

Ankit Mishra and Michael C.B. Morgan

Introduction

Visiting the operating theatre and being part of the surgical environment can be an extremely fulfilling experience for a medical student, even in the pre-clinical years. However, students are typically not formally taught the basic practical skills that are necessary to make any surgical exposure worthwhile. These skills include scrubbing, gowning and gloving, and being able to identify surgical instruments and equipment. This chapter will cover these basics and more, and we recommend that you give it a read-through at the beginning of any hands-on surgical rotation – particularly if you are about to embark on a surgical elective!

Most of all, remember that theatre staff strive for safety in their work, and so it is very important for you to be honest about what you are able to do. It is always better to ask for someone to supervise you while you scrub for the first few times as it will give them (and you) peace of mind and ensure that you learn correctly.

Ankit Mishra and Michael Morgan are joint first authors.

A. Mishra (✉) • M.C.B. Morgan
GKT School of Medical Education,
King's College London, Great Maze Pond,
London SE1 3QD, UK
e-mail: ankit.mishra@kcl.ac.uk;
michael.m.morgan@kcl.ac.uk

The Surgical Scrub

Preparation for Scrubbing

Personal cleanliness is extremely important for staff in the operating theatre. Frequent hair washing, a daily shower and care of the hands and fingernails are vital. Nails should be trimmed so that they do not protrude over the tips of the fingers and should also be free from any polish or nail treatments. This will prevent them from puncturing gloves and make them easier to clean. If there is an infection, rash or open lesion on ones hands, nails or arms it should be reported to the person in charge. You should also attempt to use the restroom facilities before scrubbing to avoid having to leave the operating room once the procedure has begun.

Jewellery

Wrist watches and jewellery of any kind are a hazard in theatres and must not be worn. If possible, wedding rings should be removed before scrubbing as they harbour bacteria, although plain bands are permitted by most hospitals. There is a risk of earrings falling into the wound and they should also not be worn. Before any clinical contact with patients, staff should be bare below the elbows.

Hats

Hair must be completely covered with a clean disposable scrub that is changed daily, and on leaving the department or if it becomes visibly contaminated. The hats prevent falling hair or dandruff contaminating the sterile field. Beards must be covered with a hood.

Footwear

Closed-toe non-slip footwear is usually available for theatre staff. If there is a high risk of heavy blood or other fluid loss, boots should be worn.

Masks

The primary purpose of surgical masks is to protect the patient from the bacteria exhaled by the theatre staff. The scrub team is required to wear masks. It is at the discretion of the consultant in charge whether or not the other theatre members should wear a mask. If a prosthesis or implant is being surgically placed, all members of the theatre staff should wear a mask. The mask should be worn before the scrubbing procedure takes place and is not considered sterile. The mask should be changed between procedures as the barrier it provides can be disrupted by the mask becoming damp. This would allow droplets from the nose or mouth to penetrate the mask. A mask must fit snugly to the face to stop the passage of air around the sides and to prevent the fogging of glasses, if they are worn.

Scrubbing

The surgical scrub is part of establishing surgical hand antisepsis and is performed before donning the surgical gown and gloves. It aims to reduce the number of resident and transient microflora of the hands, wrists, and forearms, as well as inhibit their re-growth [1]. The first part of scrubbing is the hand wash with scrub solution (usually povidone-iodine or chlorhexidine) and

should last for 5 min. The following steps involve a sterile nailbrush and sponge and should last for 3 min (Figs. 9.1–9.12).

Gowning and Gloving

The sterile surgical gown and gloves are donned in a rather complex manoeuvre to avoid contaminating their outer surfaces. Both procedures require the aid of a circulating person, to open the unsterile packages and tie the gown at the back. The only parts of the surgical gown that are considered sterile are the sleeves (except the axillae), and the front between the neck and waist [5].

We have included step-by-step guides on gowning and gloving, but don't worry if you can't remember it all precisely! If you need to scrub up, theatre staff in the scrub room will be happy to help you (Figs. 9.13–9.39).

Incisions and Closures

Surgical Incisions

The surgical incision is a cut made through the skin (typically using a scalpel) by the surgeon in order to access internal viscera. The placement and length of incisions depend on the surgical procedure taking place, and in some cases multiple incisions may be necessary. Any surgical incision is traumatic and will impinge on the post-surgical stress response, the risk of surgical site infection (SSI), and the final cosmetic outcome. As such, it is important to minimise the size of an incision by placing it appropriately while at the same time allowing sufficient access to carry out the operation. Incisions may sometimes have to be extended, for example in order to remove a larger than expected mass or organ. The rationale behind reducing incision size has played a part in the development of minimally invasive surgical techniques, such as laparoscopy.

There are a number of common incisions, particularly in the thorax and the abdomen, which it will be useful to know as a medical student.

Figs. 9.1–9.12 Guide to surgical scrubbing

Ensure the temperature and flow of the water is to your liking (**Fig. 9.1**). Open the nailbrush package and place the nailbrush (still contained in the packaging) at the back of the scrub sink

**Fig. 9.1**

Wet your hands and arms with the prescrub wash. Create a heavy lather and wash from your hands all the way to your elbows (**Fig. 9.2**)

**Fig. 9.2**

Hands and arms should be rinsed thoroughly allowing water to run from the hands to the elbows. Do not retrace or shake your arms, rather let the water drip from the elbows (**Fig. 9.3**)

**Fig. 9.3**

Open the sterile brush and pick's package and remove them. Use the pick to clean underneath fingernails and then discard it. (**Fig. 9.4**)

**Fig. 9.4**

(continued)

Figs. 9.1–9.12 (continued)

Use the sponge side of the brush to lather the fingertips. Then use the bristle side of the brush to scrub the spaces under the fingernails on both hands (**Fig. 9.5**). When scrubbing it is essential that the hands remain above the level of the elbows and distant to the theatre wear to avoid splashing and contamination

**Fig. 9.5**

Using the sponge side of the brush, lather and wash the all sides of the finger (**Fig. 9.6**)

**Fig. 9.6**

Ensure the hands are scrubbed in the following order:

- (1) Palm to palm
- (2) Right palm over left dorsum and left palm over right dorsum
- (3) Palms together with the fingers interlaced
- (4) Palms to the dorsum of the opposing fingers interlocked
- (5) Rotational washing of right thumb in left palm and vice versa
- (6) Clasp fingers of right hand in left palm and rub. Repeat on opposite side

Wash the arms up until the two thirds of the forearm to avoid compromising the cleanliness of the hands

Rinse the hands and arms thoroughly from the fingertip to the elbow without retracing (**Fig. 9.7**). Ensure water drips from the elbow before moving on to the gown pack

**Fig. 9.7**

Figs. 9.1–9.12 (continued)

The gown pack should be opened for you. Pick up a single hand towel from the gown pack and step away from the table (**Fig. 9.8**)
Open the towel fully ensuring the towel does not contact anything unsterile – including unsterile parts of your body. Keep your hands and arms above elbow level whilst simultaneously keeping your arms away from your body (**Fig. 9.9**)



Fig. 9.8



Fig. 9.9

(continued)

Figs. 9.1–9.12 (continued)

Grasp the towel in one hand and use it to dry the fingers of the opposite hand using a blotting motion (**Fig. 9.10**)
 Continue this down the arm from forearm to elbow using the dry areas of the towel. Do not retrace any areas. Once completed discard the towel (**Fig. 9.11**)
 Repeat the previous steps with the second towel using the other hand (**Fig. 9.12**)

**Fig. 9.10****Fig. 9.11****Fig. 9.12****Figs. 9.13–9.17** Guide to gowning

Using one hand pick up the entire pre-folded gown from the packaging by grasping the gown through all of its layers. Ensure that only the inside top layer – which is exposed- is touched. Move away from the trolley or shelf (**Fig. 9.13**)

**Fig. 9.13**

Figs. 9.13–9.17 (continued)

Hold the gown as shown in the corresponding image – near the gowns neck and allow it to unfold whilst ensuring it does not touch any unsterile object or the body (**Fig. 9.14**)



Fig. 9.14

Slip arms partially into the sleeves of the gown whilst keeping hands at the level of the shoulders and away from the body (**Fig. 9.15**)



Fig. 9.15

(continued)

Figs. 9.13–9.17 (continued)

Slide arms in the gown sleeves up until the fingertips touch to proximal boundary of the cuff. Using the thumb and index finger grasp the interior of the seam at the cuff hem ensuring that no part of the hand protrudes out of the cuff (**Fig. 9.16**)

**Fig. 9.16**

A circulating individual should now assist to help position the gown over the gowning individual's shoulders by grasping the interior surface of the gown at the seams of the shoulder. The circulating person can now adjust the gown comfortably over the person's shoulder

The circulating individual's hands should only be in contact with the interior surface of the gown (**Fig. 9.17**)

The circulating individual now prepares to secure the gown. The neck and back are secured using Velcro tabs or ties. They tie the gown at waist level at the back

This method prevents contaminated surfaces at the posterior of the gown contacting anterior portions of the gown

**Fig. 9.17**

Figs. 9.18–9.25 Guide to gloving

Using the index finger and thumb contained still contained in the proximal cuff edge, open the inner package of the gloves and pick up one glove (**Fig. 9.18**)

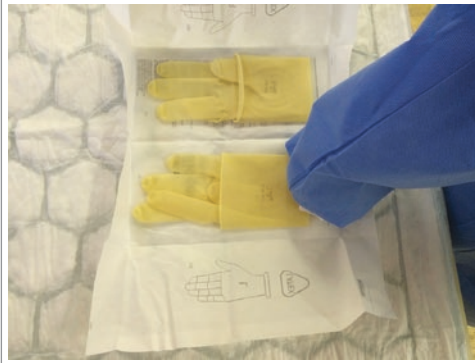


Fig. 9.18

Put the glove palm down on the opposite gown's sleeve. The glove fingers should be pointing in the direction of the shoulder. The palm inside the sleeve should be facing upwards (**Fig. 9.19**)



Fig. 9.19

The gloves rolled cuff edge should overlay the seam between the gown sleeve and cuff. Pinch the bottom of the rolled cuff edge of the glove using the thumb and index finger (**Fig. 9.20**)



Fig. 9.20

(continued)

Figs. 9.18–9.25 (continued)

While still pinching the gloves cuff edge with the ipsilateral hand, grasp the uppermost edge of the glove cuff with the opposite hand. Do not let the fingers protrude from either gown cuff (**Fig. 9.21**)

**Fig. 9.21**

Whilst still grasping the glove, stretch and unroll the glove cuff over the hand contained in the gown (**Fig. 9.22**)

**Fig. 9.22**

The opposite sleeve covered hand should grasp both the glove cuff and sleeve cuff seam and pull the glove over the hand (**Fig. 9.23**)

**Fig. 9.23**

Figs. 9.18–9.25 (continued)

Use the hand that is now gloved to repeat the process on the other hand (**Fig. 9.24**)



Fig. 9.24

When gloving is completed correctly, no part of the skin should have touched the exterior surface of the glove. Check that the cuff of the gown is covered completely by the glove. Adjust fingers of the glove as necessary to ensure a snug fit (**Fig. 9.25**)



Fig. 9.25

Figs. 9.26–9.30 Guide to the final gown tie

The scrubbed person will hold the belt tab proximal to any boundary line – here indicated in blue – in the right hand. The left hand will hold onto the left tie. Pull the tab with the right hand and give it to the circulating assisting person (**Fig. 9.26**)



Fig. 9.26

(continued)

Figs. 9.26–9.30 (continued)

The circulating person will take hold of the tab distal to any indicating line (**Fig. 9.27**)



Fig. 9.27

The circulating person will walk clockwise around the scrubbing person (**Fig. 9.28**)



Fig. 9.28

Figs. 9.26–9.30 (continued)

The scrubbing person will turn if necessary to receive the tie that is being carried by the circulating person

When the scrubbing person is properly positioned to receive the circulating tie, they can take hold of it without touching the tab. The scrubbing person now pulls the tie free from the tab leaving the tab in the hands of the circulating person (Fig. 9.29)



Fig. 9.29

The scrubbing person can now secure the ties on the left side (Fig. 9.30)



Fig. 9.30

Figs. 9.31–9.39 Guide to disposing of the gown and gloves

The circulating person unties the neck (**Fig. 9.31**) and back ties (**Fig. 9.32**)



Fig. 9.31



Fig. 9.32

Figs. 9.31–9.39 (continued)

The scrubbing person now grasps the gown at the shoulders (**Fig. 9.33**) and pulls the gown forward and down over the arms and gloved hands (**Fig. 9.34**)



Fig. 9.33



Fig. 9.34

(continued)

Figs. 9.31–9.39 (continued)

Keeping the arms away from the body, the scrubbing person now folds the gown ensuring the outside is folded inwards. The gown is then discarded in the appropriate bag/container (**Fig. 9.35**)

**Fig. 9.35**

Using a gloved hand, grasp the outer surface of one hand (**Fig. 9.36**) and peel off (**Fig. 9.37**). This is a 'rubber to rubber' peel. The glove is then discarded in the appropriate container

**Fig. 9.36****Fig. 9.37**

Figs. 9.31–9.39 (continued)

The second glove is removed by placing the fingers of the ungloved hand inside the cuff of the gloved hand (**Fig. 9.38**). This is a ‘**skin to skin**’ peel. The glove is then pulled up off the hand and then discarded into the appropriate container (**Fig. 9.39**)

**Fig. 9.38****Fig. 9.39**

While some incisions, such as the midline, are utilised in many surgical procedures, others are commonly associated with one operation in particular. It is therefore possible to deduce a little of a patient’s medical history just by observing their surgical scars.

Horizontal Versus Vertical Incisions

Horizontal (transverse) incisions follow Langer’s lines (the general direction that collagen fibres are organised in the dermis) and typically yield better cosmetic results with less pain. Vertical incisions are faster, may afford better exposure of internal structures, and are more easily extensi-

ble, but are more likely to become infected or dehisce (fall apart) [8].

Common Thoracoabdominal Incisions (Fig. 9.40)

- **Midline laparotomy** – A vertical incision is made along the *linea alba* except where it curves to avoid the umbilicus. It can be longer either above (upper) or below (lower) the umbilicus, or extend from the xyphoid process to the pubic symphysis. This latter variation is typically employed in trauma cases as it offers clear access to the majority of the abdominal cavity.

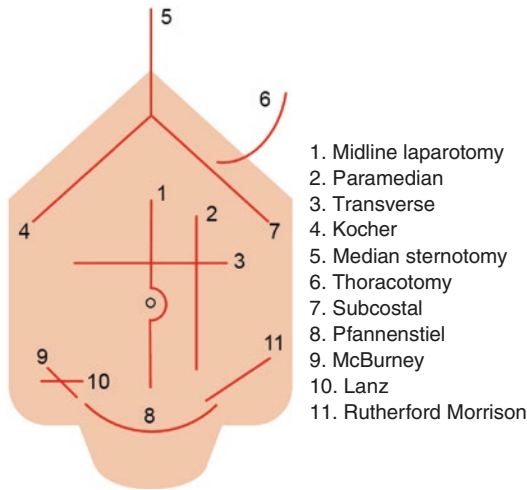


Fig. 9.40 Common thoracoabdominal incisions

- **Paramedian** – Any vertical incision placed laterally to the midline. It provides access to lateral abdominal structures, e.g. kidneys, and can be used in simple nephrectomy.
- **Transverse** – Any horizontal abdominal incision. They afford better exposure to the abdominal cavity than vertical incisions in children and obese patients due to their increased transverse abdominal length.
- **Kocher** – A right-sided subcostal incision used to access the gallbladder and biliary tree in open cholecystectomy.
- **Median sternotomy** – A midline thoracic incision made along the sternum, with a division of the sternum itself. It is often used in open cardiac surgeries, such as coronary artery bypass.
- **Rooftop** – Bilateral subcostal incisions, with improved access to upper abdominal structures (e.g. oesophagus, stomach, adrenal glands) compared to the Kocher. Also known as a chevron or gable incision.
- **Mercedes (–Benz)** – A median sternotomy (without the division of sternum) combined with a rooftop incision. It is named after its resemblance to the Mercedes-Benz logo and affords better access to the upper abdominal organs and is used in hepatectomy.
- **Thoracotomy** – An incision made between two ribs to access the thoracic cavity in

cardiothoracic surgical procedures. It is typically placed in the sixth intercostal space.

- **Pfannenstiel** – A convex 10–15 cm long incision located 2 cm above the pubic symphysis. It is typically used in abdominal hysterectomy for smaller uteruses (≤ 20 weeks gestation size). Also known as a bikini-line incision.
- **McBurney** – An oblique incision centred at McBurney's point (two-thirds along a line from the umbilicus to the right anterior superior iliac spine). It is used in appendectomy. Also known as a grid-iron incision.
- **Lanz** – A transverse incision centred at McBurney's point. It is also used in appendectomy, and is deemed to give a better cosmetic result than the McBurney [7].
- **Rutherford Morrison** – An oblique, lower quadrant, muscle-cutting incision. It can be used to access the lower abdominal viscera in colectomies, and is also used in acute appendectomy.

Methods of Closure

After the surgical procedure, it is important to correctly approximate and close incisions. Failure to achieve proper closure leads to poor cosmesis, impaired wound healing, increased rates of infection, and dehiscence. There are several methods of incisional closure available:

- **Sutures** – The most common method of surgical closure, where the incision margins are stitched together. Various suture types are available, including monofilament vs. braided and absorbable vs. non-absorbable.
- **Staples** – Both absorbable and non-absorbable surgical staples are available for incisional closure. Non-absorbable staples are made from stainless steel, offering both high tensile strength and low tissue reactivity. Absorbable polymer staples may give a better cosmetic outcome.
- **Tissue adhesives** – These adhesives can be biological or synthetic, and are used to glue incision margins together. Although this closure method has a lower tensile strength than both sutures and staples, it has similar rates of infection and dehiscence while being faster to use.

- **Adhesive strips** – Placing adhesive strips across the incision is a non-traumatic method of closure, but the strips will not stick to moist areas or areas under tension [3].

Surgical Instruments

Instruments in Open Surgery

A wide variety of instruments are available to the surgeon, each designed to perform specific tasks during the course of an operation. While each surgical field makes use of specialised instruments particular to their own fields, there are many surgical instruments that will be found in any operating theatre. It will be useful for a medical student observing in theatre to be able to recognise these commonly used instruments (Fig. 9.41).

Surgical instruments come in various lengths and come in curved and straight forms (apart from scalpels). Their differences in length (Fig. 9.42) and degree of curvature (Fig. 9.43) best suit them to different tasks. Many of these common instruments have their counterparts in microsurgery, which are smaller, and laparoscopic surgery, where the instrument is at the tip of a long rod in order to pass through a trocar (laparoscopic port). You are not required to know the names of these instruments whilst at medical school, but the most common ones are outlined below to help you orientate yourself.

Common Surgical Instruments

- **Scalpels** – A bladed instrument with a BP (Bard-Parker) handle and disposable blade used to make incisions and in sharp dissection. Both the handles and blades come in a variety of sizes and shapes to perform specialised tasks (Figs. 9.44, 9.45, 9.46, 9.47, 9.48, 9.49 and 9.50).
- **Scissors** – Surgical scissors come in various types and are used for both cutting through tissues and also separating them in blunt dissection. For this reason, surgical scissors typically have rounded tips to avoid damaging structures. Scissors can be straight, for cutting sutures, or curved, for cutting tissue. Examples include Mayo, Metzenbaum, and Nelson (Figs. 9.50, 9.51, 9.52 and 9.53). Surgical scissors are held in the same way as surgical clamps (Fig. 9.54).
- **Dissecting forceps** – In a surgical context, ‘forceps’ typically refers to these non-locking dissecting instruments. Although they are essentially tweezers, don’t refer to them as such if there’s a surgeon nearby! Dissecting forceps can be toothed, for grasping skin and promoting bleeding, or non-toothed, to atraumatically grasp tissues and needles. They should be held in a pencil grip. Examples include Debaquey, Gillie, Lane, and McIndoe (Figs. 9.55, 9.56, 9.57 and 9.58).
- **Haemostats** – Locking clamps used to occlude vessels and control bleeding. Also called artery forceps or clips. Examples include Dunhill, Frazer, Kilner, Lahey, Roberts, and Spencer Wells (Figs. 9.59, 9.60, 9.61, 9.62, 9.63 and 9.64).

Fig. 9.41 Selection of common open surgical instruments. *Upper row* (L-R): Duval tissue graspers, Crile-Wood needle holders, Robert haemostat, Metzenbaum scissors. *Bottom row*: Debaquey dissecting forceps, scalpel, Watson-Cheyne retractor, Langenbeck retractor





Fig. 9.42 Length range in surgical instruments



Fig. 9.46 Scalpel with no. 4 BP handle and no. 20 blade



Fig. 9.47 Scalpel with no. 7 BP handle and no. 15 blade

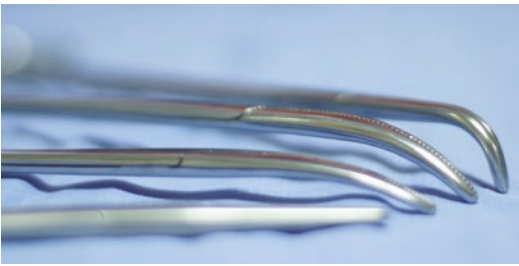


Fig. 9.43 Tip angulation in surgical instruments



Fig. 9.48 Scalpel in a pencil grip



Fig. 9.44 BP scalpel handles



Fig. 9.49 Scalpel in a palmar grip



Fig. 9.50 Mayo scissors, 6" straight



Fig. 9.45 Disposable no. 15 scalpel blade



Fig. 9.51 Mayo scissors, 6" curved

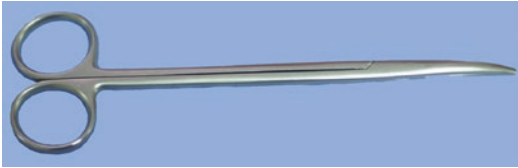


Fig. 9.52 Metzenbaum scissors, 9" curved

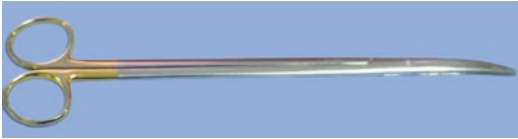


Fig. 9.53 Nelson scissors, 9" curved

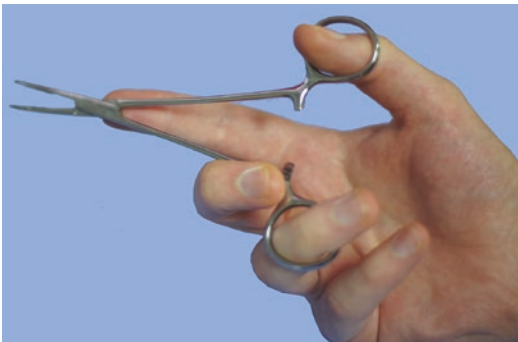


Fig. 9.54 How to hold surgical scissors and clamps



Fig. 9.55 Debaquey dissecting forceps, 7" non-toothed



Fig. 9.56 Gillies dissecting forceps, 6" toothed

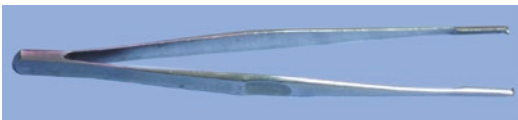


Fig. 9.57 Lane dissecting forceps, 7" toothed



Fig. 9.58 McIndoe dissecting forceps, 6" non-toothed

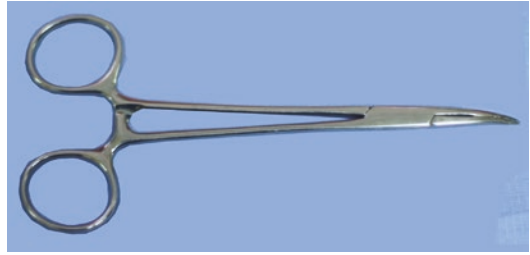


Fig. 9.59 Dunhill haemostat, 7.5" curved

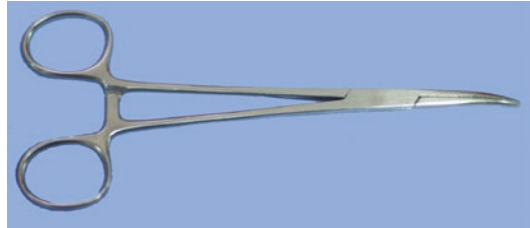


Fig. 9.60 Frazer haemostat, 7.5" curved

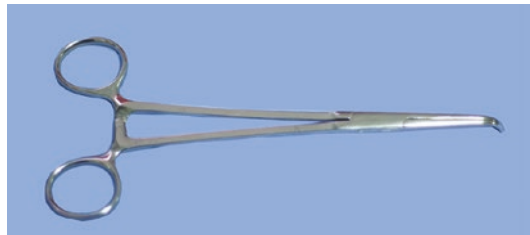


Fig. 9.61 Lahey haemostat, 7.75" curved



Fig. 9.62 Kilner haemostat, 5" curved

- **Needle holders** – Locking clamps used to safely hold needles while suturing. Needle holders can be distinguished from haemostats by the crossed knurling on the gripping surface of their tips. This allows the needle holder to maintain a firm grip on the needle at all angles. Examples include Crile-Wood and Mayo (Figs. 9.65 and 9.66).
- **Tissue graspers** – Locking clamps used to grasp and manipulate tissue. Examples include

Babcock, Duval, Judd-Aliss, and Lane (Figs. 9.67, 9.68, 9.69 and 9.70).

- **Sponge/Towel holders** – Locking clamps used to hold surgical sponges and towels. Examples include Lane towel graspers and Rampley sponge holders (Figs. 9.71 and 9.72).
- **Retractors** – Surgical devices used move apart tissues and organs to allow surgical access or a better view. Examples include Deaver, Morris, Langenbeck, and Ogilvie (Figs. 9.73, 9.74, 9.75, 9.76, 9.77 and 9.78).
- **Probes** – Simple instruments used in dissection. Examples include the straight probe, MacDonald dissector, and Watson-Cheyne retractor (Figs. 9.79 and 9.80).



Fig. 9.63 Roberts haemostat, 8" curved

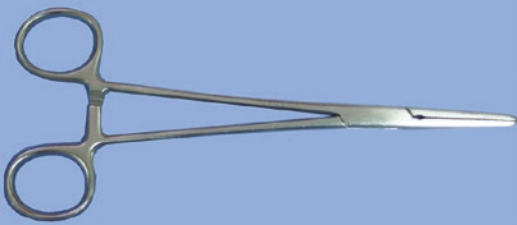


Fig. 9.64 Spencer Wells haemostat, 7" straight

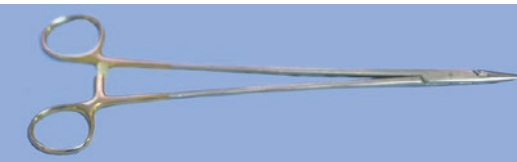


Fig. 9.65 Crile-Wood needle holder, 9.5" straight

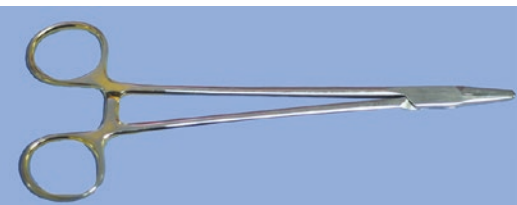


Fig. 9.66 Mayo needle holder, 6.5" straight

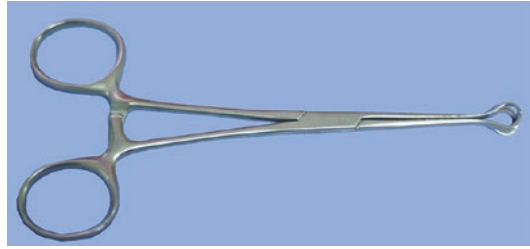


Fig. 9.67 Babcock tissue graspers, 8"

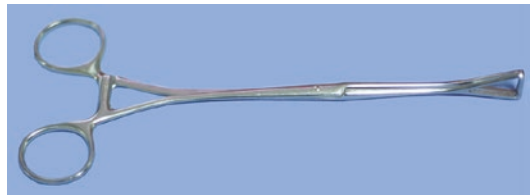


Fig. 9.68 Duval tissue graspers, 8"

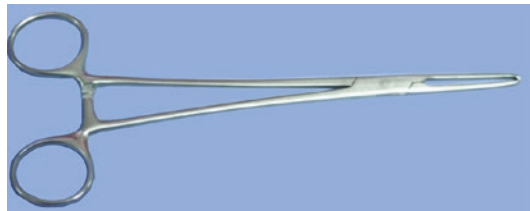


Fig. 9.69 Judd-Aliss tissue graspers

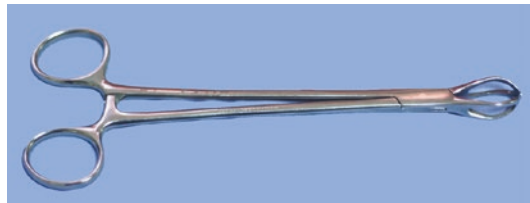


Fig. 9.70 Lane tissue graspers, 8"

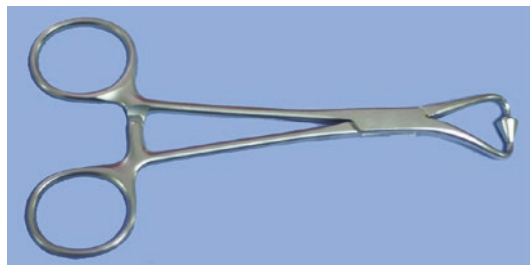


Fig. 9.71 Mayo ball and socket towel clips

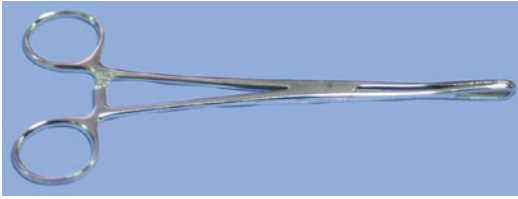


Fig. 9.72 Rampley sponge holders, 9.5"

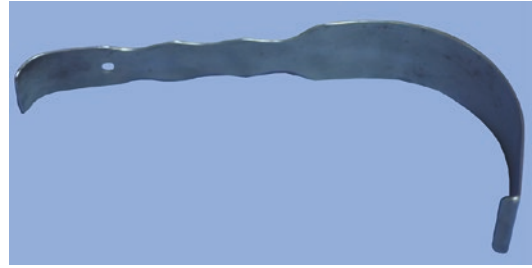


Fig. 9.77 Ogilvie retractor, 1.75" medium



Fig. 9.73 Deaver retractor, 2"

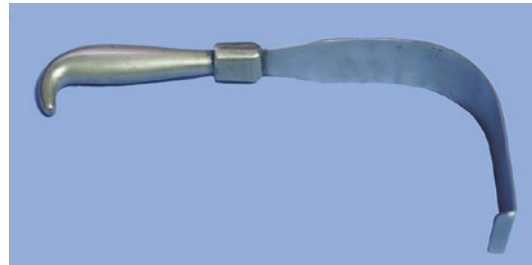


Fig. 9.78 Ogilvie retractor, 2" large



Fig. 9.74 Morris double-ended retractor



Fig. 9.79 MacDonald dissector



Fig. 9.75 Langenbeck retractor, medium



Fig. 9.80 Watson-Cheyne retractor



Fig. 9.76 Ogilvie retractor, 1.25" small

Instruments in Laparoscopic Surgery

The primary difference between laparoscopic and open surgical instrumentation is that laparoscopic instruments must be both narrow enough

to pass through a trocar (Figs. 9.81 and 9.82) and long enough to reach deep tissues in the insufflated abdomen. As such, laparoscopic instruments typically consist of specialised instrument tips at the end of a standard-length shaft. Many laparoscopic instruments are versions of open instruments, such as the Mayo and Metzenbaum scissors shown in Fig. 9.83. As with their open counterparts, there is a vast array of instrument tips used across many specialties. It is not important for a medical student to know the precise names and uses for every laparoscopic instrument; the ones shown in Figs. 9.84 and 9.85

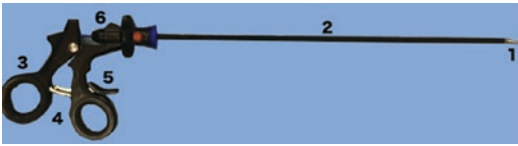


Fig. 9.81 Laparoscopic instrument

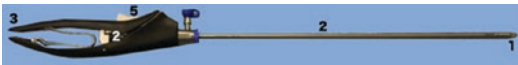


Fig. 9.82 Laparoscopic needle holder

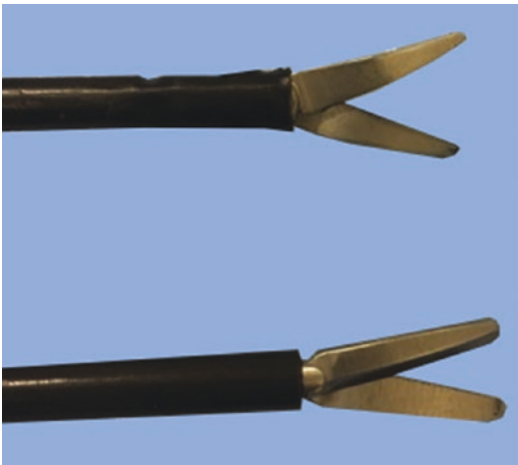


Fig. 9.83 Laparoscopic scissors instrument tips. *Upper: Mayo; Lower: Metzenbaum*

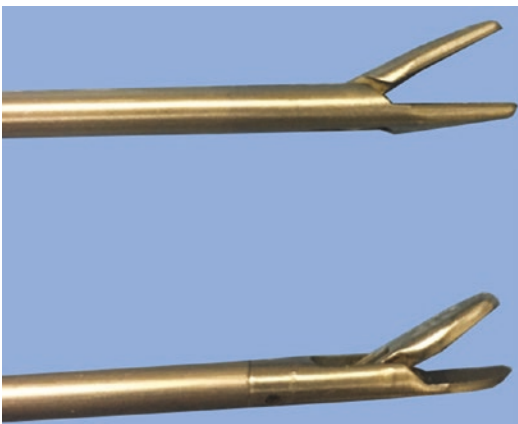


Fig. 9.84 Laparoscopic needle holder instrument tips. *Upper: straight; Lower: curved*

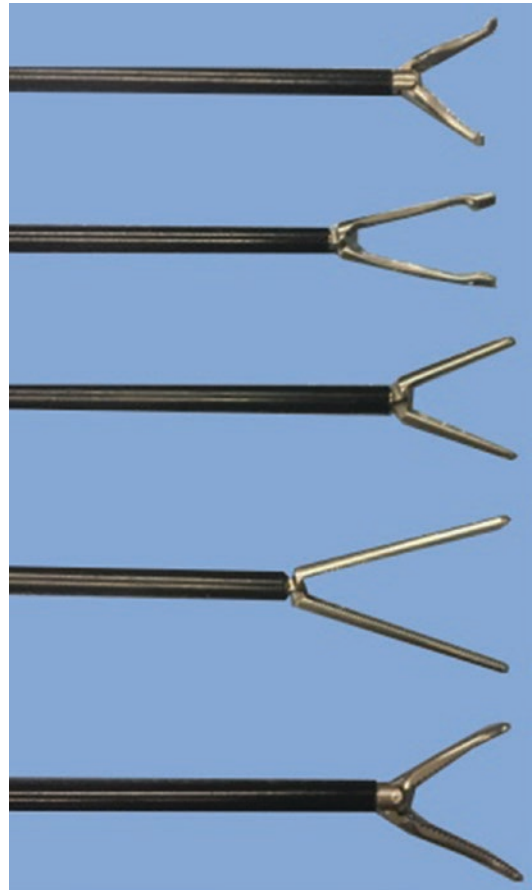


Fig. 9.85 Laparoscopic grasper instrument tips



Fig. 9.86 How to hold a laparoscopic instrument

are provided to give an indication of some common instrument tips.

Using laparoscopic instruments for the first time can be difficult, particularly when

combined with with 2D camera systems that confound depth perception. Another factor to keep in mind if you are called upon to assist in laparoscopic surgery is the ‘fulcrum effect’, which inverts movements and affects the perception of scaling [6]. Figs. 9.86 and 9.87 demonstrate the correct way to hold laparoscopic instruments.

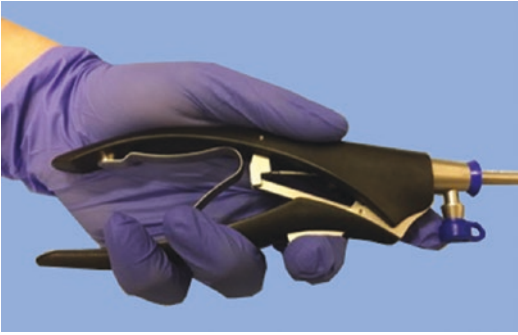


Fig. 9.87 How to hold a laparoscopic needle holder

coated in a range of materials such as silicon, wax or calcium stearate. However, the crevices between the filaments of the braid can harbour microorganisms, resulting in higher infection rates.

Reactivity

As with all foreign materials in the body, sutures may elicit an inflammatory tissue reaction. Natural materials (e.g. catgut, cotton, silk) will elicit a more intense inflammatory reaction than synthetic ones. Nylon and steel are among the least reactive suture materials.

Sutures and Ties

Sutures

Sutures are used to hold skin, organs, blood vessels and other tissues of the body together after they have been disrupted by trauma – including surgery. The closure they create aids in wound healing. If a suture is used on a wound it can be said to be healing by ‘primary intention’.

Sutures are generally classified into two groups, absorbable and non-absorbable. Other ways to classify sutures include their construction, number of filaments and whether they are synthetic or natural. The ideal sutures is non-toxic, hypoallergenic, flexible and strong.

Absorbable Versus Non-absorbable

Absorbable sutures are broken down by the body’s tissue over time. Absorbable sutures tend to be used internally as it removes the requirement for the wound to be re-opened. Non-absorbable sutures resist being broken down by the body.

Monofilament Versus Braided

Monofilament sutures pass more easily through tissues but do not hold knots as well as braided sutures, with an increased risk of dehiscence. Braided sutures generally grip better and are

Suture Size

The diameter of sutures are designated according to the United States Pharmacopeia in descending thickness from 10 to 12-0. After 0, the next thinnest suture is 1-0, then 2-0, etc. It is useful to think of the first number (1-0, 2-0, etc.) as the number of decimal places, making 12-0 much smaller than a 1-0. Sutures above 0 size tend to be used in orthopaedics.

Special Sutures

Some procedures make use of special suture types, such as wires in a median sternotomy, deep tension sutures in mass closure, and barbed sutures in urological anastomoses.

Surgical Needles

The needles used in suturing vary in size, curvature, and cross-section. Surgical needles are usually curved, and the degree of curvature is designated as a fraction of a circle. A needle may be round-bodied (circular cross-section), cutting (triangular cross-section, sharp edge inside the curve), or reverse-cutting (triangular cross-section, sharp edge on the outside of the curve) (Fig. 9.88). While some needles are eyed, most modern examples are swaged and come pre-attached with the suture. The suture pack details the properties of the suture and needle (Fig. 9.89).

Surgical Knots and Ties

A useful hand tie for a medical student is the reef knot (Fig. 9.90), which can be used in simple sutures e.g. to affix an arterial line. Figures 9.91–9.108 are a step-by-step guide on how to tie the reef knot. The surgeon’s knot is a modification of the reef knot, with an extra turn in the first throw to provide more grip (Fig. 9.90). As well as by hand, this knot is commonly tied with instruments as part of a stitch. Figures 9.109–9.116 are a guide on tying the surgeon’s knot and Figs. 9.117–9.133 are a guide on performing a simple interrupted stitch with instrument tie (surgeon’s knot). Other common stitches using an instrument-tied surgeon’s knot are the continuous stitch and mattress stitch.

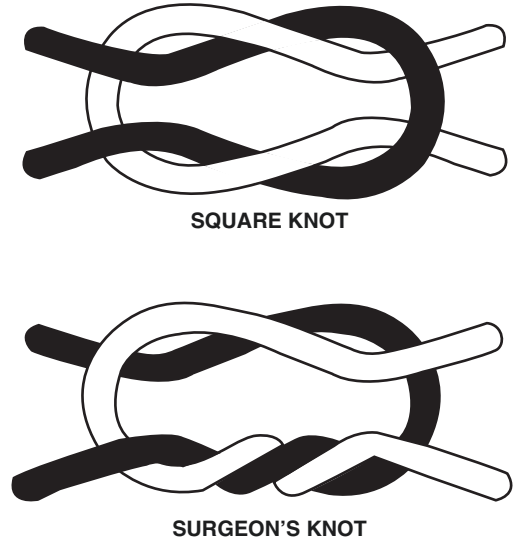
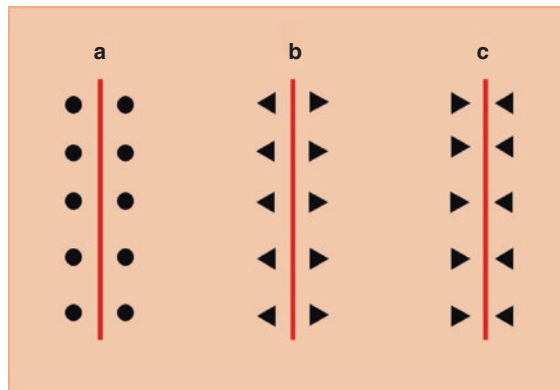


Fig. 9.90 Reef knot and surgeon’s knot

Fig. 9.88 Surgical needle cross-sections



This figure demonstrates the shape of the puncture holes as surgical needles of a particular cross-section pass through the wound edges. A–round-bodied, B–cutting, C–reverse-cutting.

Fig. 9.89 Suture pack

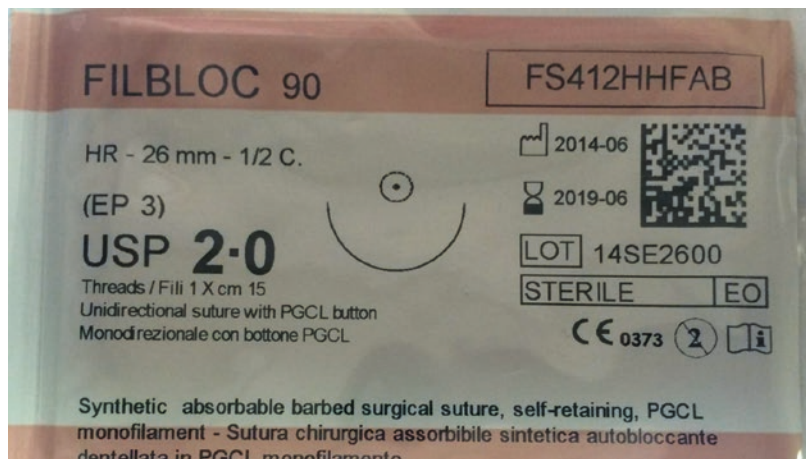


Fig. 9.91–9.108 Guide to hand-tying a reef knot

Grasp the suture between the ring finger and thumb of your non-dominant hand (**Fig. 9.91**)

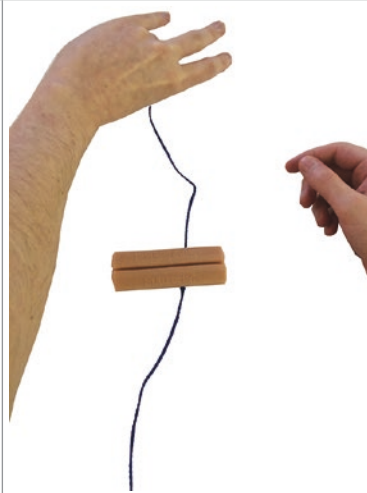


Fig. 9.91

Bring the distal end of the suture over the area you are tying. Make sure it wraps around your index and middle fingers (**Fig. 9.92**)

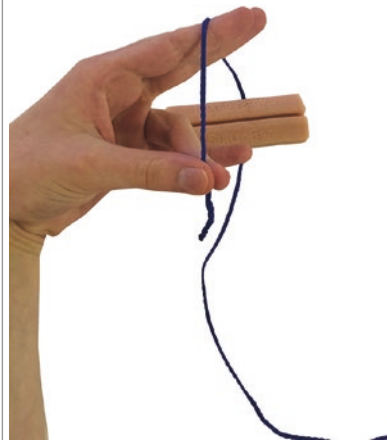


Fig. 9.92

Whilst keeping your non-dominant hand in the same position, use your dominant hand to pick up the other end of the suture and bring it over the index and middle fingers of your non-dominant hand parallel to the distal suture (**Fig. 9.93**)

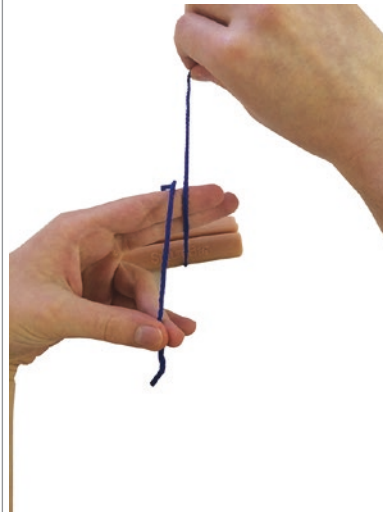
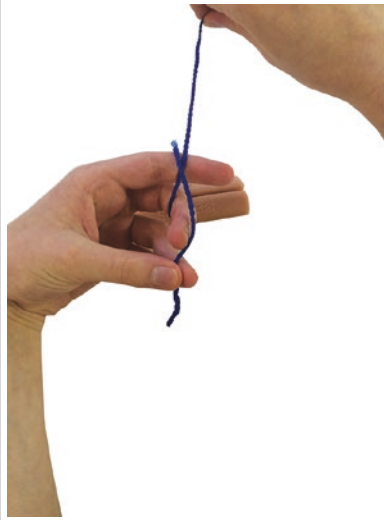


Fig. 9.93

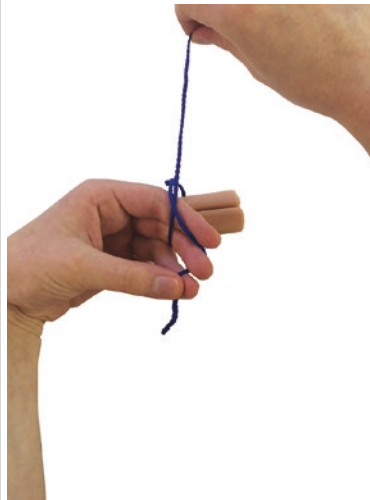
(continued)

Fig. 9.91–9.108 (continued)

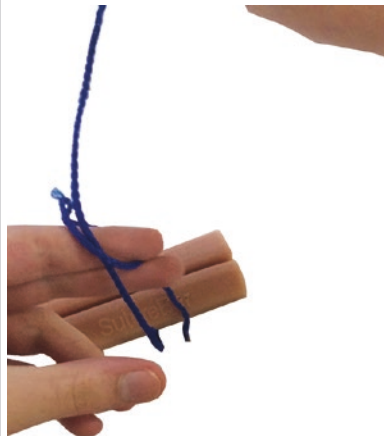
Use the middle finger of the non-dominant hand to pull the dominant hands suture towards the non-dominant hand. Keep the index finger in place (**Fig. 9.94**)

**Fig. 9.94**

Grasp the non-dominant hand's suture between the index finger and middle finger (**Fig. 9.95**)

**Fig. 9.95**

Let go of the non-dominant hand's ring finger and thumb grip (**Fig. 9.96**)

**Fig. 9.96**

Using the middle finger and index finger of the non-dominant hand, pull the end of the suture through the loop and towards yourself (**Fig. 9.97**). Make sure the dominant hand stays on the other side of the area you are tying over (**Fig. 9.98**)



Fig. 9.97

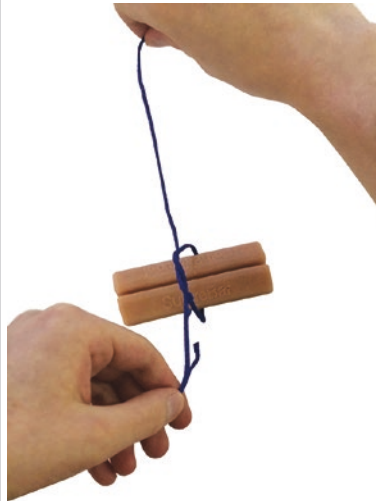


Fig. 9.98

Oppose both ends of the suture so that the tie sits squarely over the area (**Fig. 9.99**)

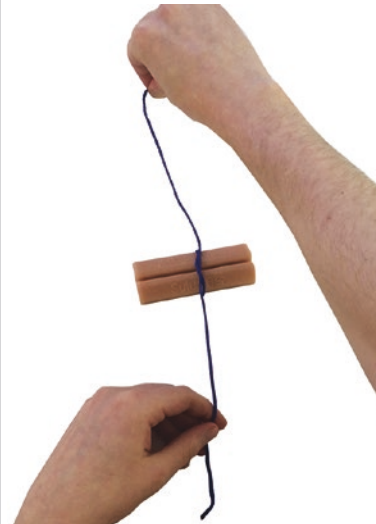
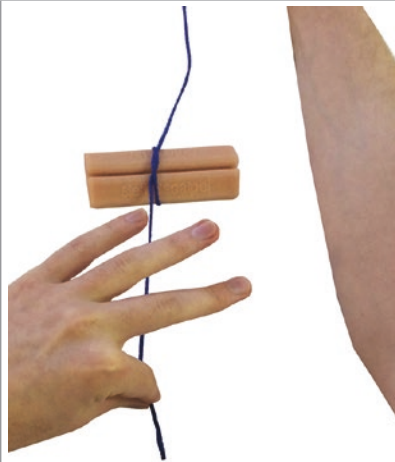


Fig. 9.99

Fig. 9.91–9.108 (continued)

The second part of the tie involves picking up the now proximal end of the suture with the index finger and thumb of the non-dominant hand (**Fig. 9.100**)

**Fig. 9.100**

Rotate the suture around the middle and ring fingers so that the proximal suture is now pointing distally (**Fig. 9.101**)

**Fig. 9.101**

Grasp the distal end of the suture with the dominant hand and bring it over the middle and ring fingers of the non-dominant hand (**Fig. 9.102**)

Use the middle finger to pull the dominant hands suture (**Fig. 9.103**)

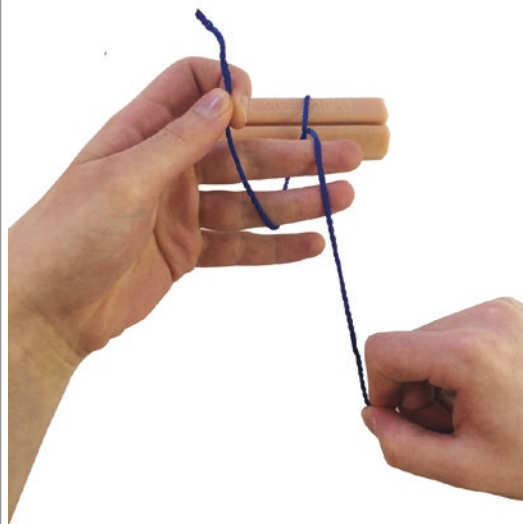
**Fig. 9.102**

Fig. 9.91–9.108 (continued)



Fig. 9.103

Using the middle finger, pull the dominant hands suture behind the non-dominant hands suture. The non-dominant hands suture should now be on the dorsal surface of the middle finger (**Fig. 9.104**)

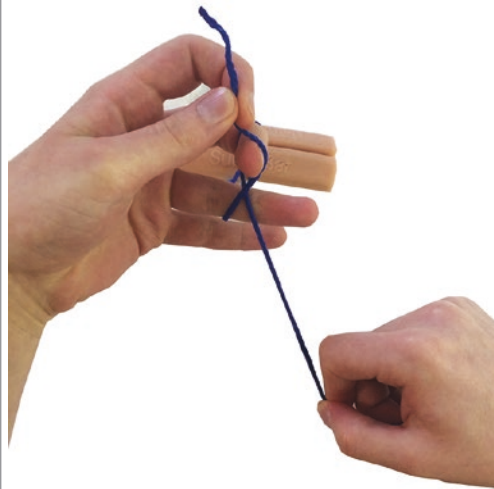


Fig. 9.104

Grasp the non-dominant hands suture between the middle finger and the ring finger (**Fig. 9.105**)

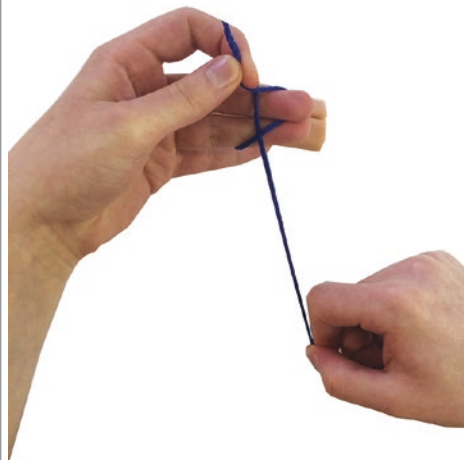
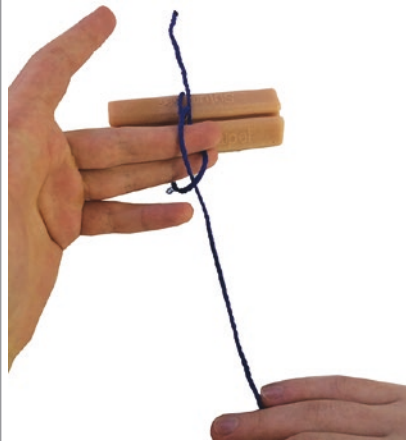


Fig. 9.105

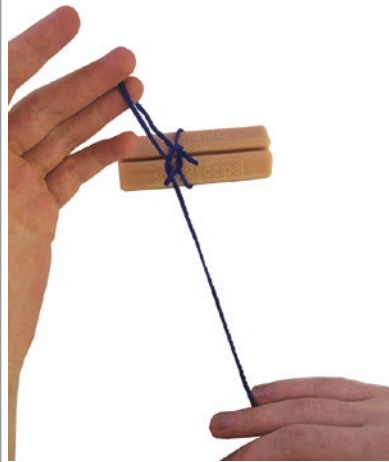
(continued)

Fig. 9.91–9.108 (continued)

Let go of the thumb and index finger grasp of the non-dominant hand (**Fig. 9.106**)

**Fig. 9.106**

Using the middle finger and ring finger, pull the suture through the loop (**Fig. 9.107**)

**Fig. 9.107**

A figure that looks somewhat like an 8 should form. Pull this flat over the wound (**Fig. 9.108**)

**Fig. 9.108**

Figs. 9.109–9.116 Guideto hand-tying a surgeon’s knot

Grip the distal suture between the thumb and ring finger of the non-dominant hand just like in the *Reef knot*. Rotate the suture around the index and middle finger of the non-dominant hand (**Fig. 9.109**)

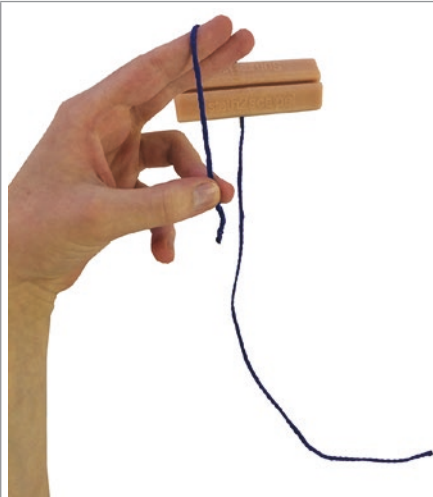


Fig. 9.109

Grasp the proximal part of the suture with the dominant hand and lay it on top of the non-dominant hand’s index and middle finger (**Fig. 9.110**)



Fig. 9.110

Wrap the suture held in the dominant hand around the middle and index fingers of the non-dominant hand (**Fig. 9.111**)

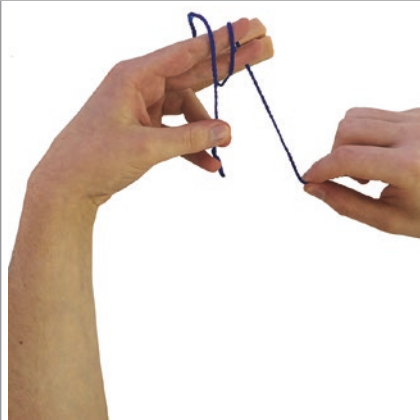


Fig. 9.111

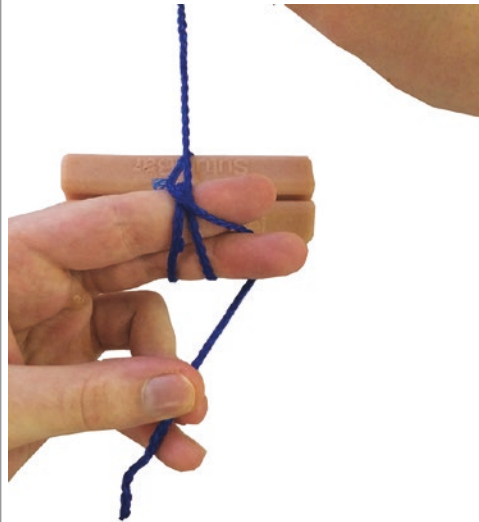
(continued)

Fig. 9.109–9.116 (continued)

There should be three parallel lines of suture over the middle and index fingers of the non-dominant hand (**Fig. 9.112**) This is a doubling of the first throw of the *Reef Knot*

**Fig. 9.112**

Bring the distal suture held in the non-dominant hand's thumb and ring finger between the non-dominant hand's index and middle finger (**Fig. 9.113**)

**Fig. 9.113**

Pull the index and middle finger of the non-dominant hand - whilst still grasping suture - through the two loops of suture. Let go of the suture with the thumb and ring finger of the non-dominant hand to allow the passage of the suture through the two loops (**Fig. 9.114**)

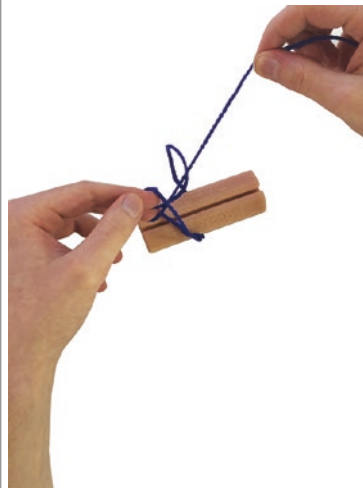
**Fig. 9.114**

Fig. 9.109–9.116 (continued)

Once through the loops, re-grasp the suture with a grip that is comfortable (index finger and thumb) and pull the two ends of the suture away from each other (**Fig. 9.115**)



Fig. 9.115

This is the completed first throw of the *Surgeons knot*. Now carry out the second and optional third throw of a *Reef knot* to complete the *Surgeons knot* (**Fig. 9.116**)

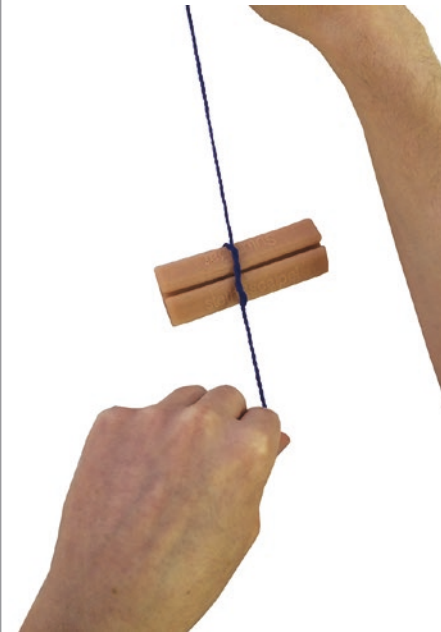


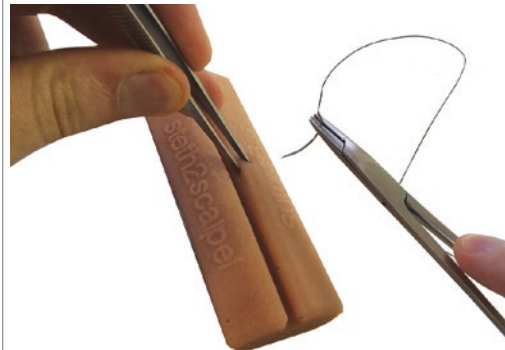
Fig. 9.116

Figs. 9.117–9.133 Simple interrupted stitch with instrument tie

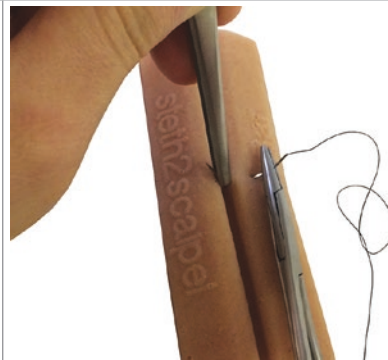
Grasp the needle of the suture 2/3's of the way along its length with a pair of needle holders (Fig. 9.117)

**Fig. 9.117**

Lift the edge of the initial point of suturing with a pair of toothed forceps (Fig. 9.118)

**Fig. 9.118**

Drive the needle through the initial edge. Use a pair of non-toothed forceps to finish driving the needle through the first part of the skin (Fig. 9.119)

**Fig. 9.119**

Ensure that the needle of the suture has been completely through the first part of the skin. Use the non-toothed forceps to hold the needle in position for the needle holders to grasp them for the second part of the driving (Fig. 9.120)

**Fig. 9.120**

Figs. 9.117–9.133 (continued)

Ensure the second bite of the suture lines up with the first bite. Use the toothed forceps to raise the edge again to make the drive easier (**Fig. 9.121**)

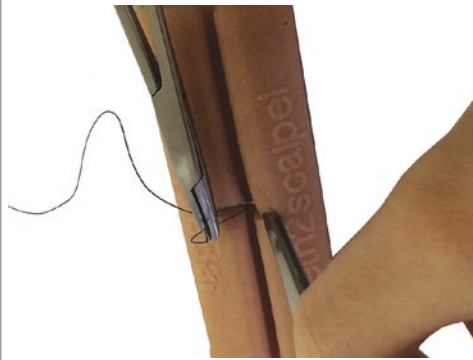


Fig. 9.121

Finish the drive of the needle with the non-toothed forceps. Re-grasp the suture with the needle-holders (**Fig. 9.122**)

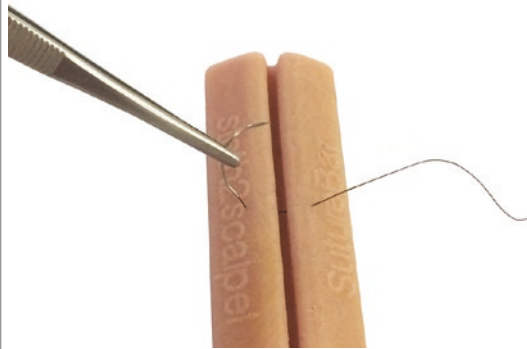


Fig. 9.122

Pull the suture through wound in the horizontal plane. Wrap the suture around the little finger to aid in pulling in the horizontal rather than vertical plane (**Fig. 9.123**)

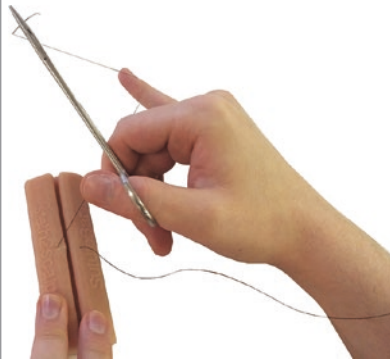


Fig. 9.123

Leave only a small amount of the suture on the initial drive for the tie (**Fig. 9.124**)

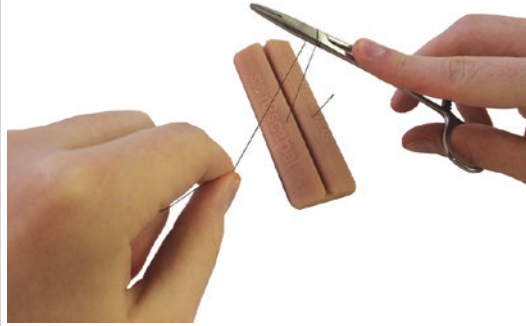


Fig. 9.124

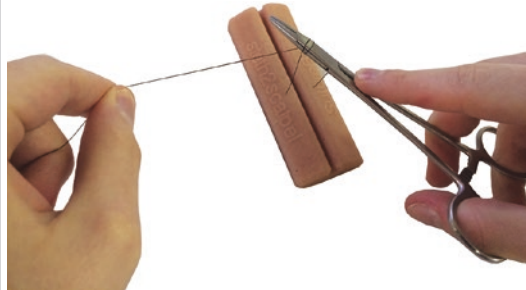
(continued)

Figs. 9.117–9.133 (continued)

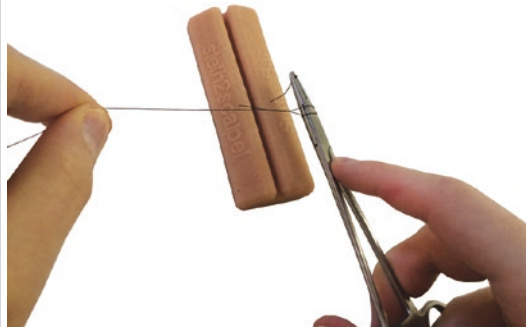
To start the *Instrument Surgeon's Tie* wrap the suture around the needle holder which is held in the dominant hand (Fig. 9.125)

**Fig. 9.125**

Make sure that the suture is wrapped twice around the needle holder. Keep them slightly loose so that the needle-holder can still be opened (Fig. 9.126)

**Fig. 9.126**

Whilst maintaining the loops around the needle holder's grasp the short free edge of the suture (Fig. 9.127)

**Fig. 9.127**

Pull this short free edge through the loops. Try to make the tie you have created lie to one side of the wound and not over the centre (Fig. 9.128). All future ties should lie on the same side

**Fig. 9.128**

Figs. 9.117–9.133 (continued)

Pull the tie square over the wound. That is the first throw of the *Instrument Surgeon's knot* completed (**Fig. 9.129**)

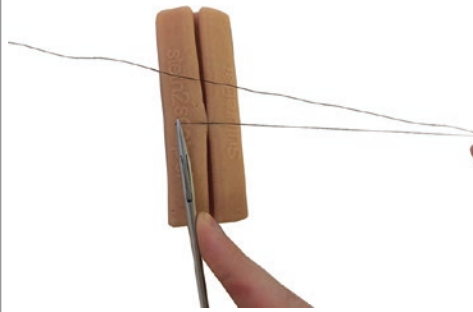


Fig. 9.129

The second throw and optional third throws are reef knots. Wrap the long end of the suture around the needle holder **once** (**Fig. 9.130**)

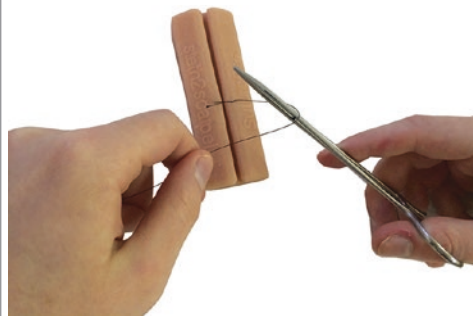


Fig. 9.130

Whilst maintaining the single loop over the needle-holder grasp the short end of the suture (**Fig. 9.131**)



Fig. 9.131

Pull the short end of the suture through the single loop. Ensure the tie stays on one side of the wound and not over the middle (**Fig. 9.132**)

An optional third throw can be completed over this

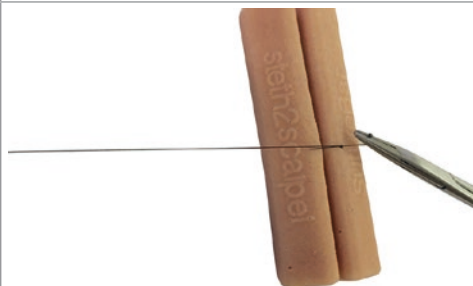


Fig. 9.132

(continued)

Figs. 9.117–9.133 (continued)

When you have completed the tie cut the long end of the suture. It should match the short end at 2–3 cm (**Fig. 9.133**)

**Fig. 9.133**

Surgical Equipment

Common Theatre Equipment

The standard operating theatre contains a lot of equipment designed to help the surgeon in the course of an operation. Most procedures make use of some general devices, such as suction systems. One ubiquitous piece of equipment is the electro-surgical diathermy device, which uses heat to cut and coagulate tissue. Other energy-based devices are used frequently in laparoscopic surgery.

Urinary Catheters

Catheterisation is necessary in all abdominal surgical procedures, both open and laparoscopic. This prevents the bladder from filling and obscuring the surgical field. In longer procedures, such as major trauma cases, measuring urine output can give an indication of the patient's intraoperative fluid status.

The Foley catheter is commonly used as an indwelling urinary catheter, and is held in place by an expandable water-filled balloon. Insertion can be either urethral (16 French diameter for men, 12–14 French for women) or suprapubic.

Suction and Irrigation

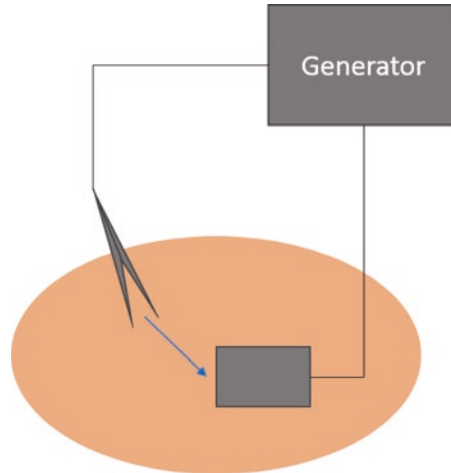
Various methods of suction are used to remove blood and debris from the surgical field to improve visualisation. Suction tubes come in open-ended and sump designs, and may be ceiling-mounted for ease of access mid-operation. Fluid irrigation is also used in laparoscopic surgeries to improve visual clarity, generally using saline.

Electrosurgical Diathermy

Diathermy is the induction of heat in a substance by passing high-frequency electromagnetic energy through it. Surgical diathermy is used to both cut tissue and cause coagulation, and is typically achieved by passing high frequency alternating current (AC) electricity through tissues. The frequency of this current is critical:

- **50 Hz** – low frequency AC (such as from mains electricity) will cause neuromuscular excitement, leading to tetanic contractions
- **>50 kHz** – high frequency AC avoids neuromuscular stimulation
- **400 kHz–10 MHz** – electrosurgical diathermy

Fig. 9.134 Monopolar electro-surgical diathermy



In monopolar systems, the alternating electrical current travels from the generator to the diathermy forceps, through the patient and back via the return plate. (Blue arrow represents the direction of the current).

Within the frequency range of electro-surgical diathermy, different AC waveforms can achieve different tissue effects [2]:

- **Coagulation** – Pulsed sinusoidal waveform at 10–75 W, coagulates by desiccating tissue.
- **Cutting** – Continuous sinusoidal waveform at 125–250 W, cuts by vaporising interstitial fluid and separating tissue.
- **Blend** – A pulsed wave current with a lower duty cycle, used to cut and coagulate at the same time.
- **Fulguration** – High-power current causing rapid heating of tissues to build up steam and violently burst cells. Used to ablate lesions.

Monopolar Versus Bipolar Diathermy Systems

The electro-surgical diathermy device consists of a 240 V AC generator and two electrodes: an **active** and **indifferent**. The placement of these two electrodes determines whether the diathermy system is monopolar or bipolar. In **monopolar** systems, the current passes from the generator through both limbs of the diathermy forceps, which represents the **active** electrode. The current then passes through the patient and back to the generator via the **indifferent** electrode, a metal return plate stuck to the patient (Fig. 9.134). This plate has to be a minimum of 70 cm² to reduce contact density and prevent burns. In

bipolar diathermy, the current passes through one limb of the diathermy forceps (**active**), between the instrument tips, and through the other limb (**indifferent**) back to the generator (Fig. 9.135). Bipolar systems are low power and have no cutting modes.

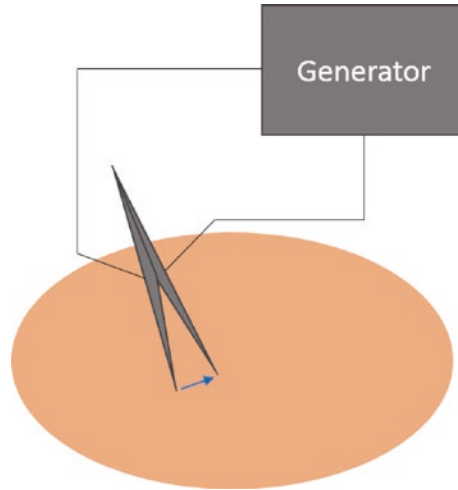
Electrosurgery and Safety

Electrosurgical diathermy comes with hazards to everybody in the operating theatre. All theatre staff should be trained in the safe usage of electrical diathermy systems, and the final responsibility to maintain safety in the theatre lies with the surgeon.

Monopolar diathermy systems can burn patients if the indifferent electrode is too small, wet, not firmly adhered to the patient, or even absent. With some systems an alarm will sound if the return plate has been forgotten. The plate should be attached close to the surgical site on a well vascularised area but away from any ECG electrodes. As electrical currents can ignite alcohol-based antiseptic solutions, keep any skin preparations away from the plate. Some gases, such as nitrous oxide, used in laparoscopic insufflation are flammable and therefore unsuitable to use with electrical diathermy.

Electrical currents can also interact with implanted cardiac devices, such as pacemakers and defibrillators. Older cardiac pacemakers are inappropriately stimulated, while newer models may be inhibited. To avoid lethal arrhythmias, a

Fig. 9.135 Bipolar electro-surgical diathermy



In bipolar systems, the alternating electrical current travels from the generator, down one limb of the forceps, through the patient, and then back up the other limb. (Blue arrow represents the direction of the current).

cardiologist should be consulted regarding the particular pacemaker model.

The use of AC diathermy in appendages such as the penis, fingers, or narrow pedicles, can result in a phenomenon known as ‘channelling’. The high current density can travel through the narrow structure and cause unwanted tissue coagulation. Diathermy should be avoided in these cases and, if unavoidable, **bipolar** diathermy should be employed [4].

Other Thermal Energy Sources

As well as AC electricity, a number of other energy sources are used to induce surgical diathermy. Surgical devices for cutting and coagulation can also pass ultrasound vibration or radio-frequency energy through tissue to generate heat:

- Harmonic ACE (Ethicon Endo-Surgery, USA) – Ultrasound
- THUNDERBEAT (Olympus, Japan) – Bipolar AC and ultrasound
- LigaSure (Covidien, USA) – Radio-frequency energy

Laparoscopic Equipment

Laparoscopic surgery requires specialised equipment in addition to the aforementioned surgical apparatus. The most obvious piece of equipment



Fig. 9.136 Forward viewing (0°) laparoscope



Fig. 9.137 Laparoscopic camera stack

is the laparoscope, which allows the surgeon to visualise anatomical structures without direct vision. These endoscopic devices can come with an eyepiece, as in Fig. 9.136, or be connected to a camera stack (Fig. 9.137). The laparoscopic camera stack houses the optical hardware includes a video monitor which displays the image taken by the laparoscope, as well as a video processing unit and a light source. The camera stack shown in Fig. 9.137 also includes an integrated electrosurgical unit, with pedals for cutting and coagulating diathermy.

In addition to the optical equipment necessary in laparoscopic surgery, an insufflator is used to establish a pneumoperitoneum. This device pumps gas (usually CO₂) into the abdominal

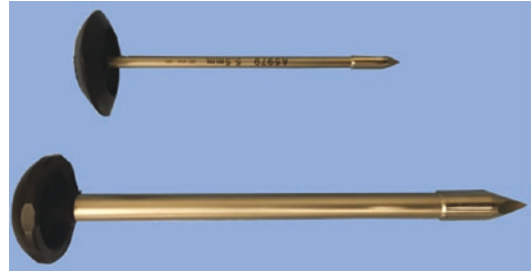


Fig. 9.138 Trocars with pyramidal tip

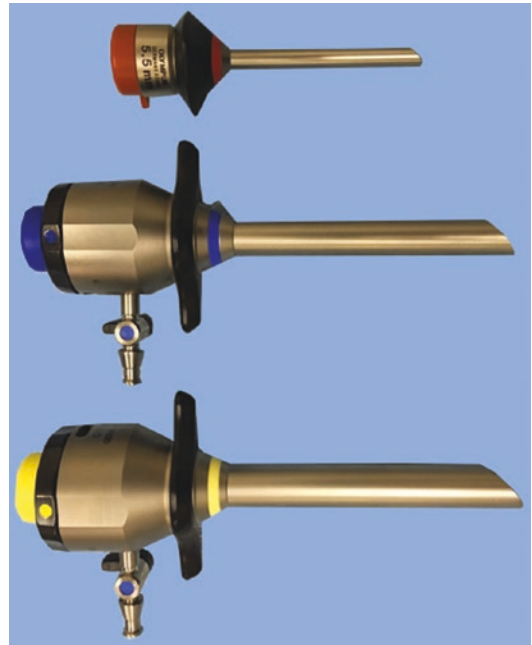


Fig. 9.139 Trocars with blunt tip, gas inlet valve and instrument sleeve

cavity via a trocar (or less commonly a Veress needle). Trocars comes in a range of shapes and sizes, with pyramidal, conical and even blunt tips. Simpler ones, as shown in Fig. 9.138, are simply used to puncture the abdominal wall. Other, more complex, models (Fig. 9.139) act as laparoscopic ports, with gas inlet valves and sleeves to allow the passage of laparoscopes or surgical instruments.

Preparing the Surgeon: Key Messages

- Pre-operative preparation for the surgeon includes the surgical scrub and the donning of the sterile surgical gown and gloves.
- Surgical incisions vary in length and placement, with some that are named and associated with particular procedures.
- Sutures are the most commonly used method of surgical closure and there are many types which vary in structure, material, and tissue reactivity.
- Surgeons use a wide variety of instruments, each with differing designs and a specific purpose in mind.
- Operating theatres contain an array of surgical equipment including several thermal energy sources for tissue cutting and coagulation, the most common of which is electrosurgical diathermy.

Surgeons' Favourite Questions for Students

1. How many minutes should the surgical scrub last for?
2. Do horizontal or vertical incisions offer better cosmetic results?
3. How is a needle holder distinguished from a haemostat?
4. Which type of suture is associated with higher rates of infection, monofilament or braided?
5. Which kind of electrical current is used in electrosurgical diathermy?

References

1. Association for Perioperative Practice (AfPP). Standards and recommendations for safe perioperative practice. 3rd ed. Harrogate: AfPP; 2011.
2. Culjat M, Singh R, Lee H. Medical devices: surgical and image-guided technologies. Hoboken: John Wiley & Sons; 2012.
3. Hochberg J, Meyer KM, Marion MD. Suture choice and other methods of skin closure. *Surg Clin N Am*. 2009;89:627–41.
4. Kingsnorth A, Majid AA. Principles of surgical practice. London: Greenwich Medical Media; 2001.
5. Newcastle Upon Tyne Hospitals NHS Foundation Trust (NuTH). Surgical scrub, gown, and glove procedure. Newcastle upon Tyne: Newcastle upon Tyne Hospitals NHS Foundation Trust; 2013.
6. Nisky I, Huang F, Milstein A, Pugh CM, Mussa-Ivaldi FA, Karniel A. Perception of stiffness in laparoscopy – the fulcrum effect. *Stud Health Technol Inform*. 2012;173:313–9.
7. Patnaik VVG, Singla RK, Bansal VK. Surgical incisions—their anatomical basis Part IV—abdomen. *J Anat Soc India*. 2001;50:170–8.
8. Raghavan R, Arya P, Arya P, China S. Abdominal incisions and sutures in obstetrics and gynaecology. *Obstet Gynaecol*. 2014;16:13–8.