Chapter 3
Cardiopulmonary Resuscitation

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Key Points
- Early recognition and initiation of basic or advanced life support is associated with better outcomes.
- Key component of basic and advanced life support is to provide early and uninterrupted chest compressions.
- During cardiopulmonary resuscitation, any potential reversible causes should be identified and treated.

Introduction

- Cardiopulmonary resuscitation (CPR) is an emergency procedure performed in the event of a cardiac arrest.
- Cardiac arrest essentially means the sudden stopping of heartbeat. CPR involves providing chest compressions and ventilation to ensure some circulatory flow and oxygenation is maintained.
- Another important aspect of resuscitation is cardiac defibrillation where indicated.
- The most common cause of cardiac arrest is ischaemic heart disease (IHD) [1, 2]. This usually results in ventricular fibrillation (VF) or pulseless ventricular tachycardia (pulseless VT). These arrhythmias are associated with no cardiac output.
- The other rhythms that are associated with cardiac arrest are asystole and pulseless electrical activity (PEA).

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- Some of the patients in a cardiac arrest may or may not have a diagnosed cardiac disease.
- In addition to certain treatments and medications causing arrhythmias, it can also be caused by drowning, electrocution, trauma, electrolyte imbalances and respiratory failure.
- Irrespective of the cause, early initiation of CPR is vital as even a delay of 4–6 min leads to irreversible brain damage and death [4].

Chain of Survival

- The sequence of actions that would be essential to ensure a good outcome following a cardiac arrest can be represented as the chain of survival [3].

  Key links in this chain are:

  1. *Early recognition and call for help*
  2. *Early initiation of CPR*
  3. *Rapid defibrillation*
  4. *Post-resuscitation care*

Outcomes are poor when any of the above links are not in place or are not done effectively (Fig 3.1).

Indications for CPR

- CPR should be commenced immediately on any person who has suddenly become unconscious and has no palpable pulse.
- Absence of spontaneous circulation (no cardiac contractility) is due to one of the following non-perfusing arrhythmias:

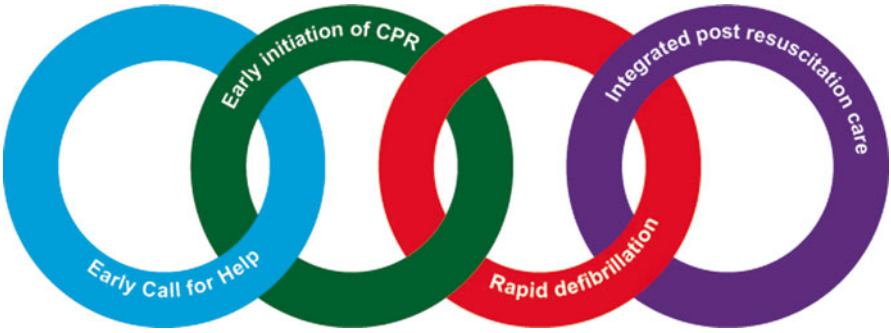

Fig. 3.1 Chain of survival

- Ventricular fibrillation (VF)
- Pulseless ventricular tachycardia (pulseless VT)
- Pulseless electrical activity (PEA)
- Asystole

Contraindications for CPR

- Except when there is 'do not attempt resuscitation' (DNAR) order in place, CPR is indicated in all other situations of cardiorespiratory arrest [5].
- It becomes a relative contraindication in situations where the medical team looking after the patient feels that it would be futile or not in the best interests of the patient (as in terminal illnesses or very poor general condition).

CPR

- Use universal precautions (like gloves, mask and apron).
- Though it is advisable to use universal precautions, it is not always possible, particularly in the prehospital setting. Fortunately, to date, no cases of disease transmission have been reported in persons providing CPR.
- Standard CPR consists of the following (C-A-B):
  - Chest compressions
  - Airway management
  - Breathing support

  However, in case of lay rescuers, compression-only CPR (CoCPR) is advised.

Please note that the order of resuscitation has been changed from A-B-C to C-A-B for adults, children and infants (excluding the newly born).

Chest Compression (Fig. 3.2)

- Place one hand on the middle of the patient's sternum and the other hand on top of the first with fingers interlocked.
- Keep the elbows extended.
- Compress the chest to a depth of at least 2 in. (5 cm).
- After compression, allow the chest to recoil completely.
- Ensure that the rate of compression is at least 100/min.

Fig. 3.2 Chest compression – Hand position

- In patients without and advanced airway, ensure a compression-to-ventilation ratio of 30:2.
- In patients with an advanced airway, chest compressions can be continuous at a rate of 100/min. Ventilation can then be provided at one breath every 6–8 s (eight to ten breaths/min).

For Effective Chest Compressions

- Place the patient on a relatively hard surface instead of a soft mattress or any other soft surface for effective compressions of the sternum.
- Position yourself high enough to use your body weight for compressions.
- Note that the depth of compression is 'at least' 2 in. and not 'up to'. Also note that the previously used '1.5–2 in.' is not correct anymore.
- Remember to 'push hard and fast'.
- Ensure that a new provider swaps in for compressions every 2–3 min to avoid fatigue and poor quality CPR.
- Untrained bystanders should perform CoCPR.

Airway

- Clear airway of any secretions or foreign bodies under direct vision.
- Use 'head tilt-chin lift' manoeuvre to open the airway if no trauma is suspected. Where trauma is suspected, use a 'jaw thrust' (Figs. 3.3 and 3.4).
- Use appropriately sized oropharyngeal or nasopharyngeal airways to ensure airway patency.

Fig. 3.3 Head tilt chin lift manoeuvre

Fig. 3.4 Jaw thrust manoeuvre

- Where available, supraglottic airway devices (SGD) like laryngeal mask airway can be used.
- Endotracheal tube (ETT) is the definitive airway of choice in a cardiac arrest scenario. Though desirable, one should try not to interrupt chest compressions to facilitate intubation.

Ventilation

If a patient is in cardiorespiratory arrest, two ventilations by mouth to mouth are given by the provider. One can also use a pocket mask if available. This procedure is performed as follows (Fig. 3.5):

- Pinch the patient's nostrils closed to get an airtight seal.
- Provider puts his mouth completely over the patient's mouth.
- Provider gives a breath for approximately 1 s with a steady force watching for the chest to rise.

Ventilations can also be achieved with a bag-valve mask (BVM), ideally by two people.

Single-person technique for BVM ventilation (Fig. 3.6):

- Ensure a tight seal between the mask and the patient's face with one hand.
- Squeeze the bag with the other hand for approximately 1 s, aiming to deliver approximately 500 ml of air into the patient's lungs. Look for the chest to rise.

Two-person technique for BVM ventilation (Fig. 3.7):

- One person holds the mask with both his hands to the patient's face throughout the CPR without removing it and ensuring a tight seal.
- The person performing chest compressions squeezes the bag after every cycle of 30 compressions.

Fig. 3.5 Mouth to mouth ventilation with a pocket mask

Ventilation

- 'Look, listen and feel for breathing' is now not part of the algorithm. The lay rescuer should now be taught to commence CPR if the patient is not breathing or only gasping.
- Avoid excessive ventilation
- Use of cricoid pressure during ventilations is generally not recommended.
- The person performing chest compressions squeezes the bag after every cycle of 30 compressions.

Fig. 3.6 Bag valve mask ventilation – One person method

Fig. 3.7 Bag valve mask ventilation – Two person method

Advanced Life Support/Advanced Cardiac Life Support (Fig. 3.8)

- Though the algorithms are called differently as either advanced cardiac life support (ACLS) or advanced life support (ALS) in different countries, they are essentially based on the same principles which have been developed and standardised from extensive review of literature on resuscitation.
- This international ALS algorithm was published in the Consensus on Science and Treatment Recommendations (CoSTR) documents produced after the last International Consensus Conference in Dallas in 2010 conducted by American Heart Association (AHA) in collaboration with International Liaison Committee on Resuscitation (ILCOR) [1] (Fig. 3.8).
- This should be seen more as a guideline than a rule and gives a simplistic approach to CPR.
- One should avoid following it rigidly, particularly when specialist help is available as some of the recommendations are not supported by a high level of scientific evidence.
- As part of the ALS algorithm, it is important to continue chest compressions.
- Apply defibrillator pads at the earliest opportunity to recognise and treat the cardiac arrest rhythm appropriately.
- The chances of defibrillation resulting in a sustained, perfusing spontaneous circulation are greatest when initiated within 90 s after cardiac arrest and declines rapidly thereafter.

Precordial Thump

- It should not be used for unwitnessed out-of-hospital cardiac arrest.
- It should be considered for a witnessed unstable VT or pulseless VT if a defibrillator is not immediately available. This should not delay defibrillation or even starting CPR.

Attaching Defibrillator/Monitor

- Do not interrupt chest compressions while applying the self-adhesive defibrillation pads.
- The position of the pads is usually antero-apical. In most cases, the manufacturer provides instructions for ideal placement of the pads. Usually, one pad is applied just below the right clavicle and the second one over the cardiac apex (V6 position over the midaxillary line).
- In case of automated external defibrillator (AED), follow the instructions after switching on the machine as it gives verbal prompts for the next action after automatically analysing the rhythm.

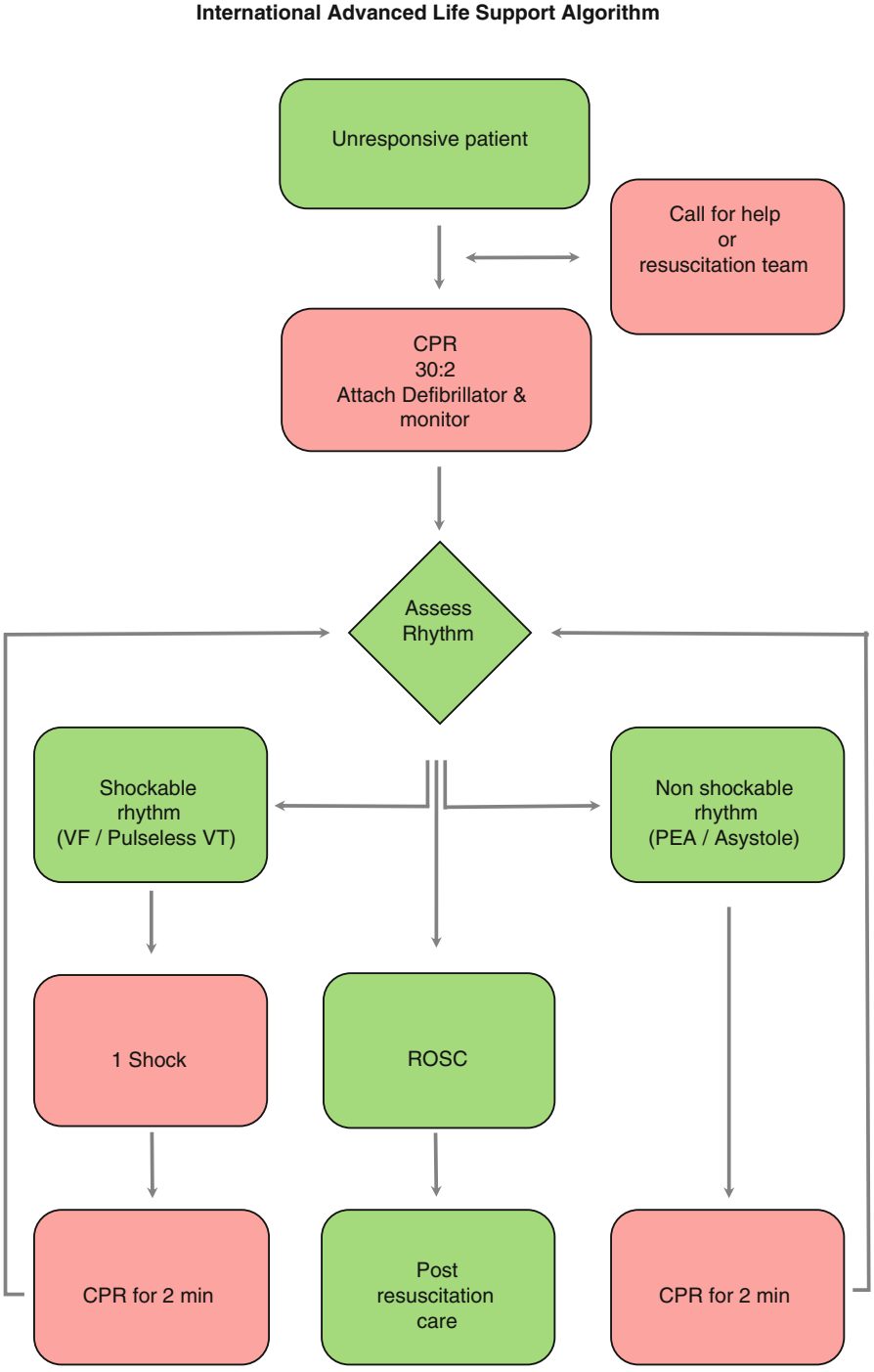

Fig. 3.8 International advanced life support algorithm

- For manual defibrillator:
  - After attaching the pads, pause briefly to analyse the rhythm. If the rhythm is VF or pulseless VT, restart chest compressions while charging the defibrillator. Safety issues should be planned beforehand to minimise interruptions to chest compression while delivering the shock.
  - Once the defibrillator is charged, and everyone other than the person delivering compressions is clear, pause chest compressions briefly ensuring everyone including any open source of oxygen is clear, and deliver the shock.
  - Recommence chest compressions immediately after delivering the shock for another 2 min before stopping to analyse the rhythm. Avoid the temptation to assess the rhythm or check for pulse immediately after delivering the shock.

Other interventions

- Procedures like intravenous cannulation and drug administration can be carried out once adequate help is available.
- It is useful to have a dedicated person for 'timekeeping' and also chart the different cycles and interventions being carried out.
- Scheme for the sequence of chest compressions; pause for analysis of rhythms; drug administration is represented in the international ALS algorithm.

It is important to:
- Minimise the delay between stopping chest compressions and delivering the shock. Studies have shown that every 5 s increase in this time delay halves the chance of a successful defibrillation.
- Address safety issues prior to stopping chest compressions to avoid doing the 'top-to-toe' safety checks traditionally done.
- Ensure safety of the patient and staff nevertheless.

Shockable Rhythms (VF/Pulseless VT)

In about a quarter of the case of cardiac arrest, the first rhythm that is seen on the monitor is a VF or VT. Even if it is not seen initially, it might occur during the resuscitation at some stage.

Treatment

1. Immediately commence uninterrupted chest compressions while defibrillation pads are being applied.
2. Pause briefly for analysis of the rhythm. Once VF/VT is confirmed, recommence chest compressions.
3. The designated person should then charge the defibrillator to the appropriate energy. Check for the manufacturer's recommendation as this figure varies.

This is usually 15–200 J (biphasic) for the first shock and 150–360 J (biphasic) for subsequent shocks
4. The person operating the defibrillator should ensure safety of the team at all times. Before delivering the shock, this person should give a loud and clear instruction to all of the team to stand away. Also ensure that any open source of oxygen is kept clear.
5. Once charged, the chest compressions are paused briefly before the shock is delivered safely. Ensure that this pause is not longer than 5 s.
6. Resume chest compressions immediately and continue CPR (30:2) without reassessing the rhythm or pulse.
7. The team leader should then start preparing the team for subsequent actions and also for the next pause in 2 min.
8. At 2 min, pause briefly again. If the patient is in VF/VT, then repeat the steps from 3 to 6 and deliver second shock.
9. Repeat steps 3–6 again if VF/VT persists. Also give 1 mg of adrenaline IV (10 ml of 1:10,000) and 300 mg of amiodarone IV after the third shock. Lidocaine (1 mg/Kg) can also be used as an alternative if amiodarone is not available.
10. Continue the 2 min cycles until VF/VT persists ensuring adrenaline is given every other cycle (3–5 min).
11. During treatment, ensure good-quality compressions and also constantly look for and treat the reversible causes (Table 3.1).

If during rhythm check an organised electrical activity is seen that is compatible with an output, then check for pulse.

- If there is a ROSC, then start post-resuscitation care.
- If there are no signs of ROSC, then continue CPR and switch to the non-shockable side of the algorithm for treatment of PEA.

If however, during rhythm check there is asystole, then continue CPR and switch to the non-shockable algorithm for treatment of asystole.

Non-shockable Rhythms (PEA and Asystole)

1. After confirming cardiac arrest and attaching the defibrillation pads, if the rhythm is PEA/asystole, then continue CPR at 30:2.
2. Give 1 mg of adrenaline IV as soon as an access is available.

Table 3.1 Reversible causes of cardiac arrest (4 Hs and Ts)

H	T
Hypoxia	Thrombosis (pulmonary or coronary)
Hypovolaemia	Tamponade (cardiac)
Hypo/hyperkalaemia or metabolic	Toxins
Hypo/hyperthermia	Tension pneumothorax

3. Check rhythm after 2 min.
   - If VF/VT at rhythm, then check. Then switch to shockable side of algorithm.
   - If asystole or agonal rhythm, continue CPR at 30:2, giving 1 mg adrenaline IV every other cycles (3–5 min).
   - If there is organised rhythm compatible with an output, then check for ROSC.
     i. If ROSC present, then start post-resuscitation care.
     ii. If no ROSC, continue CPR at 30:2, giving 1 mg adrenaline IV every other cycle (3–5 min).
4. During treatment, ensure good-quality compressions and also constantly look for and treat the reversible causes (Table 3.1).

Airway and Ventilation

- In the absence of staff trained in intubation skills, it is preferable to continue using a BVM or SGD.
- When there are trained personnel, an endotracheal intubation should be performed with minimal disruption to the ongoing CPR, particularly chest compressions.
- Once an ETT or SGD is sited, then attempt to perform continuous chest compressions at a rate of at least 100/min without stopping for ventilations. Ventilation should be given at eight to ten breaths per minute being mindful not to hyperventilate.
- Where available use end-tidal CO_2 (ET CO_2) monitoring. In addition to confirming correct position of ETT, it also is a useful monitor for determining the progress of CPR. There would be a sharp rise in ET CO_2 when there is a ROSC. However, a persistently low ET CO_2 could mean ineffective CPR either due to inadequate ventilation or due to poor cardiac output because of poor compressions. It could also be due to potentially reversible causes like hypovolaemia, pulmonary embolus (PE) or pericardial tamponade [1].

Vascular Access

- Securing an intravenous cannula (IV cannula) into a large vein in the upper limb is ideal. Alternatively, this can be sited into the external jugular vein.
- Due to poor venous return from below the level of diaphragm, lower limb veins should be avoided.
- All intravenous drug administrations should be followed by a big flush.
- If an IV cannula cannot be secured after one attempt, it is advisable to insert an intra-osseous needle (IO).
- If already in place prior to cardiac arrest, one can use a central venous cannula (CVC). However, it is not advisable to insert one during CPR as it is time consuming and also needs skill and practice to introduce without causing interruptions.

Arterial/Venous Blood Gases (ABG/VBG)

- ABGs are of limited value during cardiac arrest as they do not represent the severity of tissue hypoxaemia, hypercarbia or acidosis. However, VBG may represent the acid-base balance a bit more accurately.
- Once a ROSC is obtained, an ABG should be done to get a baseline status from which the progress of post-resuscitation care can be monitored.

Post-resuscitation Care

- It is very important to have a system of comprehensive, multidisciplinary team input that is very structured and integrated to ensure good outcomes in patients with ROSC.
- Soon after a ROSC, the team leader should ensure that any airway intervention is carried out if not already done.
- Also, blood samples should be taken for ABG analysis and workup for inflammatory markers as well as organ function (cardiac, renal and liver).
- Where suspected, samples for toxicology screen should also be sent for analysis.
- A 12-lead ECG should also be done to see any ischaemic changes or arrhythmias which are very common in the peri-arrest period.
- A portable chest x-ray should also be ordered.

One of the key objectives of post-resuscitation care is to ensure perfusion to vital organs by optimising cardiopulmonary function. It is important to look for any evidence of organ dysfunction and treat it early.

New Technology

- Several mechanical CPR devices aimed at improving the perfusion during resuscitation from cardiac arrest and to improve survival have been developed.
- Though several clinical trials have been done, none of these addresses if routine use of these devices irrespective of patient demographics, place it is used and the level of experience of the user has any better outcomes. Further studies are required to assess this.
- These devices at least initially need more personnel and training, and commencing treatment with them has the danger of either delaying treatment or interrupting ongoing CPR. However, with appropriate training, these hurdles can be overcome.

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