Improving Survival From Cardiac Arrest: A Review of Contemporary Practice and Challenges

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Cardiac arrest is a common and lethal condition frequently encountered by emergency medicine providers. Resuscitation of persons after cardiac arrest remains challenging, and outcomes remain poor overall. Successful resuscitation hinges on timely, high-quality cardiopulmonary resuscitation. The optimal method of providing chest compressions and ventilator support during cardiac arrest remains uncertain. Prompt and effective defibrillation of ventricular arrhythmias is one of the few effective therapies available for treatment of cardiac arrest. Despite numerous studies during several decades, no specific drug delivered during cardiac arrest has been shown to improve neurologically intact survival after cardiac arrest. Extracorporeal circulation can rescue a minority of highly selected patients with refractory cardiac arrest. Current management of pulseless electrical activity is associated with poor outcomes, but it is hoped that a more targeted diagnostic approach based on electrocardiography and bedside cardiac ultrasonography may improve survival. The evolution of postresuscitation care appears to have improved cardiac arrest outcomes in patients who are successfully resuscitated. The initial approach to early stabilization includes standard measures, such as support of pulmonary function, hemodynamic stabilization, and rapid diagnostic assessment. Coronary angiography is often indicated because of the high frequency of unstable coronary artery disease in comatose survivors of cardiac arrest and should be performed early after resuscitation. Optimizing and standardizing our current approach to cardiac arrest resuscitation and postresuscitation care will be essential for developing strategies for improving survival after cardiac arrest. [Ann Emerg Med. 2016;68:678-689.]

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INTRODUCTION

Cardiac arrest affects more than 500,000 US adults each year when both out-of-hospital and inhospital cardiac arrest are included.[1,2] Mortality after out-of-hospital cardiac arrest remains high. Only 25% of patients have a return of spontaneous circulation, and fewer than 10% of patients survive to hospital discharge.[1,3] Better outcomes after inhospital cardiac arrest are attributable primarily to more rapid and effective resuscitation, which achieves return of spontaneous circulation in approximately half of all patients with inhospital cardiac arrest.[2,4] Standardizing basic cardiac resuscitation and postarrest care is crucial for improving cardiac arrest outcomes, with individualized application of advanced therapies. Consensus guidelines are important to standardized care, but when guidelines change, additional evaluations of previously recommended therapies may be necessary.[5,6]

In this review, we will highlight several areas of scientific knowledge applicable to cardiac arrest resuscitation and the early postresuscitation phase for experienced emergency medicine and critical care providers. Specifically, we summarize emerging evidence and key issues for resuscitating patients from cardiac arrest, including recent guideline changes about basic and advanced life support measures, extracorporeal membrane oxygenator (ECMO) support, new approaches to management of pulseless electrical activity, and initial priorities in postresuscitation care.

INTERVENTIONS

The quality of basic cardiopulmonary resuscitation (CPR) influences the efficacy of other interventions during resuscitation, and delayed or ineffective CPR may negate the potential benefit of concurrent therapies. Consensus guidelines emphasize that rapidly initiated, high-quality chest compressions are the most important intervention for ensuring return of spontaneous circulation and neurologic recovery in persons after cardiac arrest.[5-7] Even brief interruptions in chest compressions during CPR may reduce forward flow and organ perfusion, thus the emphasis on minimizing interruptions in chest compressions.[7] Recent preclinical research suggests that impairments in venous return and cardiac output result from the increase in intrathoracic pressure that accompanies positive-pressure ventilations during CPR.[8] This research has led to advocacy of compression-only CPR during cardiac arrest. Observational studies show better survival after out-of-hospital cardiac arrest in patients who receive compression-only bystander CPR by laypersons.[9-11] Randomized studies and meta-analyses have not confirmed this benefit, leaving considerable uncertainty about efficacy.[7,12,13] Prolonged compression-only CPR without ventilation may become less effective over time, so perhaps a limited period of compression-only CPR by a bystander may be appropriate immediately after a person collapses, with subsequent initiation of rescue breaths after up to 3 cycles of 30 compressions.[7]

Studies of nearly all other interventions during cardiac arrest have been performed during standard compression/ventilation CPR and might have different efficacy with compression-only CPR. Mechanical devices designed to improve efficiency of chest compression have not consistently improved out-of-hospital cardiac arrest outcomes and are not recommended for routine use.[14-17] Failure of these devices to improve patient outcomes when applied broadly does not exclude a potential benefit during prolonged resuscitation or invasive procedures when rescuer fatigue could compromise quality of CPR.

The only intervention that improves survival after cardiac arrest, despite interrupting chest compressions, is administration of defibrillator shocks for termination of ventricular arrhythmias.[5-7,18] Defibrillator shocks should be delivered as soon as possible and should not be delayed for basic CPR.[7,18] Interruptions in CPR should be as brief as possible during defibrillation and pulse or rhythm checks. Outcomes may be improved when compressions are continued during rhythm analysis and defibrillator charging and then resumed immediately after a shock is delivered.[7,19] Multiple stacked shocks are no longer recommended because of the high first-shock efficacy of biphasic defibrillator shocks and lack of demonstrated benefit of stacked shocks.[7] Eliminating multiple stacked shocks also shortens the interruption of chest compressions.[5-7] Pulseless electrical activity is common after successful defibrillation, so CPR should be continued for another complete cycle after defibrillation, even if organized rhythm is restored.[7,19] A starting defibrillation energy of less than or equal to 200 J biphasic (either the manufacturer's suggested starting or maximum energy) is recommended; subsequent shocks should be delivered at the maximum energy for persistent ventricular arrhythmias or at the previously effective energy for recurrent ventricular arrhythmias.[7] The coarseness of the ventricular fibrillation waveform carries prognostic value during out-of-hospital cardiac arrest because of ventricular fibrillation, but algorithms guided by analysis of the ventricular fibrillation waveform do not improve survival to hospital discharge.[20]

Ventilation with a bag-valve mask or even oxygen delivered by a high-flow face mask can usually maintain adequate pulmonary and arterial oxygen tension during the early phase of CPR. Guidelines do not recommend use of any particular airway device during CPR for unselected patients.[5] Observational studies have shown conflicting outcomes with the use of advanced airways, including supraglottic airways and intubation.[21] Multiple studies suggest worse survival, neurologic outcomes, or both in patients who receive advanced airways during cardiac arrest in the out-of-hospital setting,[22] yet a recent meta-analysis suggested improved outcomes with intubation compared with a supraglottic airway.[23] The time required to deploy advanced airways is a critical element, and prolonged interruptions in CPR are likely to be detrimental. Advanced airways may not be needed early in the course of most adult cardiac arrests that are not caused by airway compromise.[5,9]

There is a paucity of data to support a survival benefit from any individual advanced cardiovascular life support (ACLS) intervention, even when provided early during resuscitation (Table 1).[5] Timely, high-quality CPR, early defibrillation, and optimal postresuscitation care predominantly determine patient outcomes. The efficacy of medications degrades with longer durations of arrest and with poor-quality CPR.[44] Interpretation of clinical trials of these medications is challenging because of heterogeneous resuscitation quality, with negative drug trial results caused by lack of efficacy under ideal circumstances, poor effectiveness in the population studied, or both. Many previous trials could have been underpowered because of low overall survival rates, and future trials should standardize all other aspects of resuscitation quality and postresuscitation care. The efficacy of drug administration in laboratory animal models of cardiac arrest likely differs from that observed in human patients, and thus results may not be easily extrapolated from animals to humans.[45]

Insertion of an intravenous line for administration of medications does not appear to improve outcomes in out-of-hospital cardiac arrest, potentially because of interruptions in CPR, lack of medication efficacy, or both.[24] The availability of rapidly deployable intraosseous line kits suitable for rapid fluid infusion and vasopressor administration has obviated the need for central line placement during arrest in most patients.[46]

The efficacy of medications for ACLS in improving survival during CPR remains uncertain, with some drugs improving return of spontaneous circulation and survival to hospital admission but not survival to hospital discharge (Table 1).[5] Vasopressors remain central to the ACLS algorithm to maintain coronary and cerebral perfusion pressure during CPR, particularly for patients with nonshockable rhythms.[5] Epinephrine has been the standard vasopressor for ACLS for many years despite an absence of