Section 1 Clinical surgery in general

Chapter 1

Clinical surgery in general

Suture materials

What different types of suture do you know of?

Suture materials may be categorized as (1) natural, synthetic and metallic, (2) absorbable or non-absorbable, or (3) monofilament or multifilament.

Give examples of natural, synthetic and metallic sutures and their uses

Natural sutures

Catgut	Not used as has been banned in Europe and Japan, owing to concerns about transmission of prion disease.
Silk	General soft tissue closure and ligation. Avoid in vascular anastamoses and skin closure, owing to formation of stitch sinuses and abscesses.

Synthetic sutures

Vicryl/Vicryl Rapide (polyglactin)	Bowel anastamoses.
PDS (polydioxanone)	Mass closure of midline laparotomy incision.
Proline (polypropylene)	Closure of facial wounds and vascular anastamoses.
Ethilon (nylon, polyamide)	In ligation or general soft tissue approximation.

Metallic sutures

Steel	Closure of the sternum after median sternotomy.

How would you classify sutures according to absorbability?

Absorbable	Vicryl/Vicryl Rapide, PDS, catgut.
Non-absorbable	Prolene, nylon, silk, steel.

Over what period do the absorbable sutures degenerate?

Vicryl –– Complete absorption at 56–70 days. Retains 40% of its tensile strength at 4 weeks.

Vicryl Rapide –– Complete absorption at 42 days. Retains 0% of its tensile strength at 10–14 days.

PDS –– Completely hydrolyzed at 182–238 days. Retains 35–60% of its tensile strength at 6 weeks (depending on size of suture).

Chromic catgut –– Full tensile strength remains for 7–10 days and is fully hydrolyzed at 90 days. Pure catgut is absorbed more quickly and causes an intense tissue reaction.

Give examples of monofilament and multifilament sutures

Monofilament –– PDS, prolene, nylon.

Multifilament –– Vicryl or Vicryl Rapide, silk, catgut.

What are the advantages and disadvantages of monofilament sutures?

Advantages –– Less tissue reaction; glides easily; infection is less likely to settle in between the filaments, as may occur with braided sutures; less platelet activation (ideal for vascular anastamoses).

Disadvantages –– Monofilament sutures often have memory and can be difficult to handle and tie; requiring more throws to form a secure knot.

Summarize the sizing of suture materials

Suture sizes are defined by the United States Pharmacopeia (USP) scale. This scale uses zero as the baseline. As the suture diameter decreases below the baseline, zeros are added (e.g., 0000 or 4-0). As the suture diameter increases above the baseline, a number is given to denote the size (e.g., number 4). The smallest available suture is 11-0 (0.01 mm diameter) and is used in microsurgery and ophthalmology. The largest is a braided number 5 suture (0.7 mm diameter), which is often used in orthopaedics.

What types of needle are available? Give examples

Needles may be straight, curved or J-shaped. These may then be further categorized according to the body and the point of the needle. The body may be cutting, reverse-cutting or round-bodied. The point may be cutting, blunt or tapered. A forward-cutting needle has the sharp edge on the inside of the curve and a reverse-cutting needle has the cutting edge on the outside (preventing inside cut-out). Round-bodied, blunt needles are used in tissues that may be easily penetrated and damaged (e.g., in mass closure of abdominal midline laparotomy incisions, to prevent damage to the underlying bowel).

Diathermy

What different types of diathermy are available?

Monopolar (cutting, coagulation and blend) and bipolar (coagulation only). Both use alternating current (ac).

Give examples of uses of each

Monopolar diathermy is used in most general surgical procedures. Cutting diathermy may be used on dissection though soft tissues, whereas coagulation is often used on small vessels. Bipolar diathermy is used in extremity surgery to prevent high current densities over a small area of tissue (e.g., fingers). It is also used in neurosurgical and plastic surgical procedures, where finer precision is required.

What is the difference between monopolar and bipolar diathermy?

Monopolar –– A high current density is produced at the tip of the diathermy probe, which then disseminates throughout the body as it is conducted to the diathermy plate (or indifferent electrode). To reduce the current density at the diathermy plate and prevent a heating effect, the diathermy plate must have a minimum surface area of 70 cm^2. Incorrect placement of the plate or contact with other conducting materials may result in burns. Power used is up to 400 W.

Bipolar –– The diathermy instrument consists of two electrodes (commonly combined as forceps) and current is conducted between the two electrodes; it only passes through the tissue that is being treated. It uses significantly lower power than monopolar diathermy and there is no need for a diathermy plate. Cutting is not possible with bipolar diathermy. Power used is up to 50 W.

Why does surgical diathermy not produce muscle stimulation?

The high frequency of current in the diathermy circuit prevents muscle stimulation unless applied directly to striated muscle. The frequency of current used by diathermy units is 400 kHz to 10 MHz (mains frequency is 50 kHz). Muscle stimulation is produced at frequencies of <50 kHz and at this frequency even small currents (5–10 mA) may cause muscle stimulation. The use of higher frequencies therefore also allows much higher currents to be safely conducted through tissues.

What is the difference between the cutting and coagulation settings? What other settings may be used?

Cutting –– A continuous current output allows arcing of the current between the tip of the electrode and the tissue. This creates a temperature of

approximately 1000 °C in the local tissue, resulting in vaporization of cell water and tissue disruption. There is little coagulation when this setting is used.

Coagulation –– A pulsed current output is generated, resulting in local heat production with tissue desiccation and sealing of blood vessels. There is minimal tissue disruption.

Other available settings include fulguration (spray coagulation) and blend. Fulguration uses a high voltage to coagulate over a wider area. Blend produces a continuous output with pulses that allows simultaneous coagulation and cutting.

What are the risks associated with diathermy?

1. Incorrect plate position may result in burns, owing to poor heat dissipation. The plate must be positioned over areas with good blood supply and away from bony prominences, scar tissue and metal implants.
2. Bowel gas and alcoholic skin preparations that are not sufficiently allowed to dry may result in explosion.
3. There is potential for diathermy smoke to contain carcinogens. Direct inhalation should be avoided.
4. Use of monopolar diathermy on appendages may result in setting up high current density locally (without the ability to dissipate current), causing tissue damage distant from the site of the electrode.
5. The use of diathermy adjacent to metal implants or other metal objects may allow current to be induced in a metal object without direct contact between it and the diathermy electrode. This could result in heating around the metal object and tissue damage.
6. Capacitance coupling: the diathermy electrode comprises a metal active wire surrounded by an insulating layer. In laparoscopic surgery, this is then contained within a metal cannula, which passes through a port (either metal or plastic) into the abdominal cavity. In this set-up, ac current may be conducted from the active wire to the surrounding metal cannula without direct contact, as the insulating layer acts as the capacitor. The stray current is then dissipated through the patient's body to the diathermy plate, provided that the cannula is housed within a metal port. The current density is usually low and little or no heating effect occurs around the port site. If however, a metal cannula is used with a non-conducting port there will be no discharge current from the cannula before its entry into the abdominal cavity. This may result in damage to structures (e.g., the bowel) that are in contact with the cannula but out of view.
7. Direct coupling: if the electrode is in contact with another metal object, this will result in conduction of current through this object and may cause heating and damage to adjacent tissues.

What are the relative contraindications to the use of diathermy?

Pacemakers or implantable cardiac defibrillators (ICDs). Monopolar diathermy should be avoided where possible, as it may cause:

1. Induced current down the pacemaker wires, resulting in myocardial burns.
2. Induced currents in the pacemaker unit resulting in potential change to pacing rate or inhibition of output. An ICD may be inappropriately stimulated, owing to misinterpretation of an interference signal as myocardial activity. Both these instances may result in fatal arrhythmias.

Which measures may be taken to reduce the risks when using diathermy in patients with pacemakers or ICDs?

1. Avoid monopolar diathermy: use only bipolar diathermy devices.
2. Avoid the use of cutting diathermy.
3. Where coagulation diathermy is used, this should only be in short bursts.
4. The active electrode and diathermy plate should be positioned as far as possible from the thorax.
5. The thorax should not form part of the current path.
6. External pacing should be available for emergency use in the case of pacemaker malfunction.

Skin preparation and asepsis

What different types of skin preparation solutions are you aware of?

The solutions most commonly used are:

10% Povidone-iodine –– Bactericidal as well as bacteriostatic, with little irritation to skin or mucosa. It can be used as a skin preparation solution and in areas where the skin is breached.

Chlorhexidine 0.5% in 70% alcohol –– Bactericidal and bacteriostatic, although reduced bactericidal effect with some gram-negative bacteria. Care should be taken to allow alcohol preparation solutions to dry before the use of electrocautery, as there is a risk that vapour may ignite.

What are the most commonly used surgical scrub solutions?

Povidone-iodine 7.5% (Betadine) and Chlorhexidine gluconate 4%.

What is the difference between sterilization and disinfection?

Sterilization is defined as a process by which all microorganisms (bacteria, fungi and viruses) are destroyed. Disinfection is a process in which infective microorganisms are removed (bacteria, fungi and viruses).

What are the different methods of sterilization?

Steam (via autoclave) –– Autoclaves produce moist heat, combining temperature and pressure. Requirements to achieve sterilization are 134 °C for 3 min at 2 kPa or 121 °C for 15 min at 1 kPa. Autoclaving does not necessarily eliminate prions (usually treated with sodium hydroxide for 2 hours plus autoclaving for 1 hour at 160 °C).

Dry heat –– Requires much longer duration than moist heat, used for moisture-sensitive objects. Requirements for sterilization are at least 2 hours at 160 °C or 6–12 minutes at 190 °C.

Ethylene oxide –– Used in heat-sensitive objects: it kills all known bacteria, spores, fungi and viruses. The disadvantages are that it requires a longer period of sterilization, requires poststerilization aeration to remove toxic residues and is highly flammable.

Peracetic acid (0.2%) –– Used in sterilization of endoscopes.

Radiation –– Gamma radiation is used for industrial sterilization of instruments and other equipment (cannulae, syringes, giving sets, etc.). Not used on a small scale, owing to the requirements for housing and safe use of gamma radioisotopes.

What systems are in place in the operating theatre to reduce the risk of infection?

Laminar flow operating rooms –– Air cycles with a minimum of 300 changes per hour. Used in orthopaedic theatres to reduce the risk of implant infection (a fourfold reduction has been shown in studies).

Positive pressure ventilation –– Approximately 20 changes per hour. Higher pressure in the clean areas and lower pressure in the dirty areas results in flow of air from clean to dirty areas. This reduces the bacterial count in clean areas.

Laparoscopy: the basics

What techniques do you know to achieve pneumoperitoneum?

Hasson technique (open) –– Recommended by the Royal College of Surgeons. Make an infraumbilical incision of approximately 1–2 cm. Dissect through subcutaneous tissues until reaching the linea alba. Make an incision in the linea alba and place either a purse string or stay sutures around the incision. Continue to dissect through the extraperitoneal fat until the peritoneum is visualized. Make a 1–2 cm incision in the peritoneum and under direct vision introduce a 10 mm camera port with the sharp trocar removed (or use a blunt-tipped trocar). Insufflate the peritoneum with carbon dioxide. A low pressure

with high flow indicates correct positioning of the port within the peritoneal cavity. Aim for a pressure of 12–14 mmHg (can preset).

Veress needle (blind) –– A small infraumbilical incision should be made and the Veress needle carefully inserted through the deeper structures, directed towards the coccyx. A 'pop' is usually felt as the needle passes through the linea alba and peritoneum. Various methods are used to confirm pneumoperitoneum; the commonest is the 'saline drop test'. A drop of saline placed at the Veress needle bulb is immediately sucked into the needle as it is inserted through the peritoneum, owing to the negative intra-abdominal pressure.

OptiView ports –– These are an alternative method of obtaining a 'closed' pneumoperitoneum. The laparoscope is inserted into the 12 mm trocar as it is advanced into the peritoneal cavity. The tip of the trocar is transparent, allowing direct visualization of each tissue layer as it is traversed. The peritoneal cavity is therefore entered under direct vision and the length of the incision made is minimized.

What are the complications associated with pneumoperitoneum?

Respiratory –– High intra-abdominal pressure may result in diaphragmatic splinting and hence reduce pulmonary compliance, leading to ventilation–perfusion mismatch, reducing gaseous exchange. Carbon dioxide insufflation can lead to hypercapnia and respiratory acidosis. High ventilation pressures used to compensate for high insufflation pressures may lead to barotrauma and pneumothorax.

Cardiovascular –– Raised intra-abdominal pressure reduces venous return (worsened by head-up positioning) resulting in a reduction in cardiac output. The subsequent venous stasis as a result of a reduction in venous return may increase the incidence of thromboembolism.

General

1. Gas embolism, either due to inadvertent venepuncture with Veress needle or, infrequently, as a direct result of intraperitoneal gas pressure,
2. Visceral puncture.
3. Insufflation of the omentum.

What are the advantages and disadvantages of laparoscopic surgery over open surgery?

Advantages –– Smaller incisions; less postoperative pain; decreased incidence of wound complications; shorter hospital stay; earlier return to work; improved cosmesis; reduced adhesion formation (although similar rates of

adhesion-related complications have been seen with laparoscopic gynaecological surgery).[1]

Disadvantages –– Inadvertent damage to surrounding structures due to limited view of operating field; reduced tactile feedback; not suitable for all patients; steep learning curve.

What are the contraindications to laparoscopic surgery?

Relative –– Clotting abnormalities; deranged liver function; cardiac failure; raised intracranial pressure; respiratory dysfunction; generalized peritonitis; obliteration of the intraperitoneal space (e.g., due to adhesions, organomegaly, reoperation and pregnancy).

Absolute –– Uncontrolled shock; intestinal obstruction.

[1] A. M. Lower, R. J. S. Hawthorn, H. Ellis *et al.* (2000). The impact of adhesions on hospital readmissions over ten years after 8849 open gynaecological operations: an assessment from the Surgical and Clinical Adhesions Research Study. *Br. J. Obstet. Gynaecol.* **107**:855–862.

Section 2 Thorax

Chapter 2

Applied surgical anatomy

What is the anatomical position of the heart within the chest?

The heart is located in the middle mediastinum and is covered anteriorly by the costal cartilages of the third, fourth and fifth ribs.

Describe the reflections of the pericardium and describe the location of the transverse and oblique sinuses

The pericardium is made up of a visceral layer, which is adherent to the heart, and a parietal layer, which forms the inner surface of the pericardial sac. There is a small amount of serous pericardial fluid between the two layers. There are two recesses within the pericardium: the transverse sinus and the oblique sinus. The transverse sinus is bounded anteriorly by the posterior surface of the aorta and the pulmonary trunk and posteriorly by the anterior surface of the interatrial groove. The oblique sinus is the space behind the left atrium and is bounded by the pericardial reflections of the inferior vena cava and the pulmonary veins.

What is meant by coronary artery dominance?

Dominance is determined by the artery supplying the posterior descending artery (PDA). Approximately 85% of the population are right coronary dominant (PDA supplied by the right coronary artery), and 10% are left dominant (PDA supplied by the circumflex artery). Co-dominance is seen in the remaining 5%.

Briefly describe the course of the right coronary artery

The right coronary artery arises from the anterior aortic sinus between the right atrium and the pulmonary trunk. It descends in the right atrioventricular groove supplying the right atrium and ventricle before reaching the inferior border of the heart where it gives off an acute marginal branch and, in 85% of the population, the posterior descending artery (PDA). The PDA continues to the apex, where it anastamoses with the corresponding branch of the left coronary artery.

What are the key branches of the right coronary artery?

The (sino-atrial) nodal artery –– The blood supply to the sino-atrial node is from the RCA in approximately 60% of individuals.

The atrioventricular nodal artery –– This arises from the RCA in approximately 85% of the population. The RCA then gives rise to a marginal artery and the posterior descending artery (posterior intraventricular artery) in approximately 85% (see note on dominance) of the population.

Briefly describe the course of the left coronary artery and its branches

The left coronary artery arises as the left mainstem from the posterior (left) aortic sinus and passes posterior and to the left of the pulmonary trunk. It then bifurcates to form the circumflex and left anterior descending arteries.

Briefly describe the structure and position of the aortic valve

The surface marking of the aortic valve is the left sternal edge in the third intercostal space (ICS). The normal aortic valve has three cup-shaped cusps and lies within the bulge of the proximal aorta. The aortic sinuses prevent the cusps being flattened against the wall of the aorta during ventricular systole and allow blood flow into the sinuses during diastole. This in turn distends the cusps, forcing them together and closing the valve.

Briefly describe the structure and position of the mitral valve

The surface marking of the mitral valve is the fourth costal cartilage at the left sternal edge. The mitral valve is a bicuspid valve, made up of a fibrous annulus, the anterior and posterior leaflets, the chordae tendinae and the papillary muscles.

What is the anatomical position of the sino-atrial node (SAN)?

The SAN lies at the junction between the right atrium and the superior vena cava at the anterior and superior extent of the terminal groove. It is usually to the right or lateral of the superior cavo-atrial junction.

What is the blood supply to the SAN?

In approximately 60% of people, the SAN is supplied by the nodal artery, which is a branch of the right coronary artery. In the remaining 40%, it arises from a branch of the circumflex artery. From its origin, it usually runs along the anterior interatrial groove to the position of the SAN at the superior cavo-atrial junction.

What is the anatomical position of the atrioventricular node (AVN)?

It occupies the upper part of Koch's triangle. Koch's triangle is bounded by the septal leaflet of the tricuspid valve, the ostium of the coronary sinus and the tendon of Todaro. The tendon of Todaro is a fibrous structure formed by the junction of the eustachian valve (within the inferior vena cava) and the thebesian valve (within the coronary sinus).