



T.I.G.E.R.

#4 Resuscitative Thoracotomy

Resuscitative thoracotomy (RT) is a time critical, integral part of traumatic cardiac arrest (TCA) algorithms. It is most effectively performed using a clamshell technique (bilateral antero-lateral thoracotomy) and should be carried out by adequately trained personnel.

Whilst RT is well established in TCA related to penetrating torso injury, latest data suggests that RT should also be considered in certain arrest scenarios caused by blunt injuries to the torso.

The main goals of the procedure are:

- relieve cardiac tamponade and repair of myocardial injury
- occlude the aorta to increase blood flow to heart and brain
- control life threatening thoracic bleeding
- perform open cardiac massage

Survival rates following Emergency Department (ED) RT remain low (8.3% for penetrating TWA and 4.6% for blunt TWA), but the alternative of not performing the procedure is almost certain death.

Consideration should be given to providing welfare support to members of the team, as the procedure can appear dramatic, and some team members may be unprepared for such events.

In all cases, please ensure that the consultant in charge of the department has been informed of any patients requiring emergency intubation following traumatic injury. It is expected that local, consultant led advice has been sought prior to referral to The Royal London Major Trauma Centre. Ensure this is documented in the clinical notes accordingly (date, time and colleagues name and grade).

Situation

- Trauma patient in TCA with:
 - **Penetrating injury to torso and loss of vital signs < 15 min or**
 - **Blunt, likely single haemorrhagic injury to thorax, abdomen or pelvis with loss of vital signs < 5 min**
- In the ED Resuscitation Area
- The whole trauma team in attendance
- At least one clinician trained to perform a clamshell thoracotomy
- Senior surgical staff and emergency theatre access available in case of ROSC

PROCEDURE

Preparation



Patient

Indication:

- Penetrating injury to the chest and epigastrium and loss of vital signs < 15 min

Consider:

- Penetrating injury to abdomen and pelvis and loss of vital signs < 15 min
- Blunt injury, likely single haemorrhagic injury to thorax, abdomen or pelvis in the absence of catastrophic head injury and a loss of vital signs < 5 min

Assessment

- This is a time critical procedure and assessment has to be fast
- Undress the patient completely and assess both front and back for penetrating torso injuries
- Establish TAC by checking for absence of vital signs i.e. spontaneous ventilation, carotid pulse, measurable BP, extremity movements
- Establish the exact time when vital signs were last detected
- Proceed immediately to RT if inclusion criteria are met and TCA established
- Chest compressions in the context of TCA are of questionable benefit and should be interrupted to provide definitive care
- Anaesthetic team to intubate patient
- Whilst RT is undertaken, ensure the following:
 - Activate major haemorrhage protocol
 - Inform senior surgeon (vascular +/- cardio-thoracic if available)
 - Ensure emergency theatre becomes available
 - Contact HEMS desk on ...

Equipment

- Anaesthetic equipment for RSI
- PPE as per current Trust guidance (RT is a AGP), skin disinfectant, drapes
- A pre-packed RT-set should contain the following:

1-2 large scalpels i.e. size 12	2 packs of 3.0 Ethilon sutures
1-2 pairs of heavy forceps i.e. Spencer-Wells	2 packs 3.0 Vicryl sutures
1-2 pairs of trauma scissors	2 packs 1.0 Ethilon sutures
1 pair of large shear cut scissors +/- 1 gigli saw	2 skin staple guns (optional)
Minimum 4 pairs of small artery forceps	1 aortic cross clamp (optional)
1 suture pack	1 rib spreader (optional)
1 foley catheter	

PROCEDURE

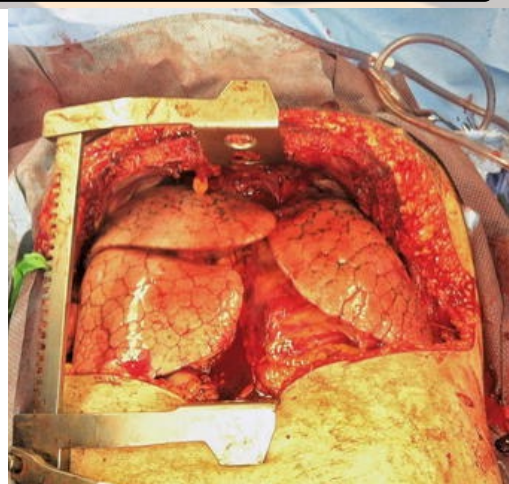
Delivery of Intervention

Anatomy

The clamshell or bilateral antero-lateral thoracotomy gives the operator easy access to the heart, both lungs and the great vessels.

Consideration has to be given to:

- The left phrenic nerve runs intimately with the lateral pericardial sac and is vulnerable to injury during thoracotomy.
- Coronary arteries are endangered during myocardial wound sutures.

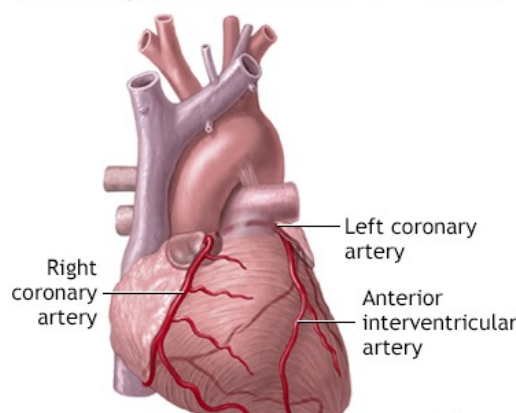
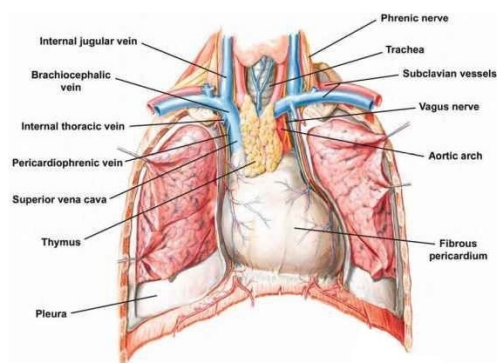


Technique

- Position the patient supine with 360 degrees of access. Intubation, ventilation, i.v. access, etc. are simultaneously performed by team members other than the operator to prevent delaying RT
- Wear PPE, sterile gown and sterile gloves
- Restrict aseptic technique to rapid application of skin preparation and drapes

Opening the chest:

- Perform bilateral thoracostomies in the mid-axillary line, 5th intercostal space using scalpel and blunt forceps. Quickly re-assess the patient at this point and proceed if no vital signs are detected:
- Make a clamshell skin incision in the 5th interspace joining the thoracostomy wounds.
- Insert two fingers into thoracostomy (holding the lung out of the way) whilst extending the thoracostomy wounds on both sides up to the sternum using heavy scissors.
- The sternum can usually be divided with scissors. If not, pass blunt forceps behind the sternum and pull the serrated wire of a Gigli saw behind the sternum. Attach wire to the saw handles and divide the sternum horizontally with a few saw strokes.



PROCEDURE

Delivery of Intervention



Intervention

- The incision in the intercostal space is then extended posteriorly to the posterior axillary line to allow full chest opening in a 'clamshell' fashion. A self-retaining rib spreader can be inserted to maximise the exposure of the heart.

Treatment of pericardial tamponade and cardiac injury

- Blunt forceps are used to raise a 'tent' of pericardium on the anterior surface of the heart.
- The pericardium is opened with surgical scissors vertically and the incision extended to expose the heart. Vertical incision minimises the risk of phrenic nerve damage.
- Evacuate blood clots by hand from the open pericardium. The heart may fibrillate or beat spontaneously after pericardial decompression.
- Cardiac wounds should be controlled initially with direct finger pressure. Large wounds may be controlled temporarily by the insertion of a Foley catheter with inflation of the balloon. Take care also not to miss posterior cardiac wounds. Examination of the posterior surface of the heart requires displacing it anteriorly, which may obstruct venous inflow.
- Cardiac wounds can be directly sutured using non-absorbable 3.0 sutures. Use mattress sutures for wounds in the region of the coronary vessels to avoid obstructing coronary flow. Atrial wounds are best sutured using a continuous suture technique.

Hilar techniques

- Massive haemorrhage from the lung or pulmonary hilum can temporarily be controlled with finger pressure at the pulmonary hilum. This may be augmented by tying off the pulmonary hilum using a tracheal tube tie.
- In experienced hands, the hilum twist manoeuvre can be used to control massive haemorrhage from hilar vessels or the lungs.

Compression of the descending thoracic aorta

- The rationale for manually compressing or cross clamping the aorta is to redistribute blood flow to the coronary vessels, lungs and brain in persistent hypotension, or when an exsanguinating injury is suspected below the diaphragm.
- Access to the aorta is achieved by retracting the left lung superiorly and then dividing the pulmonary ligament.
- The descending aortic aorta lies anteriorly to the spine and can be manually compressed against the vertebrae just above the diaphragm.
- In order to facilitate cross clamping, the aorta has to be dissected free from surrounding structures to allow the clamp to be applied.
- Occlusion time should ideally not exceed 30 minutes.



PROCEDURE

Following the Intervention

Specific considerations

Ventricular fibrillation

- In case of ventricular fibrillation, remove the rib spreader, close the chest, apply electrodes to the chest wall, and defibrillate as per ALS protocol.
- Alternatively, if internal paddles are immediately available, internal defibrillation can be used with the first shock at 10 J increasing to 20 J if required.

Internal cardiac massage

- If there is no spontaneous cardiac contraction, attempt stimulation by flicking the heart with a finger.
- If this is ineffective, begin cardiac massage, ensuring the heart has sufficient volume to allow effective massage.
- A two-handed technique should be used ensuring that the heart is horizontal and not kinked on its vascular pedicle.
- Blood is 'milked' from the apex upwards, initially at a slow rate allowing the heart to fill, gradually increasing to a rate of 80 beats/min.
- An assistant can compress the descending aorta against the spinal column.

After ROSC

Anaesthesia

- If the procedure is successful, the patient may begin to wake up so be prepared to provide immediate anaesthesia. An anaesthetic agent with minimal cardiac depression should be used and ketamine is frequently the agent of choice.

Haemorrhage control

- Bleeding may occur particularly from the internal mammary and intercostal vessels which can either be clamped or tied off.

Transfer to definitive care

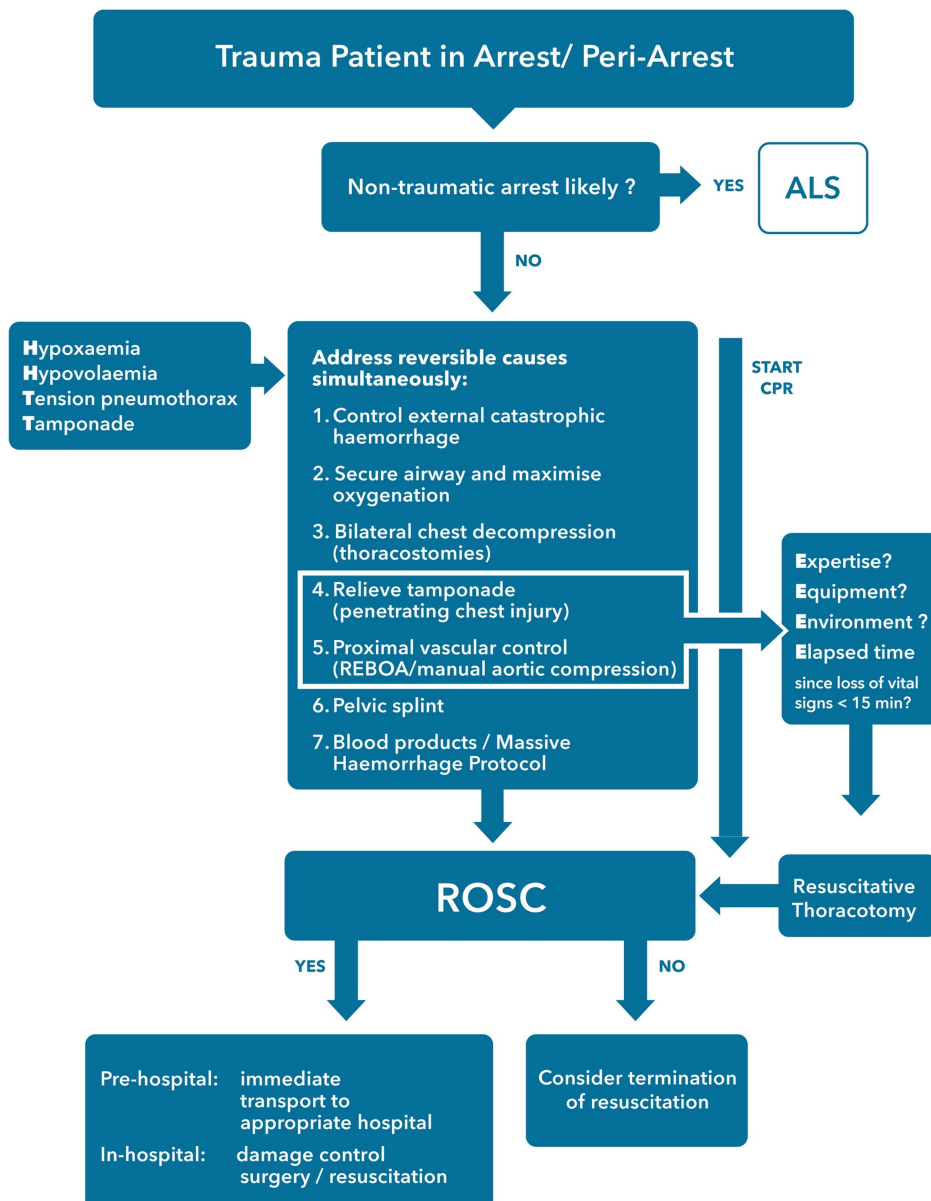
- Once perfusion has been restored, the patient needs to be transferred to an operating facility where definitive repair can be provided.
- Depending on to local set-up, this can be one of the following options:
 1. Transfer to the local emergency theatre in particular where senior vascular/cardiothoracic surgical expertise is available.
 2. If the patient remains haemodynamically stable, immediate transfer to the RLH can be an option. Careful consideration has to be given to the constellation of the transfer team. Contemplate temporary wound closure in this scenario.
- Ring 999 and request to speak directly to the HEMS desk paramedic for support with a thoracotomy – if HEMS is dispatched then the HEMS paramedic will pass you back to the call handler where additional details will be taken and an IFT 1 (inter-facility transfer type 1) should be requested

APPENDIX

Traumatic cardiac arrest algorithm

European Resuscitation Council Guidelines 2021:

TRAUMATIC CARDIAC ARREST/ PERI-ARREST ALGORITHM



Aide Memoir – Resuscitative Thoracotomy



Please note that this quick list is not designed to replace formal training prior to performing this procedure.

Indication:

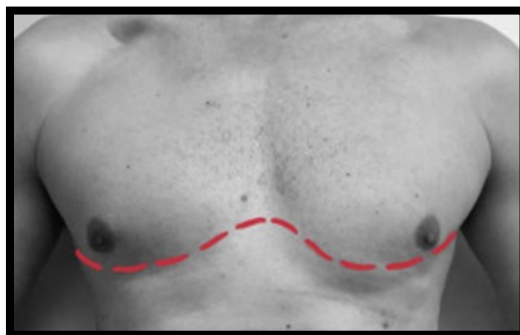
- Penetrating injury to torso and loss of vital signs < 15 min or
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Parallel actions to be delegated

- Intubation – no drugs required at this stage (anaesthetic drugs when ROSC established)
- Inform ED consultant in charge
- Bilateral IV access and transfuse 2 units RBC

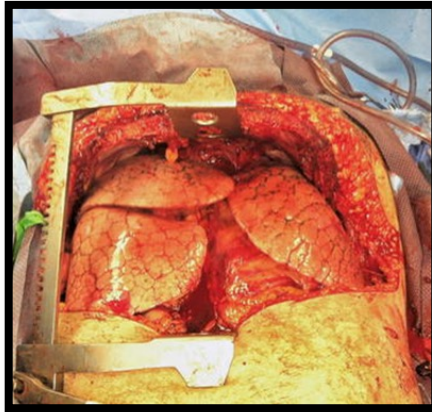
Step-by-step procedure

- Bilateral thoracostomies in 4th or 5th intercostal space (aim for same level at both sides) using scalpel and Spencer Wells forceps – injured side first.
- Re-assess patient – if ROSC at this stage, stop and insert chest drains. Otherwise continue:
- Clamshell skin incision connecting the two thoracostomies using a scalpel, in 4th or 5th intercostal space going from one posterior axillary line to the other posterior axillary line.



- Extend incision through intercostal muscles using trauma scissors from thoracostomy to sternum bilaterally.
- Pass Spencer Wells forceps behind the sternum, grab the Gigli wire and pull it behind the sternum.

- Pull Gigli saw 2-3 times to divide the sternum. (Use spencer wells/ clips to hold Gigli wire if required)
- Lift chest open – top half towards head and identify the heart. Insert thoracotomy rib spreader when available.



- Using two artery forceps, lift a bit of pericardium on anterior heart surface and cut a small vertical hole and extend it vertically with scissors.
- If pericardial blood clots present, remove those with hands.
- If still no heart movement at this point, perform internal cardiac massage. Keep the heart flat and squeeze from apex towards the top avoiding to tilt or pull the heart forwards. Allow time for heart to refill)
- If myocardial activity is poor after filling and chest ventilation, give 1mg of intra cardiac adrenaline to the right ventricle and consider compression of the descending thoracic aorta against the spine just above the diaphragm.
- Continue cardiac massage.

Cardiac wounds

- Small wounds (<1cm) can be left if minimal blood loss
- If bleeding from a small wound, place finger over the top
- Consider suturing other wounds with interrupted monofilament non-absorbable sutures, size 1-0 to 3-0.
- Foley catheters can be used temporarily, but they may obstruct the space in the heart.

Ventricular Fibrillation

- Close the chest, remove rib spreaders and apply external pads as normally and deliver shock as per ALS protocol.
- Alternatively, if internal paddles are immediately available, internal defibrillation can be used with the first shock at 10 J increasing to 20 J if required.