Best evidence topic - Cardiac general

Should adrenaline be routinely used by the resuscitation team if a patient suffers a cardiac arrest shortly 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 adrenaline might be a useful addition to a protocol for the management of cardiac arrests for patients shortly after cardiac surgery. Altogether 889 papers were found using the reported search, of which 16 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. The quality and level of evidence was assessed using the International Liaison Committee on Resuscitation guideline recommendations. We conclude that the European Resuscitation Council and the American Heart Association both recommend 1 mg of adrenaline as soon as pulseless electrical activity or asystole is identified or after the second failed shock if the rhythm is VF. However, they acknowledge that the evidence behind this recommendation is lacking and based entirely on animal studies which have as yet not been successfully replicated in human studies to show a benefit of survival to hospital discharge. They acknowledge that the current evidence is insufficient to support or refute the use of adrenaline in arrests and the International Liaison Committee on Resuscitation grade the recommendation to give adrenaline in cardiac arrests as ‘indeterminate’. Thus, in the particular situation of a patient who arrests shortly after cardiac surgery where the chance of restoring sinus rhythm either by defibrillation or by an emergency re-sternotomy is high, and where adrenaline could in this situation be highly dangerous once sinus rhythm is restored, we recommend that 1 mg of adrenaline forms no part of the resuscitation protocol for patients who arrest after cardiac surgery.

Keywords: Thoracic surgery; Cardiopulmonary resuscitation; Epinephrine; Adrenaline; Evidence based medicine

1. Introduction

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS [1]. The quality of each study was assessed using the International Liaison Committee on Resuscitation 2005 protocol [2].

2. Three-part question

In [patients who have arrested shortly after cardiac surgery] does [the routine administration of 1 mg of adrenaline] improve [survival]?

3. Clinical scenario

A 72-year-old patient suffers a cardiac arrest 1 h after triple coronary artery bypass graft. The rhythm is pulseless electrical activity (PEA). The nursing staff commence cardiopulmonary resuscitation with resuscitation. The quality and level of evidence was assessed using the International Liaison Committee on Resuscitation guideline which is to give 1 mg of adrenaline immediately for pulseless electrical activity (PEA) or asystole. The surgeon is rapidly available and performs an emergency re-sternotomy within 3 min. On reopening there is a considerable gush of blood and a tamponade is relieved. Sinus rhythm returns but unfortunately the blood pressure rapidly rises to 250/150 due to the adrenaline, and several of the proximal graft anastomosis sutures cut through. After redoing both top-ends and oversewing the aortic and venous cannulation sites, you wonder what possible benefit adrenaline was in that arrest scenario.

4. Search strategy

Medline-1990 to Nov-2007 using OVID interface. [adrenaline.mp OR epinephrine.mp OR exp Epinephrine/] AND [exp Resuscitation/OR resuscitation.mp OR exp Cardiopulmonary resuscitation/] AND [exp survival/OR survival.mp OR exp Patient discharge/OR discharge.mp].


Cochrane DSR, ACP journal club and DARE searched using the term ‘Adrenaline’.

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## Table 1

<table>
<thead>
<tr>
<th>Author, date and country</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Long et al., (2005), Circulation, USA, [5] Systematic review of experimental studies (level 6, excellent)</td>
<td>ILCOR worksheet</td>
<td>Recommendations</td>
<td>The use of epinephrine in cardiac arrest due to ventricular fibrillation is supported by animal studies: many in the past and 3 in the last 5 years. (level of evidence 6). It does provide adverse consequences as well, and subsequent doses do not appear to provide as dramatic an effect in raising coronary perfusion pressure (and thus chance of ROSC) as the first dose. However, due to the lack of human placebo-controlled trials, epinephrine is Class Indeterminate. For PEA and asystole, the use of epinephrine is also Class Indeterminate. Epinephrine, 1 mg IV, given every 3–5 min, is generally accepted as useful in cardiac arrest from all rhythms although no human trials have compared epinephrine to placebo.</td>
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<td>Cairns et al., (1998), Resuscitation, USA, [7] Experimental study (level 6, fair)</td>
<td>14 Dogs had induced VF and were left without CPR for 7.5 min</td>
<td>ROSC</td>
<td>– n = 11 animals could not be resuscitated – 13 successfully resuscitated</td>
<td>The hemodynamic response to the first dose of EPI determines if the critical CPP needed for ROSC and survival will occur. Repeat doses of EPI do not appear to improve CPP to a degree to affect clinically meaningful measures of outcome, i.e. successful countershock and survival.</td>
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<td>CPR was then resumed and Epinephrine and countershocks were as per guidelines from 1998</td>
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<td></td>
<td>Success measured as return of spontaneous circulation for 30 min</td>
<td>CPP</td>
<td>In those animals that could not be resuscitated the increase in CPP after EPI averaged only 3 ± 2 mmHg</td>
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<td></td>
<td>– Epinephrine 1 mg was administered when indicated and at recommended time intervals</td>
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<td>Subsequent doses produced no significant effect on CPP (2 ± 4 mmHg)</td>
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<td></td>
<td>2 human studies and 33 animal studies found</td>
<td>ROCS in animal studiesvasopressin vs. adrenaline</td>
<td>Vasopressin 84% (225/268) Adrenaline 95% (117/224) P = 0.001</td>
<td>Did not search EMBASE</td>
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<td></td>
<td>Search for studies that compared treatment of cardiac arrest using vasopressin with either placebo or adrenaline</td>
<td></td>
<td></td>
<td>Details of individual studies not presented in adequate detail</td>
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<td>KIouche et al., (2003), Resuscitation, USA, [8] Experimental study (level 6, fair)</td>
<td>Twenty rats with ventricular fibrillation (VF) untreated for 8 min and then CPR (at a rate of 200 bpm and ventilation at 100 breaths per min)</td>
<td>Survival in hours</td>
<td>Alpha-MNE 57 ± 14 h VPN 41 ± 8 h Epinephrine 31 ± 10 h Control 15 ± 6 h</td>
<td>Both post-resuscitation myocardial function and survival were most improved after administration of the selective alpha(2A)-adrenergic agonist, intermediate after vasopressin and least after epinephrine and saline placebo.</td>
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<td>Drug treatment was: Alpha-MNE in a dose of 100 μg/kg, Vasopressin in a dose of 0.4 U/kg.</td>
<td>CPR (coronary perfusion pressure)</td>
<td>Rise to around 30 mmHg in all drug groups. In controls rise was to 20 mmHg</td>
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<td>Lindberg et al., (2000), Resuscitation, Sweden, [9]</td>
<td>18 Swedish bred pigs with full monitoring after a sternotomy, monitor insertion and chest closure. VF arrest without CPR for 1 min and 5 min of chest compressions using a chest compressor</td>
<td>Coronary perfusion pressure during arrest</td>
<td>Control 7±2 mmHg&lt;br&gt;Adrenaline 45±5 mmHg&lt;br&gt;Noradrenaline 38±5 mmHg&lt;br&gt;Control 106±15 ml/min&lt;br&gt;Adrenaline 66±5 ml/min&lt;br&gt;Noradrenaline 62±6 ml/min</td>
<td>Vasopressors increased coronary perfusion pressure and the likelihood of a return of spontaneous circulation, but decreased end-tidal CO₂ concentration and induced a critical deterioration in cardiac output and thus oxygen delivery in this model of cardiopulmonary resuscitation. Doesn’t address question directly of whether adrenaline is good in cardiac arrest, just elucidates details of what its physiologic effects are.</td>
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<td>Holmberg et al., (2002), Resuscitation, Sweden, [15]</td>
<td>A national survey of ambulance organisations in Sweden between 1990–1995 among 14065 patients with out-of-hospital cardiac arrest. Of these, resuscitation was attempted in 10966 cases Multivariate risk factors for adverse outcome assessed</td>
<td>% patients who received adrenaline&lt;br&gt;% patients who were intubated&lt;br&gt;Survival in patients with ventricular fibrillation</td>
<td>Adrenaline was given in 42.4% of patients&lt;br&gt;47.5% of patients were intubated&lt;br&gt;Independent predictor for adverse outcome (OR 0.43, CI 0.27–0.66)&lt;br&gt;Independent predictor for lower survival (OR 0.30, CI 0.07–0.82)</td>
<td>Neither in total nor in any subgroup did they find results indicating beneficial effects of any of these two interventions. Due to the retrospective cohort design of the study many factors determine administration of adrenaline including prolonged arrest and also certain ambulance crews were not licenced to give it, therefore, little inference can be drawn from these results.</td>
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<td>Behringer et al., (1998), Ann Int Med, Austria, [16]</td>
<td>178 adults with non-traumatic, normothermic VF cardiac arrest brought to the emergency department with an unsuccessful initial defibrillation</td>
<td>ROSC&lt;br&gt;Neurologic outcome assessed by cerebral performance category (CPC) within 6 months after cardiac arrest. A CPC of 1 or 2 was defined as favourable</td>
<td>In 178 patients: a) n = 151 (84%) spontaneous circulation was restored&lt;br&gt;b) n = 63 (42%) had favourable neurologic recovery. Patients with an unfavourable CPC received a significantly higher cumulative dose of epinephrine than did patients with a favourable CPC (4 mg compared with 1 mg)</td>
<td>The authors controlled for the length of resuscitation as a confounder, but despite this, many other confounders might have caused this result, i.e. asystolic patients tend to receive more adrenaline as less time is spent on defibrillation, and asystole is known to have a poorer outcome compared to VF.</td>
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<td>Vandycke et al., (2000), Resuscitation, Belgium, [12]</td>
<td>5 randomised trials where high dose of adrenaline was compared vs. standard dose epinephrine in cardiac arrest identified from a&lt;br&gt;Meta-analysis of randomised trials (level 1, excellent)</td>
<td>ROSC&lt;br&gt;Survival to hospital admission</td>
<td>Odd ratio favoured High-dose adrenaline 1.14 (1.02–1.27)&lt;br&gt;No difference 1.03 (0.86–1.24)</td>
<td>No statistically significant beneficial effect of high and/or escalating doses of epinephrine in comparison with standard dose of epinephrine in survival. (Continued on next page)</td>
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<tr>
<td>Author, date and country</td>
<td>Study type (level of evidence)</td>
<td>Patient group</td>
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<td>Chen et al., (2007), Am J Emerg Med, China, [10]</td>
<td>Experimental study (level 6, good)</td>
<td>47 rabbits with cardiac arrest induced by clamping the endotracheal tube that did not recover with CPR</td>
<td>Hospital discharge</td>
<td>Odd ratio was against high dose adrenaline 0.74 (0.53–1.03)</td>
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<td>Ristagno et al., (2007), Crit Care Med, USA, [11]</td>
<td>Experimental study (level 6, good)</td>
<td>10 Yorkshire-cross domestic pigs had untreated VF arrest for 3 min</td>
<td>CPP in adrenaline group</td>
<td>4–36 mmHg at peak value, P = 0.000</td>
</tr>
<tr>
<td>Wenzel et al., for the European Resuscitation Council Vasopressor during Cardiopulmonary Resuscitation Study Group (2004), New Engl J Med, Austria, [17]</td>
<td>PRCT (level 2, excellent)</td>
<td>1186 patients with an out of hospital arrest were randomly assigned:</td>
<td>Cerebral cortical microcirculatory blood flow and cortical tissue Po2, and Pco2 as indicators of cortical tissue ischaemia</td>
<td>Post resuscitation microvascular flows and P O2 were greater and P CO2 less after vasopressin when compared with epinephrine A significantly greater number of cortical microvessels were perfused after vasopressin</td>
</tr>
<tr>
<td>Pytte et al., (2006), Resuscitation, Norway, [18]</td>
<td>Experimental study (level 6, excellent)</td>
<td>17 pigs had full monitoring, then 3 min of untreated VF arrest Adrenaline administered and types of CPR given:</td>
<td>Hospital admission in patients with ventricular fibrillation, pulseless electrical activity</td>
<td>Vasopressin group 46.2% Epinephrine group 43.0% (P = 0.48)</td>
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5. Search outcome

Three hundred and twenty-eight papers were found in MEDLINE, 499 in EMBASE and 62 in the Cochrane collection using the reported search. From these, 16 papers were identified that provided the best evidence to answer the question. These are presented in Table 1.

6. Results

The 2005 European Resuscitation Council Guidelines (ERC [3]) and the American Heart Association guidelines [4] state that for patients suffering a cardiac arrest with PEA or asystole, 1 mg of adrenaline should be given as soon as intravascular access is achieved and for every 3–5 min or every other loop of the algorithm. For VF/VT, adrenaline should be given after the second failed shock. However, the ERC state that ‘despite the widespread use of adrenaline during resuscitation, and several studies involving vasopressin, there is no placebo controlled study that shows that the routine use of any vasopressor at any stage during human cardiac arrest increases survival to hospital discharge. Current evidence is insufficient to support or refute the routine use of any particular drug or sequence of drugs. Despite the lack of human data, the use of adrenaline is still recommended, based largely on animal data.’ The evidence that they base this recommendation on are the works produced by Long and Paradis [5] and Wenzel [6]. Long concludes that adrenaline use is supported by recent animal studies but that no human studies compare it to placebo. Also, they note that it produces adverse consequences and also subsequent doses are less effective. They give the level of evidence for adrenaline for VF or PEA/asystole as ‘indeterminate’ which is defined as ‘minimal evidence available, results inconsistent and contradictory and results not compelling’.

Cairns and Niemann [7] studied 14 dogs who had VF for 7.5 min prior to resuscitation attempts. Three dogs survived and adrenaline increased their coronary perfusion pressure (CPP) by 21 ± 11 mmHg. However, in the remainder, adrenaline only increased the CPP by 3 ± 2 mmHg. Also subsequent doses had minimal effect on CPP.

Klouche et al. [8] studied 20 rats using differing resuscitative drugs after VF. They found that adrenaline impaired post-resuscitation myocardial function more than vasopressin and a selective alpha-agonist, and this function was similar to saline-placebo controls. However, survival was superior with adrenaline than with controls.

Lindberg et al. [9] in 18 pigs who had a sternotomy and chest closure, and then VF, showed that while either adrenaline or noradrenaline increased CPP during the arrest up to 45 mmHg compared to only 7 mmHg for controls, it significantly impaired cardiac output and oxygen delivery after successful resuscitation.

Chen et al. [10], in 47 rabbits arrested after ET-tube clamping, found that adrenaline increased CPP from 4 to 38 mmHg whereas vasopressin failed to do this. Half the rabbits given adrenaline survived compared to 10% of the vasopressin group.

Ristagno et al. [11] showed significantly worse cerebral blood flows and oxygenation with adrenaline compared to vasopressin in 10 pigs after cardiac arrest.

Vandycke and Martens [12] performed a meta-analysis of five RCTs of high-dose adrenaline vs. standard dose adrenaline. They found a superior odds of return of spontaneous circulation but no difference to hospital admission and a poorer outcome to hospital discharge with higher doses of adrenaline. Biondi-Zoccai et al. [13] performed a meta-analysis of vasopressin vs. adrenaline, finding only two human studies but demonstrating superiority of vasopressin across 33 animal studies. Zhong and Dorian [14] performed a review of adrenaline and vasopressin in cardiac arrest stating that adrenaline had many adverse effects post-resuscitation including myocardial dysfunction, worsening arrhythmias and increased myocardial oxygen demand and that human studies in this area were urgently needed.

Holmberg et al. [15] in a survey of 11,000 patients in patient-care who had arrested out-of-hospital looked at risk factors for adverse survival. They found that adrenaline was a predictor of adverse outcome for asystolic and VF arrests. Behringer et al. [16] reported that in 178 patients who survived an out-of-hospital arrest that adrenaline cumulative dose was much higher in those patients with a poor neurological outcome. The best human study in this area compared vasopressin with adrenaline but had no placebo group. Wenzel et al. [17] randomized over 1000 patients who arrested out-of-hospital to vasopressin or adrenaline. There was no difference in VF arrests but asystole and combined vasopressin and adrenaline showed better survival to hospital admission.

Pytte et al. [18] was struck by the fact that the benefit of adrenaline seen in experimental studies had not translated into clinical studies and hypothesised that this may be due to the difference between clinical CPR and the CPR obtained in a laboratory by hydraulic-compression devices. They compared these types of CPR and found that while...
CPR produced significant haemodynamic effects with adrenaline, no haemodynamic increases were seen with clinical CPR. Also the peak adrenaline level took 2.5 min to achieve in the clinical CPR group after a single administration.

7. Clinical bottom line

The European Resuscitation Council and the American Heart Association both recommend 1 mg of adrenaline as soon as pulseless electrical activity or asystole is identified or after the second failed shock if the rhythm is VF/ pulseless VT. However, they acknowledge that the evidence behind this recommendation is lacking and based entirely on animal studies which have as yet not been successfully replicated in human studies and thus the evidence for this recommendation is ‘indeterminate’. Thus, in the particular situation of a patient who arrests shortly after cardiac surgery where the chance of restoring sinus rhythm either by defibrillation or by an emergency re-sternotomy is high, and where adrenaline could in this situation be highly dangerous once sinus rhythm is restored, we recommend that 1 mg of adrenaline forms no part of the resuscitation protocol for patients after cardiac surgery.

References


eComment: Avoidance of administration of 1 mg of adrenaline in cardiac arrest after cardiac surgery

Author: Stephen T. Webb, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BA, UK
doi:10.1510/icvts.2007.171447A
Cardiac arrest in the early postoperative period after cardiac surgery is usually rapidly reversible by appropriate treatment of the underlying cause [1]. Excessive hypertension induced by adrenaline following return of spontaneous circulation in this setting may cause catastrophic disruption of surgical anastomoses. The intravenous administration of a relatively low dose of adrenaline in the peri-arrest scenario may have similar consequences. The evidence to support the use of adrenaline in cardiac arrest is weak [2].

The intravenous administration of 1 mg of adrenaline should not be recommended in cardiac arrest after cardiac surgery. Emphasis should instead be given to external cardiac compression, immediate defibrillation, rapid correction of reversible causes and early emergency re-sternotomy if appropriate. The European Resuscitation Council (ERC) should consider changing their guidelines for the resuscitation of patients who suffer cardiac arrest following cardiac surgery [3].

References


eComment: Should adrenaline be routinely used by the resuscitation team if a patient suffers a cardiac arrest shortly after cardiac surgery?

Author: Michael J. Versteegh, Leiden University Medical Center, Department of Cardio-thoracic Surgery, Albinusdreef 2, 2333 AC Leiden, NLDoi:10.1510/icvts.2007.171447B
Most of the time emergency re-thoracotomy is the effective method to solve the problem causing a circulatory arrest after cardiac surgery. The authors state correctly that there is no evidence for injecting adrenaline to treat the loss of circulation [1]. If the cause of the cardiac arrest is not resolved by the re-thoracotomy, the surgeon can very easily inject adrenaline directly into the left ventricle of the heart. Moreover, this method in combination with internal cardiac massage guarantees that the adrenaline
reaches the coronary circulation in contrast to an intravenous injection of adrenaline in the circumstances of a circulatory arrest.

**Reference**


**eComment: Avoidance of administration of 1 mg of adrenaline in cardiac arrest after cardiac surgery**

**Author:** Amanollah Heidari, Golestan Hospital, Jondishapur University, Ahvaz 6135713119, Iran
doi:10.1510/icvts.2007.171447C

I don’t recommend adrenaline for post CABG arrest [1]. I think it is better to come back to the operating room promptly, if normal condition doesn’t return after primary works. Placement of CPB, examination of grafts and redoing CABG (on pump, beating) is the best option. If grafts are apparently normal, then redo CABG from the most important target vessels (on pump, beating). After each graft we try to be off from CPB. If everything is OK, the chest is closed, if not, other important grafts will begin. I think immediate re-sternotomy for other post cardiac surgery arrest is the procedure of choice if external massage is ineffective.

**Reference**


**eComment: Post CABG cardiac arrest**

**Author:** Mark K. Reed, Saint Barnabas/Newark Beth-Israel Cardiac Surgical ICU, Newark, New Jersey 07039, USA
doi:10.1510/icvts.2007.171447D

Regarding the administration of (intravenous) epinephrine for the early post-operative cardiac surgical patient after the fact of the occurrence of complete circulatory arrest [1] I am an agnostic. That said, I have found i.v. bolus epinephrine can occasionally avert the aforementioned scenario for the patient in a rapid downward ‘death spiral’. In my experience this near-arrest physiology results from abrupt vasodilatory decompensation, for example when suddenly coughing (i.e. valsalva condition) as sedation wears off. And here is the point I would like to emphasize. The crucial form of epinephrine here is the 1 mg/10 cc (usually as a ‘Bristoject’ male leer lock adapter). Push and flush 50 to 100 mg (0.5 to 1 cc) of a 1:1000 epinephrine solution, such as low PO2, metabolic acidosis, renal failure, hypothermia, hemolysis and myocardial trauma, contribute to a partial depolarization of normal or already diseased His-Purkinje system [4]. In this case of arrest, the administration of adrenaline and the abrupt performance of external cardiac massage, may ‘brake down’ the vicious circle until the reopening of sternotomy for a more effective massage. Obviously, after recovery of VT or VF and an unsuccessful defibrillation, administration of 1 mg adrenaline every 3 to 5 minutes is clearly indicated [2, 3]. While the moderate use of adrenaline during post-cardiac surgery arrest is desirable; as we avoid all its adverse effects on the myocardium (increased myocardial oxygen consumption, sustained arrhythmias, and further dysfunction), as well as on the brain (decreased cerebral flow, worsening of brain ischemia) [5].

**References**


