SRFAC
SINGAPORE RESUSCITATION AND FIRST AID COUNCIL

Cardio-Pulmonary Resuscitation and Automated External Defibrillation (CPR+AED) Provider Course Manual

REV 1 / 2022

CONTENTS

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CHAPTER 1

Cardiac Arrest and You

1.1: INTRODUCTION

Based on national health statistics from the Ministry of Health in 2019, Singapore, ischemic heart disease (lack of blood circulation to heart muscles) is the **third most common cause of death, contributing to 18.8% of total mortality**.

A person with heart disease is prone to a heart attack, which could result in cardiac arrest and sudden death. According to a study conducted in Singapore*, the crude incidence rate of Out-of-Hospital Cardiac Arrest (OHCA) in 2019 was 56.7 per 100,000 population in 2019 (**3233 casualties**), of which, **2239 cases (74%)** of cardiac arrests occur in the home. Bystander CPR was performed on **1937 casualties (60%)** and bystander defibrillation was performed on **340 (10.5%)** of them. Out of **200 survivors (6.2%), 156 (4.8%)** of them survived to be discharged with good-to-moderate neurological functions.

Survival from sudden death can be maximized 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 anyone, anywhere and anytime. All that is needed is the rescuer's two hands.

** White AE, Shaidah N, Asyikin N et al. Singapore Out-of-Hospital Cardiac Arrest Registry Report 2011-2019. July 2021. Republic of Singapore. Unit for Pre-hospital Emergency Care.*

1.2: THE HEART, LUNGS AND CIRCULATION

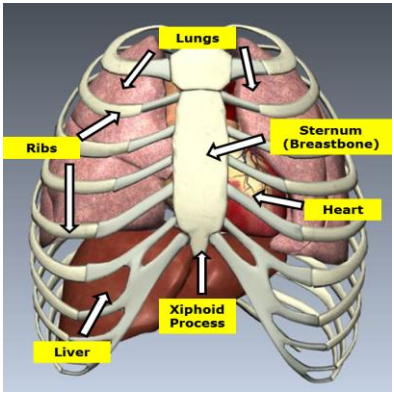


Figure 1-1 - The heart and lungs

The heart is a muscular pump located in the center of the chest and slightly towards the left. (See figure 1-1)

The heart has two halves. The right side receives low oxygen blood from all parts of the body through veins and pumps it to the lungs via the pulmonary arteries to pick up oxygen. (See figure 1-2)

The left side receives oxygen-rich blood from the lungs through the pulmonary veins and delivers it to all parts of the body, including the vital organs such as the heart, lungs, kidneys and brain.

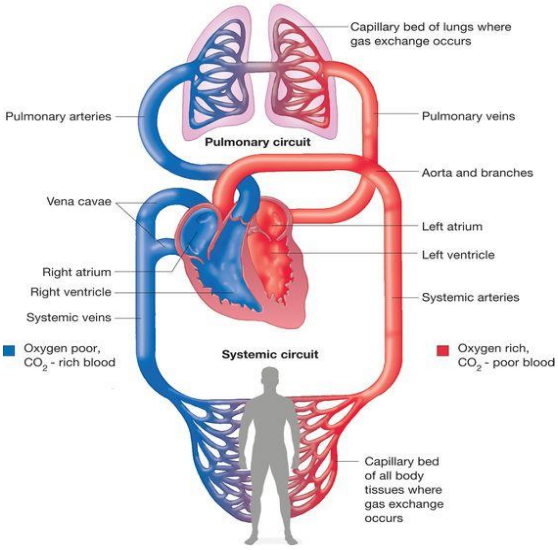


Figure 1-2 - The circulatory system

The heart muscles receive oxygen rich blood via a set of coronary arteries.

The pumping action of the heart is initiated by electrical signals from a pacemaker (sinoatrial or SA node), these signals travel to other parts of the heart in an orderly manner through a conductive network. The electrical signals from the heart can be picked up by an electrocardiogram (ECG). (See figure 1-3)

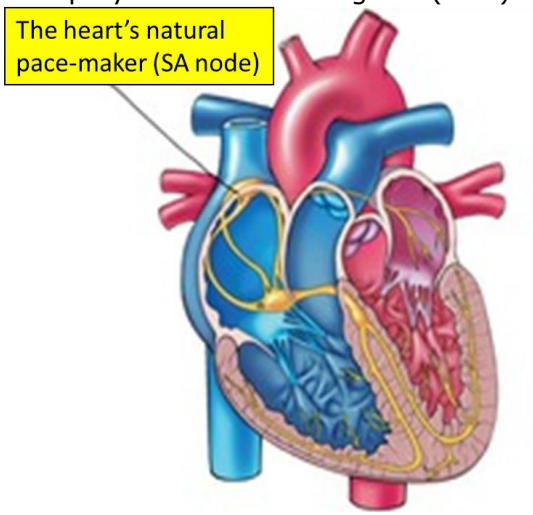


Figure 1-3 - The heart's electrical conduction

The pumping action gives rise to an organized heart-beat at regular rate of 60-100 beats per minute in a normal person.

On an ECG, normal heart rhythm, also known as the Normal Sinus Rhythm, appears as below (see figure 1-4):

Figure 1-4 - Normal Sinus Rhythm

The human body has two lungs which absorb oxygen from the air that is breathed in. 21% of air consists of oxygen, of which 5% is extracted by the lungs. The extracted oxygen is passed to the blood within the capillaries of the lungs. The capillaries confluence into the pulmonary vein, which transports the oxygenated blood into the left side of the heart. (See figure 1-5)

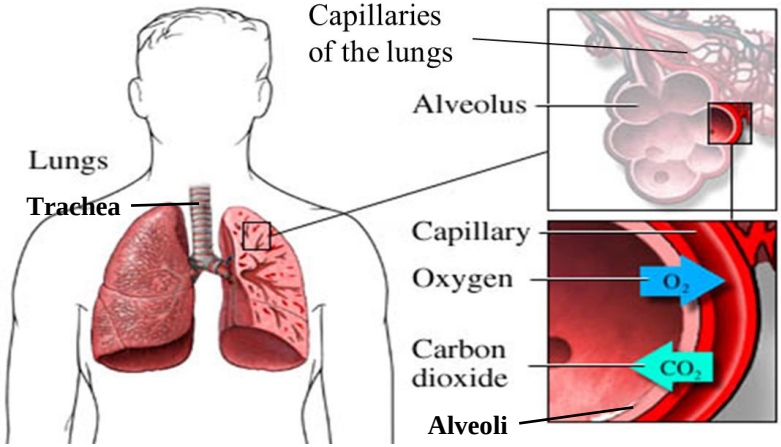


Figure 1-5 - Exchange of Oxygen and Carbon Dioxide in the lungs

The remaining 16% of unabsorbed oxygen is breathed out. This is extremely important in the context of mouth-to-mouth ventilation; the air that the rescuer ventilate into a cardiac arrest casualty can deliver sufficient oxygen to save and sustain life.

1.3: RISK FACTORS FOR HEART ATTACK

Survival rates of Sudden Cardiac Arrest is dismal even in the best cities. Prevention is of paramount importance to prevent heart attack from occurring. Several key risk factors contribute to the development of a heart attack. Human Beings 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 by two-fold. This habit should be avoided altogether. (See figure 1-6)

Figure 1-6 - Avoid smoking

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 and check their blood pressure regularly as instructed. (See figure 1-7)

Figure 1-7 - Check your blood pressure regularly

Blood Sugars – Avoid a diet high in carbohydrates or refined sugars and control body weight through diet and exercise. (See figures 1-8 and 1-9) If you have diabetes, take your medications regularly as instructed.

Figure 1-8 - Eat healthily

Blood Lipids - Manage blood lipids (fats) by avoiding foods high in fats. Doing regular exercise could improve your blood lipid profile and take your medications regularly as instructed. (See figure 1-9)

Adopting healthy lifestyles by not smoking, eating foods in moderate amounts and regular exercise will decrease the risk of heart disease and other illnesses.

Figure 1-9 - Exercise regularly

1.4: WHAT HAPPENS IN A HEART ATTACK?

A heart attack occurs when cholesterol deposits and / or blood clots block one of the coronary arteries supplying the heart muscle. (See figure 1-10) The heart muscles beyond the blocked vessel dies due to lack of oxygenated blood. This is heart attack.

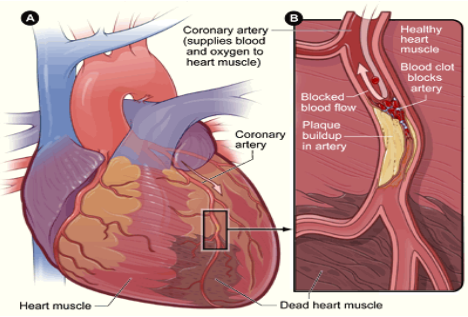


Figure 1-10 - Blocked coronary artery

Symptoms of a Heart Attack

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

Pain – described as tightness or discomfort either over the chest or upper part of the abdomen. (See figure 1-11) This pain may also spread to the left shoulder, left arm, neck or lower jaw. Some may mistake this for indigestion or fatigue.

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.

Figure 1-11 - Pain or discomfort over the chest or upper abdomen

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

1.5: 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 electrical signals within the heart is disrupted. This is a dangerous situation and an irregular, chaotic electrical rhythm called Ventricular Fibrillation (**VF**) develops in many cases (see figure 1.12).

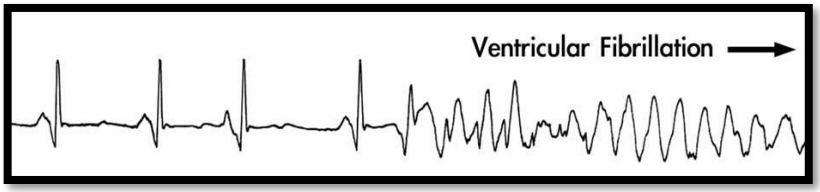


Figure 1-12 - Normal Sinus Rhythm to Ventricular

When VF occurs, the heart does not pump the blood to the rest of the body. This is a state of **cardiac arrest** and the casualty will be unconscious and stops breathing normally.

Biological death and Clinical death

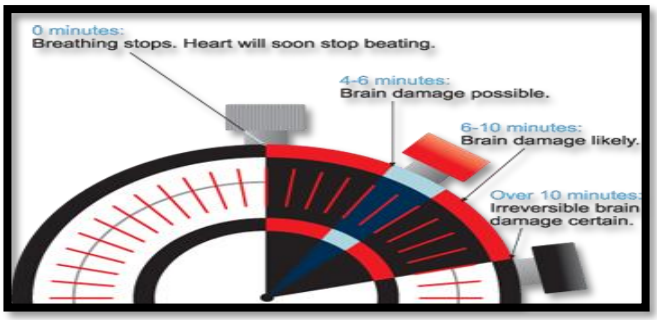


Figure 1-13 - Irreversible brain damage after 10 minutes

When cardiac arrest occurs, the heart stops pumping and circulation stops. The oxygen level in the blood decreases, causing brain damage. If this situation is reversed immediately, survival chance could be as high as 90%. With a 6 minutes delay, this drops to 40–50% and at 9 minutes, it is a dismal 10%. (See figure 1-13) This is known as clinical death. Unless the circulation is restarted quickly, organ death will start to occur. The most sensitive organ is the brain and if the

circulation to the brain is not started within about 4 minutes, permanent and irreversible brain damage will start to occur. This is known as biological death. It is therefore important to start CPR as quickly as possible

Air contains approximately 21% oxygen at sea level. During its passage through the body, only about ¼ of oxygen is utilised and hence exhaled air contains approximately 16% oxygen. When mouth-to-mouth ventilation is done during CPR, there is sufficient oxygen in the exhaled air to keep the casualty alive. Chest compression squeezes the heart between the breastbone and the spine, thereby helping to circulate the blood and deliver oxygen to the vital organs, especially the brain.

Immediate CPR and defibrillation are key components for increased chances of survival.

1.6: OTHER COMMON CAUSES OF CARDIAC ARREST

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

Figure 1-14 - Other common causes of cardiac arrest

Death in these situations can be prevented if someone trained in CPR and first-aid skills provides prompt help.

1.7: THE CHAIN OF SURVIVAL

The essential steps for helping a cardiac arrest victim are illustrated in a system called the "Chain of Survival". The seven rings in this chain are: Prevention, Early Recognition and Access, Early CPR, Early Defibrillation, Emergency Medical Services (Ambulance), Advanced Cardiac Life Support and Recovery. (See figure 1-15)

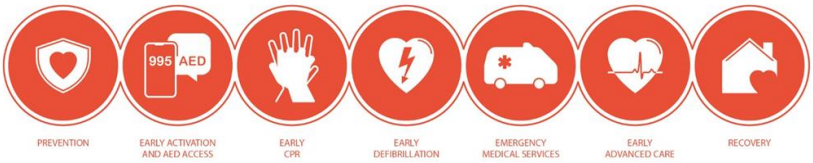


Figure 1-15 - The chain of survival

First Ring: Prevention
Prevention is better than intervention. A healthy diet and lifestyle can reduce the risk of heart diseases. Going for regular medical check-ups can help detect problems early and prompt the individuals to seek treatment early and adjust their diet and lifestyles.

Second Ring: Early Activation and AED Access
Call for ambulance (dial 995) and get an AED if visible and near-by. Follow the SCDF dispatcher's instructions.

Third Ring: Early CPR
The brain cells start dying within 4-6 minutes of cardiac arrest. CPR must be initiated as soon as possible to provide blood and oxygen flow to the brain and heart.

Fourth Ring: Early Defibrillation
Automated external defibrillators (AEDs) are increasingly available in the community, at lift lobbies, void decks, gymnasium, shopping malls, hotels, airports and schools etc. Apply onto the casualty and be ready to defibrillate.

Fifth Ring: Emergency Medical Services (Ambulance)
Quick access to the scene and transport to the hospital makes a difference to the casualty's chances of survival.

Sixth Ring: Advanced Cardiac Life Support
Medical teams will provide advanced cardiac life support at the hospital with the use of Intravenous/Intraosseous (IV/IO) medication and delivery of oxygen via mechanical systems (ie. Bag-Valve Masks and ventilators).

Seventh Ring: Recovery
To ensure a good survival outcome after OHCA requires continued community and medical support (ie. social services, physio/occupational therapy, nutritional guidance, etc) and therapy to re-habilitate the individual back to normalcy.

1.8: SCDF MYRESPONDER MOBILE APPLICATION

In Singapore, many of the emergency cases SCDF responds to could be quickly attended to by members of the public even before SCDF's arrival. For example, more than 3000 people suffer from Out-of-Hospital Cardiac Arrest (OHCA), with a survival rate of just 5%, which could be improved by simple medical intervention within the first few critical minutes. At the same time, there are more than 1,000 minor fires (such as rubbish chute/bin fire) that could easily be extinguished using publicly-available means. (See figure 1-16)

Cardiac Arrest	• Accept the myResponder alert, and proceed to the given location • You may use the app to locate nearby AEDs • Upon arrival at the patient's side, perform CPR, or apply an AED • Hand-over the case to the SCDF paramedics when they arrive
Minor Fire	• Accept the myResponder alert, and proceed to the given location • Extinguish the fire using available means, such as nearby extinguishers, buckets of water, domestic water taps and hoses, or drencher systems for rubbish chutes • Provide SCDF with up to 3 photos for scene assessment
Major Incident	• Accept the myResponder alert, but do not proceed any closer to the given location • Provide SCDF with up to 3 photos and 1 video of the developing incident, if it is safe to do so • If you receive any instructions for evacuation, do so immediately

Figure 1-16 – Incidents that will trigger myResponder notifications

Figure 1-17 – The myResponder mobile application is available on Apple and Android stores.

myResponder is an application by SCDF to alert members of the public to nearby fire and medical cases, and thereby save lives and increase the survival rate for OHCA, as well as mitigate minor fires in the first few critical minutes. myResponder is also a means by which members of the public may be asked to provide onsite information (via submission of photos and videos) for SCDF to gain an understanding of the situation. Through the 'Call 995' button in the app, users can also send their geolocation to SCDF's 995 Operations Centre, enabling SCDF to dispatch the emergency resources to the scene sooner.

myResponder works by notifying members of the public – also known as Community First Responders (CFRs) – of cardiac arrest and fire cases within 400m of their location. myResponder will also highlight nearby AEDs that may be available to responders, and provide guided advisories in the mitigation of minor fires. CFRs can then proceed to the stated location and assist by performing CPR or applying an AED to revive the patient, mitigating minor fires using available extinguishing means, or providing further information to SCDF's 995 Operations Centre.

Response is entirely voluntary, however, volunteers are encouraged to respond, when they are available and within safe and reasonable means.

Fig 1-18 – The above QR code works for both Apple iOS and Google Android OS and will direct to the App Store or Google Play respectively. The myResponder function is also available within the SGSecure application.

CHAPTER 2

Cardio-Pulmonary Resuscitation (CPR)

2.1: THE IMPORTANCE OF EARLY CPR

2.2: ADULT ONE-RESCUER CPR

2.3: CPR IN SPECIAL CIRCUMSTANCES

2.1: THE IMPORTANCE OF EARLY CPR

When the heart stops beating, blood stops flowing through the body. Unless the flow is restarted quickly, other organs in the body will stop functioning. For example, if the blood does not flow to the brain for 4 to 6 minutes, it could result in brain death. CPR is a series of actions required to restart the heart and get the blood flowing once again as soon as possible.

CPR includes mouth-to-mouth ventilation and chest compressions. When mouth-to-mouth ventilation is done during CPR, oxygen is introduced into the body. However, in view of COVID-19 pandemic, healthcare providers were taught on the use of bag-valve-mask (BVM) instead of mouth-to-mouth (MTM) ventilation. Chest compression squeezes the heart between the breastbone and the spine and thereby helps to circulate the blood and deliver the oxygen to the vital organs, especially the brain, heart, and kidneys.

If CPR is performed promptly and correctly:

- Heart function may be restored, and
- Circulation may be maintained until institution of other life support measures.

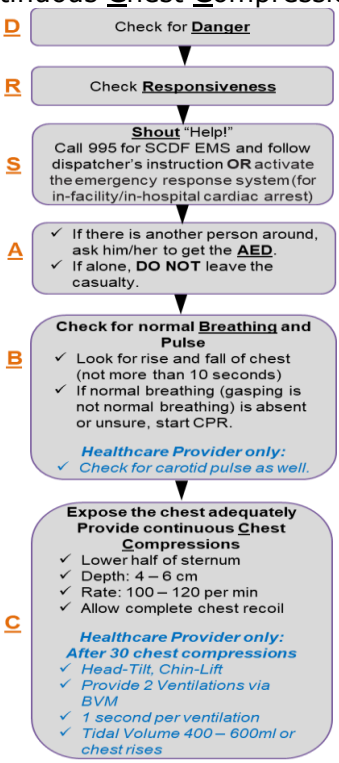
In many cases, rescuers in the community are unwilling and/or unable to provide ventilations. Hands only (chest compressions only) CPR can be initiated. This only requires continuous chest compressions without mouth-to-mouth ventilation, is easier to learn and is as effective as standard CPR.

The next section takes you step-by-step through the procedures needed to perform CPR – the basic skill needed to save lives in the event of cardiac arrest.

2.2: ADULT ONE-RESCUER CPR

MNEMONIC: **DRSABC**

D Check for **D**anger
R Check **R**esponsiveness
S **S**hout to get help and call 995 for Singapore Civil Defence Force (SCDF) Emergency Medical Services (EMS)
A Ask someone to get an **A**ED
B Check for Normal **B**reathing and Pulse (for trained Healthcare Providers)
C Provide continuous **C**hest **C**ompressions



Notes:
1. If you are a single rescuer and feeling tired, you may take a rest of not more than 10 seconds (preferably after 100 continuous chest compressions).
2. For Healthcare Provider only: If no BVM is available and you are unable or unwilling to do mouth-to-mouth ventilations, perform continuous chest compressions.

Figure 2-1 – One rescuer CPR steps
**BVM: Bag Valve Mask*

(D) Check for Danger

Ensure that the rescuer operates in a safe environment. Resuscitation should start where the casualty is found, unless the site is unsafe or unconducive (eg. roads which are still open to traffic, burning building, etc), then the casualty should be removed to a safe, flat and open space as soon as possible.

(R) Check for Responsiveness

- The rescuer should tap the casualty's shoulders firmly and ask loudly: 'Hello! Hello! Are you okay?' (See figure 2-2)
- Avoid violent shaking of the casualty as this may result in injury.
- Avoid unnecessary movements of the neck in the event of injuries to the head and neck.

Figure 2-2 – Tap shoulder for response

For CPR to be effective, the casualty must be lying on his/her back on a firm, flat surface. If the casualty is lying face down (prone position), or on his/her side, rescuer will need to roll the casualty over onto his/her back.

(S) Shout to get help

- If the adult is unresponsive, shout to get help from bystanders to call '995' for SCDF EMS or activate the emergency response system (for in-facility/in-hospital cardiac arrest). If alone, use a handphone to call 995 for SCDF EMS and put on speaker phone mode. An SCDF emergency medical dispatcher can help a lay rescuer recognise cardiac arrest, and once this is established, the dispatcher will guide the rescuer to begin CPR by providing

Figure 2-3 – Call 995 for an ambulance

instructions on how to perform Chest Compressions via a handphone. (See figure 2-3)

- In a situation where a lone rescuer found an unresponsive casualty in a remote area with no accessibility to activate emergency medical service, it is necessary for the lone rescuer to assess the casualty's responsiveness and breathing. If normal breathing is absent, chest compressions should commence immediately and continued for at least two minutes before leaving the casualty to seek help.

Note:

♥ However, if there is another person around, ask him/her to call 995 for SCDF EMS and get an AED.

(A) Ask someone to get an AED

Figure 2-4 – Ask someone to get an AED

- Ask someone to get an AED if there is one within a 60-second walking distance. The SCDF emergency medical dispatcher may be able to locate the nearest AED and summon help from CPR-trained rescuers in the vicinity. However, if you are the lone rescuer, do not leave the casualty. (See figure 2-4)

(B) Check for normal Breathing

Figure 2-5 - Look for normal breathing

- Look for the rise and fall of the chest. (See figure 2-5)
- Checking for normal breathing should not take more than ten seconds.
- It is important to recognize that gasping is **NOT** normal breathing but a sign of cardiac arrest (gasping can also happen in severe asthmatic

attack). Start chest compressions immediately if you are unsure whether the casualty has abnormal breathing or gasping. (See https://youtu.be/T85vd3CBs04 for video of contrast between gasping and normal breathing)

For trained healthcare providers

- Checking of carotid pulse and breathing should not take more than 10 seconds.
- Check for carotid pulse when checking for normal breathing. Slide your fingers down to the groove at the side of the neck near you (this is the location of the carotid pulse).
- If unsure about the presence of carotid pulse and no normal breathing, assume cardiac arrest and commence chest compressions.

(C) Chest Compressions

- Site of chest compression should be at the centre of the chest at the lower half of the sternum (breastbone). (See figures 2-6 and 2-7)
  - Ensure adequate exposure of the chest.
  - Kneel by the side of the casualty.
  - Place the heel of one hand on the lower half of the sternum (breastbone) and avoid the **Xiphoid Process**.
  - Place the heel of the second hand on top of the first.
  - Interlace the fingers of both hands and lift the fingers off the chest wall. (See figure 2-8)
  - Straighten both the elbows and lock them into position.
  - Position the shoulders directly over the casualty's chest. Use the body weight to compress the casualty's sternum (breastbone).
  - Depth of chest compression for adults must be at least 4 cm but not more than 6 cm.
  - The compression rate is 100–120 per minute.
  - Ensure complete recoil of the chest wall after each compression. (See figure 2-9)
  - Loud counting of the chest compressions should be encouraged: 1&2&3&4&5&, 1&2&3&4&10&,

1&2&3&4&15, 1&2&3&4&20, 1&2&3&4&25, 1&2&3&4&30… up to 100. Chest compressions consist of a series of rhythmic applications of pressure over the lower half of the sternum (breastbone). These compressions create blood flow to the vital organs (heart, lungs and brain).

- If tired after 100 compressions, rescuer can take up to 10 seconds of rest and then resume chest compressions.

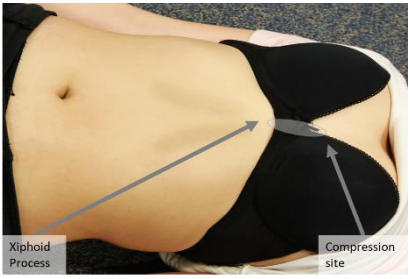


Figure 2-6 - Xiphoid Process (Female casualty) – to be avoided

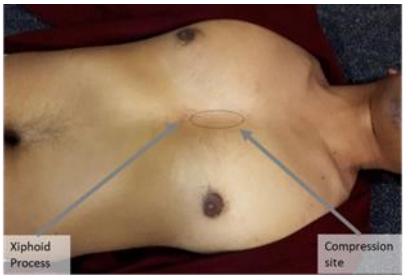


Figure 2-7 - Xiphoid Process (Male casualty) – to be avoided

Figure 2-8 – Lift fingers off the chest wall and interlock hands

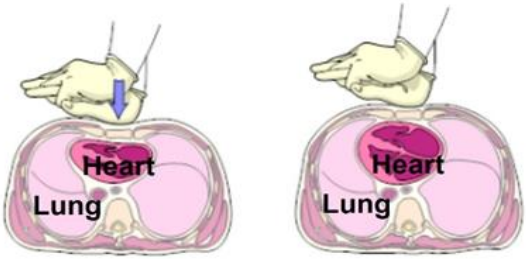


Figure 2-9 - Compression and release during CPR

For trained healthcare providers

- Perform 30 chest compressions and provide 2 ventilations via a BVM.
- Complete 5 cycles of 30 compressions and 2 ventilations before re-assessing breathing and circulation.

Perform BVM ventilations:

- Perform a Head-Tilt, Chin-Lift manoeuvre. An open airway will ensure BVM ventilations are effective. In the unresponsive casualty, muscle tone is impaired resulting in the tongue falling backward and obstructing the airway. (See figure 2-10) As the tongue is attached to the lower jaw, moving the lower jaw forward will lift the tongue away from the back of the throat and open the airway.

- **Head-tilt** - Place your palm on the forehead and push it backwards.

- **Chin-lift** – Use the index and middle fingers of your other hand to lift the bony part of the chin upwards. (See figure 2-11)

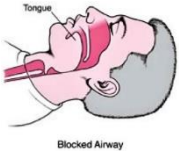


Figure 2-10 - The airway blocked by the tongue

Figure 2-11 - The Head-Tilt, Chin-Lift Manoeuvre

- When using a Bag Valve Mask (BVM), select a mask that fits over the mouth and nose of the casualty – The nasal portion of the mask over casualty's nose high enough to cover the bridge without air leaks

appropriate mask

and the lower portion of the mask over the chin, allowing it to seal along the two cheekbones. (See figure 2-12)

- **E – C hand placement –** 'E': Using one hand, hold the mask with
your middle and index finger wrapped around the connector stem of the mask. 'C': Extend your thumb underneath the casualty's jaw, and pull it upward into the mask. (See figure 2-13)

Figure 2-13 – 'E-C' hand placement

- While maintaining the upward traction on casualty's jaw, press the mask downward onto the face to attain a tight mask seal. (See figure 2-14)


Figure 2-14 – Maintaining the upward traction of the jaw and downward traction of the mask

- Perform ventilation by squeezing the bag steadily and smoothly using your other hand over 1 second. Then, release the bag to allow it to reinflate fully before providing second ventilation.

- Each ventilation should be enough to make the chest rise. This is approximately 400 – 600 ml of air.

- Do not interrupt chest compressions for more than 10 seconds to perform 2 ventilations.

Note:

- Do not press deeply into the soft tissues under the chin.
- Do not place your hands or the mask on the casualty's eyes as doing so may damage the eyes or cause a vagal reaction.
- Excessive force and rapid insufflation increase gastric distension.
- If BVM is not available, you may provide mouth-to-mouth ventilations if you are trained and willing to perform.
- If you are unable or unwilling to perform ventilations for any reasons, please perform continuous chest compressions at the rate of 100 – 120 per minute. If you are a single rescuer and feeling tired, you may take a rest of not more than 10 seconds (preferably after 100 compressions).

The cycles of 30 chest compressions to 2 ventilations (see figure 2-15) should be continued until one of the following occurs:

Figure 2-15 – 30 chest compressions followed by 2 ventilations via bag-valve-mask (BVM)

- 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 normal breathing or consciousness.

Continue to perform CPR until:

- Paramedic takes over from the rescuer; or
- AED prompts to analyse the casualty's heart rhythm, is charging or when shock is to be delivered; or
- Casualty wakes up or regains normal breathing.
- Healthcare providers who are trained and confident in pulse check should check the pulse after at least five cycles

of 30 compressions to two ventilations (done via a bag-valve mask). Checking of pulse should not take more than ten seconds. If unsure of the presence of a pulse by the end of ten seconds, the rescuer should resume CPR.

Summary on selection of appropriate mask & ventilation bag size for bag-valve-mask (BVM) ventilation

	Adult (>12 yrs old)	Child (1–12 yrs old)	Infant (<1 yr old)
			
Mask size 	Face mask should extend from the bridge of the nose to the cleft of the chin, covering the nose and the mouth but avoiding compression of the eyes.		
Ventilation bag size 	1500-2000 mls	500-1500 mls	500 mls

Note:

♥ **The tidal volume delivered should be sufficient to produce a normal chest rise**.

For Trained-Healthcare Providers

- Check for normal breathing and pulse after every 5 cycles of CPR 30:2.
- If normal breathing and pulse are absent or you are unsure, continue CPR 30:2.

- If pulse is present and normal breathing is absent, perform rescue breathing at a rate of **12 breaths per minute** (one breath every 5 seconds) by giving one breath and counting **2-a-thousand, 3-a-thousand, 4-a-thousand, 5-a-thousand**.
- Repeat the sequence until you have completed a total of 12 breaths. Re-assess for normal breathing and pulse.
- If both the breathing and pulse are present, maintain the casualty in a supine position and continuously monitor the casualty until help arrives.

2.3: CPR IN SPECIAL CIRCUMSTANCES

Resuscitation training should simulate the environment that rescuers may find themselves in. For example, healthcare providers should practice resuscitation skills on manikins on a trolley bed (see figure 2-16) or stand on a step stool at the side of the trolley bed. This is to ensure the elbows can be straightened to facilitate chest compressions.

Figure 2-16 – CPR on a trolley bed

For resuscitation involving two or more rescuers, one rescuer can focus on chest compressions with the other handling the ventilations. Additional rescuers can be delegated with other tasks such as calling 995 for SCDF or retrieving and using the AED.

Although chest compressions are commonly performed by kneeling at the side of the casualty, there may be specific circumstances involving narrow alleys, walkways or corridors where the rescuer may have to perform chest compressions by positioning over the head instead of the usual lateral side. (See figure 2-17)

Figure 2-17 – Overhead CPR

In the case of a passenger aircraft, a rescuer should kneel in the leg-space in front of the aisle seats to perform chest compressions if the casualty cannot be transferred within a few seconds to an area with adequate floor space such as the galley.

For transferring a collapsed person from a chair to the floor, the following link provides some guidance (see item 10iv within the document in the link) – http://lgnbe.org.uk/resources/g26.pdf.

The above-mentioned are not definitive guidelines to resuscitation in tight spaces but can be taken as a reference should anyone be caught in similar situations.

CHAPTER 3

AUTOMATED EXTERNAL DEFIBRILLATION (AED)

3.1: The Importance of Early Defibrillation

At the time of a sudden cardiac arrest, the most common underlying cardiac rhythm is an irregular and chaotic electrical rhythm (shockable rhythms) called **Ventricular Fibrillation (VF) or Ventricular Tachycardia (VT) without pulse**. (See figure 3-1) However, not all cardiac arrests present as VF and may appear as other electrical rhythms (eg. asystole which is non-shockable).

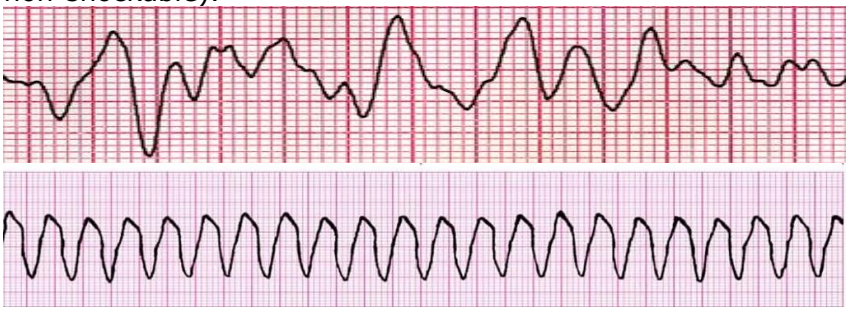


Figure 3-1 - Ventricular Fibrillation & Ventricular Tachycardia without pulse

During VF, the heart muscles do not contract effectively and delivery of blood to the rest of the body ceases. The treatment for VF is a shock administered using an AED. This shock, together with chest compressions, will reinstate normal heart rhythm and contractility if administered as soon as possible (within 4 minutes). The survival rate decreases by 7-10% for every minute of delay in treating VF. If delayed or untreated, VF eventually degenerates into a fatal rhythm known as **asystole** where the heart has no electrical activity as reflected by a flat line tracing. (See figure 3-2) At this juncture, the only treatment possible is to administer CPR.

In the past, only trained doctors, nurses and paramedics, could perform manual defibrillation as it requires the operator to recognize the cardiac rhythm of the casualty, whether it is **shockable** or **non-shockable**. Since the invention of AEDs, which are able to analyse the casualty's cardiac rhythm through the electrode pads and advise if a shock is needed, a lay rescuer can now perform the defibrillation, thus improving survival rates.

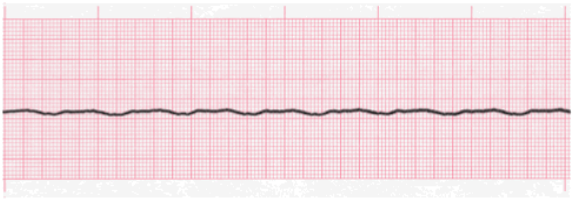


Figure 3-2 - Asystole

The AED should be brought to every person in cardiac arrest. Therefore, when calling 995 for SCDF ambulance, also call for an AED by instructing others nearby **"Get AED"**. However, if you are the lone rescuer, do not leave the casualty.

Research has shown that cardiac arrest casualties with VF who are treated promptly have the best chances of survival. Similar experiences from around the world has also demonstrated that more lives are saved if early CPR is combined with early defibrillation. (See figure 3-3)

Chain of survival factors in cardiac arrest and their impact on outcomes

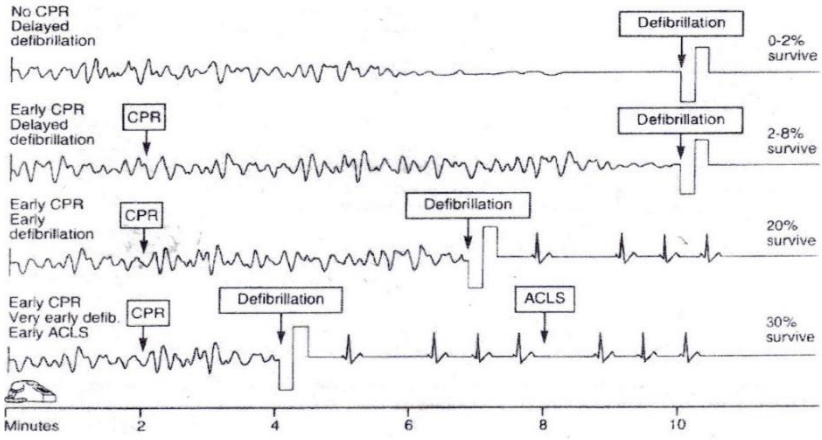


Figure 3-3 - Importance of the chain of survival

Richard O. Cummings ACLS – Principles and Practice. American Heart Association; 2003. Chapter 6: Defibrillation: Principles and Practice; p93

3.2: AUTOMATED EXTERNAL DEFIBRILLATORS (AEDs)

Automated External Defibrillators (AED) are devices that deliver electrical shocks to shockable rhythms like VF & Pulseless VT, 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 electrical rhythm of the heart.
- Determine whether the heart 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-up.
- 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.

3.3: PREPARATION FOR AED USE

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

- **Metallic surface -** Remove casualty from contact with metal surfaces. These can conduct electric currents to the rescuer.

- **Water** - Sweat and moisture are good conductors of electricity 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 are fire hazards. Move the casualty away from these before applying AED.

Steps in chest preparation and applying the AED electrode pads (see figure 3-4):

- Expose the chest of the casualty to facilitate application of AED electrode pads. If needed, cut away the clothing.
- If chest hair prevents proper electrode pad placement, shave the hair from these sites promptly. AEDs come with a shaver blade to expedite this.
- Metallic objects such as necklace and chains should be moved away from the pads. These may result in sparks and potential burns to the chest wall.
- For casualties with a pacemaker or implanted cardiac defibrillator on the right, apply the pads at least four fingers' breadth away from these devices.
- Medication patches or monitoring electrodes on the chest wall should be removed as they may interfere with electrode pads placement.
- Wipe dry a wet or sweaty chest to ensure proper adhesion of the electrode pads to the chest. Application of AED electrode pads to the chest wall must be done quickly with minimal interruptions to chest compressions.

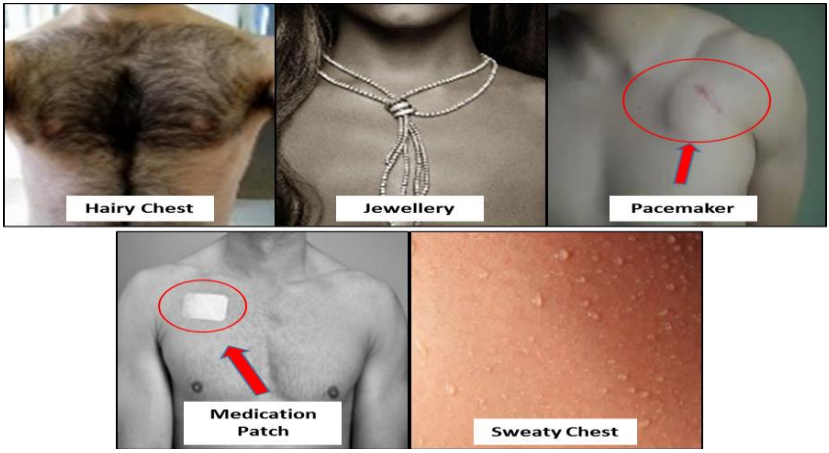


Figure 3-4 - Things to take note of during chest preparation

3.4: PLACEMENT OF AED ELECTRODE PADS

1. Switch on the AED. Some AEDs would automatically turn ON when the AED cover is lifted.

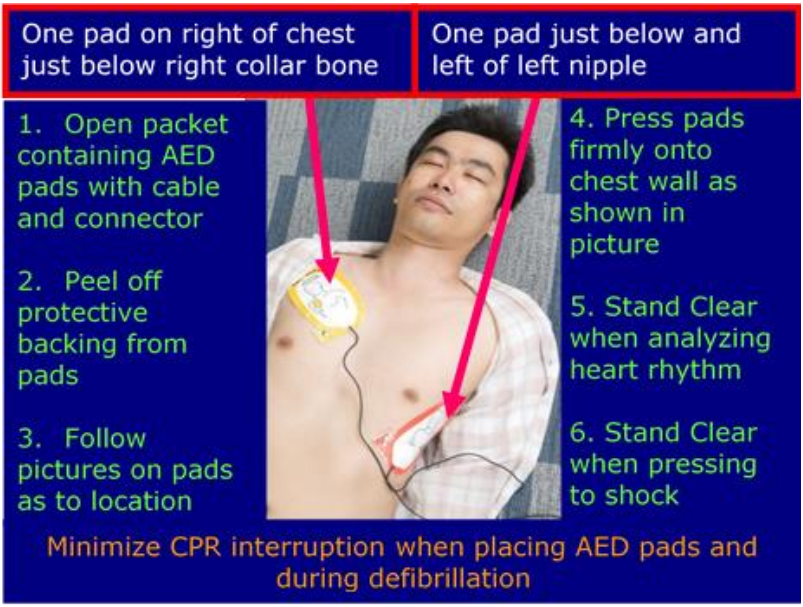
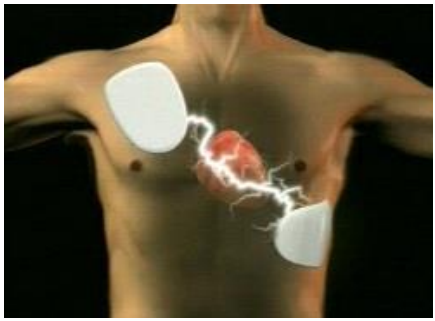


Figure 3-5 – Application and use of AED

2. Apply the AED pads on the chest according to the instructions on the AED. (See figure 3-5)

Figure 3-6 - How AED shocks the heart



3. The right pad is placed on the casualty's right chest just below the collar bone. The left pad is placed on the left

chest just below and to the left of the left nipple. (See figure 3-6)

4. Plug the connector end of the cable into the AED. Some AEDs already have pre-connected electrode pads cable and may start analysis once the pads are in place.

Minimize CPR interruption when preparing the chest and placing of AED pads

3.5: DEFIBRILLATION PROCEDURES

1. The AED will initially analyse the heart's electrical rhythm. It will give a voice prompt, such as

   "ANALYSING HEART RHYTHM. DO NOT TOUCH THE CASUALTY."

   If you hear this, stop chest compressions. Do not touch the casualty and do not allow others to touch the casualty while the AED is analysing.

2. Spread your arms apart and say clearly **"Stay Clear"**. (See figure 3-7)

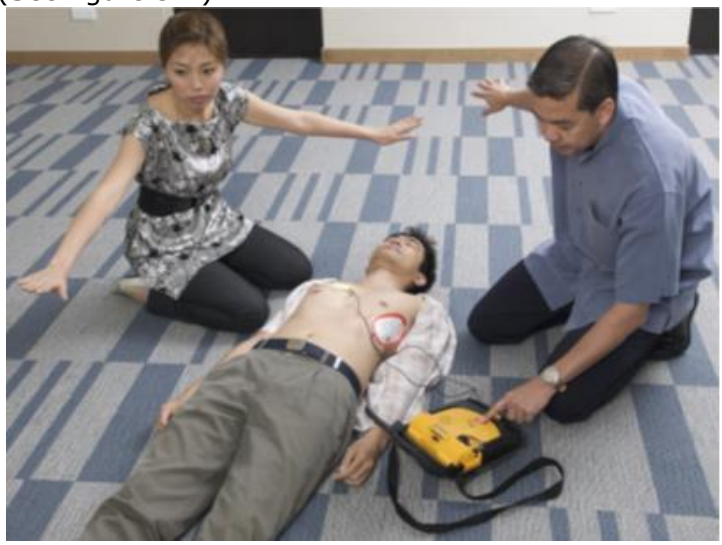


Figure 3-7 – "Stay clear!"

3. If the casualty has a shockable rhythm, AED machine will charge automatically. Charging takes a few seconds and may be indicated by a warning tone from AED. No one should touch the casualty during this brief charging phase.

4. Once the AED is fully charged, it will prompt "PRESS THE SHOCK BUTTON NOW". The rescuer then states clearly **"Stay Clear"**, ensures quickly that no one is touching the

casualty, and then presses the shock button on the AED firmly before releasing it.

5. Once the shock is delivered, restart chest compressions. Continue the chest compressions until the AED repeats the voice prompt (every 2 minutes): **"ANALYSING HEART RHYTHM. DO NOT TOUCH THE CASUALTY."**

6. If the AED prompts: "NO SHOCK ADVISED", the lay rescuer should resume continuous chest compressions until the emergency medical team arrives to take over, or the AED prompts the rescuer not to touch the casualty, or the casualty starts breathing normally.

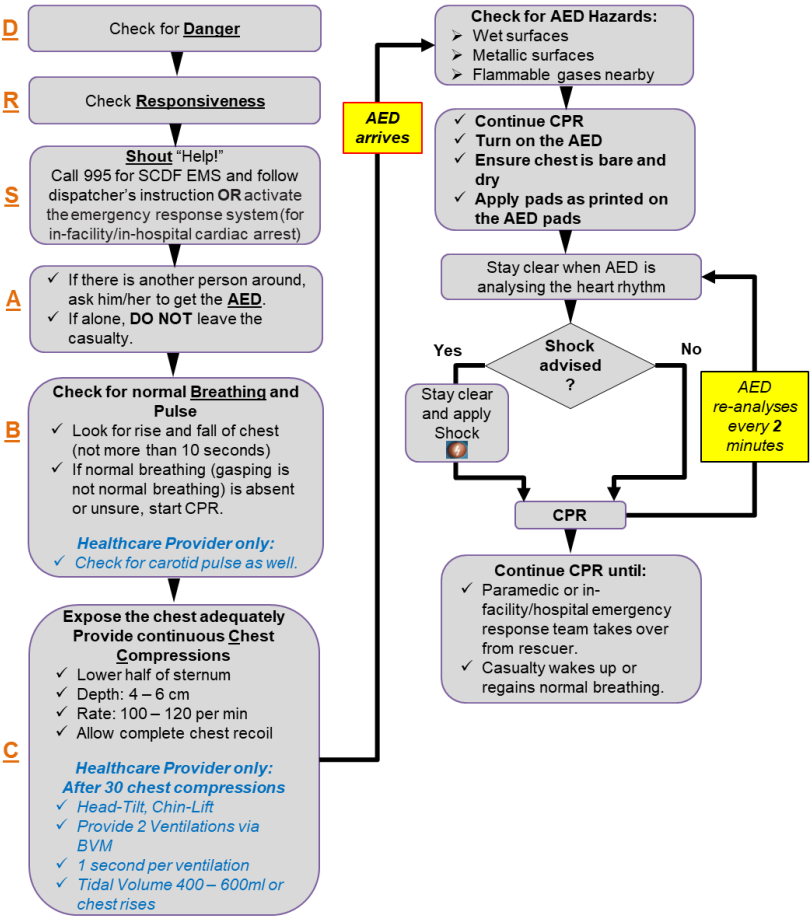
   Healthcare providers who are trained and confident in pulse check should check the pulse when the AED prompts to analyse the casualty's heart rhythm every two minutes, or when breathing or movement is detected. Checking of pulse should not take more than ten seconds. If unsure of the presence of a pulse by the end of ten seconds, the rescuer should resume CPR. If the pulse is present but not breathing, start rescue breathing.

7. Only stop CPR when:
   a. Paramedic takes over from rescuer; or
   b. AED prompts to analyse the casualty's heart rhythm, is charging or when shock is to be delivered; or
   c. Casualty wakes up or regains normal breathing.

8. Keep casualty in the same (supine) position and continue to monitor the casualty until help arrives.

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

Algorithm for One-Rescuer CPR and Use of AED



Notes:

1. If you are a single rescuer and feeling tired, you may take a rest of not more than 10 seconds (preferably after 100 continuous compressions).
2. For Healthcare Provider only: If no BVM is available and you are unable or unwilling to do mouth-to-mouth ventilations, perform continuous chest compressions.

Figure 3-8 – Flowchart of CPR and AED algorithm.

3.6: POST-INCIDENT PROCEDURES

Hand-over to emergency services

When paramedics takes over the casualty, they may require a summary of the events that has occurred:

- Time of collapse (best estimate)
- 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 paramedics:

- Until casualty is loaded into the ambulance.
- The AED electrode pads should remain on the casualty while transporting to hospital.

What are the duties for the person in charge of the AED after AED has been used?

The facility or safety manager must be informed on the usage of AED.

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

For commercial establishments or work places, or the local community centre or management office for residential areas
1. For AEDs located in places other than HDB blocks, they should be returned to the AED owner (building management or security staff) after use. 2. Replace the AED consumables such as the electrode pads, shaver kit, towel and gloves if used (replacement done by AED owner or AED vendor). 3. The AED battery must be checked. Contact the vendor of the AED device for advice on battery replacement. 4. 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 onto the holder (replaced by the AED vendor).
5. 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.
6. AEDs are almost maintenance-free.
7. The battery indicator on the AED needs to be checked annually (or as advised by the AED vendor) to ensure that it is still functional. Once it gives a low-battery display, steps to replace the battery promptly should be undertaken.

For Public Access AEDs from Housing Development Board (HDB)

1. SCDF Ambulance crew will convey the casualty to the hospital along with the public access AED. The used AED will be collected by the contracted vendor at the respective fire stations. The vendor will restock and replace the AED back to its original location.
2. AEDs are almost maintenance-free.
3. The battery indicator on the AED needs to be checked periodically to ensure that it is still functional. Once it gives a low-battery display, steps to replace the battery promptly should be undertaken (facilitated by SCDF/HDB).

3.7: RETRIEVAL OF AUTOMATED EXTERNAL DEFIBRILLATOR

Public access Automated External Defibrillators (AEDs) in Singapore are typically secured in a locked box with a break glass mechanism. The glass must be broken to retrieve the key and to unlock the box.

During emergencies, members of the public responding to potential cardiac arrests case have been reported to have suffered injuries while retrieving AEDs, such as by being cut by glass while breaking the pane of glass or while trying to retrieve the key. (See figure 3-9)

Figure 3-9 – Examples of injuries sustained when retrieving key

A recent survey of cardiac arrest responders who retrieved AEDs conducted locally highlighted that a pattern of injuries exists.

Jonathan SY Ng, Reuben JS Ho, JY Yu, YY Ng. Factors influencing success and safety of AED retrieval in out of hospital cardiac arrests in Singapore. Korean J Emerg Med Ser. 2022 Aug; 26(2), 97-111.

The following are recommendations for retrieval of AEDs:

1. Download the SCDF myResponder application! (See Chapter 1.8) Responders with the app have a much better chance to find the nearest defibrillator with the help of the AED map.
2. To safely retrieve the AED:
    a. Do not use your bare hands/elbows to break the glass – most injuries from retrieving occur with breaking the glass. Use personal items instead e.g. mobile phone, shoes, keys etc. to reduce the risk of injuries sustained.
    b. Clear all glass fragments around the edges with the object used to break the glass before retrieving the key. Another common mechanism of injury is due to lacerations when reaching for the key inside.

3.8: SAMPLE PRACTICAL SCENARIOS (FOR ADULTS)

The following scenarios may be used by the instructor to depict possible situations which you may encounter due to the varied nature of an emergency. By practicing these scenarios, you can be more confident to assist a casualty in emergencies.

1) Shock – No Shock – No Shock
2) No Shock – Shock – No Shock
3) Shock – Shock – No Shock
4) No Shock – No Shock – Shock
5) No Shock – No Shock – No Shock

3.9: CHILD/INFANT DEFIBRILLATION

Use of AED in Children

Out-of-hospital cardiac arrest in children are usually from non-cardiac causes with majority of the casualties 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 or pulseless ventricular tachycardia)** as the initial cardiac rhythm to be from 5-19%.[1] School-going children and adolescents were reported to have higher incidence of shockable rhythms compared to infants, toddlers and preschoolers.[2]

1. *Kitamura T, Iwami T, Kawamura T, Nagao K, Tanaka H, Nadkarni VM, Berg RA, Hiraide A. Conventional and chest-compression-only cardiopulmonary resuscitation by bystanders for children who have out-of-hospital cardiac arrests: a prospective, nationwide, population-based cohort study. Lancet. 2010 Apr 17;375(9723):1347-54. doi: 10.1016/S0140-6736(10)60064-5.*
2. *Akahane M, Tanabe S, Ogawa T, Koike S, Horiguchi H, Yasunaga H, Imamura T. Characteristics and outcomes of pediatric out-of-hospital cardiac arrest by scholastic age category. Pediatr Crit Care Med. 2013 Feb;14(2):130-6.*

Recommendation for AED Use in Children

The International Liaison Committee on Resuscitation (ILCOR) 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 rapidly treated, paediatric patients with ventricular fibrillation or pulseless ventricular tachycardia have a higher survival rate than those with other rhythms.

It is recommended that a paediatric dose-attenuating system be used in children aged 1-12 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-attenuating system is unavailable, then a standard AED should be used.

Use of AED for Child/Infant

- If an AED with paediatric pads or mode is not available, an AED with adult pads may be used.
- In these cases, the risk/benefit ratio may be favourable, and the use of an AED (preferably with paediatric pads or mode) should be considered.
- For AEDs **with** paediatric pads or mode:
    - When the AED arrives, switch it on.
    - Switch to the paediatric electrode pads or mode.
    - Attach the electrode pads according to the illustrations on the placement of electrode pads (see figure 3-9).
    - Follow the AED's instructions and continue chest compressions and ventilations until medical help arrives.
- For AEDs **without** paediatric pads or mode:
    - When the AED arrives, switch it on.
    - If only adult pads are available, ensure that the pads do not touch or overlap each other. Attach the defibrillation pads on front (right pad on central sternum) and back (left pad on the upper back between the shoulder blades) in an anterior-posterior electrode pads placement as shown (see figure 3-9).
    - Follow the AED's instructions and continue chest compressions and ventilations until medical help arrives.

Placement of Defibrillation Pads for Children/Infant

1. For AEDs recommending anterior-anterior electrode pads placement, ensure that the electrode pads are not touching or overlapping each other, and are at least 2cm apart (see figure 3-10).

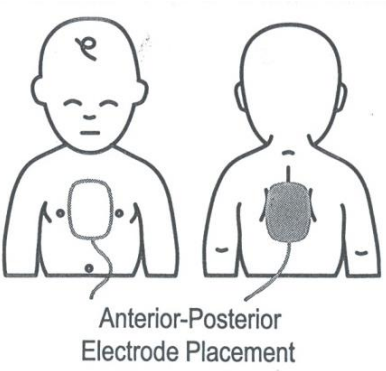


Figure 3-9 - Anterior-posterior AED electrode pads placement for children

Figure 3-10 - Anterior-anterior AED electrode pads placement