I Guideline for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care – Brazilian Society of Cardiology: Executive Summary

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Abstract

Despite advances related to the prevention and treatment in the past few years, many lives are lost to cardiac arrest and cardiovascular events in general in Brazil every year. Basic Life Support involves cardiovascular emergency treatment mainly in the pre-hospital environment, with emphasis on the early recognition and delivery of cardiopulmonary resuscitation maneuvers focused on high-quality thoracic compressions and rapid defibrillation by means of the implementation of public access-to-defibrillation programs**.** These aspects are of the utmost importance and may make the difference on the patient's outcomes, such as on hospital survival with no permanent neurological damage. Early initiation of the Advanced Cardiology Life Support also plays an essential role by keeping the quality of thoracic compressions; adequate airway management; specific treatment for the different arrest rhythms; defibrillation; and assessment and treatment of the possible causes during all the assistance. More recently, emphasis has been given to post-resuscitation care, with the purpose of reducing mortality by means of early recognition and treatment of the post-cardiac arrest syndrome. Therapeutic hypothermia has provided significant improvement of neurological damage and should be performed in comatose individuals post-cardiac arrest. For physicians working in the emergency department or intensive care unit, it is extremely important to improve the treatment given to these patients by means of specific training, thus giving them the chance of higher success and of better survival rates.

Introduction

Based on the 2010 International Scientific Consensus and updated with some new scientific evidence gathered in the past two years, the I Guideline for Cardiopulmonary Resuscitation and Cardiovascular Care of the Brazilian Society of Cardiology is launched with the aim of meeting the Brazilian scenario realities.

Keywords

Cardiopulmonary Resuscitation / chest compression; Heart Arrest; Hypothermia.

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Epidemiological aspects

Despite advances related to the prevention and treatment in recent years, many lives are still lost to cardiopulmonary arrest (CPA) in Brazil every year, although the exact magnitude of the problem is unknown due to the lack of robust statistics. The advances have also reached the legislation regarding the public access to defibrillation and mandatory availability of automatic external defibrillators (AED), as well the training in cardiopulmonary resuscitation (CPR), an area in which the Brazilian Society of Cardiology has for many years been placed among the best. We can estimate approximately 200,000 CPRs in Brazil each year, with half of them being in-hospital and the other half, out-of-hospital cases.

Advice to health professionals in adult basic life support

Immediate delivery of CPR to a CPA victim, albeit using only pre-hospital thoracic compressions, significantly contributes to increase the survival rates[1-6]. Therefore, actions taken within the first minutes of an emergency care are critical in relation to the victim's survival, and this includes the Basic Life Support (BLS).

In a CPA situation, a mnemonic may be used to describe the simplified steps in BLS care: the "primary CABD"[7,8]: check responsiveness and patient's breathing; call for help; check victim's pulse; compressions (30 compressions); open the airway; good ventilation (2 ventilations); defibrillation.

Before any out-of-hospital treatment, safety of the site should be checked. If the place is safe, gently shake the victim's shoulder when addressing him/her. Look for chest movement within less than 10 seconds; if absent, or if the victim is only gasping, call for help immediately by dialing the local emergency telephone number. Verify the victim's pulse within less than 10 seconds. If pulse is present, apply ventilation every 5 or 6 seconds and check pulse every 2 minutes; if not, or in case of doubt, start compression and ventilation cycles. Start 30-compression and 2-ventilation cycles, considering that there is a barrier device (for example, pocket masks to apply rescue breaths).

To perform thoracic compressions: position yourself by the side of the victim – who should be bare-chested - place the heel of one hand on the victim's sternum, and the heel of your other hand on top of the first hand. Interlock the fingers of your hands, keep your arms straight and position yourself at approximately 90° above the victim. Apply compressions at a rate of at least 100 compressions/minute, to a depth of at least 5 cm, allowing complete chest recoil after each compression without losing contact of the hands with the chest. Minimize interruptions in compressions, and rotate the task with another rescuer every two minutes to prevent fatigue and poor-quality compressions.

In order not to delay the initiation of thoracic compressions, the airway should be opened only after thirty compressions are delivered. Ventilations should be performed at a ratio of 30 compressions to 2 ventilations, one second-long each, with enough volume to make the victim's chest rise. Regardless of the technique used to apply ventilations, the airways have to be opened. This can be achieved by head tilt and chin lift or, if trauma is suspected, by jaw thrust. Bag-valve-mask ventilation should be performed when two rescuers are present, one in charge of the compressions and the other, of applying ventilation using the device.

A victim who is not breathing or is not breathing normally (only gasping), but has a palpable pulse, is therefore in respiratory arrest. In these cases, apply one ventilation every 5 or 6 seconds for adult victims. For infants and toddlers, apply one ventilation every 3 to 5 seconds.

Early defibrillation is the specific treatment for cardiopulmonary arrest in VF/pulseless ventricular tachycardia; it may be performed using manual equipment (only handled by a doctor) or an AED, which may be used by any person as soon as possible. This device may be handled by laypeople; all that is necessary is to switch it on and follow directions given by the device.

Table 1 includes the main directions regarding compressions, ventilations, and the use of AED.

Advanced adult cardiac life support

A large part of adults victim of in-hospital cardiac arrest present with pulseless electrical activity (37%) and asystole (39%) as the baseline CPA rhythm[9]. Ventricular fibrillation and pulseless ventricular tachycardia (VF/PVT) account for 23% to 24% of the in-hospital CPA events, and have the highest survival rates, of 36% to 37%. The overall survival is of 18%, considering all CPA rhythms[9,10].

Airway management

The choice of the best ventilation method should be made based on the rescuer's experience. The use of the bag-valve-mask device alone or in combination with the tracheal tube, laryngeal mask, combitube or laryngeal tube is acceptable. Use of oxygen at 100% is reasonable during CPR maneuvers with the objective of increasing the arterial oxyhemoglobin and oxygen supply. Although prolonged exposure to oxygen at 100% is toxic, there are no evidences that toxicity occurs with short-term exposure, as in the setting of adult CPA.

Ventilation with a bag-valve-mask device is an acceptable method during CPR maneuvers, but requires continuous

Table 1 – Directions for thoracic compressions, ventilations and use of automatic external defibrillators in adults

Recommendation class	Indication	Level of evidence
Class I	Deliver effective thoracic compressions in all patients in cardiac arrest	B
Class IIa	Deliver compressions at a frequency of at least 100 compressions/minute	B
Class IIa	Delivercompressions to a depth of at least 5 cm	B
Class IIa	Allow complete chest recoil after each compression	B
Class IIa	Minimize interruptions of compressions	B
Class IIa	Rotate CPR every 2 minutes to prevent fatigue or deliver poor-quality compressions	B
Class IIa	Deliver rescue breaths with enough volume to make the victim`s chest rise	C
Class III	Avoid hyperventilation, because it increases the risk of gastric inflation, thus causing regurgitation and aspiration	B
Class Iib	Open airway by head tilt/chin lift or jaw thrust	C
Class III	Do not interrupt compressions to apply ventilation in sited advanced airway	B
Class I	Defibrillation is the treatment of choice for in ventricular fibrillation/pulseless ventricular tachycardia	A
Class IIa	The positions of the four paddles (anterolateral, anteroposterior, right-anterior infrascapular, left-anterior infrascapular) are equivalent as regards the efficacy of the shock	B
Class IIa	Purpose-made pediatric pads or software to attenuate the output, if available, are recommended for children aged 1- 8 years	C
Class IIb	For children < 1 year of age, a manual defibrillator is preferable; if not available, an AED with attenuated shock may be used; if none of these options are available, an unmodified adult AED may be used	C
Class I	Public access defibrillation programs are recommended in places where a cardiac arrest is very likely to occur (airports, academys, clubs)	B

training for its adequate use. Ideally, this device should be used by two rescuers. During CPR, 2 ventilations should be delivered after every 30 thoracic compressions.

In the case of in-hospital CPA refratory VF/VT, and, mainly, PEA/asystole, ventilation with tracheal tube is the most frequently recommended method for airway management. Interruption of thoracic compressions to perform tracheal intubation should be minimized, and intubation should be performed only at the right time, when it does not interfere with other resuscitation maneuvers. Training and retraining of this skill are recommended for rescuers who perform this procedure. There is no evidence in the literature about the best moment to perform tracheal intubation during cardiopulmonary arrest maneuvers.

Confirmation of correct placement of the tracheal tube is necessary. This is initially done by clinical assessment which consists of the observation of chest expansion, condensation in the tube during ventilation, and auscultation of 5 areas: the epigastrium, left and right pulmonary bases, left and right pulmonary apices, preferably in this order. Secondary confirmation of tracheal tube placement should be made with the help of a device; the most frequently recommended of these is quantitative capnography. If not available, esophageal detectors and carbon dioxide detectors could also be used[11-14]. Ventilation and oxygenation should be maintained at intervals of one ventilation every 6 to 8 second; this corresponds to 8 to 10 ventilations per minute, asynchronously with thoracic compressions, which should be maintained at a frequency equal to or higher than one hundred per minute[15,16].

Monitoring during CPA

End-tidal carbon dioxide (expressed in mmHg - $PETCO_2$) detected by quantitative capnography in intubated patients correlates with the quality of CPR and with restoration of spontaneous circulation (ROSC). During untreated CPA, the CO_2 production is maintained; however it is not released by the lungs, and the presence of cardiac output is the most important determinant of $PETCO_2$ release. $PETCO_2$ values correlate with ROSC and with the coronary perfusion pressure. Values < 10 mmHg show a low probability of ROSC, thus indicating the need for improvement in the quality of CPR[17-20].

Another very useful mechanism for CPR monitoring is the diastolic blood pressure (DBP) measurement in patients with invasive arterial monitoring at the moment of CPA. Its value correlates with the coronary perfusion pressure as well as with ROSC. In situations in which the relaxation (diastolic) pressure is < 20 mmHg, it is reasonable to consider improving the quality of CPR by means of better thoracic compressions and the use of vasoactive drugs. It is worth mentioning that the presence of arterial devices may also reduce the time of CPR interruption with pulse checking in patients with organized electrical activity.

Central venous saturation < 30% is related to the impossibility to achieve ROSC. Thus, it is necessary to maintain values above 30% during CPA.

Table 2 shows the main recommendations for airway management and monitoring during CPA.

Cardiac arrest management

Cardiac arrest may be caused by four rhythms: ventricular fibrillation (VF), pulseless ventricular tachycardia (PVT), pulseless electrical activity (PEA), and asystole. Patients' survival depends on the integration of BLS, advanced cardiovascular life support (ACLS), and post-resuscitation care.

Pauses during CPR maneuvers should be minimized and restricted to rhythm checking, defibrillation, pulse checking when an organized rhythm is present, and a brief pause to obtain and confirm an advanced airway[21,22]. CPR quality monitoring is strongly recommended. Delay to start the administration of vasopressors beyond the first five minutes of CPA, as well as delay in establishing an advanced airway may be associated with a worse prognosis. Thus, it is suggested that vasopressors be started in the first few cycles of CPR[23-25].

During attempted resuscitation, the rescuer should try to identify the cause of CPA – differential diagnosis. Most of the arrest causes can be summarized in the mnemonics "5 Hs and 5 Ts", namely: Hypoxia, Hypovolemia, Hydrogen (acidosis), Hyper/Hypocalemia, Hypothermia; Toxics, cardiac Tamponade, thoracic Tension (hypertensive pneumothorax), coronary Thrombosis (acute myocardial infarction), and pulmonary Thromboembolism[26-28].

For an ideal management of CPA, in addition to the emphasis on high-quality CPR, special attention should be

Table 2 – Directions for ventilation with advanced airway and monitoring during cardiopulmonary arrest

Recommendation class	Indication	Level of evidence
Class IIa	Tracheal intubation in in-hospital cardiopulmonary arrest due to ventricular fibrillation / refractory pulseless ventricular tachycardia or pulseless electrical activity/asystole	C
Class I	Quantitative capnography to check correct tracheal tube placement	A
Class IIa	Esophageal detectors to check correct tracheal tube placement in the absence of quantitative capnography	B
Class IIa	Exhaled carbon dioxide monitoring (> 10 mmHg) as an indicator of the quality of resuscitation	B
Class IIa	Tracheal intubation in in-hospital cardiopulmonary arrest due to ventricular fibrillation/refractory pulseless ventricular tachycardia or pulseless electrical activity / asystole	C

given to each member of the resuscitation team. Training CPA team management minimizes errors and is recommended[29]. The two fundamental principles for good team work are leadership and effective communication[30,31]. Thus, there should be a professional playing the role of the leader in the management of every case attended. This professional should: ensure that all tasks have been understood and performed by the different team members; incorporate new information; reassess the case; centralize communication among the team members; assess their colleagues' performance, thus ensuring high-quality CPR, adequate airway management, and confidence to manipulate the defibrillator.

Treatment of ventricular fibrillation and pulseless ventricular tachycardia

When monitoring with a manual defibrillator reveals VF/PVT rhythm, the priority should be defibrillation as soon as possible, as soon as available, since the duration of arrhythmia is a prognostic factor for a successful defibrillation, with the highest success rate achieved when defibrillation is performed with a manual or automated defibrillator within up to 3 minutes of the onset of VF. During resuscitation, the use of vasoactive and antiarrhythmic drugs as well as the identification and treatment of potentially reversible causes should be considered[26-28].

If a biphasic defibrillator is available, the shock energy level should be of 120-200J, according to the manufacturer's recommendations. If the rescuer is not aware of the manufacturer's recommendations, shock should be delivered using the highest energy level available in the device. If a monophasic defibrillator is available, shock should be delivered with 360J, same for subsequent shocks[26].

After the first shock, preferably with a biphasic defibrillator, CPR is resumed for 2 minutes, followed by rhythm checking on the monitor. If VF/VT persists, a new high-energy level shock is delivered, followed by CPR for 2 minutes. The best moment to administrate a vasopressor has not been determined, and its use should be considered after an intravenous access is established. Early administration could optimize the myocardial blood flow prior to the next shock. There are evidences suggesting that the early initiation of drugs improves the prognosis[21,24,25].

In any CPA rhythm, the first drug to be used should be a vasopressor. Although the level of evidence is limited, administration of adrenalin 1 mg every three or five minutes is recommended[32].

The first or second dose of adrenalin may be replaced by vasopressin 40 U. If VF or PVT persists despite CPR, defibrillation and vasopressor, an antiarrhythmic drug is indicated (amiodarone – the antiarrhythmic drug of choice, or lidocaine). Amiodarone, a Vaughan-Williams class III antiarrhythmic drug, is the first choice antiarrhythmic drug in the treatment of VF/PVT refractory to vasopressor and new defibrillation.

Recommendations for the management of CPA in VF/PVT are shown in Table 3.

Figure 1 shows the Treatment of cardiac arrest in ventricular fibrillation/pulseless ventricular tachycardia algorithm.

Treatment of asystole and pulseless electrical activity (PEA)

Defibrillation is not indicated for these rhythms. Therefore, their management consists of delivery of high-quality CPR, administration of the drugs recommended, and identification and treatment of reversible causes[27].

If, when checking the rhythm two minutes after continuous CPR, an organized rhythm is observed on the monitor, the central carotid pulse should be checked for five to 10 seconds. No palpable pulse identified within this period characterizes PEA.

For asystole or PEA, a vasopressor –adrenalin or vasopressin, may be administered with the objective of increasing cerebral and myocardial blood flow[33]. Routine use of atropin is not recommended.

Vasopressin may be used instead of the first or second adrenalin dose, but a meta-analysis did not show differences between these two drugs for any of the CPA rhythms.

There is no clear evidence of the therapeutic benefit of the routine use of atropin on the treatment of CPA with PEA.

PEA and asystole may be caused by reversible conditions which can be successfully treated, if detected. For the two minutes of CPR, rescuers should remember the "5Hs and 5Ts". In PEA, when pulmonary thromboembolism is suspected, empirical use of thrombolytic drugs should be considered.

Recommendations for the management of CPA with asystole and PEA are shown in Table 4.

Figure 2 shows the treatment of cardiac arrest in pulseless electrical activity or asystole algorithm.

Routes of drug administration

During cardiac arrest, the priority is always to deliver high-quality CPR and immediate defibrillation; drug administration is secondary. After attempted defibrillation, rescuers should establish an intravenous (IV) or intraosseous (IO) access, without interrupting the thoracic compressions.

Peripheral venous access in the upper limbs (antecubital vein) is preferred. If an IV access cannot be established, the intraosseous

Table 3 – Directions for medications for ventricular fibrillation/pulseless ventricular tachycardia

Recommendation class	Indication	Level of evidence
Class IIb	Vasopressor for CPA refractory to defibrillation and CPR	A
Class IIb	Amiodarone for CPA refractory to defibrillation, CPR, and vasopressor	A
Class IIb	Lidocaine as antiarrhythmic drug if amiodarone is unavailable	B
Class IIb	Magnesium sulphate for torsades de pointes associated with prolonged QT	B

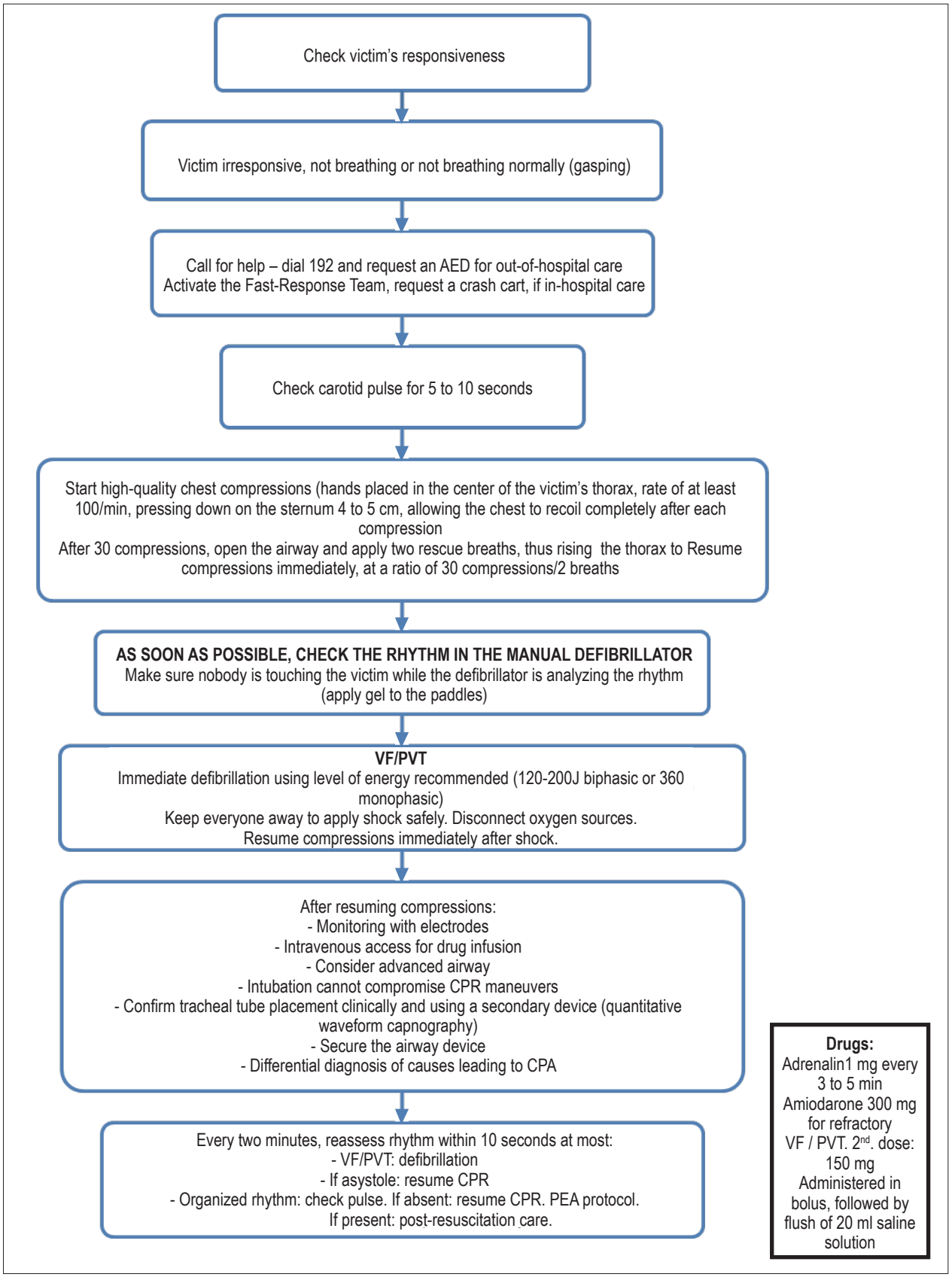

Figure 1 – *Treatment of cardiac arrest in ventricular fibrillation / pulseless ventricular tachycardia algorithm.*

(IO) route may provide adequate plasma drug concentrations similar to those obtained with the intravenous access. Drug administration via a central access may be considered if not contraindicated. Studies have demonstrated that drugs such as lidocaine, adrenalin, atropine, naloxone, and vasopressin may be absorbed via the endotracheal route. However, IV or IO drug administration is preferable to endotracheal administration.

Post-cardiopulmonary resuscitation care

In an initial phase, the purpose of organized post-CPR care with emphasis on multidisciplinary programs is to reduce mortality associated with hemodynamic instability and, consequently, to limit brain damage and other organ damage. Treatment should be targeted at making available a support that includes fluid resuscitation, the use of vasoactive drugs, mechanical ventilation, and circulatory assistance devices.

The term post-CPR syndrome refers to a complex pathophysiological process of tissue damage secondary to ischemia, with additional reperfusion injury[34]. In this syndrome, four main components are present and recognized: brain injury, myocardial dysfunction, reperfusion ischemia, and intervention on the triggering condition[35].

After ROSC, it is necessary to obtain an adequate permanent airway for mechanical ventilation support. At this moment, for instance, the laryngeal mask placed under emergency should be replaced by a tracheal tube.

Patient oxygenation should be monitored continuously with a pulse oximeter. When available, a capnograph may help establish a permanent airway in an appropriate place. If not contraindicated, the headboard should be kept elevated at at least 30° to prevent cerebral edema, aspiration and mechanical ventilation-associated pneumonia.

As regards the optimal oxygen supply, it is recommended that, as of the first hour, the fraction of inspired oxygen (FIO_2) be adjusted to an arterial saturation between 94% and 96%, thus preventing hyperoxia – which facilitates increased oxidative stress and is associated with a worse neurological outcome[36].

Care should be taken with the tidal volume to prevent barotrauma, volutrauma and biotrauma. A 12-lead electrocardiogram should be performed early after ROSC to detect ST-segment elevations or presumed new left bundle branch block. Even if ST-segment elevation is absent, but acute coronary syndrome is suspected, drug and intervention treatments should be initiated and should not be delayed if the patient is comatose. The simultaneous use of percutaneous coronary intervention and hypothermia is safe and provides good results.

The use of vasoactive drugs is indicated to adjust the cardiac output; these drugs should be administered preferably via a central venous access.

Because therapeutic hypothermia (TH) is the only intervention that proved to provide better neurological recovery, it should be considered for any patient unable to respond to verbal commands after ROSC[37-40].

Evidence show that comatose adult patients, i.e., those who do not respond adequately to verbal commands, and who present with ROSC after out-of-hospital CPA in VF/PVT, should be cooled down to 32° to 34° C for 12 to 24 hours.

Although consistent specific studies on hypothermia in subgroups of patients who had CPA in a non-shockable rhythm are not available, induced hypothermia may also benefit adult comatose patients with ROSC after out-of-hospital CPA with other rhythms such as asystole or pulseless electrical activity, or in in-hospital cardiac arrests.

The patient's core temperature should be monitored continuously by means of an esophageal thermometer, urinary bladder catheter or pulmonary artery catheter. Cooling down should be promptly started, preferably in the site of the event, or up to 6 hours after ROSC.

The maintenance phase starts when the temperature of 34° C is reached, and lasts 24 hours. Care is directed toward a strict temperature control to prevent overcooling (temperature $< 32°$ C).

The beginning of the rewarming phase does not imply immediate discontinuation of the cooling devices, since the temperature gain should be gradual. The optimal speed of rewarming is unknown; consensus has been that 0.25 to 0.5° C are gained very hour.

Follow-up for more than 72 hours is recommended for patients undergoing HT before a prognostic assessment. Strategies to treat high blood glucose levels should be considered, since levels > 180 mg/dL in patients with ROSC may be deleterious. Low blood glucose should be avoided. Thus, strategies for a moderate blood glucose control – blood glucose levels between 144 mg/dL and 180 mg/dL – may be started for adults with ROSC.

The complexity of post-CPA care has already been proven. Technological advances and early intervention have provided better survival rates; however, there are great challenges ahead. In this context, hypothermia is one of the topics that will certainly play a more important role in the treatment to be offered.

Table 4 – Directions for medications for asystole and pulseless electrical activity

Recommendation class	Indication	Level of evidence
Class IIb	Start vasopressor as soon as available	A
Class III	Administration of Atropine during Asystole or PEA	B

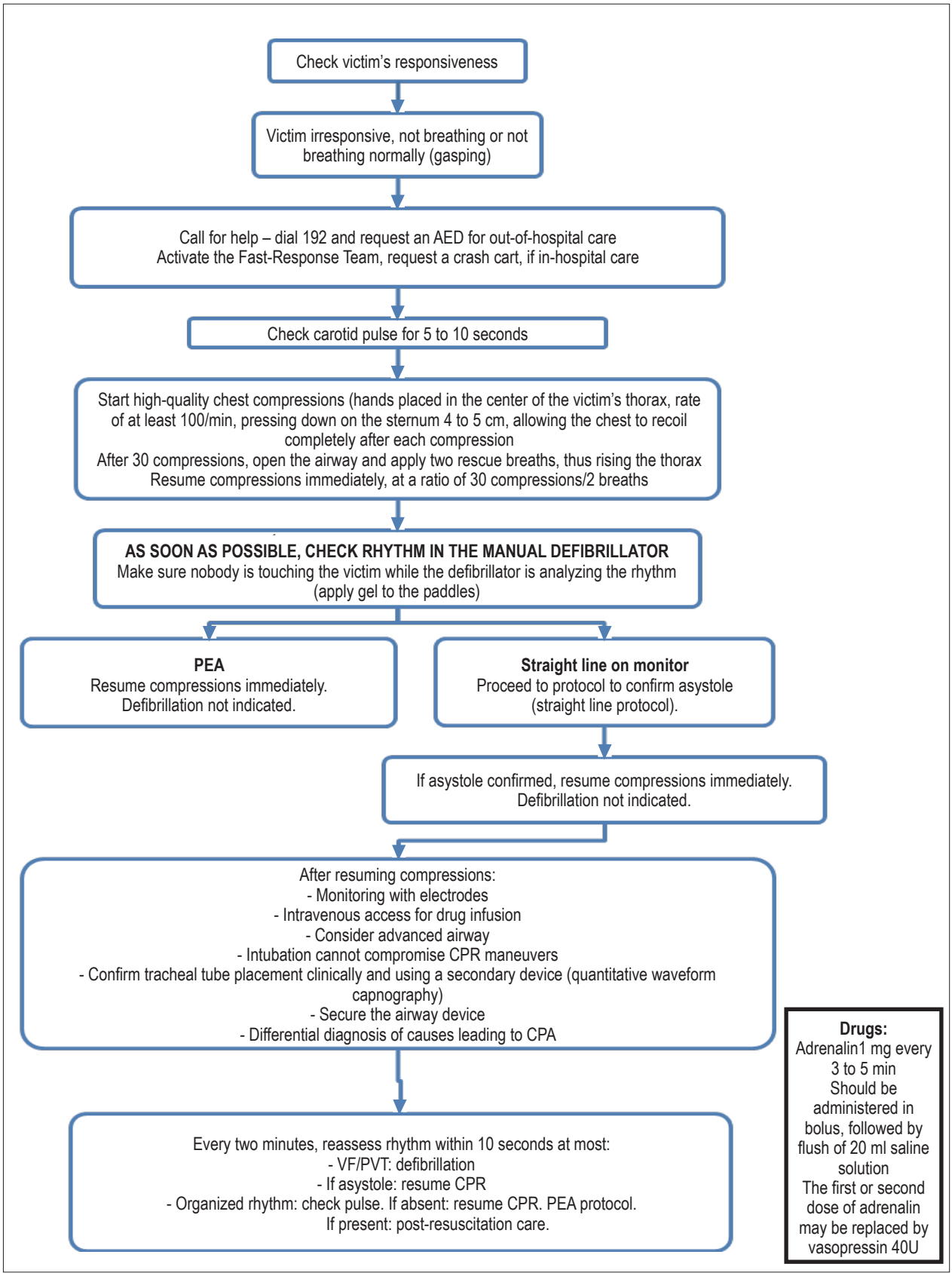

Figure 2 – *Treatment of cardiac arrest in pulseless electrical activity or asystole algorithm.*

Author contributions

Conception and design of the research: Gonzalez MM, Oliveira RG, Polastri TF, Araújo S; Acquisition of data: Polastri TF, Dallan LAP, Araújo S; Analysis and interpretation of the data: Schmidt A; Writing of the manuscript: Oliveira RG, Dallan LAP, Lage SG, Schmidt A, Bernoche CSM; Critical revision of the manuscript for intellectual content: Gonzalez MM, Timerman S, Oliveira RG, Lage SG, Bernoche CSM, Canesin MF, Mancuso FJN, Favarato, MH.

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