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Best evidence topic - Cardiac general

Could we use abdominal compressions rather than chest compression in patients who arrest after cardiac surgery?

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Summary

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was whether abdominal cardiopulmonary resuscitation (CPR) could be used instead of external cardiac massage either to protect the recent sternotomy or while chest compressions are not possible whilst a sternotomy is being performed. Altogether 386 papers were found using the reported search, of which 10 represented the best evidence to answer the clinical question. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. Patients who arrest after cardiac surgery and require chest reopening will have a period of no external chest compression and therefore, no cerebral or coronary perfusion. In addition, if a patient arrests prior to cardiac surgery there will be a period of time performing the sternotomy during which there will be no external compressions. We found only one paper in a porcine model that looked at the effectiveness of abdominal only CPR although it did show that abdominal CPR was actually 60% better than chest CPR. Interposed abdominal and chest compressions has been much more extensively studied and has been shown to be significantly better in return of spontaneous circulation than chest compressions alone. We conclude that currently there is very little evidence to support abdominal only CPR although these studies may support the concept that it may potentially increase the coronary and cerebral perfusion pressure.

Keywords: Cardiopulmonary resuscitation; Abdominal compression

1. Introduction

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1].

2. Three-part question

In [patients who require salvage sternotomy or resternotomy] is [abdominal CPR] of benefit to improve [coronary perfusion pressure]?

3. Clinical scenario

A patient returns to the intensive care unit following emergency coronary artery bypass grafting. His sternum is very fragile and therefore, a Robicsek sternal closure is performed. One hour post surgery, he suddenly arrests. The nurses start to perform external cardiac massage. You are concerned that the arrest may be due to tamponade and proceed to reopen the chest. It is taking longer than usual to reopen the chest. During this time, no active external chest compression is taking place. You have heard of a novel resuscitation technique called abdominal only compression (OAC) and you get your nurse to try it. You eventually manage to reopen the chest and later resolve to check the literature.

4. Search strategy

Medline 1950 to September 2008 using OVID interface.
[Abdominal compression$.mp OR abdominal CPR.mp OR abdominal counterpulsation.mp].

5. Search outcome

Three hundred and eighty-six papers were found using the reported search. From these, 10 papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

6. Results

We found only one study that looked at abdominal only compression (OAC) cardiopulmonary resuscitation which was in animals. Geddes et al. [2] measured the coronary perfusion index in 11 pigs to determine the efficacy of CPR during ventricular fibrillation (VF). They were able to show that OAC-CPR was superior to standard CPR (SCPR), providing 60% higher coronary perfusion than standard CPR.

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Table 1
Best evidence papers

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Geddes et al., (2007), Am J Emerg Med, USA, [2] Experimental (level 6, good)	In 11 pigs (25–35 kg), VF was electrically induced and coronary perfusion index (CPI) – Area between Ao and RA pressure curves was measured for standard chest CPR and only abdominal compression (OAC) CPR	Coronary perfusion index ratios between beating heart vs. OAC-CPR	Average 0.24±0.08 (24% of normal coronary perfusion)	Study limited to pigs not directly related to humans No damage to visceral organs with OAC-CPR Thumper device used for OAC
		Coronary perfusion index ratios between beating heart vs. standard CPR	Average 0.17±0.06 (17% of normal coronary perfusion)	
		OAC-CPR/standard CPR ratios	Average 1.60±0.73 (60% more coronary perfusion)	
Lottes et al., (2007), Resuscitation, USA, [3] Experimental (level 6, good)	VF was electrically induced in anaesthetised 30 kg juvenile pigs. Thumper CPR was supplemented at intervals either with constant abdominal compression at 100–500 mmHg using an inflated contoured cuff or by administration of vasopressor drugs (epinephrine, vasopressin or glibenclamide)	Coronary perfusion pressure (CPP) before and after either cuff inflation or drug administration	Sustained abdominal compression at 200 mmHg (during VF and otherwise standard CPR) raised the cerebral perfusion pressure by 8–18 mmHg Similar result obtained to that achieved with vasopressor drugs CPP would be augmented with sustained abdominal compression when prior vasopressor drugs were given	Animal study Sustained abdominal compression used Thumper device used for CPR Particular benefit could be decreased incidence of phenomena such as post-resuscitation myocardial depression which has been described with pharmacological agents
Sack et al., (1992), J Am Med Assoc, USA, [4] Randomised controlled trial (level 1, fair)	103 patients were selected in whom 135 resuscitation attempts happened in a University-affiliated hospital during a six-month period. Patients were randomly selected to have either standard CPR (chest compression only) or interposed abdominal compression (IAC) during the relaxation phase of the chest compressions in the event of cardiac arrest	Return of spontaneous circulation (ROSC)	29 of 48 patients with IAC-CPR vs. 14 of 55 patients with standard CPR ($P=0.003$)	Involved IAC-CPR as opposed OAC-CPR but does show benefit of abdominal compression
		24 h survival	16 of 48 with IAC vs. 7 of 55 with standard ($P=0.02$)	
		Survival to hospital discharge	12 of 48 (25%) of patients receiving IAC 4 of 55 (7%) in cases with standard CPR ($P=0$ 02)	
		Neurological outcome in patients who survived to discharge	8 of 48 (17%) patients who received IAC-CPR made it to hospital discharge neurologically intact 3 of 55 patients (6%) who received standard CPR made it to discharge neurologically intact	
Sack et al., (1992), Circulation, USA, [5] Randomised prospective trial (level 1, fair)	143 patients in a university-affiliated hospital in which the initial rhythm was asystole or electromechanical dissociation (EMD). Patients were randomised to receive either standard CPR or IAC-CPR	ROSC	Overall rate was 38% (both groups). In IAC-CPR group ROSC was in 49% cases In standard CPR group ROSC was in 28% of cases ($P=0.01$)	IAC-CPR study
		Survival to 24 h	33% in IAC-CPR group 13% in standard CPR group ($P=0.009$)	
		Complications with IAC-CPR (in small subset of patients who died and had autopsy)	No complication directly related to IAC-CPR	
Ward et al., (1989), Ann Emerg Med, USA, [6]	33 patients with non-traumatic cardiac arrest. Previous animal and human studies have correlated end tidal PCO_2	Average $ETPCO_2$ measurement	17.1 mmHg with IAC-CPR. 9.6 mmHg with standard CPR Difference of 78% ($P<0.001$)	IAC-CPR study

(Continued on next page)

Table 1 *(Continued)*

Author, date and country Study type (level of evidence)	Patient group	Outcomes	Key results	Comments
Randomised prospective trial (level 1, good)	($ETPCO_2$) with cardiac output after precordial compressions. The higher the $ETPCO_2$, the better the cardiac output. Patients were randomly assigned to have either standard CPR or IAC-CPR	ROSC	6 patients with IAC-CPR (30%) 1 patient with standard CPR (6%) ($P=0.07$)	
Babbs, (2003), Resuscitation, USA, [7] Meta-analysis (level 1, fair)	Meta-analysis of human trials comparing IAC-CPR with standard CPR	Short-term survival i.e. ROSC Long-term survival i.e. hospital discharge with intact neurological function	Difference in proportion of survivors for in and out of hospital arrest was 10.7% in favour of IAC-CPR. ($P=0.006$) Difference in proportion of survivors for in and out of hospital arrest was 8.7% in favour of IAC-CPR. ($P=0.06$)	Long-term survival not statistically significant Main objective of paper was to show the methods of performing a meta-analysis and IAC-CPR papers were used as an example to demonstrate this
Christenson et al., (1992), Emerg Med, Canada, [8] Animal study (level 6, fair)	8 anaesthetised dogs were used. Three levels of pressure (25, 50 and 100 torr) were applied to the abdomen continuously or as 500 ms pulses at 10 different phases during the CPR cycle	 Mean aortic pressure Coronary perfusion gradient pressure	High pressure AC at 100 torr applied for 500 ms starting 200 ms before chest compressions had the best outcomes Provided an increase of 26 torr ($P<0.001$) Provided an increase of 17 torr ($P<0.02$)	Animal study Showed that high pressure abdominal compression in pulses was better than applying pressure continuously Continuous infusion of epinephrine used Pneumatic compressors used
Ralston et al., (1982), Anesth Anal, USA, [9] Animal study (level 6, good)	VF was induced in 10 anaesthetised dogs and either SCPR or IAC-CPR was initiated whilst the cardiac output, venous and arterial blood pressures were monitored. The two CPR methods were alternated for 3 min over a period of 30 min	Brachial arterial Blood pressure Cardiac output ($\pm$S.E.)	Average 87/32 mmHg during IAC-CPR vs. 58/16 mmHg during SCPR Average 24.2 ± 5.7 during IAC-CPR Average 13.8 ± 2.6 during SCPR	Animal study One of the original papers that showed that IAC may improve resuscitation
Chandra et al., (1981), J Am Med Assoc, USA, [10] Case series (level 5, fair)	In 10 patients during CPR for cardiac arrest, the effect of abdominal binding at pressures of 60–110 cm H_2O was measured	Effect of abdominal binding on mean arterial pressure during CPR	Abdominal binding for brief periods (30–60 s) raised mean arterial pressure from 53.9 ± 7.1 mmHg before binding to 67.2 ± 8.4 mmHg after binding six patients had abdominal binding for 4 min and beneficial effect was maintained throughout the time period	Abdominal binding study i.e. sustained pressure as opposed to abdominal compression No abdominal or visceral injury in 6 patients at autopsy
Babbs, (2006), Resuscitation, USA, [11] Computer based model (level 6, good)	Computer modelling using a hybrid analytical-numerical approach based upon Newton's second law of motion for fluid columns in the aorta and vena cavae, Ohm's law for resistive flow through vascular beds, and a 10 compartment representation of the human circulation idealized 70 kg human model was exercised to explore the effects of whole body z-axis acceleration at frequencies ranging from 0.5–5 Hz. The results suggested studies of abdominal compression at these frequencies	Explain haemodynamic mechanism of periodic z-axis acceleration (pGz)-CPR	For ±1.0 G acceleration at 3.5 Hz, systemic perfusion pressure was 80 mmHg and forward flow was 3.8 l/min. Similar results with abdominal compression can be obtained for 20 mmHg abdominal pressure pulses at 3.8 Hz, systemic perfusion pressure is 71 mmHg and forward flow is 2.8 l/min	Based on idealized 70 kg human model Theoretical model

No other studies look at abdominal only compressions but there has been considerable interest in adding this to chest compressions. The 2005 International Liaison Committee on Resuscitation (ILCOR) consensus on science document provided a summary of the literature and concluded that when abdominal compression is interposed with chest compression, there is an improved return of spontaneous circulation [12]. There have been three level 1 studies [4–6] that have shown an improvement in outcome measures of interposed abdominal compression-CPR (IAC-CPR) for in-hospital cardiac arrest. Sack et al. [4] in their study of 103 patients showed that 29/48 (60%) of patients had return of spontaneous circulation (ROSC) compared to 14/55 (25%) with SCPR ($P=0.03$). They also showed better survival to discharge with 12/48 (25%) in the IAC-CPR group vs. 4/55 (7%) in the SCPR group ($P=0.02$). Another study by Sack et al. [5], which compared 143 patients who had cardiac arrest where the initial rhythm was pulseless electrical activity or asystole, showed that 33/67 (49%) had ROSC in the IAC-CPR group compared to 21/76 (28%) in the SCPR group ($P=0.01$). Ward et al. [6] in their study of 33 patients measured end tidal PCO_2 ($ETPCO_2$) and showed $ETPCO_2$ averaged 17.1 mmHg with IAC-CPR vs. 9.6 mmHg with SCPR ($P<0.001$). They also showed that 6/16 (37%) in the IAC-CPR group had ROSC compared to 1/17 (6%) in the SCPR group ($P=0.07$). Trials involving CPR are often small but a meta-analysis of IAC-CPR [7] limited to human clinical trials comparing IAC-CPR to SCPR also showed a statistically significant benefit in favour of IAC-CPR in terms of return of spontaneous circulation. Babbs [11] has also shown in his computer model, using an idealized 70 kg human, that high frequency abdominal CPR can produce sufficient systemic perfusion pressures during cardiac arrest.

Sustained abdominal compression has also been evaluated recently in one animal based study [3]. This was rather interesting in that it showed that sustained abdominal compression produced a similar increase in coronary perfusion pressure when compared to vasopressor drugs. Abdominal binding during CPR has been previously investigated [10] and mean arterial pressure was higher in the 10 patients that were studied. Christenson et al. [8], however, showed in their experimental study that abdominal pressure in pulses was better than continuous abdominal compression during CPR.

All of the studies reported that there had been no visceral organ damage during any of the abdominal compression techniques.

7. Clinical bottom line

Patients who arrest after cardiac surgery who require chest reopening will have a period of no external chest compression and therefore, no cerebral or coronary perfusion. In addition, if a patient has a cardiac arrest prior to cardiac surgery there will be a period of time performing the sternotomy during which there will be no external compressions. However, we found only one paper in a porcine model that looked at the effectiveness of abdominal only CPR although it did show that abdominal CPR was actually 60% better than chest CPR. Interposed abdominal and chest compressions has been much more extensively studied and has been shown to be significantly better in return of spontaneous circulation than chest compressions alone. Currently there is very little evidence to support abdominal only CPR although these studies may support the concept that it may potentially increase the coronary and cerebral perfusion pressure.

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eComment: Questioning a 'best evidence' search arguing against abdominal-only cardiopulmonary resuscitation and for external cardiac massage

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Adam and colleagues [1] published results from their 'best evidence' search, which addressed whether abdominal-only cardiopulmonary resuscitation (AO-CPR) could be used instead of external cardiac massage either to protect the recent sternotomy or while chest compressions are not possible during resternotomy. They found only one study that looked at abdominal compressions alone; other studies they found combined it with chest compressions. They concluded that currently there is very little evidence to support AO-CPR; although, these studies may support the concept that it may potentially increase the coronary and cerebral perfusion. However, there are three issues with their implied recommendations to use external cardiac massage.

First, the adverse consequences of external cardiac massage can, in fact, be avoided with the use of minimally invasive direct cardiac massage; which is more effective than standard CPR [2]. Minimally invasive direct cardiac massage is a technique that uses a commercially available hand-held device (TheraCardia, Inc) that is introduced through a small thoracostomy to manually achieve direct cardiac compression with a 4-cm up-and-down stroke at a rate of 80–100 compression–decompressions per minute. Because this technique is similar to inserting a chest tube, minimally invasive direct cardiac massage can be rapidly delivered. A human pre-hospital pilot study of 25 patients concluded that minimally invasive direct cardiac massage produces greater blood flow than conventional CPR.

Second, their search missed two level 6 studies of good quality that reported using rhythmic abdominal compressions alone, which they termed abdominal counterpulsation, in dogs as a method of cardiac assist to support circulation after successful resuscitation [3, 4]. In the second study [4], drug-induced cardiac depression of 30–80% of control common carotid blood flow was achieved in a step-wise fashion; during which measurements of the effects of abdominal counterpulsation on coronary and carotid blood flow were recorded. They reported that abdominal counterpulsation was progressively more effective hemodynamically at greater levels of cardiac depression. From the results of both studies, it was concluded that abdominal counterpulsation is a safe and readily available form of temporary mechanical assist that deserves further evaluation either alone or in combination with CPR techniques.

Third, in a significant majority of cases, the average health-care-professional-rescuer is unable to consistently perform adequate-depth chest compressions [5]; therefore external cardiac massage is unreliably effective. On the other hand, AO-CPR can immediately be applied during the performance of a sternotomy, resternotomy or thoracostomy and requires significantly less force, therefore even the typical female-rescuer is likely able to perform it effectively. Because there is no direct pressure over the heart to empty the left ventricle with each compression during AO-CPR and because left ventricular volume will increase as a result of flow from the higher-pressure pulmonary arteries to the lower-pressure left atrium and left ventricle, the heart acts as a conduit, thereby allowing significant increases in ventricular volume during AO-CPR. 'Priming the pump' with abdominal compressions would allow greater increases in aortic volume when blood flows from the heart into the aorta due to sternal compressions (and therefore minimally invasive direct cardiac massage), which would lead to even greater increases in aortic diastolic pressure and ultimately coronary perfusion pressure [5].

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