Northern Ireland Major Trauma Network

Clinical Practice Guideline 12:

Resuscitative Thoracotomy

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KEY MESSAGES

- **Resuscitative Thoracotomy is a potentially lifesaving procedure.**
- **Strict indications, contraindications and timeframes must inform the decision-making process.**
- **The main aims of Resuscitative Thoracotomy are to relieve Cardiac Tamponade and control haemorrhage.**
- **Training and a robust governance framework are essential.**

NIMTN Clinical Practice Guidelines are intended to inform standardised, best-practice care for injured patients across Northern Ireland. Although they are based on up to date evidence at the time of writing, readers should note that it remains the responsibility of individual clinicians to make final decisions regarding the most appropriate treatment for specific patients in their care.

Prehospital practitioners employed by Northern Ireland Ambulance Service (including those involved in specialist teams such as HEMS and HART) may find these guidelines informative but should continue to follow guidance contained within JRCALC, NIAS and HEMS guidelines and SOPs.

Background

Since its first formal description nearly 50 years ago, Resuscitative Thoracotomy (RT) has remained among the most polarising and controversial procedures that clinicians perform. However, there is now a good evidence base with robust recommendations on indications and methods.

Critically injured trauma patients who present in extremis continue to pose a clinical, administrative, and philosophical dilemma. While the role of cardiopulmonary resuscitation (CPR) in cardiac arrest patients is well described, the use of conventional CPR in traumatic arrest is usually ineffective. Using RT when indicated has improved survival in very select patients with life-threatening injuries. Despite limited survival after traumatic arrest, this resuscitative technique may offer the only hope for the survival of critically injured patients and remains widely practiced.

At this point it should be stressed that patient outcomes following an RT performed in an operating theatre are superior and this should be facilitated immediately if at all possible.

However, specialist Cardiothoracic surgical support is not immediately available in most EDs, so the task of performing an immediate RT may fall to other specialists. RT is nearly always performed in the ED and the Royal College of Emergency Medicine states that this procedure is definitely within the remit of the Emergency Physician.

Regardless of who performs the procedure, it is important that RT should be performed by trauma teams with adequate training and experience in damage control resuscitation strategies.

Related Guidelines

CPG 7: Breathing
CPG 11: Traumatic Cardiac Arrest

Nomenclature

There are several names and abbreviations used in the literature to describe this procedure, differing mainly due to the physical location of where the intervention is performed. This guideline focuses on the use of a Thoracotomy in an immediate resuscitation setting and although it more commonly occurs in an Emergency Department (ED) it is important to acknowledge that it can also occur in the Pre-hospital environment (HEMS) and in the operating theatre.

It should not be confused with an Urgent Thoracotomy which is solely in the remit of Cardiacthoracic/Surgical teams and is not addressed here.

For the purposes of this guideline the term Resuscitative Thoracotomy (RT) will be used.

Rationale = Cardiac Tamponade

Cardiac tamponade is a pathological restraint of cardiac filling due to increased pericardial pressure, caused by the excess of blood/fluid in the pericardial cavity. Typical characteristics of tamponade are: equalisation of left and right ventricular filling pressure, restricted diastolic filling of both ventricles and decreased cardiac output with development of shock.

The compressive effect of increasing pericardial pressure is exerted primarily on the right heart and caval vessels with left ventricle function becoming compromised later as a consequence of inadequate filling.

Cardiac arrest secondary to cardiac tamponade in penetrating thoracic trauma is the clearest indication for RT and indeed, mortality is certain without immediate intervention. The European Resuscitation Council and American College of Surgeons are clear that immediate RT via a clamshell is indicated to restore circulation in this group. On occasion where an experienced team or experienced surgeon is present a left anterior thoracotomy may be performed.

Current ATLS and ERC guidelines emphasise the use of RT in lieu of pericardiocentesis in this population; this is supported by evidence suggesting that a significant percentage of tamponades (47%) are composed of clotted haemopericardium.

RT therefore offers the most effective treatment to reverse obstructive shock/cardiac arrest in the setting of isolated traumatic Cardiac Tamponade.

Ultrasound

Progression to RT should follow a firm or highly suspected diagnosis of Cardiac Tamponade.

Extended Focused Assessment with Sonography for Trauma (eFAST) imaging is well established in trauma and is advocated by NICE for use in the primary survey assessment in adults with respiratory compromise in chest trauma.

eFAST also greatly facilitates the early detection of haemopericardium after penetrating injury. FAST is 90–95% accurate in identifying the presence of pericardial fluid for the experienced operator with subcostal and parasternal FAST views reported to be both highly sensitive and specific in detecting pericardial blood in penetrating trauma.

eFAST is both a rapid and accurate method of imaging the heart and pericardium that can effectively identify Cardiac Tamponade.

In the absence of a clinician who is confident in the use of eFAST, where images are non-binary or where time is of critical importance, proceeding directly to a RT may be indicated.

Decision making

Confident decision making is key to the success of RT. It should only be undertaken after consideration of the following three areas. An experienced trauma team leader will be able to navigate through these rapidly.

1. Survival Predictors
2. Indications and Contraindications
3. “4 Es Rule”

1. Survival Predictors

Physiologic variables such as duration of cardiopulmonary arrest, the presence of prehospital and ED signs of life, presenting cardiac rhythm and the presence of vital signs are strongly related to injury mechanism and anatomic injury and are all important RT survival determinants.

The premise of decision making should centre around three key survival predictors that form the basis of indicating the patients who will most benefit from RT.

Survival predictors	Considerations
Injury mechanism	Blunt vs. Penetrating
Anatomic injury location	Thorax/abdomen vs. multi-region
Presence of "signs of life" on presentation	*"Signs of life"* • Pupillary response to light • Respiratory effort • Cardiac electrical activity / contractility confirmed on eFAST • Spontaneous movement • Palpable carotid pulse

2. Indications & Contraindications

Primary aim of RT = *"to alleviate obstructive shock secondary to cardiac tamponade"*

Indications 	• **Cardiorespiratory arrest** following **penetrating injury to the thorax**, with **witnessed signs of life in the previous 10-15 mins** • **Cardiorespiratory arrest** following **penetrating injury to the epigastrium** + **witnessed signs of life in the previous 10-15 mins**

Contraindications 	• **Cardiorespiratory arrest** following **blunt trauma** in the **absence of a senior Cardiothoracic Surgeon** •**Absence of signs of life** at scene and on arrival, following cardiopulmonary resuscitation for **>10-15 mins** • Associated **severe head injury or thoracic injury** as part of **severe multisystem trauma** • Patient's **age and pre-existing co-morbidities** mean that successful resuscitation is highly unlikely • **Lack of training** in the procedure

3. “Four Es rule”

The prerequisites for a successful RT can be summarised as the “four E rule”:

1. Expertise: teams that perform RT must be led by a senior and competent healthcare practitioner. These teams must operate under a robust governance framework.

2. Equipment: adequate equipment to carry out RT and to deal with the intrathoracic findings is mandatory.

3. Environment: ideally RT should be carried out in an operating theatre. RT should not be carried out if there is inadequate physical access to the patient, or if the receiving hospital is not easy to reach.

4. Elapsed time: the time from loss of vital signs to commencing a RT should not be longer than 10-15 min.

If any of the four criteria is not met, RT is likely futile and exposes the team to unnecessary risks. RT is also a viable therapeutic option in the prehospital environment.

Governance

The four Es can be maximised through preparation within an effective governance framework. This can be achieved in both the "COLD" and "HOT" phases to ensure optimal outcomes.

COLD **(Preparation)**	**Departmental preparation** Equipment/PPE Environment (dedicated trauma resus bay) **Simulation** Trauma team training Human factors and mental models Rehearse and plan for movements to definitive surgery **Individual competency** Know the evidence base around RT Practical skills
HOT **(Procedure)**	**Act in patient's best interest** **Rapid senior decision making** Key survival predictors Indications/contraindications 4 Es **Expertise** An experienced clinician should lead the team or perform the procedure. **Ensure sharps control and staff safety at all times** **Move to definitive surgery as soon as practical**
COLD **(Learning and Debrief)**	**Replace used stock/equipment** **Cold multi-disciplinary debrief to include peer (Cardiothoracic) input** **Share learning/experience** **Staff welfare considered and supported**

Practical procedure - How to do it

Emergency thoracotomy: ''how to do it'' D Wise, G Davies, T Coats, D Lockey, J Hyde, A Good

1	Position the patient in the supine position if not already so. Intubation, ventilation, intravenous access, etc. should be performed by other members of the trauma team and not delay the thoracotomy.
2	Time should not be wasted on full asepsis (that is, fully preparing the skin and surgically draping the patient) but a rapid application of skin preparation is appropriate.
3	Using a scalpel and blunt forceps make bilateral 4 cm thoracostomies (breaching the intercostal muscles and parietal pleura) in the 4th or 5th intercostal space in the mid- axillary line; the same technique and landmarks as for conventional chest drains. ***Note: The procedure is stopped at this point if tension pneumothorax is decompressed and cardiac output returns.***
4	Connect the thoracostomies with a deep skin incision following the 4th or 5th intercostal space.
5	Insert two fingers into a thoracostomy to hold the lung out of the way while cutting through all layers of the intercostal muscles and pleura towards the sternum using heavy scissors. Perform this on left and right sides leaving only a sternal bridge between the two anterolateral thoracotomies.
6	Cut through the sternum using the heavy scissors. If unable to cut through bone with scissors, use the Gigli saw (serrated wire) as follows: • Pass the large clamp/forceps under the sternum • Grasp one end of the Gigli saw with the clamp/forceps and pull back under sternum. • Connect saw handles and with smooth, long strokes cut through the sternum from inside out.
7	Open the ''clam shell'' using one or two large self-retaining retractors/rib spreaders from the full thoracotomy set. If this is not available, the incision can be held open manually by one or two gloved assistants. The retractor should be opened to its full extent to provide adequate exposure of the chest cavity with access to all areas. ***If exposure is inadequate the incisions need to be extended posteriorly.***
8	Lift (''tent'') the pericardium with clamp/forceps and make a large midline longitudinal incision using scissors. This approach minimises the risk of damage to the phrenic nerves, which run in the lateral walls of the pericardial sac. Making the incision too short will prevent full access to the heart.
9	Evacuate all blood and clot present, then inspect the heart rapidly but systematically for the site of bleeding.
10	One of three scenarios is now likely: a) The heart will begin to beat spontaneously with a return of cardiac output. In this situation any cardiac wounds should be closed as described below. b) The heart begins to beat slowly with a considerably reduced cardiac output. In this situation wounds should be closed quickly, then attempt

	to improve cardiac output with supplementary internal cardiac massage and inotropic support. c) The heart remains in asystole. In this case wounds should be quickly closed and then attempts made to restart the heart as in step 10b. Simply flicking the heart may produce a return of contractions.
11	When massage is required it must be of optimal quality. The authors' preference is a two handed technique. One flat hand is applied to the posterior surface of the heart and one on the anterior surface. Blood is ''milked'' from the apex upwards at a rate of 80 beats per minute. Alternatively a single hand can be used if it is large enough. Using this technique straight fingers are applied to the posterior surface of the heart, the apex is positioned in the palm of the hand and the thumb on the anterior surface. Whichever technique is used ensure that the heart remains horizontal during massage. Lifting the apex of the heart too far out of the chest can prevent venous filling. An assistant can compress the aorta against the spinal column using a thumb or fingers to maximise coronary and cerebral perfusion.
12	Control any bleeding: • Holes less than 1 cm can usually be occluded temporarily using a finger or gauze swab. If this is successful no other method should be attempted. • For larger defects, a Foley urinary catheter can be passed through the hole then inflated and gently pulled back. This technique reduces the volume of the ventricular cavity (with subsequent reduction in stroke volume) therefore only a small volume (10 ml) should be used in the balloon. Ensure that the catheter is clamped to prevent blood loss from it. If a catheter is used in this way, a ''giving set'' can be attached to permit rapid volume infusion directly into the heart. • If bleeding cannot be controlled with finger/gauze/Foley catheter, it may be necessary to close the defect with large sutures, but it should be emphasised this is a last resort as there is a risk of occluding coronary arteries. If sutures are used the minimum required to achieve haemostasis facilitated by finger/gauze/Foley catheter should be used. Non-absorbable size 0/0 or 1/0 monofilament or braided are appropriate; take 1–2 cm ''bites''.
13	If defibrillation is required use internal paddles with an initial energy level of 10 joules. If these are not available, close the clam shell and defibrillate using conventional external pads.
14	If the procedure is successful the patient may begin to wake up so be prepared to provide immediate anaesthesia.
15	***Restoration of circulation will be associated with bleeding, particularly from the internal mammary and intercostal vessels.*** Large bleeders may be controlled with artery forceps.
16	Once perfusion has been restored the patient should be moved to theatre (optimally a cardiothoracic facility although this will depend on local expertise) for definitive repair.

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