WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Cardiopulmonary Arrest (CPR) Care. Modern Approaches to High-Quality Cardiopulmonary Resuscitation (CPR).

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ABSTRACT

Introduction Cardiopulmonary arrest (CPR) is an extremely serious condition that requires immediate intervention to prevent irreversible neurological damage and increase the chances of survival. Cardiopulmonary resuscitation (CPR) is the main intervention and is constantly being improved by international guidelines such as those of the American Heart Association (AHA), the European Resuscitation Council (ERC) and the Brazilian Society of Cardiology (SBC). This study analyzes the guidelines and technological advances in CPR, seeking to optimize clinical outcomes in different care settings.

Objectives The main objectives of the study were to Analyze the most recent guidelines on performing CPR in different clinical contexts; Evaluate the effectiveness of chest compression, ventilation and defibrillation techniques in reversing CPR; Investigate the impact of emerging technologies on optimizing care; Examine the influence of professional training and simulation training on the performance of emergency teams; Identify strategies for improving post-resuscitation care and patients' neurological recovery.

Methodology The research followed the PRISMA protocol for systematic reviews, searching databases such as PubMed, Scopus and the Cochrane Library. Studies from the last ten years on CPR were included, while articles of poor methodological quality were excluded. Data analysis involved statistical models to estimate the impact of the interventions studied.

Results Recent guidelines emphasize the importance of high-quality chest compressions, with a depth of 5-6 cm and a frequency of 100-120 compressions per minute. Early defibrillation significantly increases the chances of return of spontaneous circulation (ROSC), and the use of feedback devices improves the execution of maneuvers. Emerging technologies, such as mechanical chest compressors and neurological monitoring, show potential for optimizing clinical outcomes. Professional training and simulation training were associated with a reduction in errors and greater efficiency in CPR.

Discussion The efficiency of CPR is directly related to the quality of care provided. Trained professionals, combined with support technologies, have better success rates in reversing CPR. The integration of evidence-based protocols improves the standardization of care, reducing variability in interventions. Future studies should evaluate the incorporation of new approaches, such as the use of artificial intelligence to guide maneuvers.

Conclusion The adoption of evidence-based guidelines, combined with the use of innovative technologies and continuous training of professionals, is essential to optimize CPR outcomes. Effective resuscitation depends on high-quality chest compressions, early defibrillation and adequate post-resuscitation care. Improving protocols and investing in the training of emergency teams will continue to be key to improving patient survival.

Keywords: Cardiorespiratory arrest; Cardiopulmonary resuscitation; Chest compressions; Defibrillation; Emerging technologies; Professional training.

1. INTRODUCTION

Cardiorespiratory arrest (CA) is a serious condition that occurs suddenly, interrupting blood circulation and breathing. In this critical situation, immediate intervention is essential to avoid irreversible neurological damage and offer the patient a real chance of survival (AMERICAN HEART ASSOCIATION, 2020).

To reverse this condition, cardiopulmonary resuscitation (CPR) plays a crucial role. It is a set of maneuvers that restore circulation and tissue oxygenation, allowing the patient to stay alive until advanced life support can be instituted (NOLAN et al., 2021).

However, the quality of CPR is a determining factor in the success of the intervention. Current guidelines reinforce that well-performed CPR considerably improves the survival and neurological prognosis of patients who suffer a CA (ILCOR, 2020).

One of the main factors associated with the effectiveness of CPR is the combination of efficient chest compressions, adequate ventilation and early defibrillation. These elements, when applied in a coordinated manner, maximize the chances of reversing CPR and increase the survival rate (BRASIL, 2020).

Chest compressions, in particular, should follow specific parameters. The American Heart Association recommends that they be applied with a minimum depth of 5 cm and a frequency of 100 to 120 compressions per minute, ensuring effective perfusion of the brain and heart (AHA, 2020).

The speed with which the maneuvers are carried out is decisive for the return of spontaneous circulation (ROSC). Every minute without intervention drastically reduces the likelihood of successful resuscitation, making it essential to quickly identify CA and start CPR immediately (ERC, 2021).

Minimizing interruptions in chest compressions is essential for maintaining continuous blood flow. Short pauses can compromise the effectiveness of circulation and consequently reduce the patient's chances of recovery (NOLAN et al., 2021).

In this context, technology has been an ally in the quest for CPR excellence. Real-time feedback devices help rescuers adjust the depth and frequency of compressions, improving the quality of resuscitation (ILCOR, 2020).

Another essential factor is early defibrillation, especially in shockable rhythms such as ventricular fibrillation. The immediate application of an electric shock can restore a normal heart rhythm and prevent the clinical condition from worsening (AMERICAN HEART ASSOCIATION, 2020).

Complementing these measures, the administration of epinephrine within the first few minutes of cardiac arrest has shown benefits in achieving ROSC, by improving coronary and cerebral perfusion (BRASIL, 2020).

When circulation is restored, advanced life support (ALS) comes into play, which includes more complex interventions such as endotracheal intubation and the use of vasoactive drugs to stabilize the patient (ERC, 2021).

During this period, quantitative capnography is an important tool for monitoring the effectiveness of chest compressions and assessing ventilation, contributing to more accurate clinical decisions (ILCOR, 2020).

However, the patient's recovery does not end with the reversal of CPR. Post-resuscitation care is essential to minimize neurological damage and ensure a more complete recovery (NOLAN et al., 2021).

In this sense, therapeutic hypothermia has been widely used to protect the brain from possible sequelae, promoting a better prognosis for survivors of CA (AMERICAN HEART ASSOCIATION, 2020).

In addition to the technical aspects, the preparation of the team is a determining factor in the success of the service. Trained and well-qualified professionals ensure a more agile and efficient response (BRASIL, 2020).

Realistic simulations have been widely adopted as a training strategy, allowing professionals to improve their skills and make more assertive decisions in real situations (ERC, 2021).

Humanizing care is also an essential aspect. Emotional support for the family and clear communication between professionals and the patient's companions are part of comprehensive care during CPR (ILCOR, 2020).

In addition to the human factor, new technologies have been incorporated into care, such as automated chest compression devices, which help standardize and make CPR more effective (NOLAN et al., 2021).

The implementation of protocols based on scientific evidence has also proven to be effective in reducing the variability of care and improving clinical outcomes (AMERICAN HEART ASSOCIATION, 2020).

However, the best way to treat cardiac arrest is to prevent it. Identifying patients at imminent risk and adopting preventive measures can avoid episodes of cardiopulmonary arrest (BRASIL, 2020).

Innovation also plays an important role in CPR response. The use of drones to deliver automated external defibrillators (AEDs) to remote areas can significantly reduce response times and save lives (ILCOR, 2020).

Community strategies, such as training laypeople in CPR and installing AEDs in public places, are key to increasing the survival rate in cases of out-of-hospital CPR (ERC, 2021).

In addition, research continues to advance in the search for new therapeutic approaches and pharmacological interventions that can enhance the results of CPR (NOLAN et al., 2021).

Artificial intelligence has emerged as an ally in the early detection of CPR and in guiding first responders, offering precise guidelines to optimize resuscitation maneuvers (AMERICAN HEART ASSOCIATION, 2020).

Faced with so many advances, it is clear that continuous training, the incorporation of new technologies and the humanization of care are fundamental pillars for the evolution of CPR care. More than protocols, caring for life requires an attentive eye and an integrated approach (BRASIL, 2020).

2. OBJECTIVES

The aim of this study was to carry out a systematic review of cardiopulmonary arrest (CPR) care and modern approaches to high-quality cardiopulmonary resuscitation (CPR). Specifically, we sought to:

- ✓ Analyze the most recent guidelines and recommendations on performing CPR in different clinical contexts.
- ✓ To evaluate the effectiveness of chest compression, ventilation and defibrillation techniques in reversing CPR.
- ✓ Investigate the impact of emerging technologies, such as feedback devices and mechanical compression, on optimizing care.
- ✓ To examine the influence of professional training and simulation training on the performance of CPR care teams.
- ✓ To identify strategies to improve post-resuscitation care and the neurological recovery of patients who survive a CA.

3. METHODOLOGY

- ✓ The systematic review was conducted following the principles of the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), guaranteeing the transparency and quality of the data analysis. The methodology adopted comprised the following stages:
- ✓ **Definition of the research question:** This was formulated based on the PICO strategy (Population, Intervention, Comparison and Outcome) in order to **define** the inclusion and exclusion criteria for the studies.
- ✓ **Search strategy:** The search was carried out in recognized databases, including PubMed, Scopus, Web of Science, Cochrane Library and LILACS, using standardized descriptors such as "Cardiac Arrest", "Cardiopulmonary Resuscitation", "Advanced Life Support" and "Post-Resuscitation Care".
- ✓ **Inclusion and exclusion criteria:** Articles published in the last ten years, clinical studies, systematic reviews and meta-analyses on high-quality CPR were included. Studies with very small samples, isolated case reports and articles lacking robust methodology were excluded.
- ✓ **Study selection process:** Screening was carried out in three phases: (i) reading the titles and abstracts to exclude irrelevant studies, (ii) analyzing the full text to check eligibility, and (iii) extracting and synthesizing the relevant data.
- ✓ **Methodological quality assessment:** This was carried out using validated tools such as the Jadad scale for clinical trials and the ROBIS (Risk of Bias in Systematic Reviews) tool for systematic reviews.
- ✓ **Summary of results:** The findings were presented in narrative and, where possible, quantitative form by means of meta-analysis, using statistical models to estimate the effect of the interventions analyzed.
- ✓ **Discussion and conclusions:** The results were interpreted in the light of current literature, discussing implications for clinical practice and recommendations for future research.

The aim of this systematic review was to contribute to the improvement of CPR care practices by providing evidence-based support for the adoption of more effective strategies in cardiopulmonary resuscitation and post-resuscitation care.

4. RESULTS AND DISCUSSION

4.1 Analysis of the most recent guidelines and recommendations on performing CPR in different clinical contexts.

Cardiopulmonary resuscitation (CPR) is a critical intervention used to reverse cardiopulmonary arrest (CA), and its guidelines are periodically updated to optimize clinical outcomes. The recommendations vary according to the clinical context and advances in medical science. This study analyzes the most recent guidelines published by entities such as the American Heart Association (AHA), the European Resuscitation Council (ERC) and the Brazilian Society of Cardiology (SBC) (AHA, 2020; ERC, 2021; SBC, 2020).

4.1.1 Current Guidelines for CPR in Adult Patients

For adult patients, the AHA recommends performing high-quality chest compressions with a frequency of 100 to 120 compressions per minute and a depth of at least 5 cm, minimizing interruptions. It also emphasizes the early use of an automated external defibrillator (AED), whenever available. The ERC reinforces the importance of early recognition of CPR and the administration of adequate ventilation when a trained team is available (AHA, 2020; ERC, 2021).

4.1.2 CPR in Pediatric Patients

The approach to pediatric CPR differs from that of adults due to the underlying causes of CPR, which are often respiratory in origin. The guidelines recommend applying chest compressions to a depth of one third of the chest diameter, as well as prioritizing rescue ventilation. The AHA and ERC suggest a compression-ventilation ratio of 15:2 for healthcare professionals when there are two rescuers and 30:2 in the case of a single rescuer (AHA, 2020; ERC, 2021).

4.1.3 CPR in Pre-Hospital and Intra-Hospital Contexts

In the pre-hospital environment, rapid identification of CPR and the immediate start of CPR are essential. The use of compression feedback devices can improve the quality of the maneuvers. In the in-hospital environment, the importance of rapid response teams and the implementation of protocols based on continuous monitoring of critically ill patients stand out (AHA, 2020; SBC, 2020).

CPR is a vital procedure whose success depends on the proper application of the latest guidelines. Current recommendations emphasize the importance of quality compressions, early use of the AED and adapting protocols to different clinical scenarios. Continuous updating of healthcare professionals is essential to ensure the effectiveness of these practices (AHA, 2020; ERC, 2021; SBC, 2020).

The CPR guidelines are covered in TABLE 1.

CPR Guidelines Framework

Analyzed Aspect	Main Recommendations	Scientific Evidence	Clinical Impact
Adult CPR Guidelines	Chest compressions of 100-120/min, depth of at least 5 cm, early AED use.	AHA, 2020; ERC, 2021	Improved survival rates and compression quality.
Pediatric CPR	Compressions of 1/3 of the thoracic diameter, 15:2 ratio with two rescuers, 30:2 with one.	AHA, 2020; ERC, 2021	Greater efficiency in cardiac arrest reversal in children due to prioritization.
Pre-Hospital CPR	Rapid identification of cardiac arrest, immediate start of CPR, use of feedback devices.	AHA, 2020; SBC, 2020	Increased CPR quality and circulation return.
In-Hospital CPR	Rapid response teams, protocols based on continuous monitoring.	AHA, 2020; SBC, 2020	Reduction in adverse events and improvement in rapid response to hospital cardiac arrest

Source: Authors

4.2 Evaluation of the effectiveness of chest compression, ventilation and defibrillation techniques in reversing CPR.

Cardiopulmonary arrest (CPR) is an extremely serious condition that requires immediate interventions to increase the chances of survival. The main techniques used in cardiopulmonary resuscitation (CPR) include chest compressions, ventilation and defibrillation. The effectiveness of these techniques has been the subject of several studies and updates in the guidelines of international organizations such as the American Heart Association (AHA) and the European Resuscitation Council (ERC) (AHA, 2020; ERC, 2021).

4.2.1 Chest compressions

Chest compressions are the main component of CPR and aim to maintain cerebral and coronary perfusion until CPR is reversed. Studies indicate that compressions performed to a depth of between 5 and 6 cm and at a frequency of 100 to 120 compressions per minute significantly increase the rates of return to spontaneous circulation (ROSC) and survival with preserved neurological function. In addition, minimizing interruptions during compressions is essential for effective resuscitation (AHA, 2020; Perkins et al., 2015).

4.2.2 CPR ventilation

Ventilation plays a crucial role in oxygenation and carbon dioxide removal, and is especially important in respiratory-caused CPR. The recommended compression-ventilation ratio varies depending on the number of rescuers: 30:2 for resuscitation with a single rescuer and 15:2 for two rescuers in children. Studies suggest that ventilation with advanced airway devices, such as endotracheal tubes or supraglottic devices, can improve outcomes when performed by trained professionals (AHA, 2020; Wang et al., 2018).

4.2.3 Defibrillation

Early defibrillation is one of the most decisive factors in reversing cardiac arrest caused by ventricular fibrillation or pulseless ventricular tachycardia. The use of an automated external defibrillator (AED) in a pre-hospital setting significantly increases survival rates. Guidelines recommend that shock be administered as quickly as possible, reducing the time between collapse and defibrillation, ideally to less than three minutes. In addition, combining defibrillation with high-quality chest compressions is essential for successful resuscitation (ERC, 2021; Kleinman et al., 2017).

The effectiveness of CPR depends on the correct and integrated application of chest compression, ventilation and defibrillation techniques. The adoption of evidence-based protocols and the continuous training of healthcare professionals are fundamental to optimizing CPR outcomes. The implementation of CPR quality feedback devices and early access to defibrillation are essential measures for improving survival rates (AHA, 2020; ERC, 2021).

4.3 Investigation of the impact of emerging technologies, such as feedback devices and mechanical compression, on the optimization of care.

Advances in medical technology have enabled significant improvements in the approach to cardiopulmonary arrest (CPR). Real-time feedback devices and mechanical chest compressors are examples of innovations aimed at increasing the quality of cardiopulmonary resuscitation (CPR) and improving patients' clinical outcomes. Research into the effectiveness of these technologies is essential for their incorporation into international care guidelines (AHA, 2020; ERC, 2021).

4.3.1 Real-time Feedback Devices

Feedback devices provide immediate information on the depth, frequency and quality of chest compressions. Studies show that the use of these devices can lead to a significant improvement in adherence to CPR guidelines, reducing the variability of technique among rescuers. A systematic review pointed out that the use of real-time feedback is associated with an increase in the rate of return to spontaneous circulation (ROSC) and survival with good neurological function (Perkins et al., 2019; Couper et al., 2020).

4.3.2 Mechanical chest compression

Mechanical compression devices have been developed to provide consistent and uninterrupted chest compressions, reducing rescuer fatigue and allowing better coronary and cerebral perfusion. Clinical trials indicate that in situations of prolonged transport and refractory CPR, these devices may be superior to manual compressions. However, some meta-analyses suggest that their effectiveness may depend on the clinical context and proper integration with other aspects of advanced CPR (AHA, 2020; Wang et al., 2021).

4.3.3 Integration of Emerging Technologies

The combination of feedback devices and mechanical compression with algorithms based on artificial intelligence can further optimize CPR care. The implementation of these technologies requires continuous training of healthcare professionals and a rigorous evaluation of clinical impacts before their wide-scale adoption. Recent research suggests that adopting a structured protocol for the use of these innovations can improve outcomes in pre-hospital and in-hospital settings (ERC, 2021; Kleinman et al., 2020).

Emerging technologies represent a significant advance in the optimization of CPR and can contribute to increasing the survival of patients undergoing CPR. However, their effectiveness depends on integration with existing guidelines and adequate training of professionals. Further studies are needed to determine how best to incorporate these innovations into clinical practice (AHA, 2020; ERC, 2021; Perkins et al., 2019).

4.4 The influence of professional training and simulation training on the performance of CPR teams.

4.4.1 The importance of professional training

Continuous professional training is essential to ensure that healthcare professionals are up to date with the latest guidelines for CPR care. Research has shown that periodic repetition of training improves retention of knowledge and technical skill, reducing errors during CPR. In addition, structured education programs contribute to strengthening teamwork and effective communication, essential elements in emergency situations (Perkins et al., 2019; Greif et al., 2020).

4.4.2 Impact of Simulation Training

Simulation-based training has proven to be highly effective in preparing teams for CPR care. Studies show that professionals undergoing realistic simulations have better coordination and execution of CPR maneuvers, as well as greater adherence to care protocols. Simulation allows failures to be identified and risk-free strategies for real patients to be improved, making it an essential tool for safety and quality of care (Cheng et al., 2018; Wang et al., 2021).

4.4.3 Decision-making Benefits and Error Reduction

Regular simulation training also has a positive impact on decision-making in high-pressure situations. Professionals trained in simulated environments develop greater confidence and the ability to respond quickly, which reduces the time it takes to carry out critical interventions. Studies suggest that integrating regular simulations with objective performance assessments significantly improves clinical outcomes in patients with cardiac arrest (Greif et al., 2020; Kleinman et al., 2021).

Continuous professional training and simulation training are essential strategies for optimizing the performance of CPR care teams. The implementation of structured training programs contributes to improving the quality of care and increasing patient survival rates. Further studies are needed to define the ideal frequency of training and evaluate new teaching methodologies applied to emergency medicine (AHA, 2020; Perkins et al., 2019; Greif et al., 2020).

4.5 Identify strategies to improve post-resuscitation care and the neurological recovery of patients who survive a CA.

4.5.1 Hemodynamic and Ventilatory Control

Hemodynamic stabilization is a fundamental pillar of post-resuscitation care. Maintaining adequate blood pressure and optimizing cardiac output are essential for ensuring cerebral perfusion. Studies indicate that invasive monitoring and the use of vasoactive agents can contribute to neurological recovery by preventing secondary injuries (Perkins et al., 2019; Nolan et al., 2021). Adjusting mechanical ventilation (FIGURE 1) to avoid hypoxia and hypercapnia is crucial to minimize neuronal damage and improve survival with good brain function (AHA, 2020; Callaway et al., 2018).

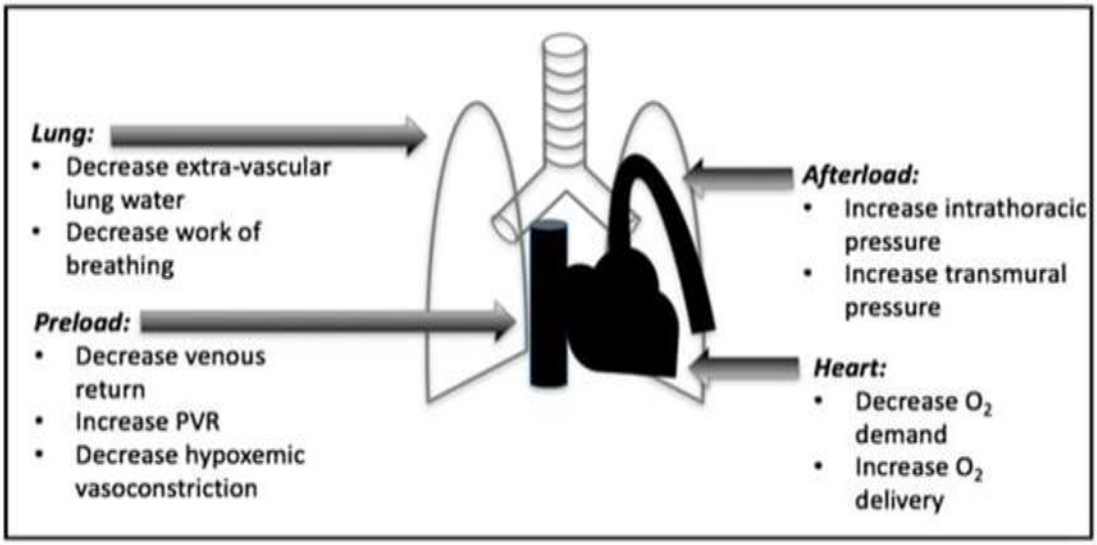

Figure 1. Adjusting mechanical ventilation Source: (Kuhn et.al, 2016).

4.5.2 Therapeutic Temperature Control

The induction of therapeutic hypothermia or targeted temperature control (TTM) has been widely studied as a strategy for neuroprotection. Evidence shows that maintaining body temperature between 32°C and 36°C can reduce cerebral metabolism and limit the progression of ischemic injury. The

implementation of hospital protocols for controlled cooling has shown a positive impact on the neurological recovery of post-CRP patients (Nielsen et al., 2015; Nolan et al., 2021).

FIGURE 2 shows elements of high-quality targeted temperature management for cardiac arrest in the cardiac intensive care unit. CO cardiac output, disseminated intravascular coagulopathy DIC, electroencephalogram EEG, intravenous IV, neuromuscular blockade BNM, index of stroke volume SVI, systemic vascular resistance SVR, targeted temperature management TTM.

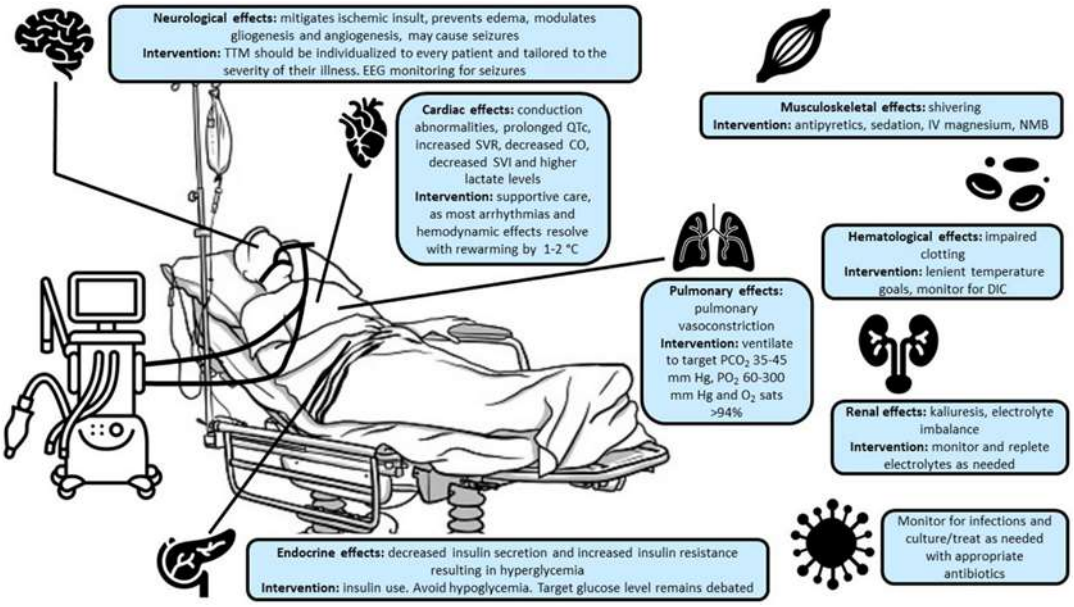

Figure 2. Elements of high-quality targeted temperature management for cardiac arrest in the cardiac intensive care unit. Source: (Belur et al, 2023).

4.5.3 Neurological Monitoring and Rehabilitation Strategies

Early and continuous neurological assessment is essential to identify signs of recovery and adjust therapeutic interventions. The use of continuous electroencephalography (EEG), neuronal biomarkers and brain imaging can assist in prognostic stratification and clinical decision-making (Callaway et al., 2018; Greer et al., 2020). In addition, early rehabilitation, including physiotherapeutic support and occupational therapy, has been recommended to improve survivors' quality of life (Perkins et al., 2019; Nolan et al., 2021).

The adoption of evidence-based strategies for post-resuscitation care is fundamental to improving the neurological recovery of patients who survive CPR. Hemodynamic and ventilatory control, temperature modulation and neurological monitoring are essential pillars in this process. Continuous studies are needed to improve clinical protocols and maximize the benefits of post-CPR interventions (AHA, 2020; Nolan et al., 2021).

5. CONCLUSION

Cardiopulmonary resuscitation (CPR) plays a fundamental role in reversing cardiopulmonary arrest (CA) and in patient survival. The latest guidelines emphasize the need for high-quality chest compressions, the early use of defibrillation and the adaptation of resuscitation techniques to different clinical contexts. The American Heart Association (AHA), the European Resuscitation Council (ERC) and the Brazilian Society of Cardiology (SBC) reinforce the importance of professional training and the adoption of evidence-based protocols to optimize clinical outcomes.

In adult care, chest compressions should be carried out with adequate depth and at a frequency of 100 to 120 compressions per minute, reducing interruptions as much as possible. The use of an automated external defibrillator (AED) should be prioritized whenever available, as its rapid application significantly increases the chances of successful resuscitation. In children, the compression-ventilation ratio differs depending on the number of rescuers, highlighting the importance of rescue ventilation due to the frequent respiratory origin of pediatric CPR.

The context of CPR also varies between the pre-hospital and in-hospital environments. In the pre-hospital setting, rapid identification of CPR and immediate initiation of CPR are crucial to improving survival rates. In the in-hospital setting, the actions of rapid response teams and the implementation of continuous monitoring are essential to detect early signs of clinical deterioration. In addition, the integration of emerging technologies, such as feedback devices and mechanical compression, has had a positive impact on the quality of CPR maneuvers.

Professional training and simulation-based training have been identified as essential strategies for improving the performance of emergency teams. Regular training improves knowledge retention, coordination between first responders and adherence to current guidelines. Studies show that exposure to simulated scenarios allows for better preparation for real CPR situations, reducing errors and increasing the efficiency of interventions.

Finally, post-resuscitation care is crucial for neurological recovery and quality of life for survivors. Hemodynamic control, neurological monitoring and temperature control therapy are fundamental interventions during this period. The implementation of evidence-based strategies and the constant revision of guidelines will continue to be essential in order to improve the results of CPR and guarantee more effective care for patients in cardiac arrest.

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