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# Technical tutorial

## Penetrating cardiac injury

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### *Background*

With an increasing incidence of penetrating wounds in the UK, there is a need for all surgeons to be familiar with the management of penetrating cardiac injuries (PCIs).[1] PCIs are amongst the most lethal of injuries; typically < 10% of patients with PCI arrive at hospital alive.[2] Nevertheless, rapid diagnosis and operation can salvage patients who would otherwise be lost.[3,4] All general surgeons should be capable of recognising these injuries and intervening if a cardiothoracic surgeon is not immediately available.

### *Diagnosis*

Patients with PCI can be classified into five groups: lifeless, critically unstable, cardiac tamponade, thoraco-abdominal injury and those with a benign presentation.[5] Rapid clinical diagnosis of unstable patients is based on the site of penetration together with signs of shock, cardiac tamponade or exsanguination. Compensating, stable patients may be agitated and unwilling to lie supine.[6] Ultrasound can rapidly diagnose the presence of pericardial blood with high levels of accuracy.[7,8] However, small myocardial wounds may seal off and the patient respond to resuscitation; hence, the assessment of a stable patient can be difficult. Occult cardiac injuries do occur and ultrasound may occasionally be falsely negative; a high index of suspicion is required and repeat ultrasound studies should be obtained.[9] Pericardiocentesis and subxiphoid window are not always helpful in establishing the diagnosis;[9] if diagnostic uncertainty persists, videothoracoscopy enables direct pericardial inspection and window.[10]

### *Surgical technique*

If the penetrating implement remains *in situ*, it should not be removed until the chest is open. Every effort is made to convey the injured patient to an operating theatre, though lifeless or critically unstable patients must be opened in the resuscitation area.

### *Median sternotomy*

Median sternotomy is preferable in most stable patients in whom the diagnosis of PCI is reasonably certain and the presence of another lesion is not suspected.[11] Median sternotomy gives access to the heart and great vessels, to other structures in the mediastinum and to both pleural cavities.

### *Left antero-lateral thoracotomy*

Left antero-lateral thoracotomy (ALT) provides rapid access to the right and left ventricles and to the pulmonary artery; this is our approach of choice for emergency room thoracotomy. ALT is a less satisfactory approach to the right atrium and superior or inferior vena cava and proximal aorta; however, ALT is fast, may be continued across into the right chest as a 'clam-shell" incision, allows access to other injuries and allows cross-clamping of the descending thoracic aorta if the patient is close to exsanguination.

The chest is opened through the fifth intercostal space (just below the level of the male nipple) and the sternum is transected with heavy scissors, the two divided internal mammary arteries are immediately controlled. Although, in some cases, it is possible to repair an anterior stab wound of the heart without transecting the sternum,[11] we do it as a routine. Rapid spreading of the ribs often results in rib fractures and attention must be paid to avoid accidental injury from sharp rib splinters. Universal precautions must be observed and time spent donning a visor, double gloves, an apron and gown has never been regretted in the authors' experience.

### *Access to the heart*

In the presence of tamponade, opening the pericardium can be difficult if attempts are made to pick up the tense fibrous tissue; it is easier to make an initial cut with a blade and then continue the incision with scissors. The pericardium is opened longitudinally in an incision made 3 cm anterior and parallel to the phrenic nerve, extending the pericardial incision as an 'inverted-T' enhances exposure. Clot and blood are evacuated from around the heart and the site of injury and cardiac rhythm ascertained. If the heart is in asystole or fibrillation, internal massage is commenced using rapid, but gentle, compression taking care not to distract the heart or damage it. For a non-perfusing ventricular arrhythmia, start with a shock of 20 J with one internal paddle behind the heart and the other in front. Defibrillation should be repeated if required, but the maximum application should not exceed 40 J. Do not defibrillate complete cardiac standstill, as this can further damage myocardium; close communication with the anaesthetist is essential.

### *Control of ventricular bleeding*

Ventricular bleeding is best controlled by placing a finger pulp over the wound, then using 3/0 prolene on a large, round-bodied needle to go through both sides of the laceration in one pass of the needle. The two ends of the suture are pulled upwards with one hand, greatly reducing bleeding as the edges of the wound are approximated; the needle is then re-inserted to complete a figure-of-eight stitch. If tachycardia and vigorous ventricular contraction makes digital control and suturing difficult, insertion of a Foley's catheter through the wound, inflating the balloon with saline and gently pulling it against the inside of the heart controls bleeding. During suturing, the catheter must be pushed down to avoid bursting the balloon, or including the catheter in the stitch. Routine use of pledgets is not mandatory; however, individual pledget squares, either commercially available or cut from pericardium, can be used. More extensive injuries can be controlled by occluding the wound digitally and placing multiple sutures beneath the finger. An assistant can then tie each suture as the surgeon withdraws the finger. This technique is particularly well suited for inaccessible injuries, such as the posterior aspect of the left ventricle. Skin staples can be used to close a large myocardial wound with equivalent results to sutures, but less risk of needlestick injury.[12,13]

## *Control of atrial bleeding*

Applying a right-angled vascular clamp can control bleeding from atrial injuries; care must be taken not to apply traction as this can lacerate the thin atrial wall. Repair should be with 5/0 continuous prolene sutures, or interrupted pledgeted sutures. Cardiac arrest or severe arrhythmia may occur due to air embolism; this phenomenon is more likely to occur with atrial injuries. Air entering the left atrium directly or through a septal communication may manifest as air bubbles in the coronary arteries. If air embolism is suspected, the appropriate ventricle should be aspirated immediately.[14]

## *Posterior injuries*

Small puncture wounds may not be bleeding, even when the pericardium is opened. Take a good look at the posterior aspect of the heart as through and through injuries are common and the posterior wound tends to be smaller and may not be obvious at the time of operation. A view of the posterior aspect mandates lifting the heart, resulting in kinking of the vessels in an already ischaemic heart. It is of paramount importance to inform the anaesthetist prior to this manoeuvre, which frequently results in bradycardia or asystole. If this occurs, replace the heart in its bed and allow it to recover from the abnormal rhythm; further attempts can then take place. Pouring hot saline on a bradycardic heart frequently results in improvements in myocardial rhythm and performance.

## *Coronary arteries*

PCIs near the coronary arteries should be repaired with pledgeted mattress sutures, to prevent occlusion of the coronary vessels. Damaged peripheral branches of coronary vessels should be ligated. If the vessel is supplying a significant ventricular mass an attempt can be made to repair it. If repair is not possible, then ligation is recommended.[10] If signs of progressive ischaemia, cardiac failure or uncontrolled arrhythmias develop then formal repair with bypass is indicated.[15] Occasionally, revascularisation may be achieved on the beating heart, using myocardial stabilising devices.[16]

## *Closure*

The pericardium can be left open and mediastinal and thoracic drains placed. The bleeding edges of the cut sternum can be controlled by application of bone wax. The two halves of the sternum are approximated by wire sutures; facilitated by applying the needle holder at the junction of the front and middle third of the needle and advancing it in a vertical direction, rather than the usual rotational movement. As the sternum may yield suddenly to the needle, a sterile spoon (with the concavity facing upwards) can be placed below the sternum to avoid inadvertent injury to underlying structures. Closure of ALT is easy; the sternal part is easily approximated with one wire, while the thoracic portion of the incision is closed in the standard fashion.

## *Thoraco-abdominal injuries*

Approximately 10% of patients who reach the operating room alive with PCI require a laparotomy for associated intra-abdominal injury.[5] The trajectory of the penetrating wound must be assessed and laparotomy undertaken promptly where there is clear sign of intra-abdominal injury or if haemodynamic instability persists unexplained by intrathoracic injury. In addition, the surgeon operating on a patient with a high penetrating abdominal injury must be ready to undertake a transdiaphragmatic pericardial window and, if blood is found in the pericardium, to proceed to operate on the wounded heart.

## *Post-surgical care*

All patients with PCI will require admission to ICU for optimisation of haemodynamic and respiratory variables. Once immediate problems are controlled, particular attention should be paid to the development of a heart murmur, suggestive of a traumatic septal defect; routine echocardiogram should be mandatory.[17]

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# Technical notes

## Helping hands – a simple technique to ensure a secure sternal closure following open cardiac surgery


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### Background

Sternal dehiscence and infection occurs in 0.5–2.5% of patients undergoing cardiac operations. Mediastinitis carries a mortality of 10–40%.[1] A low incidence of mediastinitis can be achieved with strict adherence to aseptic technique, attention to haemostasis and a precise, stable and tension-free sternal closure.[1]

### Method

Using a standard eight-wire method to close the sternum, three wires are placed through the manubrium and five wires around the sternum. Having checked for bleeding at the wire sites, the wires are crossed. At this point, the anaesthetist places both hands, palms-up on the scapulae. By flexing their fingers, the scapulae can be easily lifted forward on the pectoral girdle with little effort. This simple manoeuvre transmits force upwards and medially to approximate the two sternal edges, thus facilitating wire approximation without stress. The wires are twisted and the anaesthetist relaxes on the scapulae. The wires are cut, and the manoeuvre is then repeated whilst the wires are tightened and the stumps buried. The result is a secure, tension-free and well-aligned sternal closure.

### Discussion

The technique applies an understanding of the anatomy of the pectoral girdle to allow closure of the sternum with minimal stress and correct apposition of sternal edges to obtain rigid sternal fixation.

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## The lifting of substernal goitres using a Fogarty catheter


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### Background

During total thyroidectomy, sometimes lifting the intrathoracic component of the goitre into the neck is extremely difficult.

### Method

During the capsular dissection, we routinely use a 2.5x magnification.1 A No. 7 Fogarty catheter with a 5 cc balloon is carefully introduced into the thoracic inlet at the bottom of the goitre. Subsequently, the balloon is inflated and a slow and progressive traction is performed to lift the substernal portion of the gland out of the thorax inlet. Between January 1998 and December 2003, out of 25 patients operated for cervico-mediastinal goitres, 11 (44%) were efficaciously treated by this technique without pneumothorax or any other morbidity.

### Discussion

The drawer technique is sometimes extremely difficult because the surgeon's finger cannot reach below the gland. The morcellation technique[2] heightens the risk of bleeding and the fragmentation of the goitre increases the risk of further surgery for malignancy or recurrence. The externalisation of the mass


**Figure 1** A No. 7 Fogarty catheter with a 5-cc balloon is carefully introduced into the thoracic inlet at the bottom of the goitre (A). The substernal portion of the gland is lifted out of the thorax inlet (B).

using traction by a suture can cause laceration of the gland. The use of a No. 18 French Foley catheter proposed by Pandya and Sanders[3] is not always satisfactory because the catheter is soft and it is not easily controllable during its introduction into the thoracic inlet and because the diameter of the catheter is sometimes too wide. The risk of pneumothorax using the Fogarty catheter is not increased compared to other techniques.

The cervicalization of substernal goitres by a No. 7 Fogarty catheter is a safe, simple and effective technique.

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## The use of pulsed-lavage in severe peritonitis

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### Background

Generalised peritonitis is associated with a high mortality, influenced by the degree of contamination, delay to treatment and the patient's co-morbidity. We use pulsed-lavage, as used in joint replacement and wound debridement surgery, to provide effective decontamination in gross peritoneal soiling.

### Method

Pulsed-lavage units deliver warmed saline through a hand-piece, backed by an electronically powered pump. This gives a constant baseline flow of fluid with timed pulses of flow at higher pressure. When the high-pressure flow makes contact with its target tissue, the tissue stretches and then recoils during the low-pressure phase of the cycle. It is during recoil that the contaminant will be removed from the tissue. We use a Stryker® system with integral suction device (Stryker House, Berkshire RG14 5EG, UK).

Different tips and power settings deliver varied pressure flows dispersing the jets in spray or unidirectional manner. Care is needed to avoid direct contact between high-pressure flow and fragile organs such as the spleen; therefore, we have used a spray tip at the lowest pressure setting. This is recommended for use at a distance of 10 cm; however, the pressure flow can be decreased by increasing the distance to the target tissue. The pulsed-lavage is aimed specifically at areas of contamination under direct vision.

### Discussion

We have found pulsed-lavage, using 0.9% saline, a useful technique in aiding macroscopic decontamination in gross intra-abdominal sepsis. For the cost of £60.00 per use, we suggest that pulsed-lavage is a useful addition to the surgeon's armament in the management of severe peritonitis.

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## An effective abdominal washout system

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### Background

Emergency abdominal operations are commonly dirty and require copious lavage to dilute bacterial load and prevention infection. Common practice is to pour saline into the abdomen using a jug and remove with suction. Overflow and misdirection often soak the surgeon and patient. It is slow and difficult to direct flow into paracolic and perihepatic spaces.

### Method

We describe an effective method for lavage of the abdominal cavity (Fig. 1). Two warmed 3-l saline bags are connected to large-bore bladder wash-out tubing and a small length of soft silicone tubing is attached distally with holes cut at intervals. The soft silicone end is placed inside the abdominal cavity and saline is infused in 500 ml boluses, before suctioning. The surgeon controls the rate of flow.

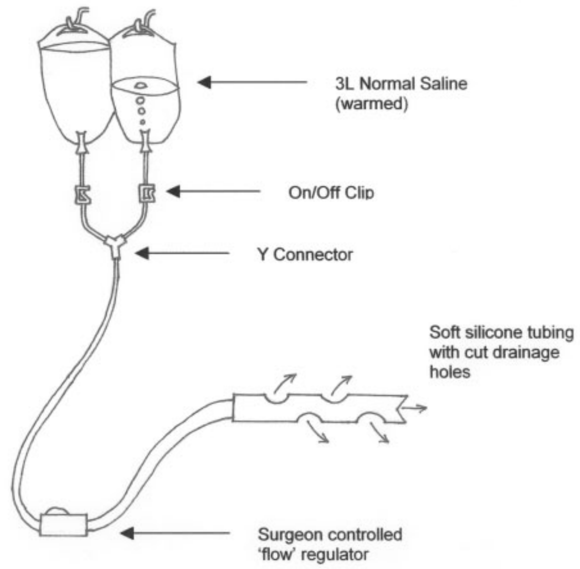


**Figure 1** Diagrammatic representation of an abdominal washout system.

### Discussion

This method allows 6 l of warmed saline to be instilled into the abdominal cavity in a controlled and directed manner. Areas where debris often collects can be washed out effectively. The method is effective, accurate and time saving.

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## Parastomal hernia repair: a new technique

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### Background

The options for parastomal hernia repair include stoma relocation, primary fascial repair, or the use of prosthetic mesh, which may involve laparotomy. We describe a preperitoneal mesh repair without needing a laparotomy.

### Method

A swab is plugged into the stoma and secured in place with polypropylene sutures. An adhesive drape is placed over the stoma. A horizontal skin incision is made over the hernia. The hernial sac is identified and the defect in the fascia is dissected all around the stoma. The dissection is carried out in the preperitoneal plane. The hernial sac is then reduced without opening the peritoneum by taking plicating sutures all around with 2-0 polyglactin. A large polypropylene mesh is placed under the fascia in the preperitoneal space. A circular defect is made in the mesh to accommodate the stoma. It is secured in place using 2-0 interrupted polypropylene sutures by parachute technique. A running 2-0 polypropylene stitch is taken to appose mesh with fascial edge all around. The mesh is also sutured to the stoma about 4 cm proximal to its opening using interrupted 2-0 polypropylene. Yates drain is placed and Scarpa's fascia is closed. The skin is closed using a subcuticular stitch.

### Discussion

The incidence of parastomal hernia varies from 5–50%.[1] About 10% of these require surgical correction.[2] Prosthetic material reinforcement offers the best results. The recurrence with mesh repair is low and they are due to technical mistakes, which could be avoided.[3] Our technique is simple, effective, anatomical and avoids laparotomy.

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# Technical tips

## Catheterisation in a large inguinoscrotal hernia

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The urological surgeon is frequently faced with the challenge of difficult catheterisation. One such example is that of the patient with a massive inguinoscrotal hernia. A novel technique to overcome this problem is to use a proctoscope. The tip of the proctoscope is passed within the foreskin, the introducer removed and a light source attached to expose the glans penis and urethral meatus (Fig. 1). A urethral catheter (size 12–14 Ch) is then passed through the proctoscope with some resistance on passing the exit lumen/balloon port. Such a technique may have an application in the lymphoedematous penis.

**Figure 1** Catheter inserted with proctoscope.

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## Cystoscopy or colonoscopy?

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Identifying the source of massive lower gastrointestinal bleeding remains a formidable clinical problem. Right-sided bleeding originates most commonly in the caecum but is rarely proven with colonoscopy. Direct visualisation of the bleeding point, however, allows hemicolectomy to be performed with confidence. This avoids inappropriate surgery.

Recently, we had two patients with severe bleeding from suspected right-sided colonic lesions. We performed antegrade endoscopy through the appendix with a flexible cystoscope, and irrigation with saline to confirm the site of bleeding prior to right hemicolectomy.[1] Thus, we avoided the much more elaborate on-table colonic washout with retrograde colonoscopy.

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## A simple method to prevent other people wearing your theatre shoes

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Surgical trainees rarely have personal lockers. Consequently, their theatre shoes can not be locked away, and are often worn by other people. This can transmit infection (e.g. athletes foot), and can be frustrating when no appropriately sized shoes remain. Making holes in the side of each shoe using the tip of a pair of scissors, allows the use of a padlock to lock the shoes together (Fig. 1). This prevents other people from wearing your theatre shoes.

**Figure 1** Restrained theatre shoes.

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## Good news tattoos!

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**Figure 1** A life-saving tattoo?

Tattoos are associated with a number of risks and do not generally gain medical approval. However, the complications of diabetes make an indelible warning to medical personnel sensible and possibly life-saving. We display a patient's choice of an informative wrist tattoo (Fig. 1), which is a tasteful alternative to a hazard bracelet!

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