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PREHOSPITAL CARDIAC RESUSCITATION. FROM PREHOSPITAL TO THE EMERGENCY ROOM: MINUTES THAT SAVE A LIFE - BASIC SUPPORT

RESSUSCITAÇÃO CARDÍACA PRÉ-HOSPITALAR. DO PRÉ-HOSPITALAR À SALA DE EMERGÊNCIA: MINUTOS QUE SALVAM UMA VIDA – SUPORTE BÁSICO

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ABSTRACT

The exact incidence of cardiorespiratory arrest (CRA) even in countries with well-structured clinical records is still unknown, but estimates range from 180,000 to over 450,000 annual deaths. The most common etiology of CRA is ischemic cardiovascular disease, resulting in the development of lethal arrhythmias. Survival of CRA shows divergent outcomes. In the out-of-hospital setting, studies have reported survival rates of 1% to 6%. Three systematic reviews of hospital discharge on extra-hospital CRA showed 5% to 10% survival between those treated by emergency medical services and 15% when the rhythm disorder was ventricular fibrillation (VF). Basic life support consists of cardiopulmonary resuscitation (CPR) and, when available, defibrillation with an automatic external defibrillator (AED). The keys to survival of CRA are early recognition and treatment, specifically, immediate onset of excellent CPR and early defibrillation. This article will discuss the basics of adult life support from prehospital to emergency room, as outlined in the ILCOR and AHA Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, updated in November 2017.

Keywords: Heart Arrest; Cardiopulmonar Resuscitation; Prehospital Care; Emergency Treatment.

RESUMO

A incidência exata de parada cardiorrespiratória (PCR) mesmo em países com registros clínicos bem estruturados ainda é desconhecida, mas as estimativas variam de 180.000 a mais de 450.000 mortes anuais. A etiologia mais comum da PCR é a doença cardiovascular isquêmica que ocasiona no desenvolvimento de arritmias letais. A sobrevivência decorrente da PCR apresenta desfechos divergentes. No cenário extra-hospitalar, os estudos relataram taxas de sobrevida de 1% a 6%. Três revisões sistemáticas de alta hospitalar sobre a PCR extra-hospitalar mostraram 5% a 10% de sobrevida entre aqueles tratados através de serviços médicos de emergência e 15% quando o distúrbio do ritmo era a fibrilação ventricular (FV). O suporte básico de vida consiste em ressuscitação cardiopulmonar (RCP) e, quando disponível, desfibrilação com desfibrilador externo automático (DEA). As chaves para a sobrevivência após a PCR são reconhecimento e tratamento precoces, especificamente, início imediato de excelente RCP e desfibrilação precoce. O presente artigo discutirá os princípios do suporte básico de vida em adultos do pré-hospitalar à sala de emergência, conforme descritos nas Diretrizes de Ressuscitação Cardiopulmonar e Atendimento Cardiovascular de Emergência do ILCOR e AHA, atualizadas em novembro de 2017.

Descritores: *Parada cardíaca; Ressuscitação Cardiopulmonar; Assistência Pré-Hospitalar; Tratamento de Emergência.*

INTRODUCTION

The current cardiopulmonary resuscitation (CPR) protocol was developed in the late 1950s and 1960s. Elam and Safar first described the technique and benefits of mouth-to-mouth ventilation in 1958.[1] Kouwenhoven, Knickerbocker, and Jude subsequently described the benefits of external chest compressions,[1] which, combined with mouth-to-mouth ventilation, forms the basis of modern CPR. External defibrillation was first described in 1957 by Kouwenhoven and incorporated into the existing resuscitation guidelines.

Basic life support (BLS) consists of CPR and, when available, defibrillation using an automatic external defibrillator (AED). The keys to surviving cardiorespiratory arrest (CRA) are early recognition and treatment, specifically immediate excellent CPR and early defibrillation.[1]

This article will discuss the basics of adult life support from prehospital to the emergency room as outlined in the International Liaison Committee on Resuscitation (ILCOR) and American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care updated in November 2017.

Epidemiology and survival

The exact CRA incidence is unknown, even in countries with well-structured CPR records such as the United States, but estimates range from 180,000 to >450,000 cases.[2] The most common etiology of CRA is ischemic cardiovascular disease, which results in the development of lethal arrhythmias.[2] Despite the use of CPR, electrical defibrillation, and other advanced resuscitation techniques over the past 50 years, CRA survival rates remain low.[2]

CRA survival shows divergent outcomes. In the out-of-hospital scenario, studies have reported survival rates of 1–6%. Three systematic reviews of hospital discharge after out-of-hospital CRA showed 5–10% survival rates among patients treated by emergency medical services and 15% when the rhythm disorder was ventricular fibrillation (VF).[2]

Early CPR can improve results, but failure to perform CPR or its poor delivery are important factors that contribute to unfavorable outcomes.[2] Multiple studies evaluating in- and pre-hospital CPR performance showed that trained health care professionals fail to meet BLS guidelines.

ETIOLOGY OF CRA

The etiology of CRA can be defined according to arrest rhythm or triggering cause. When defined by arrest rhythm, CRA can be divided into VF, pulseless ventricular tachycardia (VT), pulseless electrical activity, and asystole. In in-hospital environments, VF and VT account for 1/3 of cases. In the out-of-hospital scenario, they account for approximately 75% of cases, the most common being the occurrence of home-based CRA, where the main cause is ischemic coronary disease.[3]

Contrary to out-of-hospital CRA, which is predominantly cardiac and occurs unexpectedly, in-hospital CRA is much more predictable since it often occurs in circumstances of acute respiratory distress and/or circulatory shock, with progressive deterioration occurring before the episode.[3]

About 70% of out-of-hospital CRA cases are attributed to coronary disease. CRA can occur both during an acute coronary syndrome and in the context of a stable chronic coronary disease in patients with coronary disease (these patients often had previous myocardial lesion and fibrosis, which serve as a substrate for CRA).[3]

MAIN TREATABLE CAUSES OF CRA

The most common etiologies related to CRA rhythms are described in the "5Hs and 5Ts" mnemonic pattern. The reversible cause must be investigated and treated for all CRAs. Table 1 shows this mnemonic rule.[4]

RESUSCITATION GUIDELINES

The worldwide guidelines for CPR and emergency cardiovascular care are based on an extensive review of clinical and laboratory evidence from the ILCOR.[5] Guidelines and algorithms are designed to be simple, practical, and effective (algorithm 1).[5] A guideline update published in November 2017 contained minor updates and maintained most of the evidence published in 2015. The most recent version of the AHA BLS algorithm is shown in Figure 1.

Important concepts and practices of the AHA Guidelines for BLS include the following:

- Immediate recognition of CRA, noting unresponsiveness or absent/gasping breathing.
- Immediate excellent CPR – "push hard, push fast" – paying continuous attention to chest compression quality and ventilation frequency.
- Minimize CPR interruptions.
- For professional first responders: Do not take more than 10 seconds to check pulse.
- For rescue teams not adequately trained: Focus on excellent hands-only CPR (HO-CPR).
- Use an AED as soon as it is available.
- Employ emergency medical services as soon as possible.

Patient survival depends mostly on immediate excellent CPR and early defibrillation.[6]

PHASES OF RESUSCITATION

Many resuscitation researchers consider three distinct CRA phases in VF: electrical, hemodynamic, and metabolic.[6] Treatment focus varies among phases.

Electrical phase

The electrical phase is defined as the first 4–5 minutes of CRA in VF. Immediate defibrillation is necessary to increase the survival rate of these patients. Excellent chest compressions during defibrillator preparation also improve survival.[6]

Hemodynamic phase

The hemodynamic phase follows the electrical phase and is defined as the period of 4–10 minutes after the event, during which VF can persist. Early defibrillation is essential for the

Table 1. 5Hs and 5Ts.[4]

5Hs	5Ts
Hypovolemia	Coronary thrombosis (AMI)
Hypoxia	Cardiac tamponade
Hypo/hyperkalemia	Chest tension (hypertensive pneumothorax)
H+ (acidosis)	Pulmonary thromboembolism (PTE)
Hypothermia	Toxic (exogenous intoxication)

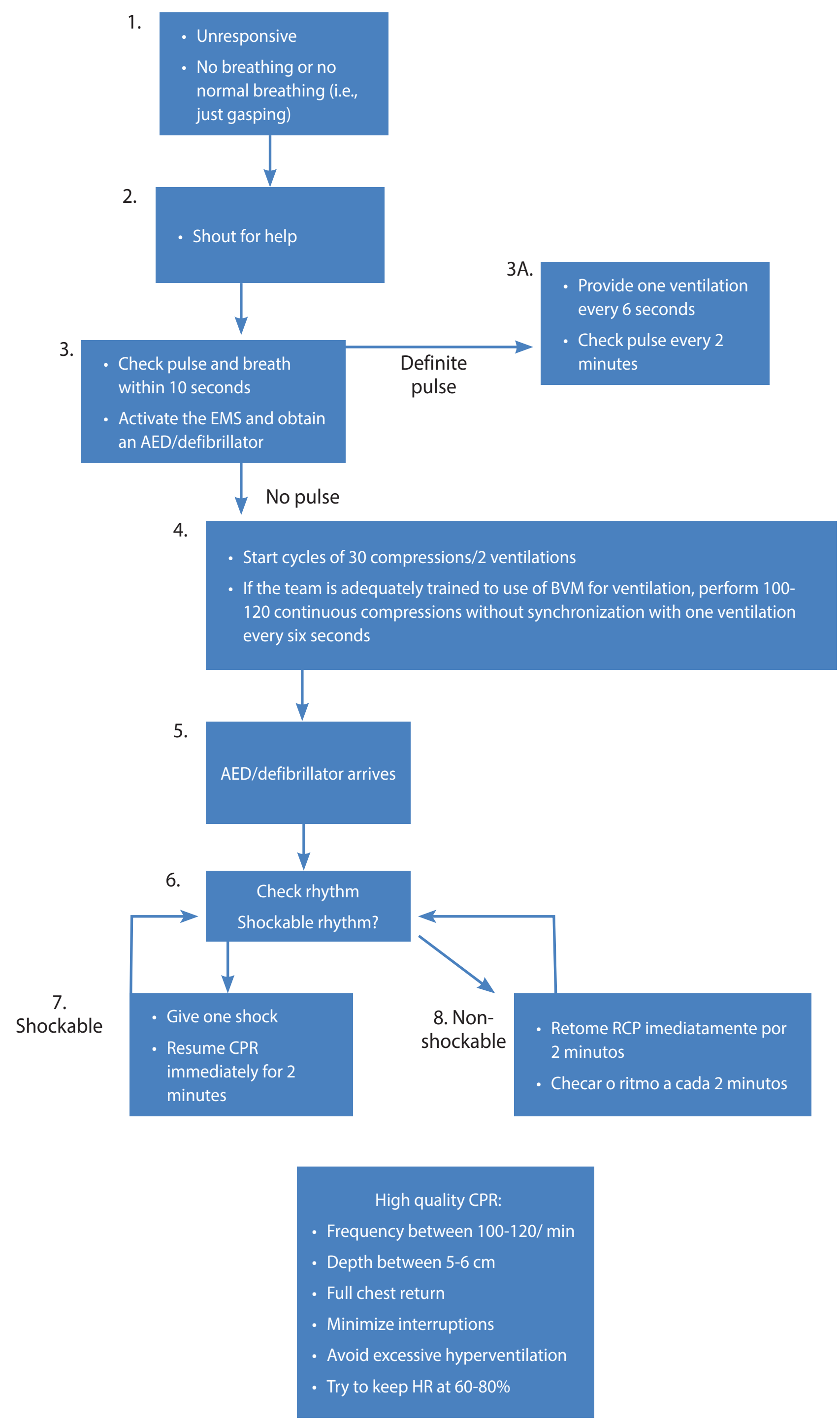

Figure 1. Algorithm 1: Basic life support.[5]

survival of VF patients. Excellent chest compressions should be started immediately after the recognition of CRA and continued until shortly before defibrillation (i.e., load the defibrillator during active compressions, stop briefly to confirm rhythm, and give the shock). Resume CPR immediately after giving the shock.[6]

It remains unclear whether it is beneficial to delay defibrillation to perform 2–3 minutes of CPR during the hemodynamic phase. Randomized trials have reached inconsistent conclusions:

• In one study, the researchers randomly assigned 200 patients with out-of-hospital VF arrest to receive immediate defibrillation or 3 minutes of CPR prior to defibrillation.[7] Among the cases with an ambulance response time > 5 minutes, patients treated with CPR prior to defibrillation had higher survival rates to discharge than did those immediately defibrillated (22% versus 4%, respectively). In contrast, patient results did not differ among the cases with a rapid ambulance response.
• A similar study of 202 patients did not find a statistically significant survival to discharge improvement with 3 minutes of CPR prior to defibrillation regardless of ambulance response time (17% versus 10%, respectively; $p = 0.16$).[8]
• A third trial included 256 patients with out-of-hospital CRA who received immediate defibrillation or 90 seconds (instead of 3 minutes) of CPR immediately followed by defibrillation. There was no significant difference in survival to hospital discharge (4.2% versus 5.1%, respectively).

The ILCOR guidelines state that there is insufficient evidence to determine whether a period of CPR prior to defibrillation is beneficial in all CRA cases. A meta-analysis of the randomized studies concluded that any approach is reasonable, while another meta-analysis with more liberal inclusion criteria emphasized the conflicting nature of the evidence.[2,3]

Although it is essential to provide excellent CPR until the defibrillator is connected to the patient and loaded and resume CPR immediately after the shock, there is still insufficient evidence to justify a defibrillation delay to perform chest compressions for a predetermined period before defibrillation. Emergency medical service teams that advocate this approach should consider both the patient's down time and their own response time when deciding to delay defibrillation to first provide CPR. For example, it would be reasonable to perform 2 minutes of excellent CPR prior to defibrillation in patients with unconfirmed CRA and fine VF whose down time exceeds 3–5 minutes.[6]

Metabolic phase

The treatment of the metabolic phase, defined as absence of pulse for >10 minutes, is mainly based on resuscitative measures. If it is not rapidly converted into an infusion rhythm, patients at this stage generally do not survive.[6]

RECOGNITION OF CRA

Recognizing CRA is the first essential step of successful resuscitation. According to the ILCOR Guidelines, the first responder who witnesses the event should check if the area is safe before approaching the victim and confirm their unresponsiveness by tapping the person on the shoulder and asking: "Are you okay?"[7] If the person is unresponsive, the first responder should ask for help, activate the emergency response system, and initiate excellent chest compressions. The 2015 guidelines, reinforced once again in 2017, emphasize the use of mobile phones to activate the system. Many emergency centers have adopted protocols to instruct untrained lay responders to perform HO-CPR to improve survival.

The AHA Guidelines emphasize that even well-trained professionals may have difficulty determining if a pulse is present and breathing is adequate in unresponsive patients. An experienced clinician can check for a carotid pulse. However, a pulse check should take no longer than 10 seconds. The same criteria to establish apnea are used both by lay responders and health professionals. If the unresponsive patient is not breathing normally, apnea should be considered. The fundamental principle is not to delay CPR in patients who need it (algorithm 1).[5]

Therefore, after assessing responsiveness, health care professionals should quickly check for the patient's pulse. When doing so, it is reasonable to visually assess the patient's breathing status. It is appropriate to assume that the patient is in CRA if there is no or abnormal breathing (e.g., gasping) or if the pulse cannot be readily palpated within 10 seconds.

THORACIC COMPRESSIONS

Performance of excellent chest compressions

Chest compressions are the most important CPR element. The coronary perfusion pressure and return of spontaneous circulation (ROSC) are maximized when excellent chest compressions are performed. The icon of the AHA BLS Guideline was: "push hard and fast in the center of the chest" (algorithm 1).[5] Although this is easy to learn and remember, the reviewed guidelines added upper limits to what is considered "difficult" and "fast" when performing chest compressions.

The following objectives are essential to achieving excellent chest compressions:

• Compress the chest at a rate of 100–120 compressions per minute;
• Deliver a depth of compression of at least 5 cm but not more than 6 cm;
• Allow full return of the chest between compressions; and
• Minimize interruption frequency and duration.

The first responder places the hypothenar region of one hand on the center of the chest on the lower third of the sternum and the thenar region of the other hand on the first hand. The first responder's own chest should be directly above his/her hands to allow the first responder to use his/her body weight to compress the patient's chest.[6] An inadequate chest compression rate reduces the probability of ROSC and intact neurologic outcome after sudden cardiac arrest. The ILCOR Guidelines recommend a rate of at least 100 but not more than 120 compressions per minute. Audiovisual tools that provide immediate feedback can help rescue teams maintain adequate rates.[7]

Observational clinical studies suggest that the delivery of chest compressions of adequate depth (at least 5 cm) plays an important role in successful resuscitation. In addition, the full return of the chest reduces intrathoracic pressure, resulting in increased cardiac preload and increased coronary perfusion pressures.[8]

The ILCOR Guidelines suggest that the first responder performing chest compressions should be replaced every 2 minutes whenever possible. Chest compression interruptions are reduced by changing the first responder every 2 minutes when rhythm can be assessed and the patient is defibrillated if necessary. However, if the first responder is unable to perform adequate compressions, it is necessary to immediately replace him/her with a trained first responder.[7,8]

Minimizing interruptions

Chest compression interruptions during CPR, however brief, result in unacceptable decreases in coronary and cerebral perfusion pressure and poorer results. Two minutes of continuous CPR must be performed after any interruption.[6]

First responders should ensure the delivery of excellent chest compressions with minimal interruptions. Pulse checks and rhythm analysis without compression should only be performed at pre-programmed intervals (every 2 minutes). Such interruptions should not exceed 10 seconds except for specific interventions such as defibrillation. Chest compression fraction should be at least 60% and ideally close to 80%.

First responders should continue excellent chest compressions while they prepare for defibrillation, load the defibrillator until just before the shock is given, and resume compressions immediately after the shock. It should not take more than 3–5 seconds between the interruption and the shock. If a single lay responder is providing CPR, excellent chest compressions should be performed continuously without ventilation.[6-8]

Hands-only CPR

When multiple trained professionals are present, the ILCOR and AHA recommend the simultaneous performance of excellent continuous chest compressions and adequate ventilation using a 30:2 compression-to-ventilation ratio to manage CRA.[7] However, if a single lay responder is present or several lay responders are reluctant to perform mouth-to-mouth ventilation, the ILCOR Guidelines recommend HO-CPR using excellent chest compressions, and results from several randomized trials support this approach. The guidelines also state that lay first responders should not interrupt chest compressions to check pulses or ROSC. They should continue CPR until an AED is ready to defibrillate, the emergency medical service team takes over the case, or the patient awakens. This measure is not recommended for children or in cases of non-cardiac arrest (e.g., drowning, trauma, and exogenous poisoning).[8]

The need to perform mouth-to-mouth breathing is a significant barrier to CPR performance. This reluctance may be due to anxiety related to performing the CPR correctly or fear of contracting a contagious disease despite insufficient reports of infection transmission by mouth-to-mouth ventilation, none of which involve human immunodeficiency virus.[8] HO-CPR avoids these problems, potentially increasing witness willingness to perform CPR.

There is little evidence directly comparing HO-CPR with conventional CPR (using a 30:2 compression-to-ventilation ratio); the available data are limited to those from a large observational study that suggests improved survival when conventional CPR is performed. However, HO-CPR can be used when there is no possibility of conventional 30:2 CPR.[8]

VENTILATION

During the early phase of CRA, when pulmonary alveoli probably contain adequate oxygen levels and pulmonary vessels and the heart probably contain enough oxygenated blood to meet markedly reduced demands, the importance of compressions outweighs that of ventilation. Consequently, the start of excellent chest compressions is the first step to improve oxygen supply to tissues (algorithm 1). This is the rationale behind the compression, airway, and breathing (CAB) approach for CRA advocated in the ILCOR/AHA Guidelines.[7]

However, when cardiac arrest is associated with hypoxia, oxygen stores have probably already been reduced, requiring excellent standard CPR with ventilation.[7]

Properly performed ventilation becomes increasingly important when the pulse continues to be absent. In this metabolic phase of resuscitation, clinicians should ensure that ventilation does not interfere with the cadence and continuity of chest compressions.

Proper adult ventilation should:

- Give 2 ventilations every 30 compressions for patients without an advanced airway;
- Give each ventilation > 1 second;
- Give sufficient tidal volume to see chest expansion (approximately 500–600 mL or 6–7 mL/kg);
- Avoid hyperventilation; and
- Deliver asynchronous ventilation every 10 seconds (6–8 breaths per minute) to patients with an advanced airway (e.g., supraglottic device, endotracheal tube).

The term "asynchronous" implies that ventilations need not be coordinated with chest compressions. Ventilation should be administered in the shortest time possible, not exceeding 1 second per breath to avoid excessive ventilatory force, and provide sufficient tidal volume to confirm the initial chest expansion. This approach immediately resumes compression and improves cerebral and coronary perfusion.

Excessive ventilation, either via high ventilatory rates or increased volumes, should be avoided. Positive-pressure ventilation increases intrathoracic pressure, which decreases venous return, pulmonary perfusion, cardiac output, and cerebral and coronary perfusion pressures.[8]

Despite the risk of compromised perfusion, first responders routinely excessively ventilate patients. A prehospital resuscitation study reported that mean ventilation rates during CPR were 30 per minute, while an in-hospital CPR study revealed ventilation rates exceeding 20 per minute. This rate and the volume of ventilations should be continuously reevaluated and corrections should be made during resuscitation. Resuscitation teams often believe that ventilation is being effectively performed when they are actually not (usually due to the use of bag-mask ventilation), resulting in inadequate cerebral perfusion and reducing the chance of achieving neurologically intact patient survival.[8]

DEFIBRILLATION

The efficacy of early defibrillation in VF patients and short "arrest times" is well supported by the resuscitation literature. Early defibrillation is a key recommendation of the ILCOR/AHA BLS Guidelines.[8] Once a defibrillator is available, professionals should assess heart rate and, when recommended, defibrillate the patient as soon as possible. Except in cases of excellent CPR, no intervention (e.g., intubation, intravenous catheter placement, drug administration) should be performed before the assessment of rhythm and defibrillation. BLS Guidelines state that a single AED shock should be immediately followed by the resumption of excellent chest compressions. For advanced cardiac life support (ACLS), a single shock is recommended regardless of the use of a bi- or monophasic defibrillator.[9]

Biphasic defibrillators are favored because of the low energy levels required for an effective shock. Biphasic defibrillators measure the impedance between the electrodes placed on the patient and adjust the supplied energy accordingly. Successful first shock rates are reportedly approximately 85%.[9]

The use of power levels recommended by the device manufacturer is indicated. We recommend that all adult cardiac arrest patient defibrillations use the highest available energy (usually 360 J for a monophasic defibrillator and 200 J for a biphasic defibrillator). This approach decreases CPR interruptions and is implicitly supported by a study in which out-of-hospital cardiac arrest patients randomly assigned to staged energy therapy using a biphasic device had higher VF conversion and termination rates than those assigned to lower energy treatment.[9]

Possible benefits of delaying defibrillation to perform excellent chest compressions for a predetermined period remain controversial (e.g., 60–120 seconds).

Pulse check and rhythm analysis

It is essential to minimize delays and interruptions during the delivery of excellent chest compressions. Therefore, the heart rate analysis should only be performed during planned interruptions at 2-minute intervals after a full CPR cycle. Even short CPR delays or interruptions can compromise cerebral and coronary perfusion pressure and decrease survival rates. After any interruption, sustained chest compressions are required to recover pre-interruption blood flow rates.

There is great variation in the ability of lay first responders and health care providers to determine the absence of pulse accurately and efficiently.[9] Therefore, the BLS Guidelines recommend that inexperienced first responders start CPR immediately after determining that the patient is unresponsive and has abnormal breathing without stopping to check the pulse. Health care providers should spend no more than 10 seconds checking for a pulse and CPR should be immediately started if they do not feel a pulse.

After any defibrillation attempt, CPR should be resumed for 2 minutes without a pulse check regardless of the resulting rhythm. The data suggest that the heart does not immediately generate an effective output after defibrillation and that CPR can improve post-defibrillation perfusion.[7-9]

Factors affecting defibrillation success

A variety of device- and patient-related factors influence the chances of successful defibrillation. Device-related variables include factors related to electrodes (i.e., position, size) and supplied energy (i.e., number of joules, waveform type), while patient-related variables include the transthoracic impedance through which energy travels as well as arrhythmia type and duration.[8]

Patients with an underlying cardiac implantable electronic device

Patients with an underlying cardiac implantable electronic device, such as a permanent pacemaker or an implantable cardioverter-defibrillator, require special attention when electrodes are placed. In these patients, the external electrodes should be placed in the anteroposterior position to avoid contact with the skin over the device. This electrode positioning is crucial to maximizing the effectiveness of the externally given shock and minimizing the probability of damaging the device with the external shock.

Energy selection for defibrillation

The amount of energy selected for the first defibrillation attempts is controversial. The energy should be sufficient to perform an immediate defibrillation because repeated failure exposes the heart to damage due to prolonged ischemia and multiple shocks. However, excessive energy should be avoided as myocardial damage from high-energy shocks has been demonstrated in experimental studies, although the frequency of its occurrence in humans is unknown.

Device-related variables

Electrodes

Several electrode characteristics, including electrode position, size, and type, can affect the cardioversion result.[9]

Electrode position - The placement of defibrillation electrodes on the chest determines the path of the transthoracic current for external defibrillation. There are two conventional electrode positions (Figure 2):

- Anterolateral orientation; and
- Anteroposterior orientation.

Electrode size - Electrode size is an important determinant of transthoracic current flow during external impact.[9] A larger paddle surface is associated with decreased resistance and increased current and may be less likely to cause myocardial necrosis. However, there seems to be an optimum electrode size (approximately 12.8 cm) above which any increase in electrode area decreases current density.[10]

Mono- versus biphasic waveforms - Defibrillators can provide power in a variety of waveforms that are broadly characterized as mono- or biphasic. Defibrillators developed before 2000 provide a monophasic wave of direct current. Since then, biphasic devices that reverse current polarity from 5 to 10 milliseconds after the start of the discharge have been developed. Biphasic waveforms defibrillate more effectively and at lower energy compared with monophasic waveforms. However, monophasic defibrillation is still highly effective in most situations, and it is not clear whether the superior efficacy of biphasic defibrillation results in important clinical advantages.[10]

Ventricular fibrillation

Several randomized trials compared mono- and biphasic waveforms in VF treatment. In the Optimized Response to Cardiac Arrest trial, 115 patients with out-of-hospital cardiac arrest due to VF were randomly assigned to defibrillation using one 150-J biphasic shock or traditional high-energy (200–360 J) monophasic shocks. Successful defibrillation was significantly more likely to occur in cases of biphasic waveforms compared to monophasic waveforms after one shock and total treatment by the emergency medical services team (96% versus 59% and 100% versus 84%, respectively). In addition, the ROSC rate was greater with biphasic shock therapy (76% versus 54%, respectively). However, there was no difference in the survival to discharge rate between the two therapies. Among the patients who survived to discharge, those treated with one biphasic shock were more likely to have a better cerebral outcome (87% versus 53%, respectively).

In the Transthoracic Incremental Monophasic versus Biphasic defibrillation by Emergency Responders trial, 168 patients with out-of-hospital cardiac arrest due to VF were randomly assigned to treatment with mono- or biphasic defibrillation. The emergency medical service team initially performed defibrillation with an AED and, if necessary, paramedics who arrived later used a manual defibrillator. Patients were included only if all shocks had the same waveform. There were no statistically significant differences between treatment arms in relation to initial shock success, survival rate, or neurological results. However, biphasic defibrillation resulted in non-significant trends toward early ROSC and increased overall survival rates (41% versus 34% compared with monophasic defibrillation).[10,11]

Based on the increased efficacy of biphasic defibrillation demonstrated in other scenarios, in the absence of evident damage caused by biphasic defibrillation and on the resulting benefit trends suggested by clinical trials, biphasic defibrillation is recommended for the treatment of ventricular arrhythmias.

Patient-related variables

Transthoracic impedance

To compensate for transthoracic impedance during transthoracic defibrillation, a considerably greater current should be delivered to the chest than the one required for internal defibrillation. Impedance results in the dissipation of energy to the lungs, rib cage, and other thoracic elements.

Transthoracic impedance is determined by multiple factors, including the following:

- Energy level;
- Electrode–skin interface;
- Interelectrode distance;
- Electrode pressure (with hand electrodes);
- Ventilation phase; and
- Myocardial tissue and blood conduction properties.

An important characteristic is the effect of a previous sternotomy on transthoracic impedance. Transthoracic impedance decreased after sternotomy and remained below preoperative levels even after complete healing, suggesting that hyperemia, inflammation, tissue edema, and pleural effusion associated with sternotomy were the main contributors to the reduced impedance.[10] The ventilation phase is another

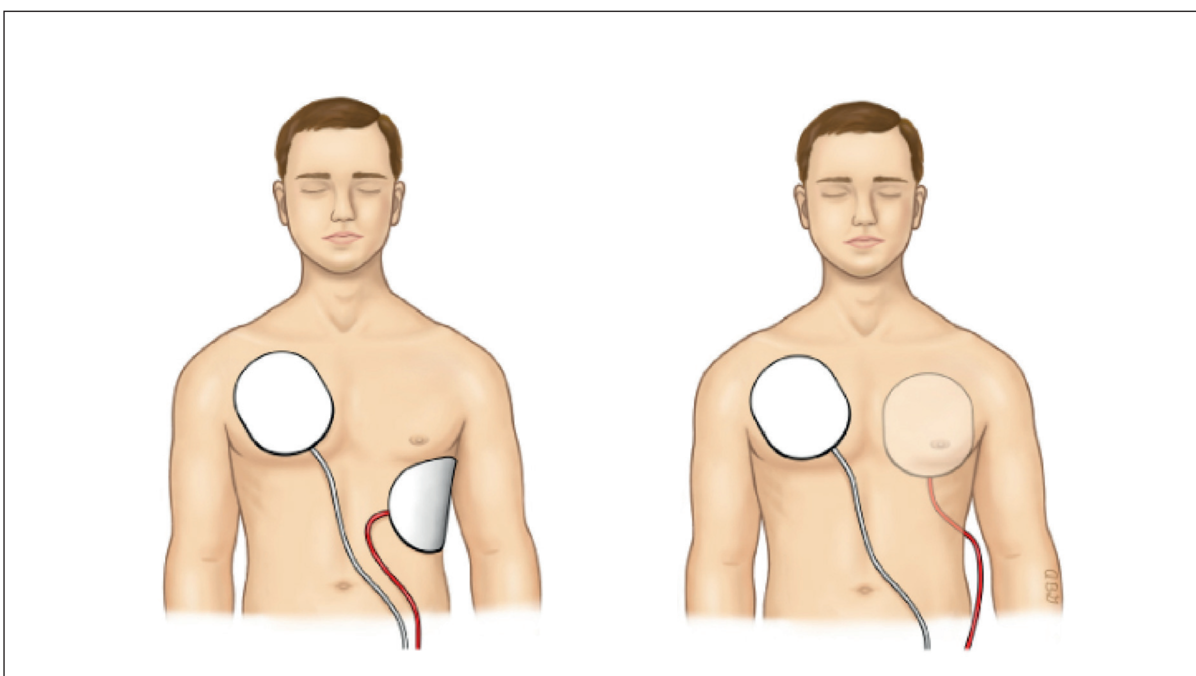

Figure 2. Pacemaker/defibrillator electrode positioning showing anterior/lateral (left) and anterior/posterior (right) positions. Source: UpToDate 2018.

factor that changes transthoracic impedance. Inspiration (and the increased air volume inside the lungs) is associated with a transthoracic impedance that is 13% higher than that of expiration. The composition of the gel used during the shock also affects the transthoracic impedance. In a study comparing gel without salt to that with salt, transthoracic impedance was 20% higher with the gel without salt.[10]

Arrhythmia type

Different energetic requirements between organized and disorganized arrhythmias may be related to electrophysiological characteristics of arrhythmia. Organized arrhythmias, such as sustained monomorphic VT, arise from a discrete reentry circuit that is easily depolarized by smaller amounts of current. In contrast, in disorganized rhythms, such as polymorphic VT and VF, wave fronts are multiple and involve more myocardial mass, requiring more energy.[10]

Duration of arrhythmia

Arrhythmia duration is an additional factor related to the probability of successful defibrillation. Arrhythmia duration determines the degree of electrical impulse organization in VF. Even when a biphasic waveform is used, defibrillation efficacy is reduced in cases of longer arrhythmia. The more recent the VF, the coarser the fibrillatory waves and the greater the defibrillation success. As arrhythmia persists (i.e., >10–30 seconds), fibrillatory waves become finer and the probability of success decreases.[10]

THE PATIENT DID NOT ACHIEVE ROSC AFTER BLS: WHAT IS THE NEXT PROCEDURE?

ACLS is the best care procedure to use when the patient's condition is refractory to BLS measures. ACLS-related skills include chest compressions and defibrillation associated with more advanced or complex devices and techniques such as invasive airway procedures, venous access, drug handling, or the use of new tools (e.g., mechanical compression with artificial compressors or resuscitation with extracorporeal circulation). ACLS can be initiated in an in- or out-of-hospital environment and is the continuation of BLS.[7,11,12]

BLS, ACLS, and post-ROSC care (post-CRA care) represent a systematically applied set of measures for the treatment of CRA patients, which sometimes overlap as the service care advances to the next level.[6,13]

Antiarrhythmic drugs may increase or decrease the energy required for VF defibrillation. Sodium channel blockers generally increase the amount of energy needed for defibrillation, while potassium channel blockers and catecholamines decrease the amount of energy needed. For example, lidocaine increases the energy required for defibrillation, while sotalol and ibutilide decrease the energy required. The effect of epinephrine on cycle length, synchronization, and the dispersion of repolarization of fibrillatory waves may be the mechanism that facilitates defibrillation.[11,14] These observations are relevant to the success of external defibrillation in the context of a CRA.

Algorithm 2 shows the care sequence and overlap among basic and advanced life support measures (Figure 3).

CONCLUSIONS

According to the literature, an average loss of 7–10% in the probability of survival is observed with a delay of one minute in CRA cases. This means that after 12 minutes, the survival rate averages approximately 2.5%. There is no doubt that identifying the CRA and starting BLS are fundamental for better patient outcomes.

Each BLS phase follows a sequence of procedures that may decrease the victim's recovery chances if not performed properly. The change from the airway, breathing, and chest compressions approach to the CAB approach was very important since there was a significant gain in patient recovery time when chest compressions were started earlier and the ventilation delay was minimized.

Constant updates on this theme are of utmost importance to ensuring that CRP management becomes increasingly systematized and consolidated. The guideline recommendations discussed here facilitate the CRA approach, resulting in a better quality of care.

CONFLICTS OF INTEREST

The author declares that he has no conflicts of interest in this work.

AUTHORS' CONTRIBUTIONS: HPG, GB, and AP contributed substantially to the study concept and design as well as the acquisition, analysis, or interpretation of the data used; wrote or critically reviewed its intellectual content; approved the final version of the manuscript to be published; and agree to be accountable for all aspects of this study to ensure that any doubts related to the integrity or accuracy of any of its parts will be properly investigated and resolved.

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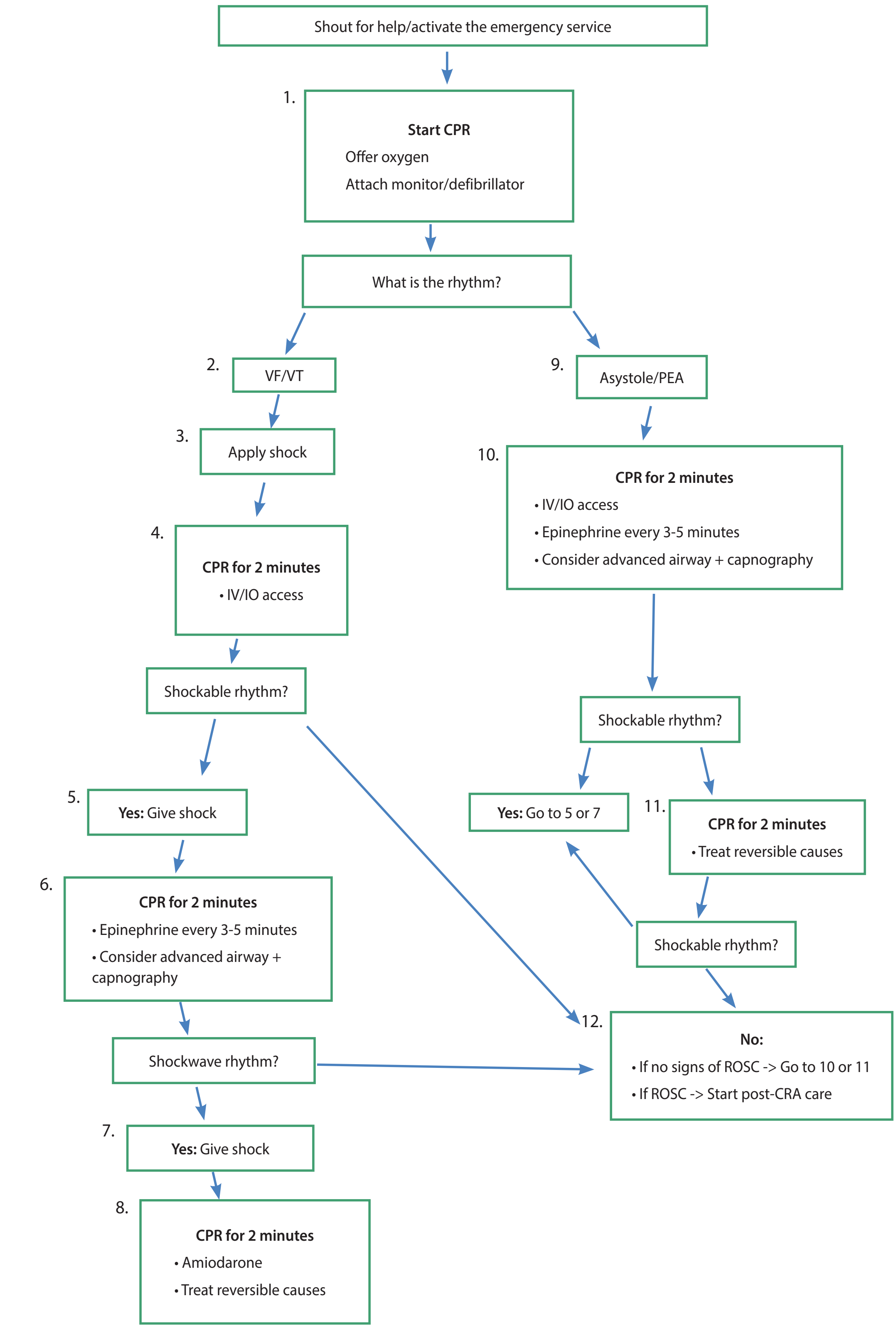

CPR, cardiopulmonary resuscitation; VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation

Figure 3. Algorithm 2: General management.[11]

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