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06.a.ii • Resuscitative thoracotomy

Patients who lose their cardiac output through penetrating trauma have a poor prognosis. Cardiopulmonary resuscitation is pointless: in potentially salvageable patients either blood flow through the heart is obstructed or the heart is empty due to hypovolaemia.

To maximise the chance of survival, surgical intervention should be immediate (within 10–15 mins of loss of cardiac output, or in the peri-arrest state). Resuscitative thoracotomy (RT) for penetrating chest injury primarily aims to address one specific group of patients – those with a simple cardiac wound leading to tamponade and cardiac arrest. It does not aim to address more complicated wounds (for example to the subclavian vessels) leading to hypovolaemic arrest. As the majority of tamponades are caused by clotted blood, pericardiocentesis is not indicated; formal thoracotomy and pericardotomy is essential. Patients may also require 'quality' internal cardiac massage to ensure return of spontaneous cardiac activity.

In the 'peri-arrest' patient, the decision whether or not to perform an immediate thoracotomy vs rapid transfer to hospital (for pre-hospital teams) or theatre (for TU trauma teams) will depend largely on the distribution of wounds and what the clinician 'expects to find' (ie. a readily treatable disease such as tamponade vs an aortic injury or high energy lung laceration from gun shot wound).

Some centres are now advocating thoracotomy solely for aortic compression to control bleeding (for example from the pelvic vessels) in blunt traumatic cardiac arrest or peri-arrest patients within 15 mins of loss of output. This is outside the scope of this guideline and we would recommend that teams considering this involve senior consultants. In-hospital teams should consider immediate laparotomy and packing +/- cross-clamping of the aorta.

Equipment

A clearly marked pack with the following equipment should be in every ED resus:

- skin cleansing chlorprep
- 2 x size 22 scalpels
- 2 x tuffcut shears
- 2 x mosquito forceps
- 2 x 2/0 silk sutures on a curved needle
- 2 x 2/0 vicryl ties
- staple gun
- 2 x Spencer Wells straight forceps
- Gigli saw (optional)
- Finichietto rib spreader (optional)

Procedure

Indication

Cardiac arrest or peri-arrest as a result of a penetrating injury likely to have breached the thoracic cavity.

- The decision to undertake a thoracotomy should be made quickly. It is a clinical decision and does not depend on the readings shown on multi-modality monitors.
- The patient should be rapidly moved to an area where there is 360 degrees of access, ideally with good lighting.

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- Sterile gloves and eye protection must be worn.
- Two operators should be identified and should position themselves each side of the patient, with the patient's arms abducted. A third team member should intubate the trachea (or insert an igel/LMA as appropriate) and a fourth obtain intravenous or intraosseous access, preferably in the femoral vessels or lower limbs so that they are not trying to work around the operating site. In the pre-hospital environment an enhanced care team will typically undertake the RT while ambulance personnel manage the airway and secure IV/IO access. All other team members and bystanders should be kept away as the incidence of sharps and splash injury is significant.
- Consider cleaning the skin if time allows and equipment immediately to hand.
- Both operators should simultaneously identify the 4th intercostal space at the sternal edge and trace it down to the mid-axillary line (to ensure that they are both operating in the same space – the 4th intercostal space is approximately level with the nipple in men and the infra-mammary fold in women).
- Undertake bilateral open thoracostomies using a size 22 scalpel blade through the skin and blunt dissection with straight Spencer Wells forceps through the intercostal muscles.
- If there is a large hiss of air (suggesting relief of a tension pneumothorax) re-check the patient before continuing with the thoracotomy. If the patient recovers, maintain anaesthesia as they may rapidly regain consciousness. Consider inserting a chest drain at this stage only if there is a continuous leak and/or to keep the thoracotomy patent. In the pre-hospital environment transport the patient to hospital immediately. In hospital continue care according to the findings of the primary survey. If there is no hiss of air or recovery proceed to RT.
- Extend both thoracostomies backwards towards the posterior axillary line.
- The operator on the patient's left side should ensure that the other operator's hands are clear of the chest, then make an incision with a size 22 scalpel through all the skin layers to fat/intercostal muscle along the line of the 4th intercostal space, joining both thoracotomy wounds. The incision should take the shape of swallow under both areolae and up towards the sternum.
- Using a pair of Tuffcut Shears extend the thoracotomy wounds on both sides up to the breastbone in the line of the 4th space. It may be possible to cut through the sternum with the shears; if not it should be divided with a Gigli saw. Pass Spencer Wells forceps behind the sternum, grasp the Gigli wire and pull it behind the sternum. Attach the wire to the Gigli handles and cut maintaining the wire horizontally rather than vertically (otherwise the wire will break.) It should not take more than 2 or 3 pulls. Beware the saw springing up and splashing operators/bystanders.
- Insert the Finechietto spreader (if available) anteriorly and wind the ribs apart in a 'clamshell' fashion, maximising exposure and aiding identification of anatomy. If no spreaders are available, the operator on the patient's right side should pull the chest wall up to allow maximum visibility. The operator on the patient's left side should continue the procedure.
- If necessary, use suction to clear the field and rub a swab up and down over the central pericardium to clear fatty tissue. The pericardium can now be identified.
- If tamponade is present the pericardium may look tense. Open the pericardium even if there is no tamponade to inspect the heart and perform massage. Using two Mosquito forceps, raise a 'tent' of pericardium anteriorly, then cut a small vertical hole. Extend the hole fully upwards to the aorta and downwards vertically with scissors.
- Remove any blood clots with your hands. The heart may fibrillate or beat spontaneously as this happens.

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- If the heart makes no spontaneous movement or is fibrillating, try flicking the apex with your finger. If the heart is not beating begin internal cardiac massage. Focus on the quality of massage you are providing. Put one hand flat underneath the heart and the other flat on top, and begin compressing the heart from the apex towards the atria, ensuring that the heart is as near to its anatomical position as possible and the great vessels are not kinked.
- If the heart is still fibrillating, remove the Finechietto spreader and close the chest as much as possible (if necessary holding it closed with an insulated item). Apply external defibrillation pads in the normal manner (preferably AP) and deliver a standard DC shock. Recommence internal cardiac massage if the heart is still not beating and shock again every 2 minutes if still fibrillating until either the heart beats or becomes motionless.
- If the heart is empty, the patient is profoundly hypovolaemic and the outcome is poor. Use the IV/IO access that should now be available to rapidly infuse 2 litres (adults) or 20–40ml/kg (paeds) of blood (if available) or crystalloid. Performing cardiac massage on an empty heart is futile and may injure the heart.
- Massage should be continued until myocardial activity occurs or a decision is made that further resuscitation is futile. Futility should only be considered once the patient has good airway management and ventilation and an adequate fluid bolus has been given.
- If the procedure is successful the internal mammary arteries may bleed profusely once reperfusion occurs and if this occurs they should be ligated (or clipped or oversewn if this is difficult.) Consider applying haemostatic dressings to the wound edges to reduce bleeding from the subcutaneous tissue, intercostal muscles and vessels.
- Spontaneous ventilation and awareness may occur rapidly and the patient should therefore be rapidly anaesthetised as required.

Cardiac wounds

- Bleeding from a cardiac wound should be controlled directly with a finger gently applied to the area. In the pre-hospital environment a black silk suture on a hand-held needle can be carefully inserted, avoiding tearing the fragile myocardium and avoiding the coronary arteries. If you think that the suture may pull through the muscle, use a piece of pericardium as a pledget. A horizontal mattress suture is preferred as it is less likely to tie off the coronary arteries. In hospital, prolene sutures and pledgets can be used instead.
- Alternatively, staples can be used. Foley catheters have been used to reduce flow from cardiac wounds but can be pulled through the myocardium, making the wound larger. They can also almost completely occlude the ventricle.

Aortic occlusion

- Aortic occlusion should be used if you feel that exsanguination is a likely contributor to the cardiac arrest/low flow state. From the patient's left side, pass your hand down behind the lung until you can feel the spine. If you can, identify the aorta (you may feel a pulse if it is sufficiently filled and cardiac massage or a low flow state is occurring) and compress it against the anterior surface of the spine with your fingers. Maintain this pressure during the transfer to hospital or the operating theatre.

Triage and disposition

All patients who have undergone successful active resuscitation in the pre-hospital setting will be Triage Tool positive. Pre-alert the hospital through NCS and request that they activate the massive blood loss protocol, prepare a theatre and alert the general surgical Consultant and that they speak to the NCS Consultant immediately (prior to patient arrival) for advice on obtaining cardiothoracic support. Give the TU as much notice as you can.

In a TU, patients who have been successfully resuscitated will need haemostasis and usually further fluid resuscitation. The Trauma Team Leader or General Surgical Consultant/Registrar should call the NCS Consultant as soon as possible to obtain advice and cardiothoracic support.

In the MTC, the patient will be managed jointly by the General Surgical and Vascular Consultants jointly, with advice and support from the cardiac surgeon at Papworth.

If despite maximal resuscitation the situation appears hopeless, then life may be pronounced extinct.

Documentation and audit

Clear documentation of the procedure should be included in the appropriate patient care record.

It is recommended that cases are debriefed and audited as soon as possible after the intervention by the pre-hospital organisation or in-hospital trauma lead. All thoracotomies in the MTC will be investigated by a multi-disciplinary team and learning points shared with all parties. Pre-hospital and TU thoracotomies will trigger a Trauma Network After Action Review, again with the aim of sharing learning points.

Training

It is essential that those who could be involved in performing or assisting with a resuscitative thoracotomy receive appropriate training in both the surgical technique and the team approach.

