thromboembolism and compartment syndrome. The longer the procedure, the higher the risk. If positioning the patient in lithotomy for over 5 hours invasive monitoring of calf pressures may be considered.

Eye injury

Corneal abrasion is the most common type of injury. The application of tape to keep the eyelid gently closed should minimize this risk, but eye ointment does not influence it. Direct pressure to the eyeball has the potential to cause retinal artery occlusion with the risk of loss of vision. During prone positioning a suitable head support that keeps pressure off the eyes must be used and the position of it checked during the course of surgery.

Patient falls

Major injury can arise as a result of a patient falling from the operating table during anaesthesia. Adequate measures should be taken to minimize this risk. This may be in the form of side supports, arm boards, and straps placed around the patient’s legs and pelvis. When a patient is being transferred between bed or trolley and operating table it is vital for both patient and staff safety that staff are trained in techniques for transfer.

Physiological compromise from positioning

The supine position, particularly when associated with head-down tilt, increases the pressure applied to the diaphragm by the viscera. This causes reduction in lung volumes and increased atelectasis. Hypotension may arise as a result of venacaval obstruction against the vertebral
bodies. Intracranial and intra-ocular pressures rise. There is an increased risk of passive regurgitation and aspiration of gastric contents. These features are magnified in the patient with morbid obesity. With head-up position the reverse applies but the risk of venous air embolism must be considered.

**Temperature management**

**Inadvertent hypothermia**

Inadvertent perioperative hypothermia is a common but preventable complication of operative procedures. Heat loss occurs from various physical processes (radiation, evaporation, conduction, and convection). Administration of cold fluids (intravenously or as intraperitoneal lavage) plus impairment of thermoregulatory heat-preserving mechanisms (i.e. peripheral vasoconstriction) caused by general or regional anaesthesia will further exacerbate this. Core temperature can be monitored at a variety of sites including nasopharynx, distal oesophagus, tympanic membrane (beware of errors relating to ear wax occluding the canal), rectum, and bladder.

Hypothermia, as well as being distressing for the patient, is associated with a variety of physiological disturbances, such as increased sympathetic activity, coagulopathy, and immunosuppression. Metabolic demands on the patients in the recovery phase increase due to shivering. Other risks from hypothermia include cardiovascular events, bleeding, delayed wound healing, infection, and increased morbidity. National Institute of Health and Care Excellence clinical guideline 65 addresses these issues.4

**National Institute of Health and Care Excellence guidance**

Hypothermia is defined as a patient’s core temperature of below 36.0°C. Elective surgery should not commence if the patient’s temperature is below 36.0°C. A variety of methods are available to actively warm patients but according to NICE there is only sufficient evidence to recommend forced air warming.4

Patients should be managed as higher risk for perioperative hypothermia if any two of the following apply:

- ASA grade II to V (higher the grade, greater the risk)
- preoperative temperature below 36.0°C (and preoperative warming not possible because of clinical urgency)
- undergoing combined general and regional anaesthesia
- undergoing major or intermediate surgery
- at risk of cardiovascular complications.
Those at higher risk who are having anaesthesia for less than 30 minutes and all patients for operations lasting longer than 30 minutes should be actively warmed intraoperatively.

All patients should be adequately covered throughout the intraoperative phase to conserve heat, and exposed only during surgical preparation. All intravenous fluids (500 mL or more) and blood products should be warmed to 37°C. All irrigation fluids used intraoperatively should be warmed to 38-40°C.

**Monitoring standards during surgery**

**Basic and advanced techniques**

In March 2007 the Association of Anaesthetists of Great Britain and Ireland (AAGBI) produced guidelines on perioperative monitoring standards. Monitoring devices supplement usual clinical observation by qualified medical staff. The minimum standard includes pulse oximeter (SpO2), electrocardiograph, and non-invasive blood pressure with appropriate alarm limits set. Advanced monitoring (CVC, arterial line, cardiac output assessment) may be indicated for specific patient co-morbidities or for certain operations associated with major physiological challenges. The key features of these monitoring modalities are outlined in Box 5.2.1 and 5.2.2.

**Box 5.2.1 Principles of basic monitoring**

**Electrocardiography**

- Allows interpretation of rate and rhythm, identifies conduction disorders, coronary ischaemia can be detected by ST segment depression
- Prone to artefacts from skin impedance and electromyographic noise
- Three or five electrode combinations can be used. The CM5 (clavicle-manubrium-V5) lead modification is good for identifying left ventricular ischaemia

**Non-invasive blood pressure**

- Oscillometry is the most common method. The cuff is inflated above systolic pressure and then slowly deflates. The vibrations of arterial wall are detected. Systolic and diastolic arterial pressure are measured, mean is calculated. The cuff width must
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- be 20% greater than the arm’s diameter (too small a cuff will cause over-reading and too large under-reading)
  - Arrhythmias and external pressure cause measurement inaccuracies
  - Repeated measurements during prolonged surgical cases may cause pressure injuries and ulnar nerve damage

**SpO2: Pulse oximetry**

- Continuous measurement of arterial blood oxygen saturation, based on the difference in absorption spectra of oxygenated and de-oxygenated haemoglobin at 660 and 940 nm wavelengths
- Inaccuracies can arise due to low perfusion states, motion artefact, ambient light, venous congestion, carboxyhaemoglobin (artefactually high reading) and methaemoglobin (artefactually low reading), signal interference from nail varnish
- Prolonged use maybe associated with localized heat or pressure injury


**Box 5.2.2 Principles of advanced monitoring**

**Arterial line**

- Records reliable beat-to-beat variation in blood pressure (important with expected rapid changes in blood pressure: rapid haemorrhage, planned hypotensive-anaesthesia (ear, nose, and throat, craniotomy, etc.))
- During long operations it avoids potential injury caused by repeated blood pressure cuff inflation
- It allows repeated blood gas sampling and analysis
- It may facilitate calculation of cardiac output (PiCCO, LiDCO, pulse pressure variation)
- There is an inherent risk of disconnection and exsanguination, arterial wall damage, thrombosis or vasospasm with distal ischaemia and infection
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### Central venous catheter

- May assist in the diagnosis of hypovolaemia/cardiac failure.
- Provides an estimate of right ventricular filling
- Monitors response to fluid volume challenge
- Provides central venous access to administer vasoconstrictors, inotropes and parenteral nutrition, and thrombophlebitic drugs
- Potential sites include jugular (preferred site NICE guidance), subclavian and femoral veins
- Ultrasound guidance with full asepsis for insertion is a NICE recommendation
- Complications include arrhythmias (from wire), vessel damage (including neighbouring artery) and haemorrhage (check for coagulopathy prior to insertion), catheter related infections (increased with femoral site) & thrombosis, pneumothorax, haemothorax, air embolus (use head-down position and occlusive ports for all access points during insertion and use)

### Oesophageal Doppler

- Provides an estimate of cardiac output using Doppler principle to measure speed of flow and estimated vessel diameter to calculate volume of flow
- It displays beat-to-beat variation in cardiac output and helps to guide optimization of cardiac function
- Patient tolerance is poor unless under general anaesthesia
- NICE published guidance in 2011 supporting the adoption of ODM and other technologies that can monitor cardiac output and guide intraoperative fluid therapy.

### Transoesophageal echocardiography

- Provides real time information and images of cardiovascular anatomy and physiology
- It can be used to assess cardiac status during non-cardiac surgery and to evaluate the effects of surgical intervention on the heart during cardiac surgery

Universal precautions

‘Standard precautions’ are the basic level of infection control precautions that are to be used in the care of all patients to minimize the risk of transmission of blood-borne and other pathogens from both recognized and unrecognized sources to or from patients. In addition to hand hygiene, WHO recommends that the use of personal protective equipment by staff should be guided by risk assessment and the extent of contact anticipated with blood and body fluids, or pathogens. An effective screening programme of high-risk patient groups may facilitate risk assessment but cannot be fool proof. Since, without testing, there may be no way of telling who is infected with a blood-borne virus, most UK organizations recommend staff should practice ‘Universal Precautions’ for all patients in their care.

Personal protective equipment

This comprises, as a minimum, gloves (double-gloving may be appropriate for high-risk circumstances) and a fluid-resistant gown (sterile for most operative procedures otherwise clean but non-sterile) and facemask and eye protection or a face shield.

Gloves should be worn when touching blood, body fluids, secretions, excretions, mucous membranes, and non-intact skin. Facial protection should be worn during any activities that are likely to generate splashes of blood, body fluids, secretions, or excretions. Gowns are worn to protect skin and clothing during similar episodes.

Sharps injury prevention

It is the duty of all healthcare workers to reduce the risk of needle stick injury to themselves, their co-workers, and patients. Institutions can assist in this by the provision of appropriately designed equipment such as non-cutting suture needles and safety cannulae for intravenous access. All used sharps should be discarded immediately into a sharps bin. Never re-sheath, bend, or disconnect needles. Do not overfill sharps bins, seal and replace when three-quarters full.
Actions for needle stick and other contamination injuries

Each institution is likely to provide guidance on procedure to follow in the event of contamination injuries. For eye splash this usually includes profuse irrigation of the eyes with saline. For sharps injuries an immediate attempt to ‘bleed’ the injury by squeezing is often advised to assist in flushing out pathogens or infected blood, thereafter thorough washing of the area with chlorhexidine or other antimicrobial scrubs is routine. Once these measures have been taken it is essential to assess the risk of infection arising from the injury: the type of injury (superficial or deep), the type of contaminated fluid (is it high risk for viral agents [blood, cerebrospinal fluid, semen, etc.] or low risk [faeces, urine, vomit, etc.]), the potential quantity of inoculation (visibly contaminated implements, in particular hollow needles, etc.), the risk of the ‘source’ individual from whom the body fluids were contacted. Assessment will usually involve asking the ‘source’ individual to give a blood sample for viral testing. The person sustaining the contamination injury should have a baseline sample of their blood taken to demonstrate whether they were free from viral infection prior to the injury. This raises ethical issues when patients are unable to consent. Once risk is fully assessed, occupational health or infectious diseases advice should be taken to guide any anti-viral or antibiotic therapy that may be warranted and counselling of affected individuals if indicated.

Precautions for electrical safety for staff and for the patient

Electricity can damage the body by electrocution, burns, or ignition of a flammable material. Damage is dependent upon the current pathway and density, the type (direct or alternating), and the duration of current.

Electrocution

Current pathway and density

The pathway that current takes through the body will determine which tissues are damaged. Current passing through the chest may cause ventricular fibrillation or asphyxia, whereas a current passing vertically through the body may cause loss of consciousness and spinal cord damage.

Current density (the amount of current flowing per unit area) will determine the effect. A 50 Hz alternating current flowing between each hand would cause a tingling sensation at 1 mA but ventricular fibrillation at 75 mA. Theatre staff should wear antistatic shoes with high impedance to reduce any current flowing through the body.

A current flowing directly into the myocardium (or in very close proximity to it) may generate a much higher local current density; theoretically 50 μA at 50Hz could cause ventricular fibrillation. This is known as
microshock. Examples of equipment that may facilitate microshock include central venous catheters and intracardiac pacemakers.

**Electrical burns**

When an electric current passes through any substance having electrical resistance, heat is produced. Whether or not this produces a burn depends on the current density. The patient should never be in contact with an earthed object (operating table, drip stand, etc.) as if this completes an electrical circuit the patient may receive a burn at the site. Burns may also result from poor contact between a diathermy neutral plate and the patient resulting in localized increased current density.

**Fires and explosions**

Spark proof switches and electrical sockets should be used in theatres to reduce the risk of spark generation, which can ignite flammable vapours. The use of diathermy may also ignite vapours or gases such as alcohol based cleaning solutions or bowel gas.

**Surgical diathermy**

Surgical diathermy uses the heating effects of high frequency (kHz–MHz) electrical current to coagulate and cut tissues. Accidental electrical burns may be caused by inadvertent depression of the foot switch. Keeping the forceps in a protective quiver and the installation of a buzzer, activated when the switch is depressed, may reduce this risk.

There are two types of diathermy—monopolar and bipolar.

Monopolar diathermy generates electrical energy at 200 kHz to 6 MHz. The energy is applied between two electrodes (neutral and active). The neutral electrode has a large conductive surface area producing a low current density with no measurable heating effect. The active electrode has a very small contact area resulting in a very high current density and high temperature.

Bipolar diathermy operates with a much lower power output. The output is applied between the points of a pair of specially designed forceps producing high local current density. Minimal current passes throughout the rest of the body.

Monopolar diathermy can inhibit or permanently damage pacemakers. If diathermy is essential, the bipolar variety should be used. Bipolar diathermy should be applied well away from the pacemaker and its wiring.
Conclusion

Optimal perioperative care of patients requires careful planning, coordinated team work, and attention to detail. Generic structured pathways of care that highlight common potential pitfalls will reduce risk of errors. Set standards of monitoring and awareness of likely mechanisms of injury enable development of routine practices to minimize risks. A universal approach to maintain these standards for all patients is the goal.

Further reading


References


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