Updates in Cardiac Arrest Resuscitation

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KEYWORDS

• Cardiac arrest • Cardiopulmonary resuscitation • Airway management
• Vasopressor • Epinephrine • Antiarrhythmic medication • Hypothermia
• Defibrillation

KEY POINTS

- High-quality chest compressions remain a key priority for cardiac arrest management. Mechanical cardiopulmonary resuscitation (CPR) devices may be useful in situations where manual CPR cannot be performed optimally.
- Supraglottic airway is a reasonable alternative to endotracheal intubation in systems with low success rate for endotracheal intubation.
- Epinephrine improves the rate of return of spontaneous circulation, survival to hospital admission, and survival to hospital discharge after cardiac arrest. Its effect on long-term survival and neurologic outcome, however, remains inconclusive.
- Amiodarone or lidocaine may be considered for shock-refractory ventricular fibrillation or pulseless ventricular tachycardia.
- Physiologic monitoring of end-tidal CO_2 and arterial diastolic pressure during cardiac arrest may help guide resuscitative efforts.

INTRODUCTION

There are approximately 350,000 out-of-hospital cardiac arrests (OHCAs)[1] and 200,000 in-hospital cardiac arrests (IHCAs)[2] annually in the United States, with survival rates of approximately 5% to 10%[1] for OHCAs and 24% for IHCAs.[3] The critical factors that have an impact on cardiac arrest survival include prompt recognition and activation of prehospital care, early cardiopulmonary resuscitation (CPR), and rapid

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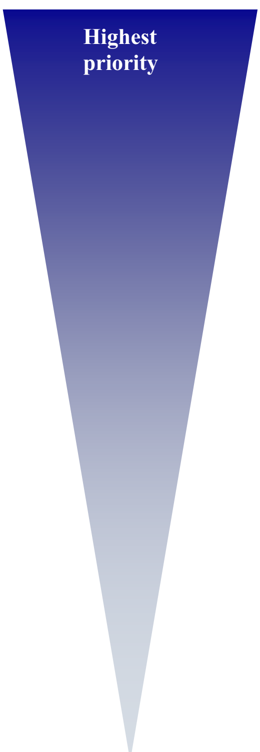
defibrillation. Despite recent advances in the evidence for many aspects of intra-arrest management, some controversies persist. They include airway management, mechanical CPR, route of drug administration, role of vasopressors and antiarrhythmic medications, hemodynamic-directed resuscitation, intracardiac arrest hypothermia, double sequential external defibrillation (DSED), and point-of-care echocardiography. Fig. 1 prioritizes the critical actions based on the timing of interventions and their strength of evidence. Table 1 summarizes the most updated International Liaison Committee on Resuscitation (ILCOR) and American Heart Association (AHA) treatment recommendations on topics discussed in this article. The AHA provides a Web-based living document of its most recent guidelines at its CPR and emergency cardiovascular care guidelines Web site (https://eccguidelines.heart.org/circulation/cpr-ecc-guidelines/).

AIRWAY MANAGEMENT DURING CARDIAC ARREST

Airway management is an integral component of cardiac arrest management. Previous observational data suggest that endotracheal intubation is superior to supraglottic airway in adult OHCA.[4] Other observational data, however, demonstrate an association between bag-valve mask ventilation and increased rate of neurologically favorable survival compared with endotracheal intubation.[5,6] A potential confounder between the association of advanced airway management and poor outcomes is that patients with longer duration of cardiac arrest are more likely to require advanced



Initiate and maintain high-quality chest compressions. Consider using a mechanical CPR device if manual CPR cannot be performed optimally.

Achieve early defibrillation for shockable rhythm.

Use bag-valve mask or establish advanced airway. A supraglottic airway may be used in settings with low rate of success for endotracheal intubation.

Monitor waveform capnography with goal end-tidal CO_2 >20 mm Hg.

Obtain IV access for drug administration. IO access can be used as alternative if IV access cannot be obtained.

Administer epinephrine as soon as feasible for nonshockable rhythm and after unsuccessful defibrillation attempts for shockable rhythm.

Consider amiodarone or lidocaine administration for shock-refractory ventricular fibrillation or pulseless ventricular tachycardia.

Establish an arterial line for hemodynamic-guided resuscitation with goal arterial diastolic pressure >30–35 mm Hg.

Perform point-of-care echocardiography only if it does not delay other resuscitative efforts.

Fig. 1. Prioritization of critical actions during cardiac arrest.

Table 1
Most updated treatment recommendations for cardiac arrest resuscitation[a,b]

Topic	Most Updated Treatment Recommendations
Airway management[11,12]	2019 ILCOR ALS CoSTR The authors suggest using bag-mask valve or an advanced airway strategy during CPR for adult cardiac arrest in any setting (weak recommendation, low to moderate certainty of evidence). If an advanced airway is used, the authors suggest • Supraglottic airway for adults with OHCA in settings with a low tracheal intubation success rate (weak recommendation, low certainty of evidence) • Supraglottic airway or tracheal intubation for adults with OHCA in settings with a high tracheal intubation success rate (weak recommendation, very low certainty of evidence) • Supraglottic airway or tracheal intubation for adults with IHCA (weak recommendation, very low certainty of evidence)
Mechanical CPR[21]	2015 ILCOR ALS CoSTR The authors suggest against the routine use of automated mechanical chest compression devices to replace manual chest compressions (weak recommendation, moderate certainty of evidence). The authors suggest that automated mechanical chest compression devices are a reasonable alternative to high-quality manual chest compressions in situations where sustained high-quality manual chest compressions are impractical or compromise provider safety (weak recommendation, low certainty of evidence).
IV vs IO[24]	2020 draft ILCOR ALS CoSTR The authors suggest IV access compared with IO access as the first attempt for drug administration during adult cardiac arrest (weak recommendation, very low certainty of evidence). If attempts at IV access are unsuccessful or IV access is not feasible, we suggest IO access as a route for drug administration during adult cardiac arrest (weak recommendation, very low certainty of evidence).
Vasopressors[12,29]	2019 ILCOR ALS CoSTR The authors recommend administration of epinephrine during CPR (strong recommendation, low to moderate certainty of evidence). For nonshockable rhythms, the authors recommend administration of epinephrine as soon as feasible during CPR (strong recommendation, very low certainty of evidence). For shockable rhythms, the authors suggest administration of epinephrine after initial defibrillation attempts are unsuccessful during CPR (weak recommendation, very low certainty of evidence). The authors suggest against the administration of vasopressin in place of epinephrine during CPR (weak recommendation, very low certainty of evidence). The suggest against the addition of vasopressin to epinephrine during CPR (weak recommendation, low certainty of evidence).

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Topic	Most Updated Treatment Recommendations
Antiarrhythmic medications[22,42]	2018 ILCOR ALS CoSTR The authors suggest the use of amiodarone or lidocaine in adults with shock-refractory ventricular fibrillation/ pulseless ventricular tachycardia (weak recommendation, low certainty of evidence). The authors suggest against the routine use of magnesium in adults with shock-refractory ventricular fibrillation/ pulseless ventricular tachycardia (weak recommendation, very low certainty of evidence).
Hemodynamics-guided resuscitation[21,25,46]	2015 ILCOR ALS CoSTR The authors recommend against using $ETCO_2$ cutoff values alone as a mortality predictor or on the decision to stop a resuscitation attempt (strong recommendation, low certainty of evidence). The authors suggest that an $ETCO_2$ greater than or equal to 10 mm Hg measured after tracheal intubation or after 20 minutes of resuscitation, may be a predictor of ROSC (weak recommendation, low certainty of evidence). The authors suggest that an $ETCO_2$ greater than or equal to 10 mm Hg measured after tracheal intubation, or an $ETCO_2$ greater than or equal to 20 mm Hg measured after 20 minutes of resuscitation may be a predictor of survival to discharge (weak recommendation, moderate certainty of evidence). 2015 AHA ACLS guidelines updates Although no clinical study has examined whether titrating resuscitative efforts to physiologic parameters during CPR improves outcome, it may be reasonable to use physiologic parameters (quantitative waveform capnography, arterial relaxation diastolic pressure, arterial pressure monitoring, and central venous oxygen saturation) when feasible to monitor and optimize CPR quality, guide vasopressor therapy, and detect ROSC (class IIb, LOE C-EO).
Prehospital/intracardiac arrest hypothermia[21]	2015 ILCOR ALS CoSTR The authors recommend against routine use of prehospital cooling with rapid infusion of large volumes of cold IV fluid immediately after ROSC (strong recommendation, moderate certainty of evidence).
DSED[62,67]	2020 draft ILCOR ALS CoSTR The authors suggest against routine use of dual (or double) sequential defibrillation strategy in comparison to a standard defibrillation strategy for cardiac arrest with a shockable rhythm (weak recommendation, very low certainty of evidence).

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Topic	Most Updated Treatment Recommendations
Point-of-care echocardiography[21,72]	2015 ILCOR ALS CoSTR The authors suggest that if cardiac ultrasound can be performed without interfering with standard ACLS protocol, it may be considered as an additional diagnostic tool to identify potentially reversible causes (weak recommendation, very low certainty of evidence). 2020 Draft ILCOR ALS CoSTR The authors suggest against using point-of-care echocardiography for prognostication during CPR (weak recommendation, very low certainty of evidence).

Abbreviations: ACLS, advanced cardiovascular life support; ALS, advanced life support; $ETCO_2$, end-tidal CO_2.; LOE C-EO, Level of Evidence C-Expert Opinion.

[a] The next ILCOR ALS CoSTR will be published in October 2020.

[b] ILCOR used the Grading of Recommendations Assessment, Development and Evaluation (www.gradeworkinggroup.org) approach to systematic reviews and guideline development, whereas the AHA used the ILCOR reviews as well as the AHA definition of classes of recommendation and levels of evidence for its 2015 guidelines update. (https://eccguidelines.heart.org/circulation/cpr-ecc-guidelines/).

airway management.[7] Variable prehospital systems also can lead to differences in training, intubation success rates, and complications.

Three randomized controlled trials comparing advanced airway strategies for OHCA were published in 2018. The AIRWAYS-2 trial compared the i-gel supraglottic airway (Intersurgical Ltd, Berkshire, UK) to endotracheal intubation by prehospital providers.[8] No significant difference was found for neurologic outcome at hospital discharge or day 30 in patients randomized to supraglottic airway compared with endotracheal intubation. Among patients who underwent advanced airway management, those who received a supraglottic airway had better outcome. The paramedics randomized to the endotracheal intubation group, however, were less likely to use advanced airway management overall, introducing bias. In a separate study, outcomes of laryngeal tube were compared with endotracheal intubation, and outcomes were improved in the laryngeal tube group.[9] A third trial compared outcomes of bag-valve mask ventilation to endotracheal intubation and did not find any difference.[10]

The most recent systematic review and 2019 Consensus on Science with Treatment Recommendations (CoSTR) stated that the heterogeneity of the aforementioned airway studies limits the ability to perform meaningful meta-analysis or generalize their findings.[11,12] Perhaps most notably, endotracheal intubation success rates were highly variable among studies.[8–10] In situations where likelihood of successful endotracheal intubation is low, a supraglottic airway is recommended as a reasonable alternative. In settings where successful endotracheal intubation rate is high, supraglottic airway or endotracheal intubation is recommended.[11,12] The threshold for high versus low success rates, however, remains ill defined.

MECHANICAL CARDIOPULMONARY RESUSCITATION

High-quality chest compressions are defined as compressions at a depth of 5 cm to 6 cm and a rate of 100 per minute to 120 per minute, allowing full chest recoil between compressions and minimization of interruptions.[13,14] Barriers to achieving optimal CPR include provider fatigue, patient anatomy, transport, and environmental factors.[15,16] Mechanical CPR devices, including the Thumper (Michigan Instruments, Grand Rapids, MI, USA), LUCAS (Physio-Control, Lund, Sweden), and AutoPulse (Zoll Medical, Chelmsford, MA, USA), are designed to improve the quality of CPR and simplify cardiac arrest management in situations where manual CPR cannot be performed optimally. Although the ability to standardize the rate and depth of compressions and eliminate the need to swap providers may increase compression fraction, device deployment also may cause potential delays in cardiac arrest care.

Several studies have compared the outcomes between manual CPR and mechanical CPR for OHCA. Three trials found no significant difference in survival of OHCA patients who received mechanical or manual CPR.[17–19] A 2015 meta-analysis found no difference between manual and mechanical CPR, and there have been inconsistent results regarding survival with good neurologic outcome between the 2 groups.[20] In 2015, ILCOR made a weak recommendation against the routine use of mechanical CPR devices in clinical practice, but they may be considered in circumstances where the delivery of high-quality manual chest compressions may be impractical or dangerous to rescuers.[21]

INTRAVENOUS VERSUS INTRAOSSEOUS DRUG ADMINISTRATION DURING CARDIAC ARREST

Current advanced life support guidelines recommend the administration of epinephrine[12] and antiarrhythmics[22] during cardiac arrest. The most optimal route of drug administration during cardiac arrest, however, remains unclear. Intravenous (IV) access requires additional skill and may be difficult to obtain during cardiac arrest. As such, intraosseous (IO) access may be a reasonable alternative. A recent observational study found that IO access was associated with faster drug delivery in OHCAs.[23]

The outcome differences between IO and IV access in adult OHCAs have been compared in observational studies with varied protocols. Pooled analysis[24] from 3 observational studies showed worse outcomes with the use of IO access compared with IV access for of return of spontaneous circulation (ROSC) and survival to hospital discharge. Given current available data showing that outcomes might be better with IV access during cardiac arrest, the current ILCOR recommendation[14,21,24,25] is that IV access should be attempted first and that IO access is a reasonable alternative if IV access cannot be obtained. It remains unclear whether the effectiveness of drug administration during cardiac arrest is dependent on the type of drug, its dose, or the anatomic location of access.

ROLE OF VASOPRESSORS

Epinephrine

The use of epinephrine is widely accepted in cardiac arrest management; however, its implementation into guidelines was based mainly on animal studies. The α-adrenergic effect of epinephrine increases aortic diastolic pressure, therefore increasing the coronary perfusion pressure (CPP) and likelihood of ROSC. It has, however, the potential to increase dysrhythmias, increase myocardial demand, and decrease cerebral microcirculation in animal studies.[26] Concerns regarding the association of epinephrine with worse neurologic outcome were based largely on older cohort studies that were highly susceptible to uncontrolled confounders and selection bias.[7,27]

The PARAMEDIC2 trial is the largest randomized study on epinephrine for OHCA to date.[28] The epinephrine group had significantly higher ROSC compared with placebo (36.3% vs 11.7%, respectively), but severe neurologic impairment was more common in the epinephrine group than the placebo group (31.0% vs 17.8%, respectively, at hospital discharge). Similar results for survival and survival with favorable neurologic outcome also were found at 3 months. There were several limitations to this study. The median time to epinephrine administration was relatively long at 21 minutes, and the neurologic outcome at 3 months was limited by very low overall survival rate (3.2% in epinephrine vs 2.3% in placebo) and loss to follow-up. As such, the study was underpowered to detect a difference in survival and survival with favorable neurologic outcome between the groups.[29]

A systematic review[29] found robust associations between epinephrine and improved short-term outcomes of ROSC and survival to hospital admission compared to placebo. Epinephrine also was associated with improved survival to hospital discharge and 30-day survival. No difference was found in 30-day neurologic outcome, and only the PARAMEDIC2 trial reported long-term outcomes of 3-month survival and neurologic outcome.[28]

Meta-analysis[29] based on initial rhythm reveals that for nonshockable rhythms, there is an association between epinephrine and more robust increase in ROSC and survival to hospital discharge. This is in contrast to shockable rhythms, where these associations with epinephrine are less robust or absent.[28] The differential effect of epinephrine based on initial rhythm could be explained by the availability of other therapies, leading to later epinephrine administration for shockable rhythms.[30–32]

Based on available evidence and the recent systematic review,[29] ILCOR recommended administration of epinephrine as soon as feasible during CPR for nonshockable rhythms and after initial defibrillation attempts are unsuccessful during CPR for shockable rhythm. Further study is needed to clarify the effects of epinephrine on long-term survival and neurologic outcomes, its use in different etiologies of cardiac arrest, and the optimal dose, timing, and route of drug administration.

Vasopressin

Studies comparing vasopressin to epinephrine have found no significant difference in any outcomes regardless of the initial presenting rhythm.[33–35] There also has been no difference in outcome between vasopressin plus epinephrine compared with epinephrine alone.[36–38] Therefore, ILCOR recommended against the administration of vasopressin, either in place of epinephrine or in addition to epinephrine, during CPR.[12]

ROLE OF ANTIARRHYTHMIC MEDICATIONS

Amiodarone Versus Lidocaine

There may be a role for antiarrhythmic medications in ventricular fibrillation and pulseless ventricular tachycardia if defibrillations fail to achieve ROSC. Amiodarone and lidocaine have been studied for this purpose. Two trials[39,40] found that giving amiodarone in refractory cardiac arrest was associated with higher survival to hospital admission compared with placebo and lidocaine. A third randomized trial (ROC-ALPS) compared the effects of amiodarone, lidocaine, and placebo on OHCA with shock-refractory ventricular fibrillation or pulseless ventricular tachycardia.[41] Treatment with amiodarone or lidocaine did not result in a higher rate of survival or favorable neurologic outcome at hospital discharge. Both medications were associated, however, with a higher rate of survival to hospital discharge among witnessed OHCA patients, suggesting that earlier recognition and time to treatment may have an impact on drug efficacy.

A recent systematic review did not find any difference between amiodarone and placebo for ROSC or survival and favorable neurologic outcome at hospital discharge.[42] It also showed no difference between amiodarone and lidocaine for these outcomes. Therefore, the 2018 ILCOR CoSTR suggested the consideration of amiodarone or lidocaine for ventricular fibrillation or pulseless ventricular tachycardia that is unresponsive to defibrillation.[22] Outstanding questions include differences in the effectiveness of antiarrhythmic medications in specific populations, by route and timing of drug administration, and their interactions with other drugs.

Magnesium

Meta-analysis of multiple randomized controlled studies showed no difference between magnesium and placebo for ROSC, survival to hospital discharge, or survival with favorable neurologic outcome at hospital discharge.[42] Thus, ILCOR recommended against the routine use of magnesium in shock-refractory ventricular fibrillation and pulseless ventricular tachycardia.[22]

HEMODYNAMIC-DIRECTED RESUSCITATION

End-Tidal CO_2

End-tidal CO_2 monitoring is a physiologic parameter that has potential utility during cardiac arrest management. During the low-flow state of CPR, when ventilation is held constant, changes in end-tidal CO_2 correlate with changes in cardiac output as pulmonary blood flow primarily determines end-tidal CO_2.[25] Multiple observational studies have found an association between end-tidal CO_2 below 10 mm Hg after 20 minutes of CPR and very poor chances of ROSC or survival in intubated cardiac arrest patients.[43–45] One study found end-tidal CO_2 greater than 20 mm Hg to be associated with greater survival,[43] but, in general, there has been inadequate evidence to determine a clear numerical goal for end-tidal CO_2. Based on current evidence, end-tidal CO_2 of less than 10 mm Hg after 20 minutes of CPR may have utility in predicting poor likelihood of ROSC. A goal end-tidal CO_2 of 20 mm Hg may be reasonable, but it is unclear if even higher end-tidal CO_2 is beneficial.[21,46]

Coronary Perfusion Pressure/Diastolic Blood Pressure

CPP, or the difference between mid-diastolic aortic pressure and mid-diastolic right atrial pressure, is the primary driving force for myocardial blood flow.[47] In a swine cardiac arrest study, chest compression depth was titrated to maintain systolic blood pressure of 90 mm Hg, and vasopressors were titrated to maintain CPP above 20 mm Hg. This protocol was associated with improvement in sustained ROSC and 4-hour survival compared with standard care by AHA guidelines.[48] Given the difficulty in calculating CPP in the clinical setting, arterial diastolic pressure has been proposed as a proxy, with a goal arterial diastolic pressure of 30 mm Hg to 35 mm Hg to approximate CPP of 20 mm Hg to 25 mm Hg, assuming a right atrial pressure of 10 mm Hg to 15 mm Hg. In humans, maximal CPP has been associated with ROSC, although data are limited to pediatric IHCA patients.[49,50]

In hemodynamic-directed resuscitation, continuous monitoring of hemodynamic variables is used to guide chest compressions and vasopressor therapy. Further study is needed to prospectively evaluate arterial diastolic pressure guidance for resuscitation in adult cardiac arrest patients. Specific knowledge gaps include end-tidal CO_2 and arterial diastolic pressure thresholds that are associated with high-quality CPR and improved outcomes for adult cardiac arrest.

PREHOSPITAL AND INTRACARDIAC ARREST HYPOTHERMIA

Hypothermic targeted temperature management is recommended as a neuroprotective strategy for post–cardiac arrest patients.[21,51] It initially was studied for OHCA patients with shockable rhythm in 2 landmark studies,[52,53] then recently showed to also improve the survival with favorable neurologic outcome for cardiac arrest patients with nonshockable presenting rhythms.[54] In addition, multiple animal studies have found protective effects from achieving intracardiac arrest hypothermia[55,56] and hypothermia within 4 hours of ROSC.[57] Previous trials, however, using cold fluid boluses during cardiac arrest, have found associations with significant adverse effects, including pulmonary edema and rearrest.[58] Some of these adverse effects are postulated to be related to the method of hypothermia. As such, the 2015 ILCOR guidelines recommended against routine prehospital hypothermia using IV fluid bolus.[21]

Other studies have examined the feasibility and efficacy of alternative cooling devices without loading intravascular volume. A randomized controlled trial (PRINCE)[59] demonstrated that a transnasal evaporative device resulted in lower temperature at hospital arrival and faster time to targeted temperature but was underpowered to detect outcome differences. A larger trial of prehospital transnasal hypothermia for OHCA (PRINCESS)[60] found that transnasal cooling again was associated with faster time to targeted temperature but without differences in sustained ROSC, survival to hospital admission, survival at 90 days, or survival with good neurologic outcome at 90 days. Propensity-matched subgroup analysis of the PRINCESS trial[61] showed that for patients with initial shockable rhythm, the transnasal hypothermia group had more favorable neurologic outcome. Further prospective studies are necessary to investigate the role of transnasal cooling in different etiologies of cardiac arrest.

DOUBLE SEQUENTIAL EXTERNAL DEFIBRILLATION FOR REFRACTORY VENTRICULAR FIBRILLATION

Shock-refractory ventricular fibrillation generally is defined as persistent ventricular defibrillation after CPR and 3 or more defibrillations. DSED generally describes the use of 2 defibrillators with anterior-anterior and anterior-posterior pad positions to deliver 2 shocks in rapid sequence, although there is no standardized approach.[62] It has been presented as a potential alternate intervention for shock-refractory ventricular fibrillation.[63–66]

A systematic review attempted to compare DSED with standard defibrillation and identified only observational studies.[67] No change in survival to discharge, ROSC, or event survival was found. An updated systematic review[62] considers additional observational data with similar reservations. Therefore, DSED currently is not recommended by ILCOR.[62] The DOSE-VF study is ongoing to compare the feasibility and the effects of standard defibrillation, DSED, and vector change defibrillation on ROSC for prehospital shock-refractory ventricular fibrillation cardiac arrest.

UTILITY OF POINT-OF-CARE ECHOCARDIOGRAPHY DURING CARDIAC ARREST

Point-of-care echocardiography has become an important adjunct for cardiac arrest management because point-of-care ultrasound utilization has increased in the emergency department. Transthoracic echocardiography potentially can provide more direct information on cardiac activity and the etiology of cardiac arrest, especially for pulseless electrical activity or asystole with reversible causes. Thus far, the evidence regarding point-of-care echocardiography in cardiac arrest has come from small observational studies.[68–70]

There currently is no standard definition for cardiac activity and standstill on ultrasound. Prior studies have defined cardiac activity as any myocardial movement/ventricular wall movement, excluding isolated valve movement or movement of blood in the chambers,[71] but this definition has not been used consistently across studies. Although cardiac standstill on transthoracic echocardiography is strongly associated with the lack of ROSC and nonsurvival, there remains a small percentage of patients with cardiac standstill who go on to attain ROSC and subsequent survival. As such, ILCOR suggested against using point-of-care echocardiography for prognostication during CPR.[72]

There are multiple barriers for the incorporation of point-of-care echocardiography during cardiac arrest management. An alternative solution is the utilization of transesophageal echocardiography, which may minimize interruptions in chest compressions, bypass difficulty in obtaining cardiac windows, and guide effective compressions in real time. A single-center, prospective cohort study examined the feasibility and impact of resuscitative transesophageal echocardiography in the emergency department for OHCA. The study demonstrated that tranesophageal echocardiography was safe and feasible and guided therapeutic interventions.[73] Further study is necessary to evaluate the impact of this relatively resource-intensive intervention on cardiac arrest outcome.

SUMMARY

Cardiac arrest resuscitation remains one of the most challenging and dynamic topics for emergency medicine and critical care. Patient heterogeneity, variabilities in prehospital systems, and complex physiology often generate uncertainties in intracardiac arrest management. In OHCA, when the likelihood of successful endotracheal intubation is low, a supraglottic airway is recommended. When endotracheal intubation success rates are high, supraglottic airway or endotracheal intubation is recommended. The routine use of mechanical CPR devices is not recommended, but they may be considered in circumstances where the delivery of high-quality manual chest compressions may be limited. IO access is a reasonable alternative if IV access cannot be obtained. Epinephrine is recommended as soon as feasible during CPR for nonshockable rhythms and after initial unsuccessful defibrillation for shockable rhythms. Further study is needed to clarify the effects of epinephrine on long-term survival and neurologic outcomes. Amiodarone or lidocaine can be considered for ventricular fibrillation or pulseless ventricular tachycardia unresponsive to defibrillation. Hemodynamic monitoring has been associated with improved outcomes in some studies, but precise targets are unclear. DSED, intracardiac arrest hypothermia, and point-of-care echocardiography have inadequate evidence of improved outcomes to make strong recommendations.

DISCLOSURE

The authors have nothing to disclose.

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