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ORIGINAL ARTICLE

Resuscitation thoracotomy

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Summary Resuscitation thoracotomy is a rarely performed procedure whose use, in France, remains marginal. It has five specific goals that correspond point-by-point to the causes of traumatic cardiac arrest: decompression of pericardial tamponade, control of cardiac hemorrhage, performance of internal cardiac massage, cross-clamping of the descending thoracic aorta, and control of lung injuries and other intra-thoracic hemorrhage. This approach is part of an overall Damage Control strategy, with a targeted operating time of less than 60 minutes. It is indicated for patients with cardiac arrest after penetrating thoracic trauma if the duration of cardiopulmonary resuscitation (CPR) is <15 minutes, or <10 minutes in case of closed trauma, and for patients with refractory shock with systolic blood pressure <65 mm Hg. The overall survival rate is 12% with a 12% incidence of neurological sequelae. Survival in case of penetrating trauma is 10%, but as high as 20% in case of stab wounds, and only 6% in case of closed trauma. As long as the above-mentioned indications are observed, resuscitation thoracotomy is fully justified in the event of an afflux of injured victims of terrorist attacks.

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Introduction

Resuscitation thoracotomy (RT) is a rarely performed procedure whose use, in France, remains marginal. However, an abundant literature shows that, in the event of cardiac arrest following a penetrating trauma, the survival rate is close to 10% and up to 30% in the case of a cardiac wound [1,2].

Terminology

The literature is sometimes confusing because of the use of multiple terminologies, such as: emergent thoracotomy, urgent thoracotomy, emergency room thoracotomy, emergency department thoracotomy, resuscitation thoracotomy, resuscitative thoracotomy.

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To our mind, resuscitative thoracotomy seems to be the most relevant term to describe a thoracotomy performed in a patient in cardiac arrest or in-extremis, unresponsive to reanimation measures, and whose evolution would be a *fortiori* fatal.

Rationale

If severe head trauma is excluded, the causes of traumatic cardiac arrest are:

- hypoxia, due to airway obstruction or failure of ventilatory mechanics;
- pericardial tamponade (hemorrhagic or gaseous);
- primary cardiac pump failure associated due to myocardial contusion or air embolism;
- subdiaphragmatic hemorrhage;
- intra-thoracic hemorrhage, due to a wound of the heart, great vessels or pulmonary vessels;

After obtaining airway control and decompressing tension pneumothorax, there are five main objectives of RT that respond point by point to the causes of traumatic cardiac arrest:

- decompression of pericardial tamponade;
- control of cardiac hemorrhage;
- performance of internal cardiac massage;
- cross-clamping the descending thoracic aorta;
- control of pulmonary injuries and other intra-thoracic hemorrhages.

This approach has to fit into a Damage Control strategy, with a target time of less than 60 minutes.

Technique

Equipment

Classically, the necessary equipment is described as rudimentary. We decline it in ten items:

- scalpel blade;
- heavy-duty scissors also called paramedic shears;
- Finochetto-type self-retaining chest retractor;
- medium length instrument set: Mayo or Metzenbaum scissors, two needle holders and two Debakey forceps, long straight aortic clamp and two large Satinsky-type counter-angled clamps;
- effective suction, ideally connected to a cell-saver[®] blood recovery device;
- Foley catheter, 18 or 20 French, with saline-filled syringe for balloon inflation;
- Prolene[®] 2.0 or 3.0 sutures;
- length 90 cm, swaged onto half-curved 36 mm needles – internal defibrillation paddles;
- laparotomy pads or large compresses;
- skin stapler.

Surgical approach

The operator stands to the patient's left, and after a rapid antiseptic skin preparation and draping, incision is made with a cold knife.

The first stage of RT is the incision, a large anterolateral left submammary thoracotomy starting from the sternal margin and extending into the axillary hollow. This approach provides exposure for opening the pericardium, the

performance of manual cardiac massage, and for clamping the descending thoracic aorta. It can be extended, without hesitation, into submammary bilateral thoracotomy, a so-called « clamshell-type » incision, offering wider exposure and, if necessary, access to the right chest and mediastinal structures. The horizontal division of the sternum is made with heavy-duty scissors after having displaced the pericardium posteriorly with finger dissection. Internal mammary vascular pedicles are divided, rarely bleeding in these circumstances. The self-retaining chest retractor is positioned at the sternum and widely opened.

Opening of the pericardium

The pericardium is opened anterior to the left phrenic nerve, from the cardiac apex to the aortic root. When the pericardial membrane is under tension and cannot be grasped, the opening is initiated by a scalpel puncture. Then, the left hand passes beneath the heart, allowing its externalization for control of hemorrhage and performance of massage.

Controlling cardiac bleeding

If a cardiac wound is present, initial hemostasis is usually obtained by simple digital pressure. It can also be obtained by insertion of a Foley catheter whose balloon is inflated within the heart and placed on tension to seal the wound. The distal end is then clamped or connected to an infusion device allowing massive intracardiac volume replacement. Atrial wounds are usually controlled by tangential placement of a Satinsky clamp. Cardiomyotomy is generally performed with interrupted u-shaped sutures, ideally in subcoronary location and possibly reinforced with Teflon or pericardial pledgets, to avoid tearing the myocardium. Finally, when the wound is linear, particularly at the level of the left ventricle, it may be possible to close this with a skin stapler. The use of topical hemostatic agents is of only marginal interest in our view.

Performance of internal cardiac massage

It is urgent to maintain circulating blood volume for cerebral and coronary perfusion. In the case of the exsanguinated patient, we routinely insert a large bore Foley catheter through a right atrial incision secured by a purse-string suture to allow for massive direct intra-cardiac volume replacement. Cardiac massage is done by picking up the heart mass with both hands flat, wrists joined, and making compressions of the palm towards the fingers, in the axis of the left ventricular outflow tract, in a clapping movement. In addition to allowing internal cardiac massage, direct access to the heart also allows performance of internal defibrillation in case of ventricular fibrillation or sustained ventricular tachycardia. Internal defibrillation is performed by applying internal paddles to the front and back of the heart at a setting of 30 Joules in association with adequate systemic anti-arrhythmic medications. Finally, if this does not result in resumption of cardiac activity, direct intra-ventricular injection of drugs, especially adrenaline, is possible.

Clamping of the descending thoracic aorta

Cross-clamping of the descending thoracic aorta achieves two ends: redistribution of the blood volume to the

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