Resuscitation practices in cardiac surgery

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During the past decade, there has been an increasing recognition that cardiac surgery patients have different resuscitative needs than other medical and surgical patients who experience in-hospital cardiac arrest. The special resuscitative needs of cardiac surgery patients were addressed in the 2010 European Resuscitation Council Guidelines for Resuscitation in the section reviewing cardiac arrest in special circumstances and the 2010 American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care in Special Situations.[1,2] To date, the most comprehensive and current analysis of survival to hospital discharge after an in-hospital cardiac arrest included 84,625 patients at 374 hospitals, 79.3% of whom had asystole or pulseless electrical activity and 20.7% of whom had pulseless ventricular tachycardia as their initial rhythm.[3] Although that study excluded patients in operating rooms, procedural suites, and emergency departments because of their distinct clinical circumstances, the risk-adjusted rate of survival to hospital discharge was 22.3% in 2009, markedly improved compared with 13.7% in 2000.

Given the continuous monitoring of patients in the intensive care units (ICUs), which decreases the risk of an unwitnessed cardiac arrest and the delay to initiation of cardiopulmonary resuscitation (CPR), cardiac arrests in ICUs represent a subgroup within the in-hospital cardiac arrest group. Although the postcardiac arrest survival rates among the patients in ICUs have varied widely (0%-79%), cardiac surgery patients seem to fare better.[4] From 2 separate studies, the survival to discharge among cardiac surgery patients who experienced an in-hospital cardiac arrest was 60% to 79%, with 45% to 69% survival at 1 year follow-up.[4-6] The differences in survival after a cardiac arrest in the cardiac surgery ICUs compared with other in-hospital cardiac arrests are likely related to the high incidence of cardiac arrests resulting from reversible causes, underscoring the need for, and importance of, a protocol-based, standardized approach to CPR in the cardiac surgery ICU.[7]

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EUROPEAN VERSUS AHA GUIDELINES

The 2010 European Resuscitation Council Guidelines for Resuscitation and the 2010 AHA Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care have emphasized the importance of basic life support and uninterrupted, high-quality external cardiac massage (ECM) as a foundation for generating survivable continuous cardiac output.[1,2] To achieve this, chest compressions in adults should be delivered at a goal rate of $\geq$100 compressions/min, with a compression depth of $\geq$2 in, allowing for complete chest recoil with minimal interruptions. Several reports have been published of fatal cardiac complications related to ECM in cardiac surgery patients during the postoperative period.[7] These reports, coupled with the observation that frequently the cause of cardiac arrest in a cardiac surgery patient can be successfully reversed by defibrillation or pacing, has led to cardiac surgery-specific modifications in the standard postcardiac arrest protocol. The European Guidelines for Resuscitation in Cardiac Surgery Patients created by the Clinical Guidelines Committee of the European Association for Cardio-Thoracic Surgery in 2009 highlight some of the major features that set cardiac surgery patients apart from patients in other ICUs, including several modes of continuous invasive and noninvasive monitoring, fresh, and sometimes very frail, suture lines prone to catastrophic bleeding, and the ability to immediately perform repeat sternotomy.[7] It is important to note that these guidelines are recommended for use only in cardiac surgery ICUs and that standard advanced cardiac life support (ACLS) protocols should be used in the cardiac surgery step down units.

The most notable modification to the standard ACLS protocol in cardiac surgery ICUs has been the priority given to defibrillation. Because ventricular fibrillation (VF) is the initial rhythm in 25% to 50% of cardiac arrests in cardiac surgery ICUs and the recognition of a cardiac arrest is almost immediate owing to the continuous extensive monitoring, in cases of cardiac arrest due to ventricular tachycardia or VF, cardioversion should be attempted before potentially harmful ECM is initiated. Three sequential, stacked attempts of immediate cardioversion without intervening ECM have been recommended for patients with ventricular tachycardia or VF.[1,7] The success rate for the first, second, and third shock, on average, has been 75%, 35%, and 14%, respectively.[7] If spontaneous rhythm fails to return after the third shock, ECM should be initiated, and the team should proceed to repeat sternotomy. Chan and colleagues[8] reported that defibrillation that occurred in <2 minutes from the arrest carried the best survival and prognosis; therefore, cardioversion should be performed within

Abbreviations and Acronyms

ACLS = advanced cardiac life support
AHA = American Heart Association
CPR = cardiopulmonary resuscitation
ECM = external cardiac massage
IABP = intra-aortic balloon pump
ICU = intensive care unit
LVAD = left ventricular assist device
VF = ventricular fibrillation

1 minute of cardiac arrest, otherwise, ECM should be initiated per the ACLS protocol.[8] When ECM is initiated, the adequacy of chest compressions in patients with preexisting arterial lines should be confirmed by ensuring that a systolic pressure >60 mm Hg is achieved.

The European guidelines, unlike the AHA guidelines, do not recommend the routine use of vasopressors during a cardiac arrest in cardiac surgery patients.[1,7] Because of the risk of rebound hypertension with impending catastrophic bleeding and the potential reversibility of the cause of the arrest in cardiac surgery patients, vasopressor therapy should not be routinely implemented, and its use should be guided by a senior experienced clinician. Although the 2010 AHA resuscitation guidelines acknowledged the risks of rebound hypertension after administration of a vasopressor, they did not recommend deviation from the standard dosing owing to a lack of evidence.[2]

In the case of an asystolic arrest or extreme bradycardia, pacing with epicardial wires connected to an external pacer set at a rate of 90 beats/min in DDD mode at the maximum output should precede ECM initiation if pacing can be instituted within 1 minute from the onset of the arrest. Unlike the AHA guidelines, the European guidelines have continued to recommend a single dose of 3 mg of atropine administered by way of the central line for bradycardiac or asystolic cardiac arrest.[1,7] If a pacemaker interferes with rhythm evaluation in pulseless electrical activity, the pacemaker should be turned off to assess the underlying rhythm. If the initial maneuvers do not restore spontaneous circulation, ECM should be initiated, and the team should proceed to emergency repeat sternotomy.

In addition to allowing the treatment of some of the major reversible causes of cardiac arrest in cardiac surgery patients (ie, bleeding and tamponade), the repeat sternotomy allows administration of internal cardiac massage. Multiple human and animal studies have acknowledged the superiority of internal cardiac massage compared with ECM, likely owing to better coronary perfusion pressure, improved end organ perfusion, and increased return of spontaneous circulation.[1] On chest opening, careful removal of all of the cloth and the identification of any structures at risk of disruption such as grafts or major suture lines should be performed before 2-handed internal massage is started. According to the European guidelines, chest reentry in cardiac surgery patients is beneficial and safe and should be part of the standard resuscitative protocol until the 10th postoperative day.[7]

RESUSCITATION AFTER MINIMALLY INVASIVE SURGICAL APPROACHES

Close to 8000 patients have undergone transcatheter aortic valve replacement since its approval by the US Food and Drug Administration for use in inoperable, severe, symptomatic aortic stenosis in 2011 and high-risk, operable aortic stenosis in 2012.[9] According to The Society of Thoracic Surgeons and American College of Cardiology Transcatheter Valve Therapy Registry, the overall risk of in-hospital cardiac arrest for this patient population in US centers is 5.8%, with an overall in-hospital mortality rate of 5.5%.[9] Several reports have been published of the aortic valve prosthesis deformation found at autopsy after unsuccessful resuscitation efforts in patients who experienced a cardiac arrest after minimally invasive aortic valve replacement.[10,11]

Although generally younger than patients undergoing transcatheter aortic valve replacement and with fewer comorbidities, patients who undergo mini-left thoracotomy and robotic mitral and tricuspid valve interventions have a similar risk of prosthetic valve dehiscence or deformation related to ECM during standard CPR. These specific postoperative situations in which standard ECM could potentially be harmful have not been addressed in the AHA or the European Resuscitation guidelines. However, case reports have suggested that these patients could benefit from a modified resuscitation protocol that would include alternative methods of delivering ECM, the consideration of early median sternotomy and open cardiac massage, and the use of early echocardiography to assess the integrity and function of the valve prosthesis.

CENTRAL ACCESS

A lack of intravenous access is usually not a problem commonly encountered in a cardiac surgery ICU because cardiac surgery ICU patients usually have multiple including central venous access lines; however, in the spirit of completeness, we should mention intraosseous vascular access as an emerging, ACLS-recommended, rapid, safe, and reliable vascular access option for administration of medications, blood products, and intravenous fluids. The first attempt success rate of intraosseous cannulation has been higher and required less procedure time than the landmark-guided placement of a central venous catheter in a subclavian or femoral vein during a code situation, which has been burdened with high complications and failure rate.[12] Although intraosseous access does not replace the need for central venous access, it should be considered

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