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Emergency medicine updates: Cardiopulmonary resuscitation

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ABSTRACT

Introduction: Cardiac arrest is the loss of functional cardiac activity; emergency clinicians are integral in the management of this condition.
Objective: This paper evaluates key evidence-based updates concerning cardiopulmonary resuscitation (CPR).
Discussion: Cardiac arrest includes shockable rhythms (i.e., pulseless ventricular tachycardia and ventricular fibrillation) and non-shockable rhythms (i.e., asystole and pulseless electrical activity). The goal of cardiac arrest management is to achieve survival with a good neurologic outcome, in part by restoring systemic perfusion and obtaining return of spontaneous circulation (ROSC), while seeking to diagnose and treat the underlying etiology of the arrest. CPR includes high-quality chest compressions to optimize coronary and cerebral perfusion pressure. Chest compressions should be centered over the mid-sternum, with the compressor's body weight over the middle of the chest. A compression depth of 5–6 cm is recommended at a rate of 100–120 compressions per minute, while allowing the chest to fully recoil between each compression. Clinicians should seek to minimize any interruptions in compressions. When performed by bystanders, compression-only CPR may be associated with improved survival to hospital discharge when compared to conventional CPR with ventilations. However, in trained personnel, there is likely no difference with compression-only versus conventional CPR. Mechanical approaches for CPR are not associated with improved patient outcomes, including ROSC or survival with good neurologic function, but mechanical compression devices may be beneficial in select circumstances (e.g., few rescuers available, prolonged arrest/transport). Monitoring of chest compressions is not associated with improved ROSC, survival, or neurologic outcomes, but it can improve guideline adherence. Types of monitoring include real-time feedback, a CPR coach, end tidal CO_2, arterial line monitoring, regional cerebral tissue oxygenation, and point-of-care ultrasound.
Conclusions: An understanding of CPR literature updates can improve the ED care of patients in cardiac arrest.

1. Introduction

Cardiac arrest is the loss of functional cardiac activity and systemic circulation and includes shockable rhythms (i.e., pulseless ventricular tachycardia [pVT] and ventricular fibrillation [VF]) and non-shockable rhythms (i.e., asystole and pulseless electrical activity). It has an annual incidence ranging between 55 and 113 per 100,000 population, with 180,000–450,000 patients experiencing out-of-hospital cardiac arrest (OHCA) in the United States annually [1-6]. Most cases of cardiac arrest in those older than 35 years are associated with a cardiovascular etiology [7,8]. Unfortunately, mortality is significant, with data from 2022 suggesting survival to hospital discharge for patients experiencing OHCA treated by emergency medical services (EMS) is approximately 9 %, while survival to hospital discharge with good functional status is 7 % [3].

Cardiopulmonary resuscitation (CPR) is integral to improving outcomes in those with cardiac arrest and seeks to obtain survival with good neurologic outcome, in part by restoring systemic circulation [9-15]. CPR includes high-quality chest compressions to optimize coronary and cerebral perfusion pressure [1-3]. This review is part of a series discussing cardiac arrest management in the emergency department (ED) and will focus on CPR. Other reviews in this series will cover cardiac arrest medications, airway management, defibrillation strategies, ultrasound, and extracorporeal membrane oxygenation.

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2. Discussion

2.1. What is the optimal technique and location for hand placement during chest compressions?

Cardiac arrest should be assumed in a person who is unresponsive and has absent or gasping breathing with no palpable pulse. The pulse should be checked at the same time the breathing is assessed, though this should take no longer than 10 s [11,16,17]. Following the recognition of cardiac arrest, high-quality chest compressions should be started as soon as possible, as these increase coronary and cerebral perfusion pressure and improve the likelihood of return of spontaneous circulation (ROSC) and survival with good neurologic outcome [9-15,18-24].

Integral measures of high-quality chest compressions include ensuring adequate rate and depth of compressions, while minimizing the frequency and duration of interruptions (Table 1) [1,2,9-15,22-24]. Current guidelines suggest a compression target of 100–120 beats per minute (bpm), with a chest compression fraction (total compression time divided by total resuscitation time) of at least 60 % and minimizing interruptions [11-15]. Of note, higher chest compression fractions (80 %) should be targeted if possible [14]. Compressions outside of this 100–120 bpm range reduce the likelihood of ROSC and are associated with worse outcomes [13,14,25-27]. A compression depth of 5–6 cm is recommended, with full chest recoil between compressions (Fig. 1) [12-15,25-30]. This results in negative intrathoracic pressure, increasing coronary perfusion pressure and cardiac preload [30]. Compressions may be improved with the compressor slightly removing their hands from the chest at the end of each compression.

Patients in cardiac arrest should immediately be placed supine, which is the most optimal position for high-quality compressions, with a hard surface behind the patient that serves as a counterforce to the compressions if this will not delay initiation of compression, as soft surfaces such as a mattress can significantly reduce compression depth [13,14,31,32]. This may include use of a backboard or the bed placed in CPR mode [13]. For in-hospital arrest, the International Liaison Committee on Resuscitation (ILCOR) guidelines recommend against moving the patient to the floor for compressions due to a delay in initiating compressions and creating a more hazardous environment [13]. In general, a backboard is preferred, as a meta-analysis of 6 studies found use of a backboard led to a 2 mm increase in chest compression depth, while CPR performed on a mattress or moving the patient to the floor did not affect compression depth [33]. However, the ILCOR guidelines state that if healthcare systems have not introduced backboards for use in cardiac arrest, there is insufficient evidence justifying their cost and training staff for their use [13].

The compressor should be standing beside the bed or kneeling next to the patient. Appropriate positioning may require lowering the height of the patient bed/stretcher or the compressor using a step stool. Appropriate hand positioning is also essential. The compressor's heel of their hand should be over the lower portion of the sternum, with the other heel of the hand over the first hand (Fig. 2) [1,2,13,14]. This ensures that compressions target the left ventricle, which is typically located inferior to a line connecting the nipples [34]. When performing compressions, the rescuer's chest should be directly above their hands with their arms in full extension [11-15]. This allows the rescuer to use their body weight to perform compressions, rather than relying on upper extremity strength, which can result in more rapid fatigue. Compressions may also be performed with the patient in the prone position, where the compressions are performed in the midline of the back at the T7-T9 level [35].

Table 1
Optimizing chest compressions.

- Center compressions over the mid-sternum, with the compressor's body weight over the middle of the chest.
- Compress to a depth of 5–6 cm (2–2.3 in.) with each compression.
- Allow the chest to fully recoil between compressions.
- Target a rate of 100–120 compressions per minute.
- Minimize the frequency and duration of interruptions in high-quality compressions, while maintaining a chest compression fraction over 60 % (over 80 % is optimal).
- Place a rigid surface under the patient or activate bed CPR mode to improve chest compression quality if possible; avoid moving the patient from the hospital bed to the ground.

Importantly, rescuers often tire after one minute, which results in decreasing compression quality and recoil, but this must be balanced with the necessity of reducing interruptions in compressions, which leads to decreased coronary and cerebral perfusion pressures, ultimately reducing the likelihood of ROSC and survival [1,2,12-15,27,36-44]. Thus, the compressor should be switched every 2 min during rhythm and pulse check, which should not exceed 10 s. If compressions are significantly interrupted for longer than 10 s, it can take up to 1 min of high-quality compressions to restore sufficient perfusion pressures [1,2,11-14]. However, if the compressor is unable to perform high-quality compressions prior to the full 2 min due to fatigue, another person able to perform compressions should take over. To minimize interruptions, the defibrillator may be charged while compressions are ongoing until the shock can be delivered, and following defibrillation, compressions should be resumed immediately without repeat rhythm analysis [12-14,45-47]. The compressor may also wear gloves and continue compressions during defibrillation [48]. Procedures such as obtaining intravenous (IV) or interosseous (IO) access or endotracheal intubation should be performed while compressions are ongoing.

2.2. Which CPR technique is optimal, compression-only or conventional CPR, and does the setting of the cardiac arrest make a difference in the recommended technique (e.g., lay provider/out-of-hospital versus trained provider as part of a response team)?

Conventional CPR incorporates a 30:2 compression-ventilation cycle if there is no definitive airway. If there is a definitive airway established, a breath should be delivered every 6 s with continuous chest compressions [1,2,11-14]. Compression-only CPR focuses on providing high-quality compressions while avoiding interruptions such as respirations in those without a definitive airway in order to improve coronary and cerebral perfusion pressures, as well as potentially improve the likelihood of successful defibrillation in shockable rhythms (Table 2) [12-15,27,49-53].

The rationale behind compression-only CPR is that conventional CPR may decrease blood flow and cardiac venous return and reduce coronary and cerebral perfusion during the compression pauses for breaths while increasing intrathoracic pressures [12-15,27,49-55]. Compression-only CPR may be most helpful in the initial 4–6 min of the cardiac arrest, when myocardial and cerebral tissues are most sensitive to reduced vascular flow and hypoperfusion leads to worse outcomes [11,14,56,57].

The Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (CPRECC), which are a joint publication from ILCOR, the American Heart Association (AHA), and the European Resuscitation Council (ERC), state that high-quality compressions alone may be used if a sole rescuer is present or rescuers are reluctant to perform ventilations mouth-to-mouth [1,2,9-14,58,59]. Guidelines also state that rescuers should not interrupt compressions to check for pulses or ROSC and should continue high-quality compressions until an automated external defibrillator is prepared to defibrillate, if emergency medical services (EMS) providers assume management of the patient, or if the patient awakens [1,2,9-14].

Randomized data suggest a trend towards improved survival to hospital discharge with bystander performed compression-only CPR compared with conventional CPR [52,60,61], and a 2017 Cochrane review of 3 randomized control trials (RCTs) and 1 cluster RCT evaluating untrained bystander compression-only CPR found improved survival to hospital discharge when compared to conventional CPR [57]. However,

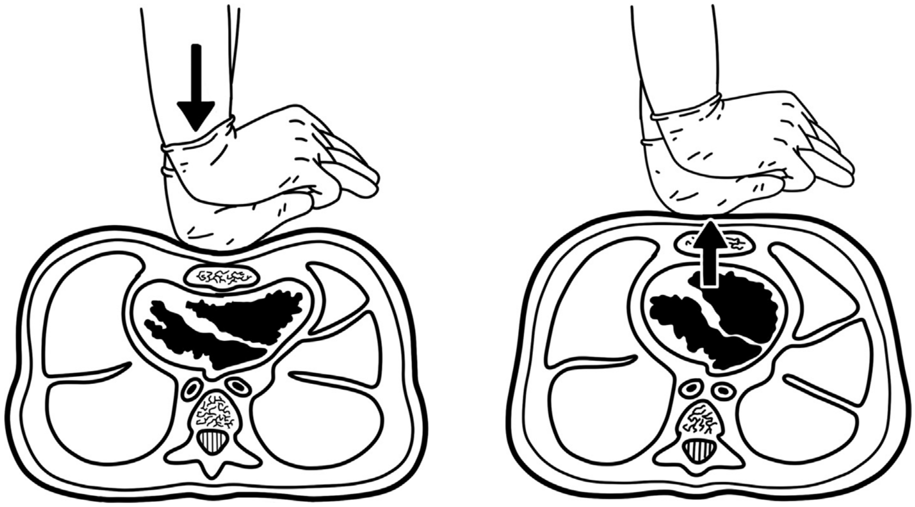

Fig. 1. Chest compression action on the heart.
(Obtained from https://commons.wikimedia.org/wiki/File:CPR-heart-compression.png.)

among EMS personnel, there was no difference. Other meta-analyses published after this Cochrane review have also found no difference in survival to hospital discharge or ROSC when evaluating compression-only and conventional CPR performed by trained personnel [62–65].

Based on the current data, compression-only CPR is likely associated with improved survival to hospital discharge when performed by bystanders when compared to conventional CPR with a 30:2 compression-ventilation ratio. However, in trained personnel, there is likely no difference with compression-only versus conventional CPR. A major consideration is the quality of compressions and chest compression fraction, which are both linked to improved outcomes. If trained personnel are alone, compression-only CPR is a viable option until assistance arrives.

2.3. When should mechanical approaches for CPR be utilized?

There are several mechanical approaches to CPR (Table 3). The most commonly utilized devices are mechanical compression devices, such as the AutoPulse (Fig. 3) (Zoll Medical Corporation, Chelmsford, MA) and Lund University Cardiopulmonary Assist System (LUCAS) (Fig. 4) (Physio-Control/Jolife AB, Lund, Sweden) currently approved by the U.S. Food and Drug Administration [66-70]. These devices differ in several aspects, though they all provide automatic delivery of compressions, minimizing interruptions in compressions, eliminating the issue of decreased perfusion from compressor fatigue, and allowing rescuers to perform other interventions.

The AutoPulse has a load-distributing band that is placed circumferentially around the chest, with a back the shortens and lengthens, providing compressions [66]. The LUCAS device utilizes a piston which moves up and down over the same site as a rescuer's hands [67]. This piston is mounted on a circumferential frame with a power source, with a board underneath the patient's back. Data from multiple meta-analyses suggest no improvement in ROSC, survival to hospital discharge, and short-term or long-term survival with mechanical compression devices compared to manual compressions [70-74]. Of note, these devices require positioning around the patient and then connecting, adjusting, and initiating the device, which can result in pauses in compressions. Thus, training with these devices is necessary, as well as a standardized team approach for application of the device [75-77].

Active compression-decompression CPR (ACD CPR) incorporates a suction device that converts passive chest wall recoil into active expansion by pulling on the chest with an approximately 20 kg of force or distance of 3 cm, which can enhance venous return [78-80]. However, in isolation ACD CPR does not create adequate negative intrathoracic pressures [81]. A meta-analysis of 10 RCTs and quasi-RCTs (majority OHCA) found no benefit in patient-oriented outcomes including immediate survival, survival at hospital discharge, and survival with good neurologic function with ACD CPR compared to standard CPR [81]. Patients undergoing ACD CPR had greater rates of skin trauma and ecchymosis, though there was no difference in sternal fractures, hemothorax, or pneumothorax [81]. Based on this, the AHA states there is insufficient evidence for the use of ACD CPR [2,11-14].

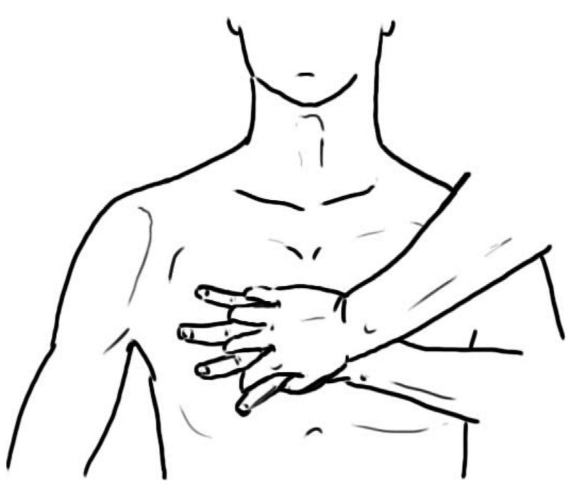

Fig. 2. Hand location for appropriate chest compressions.
(Obtained from https://commons.wikimedia.org/wiki/File:Chest-compression-hand-placement.jpg.)

Table 2
CPR technique considerations.

- Compression-only CPR has been evaluated and is likely associated with improved survival to hospital discharge when performed by bystanders compared to conventional CPR.
- In trained personnel, there is likely no difference in compression-only versus conventional CPR.
- The quality of chest compressions and chest compression fraction remain integral to optimizing neurologic outcomes in cardiac arrest.

Table 3
Mechanical devices for CPR considerations.

- A variety of mechanical devices for CPR are available (e.g., LUCAS, AutoPulse), but their use is not associated with improved patient outcomes.
- Mechanical compression devices may be assisted in cases with prolonged CPR or transport, limited availability of rescuers, and during coronary catheterization or extracorporeal membrane oxygenation cannulation.

Inspiratory impedance threshold devices (ITD) are designed to produce negative intrathoracic pressure during active or passive chest wall decompression, which may increase venous return to the heart during CPR and improve myocardial perfusion [82-85]. An ITD incorporates a plastic appliance with a silicone diaphragm between the airway (facemask, supraglottic device, endotracheal tube) and bag ventilator, which allows for positive-pressure ventilation and exhalation but does not allow air flow into the airway during relaxation of the chest wall. ITDs can produce negative intrathoracic pressures in patients undergoing bag-mask or invasive airway, and they are often used with ACD CPR to create effective negative intrathoracic force [82-85]. The combination of ITD and ACD CPR has demonstrated improved hemodynamics and vascular flow in preclinical trials [86,87]. The ROC PRIMED RCT included 8718 patients with OHCA and compared ITD with a sham device [84]. Authors found no significant difference in neurologically intact survival, ROSC on arrival, survival to admission, or survival to discharge. However, a 2015 secondary analysis of patients with "acceptable" CPR found that patients with an ITD had improved neurologically intact survival compared with the sham device (7.2 % vs. 4.1 %, P = 0.006) [88]. A 2010 study evaluating ACD CPR with an ITD compared to standard CPR in 1653 patients with OHCA found improved survival to hospital discharge in the ACD plus ITD group (8.9 % vs 5.8 %, P = 0.015), as well as increased survival with good neurologic outcome (8.6 % vs 5.8 %, P = 0.029) [89]. A meta-analysis found ITD was not associated with improved survival or neurologic outcomes, though when controlled for witnessed arrest and shorter response time, authors state ITD may improve ROSC [70]. Importantly, the AHA currently recommends against the routine use of ITD, though data suggest they may improve vascular flow [2,9-14].

Based on available evidence, mechanical approaches for CPR are not associated with improved patient outcomes, including survival, ROSC, or improved neurologic function. However, there are situations where mechanical compression devices such as the AutoPulse or LUCAS device may assist, including in cases of prolonged CPR or transport, limited availability of rescuers, and during coronary catheterization or extracorporeal membrane oxygenation cannulation [68-70].

Fig. 3. AutoPulse.
(Obtained from https://en.wikipedia.org/wiki/AutoPulse#/media/File:Mechanische_Reanimationshilfe.jpg.)

Fig. 4. LUCAS chest compression device.
(Obtained from https://en.wikipedia.org/wiki/LUCAS_device#/media/File:JASDF_Automatic_cardiopulmonary_resuscitation_device_at_Komaki_Air_Base_February_23,_2014.jpg.)

2.4. What is the evidence concerning head-up CPR?

Head-up CPR involves elevation of the head and chest during compressions (Table 4). This seeks to reduce intracranial pressure while maintaining mean arterial pressure to improve cerebral blood flow and cerebral perfusion pressure [90-92]. A 2019 study evaluating a prehospital bundle including head-up/chest-up CPR found this was safe and feasible during resuscitation [90]. A 2022 prospective registry study including 227 patients receiving head-up CPR combined with mechanical and/or ACD CPR with an ITD found a time-dependent association with ROSC. For every minute delay following the 911 phone call in applying the head-up CPR bundle, there was a 5.6 % reduction in likelihood of ROSC (between minutes 4–12) [91]. A second 2022 study evaluated head-up CPR combined with ACD CPR and ITD compared with conventional CPR. Authors found improved survival to discharge if this bundle was initiated within 18 min (odds ratio [OR] 1.88; 95 % confidence interval [CI] 1.03–3.44), with the greatest benefit within the first 9 min (OR 5.21; 95 CI% 1.74–15.59) [92]. However, there were several significant limitations, including no blinding or randomization, use of historical controls that may introduce confounding, and significant differences in the patient groups. In the 2022 study by Moore et al., the authors did not pre-establish time windows for their primary outcome, and they excluded four EMS systems, which increases the risk of selection bias [92]. The 2024 ILCOR Consensus Statement recommends that further trials are required evaluating the usefulness of head-up CPR due to the limited data [13].

Table 4
Head-up CPR considerations.

- Head-up CPR includes elevating the head and chest during compressions.
- Despite initial studies suggesting benefit, there are multiple limitations with the data (no blinding or randomization, use of historical controls that may introduce confounding, and significant differences in the patient groups).
- Further study is necessary prior to the routine use of head-up CPR.

2.5. What tools can be used to monitor chest compressions?

Chest compression quality is an integral component of cardiac arrest resuscitation, as inadequate CPR is associated with worse outcomes [11-14]. Even when performed by trained and experienced professionals, CPR quality varies and is often inadequate [11-14,93-95]. There are several means of monitoring chest compression rate and depth [11-14]. These include mechanical devices that provide real-time feedback of compression rate, depth, and chest recoil; use of a compression coach; end-tidal carbon dioxide ($EtCO_2$) measurements; diastolic blood pressure (DBP) measurement with invasive arterial pressure monitoring; regional cerebral tissue oxygenation (rSO_2); and point-of-care ultrasound (POCUS) (Table 5).

Mechanical devices can provide feedback to the compressor concerning compression rate and depth to ensure the performance of high-quality compressions. A 2020 systematic review conducted by ILCOR found no difference in patient outcomes with real-time feedback [15]. A 2023 systematic review found improved guideline compliance with chest compression depth and rate, but there was no difference in survival or ROSC [94]. A 2024 ILCOR systematic review found no improvement in patient outcomes [95]. However, authors did find that several aspects of CPR quality improved with real-time feedback provided by the device. The ILCOR 2024 Consensus statement recommends use of real-time audiovisual feedback as part of a compressive quality improvement program, but they recommend against use of these devices in isolation [13].

A CPR coach may assist during resuscitation to monitor and provide feedback on compression quality and coordinate tasks (e.g., switching compressors, defibrillation, intubation) [13,15,96,97]. Literature suggests that a dedicated CPR coach can reduce compression pauses while improving compression quality, compression fraction, and compression depth compliance [96,97]. A 2025 systematic review found improved compression quality, compression fraction, and guideline adherence, as well as reduced pre-shock pauses [98]. However, there was no difference in patient survival.

$EtCO_2$ can be used to monitor compressions and circulation, as $EtCO_2$ reflects pulmonary blood flow, and during cardiac arrest alveolar ventilation and metabolism remain constant [12-14,99,100]. Effective CPR increases cardiac output, leading to higher $EtCO_2$ which reflects increased perfusion. Several studies demonstrate that $EtCO_2$ values increase by 1.4 mm Hg for every 10 mm increase in compression death, with $EtCO_2$ values decreasing by 3 mm Hg for every increase in 10 breaths per minute [99-101]. $EtCO_2$ values less than 10 mm Hg during cardiac arrest suggest poor compression quality, as does a gradual decline in values [14,99,102-110]. If these are present, the compressor should be switched. $EtCO_2$ is also one of the earliest indicators of ROSC, as the return of cardiac activity results in a significant increase in $EtCO_2$. Thus, not only can $EtCO_2$ values be utilized for monitoring chest compression quality, they may also be used to predict and assess for ROSC without the need to check pulses. Systematic review data suggest values over 10 mm Hg during CPR are associated with greater likelihood of achieving ROSC, while persistent values less than 10 mm Hg after 20 min are associated with a 0.5 % likelihood of ROSC [99,104-112]. Sudden increases to normal values (30–40 mm Hg), or increases by at least 10 mm Hg, suggest ROSC [101,103,113-116]. However, there are several considerations, including medication use. This includes epinephrine, which may decrease values, and sodium bicarbonate, which may transiently increase values. However, an elevation in $EtCO_2$ with ROSC is more significant and will last longer [14,99].

Placement of an arterial line allows for continuous monitoring and can assist in resuscitation and determine ROSC, as it can directly provide the DBP and indirectly the coronary perfusion pressure. The coronary perfusion pressure is the pressure gradient of the aorta and right atrium during the decompression phase of CPR, when the myocardium receives blood flow. One study found a coronary perfusion pressure of ≥15–25 mm Hg was associated with ROSC, but this can be challenging to calculate during resuscitation [117]. Thus, utilizing DBP is a practical target. A 2016 study found physiologic monitoring with DBP was associated with higher ROSC, but there was no improvement in survival to hospital discharge or favorable neurologic outcomes [116]. Limited data suggest DBP between 25 and 40 mm Hg may be used as a target [117-120]. Thus, if a team member is present that can place an arterial line, or an arterial line is in place, DBP can be utilized to assess the effectiveness of resuscitation and monitor for ROSC. However, the team leader should not prioritize arterial line placement if there are limited personnel assisting with management.

Regional cerebral tissue oxygenation (rSO_2) utilizes noninvasive spectroscopy to detect hemoglobin [121-123]. In cardiac arrest, rSO_2 values decrease to undetectable or low levels [121]. During high-quality CPR, rSO_2 values improve, with a sudden sustained increase associated with ROSC. Mean values between 20 and 30 % are not associated with ROSC based on current literature, though there is no definitive threshold, and further study is required [122,124,125].

POCUS has demonstrated utility in several aspects of cardiac arrest management, including diagnosis of an underlying etiology, optimizing compression position, pulse checks, and prognosis [126]. Concerning CPR, POCUS may be utilized to monitor compression quality and optimize compression location. A 2020 study evaluated the feasibility of POCUS for optimizing location by assessing cardiac squeeze on POCUS and its effect on $EtCO_2$. Authors found POCUS improved compression position and $EtCO_2$ [127]. POCUS can also assess for a pulse with B-mode or color Doppler, which evaluates for pulsatility and pulsed-wave Doppler to evaluate for quantifiable pulsatile vascular flow. While a future review will discuss POCUS in greater detail, literature suggests POCUS pulse assessment of the carotid or femoral artery is rapid, reliable, and accurate when performed in the ED [128-136]. However, further data are necessary evaluating Doppler in isolation for assessment of systemic perfusion. If POCUS is utilized in cardiac arrest, the most experienced sonographer should perform the examination, and POCUS must not delay or interfere with compressions [126].

Based on the current evidence, monitoring of chest compressions is not associated with improved ROSC, survival, or neurologic outcomes, but it can provide important information and improve guideline adherence. Types of monitoring include real-time feedback, a CPR coach, $EtCO_2$ values, arterial line monitoring, rSO_2, and POCUS. If compression quality is poor, the resuscitation team must make modifications to improve CPR quality (e.g., switch compressor) in order to optimize patient outcomes.

Table 5
Monitoring CPR considerations.

- CPR quality varies significantly even when performed by trained individuals. - There are several means of monitoring including include real-time feedback, a CPR coach, $EtCO_2$ values, arterial line monitoring, rSO_2, and POCUS. - While literature has not demonstrated improved outcomes with CPR monitoring, any decrease in chest compression quality must be addressed to improve CPR quality.

3. Conclusions

Cardiac arrest is the loss of organized cardiac activity and systemic perfusion, which must be rapidly reversed. Treatment includes high-quality chest compressions to restore systemic perfusion. High-quality chest compressions optimize coronary and cerebral perfusion pressure, and a depth of 5–6 cm is recommended at a rate of 100–120 compressions per minute. Interruptions in compressions must be avoided, with a compression fraction of at least 60 % (over 80 % is optimal). Bystander performed compression-only CPR may be associated with improved survival to hospital discharge compared to conventional CPR with ventilations, but in trained personnel, there is likely no difference versus conventional CPR. Mechanical devices for CPR (e.g., LUCAS, AutoPulse) have not demonstrated an improvement in survival, ROSC, or neurologic function, but they may be used in certain situations (e.g., few rescuers available, prolonged arrest/transport). There are several means of monitoring chest compressions (real-time feedback, a CPR coach, $EtCO_2$, arterial line monitoring, rSO_2, and POCUS), which can improve guideline adherence.

CRediT authorship contribution statement

Brit Long: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Conceptualization. **Michael Gottlieb:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Conceptualization.

Declaration of competing interest

None. No AI program was used in the construction of this manuscript.

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