

Internal cardiac compression

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Internal cardiac compression has been shown to be more effective than external, closed-thorax compression in the artificial circulation of blood and perfusion of tissues during cardiopulmonary resuscitation (CPR). The question, therefore, is not so much whether a thoracotomy should be performed during CPR as it is when it should be performed.

Indications

Thoracotomy should be done only in a fully equipped hospital with properly trained personnel to perform the procedure and support the animal in a safe and effective manner. Within this setting, immediate thoracotomy is indicated when open or closed pneumothorax or thoracic trauma with rib fractures are found,¹⁻³ or when the size or shape of the thorax precludes effective use of external thoracic compression techniques.

Thoracotomy is not always indicated in the treatment of cardiac arrest. If spontaneous cardiac contractions can be reinitiated easily with external thoracic compression, the risks of emergency thoracotomy are best avoided. The inherent problem is that this assessment is retrospective, rather than prospective. Because the outcome of the resuscitative endeavor is unknown during the resuscitation, thoracotomy would be indicated when, in the judgment of the team leader, current techniques are ineffective and are not likely to be associated with successful resuscitation. This judgment would be made at the commencement of resuscitation in the situations outlined previously. This judgment also should be made if effective spontaneous rhythm does not return and effective artificial circulation and tissue perfusion are not evident within 5 minutes of cardiac arrest. Thoracotomy should be performed after 10 minutes if an effective spontaneous rhythm has not commenced. In several studies,⁴⁻⁶ successful resuscitation with internal cardiac compression after a period of unsuccessful external resuscitation has been demonstrated. The rate of successful resuscitations decreases markedly if internal cardiac compression is delayed be-

yond 15 minutes.⁶ Thoracotomy is not a procedure to be used as a last resort after everything else has failed to reestablish effective cardiac rhythm. If the CPR effort has been prolonged and ineffective, and cerebral and myocardial hypoxic damage is severe, improvement of circulation will do little to change the outcome.⁶⁻⁸

Advantages

Internal cardiac compression maximizes the artificial circulation of blood, compared with external techniques.⁹⁻¹² It is associated with greater cardiac output^{8,10,11,13-17} and arterial blood pressure^{9-11,16,17}; better cerebral,^{9,11,16-19} myocardial,^{11,13,14,16,18} and peripheral tissue perfusion⁹; higher mixed venous blood oxygen tension²⁰; less arterial and mixed venous metabolic acidemia⁹; lower mixed venous blood lactate concentrations²⁰; higher mixed venous blood and end-tidal CO₂ tension⁹; and higher survival rate^{4,5,7,9,14,21-23} with improved neurologic recovery,^{5,9} compared with external techniques.

Myocardial perfusion is especially improved with internal cardiac compression. With external thoracic compression, the increase in intrathoracic pressure is uniform. Because a pressure gradient between the aorta and right atrium does not exist during the compression, myocardial flow is minimal.²⁴ Myocardial flow occurs only during the diastolic phase, when aortic pressure is higher than right atrial pressure. Maximizing myocardial blood flow is a major determinant of success in any resuscitative endeavor.^{7,25}

There are additional advantages to a thoracotomy. The adequacy of diastolic filling can be assessed between each compression when the thorax is open; if the heart does not fill rapidly as it is released, lack of venous return and the need for administration of a fluid bolus or an α -adrenergic agonist are evident. Accumulation of fluid or blood in the pericardial sac also can be observed, and the pericardial sac can be incised to prevent pericardial tamponade during or subsequent to resuscitation. The descending aorta can be compressed with the index finger of the opposite hand or can be clamped, directing blood flow to the brain and

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heart. If this option is chosen, compression should remain for the duration of the resuscitation; it should be removed only after spontaneous cardiac activity has been determined to be stable, and should be removed very gradually over 10 to 20 minutes. Fibrillation can be diagnosed by direct observation, and internal defibrillation efforts may be more effective than external ones. Myocardial tone also can be assessed by direct visualization.

Technique

An strip of hair should be clipped rapidly along the line of the intended incision at the fifth intercostal space. The area should be swabbed once with an antiseptic solution, and incised midway between the ribs down to, but not through, the pleural. The pleura should be penetrated with a finger or hemostat (between positive-pressure ventilations). The incision should be extended dorsally and ventrally with scissors, taking care to avoid the internal thoracic artery, which is found longitudinally approximately 1 cm lateral to the sternum.

Small hearts can be compressed between 2 fingers; larger hearts, between the fingers and the palm of the hand; and still larger hearts between the palm and the opposite thoracic wall, or with 2 hands.²⁶ Care must be exercised not to use the fingertips (which might penetrate atrial or ventricular walls) and not to rotate or displace the heart (which might occlude inflow or tear the junction of the vena cava and right atrium). The rate of compression should be coordinated to the rate of ventricular filling (ie, as soon as the ventricle has refilled, it should be compressed).

After the heart is beating spontaneously and the rhythm is stable, the thorax should be flushed with a sterile isotonic crystalloid solution, the wound should be cleaned and flushed, and the incision should be closed in a routine manner. Infection after emergency thoracotomies has not been reported to be a major problem.^{5,27}

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