Operating Theatre: Essential Concepts and Procedures

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The World Journal of Medical Education and Research (WJMER) is the online publication of the Doctors Academy Group of Educational Establishments. Published on a quarterly basis, it's aim is to promote academia and research amongst all members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from all parts of the world. The principal objective of this journal is to encourage the aforementioned from developing countries in particular to publish their work. The journal intends to promote the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting edge technology and those who need to innovate within their resource constraints. It is our hope that this will help to develop medical knowledge and to provide optimal clinical care in different settings all over the world. We envisage an incessant stream of information will flow along the channels that WJMER will create and that a surfeit of ideas will be gleaned from this process. We look forward to sharing these experiences with our readers in our subsequent editions. We are honoured to welcome you to WJMER.

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In this edition, these topics and more....

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Operating Theatre:
Essential Concepts and Procedures

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Introduction

The aim of this article is to introduce to the reader the basic, but essential, concepts that are part of an operating theatre set-up. As a medical student or as a junior doctor, these vital concepts are seldom explained by the busy surgical team. A firm knowledge of the basic principles will enable the student/ junior doctor to gain a clearer understanding of the structure, as well as the pitfalls, and enable them to become an active participant in theatre. The basic concepts described within this article include: sterilisation, laminar flow, patient positioning, how to scrub for theatre, principles of tourniquet usage, diathermy, radiography and the different types of instruments used in some of the common surgical procedures.

Sterilisation

This is the most fundamental and crucial component in an operating theatre setting but frequently doesn't come to the attention of the surgical team. Sterilisation is the process whereby all viable micro-organisms are destroyed.[1] In practical terms it is measured by the probability of one single micro-organism surviving on one million items. The term 'sterilisation' refers to equipment and not human skin.

There are numerous methods available to sterilise surgical equipment. One such method involves the use of an autoclave. This is a piece of equipment that pressurises steam to approximately 134 degrees Celsius. The use of steam in this manner is an effective method for killing bacteria, mycobacterium tuberculosis, viruses and heat resistant-spores. The total sterilisation cycle lasts around 30 minutes. The autoclaves are regularly checked by independent organisations to reduce the risk of infection.[1]

Another method of sterilisation is incineration. This is a process whereby all materials are completely destroyed by the use of heat. This is used when a patient is suspected of having a transmissible spongiform encephalopathy (TSE), or when equipment comes into contact with high-risk tissues such as the brain, spinal cord or the eyes which increase the risks for patients to develop TSE. Therefore incineration destroys the pathogen and also the material it may have been transmitted onto. This prevents future cross contamination and hence permits sterilisation.[1]

A dry heat of 160 degrees Celsius is an effective method of sterilising non-aqueous liquids, air tight containers or ointments. However, this should not be used with non-stainless metals which have fine cutting edges. Finally, the use of chemical sterilisation with sterilising agents such as ethylene oxide, glutaraldehyde and peracetic acid can be employed.[1]

Theatre Set-up Including Laminar Flow

The theatre environment must be controlled in order to limit cross-contamination with micro-organisms. This involves measures such as controlling the temperature, humidity and air circulation within the theatre.

Air circulation can be controlled by vertical or horizontal laminar flow systems. Laminar flow involves a continuous flow of filtered air which passes through ventilators into the operating theatre. The system ensures that no air can travel back into the room. The air is filtered to reduce airborne micro-organisms which may cross-contaminate the sterile field. Studies have shown that the use of laminar flow reduces the rate of post-operative sepsis.[2]

Increasing the number of cycles of filtered air reduces the quantity of air-borne pathogens. With conventional operating theatres, one can expect 20-30 air changes per hour. This results in airborne micro-organisms typically in the order of 150-300 colony forming units/m^3. Laminar flow operating theatres have up to 300 air changes per hour. One can expect airborne micro-organisms to be in the order of 10 colony forming unites/m^3.[3,4]

The process was first pioneered in the 1960s by Charnley and was proven to result in a reduced number of post-operative wound infections. Normally, the temperature of the theatre is within the range of 20-22 degrees Celsius. If the temperature falls below 21 degrees Celsius, the patient is at risk of hypothermia during prolonged procedures. For neonates, children and elderly patients, higher temperatures will be required for longer procedures. Another example is if a patient requires extensive debridement for the management of a large, dermal burn. In this instance, the temperature in theatre will be raised as burned patients can develop hypothermia.

Patient Positioning

During an operation, it is imperative that the patient is positioned correctly for a number of reasons. Firstly, the surgeon needs adequate and comfortable access to the anatomical site. The correct positioning is vital to minimise any trauma to anatomical structures. Furthermore, the position should not cause any unnecessary restriction on the patient's respiratory system. Some of the additional factors which need to be taken into consideration when positioning a patient include age, weight and the presence of comorbidities such as paraplegia.

Poor positioning may lead to nerve injury. For example, brachial plexus injury can result from stressing the patient's upper limb. Common fibular or saphenous nerve nerve damage may be acquired from poorly positioned leg supports. Careful positioning of the patient onto a comfortable operating table is important for maintaining patient safety.[5]

Pressure ulcers may also occur due to poor positioning of a patient. These tend to develop when the patient's own weight stresses a particular area of tissue for a prolonged period of time. Pressure ulcers are more likely to develop the longer the operation continues. Gel pads are commonly used to avoid pressure ulcers to vulnerable anatomical sites.[5]

There are numerous surgical positions. Each position imposes risks to anatomical structures.

Supine

This is the most frequent position used for most surgical operations, and involves the patient being laid flat on their back (Figure 1). Some of the most prominent pressure points in this position include the heel, the occiput and the sacrum.

Severe hypotension may arise if the Inferior Vena Cava is compressed against the vertebral bodies (particularly in pregnant or obese patients). Gastric regurgitation may occur, particularly in patients with a pre-existing hiatus hernia. The eye is at risk of direct or indirect trauma from the operating light causing corneal drying. This may occur within ten minutes of exposure, if not prevented appropriately.[5,6]

C8 and T1 nerve roots of the brachial plexus are predisposed to compression as these nerve roots are in close relation to the first rib, clavicle and the humerus. The risk can be reduced by preventing the patient's arm

Figure 1: *The Supine Position.*

from being abducted more than 90 degrees and keeping their forearm in pronation.[5]

Lithotomy

The lithotomy position involves the patient's legs being separated, with the hips flexed and the knees in varying degrees of extension. The legs are then supported by stirrups (shown in Figure 2). This position is utilised in gynaecological and urological surgery.

Figure 2: *The Lithotomy Position.*

Extreme flexion of the hip joints can cause neural damage by stretch (obturator and sciatic nerves) and by direct compression (femoral, peroneal and saphenous nerves).[5,6] The sites of direct compression are listed in Table 1.

Calf compression in the lithotomy position predisposes the patient to venous thromboembolism and compartment syndrome. The risk is increased if the patient's calves are held in this position for a prolonged period of time. Foot stirrups reduce the compression on the calves; however there is little evidence to show that this reduces the risk of compartment syndrome.[5,8]

Lateral

The lateral position involves the patient being laid ontheir side, usually with their arms stretched out perpendicular to the body. Their back is supported and the arm is rested on a pillow or an over-arm rest to prevent compression of the axillary neurovascular bundle (Figures 3 and 4). The lower limbs are usually flexed, with some sort of padding between the legs to prevent saphenous and peroneal compression. This position is used for surgical access to the spine, the posterior skull or for renal procedures[5].

Figure 3: *The Lateral position. The overhanging arm is supported by a rest and a pillow is placed between the legs.*

Figure 4: *The lateral Position (Posterior aspect). A support rests against the patient's posterior trunk to hold the patient in place.*

Problems which can be encountered with this position include excess pressure on the side of the face, shoulder and breast. This position may also compromise lung expansion as the lateral surface of the ribs rest against the operating table.

Prone

Figure 5: *The Prone position. Ideally, two pillows should be placed on the chest and pelvis allowing the abdomen to move during respiration. The same effect can be achieved using a Montreal mattress or a Wilson frame to avoid compression on the abdominal wall.*

Whilst in the prone position, the entire anterior surface of the face, trunk and lower limbs face the operating table (Figure 5). This position is particularly useful for some types of spinal surgery.

Problems with this position include excess pressure on: the ocular orbit, the breasts, the genitals and the dorsum of the feet. Padding should be placed over the orbital ridges and a pillow placed over the chest and the pelvis to prevent pressure ulcers.

Pressure on the abdomen can compress the Inferior Vena Cava that leads to a reduction in the venous return, and consequently, poor cardiac output. Ideally forearm support pads should be in place to limit the risk of ulnar nerve compression against the medial epicondyle of the humerus. There is also a risk of compression of the axillary neurovascular bundle against the humerus.[5]

Position	Pressure Sore Sites	Possible complications	Neural Damage	Mechanism of Neural Damage
Supine	Occiput Sacrum Heel	Inferior Vena Cava compression (obese, pregnant) Corneal Drying Gastric Regurgitation Severe hypotension	C8, T1	Direct compression at first rib, the clavicle and the humerus
Lithotomy	Calf Heel	DVT risk from calf compression	Obturator Nerve & Sciatic Nerve	Stretch forces from hip flexion
			Femoral Nerve	Direct compression at the inguinal ligament
			Peroneal Nerve	Direct compression at the neck of the fibula.
			Saphenous Nerve	Direct compression at the medial condyle of the tibia.
Lateral	Face Shoulder Breast	Compromise lung expansion	Peroneal Nerve	Direct compression at the neck of the fibula
			Saphenous Nerve	Direct compression at the medial condyle of the tibia.
			Brachial Plexus	Compression at the Axilla
Prone	Orbit of the Eye Breast Genitals Dorsum of the feet	Compromise lung expansion Poor Cardiac Output	Ulnar Nerve	Compression of the Cubital tunnel
			Axillary Nerve	Indirect compression against the humerus

Table 1: *Summary of the complications from different surgical positions.*

Preparing for Theatre

The scrubbing procedure reduces the cross contamination of micro-organisms that exist on the surgeon's hands, finger nails and forearms. Micro-organisms are removed by the combination of strong cleansing agents, including betadine and chlorhexidine, and a systematic cleaning procedure.

Prior to the surgical scrubbing procedure itself, you must change from normal clothes into scrubs, which are usually found in the theatre changing rooms according to size. You also need to put on theatre shoes. Most theatre staff will wear special clogs, however, if you don't have a pair of your own there are usually plenty of spares in the changing rooms – just ensure that you choose a pair without someone else's name in, as there is nothing more embarrassing than being accused of wearing your consultant's favourite shoes!

Next, you should remove all of your jewellery. The only acceptable jewellery to be worn in theatre is a plain wedding band. Some people may wear earrings, but ideally these should be removed as there is the risk of them falling out.

Once changed you should put on a theatre hat, prior to leaving the changing rooms. This should completely cover the hair. Once you get into the theatre, you will also need to put on a face mask. The most important point with the face mask is to ensure that you mould the firmer part around your nose, and ensure that it is comfortable. There is nothing worse than an uncomfortable mask for the duration of an operation, which you are unable to touch once scrubbed.

Another piece of protective clothing which is not always used is eye protection. These can come as separate pieces of equipment, or attached to the face mask. Many people will not use eye protection but it is strongly recommended, especially during operations with a lot of potential for blood exposure such as in vascular and orthopaedic procedures.

Scrubbing should take place in a designated scrub room within the theatre. At the start of a list, the scrubbing procedure should last for about 3-5 minutes. This time does not account for rinsing time. During the procedure, it is important that no contact is made with non-sterile objects. If the arms or forearms come into contact with non-sterile objects, the scrub procedure must restart. It is therefore advised that at all times during the procedure the arms and forearms are carefully manoeuvred.

The surgical gown is packaged so that the person who is scrubbing in comes into contact with the inside of the gown whilst putting it on. After scrubbing, the hands must not come into contact with the outside surface of the gown. If this occurs, the gown will be considered as contaminated and must be discarded.

Whilst scrubbed in, the hands should be raised 20-30 degrees above the elbows, and must always be kept above waist height. The scrub person's hands are considered to be contaminated if the hands fall below the waist line. The areas of the surgical gown which are considered to be sterile are the sleeves and the front of the gown above waist height.

Surgical Scrubbing

Before starting to scrub in, it is essential to ensure that you have all of the equipment that you are going to need. This is because once you are sterile you are not allowed to touch anything non sterile. You should ensure that you have your theatre hat, face mask and eye protection on, and that your surgical gown and gloves are prepared to put on.

You should turn on the taps and make sure that the water is of an adequate temperature. You want it warm enough to lather up and remove dirt, but not so hot that it is unbearable for the length of time that you are required to wash your hands under it. There are two types of hand wash to choose from. The first of these is a chlorhexidine-based product, which may be referred to as "Hibiscrub". The alternative is an iodine-based product which might be referred to as "Betadine". The soap dispensers have levers attached to them so that once you have started to wash you are able to use your elbows to dispense the cleansing solutions. Once you commence washing, you should not use your hands to adjust the taps or dispense the cleaning solution.

If you are scrubbing in for the first time that day, you should scrub for approximately 5 minutes. This can then subsequently be reduced to 3 minutes. For the first minute, you should wash your arms and hands and then rinse. It is important to clean in a distal to proximal direction. For example, after washing your hands, you should then continue cleaning from your wrist down to your elbow. Once you have wash down to both elbows (as seen in Figure 6) you should then rinse. Whilst rinsing, you should tilt your hands up from your elbows and run your arms through the water in one direction. You should not pass your arms back and forth through the water.

You should then repeat this general wash for the second minute. During the third minute, you should clean your nails thoroughly using a nail pick and a nail brush provided as shown in Figures 7 and 8). The fourth and fifth minutes should concentrate on washing the hands. This involves making sure that you wash the dorsum and palms, in between the fingers and the wrists thoroughly. If you require more hand wash it is important to press the handles using your elbows as shown in Figure 9.

Figure 6: *Arms should be scrubbed to the point of the elbows.*

Figure 7: *A nail pick is used to clean under the fingernail.*

Figure 8: *The tips of the fingers are cleaned using a nail brush.*

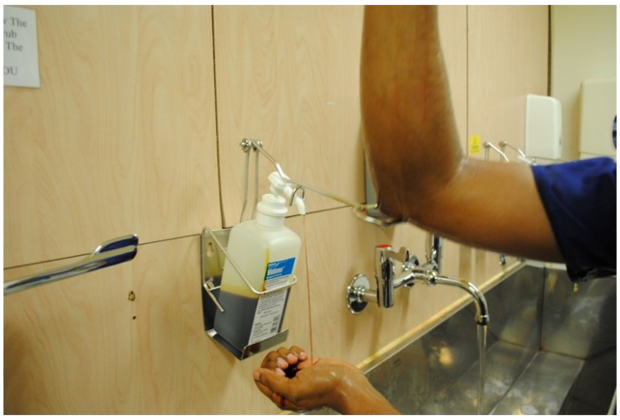

Figure9 : *The elbow should be used to press down on the lever to dispense cleaning agent.*

Once this process is complete, you should turn the taps off using your elbows only. Your arms should be positioned with your hands directly above your elbows, so that your elbow joint is forming a 90 degree angle. You should let the water drip off your arms, rather than shaking them.

Hands and arms are dried using sterile towels. You must dry one arm at a time, ensuring that you dry from hand to elbow continuously downwards, rather than returning to any sections. Once you reach the elbow, the sterile towel should be disposed of, and a new towel used for the other arm.

Now that the arms and hands are sterile, it is time to put on the surgical gown and gloves. You pick up the gown using both hands and allow it to open, ensuring that it does not touch anything else. As you are opening the gown the arm holes will become visible and you should slide your arms inside them, but keep your hands within the sleeves. A member of theatre staff will then pull the gown onto your shoulders and fasten up the ties at the back.

Keeping your hands inside the sleeves at all times, you should proceed to open up your sterile gloves and put them on (shown in Figure 10).

Figure 10: *Putting on gloves. Keep your hand within the surgical gown whilst donning the surgical gloves.*

The cuffs of the gown should be covered with the gloves because they are not water-resistant.

Finally, you must close the back of your gown. On the front of the gown, you will notice that there are some ties with a small piece of card attached to them. You should keep hold of the shortest tie, and hold the card in your hand. Give the card to a colleague, without touching them, and rotate in a circle to close the gown. Take hold of the longer tie, and secure the ties together with a knot.

Once the operation is complete, you are able to remove the protective clothing. You should start by removing the surgical gown first, followed by the gloves, and finally the mask. All should be disposed of in the appropriate bins. You should then wash your hands.

Skin preparation and draping

Prior to any surgical procedure, the patient's skin must be prepared in order to reduce the numbers of microbes on the skin surface. The cleansing solution used for this purpose needs to target a broad-spectrum of microbes, and must be fast-acting and tolerated by the patient. The patient's allergy status and surgeon's personal preference also have to be taken into account.

The main skin preparations used are either betadine or chlorhexidine, as used for surgical scrubbing. These are available in either aqueous or alcoholic preparations. The skin preparation is applied using sterile equipment starting from the centre and moving outwards.

The purpose of surgical draping is to create and maintain a sterile field. Different drapes will be used dependent on the anatomical site and the positioning of the patient.

Surgical Tourniquet

A pneumatic tourniquet is used in theatre to reduce the amount of blood loss whilst operating and also to help maintain a clear field of vision without blood obstructing the wound site. An image of a pneumatic tourniquet cuff is shown in Figure 11.

Figure 11: *Pneumatic tourniquet.*

Padding is placed around the arm where the tourniquet is to be placed (Figure 12). This is to protect the skin from trauma from the pressure of the tourniquet cuff. In local anaesthetic procedures, the patient may not tolerate the tourniquet for more than 20-30 minutes at a stretch. However when the patient is under general anaesthetic, tourniquets can be applied for longer (see below).

Figure 12: *Padding is placed around the arm before the tourniquet is put on the patient's limb.*

Tourniquets are applied at different pressures depending on the site of use and the age of the patient. In paediatrics, tourniquets are applied to children at a systolic pressure range between 140-250mmHg in the lower extremity and 155-190mmHg in the upper extremity.[9] In adults, there are two approaches for setting the tourniquet pressure. Tourniquets can be set to a fixed pressure (typically 250mmHg for the upper limb and 300mmHg for the thigh). Tourniquets may also be set at a fixed pressure above the systolic arterial pressure (100mmHg greater in the upper limb or 100-150mmHg greater at the thigh).[10] The tourniquet pressure is controlled by a tourniquet machine (Figure 13). The duration of time for which the tourniquet is to be applied is monitored by theatre staff. In principle the pressure and time of tourniquet usage should be kept at a minimum. Tourniquet use is monitored carefully because prolonged use can result in muscle fibre necrosis and micro-vascular injury leading to 'post-tourniquet syndrome'. This is when the patient has a swollen, pale, stiff limb. There is weakness however there is no paralysis.[10]

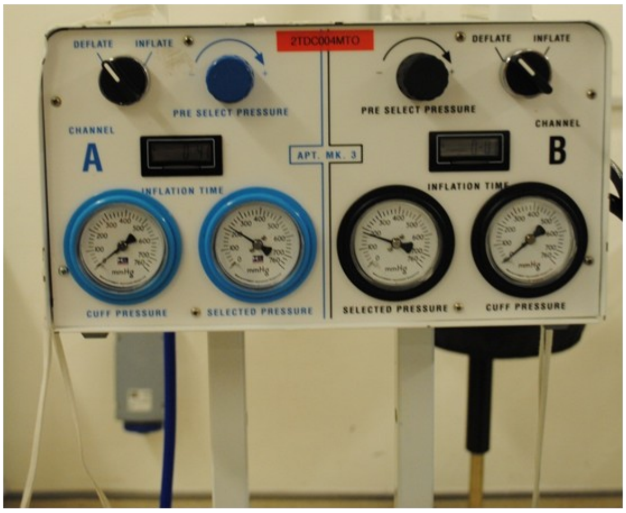

Figure 13: *Pneumatic Tourniquet machine.*

It has been reported that in the upper limb, the median, ulnar and radial nerve distal to the elbow are vulnerable to tourniquet paralysis which can take up to 210 days post operatively to recover.[11] Tourniquet use is contraindicated at sites of vascular grafts and also in patients with pre-existing deep vein thromboses.

The literature recommends that tourniquets are released for approximately 20 minutes after tourniquet application of 90-120 minutes. This is the point where ATP stores are depleted. The release of the tourniquet reduces the risk of ischaemic and neurological injury. The tourniquet is released for approximately 20 minutes and is then reapplied. At the end of an operation the tourniquet time should be documented.[10,12]

Tourniquet use can elicit pain in areas of muscle mass. There are various theories about the actual physiological mechanism of pain attributed to tourniquet application. One theory is that the ischaemia causes the release of local inflammatory mediators such as prostaglandins. This increases the excitation of local pain fibres. Another theory is that compression of the tourniquet continuously stimulates slowly conducting, unmyelinated, cutaneous C-fibres. Large nerve fibres are more susceptible to compression at the tourniquet site than these smaller C-fibres. The compressed larger nerve fibres are unable to inhibit the post-synaptic effect of the smaller C-fibres at the dorsal horn. This lack of inhibition of C fibres leads to the experience of tourniquet pain.[10,13]

Electrical Powering in theatre

A rigid clinical pendant system (Figure 14) is an integral part of the operating theatre. The pendent accommodates a number of electrical socket outlets, Anaesthetic Gas Scavenging Systems (AGSS) terminal units, data sockets and audio visual connectors. It can also be used to connect power drills (such as K-wiring, and a number of power saws used in orthopaedic procedures such as knee replacements).

Figure 14: *A rigid Clinical Pendent System.*

Surgical diathermy

Surgical diathermy requires the use of frequencies within the range of 400kHz – 3MHz. Low frequencies are not suitable as they can cause neuromuscular stimulation. High frequency currents enable enough energy to pass through to the tissue in order to heat up the particular area of tissue.

Monopolar diathermy involves an active electrode held by the surgeon which receives the high frequency current from a diathermy generator. Monopolar diathermy requires a complete circuit to be formed. The circuit consists of an arc between the active electrode, the patient's tissues and an active plate which is positioned underneath the patient. The circuit is completed by being connected back to the generator.

The monopolar diathermy device is able to cut through tissue via a continuous current or coagulate via a pulsed current. Tissue is cut through processes of initial dessication (cellular water is vaporised) and rapid tissue heating causing cells to destruct. Coagulation is possible as the pulsed signal seals the blood vessels without causing tissue disruption. In order to cut, the yellow button is pressed to produce a continuous output from the diathermy generator. In order to coagulate, the blue button is pressed to produce a pulsed output from the diathermy generator (Figures 15 and 16).

Monopolar diathermy can lead to burn complications. If a patient is not in full contact with the active plate then an incomplete arc exists. If the patient were to be in contact with a metal object, for example an intravenous drip stand or electrocardiogram electrodes, then this would complete the arc and result in a burn injury at the site where contact is made.

Figure 15: *Monopolar diathermy device. The yellow button cuts and the blue button coagulates.*

Figure 16: *A diathermy generator.*

Bipolar devices (Figure 17) are used for coagulation purposes and they do not require an active plate. Currency passes from each limb of the forceps and heats the tissue held between the two limbs. Bipolar devices are unable to cut through tissue. This is because there is no active plate and so a continuous arc cannot be formed between the electrode and the tissue, but instead between the two limbs of the forceps. Bipolar devices also cannot cut as the heat generated is insufficient to cause explosive vaporisation. For safety purposes the bipolar device is active once a foot pedal is pressed by the operating surgeon. Only when the foot pedal is pressed the device is able to be used (Figure 18).

Figure 17: *A Bipolar diathermy device (forceps).*

There are known complications of diathermy use in patients with a cardiac pacemaker in-situ. If diathermy is used near to a cardiac pacemaker, there is the chance that it may accidentally lead to contact between the active electrode and the pacemaker. If this happens, it may result in myocardial damage and lead to a cardiac arrest. Furthermore, the diathermy current can affect the circuits of the pacemaker which may lead to arrhythmias.[15]

Figure 18: *A Bipolar foot pedal.*

Finally, it is also important to take care with the application of alcohol gel when diathermy is going to be used. This is because alcohol gels are highly flammable and so if they are used at the site of a surgical wound, the diathermy could potentially ignite the gel and the skin underneath and surrounding it. If alcohol gel is applied, it should be placed away from the surgical site, or rubbed thoroughly into the patient's skin.[10]

Radiography

Radiography is used within many surgical specialities. X-rays are useful diagnostically as they allow the surgeon to image the bone during a surgical procedure. However X-rays are a source of ionising radiation. Overdoses of ionising radiation can lead to serious effects ranging from a mild burn to malignant diseases like leukaemia.

In order to regulate the use of X-rays and prevent such incidents, government guidelines have been published. There are two main regulations. The first is the Ionising Radiation Regulations 1999 (IRR99) which is to protect the staff from over-exposure to radiation. The second is the Ionising Radiation (Medical Exposure) Regulations 2000 (IRR(ME)2000) which is implemented solely to protect the patient.[1]

It must be clarified that the patient receives a low dosage of ionising radiation from each X-ray. Subsequently a patient has an extremely low risk of developing any unwanted effects from a single X-ray. However there is no 'safe' dose as every exposure can potentially cause some amount of tissue damage. Therefore the principle of 'As low as reasonably achievable (ALARA)' should be implemented. This means that the dose is as low as possible in order to obtain a perfect X-ray and ensuring that a repeat of the X-ray is not required.[1]

Staff members are at risk of over-exposure to radiation from the numerous radiographs taken in theatre over the course of many years. Therefore staff must wear protective jackets for each patient undergoing radiological investigation. Additionally, staff will wear a personal monitoring dosimeter which is processed in order to determine the value of the dose of ionising radiation the staff member has been exposed to.

The hospital appoints a Radiation Protection Adviser (RPA) who is a medical physicist who advises on staff and public safety in regards to IRR99. The RPA ensures that there are adequate contingency plans in case there is a malfunction with one of the X-ray machines.

When an X-ray is to be taken, the X-ray machines will flash a red light and an audible buzzer will signal the exposure time. Staff members without protective jackets should stand a minimum of 2 metres away from the X-ray machine, or ideally leave the room whilst the X-ray machine is in use.

All machines are serviced every 3 years to ensure that they are working safely. If there is an incidence in which a staff member receives a dose of 6mSv or greater, or 30% greater than the dose limit, they should contact the dosimetry services.[1]

WHO Surgical Safety Checklist

In industrialised countries the rate of perioperative death for inpatient surgery is 0.4-0.8% and the rate of major surgical complications is 3-17%. It has been reported that half of major surgical complications are avoidable. It has been shown that the implementation of practices to reduce surgical-site infections and anaesthesia-mishaps have improved the rate of complications. Additionally, it has also been reported that highly co-operative team work also reduces the rate of complications .The World Health Organisation (WHO) introduced the WHO Surgical Safety Checklist. This checklist is designed in three parts.[17]

The first part is the 'sign in' checklist which is checked prior to the implementation of anaesthesia. This includes confirming the correct identity of the patient and also the correct site of surgery and whether consent has been granted. Pre-operative risks are also assessed, including the risk of the patient bleeding greater than 500ml, the risk of aspiration and the risk of anaphylaxis to medication.[17]

The second part is called 'time out'. This part of the checklist is performed prior to the surgical incision. Similar to 'sign in' the identity of the patient, the site of the operation and the correct procedure is checked. Following this, the surgeon, the anaesthetist and the nursing staff consider the possibilities of complications from the procedure. First, the surgeon considers the length of the operation or anticipated blood loss. The anaesthetist considers whether there are any possible safety concerns in regards to the procedure. Finally, the nursing staff determine whether there are any issues with the operating theatre machinery and that a sterile field has been created for the procedure to take place. Additionally, checks are performed as to whether the patient has been given prophylactic antibiotic within 60 minutes of the procedure.[16, 17]

The final part is the 'Sign out' phase. This part of the checklist must be performed prior to the patient leaving the operating room. The surgeon, the anaesthetist and the nurse review any concerns they had. The nursing staff count (and later document) the numbers of swabs, scalpel blades and needles used in the operation. They also establish whether there were any problems with the operating machinery. Additional checks are performed to ascertain if prophylactic antibiotics have been administered within 60 minutes of the procedure, if applicable.[16,17]

Numerous studies have confirmed the efficacy of the WHO surgical safety checklist and that since its implementation there has been a reduction in the incidence of avoidable major complications during surgery.[16,17]

Surgical Equipment

This section will describe only the commonly used instruments in the operating theatre. Due to the many variations of instruments used between specialities, detailing all instruments is not within the remit of this chapter. The basic surgical equipment includes: scalpel handle and blades, forceps, needle holders, scissors, artery forceps, retractors and towel clips.

Scalpel blades and handles vary in size. In surgery, the most commonly used blades are sizes '10', '11', '15', '20' and '23' (Figure 19). A size '10' blade has a curved cutting edge and is used to make small surgical incisions in skin and muscle. It can also be used for more specialised types of procedures such as radial artery harvesting and inguinal hernia repair. A size '11' blade is a triangular shaped blade. It has a sharp tip ideal for making stab incisions and a flat cutting edge, ideal for chest drain insertion or opening of coronary arteries. A size '15' blade has a smaller cutting edge. It is ideal for making small and precise dissections, for example, excision of skin lesions. And finally a size '20' blade is similar in shape as a size '10'. It is used for larger incisions for general and orthopaedic procedures requiring large incisions e.g., an open laparotomy. A size '23' blade is 'leaf shaped'. It is used to make long incisions such as an upper midline incision of the abdomen.

The different blades are able to fit onto a scalpel handle (Figure 20). It is imperative that you take care whilst attaching the blade onto the handle. You should not grip the blade with your fingers but instead you should use a pair of forceps.

Figure 19: *(From Left to Right) Number 10,11,15,20,23 scalpel blades.*

Figure 20: *Scalpel handle.*

The two main types of forceps include serrated (Figure 21) and toothed dissecting forceps (Figures 22 and 23).Toothed forceps are known by this name as it has interdigitating teeth which holds tissue without it slipping (Figure 23). It is used to handle skin and dense tissue. Serrated forceps are used to handle and move delicate tissues during exploratory surgery without causing trauma. The surgeon holds forceps with his thumb on one side of the forceps and exerts pressure (in order to grip the tissue) onto the other arm of the forceps held in place by the index finger of the hand. It is also worth mentioning Babcock's forceps as in a similar nature to serrated edged forceps these also permit the handling of delicate tissue (Figure 24). It is held in a similar way to a pair of scissors or needle holders, to ensure a more

Figure 21: *Serrated edged forceps.*

Figure 22: *Toothed forceps.*

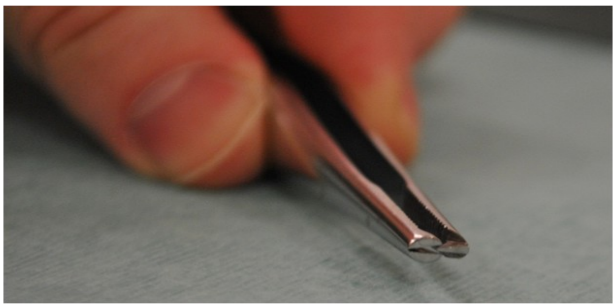

Figure 23: *The interdigitating teeth of the toothed forceps.*

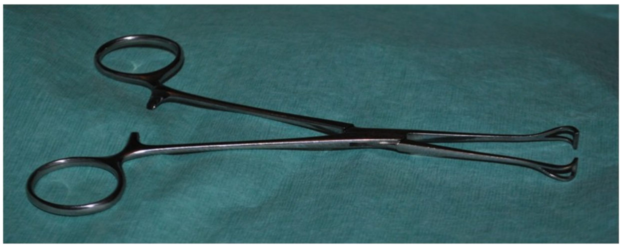

Figure 24: *Babcock's forceps.*

comfortable, firm grip of the tissue.

Artery forceps (Figure 25) are used to limit blood loss in theatre. Most types have a serrated edge that allows for a firm hold onto the artery. They are used to grasp onto an artery before it is ligated using a bipolar diathermy. There are different types, varying in size and shape. This is to suit the size of an artery that is to be held in place by the forceps (Figure 26).

Figure 25: *Artery Forceps.*

Figure 26: *Artery Forceps (From Left to Right) Halstead Mosquito Artery Forceps; Kocher Artery Forceps; Moynihan Artery Forceps; Rochester Artery Forceps; O'Shaughnessy Artery forceps.*

Needle holders are used in suturing. The needle holder has 4 key parts: the jaws, joints, the clamp and handles (Figure 27). The suturing needle is held in place between the jaws. The correct way to hold needle holders is thus; the index finger is positioned below the joint, whilst the thumb and ring finger are placed within the rings of the handles. This is shown in Figure 28.

Figure 27: *(From left to right) Debakey's needle holder, Kilner's needle holder.*

Figure 28: *The correct position to hold needle holders.*

Harold Gillies, one of the founding fathers of modern day plastic surgery, invented a needle holder which has scissor blades beneath the jaws (Figure 29). This is useful as a surgeon does not need to put down the needle holder or ask an assistant to use scissors to cut the suture thread after tying a knot.

Figure 29: *Gillies' Needle Holder. Note the scissors blades below the jaws of the needle holder.*

There are numerous types of scissors used in theatre. The main types are sharp ended and blunt ended scissors (Figures 30 and 31). In most surgical trays are the Mayo and the McIndoe scissors (Figure 31). These two types are blunted ended scissors. The Mayo scissors are used to cut sutures whilst the McIndoe scissors are used to dissect through tissue. The hardness of the scissors is important to a surgeon because scissors with harder edges stay sharp for longer and ease cutting through tissue or sutures. Different materials are used to ensure this: stainless steel or tungsten carbide. Scissors are held in a similar way to needle holders with the thumb and ring fingers passing through the rings of the scissors, the index finger supporting the shaft of the needle and the middle finger resting on one of the rings providing support.

Figure 30: *Sharp-ended scissors.*

Figure 31: *Blunt-ended Scissors. (From Left to Right) Mayo Scissors, McIndoe Scissors.*

There are too many different types of retractors to describe within this section. The two main types of retractors that will be discussed are self-retaining retractors and hand held retractors. Self-retaining retractors separate both edges of the tissue being excised (Figure 32). It has a ratchet mechanism that holds the two edges of the wound in place which frees up a surgeon's hand for him/her to use other equipment. The Mollison self-retaining retractor is commonly used for small skin incisions e.g., hand surgery, whereas Mayo-Adson and Cone self-retaining retractors are used to retract larger areas of tissue in neurosurgery for laminectomy procedures.

Figure 32: *Self-retaining Retractors. (From left to right) Mayo-Adson retractors; Cone retractors;Mollison retractors.*

Hand held retractors are used to hold other tissues and organs in place, improving the field of vision for the surgeon whilst operating. Usually the assistant in the operating theatre uses the retractors whilst the lead surgeon operates. The more commonly used types are: the Langenbeck retractor, Kilner's cheek retractor used in Oral and Maxillofacial surgery, Landon's and Doyen's retractor are both used in Obstetrics and Gynaecology, and skin hooks used mainly in plastic surgery (Figures 33 and 34). It is imperative that when you hold skin hooks that you do so with the utmost care in order to prevent an injury to yourself or a colleague. These instruments can lacerate skin with only a small amount of force.

Figure 35 shows a surgical mallet and chisel. These instruments are mainly used in orthopaedics and both vary in size. These instruments can be quite heavy. It is important to hold them with a strong, firm grip in order to prevent dropping them and injuring a colleague's foot. Towel clips are used to secure the drape over the patient. The three main types Schaedel, Backhaus and Mayo's towel clips are shown in 36. The scrub nurse will also prepare antiseptic cleaning solution in a pot and attach a sponge to the sponge holding forceps for the surgeon to clean the surgical area. In Figure 37, Rampley's sponge holding forceps are shown.

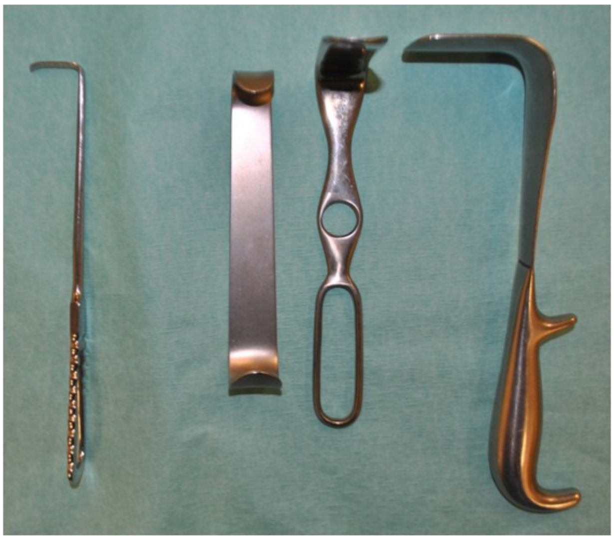

Figure 33: *Hand held retractors (From left to right) Langenbeck retractor; Kilner's cheek retractor; Doyen's retractor.*

Figure 34: *Skin Hooks. (From Left to Right) Kilner's Double skin hook; Gillie's skin hook.*

Figure 35: *(From left to right). Chisel and Mallet.*

Figure 36: *Towel Clips. (From left to Right) Schaerdal towel clip; Backhaus towel clip; Mayo's towel Clip.*

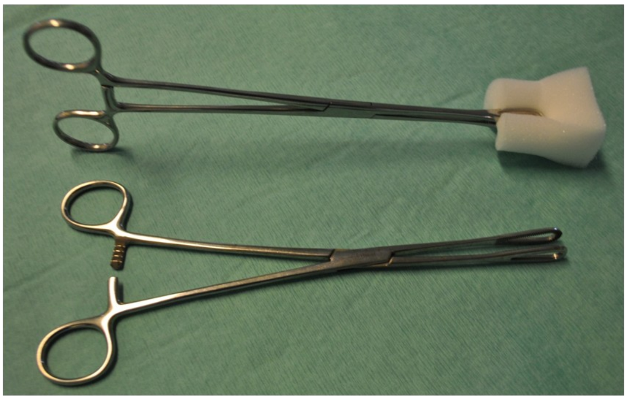

Figure 37: *Rampley's sponge holding forceps.*

Conclusion

In conclusion, there are numerous, important basic concepts about the operating theatre a student or a junior doctor must be aware of. Knowledge about diathermy and surgical instruments will allow the reader to identify these items in theatre and understand why they are used. Understanding the safety protocols of radiography and the WHO checklist will allow the reader to be safe within theatre as well as ensuring patient safety. Finally, this article teaches the reader how to scrub up for theatre. This will hopefully allow the reader to enhance and consolidate their surgical experience.

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