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Resuscitation after Cardiac Surgery: An Evidence-Based Guideline

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Over 250,000 patients undergo major cardiac surgical operations in the U.S. every year, and 0.7–2.9% of them will experience a cardiac arrest following their procedure. Survival to hospital discharge following these events is much higher than the dismal 7.9% reported for out-of-hospital arrests, or 29% for those with in-hospital arrest from ventricular tachycardia (VT) or fibrillation (VF). Dimopoulos, et al reported a 79% survival to discharge rate following cardiac surgery arrests, with 55% of these patients still alive at 4-year follow up.

A comprehensive, evidence-based guideline for resuscitation of the postoperative cardiac surgical patient has been adopted by the European Resuscitation Council (ERC) and is now the standard of care throughout Europe. This guideline includes critical deviations from current Advanced Cardiac Life Support (ACLS) techniques, with important differences outlined below.

CHEST COMPRESSIONS

American Heart Association (AHA) resuscitation algorithms were changed significantly in 2010, emphasizing external cardiac compressions (ECC) prior to airway interventions. These guidelines advocate ECC for virtually every cardiac arrest situation, and healthcare workers are well conditioned to administer cardiopulmonary resuscitation (CPR) upon finding an arrest victim. Unfortunately, the cardiopulmonary impact of ECC has been shown to prolong survival by less than one minute versus no CPR, and is suboptimal compared to internal massage. Studies in the 1980’s demonstrated consistently that ECC achieved significantly lower cerebral perfusion pressures than internal massage, and well below the critical value of 15 mmHg that is required for neurologic recovery.

In addition, the risk of performing ECC is increased in patients who have undergone recent sternotomy, with case reports of massive hemorrhage resulting from tearing of the right ventricle. One mechanism for these fatal injuries occurs when the sternal halves separate during downward compression, followed by trapping and severing of grafts or myocardium between the sternal edges upon upward recoil. The duration of ECC after cardiac surgery has been shown to correlate significantly with mortality and predict non-survivors (p=0.004).

In an arrest after cardiac surgery, external cardiac massage can be deferred until initial defibrillation or pacing (as appropriate) has been attempted, provided this can be done in less than 1 minute. The ERC guideline recommends that when external compressions are used, their effectiveness should be monitored using the arterial pressure waveform to ensure generation of a systolic blood pressure (SBP) above 60 mmHg for adequate cerebral perfusion. The inability to achieve this response during ECC is an indication for immediate reopening of the chest.

DEFIBRILLATION

The largest reported series of in-hospital arrests due to VF/VT (n=6789) was published in 2008 by Chan, et al, including 61% that occurred in an intensive care unit (ICU). Survival to discharge in patients defibrillated in less than 2 minutes was significantly higher than those taking longer to defibrillate (39% vs 22%, p <0.001), but were disappointingly low even in monitored units. In contrast, Anthi, et al reported a 79% (22/29) survival rate in arrests after cardiac surgery, with acute destabilizing...
VT or VF noted as the initial rhythm in 45% of their series; 27% were attributed to mechanical events such as tamponade or pneumothorax. Such arrests are readily apparent in the postoperative patient with continuous ECG and hemodynamic monitoring, and prior intubation typically removes the need for urgent airway management, although strategies such as removal of positive end-expiratory pressure and addition of 100% oxygen are advocated.

Time to defibrillation has been shown to be a critical determinant of survival, regardless of diagnosis or subsequent revascularization, and defibrillation without delay is the accepted standard of care. Yet, current ACLS algorithms advocate ECC for one minute prior to defibrillation of VF/VT, with delivery of a single shock prior to another two minutes of CPR before repeating defibrillation attempts. These algorithms are derived largely from research using automatic external defibrillators (AEDs) in out-of-hospital arrests; a situation quite different from a witnessed VF arrest in an intubated ICU patient. In ventricular fibrillation or pulseless ventricular tachycardia, 3 sequential shocks should be given without intervening CPR. In VF or pulseless VT, emergency resternotomy should be performed after 3 failed attempts at defibrillation.

**ASYSTOLE**

Asystole or profound bradycardia may occur transiently following cardiac surgery or be more prolonged, particularly after surgical procedures for arrhythmia control (ie, modified MAZE) or those involving the aortic valve. Insertion of temporary atrial and/or ventricular pacemaker wires is standard during most cardiac surgical procedures to better manage these events, which may occur without warning. In the event of an important loss of electrical conduction, ACLS algorithms advocate immediate ECC followed by administration of epinephrine at a dosage of 1 mg IV. The presence of temporary pacing capabilities in these patients offers alternative therapies that can be easily applied and may be life-saving. For asystole or severe bradycardia, connect the epicardial pacing wires and set to DDD at 90 bpm at the maximum atrial and ventricular output voltages.

Should the conduction system fail to respond to first internal, then transcutaneous pacing attempts, the recommendation for a “nonschockable” rhythm is ECC until prompt emergency resternotomy can be performed. However, every effort should be made to exclude the possibility of a shockable rhythm, such as fine VF, which may be masked behind pacemaker spikes in these patients.

**EPINEPHRINE**

Patients undergoing cardiac surgery with cardiopulmonary bypass exhibit a characteristic stress response that is partially mediated by increased levels of catecholamines. In addition, inotropic and vasopressor medications are commonly used to wean from cardiopulmonary bypass and during postoperative rewarming, when instability may occur. In the event of pulselessness from asystole or VF/VT, ACLS algorithms recommend the administration of 1 mg of IV epinephrine, with doses repeated every 3–5 minutes. Arguments against the use of epinephrine include a lack of placebo controlled data indicating a survival benefit in any population to date, as well as its potential adverse effects of increased myocardial oxygen demand and potentiation of arrhythmias.

In the postoperative heart patient, such “standard” epinephrine dosing can contribute to profound rebound hypertension with potential disruption of grafts, suture lines, and subsequent hemorrhage. Neither adrenaline nor vasopressin should be given during the cardiac arrest unless directed by a senior clinician experienced in their use.

While epinephrine is not indicated during arrest, it may be used prior to an arrest to support the circulation and distinguish patients who are inotrope responsive. However, ERC guidelines advocate using reduced doses of 100 mcg or less any time epinephrine is used in the postoperative cardiac surgical patient.

**RESTERNOTOMY**

Open chest cardiac massage has been shown to provide greater coronary blood flow and improved survival when compared with ECC, and can be initiated rapidly following cardiac arrest. Potentially reversible causes of arrest can be identified and remedied by re-exploration and direct visualization, such as tamponade, surgical bleeding, or graft failure, and rule out other etiologies for severe cardiopulmonary dysfunction. The Society of Thoracic Surgeons (STS) National Database reports that postoperative bleeding is the most common condition warranting resternotomy, occurring in 2.4% of patients undergoing isolated coronary artery bypass (CAB) and up to 7% of patients after combined CAB and mitral procedures. Cardiac tamponade, a condition characterized by impaired myocardial filling due to progressive
fluid accumulation in the mediastinal space, warrants rapid resternotomy to avoid profound reductions in cardiac output from mechanical causes.\(^4\) Hemodynamic collapse is associated with elevation and equalization of the cardiac filling pressures that are unresponsive to standard fluid and pharmacologic therapies. Prompt recognition of bleeding and tamponade, and the ability to offer rapid surgical correction, are paramount to successful resuscitation in the postoperative heart patient and responsible for the relatively high survival rates reported in this population. Mackay, et al reported a 48% survival rate when emergency resternotomy was performed within 10 minutes, versus 12% when time to chest reopening was more prolonged.\(^1\)

Internal cardiac massage is superior to external cardiac massage. In patients with a recent sternotomy in whom resuscitative efforts are likely to last more than 5–10 minutes, emergency resternotomy is indicated in order to perform internal cardiac massage even if a reversible cause from resternotomy seems unlikely.\(^4\)

**THE CARDIAC SURGICAL ARREST GUIDELINE**

In 2007, the European Association for Cardio-Thoracic Surgery (EACTS) initiated the development of resuscitation guidelines specific to the cardiac surgical patient. Their methodologies included a comprehensive literature review with standardized grading of evidence, surveys to the international surgical community via a cardiac surgery website (http://www.ctsnet.org) which generated 349 responses, followed by protocol testing and refinement during a large series of resuscitation courses. As a result of this effort, the first evidence-based guideline pertaining specifically to postoperative cardiac surgery resuscitation was released in 2009.\(^4\) This was followed by inclusion in the global ERC resuscitation guideline published in 2010, which is equivalent to CPR standards from the US American Heart Association.\(^5\) When introduced in 2009, the EACTS recommended that this approach “…should be used in preference to the protocol currently recommended for patients with cardiac arrest which does not follow cardiac surgery.”\(^4\) The recommendations listed here are critical elements of this guideline, which also provides a comprehensive approach to the personnel, practice, and equipment necessary for emergency resternotomy. The authors emphasize the need for repeated practice in simulated open chest resuscitations, stressing the “multi-practitioner” nature of this endeavor and the essential component of teamwork to its success. They also offer a word of caution when transitioning from one well-known standard to another, and recommend ample discussion and training before implementing this new protocol.

Healthcare personnel who work with postoperative heart patients must be familiar with the equipment and procedures necessary for sternal reopening in the ICU in a manner that is both quick and safe. Conduct during these “high risk, low volume” procedures must be well delineated and rehearsed to achieve rapid reopening with optimal survival rates. The location and contents of emergency trays, use of internal defibrillators, and possibly sternal saws (for “mini” sternotomies) must be performed without delay while using appropriate sterile technique. Although centers have developed internal protocols for such situations, there has been no standardized approach to the conduct of these emergencies; use of ACLS techniques, while inappropriate, are widespread. Using the ERC guideline, standardized techniques for cardiac surgical arrest management are now available via Cardiothoracic Advanced Life Support (CALS) courses.\(^1\) While not yet “certified” by a governing body such as the AHA, such courses offer the only evidence-based standard of care for these emergencies that exist today, and are quickly gaining acceptance in the US.

**SUMMARY**

The EACTS guideline for the resuscitation of postoperative cardiothoracic surgery patients is the first comprehensive document to specifically address this important issue, and is gaining US interest. The methodologies used have generated an excellent reflection of our current best evidence regarding the conduct of arrest after heart surgery, though we do not yet have the science to approach Class I recommendations with Level of Evidence A. Use of this protocol represents an important starting point to generate more science and further our understanding of how best to manage such emergencies with optimal results. Like all guidelines, it is subject to ongoing research and refinement as new evidence becomes available. But for the practitioner who has witnessed even once, the volatility of such a patient who was rapidly defibrillated with success, only to suffer the sequelae of epinephrine-induced hypertension, bleeding, and need for sternal reopening following even a brief period of chest compressions, the time for a new standard of care is long overdue.

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REFERENCES


