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In Singapore there are about 2,400 heart attacks every year. If heart attack does occur, actions taken during the first few minutes of an emergency are critical to a victim’s survival. Sudden cardiac arrest is usually due to abnormal heart rhythms, causing the heart to stop pumping effectively. Cardiopulmonary resuscitation (CPR) and defibrillation, provided immediately after sudden cardiac arrest, can significantly increase a casualty chance of survival.

Accredited by the Singapore National Resuscitation Council, the Cardiopulmonary Resuscitation & Automated External Defibrillation Course aims to equip participants with the necessary life-saving skills and confidence to respond during cardiac emergencies.

Be prepared to save life. Join the Cardiopulmonary Resuscitation & Automated External Defibrillation Course.


A/Prof. Lim Swee Hia
Director, Nursing

March 2017
MODULE A
CARDIOPULMONARY RESUSCITATION (CPR)
INTRODUCTION

Based on national health statistics from the Ministry of Health, Singapore, heart disease is the second most common cause of death, contributing to 22.8% of total mortality. Of these, ischaemic heart disease is the commonest (16.7%), followed by hypertensive heart disease (3.9%) and other heart disease (2.2%). The situation is similar to most countries of the world.

A person with heart disease is prone to a heart attack, which could result in cardiac arrest and sudden death. It is estimated that every year about 8,000 people in Singapore develop a heart attack. In addition, at least 1,800 people collapse in the out-of-hospital environment from sudden cardiac arrest, with a survival rate of only 3.4%. About an equivalent number develop cardiac arrest within hospitals and approximately 20% survive.

Sudden death can be minimised with the prompt application of basic life-saving skills of cardio-pulmonary resuscitation (CPR) and use of automated external defibrillators (AEDs). These can be performed by any of us, anywhere and anytime. All that is needed is our two hands.

It is well known that the most important factors affecting survival in sudden cardiac arrest are external cardiac massage and timed to first electrical defibrillation. Since the defibrillation technique can be easily learned and employed by any trained person, it is important that one understands the basics for this technique clearly so that its application can be appropriate and correct.

The initial cardiac rhythm at the time of collapse in the adult is frequently an irregular, chaotic electrical cardiac rhythm or Ventricular Fibrillation (VF). The definitive treatment for VF is electrical therapy. If VF is not treated immediately, the casualty’s chance of survival decreases by about 10% for every minute of delay in treatment.

The concept of “Chain of Survival” is the best approach to the treatment of casualty with cardiac arrest. The four links in this chain are (1) early access to the Emergency Medical Service (EMS), (2) early CPR, (3) early defibrillation and (4) early advanced cardiac care.

The Chain of Survival

![The Chain of Survival](image)
INTRODUCTION

In an emergency situation, when a person’s heartbeat and/or breathing have/has stopped (cardiopulmonary arrest), life-support techniques or Basic Cardiac Life Support can be vital for the survival of that person. With early intervention and prompt recognition of cardiopulmonary arrest, the survival rate increases. There are many causes to cardiopulmonary arrest. However, in the adult victim, the most common cause is heart attack. The best approach to the treatment of sudden cardiac death is to adopt the concept of “Chain of Survival”. There are 4 links to this chain - Early Access to Emergency Medical Service (EMS), Early Cardiopulmonary resuscitation (CPR), Early Defibrillation and Early Advanced Cardiac Care. CPR is an organised approach to assessing and providing interventions such as mouth-to-mouth breathing and chest compression. Although it encompasses more than one simple rescue technique and requires proper timing and a specific sequence to be effective, CPR can be learnt easily.

EPIDEMIOLOGY OF CARDIAC ARREST

In the year 2000 alone, ischaemic and other heart diseases account for 25.1% of the total number of deaths in Singapore. Heart disease is the second commonest cause of death. About 2,600 people develop an acute heart attack in Singapore. Of these, at least 900 people died shortly after the heart attack. 500 of these deaths occur before the patients are able to reach the hospital. The total survival rate for this group of pre-hospital collapses (occurring outside the hospital or in the community) is about 2.6%. Public education and training in cardiopulmonary resuscitation (CPR) is important to improve on the survival rate of sudden cardiac arrest.

SUDDEN DEATH

Sudden cardiac death or cardiac arrest occurs when the heart stops beating and spontaneous breathing ceases abruptly. Up to 50% of individuals may be brought back to life if CPR is provided in a timely and effective manner.

Biological and Clinical Death

When cardiac arrest occurs, the casualty loses consciousness and breathing stops quickly, within seconds of the arrest. During the early stage of cardiac arrest, prompt intervention is crucial to restore circulation to vital organs such as the brain. The sooner the circulation to the brain is restored, the higher the chance for a full recovery. Permanent and irreversible brain damage occurs within 4 to 6 minutes of clinical death and biological death results in 8 to 10 minutes.
Some Causes of Sudden Death:
• Heart attack
• Foreign body airway obstruction
• Drowning
• Stroke
• Drug overdose
• Severe asthma
• Electrocution
• Severe allergic reactions
• Severe trauma e.g. automobile accident

THE HEART

Structure and Function

The heart is a muscular organ (about the size of the owner’s clenched fist). It has three layers of tissues. The outermost layer is known as the pericardium, the middle muscular layer is the myocardium and the innermost layer that forms the lining of the heart is known as the endocardium. Folds of the endocardium form the heart valves that act as “doors” which allow blood to flow in one direction only.

The heart is located within the chest slightly to the left of the owner’s body. Its main function is to receive blood depleted of oxygen and then pumps it to the lungs for reoxygenation and at the same time pumps oxygenated blood to all parts of the body.

The heart is made up of four chambers. Each side of the heart is composed of an atrium and a ventricle. A common wall, known as the septum divides the left and right chambers of the heart. The right atrium receives deoxygenated blood from the superior and inferior venae cavae. The right ventricle receives the deoxygenated blood from the right atrium and pumps the blood to the pulmonary circulation for the blood to be reoxygenated in the lungs. The reoxygenated blood is then returned to the left atrium via the four pulmonary veins. The left atrium pumps the reoxygenated blood into the left ventricle, which will pump the blood into the systemic circulation via the aorta.

Thus, the right side of the heart deals with deoxygenated blood and the left side of the heart deals with oxygenated blood. The vessels that return blood to the heart are known as veins while those transporting blood away from the heart are known as arteries (Figure 1).
Coronary Circulation

The heart, like the other parts of the body, needs oxygen and nutrients. These are provided by the two main coronary arteries that supply blood to the heart. The left coronary artery has two branches that supply blood to the top, front and left side of the heart. While the right coronary artery supplies blood to the right side and back of the heart (Figure 2).

Conduction System of The Heart

The conduction system of the heart is composed of specialised cells that initiate and conduct electrical impulses through the heart (Figure 3). These electrical impulses normally originate from the sinoatrial (SA) node. The SA node is located at the junction of the superior vena cava and right atrium and it is able to initiate electrical impulses at 60 to 100 times per minute. This is the fastest intrinsic rate, therefore, the SA node is also known as the pacemaker of the heart. The impulses generated by the SA node are conducted along the myocardium of the atria to the atrioventricular (AV) node that is located at the right atrium near the tricuspid valve.
Similar to the SA node, the AV node is also capable of generating electrical impulses. However, it has an intrinsic rate of 40 to 60 times per minute. From the AV node the impulses will be conducted to the Bundle of His, the Bundle Branches and then the Purkinje Fibers.

The electrical activity of the heart precedes its mechanical function. Therefore, in the normal heart, the heart beats at about 60 to 100 beats per minute.

![Diagram of the heart with labeled structures](image)

**Figure 3: Conduction system of the heart**

### CORONARY ARTERY DISEASE

The gradual build-up of fatty deposit substances or plaque, in the inner lining of the coronary artery results in a condition known as atherosclerosis of the coronary arteries or coronary artery disease. The plaque causes blood to flow through narrowed coronary arteries, hence reducing the amount of oxygen supply to the heart muscles, and causing intermittent or prolonged chest pain (Figure 4). Coronary artery disease may present as:

1. Angina pectoris / chest pain - is a result of hypoxia (lack of oxygen) of the cardiac muscle. The classic description of angina pectoris is a squeezing, pressing, vice-like discomfort over the substernal or left precordial region. The pain may radiate to the neck, jaw or shoulder or down the arms. A characteristic feature of angina is the gradual build-up of discomfort. It may also occur over the posterior thorax, interscapular area, lower jaw, neck, throat area or epigastrium. Rest or medicine, such as sub-lingual nitroglycerin may relieve this experience of discomfort or transient chest pain.

2. Heart attack / Acute Myocardial Infarction (AMI)

3. Sudden death - cardiac arrest may be the first presentation as coronary artery disease may occur without warning. Sudden death may occur as a complication of AMI, especially during the first 1 to 2 hours after onset.
RISK FACTORS FOR HEART ATTACK

Several key risk factors contribute to the development of a heart attack. We can minimize the chance of getting a heart attack by controlling the risk factors. These are:

**Smoking** - Smoking promotes the development of plaques within the coronary arteries and increases the risk of heart attack two fold. This habit should be avoided altogether,

**Blood Pressure** - If the blood pressure is high, there will be tremendous stress on the heart. Frequent blood pressure checks and reduction of salt in the diet is important. Those with high blood pressure should take their medicines regularly as instructed.

**Blood Sugars** - Avoid a diet high in carbohydrates or refined sugars and control body weight through diet and exercise. If you have diabetes, take your medications regularly as instructed.

**Blood Lipids** - Manage blood lipids (fats) by avoiding foods high in fats. Doing regular exercise could improve your blood lipid profile.

We all owe it to our families and loved ones to remove or minimize our exposure to these risk factors. Adopting healthy lifestyles through avoidance of cigarette smoking, eating foods in moderate amounts and regular exercise will together decrease our risks for heart disease and other illnesses.

WHAT HAPPENS IN A HEART ATTACK

A heart attack occurs when one of the **coronary arteries** supplying the heart muscle is blocked by cholesterol deposits and blood clots. The part of the heart muscle beyond the blocked vessel dies. This is a heart attack.

![Narrowed Artery](image)
SYMPTOMS OF A HEART ATTACK

A person who has a heart attack may experience any of these:

**Pain** - described as a pain, tightness or uncomfortable either over the chest or upper part of the abdomen. This pain may also spread to the left shoulder, left arm, neck or the lower jaw.

Some may mistake this for indigestion or just tiredness.

**Shortness of breath** - A sudden difficulty in breathing may be a warning sign of a heart attack.

**Other Symptoms** - Sweating, nausea, vomiting or dizziness

If a heart attack is not treated promptly, deterioration of heart function will occur and the casualty may develop a sudden cardiac arrest.

Learn to recognize these symptoms. When someone has these, it is best to call for an emergency ambulance (telephone: 995) and be taken to the nearest Emergency Department for immediate evaluation.

**What One Should Do In A Heart Attack?**

Many people die unnecessarily each year because they do not recognise a heart attack or wait too long to get medical help. More than a third of heart attacks are fatal, and more than half of all deaths from heart attack occur in the first hour of onset. The chances of survival are much better if the patient gets to the hospital early.

This is what you should do:

- Recognise the symptoms of a heart attack
- If the patient is conscious, put him in a half-sitting position, with head and shoulders supported with pillows and knees bent
- If symptoms persist, call an ambulance (telephone number: 995) or go at once to your nearest hospital (Emergency Department)
- If possible, contact the patient's own doctor, as there may be a history of heart disease. If the doctor is not available, telephone 995 and ask for an ambulance. Inform the ambulance service that you suspect a heart attack
- If you are the patient, do let someone know of your symptoms so that he/she could monitor your condition and get help
- Loosen the patient’s clothing around the neck, chest and waist to help circulation and ease his breathing
- Do not give the patient anything to eat or drink
- Do not allow him/her to move unnecessarily; it will put extra strain on the heart
- If the patient becomes unconscious, put him/her in the recovery position (See Figures 20 to 26)
- If the heart stops, perform cardiopulmonary resuscitation (CPR). Continue to do so until help/ambulance arrives
WHAT HAPPENS IN A CARDIAC ARREST

When a portion of the heart muscles dies, it affects the electrical impulses within the heart. The orderly flow of electrocal signals within the heart is disrupted. This is a dangerous situation and frequently an irregular, chaotic electrical rhythm called Ventricular Fibrillation or VF develops.

When VF occurs, the heart does not pump and the delivery of blood to the rest of the body ceases. This is a state of **cardiac arrest**.

At the start of a cardiac arrest, the oxygen in the blood starts to drop, initiating poor heart function and brain damage. If this situation is reversed immediately, survival chance could be as high as 90%. At 6 minutes delay, this drops to 40-50% and at 9 minutes, it is only a dismal 10%.

To avoid this, immediate CPR and defibrillation is key.

OTHER COMMON CAUSES OF CARDIAC ARREST

A heart attack is the most common cause of cardiac arrest. There are other causes, which include:

- Foreign Body Airway Obstruction
- Stroke
- Smoke Inhalation
- Drug Overdose
- Severe Allergic Reactions
- Drowning
- Electrocution
- Severe Trauma

Death in these situations can be prevented if prompt help is provided, especially by someone trained in CPR and first-aid skills.
THE CHAIN OF SURVIVAL

When a collapse occurs, the heart stops pumping blood. Brain damage begins after 4 to 6 minutes and death can occur in 8 to 10 minutes without oxygen. Therefore it is critical that blood flow and breathing be continued until medical help arrives. CPR (Cardio-Pulmonary Resuscitation) is a technique that can be performed to “artificially” maintain this blood flow and breathing. A person, trained in BCLS (Basic Cardiac Life Support) can perform CPR.

Modern life-style makes heart attack the number 2 killer after cancer in Singapore. Survival of sudden cardiac arrest depends on time and a series of critical responses called the “Chain of Survival.” If one is neglected or delayed, survival is unlikely. This chain has four interdependent links.

The First Link – Early Access

Early Access encompasses the actions initiated after the patient’s collapse and the arrival of Emergency Medical Service (EMS) personnel. Recognition of early warning signs, such as chest pain and shortness of breath, and the early access to EMS (call 995) is essential. Rapid response and intervention increase the chances of surviving a heart attack.

The Second Link – Early Cardiopulmonary Resuscitation (CPR)

CPR is most effective when started immediately after the patient collapses. It keeps oxygenated blood flowing to vital organs, such as the brain and the heart. In almost all the clinical studies, bystander CPR has shown a significant positive effect on survival. It is essential in maintaining blood flow and breathing until professional help arrives. Therefore the chances of successful resuscitation for an out-of-hospital collapse depend on prompt bystander CPR and a competent EMS.
The Third Link – Early Defibrillation

Studies have shown that early defibrillation is most important for the improvement of survival rates for out-of-hospital cardiac arrest patients. The only treatment for sudden cardiac arrest is defibrillation. Defibrillation converts an abnormal heart rhythm (ventricular fibrillation) to a normal one.

The Fourth Link – Early Advanced Care

Early Advanced Cardiac Life Support (ACLS) is another critical link in the Chain of Survival concept. ACLS involves ventilation support, establishing intravenous access, administering drug therapies, controlling arrhythmias and preparing the victim for transport to the hospital. Where the Chain of Survival is strong, survival rates have been reported to be as high as 30 percent or more.

THE IMPORTANCE OF EARLY CPR

When cardiac arrest occurs, the heart stops beating and blood flow to the vital organs, viz. The heart muscle, the brain and the kidneys, stops. Without immediate intervention, the chances of survival drop over time. It is estimated that survival rate falls 10% for every passing minute when the casualty does not receive CPR or defibrillation.

It is therefore important to start CPR as quickly as possible.

CPR consists of 2 key components:

Cardiac compression - simulates the pumping action of the heart, helps deliver blood and oxygen to the body.

Mouth-to-mouth ventilation - provides oxygen to the casualty.

If CPR is performed promptly and correctly, heart function may be restored and sudden death prevented. If CPR is started early, the degree of brain damage will be reduced.

The next few pages will take you through the steps of CPR.

Practice these skills over and over again until you are confident you can do it well.
MNEMONIC: DRS ABC

D: CHECK FOR DANGER
R: CHECK FOR RESPONSIVENESS
S: SHOUT FOR HELP
A: AIRWAY
B: BREATHING
C: CHEST COMPRESSIONS

D Check for Danger

Check for responsiveness?
TAP SHOULDER FIRMLY
ASK LOUDLY

Shout “Help! call ambulance 995, get AED!”
(activate emergency response system)

Open Airway
HEAD TILT, CHIN LIFT

Breathing normally?
LOOK FOR CHEST RISE

Check Carotid Pulse
for trained healthcare providers only
DETECT PULSE AND NORMAL BREATHING
WITHIN 10 SEC

30 Chest Compressions
CENTRE OF CHEST / LOWER HALF OF STERNUM
DEPTH 4-6 CM
RATE AT LEAST 100-120 PER MIN
ALLOW COMPLETE CHEST RECOIL

Open Airway
HEAD TILT, CHIN LIFT

2 Breaths
1 SEC PER BREATH
TIDAL VOLUME 400-600 ML TILL CHEST JUST RISES

Continue Until
- Patient wakes up
- AED arrives and analyse heart rhythm
- Emergency team takes over CPR

IF UNABLE / UNWILLING TO DO MOUTH-TO-MOUTH VENTILATE FOR ANY REASON, DO CONTINUOUS CHEST COMPRESSIONS AT 100-120 / MINUTE.
STEP 1. CHECK FOR DANGER

• Quickly assess the situation for danger, so that the rescuer operates in a safe environment.

STEP 2. CHECK FOR RESPONSIVENESS

Quickly assess and determine whether the casualty is responsive. The rescuer should tap or gently shake the casualty on the shoulders and asks loudly: “Hello! Hello! Are you OK?”

• Avoid violent shaking of the casualty as this might result in injury.
• Avoid unnecessary movements of the neck in the event of injuries to the head and neck.
• If the casualty does not respond, he/she is likely to be unconscious. This may be due to:
  • An airway that is obstructed (blocked) by the tongue that has fallen backwards, food or secretions.
  • Breathing that has stopped.
  • The heart that has stopped beating, usually because of a heart attack.
  • Alcohol or drug intoxication
  • Fainting
  • Severe illness

• If the adult is unconscious, the rescuer will have to act quickly.

Fig 6: Check for Responsiveness
STEP 3. SHOUT FOR HELP. CALL FOR AMBULANCE 995. GET AN AED

ACTIVATE EMERGENCY MEDICAL SERVICES (EMS)

- Activate EMS, call ambulance 995, GET AED and give the following information:
  - Someone is having a heart attack/unconscious
  - Location of the casualty
  - Telephone number you are calling from
  - The number of persons who need help
  - Ask for immediate ambulance
  - Hang up the phone only after being instructed to do so

- If there is another person around, ask him/her to do the calling. Give him/her the information to provide to the ambulance dispatcher.

- If an AED is nearby, get the AED and apply onto the casualty. If not, get someone to retrieve the AED from a nearby known location. Tell me passerby “Get AED”.

- Remove casualty to a safe area if required

Figure 7: Call for ambulance at telephone number 995
STEP 4. POSITION CASUALTY

- To be effective, CPR must be performed on a victim who is lying flat on his/her back (supine) and on a firm and flat surface.

- If the casualty is lying face down, or on his/her side, roll the casualty over as one unit onto his/her back before starting any of the procedures.

- Support the nape of the neck gently during repositioning if the victim has or is suspected to have head/neck injury.

- Lay the casualty flat on his/her back on a flat, firm surface. Ensure that the casualty legs are straightened, and arms placed alongside the body.

![Figure 8: Roll the casualty onto his back](image-url)
STEP 5. OPEN AIRWAY

If there is no evidence of head or neck injuries, use the head-tilt and chin-lift manoeuvre to open the airway

- Head tilt: Using the palm of one hand, press the top of the head so that it is tilted backwards
- Chin lift: Lift the chin upwards with the fingers of the other hand

Note:

- Do not press deeply into the soft tissue under the chin, this may obstruct the airway
- If head/neck injury is suspected, the head-tilt and chin-lift manoeuvre must not be performed. Use the jaw-thrust or gentle chin-lift manoeuvre
- If the casualty has started to breathe, this may be all that is required. At this point, place him in the recovery position

Figure 9: Open airway (head-tilt and chin-lift)
STEP 6. CHECK FOR BREATHING

- Look (for the rise and fall of the chest wall).
- It is important to recognise that gasping is not normal breathing but a sign of cardiac arrest, start CPR immediately.

Figure 10: Check breathing (look for chest rise.)

DO BREATHING AND PULSE CHECK (For trained healthcare providers only)

The breathing and pulse check should be done simultaneously.

- The technique is as follows:
  - Maintain head-tilt
  - Locate Adam’s apple with index and middle fingers
  - Slide fingers down to groove at side of neck near you (location of carotid pulse)
  - Checking of breathing and pulse should not take more than 10 seconds.
If breathing and pulse are absent or only gasping motions seen, then presume cardiac arrest. The casualty will require Cardio-Pulmonary Resuscitation (CPR). Proceed to start Chest Compressions.

Figure 11: Check the neck pulse

STEP 7. LOCATE CORRECT LANDMARK AND PERFORM 30 CHEST COMPRESSIONS

- Place yourself at the side of the casualty
- Place the heel of your hand on the lower half of the sternum breast bone
- Keep the heel of your hand in place and put your other hand over it (fingers may be interlaced to keep them lifted off the chest). Keep your thumb and fingers raised; so that they do not press on the ribs. Press down 4-6 cm keeping your thumbs and fingers raised. Let the chest rise again.

Figure 12: Cover hand with the heel of the other hand
With arms straight, pressing vertically down on the lower half of the breastbone

Use your body weight to compress the patient’s chest to a depth of 4-6cm

Do not compress
- too low on the chest - can cause damage to the liver located in the upper abdomen
- too high on the breastbone - is ineffective
- directly on the ribs - can cause severe fractures of the ribs

Give 30 compressions then inflate the lungs twice by mouth-to-mouth respiration
Push hard, push fast on the lower half of the chest at a rate of 100-120 per minute. This rate is achieved by counting loudly as you compress:

- 1 and 2 and 3 and 4 and 5 and
- 1 and 2 and 3 and 4 and 10 and
- 1 and 2 and 3 and 4 and 15
- 1 and 2 and 3 and 4 and 20
- 1 and 2 and 3 and 4 and 25
- 1 and 2 and 3 and 4 and 30

Continue CPR until pulse returns or until the ambulance crew arrives to take over the management of the casualty.

**TIPS FOR PROPER CHEST COMPRESSIONS**

- To give effective chest compressions, rescuer should “push hard and push fast”. vertically above casualty (depth of at least 4-6cm, rate of at least 100-120 per minute)
- Locating the correct hand position for chest compressions should be done quickly.
- Make sure you allow the chest to be fully recoiled before starting the next compression.
- Do not lift the heel of your hand off the chest between each compression.
- The compression technique consists of serial, rhythmic applications of pressure out the lower half of this sternum (breastbone)

**Step 8: MOUTH-TO-MOUTH BREATHING**

- After 30 chest compressions, perform 2 breaths

**To perform mouth-to-mouth-breathing:**

- Maintain head tilt-chin lift.
- Pinch the nose with your thumb and index finger to prevent air from escaping through the casualty nose.
- Seal your lips around the victim’s mouth and give 2 breaths.
- Release the nostrils after each breath.
- The chest should rise with each breath.
- The duration for each breath is 1 second.
- Ventilation volume is between 400 to 600 ml of air.
- Allow lung deflation between each breath.
- Quickly proceed to do another cycle of chest compressions (5 cycles of 30 compressions: 2 breaths)

**Note**

- Too great a volume of air is likely to cause air to enter the stomach and result in stomach (gastric) distension
The cycles of 30 compressions to 2 ventilations should be continued until one of the following occurs:

- An AED is connected to the casualty and prompts you to stop CPR
- The ambulance crew arrives and takes over further care of the casualty
- The casualty regains consciousness

If you are a single rescuer and feeling tired, you may take a rest of not more than 10 seconds after every 3 to 5 cycles of CPR.

**STEP 9: RE-ASSESSMENT**

**FOR TRAINED-HEALTHCARE PROVIDER: RE-ASSESSMENT**

- Check pulse after every 5 cycles of CPR 30:2.
- If pulse is absent or unsure about the presence of pulse, start chest compressions and perform 5 cycles of CPR (30:2).
- If pulse is present and breathing is absent, perform rescue breathing at a rate of 12 breaths per minute (one breath every 5 seconds) by giving one breath and count 2-a-thousand, 3-a-thousand, 4-a-thousand, 5-a-thousand. Repeat the sequence until you have completed a total of 12 breaths.
- If both the pulse and breathing are present, position the victim in the recovery position.
- Continue to monitor the casualty pulse and breathing every 2 minutes as these can stop suddenly.

For **LAYPERSON:**

Continue Performing CPR until help arrives or casualty starts moving.

**TWO PERSON CPR**

Performing CPR for prolonged periods is tiring, especially for ones-person CPR. If another provider is available, two-person CPR should be performed.

Two-person CPR requires some simple coordination:

1. One rescuer performs 30 chest compressions and pausing for 3-5 seconds to allow a second rescuer to deliver 2 mouth-to-mouth ventilations.

2. This sequence continues until one of the rescuers gets tired, at which time they could switch places and continue the provision of 30:2 CPR.
MODULE B
AUTOMATED EXTERNAL DEFIBRILLATION (AED)
INTRODUCTION

It is well known that the most important factors affecting survival in sudden cardiac arrest are external defibrillation and time to first shock. Since the technique can be easily learned and employed by any trained person, it is important that one understands the basics for this technique clearly so that its application can be appropriate and correct.

The most frequent initial rhythm in sudden cardiac arrest is ventricular fibrillation (VF), and the single most effective treatment for VF is electrical defibrillation. Early defibrillation has been recognised as the crucial third link, in the chain of survival for emergency cardiac care. Epidemiological and clinical research have established that effective emergency cardiac care (ECC) depends on these four closely interconnected links. Therefore, it is important to ensure that all four links are given the special attention to achieve optimal patient survival.

The increasing availability of Automated External Defibrillators (AED) necessitates that all health care providers, especially emergency personnel, be equipped with the skills and knowledge to use an AED. Significant others who may be at the scene of sudden cardiac arrest event and where AED are available should also be equipped with the skills and knowledge to use an AED.

CARDIAC ARREST

Epidemiology of Cardiac Arrest

In Singapore, heart disease is the second commonest cause of death, being responsible for about 22.8% of total mortality. Everyday, 16 people die from cardiovascular or disease (Heart disease and stroke) in Singapore. Cardiovascular disease accounted for 29.6% of all deaths in 2015. This mean that 1 out 3 death in Singapore is due to heart disease or stroke.

It is well established that the initial cardiac rhythm at time of collapse is frequently chaotic electrical distribution of the heart. This is referred to as “Ventricular Fibrillation”. If this rhythm is not converted immediately, the patient’s chances of survival decreases. It is believed that for every minute of delay after the onset of Ventricular Fibrillation, the survival rate decreases by approximately 10%.

The definitive treatment for Ventricular Fibrillation is electrical cardiac defibrillation, which is the theme of this training programme.
Definition of Cardiac Arrest

Sudden Cardiac Arrest occurs when the heart stops pumping suddenly. When this happens, the patient immediately loses consciousness and breathing stops.

Causes of Cardiac Arrest

1. Common causes
   • Heart Attack

2. Uncommon causes
   • Drug overdose
   • Suffocation
   • Severe allergic reaction
   • Electrocution

Common Heart Rhythms in Cardiac Arrest

The most common heart rhythms associated with sudden cardiac arrest are:

1. Ventricular Fibrillation (VF): an uncoordinated, irregular heart rhythm resulting in no output from the heart.

![Figure 15: Ventricular Fibrillation](image)

2. Asystole: flat line or a “Dead heart”.

![Figure 16: Asystole](image)
THEORY OF DEFINITION

The Importance of Early Defibrillation

- The majority of people suffering from cardiac arrest have VF. VF is the most common initial rhythm in cardiac arrest. If untreated, it progresses to asystole and death of the patient.
- Immediate or rapid defibrillation is the only effective treatment for VF. The probability of successful defibrillation decreases over time – death rate increases by 10% for every minute without defibrillation.
- VF must be treated immediately. For every passing minute the effectiveness of defibrillation drops. The survival rate decrease by 7-10% for every minute of delay in treating VF.
- VF degenerates to asystole within 8 – 10 mins.
- Minimal chance of success if the patient goes into asystole.
- The AED should be brought to every person in cardiac arrest. Therefore, when calling for the emergency ambulance (995), also call for an AED. Say “Get AED”.

NB: Not all arrested patients will survive. But research shows that early defibrillation and CPR are the most important factors if the patient is to survive.
This graph shows that the chance of survival of a patient who suffers a cardiac arrest due to VF is dependent on the speed in which the Chain of Survival is implemented.

Prior to cardiac arrest, the patient is in normal sinus rhythm. At the time of cardiac arrest the rhythm deteriorates to VF. The graph shows the relationship between the time treatment is given and the survival chance of the patient.

1. The first bar shows that if no CPR is given and defibrillation attempts are delayed, approximately 2% survive.

2. The second bar shows that if early CPR and delayed defibrillation is given, the survival chance increases to 8%. CPR only buys time.

3. The third bar shows 20% survival if early CPR and early defibrillation is delivered.

4. The fourth bar shows 30 – 40% chance of survival when the full Chain of Survival is implemented.

SECTION 3: AUTOMATED EXTERNAL DEFIBRILLATOR

FUNCTIONS

The AED is a device that delivers electrical shock to restart the pumping action of the heart. Its aim is to increase the survival rate of patients suffering from sudden cardiac arrest caused by VF. The function of the AED is to interpret heart rhythm and advise the operator whether or not a shock is needed. A computer algorithm in the AED identifies a shockable rhythm. It will then advise the operator “SHOCK” or “NO SHOCK” through a voice prompt and text message. The AED cannot check whether the patient has a pulse but it can detect any normal or electrical activity.

- A shockable rhythm is usually VF/VT and the AED has a chance to convert the heart rhythm back to normal rhythm.
- A non-shockable rhythm is usually asystole/PEA and the AED will not shock the patient because it will not have a chance of reviving the heart.

Biphasic vs Monophasic AED

Biphasic waveform defibrillators are now available in Singapore hospitals today in which the current flows in a positive direction for a specified duration, after which it reverses and flows in a negative direction. The monophasic waveform defibrillators in which current is delivered in one direction to the patient are still used by some hospitals.
Defibrillators are devices that deliver electrical shocks to treat VFs, allowing the heart to restore its function. AEDs are defibrillators designed to be small in size, lightweight and portable. They generally work on similar basic principles and do the following:

- Analyze the electric rhythm of the heart.
- Determine whether electrical rhythm needs to be shocked.
- If a shock is required it automatically charges to a pre-set energy level. If no shock is required, the device will not charge.
- Deliver electric shocks via attached AED pads.
- Advise the rescuer, through voice prompts, on key actions to deliver the shock, check the casualty or continue CPR.
- Some AEDs provide counting tempo to assist rescuers in chest compressions.

Examples:
Recommended Joules for Monophasic and Biphasic Defibrillation

| Monophasic defibrillation for Adult | Initial (1st) shock and all subsequent shocks – 360 Joules |
| Biphasic defibrillation for Adult | Initial (1st) shock and all subsequent shocks – 150-360 Joules or energy level recommended by manufacturer |
| Defibrillation for Infant and children | *4 Joules/kg Children |

*Paddles should be appropriate for child’s size.

INDICATIONS FOR USE OF AED

1. The AED is used on a patient in cardiac arrest. Cardiac arrest is indicated by:

   Unconsciousness  
   +  
   No Breathing  
   +  
   No Pulse

   *When in doubt, apply the AED*

2. The rescuer has access to an AED, and is competent in its use.
PREPARATIONS OF CASUALTY FOR AED USE

The rescuer must first ascertain that the scene is safe for use of an AED. Avoid the following:

- **Metal surface** – remove casualty from contact with metal surfaces. These can conduct electric currents to the rescuer.

- **Water** – Sweat and moisture are conductors and pose danger to the rescuer. It also reduces the adhesion of pads to the chest wall. If the chest is wet, wipe dry quickly with a towel.

- **Gas** – Flammable gases and oxygen sources pose fire hazards. Move the casualty away from these before applying AED.

Steps in applying the AED Pads

- Expose the chest of the casualty to facilitate application of AED pads. If needed, cut away the clothing.

- Metallic objects such as necklace and chains should be moved away from the pads. These may result in sparking and potential skin burns. Medication patches or monitoring electrodes on the chest wall should be removed as they may interfere with pads placement.

- If chest hair prevents proper pad placement, shave the hair from these sites promptly. AEDs come with a shaver or a blade to expedite this.

Application of defibrillation pads to the chest wall must be done quickly with minimal interruptions to chest compressions. If 2-person CPR is in progress, the rescuer providing the ventilation should prepare and apply the AED pads.

PLACEMENT OF DEFIBRILLATION PADS

1. Open package containing the defibrillation pads with attached cable and connector.
2. With the casualty’s chest prepared, carefully pull off the protective backing from the pads.
3. Place one pad to the right of the upper half of the sternum (breastbone), just below the casualty’s right clavicle (collarbone) and place the other pad just below and to the left of the left nipple. For female casualty, place it just below and to the left side of the breast. Do not place it over the breast. For casualty with a pace maker/implantable cardiac defibrillator, apply the pads at least four fingers breadth away from these devices.
4. Ensure that the electrodes are firmly attached by gently pressing the pad with fingers over the centre and around the edges to avoid “air-trap” to provide good adhesion. Good contact increases shock efficiency.
5. Press the ON button, some AED would automatically turn ON when the AED cover is lifted.
6. Plug the connector end of the cable into the AED.

SAFETY ISSUES

Safety is very important for the casualty, the AED operator and the bystanders. Hence, AED must only be used by personnel who are trained and authorised to use it. It is the responsibility of the AED operator to:
• maintain his/her knowledge and skills in AED
• ensure that the area around the patient is clear

1. It is important not to allow anyone to come in contact with a casualty during

(a) Analysis : The defibrillator reads electrical activity in the heart through electrodes. CPR activity, touching or moving the patient can interfere with the accuracy of the machine’s reading.
(b) Defibrillation : Ensure that no one is touching the casualty when shock is delivered as electricity can be transmitted.
2. The casualty should not be placed on wet or metal surfaces when the AED is used on him/her as water and metal are good conductors of electricity. If there is water/metal between the casualty and the rescuer/AED operator/bystander, electricity can be transmitted to them. If the casualty is on a

(a) **WET** surface, remove the casualty to a dry area:
(b) **METAL** surface, place blankets between the casualty and the metal contact.

3. The defibrillator should not be used in the presence of flammable gases and explosive environments.

### DO NOT DEFIBRILLATE when

- **Casualty is responsive, breathing or has a pulse**
- **Someone is touching the casualty**
- **There are flammable gases or in explosive environments**

### EXERCISE CARE when

- **Casualty is on a wet or metal surface**
MEDICAL PROTOCOL

The AED Machine is programmed according to local medical guidelines on defibrillation.
1. Verify cardiac arrest – no response, no breathing and no pulse or signs of circulation
2. Start CPR (30 compressions & 2 ventilations) while awaiting AED
3. Prepare chest area for placement of defibrillation pad
4. Continue CPR till AED is attached to casualty
5. If shockable ECG rhythm is detected, the AED will charge up according to pre-set energy level (150 joules for biphasic defibrillator, 360 joules for monophasic defibrillator)
6. CPR advised for 1 minute:
   - following every shock or
   - if the AED detects a non-shockable rhythm and the casualty has no pulse or signs of circulation
7. Check for pulse or signs of circulation:
   - if the AED detects a non-shockable rhythm

Successful Defibrillation

At any time after a shock:
1. if there is pulse or signs of circulation, maintain an open airway by placing casualty in the recovery position. Do not disconnect the AED but continue to monitor the casualty every 2 minutes until handed over to medical personnel

Unsuccessful Defibrillation

1. It is important to note that defibrillation may not be successful in all situations, especially if the casualty has arrested cardiac for some time
2. Check for pulse or signs of circulation if “no shock” is advised. If absent, continue CPR for one minute before subsequent analysis by the AED or until the arrival of the ambulance

When to stop Defibrillation

1. When prompted by the AED
2. When a doctor directs the resuscitation to cease or when ambulance arrives
3. when the person has been successfully resuscitated
**MEDICAL PROTOCOL – AED OPERATIONAL CHART**

**VERIFY CARDIAC ARREST**
- Check Response
  - (No) → Call 995/get AED
- Check for pulse/* signs of circulation and breathing
  - (No) → Give 2 ventilations

**SHOCK ADVISED**
- **NO**
  - Check for pulse/* signs of circulation
    - Absent → Resume CPR 30:2 for 1-2 minutes
    - Present → Resume CPR 30:2 for 2 minutes
- **YES**
  - Press to shock
    - Resume CPR 30:2 for 2 minutes
    - Recovery position & monitor pulse/* signs of circulation every 2 minutes

* Signs of circulation = conscious, moving, breathing & coughing
** AED should remain connected until casualty is handed over to medical personnel
ROLES & RESPONSIBILITIES OF THE RESCUER

1. High priority of defibrillation – respond immediately when call for assistance is heard.

2. Rapid defibrillation – verifies that the casualty is in cardiac arrest and set up AED.

3. Scene control – ensure all surrounding bystanders do not crowd around the casualty. The importance of scene control cannot be stressed strongly enough. In the presence of the casualty’s family members, friends or bystanders, the use of a defibrillator in a resuscitation situation can create stress to the AED operator and may compromise the safety of those present.

4. Ensure that medical assistance has been called (activate Doctor/code blue team OR Call 995, when it is outside the hospital).

5. AED and first aid equipment are available.

6. Professional conduct – be confident in what you are doing. Avoid disagreeing with your colleagues

7. Rescuer/AED operator are required to minimize possible interference from bystanders and improve self-confidence by:
   • Assessing the scene upon arrival. Besides the casualty, the AED operator should attempt to identify significant bystanders.
   • Assigning a relative/friend of the casualty to look after those present. Allocation may promote a feeling of self-worth and value in the bystanders, such as getting someone to look after relatives/friends of the casualty.
   • Maintaining a calm and confident manner during the situation. Regular communication with significant bystanders (such as family members) is essential. The AED operator should quickly tell them what they intend to do and how they are going to do it.
   • Not disagreeing with colleagues. Dissent in treatment options should be presented as if a discussion of options is taking place.
   • Responding to changing attitudes with the bystanders, especially if the resuscitation is not going well.
   • Maintaining a professional attitude at all times. The rescuers must not use derogatory terms, swearing, or language that may be misconstrued.
   • Giving a complete summary of the resuscitation effort to the receiving emergency service, providing comprehensive casualty care and ensuring the professional standing of the rescuer.
   • If a doctor or trained paramedical personnel is present, give a brief summary of what has happened and what has been done. Then continue to assist as necessary.
DOCUMENTATION

It is the responsibility of the AED operator to document all incidents and information related to the use of the AED.

The following information should be documented:

- Name of casualty, AED operator and bystander who helped in the CPR+AED
- Mark the time of collapse and the time AED was put on.
- Mark the time of each shock and record the total number of shocks delivered.
- Time of ambulance arrival and when the casualty is transported the ambulance by the crew.
SECTION 5 : OPERATING PROCEDURES OF DEVICES

5.1 OPERATING PROCEDURES OF HEARTSTART FR2

A. Introduction

The Heartstart FR2 AED is lightweight, portable and battery powered. Voice prompts provide instructions and patient information, and are reinforced by messages on the LCD screen.

The Heartstart FR2 detects ECG signals and delivers the defibrillation shock using two self adhesive defibrillation pads. The defibrillation pads, cable and connector are supplied as one disposable assembly. It determines proper defibrillation pad contact by monitoring impedance between the two attached defibrillation pads.

The defibrillation shock is delivered using an impedance compensated biphasic waveform of 150 joules. The defibrillation shock can be delivered using the SHOCK Button. The Forerunner will not deliver the shock unless the SHOCK button is delivered.

B. Features Of The Heartstart FR2
<table>
<thead>
<tr>
<th>FEATURES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>On / Off</td>
</tr>
<tr>
<td>B</td>
<td>Status Indicator</td>
</tr>
<tr>
<td>C</td>
<td>Battery Latch (Lithium Battery)</td>
</tr>
<tr>
<td></td>
<td>Microphone</td>
</tr>
<tr>
<td>D</td>
<td>Optional Manual Over-ride Button (Available on Model EM only)</td>
</tr>
<tr>
<td>E</td>
<td>Contrast Buttons</td>
</tr>
<tr>
<td>F</td>
<td>Disposable/ Recyclable Battery</td>
</tr>
<tr>
<td>G</td>
<td>Optional PC Data Card</td>
</tr>
<tr>
<td>H</td>
<td>LCD Screen</td>
</tr>
<tr>
<td>I</td>
<td>Shock Button</td>
</tr>
<tr>
<td>J</td>
<td>Speaker</td>
</tr>
<tr>
<td>K</td>
<td>Defibrillation Pad Placement Illustration</td>
</tr>
<tr>
<td>L</td>
<td>Connector Socket</td>
</tr>
<tr>
<td>M</td>
<td>Defibrillation Pads</td>
</tr>
</tbody>
</table>
C. Operating Steps Of Heartstart FR2

STEP 1 - PREPARATION

Press the On / Off button to turn on the Heartstart FR2.

Follow the instructions provided by the FR2 voice and screen prompts in the order indicated.

- Remove clothing from the patient’s chest. Wipe moisture from the patient’s chest and clip or shave excessive chest hair, if necessary.
- Open the defibrillation pads package. Check to see that the pads, the attached cable and connector are undamaged.
- Pull off the protective backing from the defibrillation pads and check that the gel has not tried out. If the pads are damaged or the gel has dried out, use a new set of pads.
- Place each pad on the patient. The pads must be placed with the sticky side on the patient’s skin.

IMPORTANT:

Refer to the drawing on the back of each pad for correct positioning. One pad goes just below the patient’s right collarbone, and the other one goes over the patient’s ribs in line with the armpit and below the left breast.

- Connect the pads to the Heartstart FR2. Insert the defibrillation pads connector firmly in the connector socket. A flashing light shows you where the socket is located, at the top left of the Heartstart FR2.
STEP 2 - ANALYSIS AND MONITORING

Follow the instructions provided by the Heartstart FR2 voice and screen prompts in the order indicated.

- As soon as the FR2 detects the defibrillation pads are connected properly, it automatically begins analysing the casualty’s heart rhythm.

- If no shock is advised, the Heartstart FR2 provides voice and screen prompts to tell you so. The FR2 instructs you to perform CPR if needed, and performs background monitoring of the casualty’s heart rhythm while you give appropriate care to the casualty.

- No more voice prompts are given, until and unless the Heartstart FR2:
  - detects a change in the casualty’s heart rhythm that may be a shockable rhythm, or
  - detects interference with rhythm analysis.

- If the Heartstart FR2 detects a potentially shockable heart rhythm, it automatically goes back to analysing the rhythm to see if a shock is advised.

- If a shock is advised, the Heartstart FR2 charges to prepare for shock delivery. It gives the voice warnings and screen prompts to tell you that a shock is advised.

- Make sure no one is touching the patient.

- While the Heartstart FR2 is charging, it continues to analyse the casualty’s heart rhythm. If the rhythm changes and a shock is no longer appropriate, the Heartstart FR2 disarms and dumps the charge. Voice and display prompts advise you what action to take.

**Note**

*When the Heartstart FR2 is fully charged, you can disarm it at any time by pressing the On/Off button to turn off the FR2 and return it to standby mode.*
**STEP 3 - SHOCK DELIVERY**

Press the SHOCK button to deliver the shock.

*Important:*
You must press the button for a shock to be delivered. The Heartstart FR2 will not automatically deliver a shock.

- There are four ways you can tell that the Heartstart FR2 is ready to deliver a shock:
  - You hear a voice prompt telling you to deliver a shock,
  - You see the Shock button flashing,
  - You hear a steady tone, or
  - You see a screen prompt telling you to press the orange (Shock) button.

- After you press the Shock button, a voice prompt tells you the shock was delivered.
- Immediately after a shock, the Heartstart FR2 will provide a pause for 1 minute of CPR.
- The Heartstart FR2 goes back to analysing the casualty’s heart rhythm immediately after 1 minute of CPR. The Heartstart FR2 continues to provide voice and text prompts to guide you through additional shocks, if appropriate.

*Note*
If you do not press the Shock button within 30 seconds of being prompted, the FR2 will disarm itself and provide a pause for CPR.

- Pause for CPR. The Heartstart FR2 is programmed to automatically pause for 1 minute after every shock to allow you to perform CPR. After the voice and screen prompts tell you that the FR2 has paused, there are no further voice prompts during the rest of the pause, so that you can provide uninterrupted care.
- During the pause, the FR2 screen shows a bar that fills in as the pause time is used up. The screen also shows how much time has gone by since the FR2 was turned on, and how many shocks have been delivered.
### D. Troubleshooting

If the Forerunner detects an error condition or system fault during use, it provides a voice or display prompt, or a combination of both. The following are the common errors:

<table>
<thead>
<tr>
<th>Error Condition</th>
<th>Corrective Action by AED Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Prompt of the following:</td>
<td>• Install a new battery and observe the BIT (Battery Insertion Test).</td>
</tr>
<tr>
<td>- not ready for use</td>
<td>• If the BIT fails, contact the Heartstart FR2 customer service.</td>
</tr>
<tr>
<td>- self test failed</td>
<td></td>
</tr>
<tr>
<td>The Status indicator displays a flashing or solid red X.</td>
<td></td>
</tr>
<tr>
<td>A screen prompt alerts to low battery condition.</td>
<td>• Replace the battery as soon as possible.</td>
</tr>
<tr>
<td>A screen prompt instructs to replace the battery immediately. The Status Indicator displays a flashing red X.</td>
<td>• Replace the battery immediately.</td>
</tr>
<tr>
<td>Status Indicator does not light up.</td>
<td>• Install a new battery and observe the BIT. If the BIT fails, contact the Heartstart customer service.</td>
</tr>
<tr>
<td>Voice &amp; screen prompts instructs to attach the defibrillation pads &amp; to plug in the connector.</td>
<td>• Check the defibrillation pads connector.</td>
</tr>
<tr>
<td></td>
<td>• Check the defibrillation pads on the patient &amp; position the defibrillation pads on the patient as shown by the illustration on the defibrillation pads.</td>
</tr>
<tr>
<td></td>
<td>• If necessary, wipe moisture from the casualty’s chest &amp; shave excessive chest hair.</td>
</tr>
<tr>
<td></td>
<td>• Replace the defibrillation pads if the prompt continues.</td>
</tr>
<tr>
<td>Voice &amp; screen prompts to check the defibrillation pads or to press the defibrillation pads firmly to the casualty’s chest.</td>
<td>• Check that the defibrillation pads are not applied to clothing.</td>
</tr>
<tr>
<td></td>
<td>• Press the pads firmly to the patient’s bare chest.</td>
</tr>
<tr>
<td>Voice &amp; screen prompts to replace the defibrillation pads.</td>
<td>• Replace the defibrillation pads.</td>
</tr>
<tr>
<td>Voice &amp; screen prompts that the ECG analysis has been interrupted.</td>
<td>• Discontinue CPR; do not touch the patient. Attempt to eliminate patient motion, if possible.</td>
</tr>
</tbody>
</table>
**SUMMARY**

**Defibrillation Procedures** *(Pg 33)*

Steps:

1. The AED will initially analyze the heart’s electrical rhythm. It will give a voice prompt, such as “ANALYZING HEART RHYTHM. DONOT TOUCH THE CASUALTY”.

   If you hear this, stop CPR. Donot move away from the casualty. Do not allow others to touch the casualty while the AED is analyzing.

2. Spread your arms apart and say clearly “Stand Clear”.

3. If the casualty has a shockable rhythm (i.e. VF), it will charge automatically. Charging takes a few seconds and may be indicated by a wailing siren from AED.

4. While the AED is charging the rescuer should continue CPR.

5. Once the AED is fully charged, it will prompt the rescuer “PRESS THE SHOCK BUTTON NOW”. The rescuer then states clearly “Stand Clear”, ensures quickly that no one is touching the casualty, and then depresses the shock button on the AED firmly for two seconds before releasing it.
SUMMARY

Defibrillation Procedures (Pg 33)

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6. Once the shock is delivered, restart chest compressions. Continue the 30:2 CPR cycles for 1-2 minute until the AED repeats the voice prompt: “ANALYZING HEART RHYTHM. DO NOT TOUCH THE CASUALTY”.

7. If the AED prompts: “NO SHOCK ADVICE”, RESTART CPR immediately.

8. When the casualty starts breathing or moving and showing signs of life, place him in a recovery position. Continue to monitor the casualty till help arrives.

9. Throughout this period, the AED should remain connected to the casualty

AED Application Sequence (Pg34)

Apply AED pads while CPR is in progress
   Continue CPR Steps - A - B - C
   Open AED box
   Prepare chest
   Apply pads - right and left chest
   Turn AED on + plug in connector
   Analyze rhythm
* Checking and monitoring of pulse may only be done by trained healthcare workers. Members of the public would only need to check breathing during the regular monitoring of the casualty. While the pulse check is an additional tool that healthcare workers may use, it does not suggest any superior form of evaluation. Any such pulse check should not prolong interruptions to chest compression if CPR is in progress. The combination of pulse and breathing checks should not take longer than 10 seconds.
Port-Inscent Procedure (Pg36-37)

Hand-over to emergency service

When emergency crew takes over the casualty, provide them with a summary of the events that has occurred:

- Time of collapse (best estimate)
- Type of CPR done? 30:2 CPR or compression-only CPR
- Whether the AED was used
- How many shocks were given?
- Any previous medical history and medications, if known.
- If available, provide a document that lists these events.

Assist the crew

- until casualty is loaded onto the ambulance
- The defibrillation cable with pads will go with the casualty in the ambulance.

Resetting the AED for future use

Inform the facility or safety manager, in case of commercial establishments or work places, or the local community centre or management office for residential areas that the AED has been used.

The person in charge of the AED has the following responsibilities:

- Replace the AED pads, the shaver kit, the towel, the gloves, if used
- The AED battery must be checked for possible replacement. Contact the vendor of the AED device for advice on this.
- If the AED was removed from a box with a key in a thin glass window, the glass may have been broken to retrieve the key. This glass piece would need to be replaced and the key placed back in this holder.
- Most AEDs have a chip that records the resuscitation sequence. Get the AED vendor to print the record from this chip. It is useful for audit and quality assurance purposes.

Maintenance of AED

AEDs are almost maintenance-free. Replacement of consumed items in the AED has been described above.

The battery indicator on the AED needs to be checked daily to ensure that it is still functional. Once it gives a low-battery display, steps to replace the battery promptly should be undertaken.
**AED Deployment (Pg47)**

NRC recommends the following standards for AED deployment:

- AEDs should be deployed at strategic places, where it could be brought to a cardiac arrest victim within 3 minutes of collapse.
- AEDs should be accessible to all users. They should not be stored away or kept under lock.
- AEDs should be made available to any members of the public who wishes to help cardiac arrest casualties.
- AEDs deployment site should be visible

**Paediatric Defibrillation (Pg38-42)**

**Use of AED in Children**

Out-of-hospital cardiac arrests in children are usually from non-cardiac causes with majority of the patients presenting with non-shockable cardiac rhythms (asystole or pulseless electrical activity).

Thus proper ventilation and oxygenation are critical in paediatric resuscitation.

However, ventricular fibrillation in out-of-hospital paediatric arrest also occurs. Reviews of out-of-hospital paediatric cardiac arrest have reported incidence of shockable rhythms - ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT) - as the initial cardiac rhythm to be from 5-19%. However, this may be underestimated as AEDs may not be routinely used in all pediatric out-of-hospital arrests. School going children and adolescents are reported to have a higher incidence of shock rhythms compared to infants, toddlers and pre-schoolers.

There is also a higher reported incidence of paediatric shockable rhythms (VF or pulseless VT) seen in the inpatient setting even for the younger age groups.

**AED Energy Dose and Rhythm Recognition in Children**

The optimal energy dose required for pediatric defibrillation is unknown. An initial energy dose of 4 J/kg of either waveform (monophasic or biphasic) is reasonable when treating VF or pulseless VT in infants and children. Lower dose of 2J/kg may be less effective than 4 J/kg.

Doses above 4 J/kg and up to 10 J/kg (but not exceeding adult dose) may also be safe and effective.

Most paediatric-specific pads will deliver 50-75 J.

AEDs are capable of accurately identifying arrhythmias in children and are very unlikely to advise a shock inappropriately.
Recommendation for AED Use in Children

The International Liaison Committee on Resuscitation advocates early use of AEDs on children to analyse rhythms and provide defibrillation in cases of cardiac arrest with shockable rhythms. When recognised early and treated rapidly, paediatric patients with VF or pulseless VT have a higher survival rate than those with other rhythms.

It is recommended that a paediatric dose-lowering system be used in children aged 1-8 years to reduce the energy dose delivered by the AED. This may be done either via a paediatric-specific pad-cable system or an AED with a key or switch to select a smaller dose. If a paediatric dose-lowering system is unavailable, then a standard AED should be used.

A manual defibrillator is preferred for infants aged younger than 1 year. If one is not available, then an AED with a dose attenuator may be used.

Evidence for Community AED Use on Children

The use of public access-AEDs is associated with significantly higher rates of 1-month survival and favourable neurological outcomes.

A study compared AED use by untrained sixth-grade students versus trained paramedics and emergency medical technicians (EMTs) in mock cardiac-arrest scenarios. Mean time to defibrillation from arrival to scene was 90 seconds for the sixth-grade students and 67 seconds for the trained paramedics and EMTs. More importantly, there was no significant difference between the 2 groups in proper pad placement or clearing the victim before defibrillation. This study showed that AEDs are easy to use and that untrained bystanders can successfully use the AEDs just by following the device’s visual and audio prompts.

Another study looked at paediatric residents’ time to defibrillation using an AED versus a manual defibrillator during a mock paediatric cardiac arrest scenario. Successful defibrillation was achieved by the residents using an AED in a median time of 60 seconds, whereas the median time to defibrillation for manual defibrillator was 103 seconds.

Summary for AED Use in Children

- AEDs can be used safely for children aged one year or more.
- AEDs are capable of accurately identifying arrhythmias in children; in particular, they are very unlikely to advise a shock inappropriately.
- Those aged 1-8 years should preferably be defibrillated with paediatric pads or the AEDs should have software that lowers the output of the machine to 50-75 joules (recommended for children 1-8 years old).
- If an attenuated shock or manually adjustable machine is not available, an unmodified adult AED may be used in children more than one year old.
- For patients less than one year old, the incidence of shockable rhythms is very low except when they suffer from cardiac disease.
- In these cases, the risk/benefit ratio may be favourable, and the use of an AED (preferably with dose attenuator) should be considered.
Steps for AED Use on a Child

1. The initial preparation is similar to adults.
2. Wipe the chest and back clean and dry.
3. Remove the child defibrillation pads protective cover.
4. Check for recommended paediatric defibrillation pads placement on the cover.

Placement of Defibrillation Pads for Children

1. Attach the child defibrillation pads on front and back (anterior-posterior) as shown:

   ![Anterior-Posterior Electrode Placement](image)

   OR

2. Anterior-anterior defibrillation pads placement if advised. Ensure that the pads are not touching and are at least 1-2cm apart.

   ![Anterior-Anterior Electrode Placement](image)

   If the pads are touching, apply front (right pad on central sternum) and back (left pad on the upper back between the shoulder blades).
Paediatric CPR - AED Protocol Summary

Check Response

NO response or movement
Send someone to phone 995, get AED if available;
For lone rescuers, PHONE 995 and get AED if available after 5 cycles / 2 minutes
Position patient face up on a flat, hard surface

Open AIRWAY, check BREATHING

If NO breathing or only GASPING

Healthcare Workers
Check for signs of life or pulse check within 10 seconds
No definite pulse or No signs of life

Start 30 COMPRESSIONS followed by 2 BREATHS
Push hard and fast (100-120/min) and release completely
Minimise interruptions to chest compressions

Infants (<1 year old): Continue CPR till paramedics arrive or victim starts to move
Child (>1 year): Continue CPR, attach AED with attenuated pads after 5 cycles / 2 minutes

Give 1 shock
Resume CPR immediately for 5 cycles / 3 minutes

Shockable

Child >1 year
Check Rhythm
Shockable/rhythm?
Not Shockable

Resume CPR immediately for 5 cycles / 2 minutes
Check rhythm every 5 cycles / 2 minutes
Continue until paramedics take over or victim starts to move

RESCUE BREATHING:
Give 1 breath/ventilation every 3 seconds
Recheck for signs of life or pulse every 2 minutes

Definite pulse or signs of life

* Post intubation for cardiac arrest:
Compression 100-120/min
Ventilation 8-10/min (Asynchronous)
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