Cardio-Pulmonary Resuscitation (CPR)

Cardiac arrest is the absence of clinically detectable cardiac output and in practical terms it means absence of palpable carotid pulse. The respiratory and cardiovascular systems frequently interact implying that a problem in one of the organ would eventually lead on to a problem in the other as well. Cardio-respiratory arrest can occur because of primary airway, breathing or circulatory problem.

Causes of cardiac arrest in adults

The causes of cardiac arrest can be mainly classified in to cardiac and non cardiac causes.

Cardiac causes
- Ischaemic heart disease – almost 80 % of cardiac arrest
- Valvular heart disease

Non-cardiac causes
- Over dose of drugs like sedatives, narcotic etc
- Peripheral circulatory failure due to bleeding, sepsis etc
- Respiratory failure (Hypoxia, hypercapnoea)
- Hypovolaemia
- Hypothermia
- Electrocution
- Acute poisoning and drug overdose.

Cardio-pulmonary resuscitation (CPR) includes basic life support (BLS) using no equipment except for protective devices and advanced life support (ALS) using advanced equipment like defibrillator, endotracheal intubation and drugs.

Basis for CPR
Immediate BLS is a holding operation until a definitive treatment for the underlying condition and the rhythm can be provided. By maintaining an adequate ventilation and circulation, BLS delays the rate of deterioration of the brain and the heart until ALS can be provided by experienced personnel. In healthy individuals absence of circulation for longer than 3-4 minutes will produce permanent brain damage. Rapid defibrillation/ALS has the capacity to establish the return of spontaneous circulation (ROSC).

A consensus conference of international experts in resuscitation in 2005 (CoSTR) has produced universal guideline based on available evidences.

Management of cardiac arrest
Cardiac arrest victim who is collapsed requires immediate attention. It is important to understand the ECG features which enables to choose appropriate treatment regime during ALS.

**Rhythms associated with cardiac arrest**

1. Ventricular fibrillation (VF) and pulseless ventricular tachycardia: Both these rhythms should be treated with prompt defibrillation. VF is the most common rhythm at the time of cardiac arrest in adults.

2. Asystole: Cardiac arrest with no ECG complexes. It is important that a correct diagnosis of asystole is made and VF is not missed by checking that the electrodes are connected correctly and checking the gain in the ECG monitor.

3. Pulseless electrical activity (PEA): Presence of cardiac electrical activity in the presence of clinical signs of cardiac arrest. Exsanguination, pulmonary embolism or cardiac tamponade are the important causes.

**Adult in hospital resuscitation** *(algorithm 1)*

The first responder to an in-hospital cardiac arrest should follow the following steps.

- Make sure the rescuer and the patient are safe – is it safe to approach?
- Check for life – Gently shake the shoulders and shout loudly to see if the patient responds.
- If there is a response, leave the patient as you find provided it is safe to do so and try and find what is wrong and assess regularly. Urgent medical assessment is required and follows ABC approach. Give high concentration of oxygen, attach the monitor and get venous access while waiting for the medical team.
- If unresponsive summon for help.
- Open the airway. (for further details, refer to chapter 2)
- Breathing assessment -
  - Keeping the airway open, breathing is assessed by looking for coordinated chest movement, listening and feeling for the air movement on your cheek for not more than 10 seconds.
  - Carotid pulse can be assessed at the same time (not more than 10 seconds).
- If the patient has signs of life or pulse -
  - Keep the patient in the recovery position while waiting for the urgent assessment by medical emergency team. Follow ABCDE, give oxygen, attach the monitor and start IV line while waiting for the team.
- If the patient does not have pulse or other signs of life -
  - One person starts CPR while the rest goes to call arrest team, get the arrest trolley which contains monitor cum defibrillator, airway equipments, drugs etc.
  - Do thirty external cardiac compressions followed by two ventilations.
- External cardiac compressions are done at a rate of 100/min, for a depth of 4-5 cm at the middle of the lower half of the sternum.
- Maintain airway and breathing using appropriate equipment available immediately.
- The tidal volume should resemble that of normal breathing just enough to rise the chest with inspiratory time of 1 second and respiratory rate of 10/minute. Oxygen should be supplemented as early as possible.
- Ventilation and compressions are to be done separately until the airway is secured after which they can be done asynchronously.
- As soon as the defibrillator becomes available attach the electrodes to the patient and analyse the rhythm.

Algorithm 1. Adult in hospital resuscitation (Reprinted with permission from Resuscitation Council, UK. http://www.resus.org.uk/pages/AtoZindx.htm)

Minimise interruptions to the external cardiac compressions. External cardiac compressions are to be interrupted only to analyse the rhythm and for defibrillation but to be recommenced once the defibrillation is attempted not waiting to assess the rhythm or feel for the pulse.
- CPR has to be continued until the patient shows signs of life or the arrest team arrives. When using manual defibrillator use the ALS algorithm.
- Change the person providing compressions every two minutes.

- If the patient is not breathing but has got a pulse, the patient has respiratory arrest. Ventilate as described above but check for the pulse once every 10 breaths.
- The exact course of action following in hospital cardiac arrest depends on the following factors-
  - Site – if it is in clinical areas like CCU/ICU where the patients are monitored already in which the diagnosis is made almost instantaneously or non-clinical areas when there might be a delay in exact diagnosis.
  - Number and the proficiency of the staff members – if there is only one staff then he should go and call for assistance before initiating CPR.
  - Availability of equipments and drugs in the immediate vicinity.

- Mechanism of forward flow during cardiac compression
  External cardiac compressions produce cardiac output by compressing the heart against the spine with cardiac valve acting competently (cardiac pump theory), or the heart acting as a valveless conduit by increasing the intrathoracic pressure to squeeze blood out of the heart (thoracic pump theory). The compression rate refers to the rate at which the compressions are to be done and not the number of compressions that are given, which depends upon, apart from the rate of compression, also on the number and duration of interruptions for the other steps of CPR.

- Rationale for Recovery position
  The principle behind this position is to place the patient as near lateral position as possible with the head dependent so that any secretions or vomitus would drain out. The position should be stable and with no pressure on the chest which would impair breathing.

**Advanced life support (ALS)**

Current ALS guideline recognises that there are two different pathways during cardiac arrest: one is to treat patient with VF / pulseless VT (called shockable rhythms) by continued attempts at defibrillation and the other is to attempt to improve the myocardial contraction and reversal of underlying disease process that caused cardiac arrest in non-VF/VT i.e. in asystole and PEA (called non-shockable rhythms). Except for defibrillation there is no difference in treatment between the two groups.

**VF / pulseless VT (algorithm 2)**

- Start external cardiac compressions and ventilation in a ratio of 30:2 without waiting to assess for pulse or rhythm for two minutes.
- Stop CPR after two minutes briefly to check
  - If VF/VT persists:
- CPR to be restarted immediately and continued for another 2 min.
- Stop briefly to check the ECG.
- Give epinephrine (adrenaline) 1 mg intravenously if VF/VT persists followed immediately by third shock – 150-200 J biphasic / 360 J monophasic.
- CPR has to be continued for another two minutes.
- If the VF/VT persists give amiodarone 300 mg intravenously and follow it up with fourth shock – 150-200 J biphasic / 360 J monophasic) and continue the CPR for another 2 minutes.
- Subsequently in the case of persisting VF/VT give epinephrine (adrenaline) 1 mg intravenously before alternate shocks that is every 3-5 minutes.
- If the VF/VT persists in spite of above treatment, give further shock after each 2 minute period of CPR
  - Check for pulse if there is any organised electrical activity during brief pauses in compression –
    - If there is pulse, then start post-resuscitation care.
    - If there is no pulse, continue CPR and switch over to non-shockable part of algorithm.
  - If asystole is present, use non-shockable part of algorithm and do CPR
- Precordial thump – Administered by sharp blow using a closed fist on the patient’s sternum and may convert VF to sinus rhythm. It is given if the defibrillator is not immediately available in case of witnessed and monitored arrest.

**Practical aspects of defibrillation**

- If the rhythm can not be determined or if there is a delay in diagnosis then defibrillation should be given assuming the rhythm should have been VF / pulseless VT.
- Maximise the current traversing the myocardium by optimising paddle placement (e.g. anterior to posterior positioning, liquid gel/semisolid gel pads or self adhesive paddles, applying firmly, defibrillating during expiratory phase).
- Safety is of paramount importance during defibrillation. It is important to avoid charging the defibrillator in air, defibrillating over ECG electrode and making physical contact with the patient during defibrillation. Keep the oxygen at least 1 metre away from the patient’s chest.

Reversible causes such as hypoxia, volume depletion, hypo/hyperkalaemia, hypothermia, tension pneumothorax, tamponade of heart, drug overdose, pulmonary thrombo-embolism should be identified and treated appropriately especially if the condition recurs or resistant to treatment.

Administration of drugs during CPR

- Cannulation of central veins takes longer time and may delay the administration of drugs.
- Peripheral access is more readily attainable, peripheral administration should be followed by a 20 ml flush.
- Drugs can be administered by endobronchial route (2-3 times the intravenous dose). It should be followed by 5 ventilations to disperse the drug.
• Bicarbonate and calcium should not administered by endobronchial route.
• Epinephrine (adrenaline) is useful due to its alpha effect which increases the coronary and cerebral perfusions, though its beta effects by increasing the myocardial oxygen consumption can be potentially detrimental. The dose is 1 mg (10ml of 1 in 10,000 concentration) to be given every 3-5 minutes intravenously.
• Amiodarone 300 mg is to be given if VF/VT persists after three shocks before delivering the fourth shock followed if necessary another 150 mg for recurrent or refractory VF/VT. This has to be followed by an infusion 900 mg in 24 hrs.
• Magnesium 8 mmol is given if there is suspicion of hypomagnesaemia in the presence of refractory VF, torsade de pointes and digoxin toxicity.
• Bicarbonate: It may be given in a dose of 50 mmol intravenously in cases of cardiac arrest due to hyperkalaemia or tricyclic antidepressant overdose and to be repeated only with blood gas guidance.
• Calcium: It is indicated only when the PEA is due to hyperkalaemia, hypocalcaemia and overdose of calcium channel blocking drugs and magnesium. The dose is 10 ml of 10% calcium chloride repeated if needed. It can be given by rapid injection in cardiac arrest; otherwise give it slowly. Calcium and bicarbonate should not be given through a same line at the same time.

Non-shockable Rhythm (PEA and asystole) (algorithm 2)

• Commence CPR in the ratio of 30 compressions to 2 ventilations until the airway is secured and then do compressions without pausing for ventilation.
• Administer Epinephrine (adrenaline) 1 mg intravenously. Atropine 3 mg i.v. should be given only once for asystole and PEA with rate <60 per minute.
• Check the rhythm after 2 minutes of CPR
  ▪ If there is no change in ECG -
    • Continue CPR and recheck the ECG in 2 minutes.
    • Give epinephrine (adrenaline) 1 mg every 3-5 minutes (alternate loops).
    • Check for pulse only if the ECG changes and organised electrical activity is visible.
    • If a pulse is present start post resuscitation care.
    • If there is no pulse -
      ○ Continue CPR.
      ○ Recheck the rhythm after 2 minutes.
      ○ Give Epinephrine (adrenaline) 1 mg intravenously every 3-5 minutes (alternate loops).

Peri-arrest arrhythmias

In all patients with arrhythmias oxygen should be administered, intravenous line should be secured for administration of drugs and 12 lead ECG should be recorded. Electrolyte disturbance mainly K⁺, Mg²⁺, should be corrected.
The treatment of an arrhythmia depends on the effect that it has on the patient apart from the type of arrhythmia. The arrhythmia can produce haemodynamic instability producing following adverse features:

- Signs and symptoms of low cardiac output
  - Poor perfusion (peripheries – pallor, brain – impaired consciousness)
  - Reflex sympathetic activity (sweating, cold and clammy extremities)
  - Hypotension (systolic BP <90 mmHg)
- Very high heart rate – Excessive hear rate, by reducing the duration of diastole during which the coronary perfusion occurs, reduces coronary perfusion producing signs of coronary ischaemia like chest pain. Broad complex tachycardias (ECG QRS width ≥12 seconds) which are of ventricular origin are more serious than narrow complex tachycardias (ECG QRS width ≤12 seconds) which are of supra ventricular origin.
- Excessive bradycardia – defined as heart rate <40/min. Cardiac output may decrease with such a slow heart rate and can also occur with heart rate of <60/min in a heart with very poor reserve.
- Signs and symptoms of heart failure such as raised JVP, hepatic engorgement and pulmonary oedema.

**Bradycardia** (algorithm 3)

Bradycardia is heart rate <60/min. It may be classified as absolute (heart rate <40/min.) or relative when the heart rate is slow enough to produce adverse features in a heart with poor reserve.

**Tachycardia** (algorithm 4)

- Irregular narrow complex tachycardia is most likely to be atrial fibrillation or atrial flutter with variable AV block.
- A 12 lead ECG should be recorded.
- If the duration is >48 hrs (risk of thrombus increases) do not use cardioversion (electrical or chemical) until the patient is anticoagulated for at least 3 weeks or the trans-oesophageal echocardiogram shows no atrial thrombus.
- If the AF is of <48 hrs duration, the cardioversion can be achieved with amiodarone or electrical (which has got more success rate).
- Drugs such as adenosine, digoxin, diltiazem, or verapamil should be avoided in patients with ventricular pre-excitation syndrome (WPW syndrome), they may increase the risk of pre-excitation by blocking AV node.
If appropriate, give oxygen, cannulate a vein, and record a 12-lead ECG


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Post resuscitation care

The quality of management after ROSC would influence the final outcome from cardiac arrest. The post resuscitation care is usually delivered in areas like ICU/HDU/CCU. If the patient is unconscious, it is better to intubate the trachea and ventilate the lungs to guarantee normocarbia and oxygenation and also to prevent aspiration. Patient may need invasive monitoring like arterial blood pressure, central venous pressure, cardiac output etc. Maintain electrolytes level within normal range especially potassium and magnesium. Avoid hyperthermia and at the same time judicious use of mild hypothermia (temperature 32-34° C) for 12-24 hrs may be beneficial as it may minimise reperfusion injuries. However hypothermia can produce detrimental effects like shivering which increases the oxygen flux and increased bleeding & wound infection in the perioperative period. Patients with high blood sugar level can have adverse neurological outcome following cardiac arrest. There are no immediate neurologic signs that can indicate outcome following cardiac arrest. Highly specific signs indicating poor outcome are absence of pupillary light reflex and motor response to pain by third day.

Ethical dilemmas surrounding resuscitation

CPR was originally conceived to save the lives of the patients dying unexpectedly and efforts should be taken to minimise it to be used in patients in whom the underlying condition and general health makes the chances of success of unlikely. A do not attempt resuscitation order should be written as per the hospital protocol in a patient who does not want to be resuscitated or will not survive the cardiac arrest even if the CPR is attempted.

Further Reading


http://www.resus.org.uk/pages/AtoZindx.htm