TOPIC 1. Natural, anthropogenic emergencies, their medical consequences. First aid in the extreme and combat conditions. Primary survey of the casualty. CPR.

Lesson 2.

1. Terminal states.
2. Clinical death, its symptoms.
3. Absolute and relative signs of biological death.
4. Cardiopulmonary resuscitation (CPR) according to the European Resuscitation Council protocol 2015.
5. CPR technique.
6. Duration and termination of CPR.
7. Complications that occur during CPR.
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Q1 Terminal states.

The concept of "death" is inextricably linked with the concept of "life" and is its logical conclusion. Signs of “living” are irritability and excitability, the ability to grow independently, develop and reproduce. Such signs can be possessed by humans, animals, plants, and molecules of not only proteins, but inorganic compounds at the submolecular level, and possibly various field structures. In humans, the transition from life to death is associated with a metabolic disorder - a consequence of a violation of oxidative processes at the subcellular and molecular levels. At the body level, this is, first of all, the extinction of the basic vital functions - blood circulation, respiration, psyche and nervous system. The duration of the process of transition from life to death - dying - can vary widely. Sometimes death occurs very quickly, within seconds or minutes, in other cases, dying occurs slowly and lasts for tens of minutes or several hours.

The terminal state is a state when there is no breathing, blood circulation and the body's need for oxygen is not provided (the process of extinction of body functions or dying). A terminal state can develop in acute myocardial infarction, massive blood loss, asphyxiation, drowning, electric shock, etc.

The study of dying and death is a science called *thanatology*. Nowadays, under doctrine is understood the doctrine of the process of dying and signs of death from its initial moments to the complete decomposition of the corpse.

The clinic of dying is characterized by a deep metabolic disorder and the development of tissue hypoxia (lack of oxygen in the tissues). Hypoxia resulting from weakening of blood circulation and breathing leads to a violation of the functions of the central nervous system. Clinically, this is manifested by loss of consciousness, while the electrical activity of the cerebral cortex fades, tonic convulsions develop. Blood pressure decreases and disappears. Weakening of cardiac activity leads to pulmonary edema, which can be judged by the appearance

of white foam at the mouth opening. Cyanotic skin turns pale, eyeballs subside, the nose is pointed, the lower jaw droops.

According to the doctrine of terminal states, the process of dying goes through a series of stages:

The ***initial stage*** of dying is considered to be a predagonal state, characterized by severe circulatory and respiratory disorders.

The duration of this condition can be different - from several hours to several days.

The next stage of dying is a ***terminal pause***. It is characterized by sudden respiratory arrest, a sharp inhibition of the activity of the heart, the extinction of the bioelectrical activity of the brain, the extinction of corneal and other reflexes. The duration of the terminal pause is from a few seconds to 4 minutes.

The terminal pause is followed by ***agony*** - an outbreak of the body's struggle for life. It may not be, or they may follow one after another. Agony usually begins with short-term breath holdings. Then comes the weakening of cardiac activity and functional disorders of various systems.

The duration of agony can be different, depending on the type and mechanism of death. It can be short-term (several minutes) and long (several hours and days). In some cases, it is absent.

After stopping breathing and blood circulation, the stage of "***clinical death***" occurs, lasting 4-6 minutes. With artificial or accidental cooling of the body, this period can increase up to 10 minutes. The agony and the period of the so-called "clinical death", to which it precedes, can be reversible, with a complete restoration of body functions.

The last stage of dying - ***biological death*** - is an irreversible state and it is impossible to restore the vital functions of the human body during this period. They can only be artificially maintained. First of all, irreversible changes occur in the cerebral cortex - the "death of the brain." This moment, when the integrating activity of the central nervous system is disrupted, should be considered the beginning of biological death.

Biological death is established by the commission appointed by the chief physician of the medical institution. It should include the head of the intensive care unit, a neuropathologist, the doctor who performed the intensive care unit, and a forensic expert of the highest or first qualification category. The statement of death is made out by the act which is signed by all members of the commission.

The problem of stating the moment of death has acquired special importance in recent years in connection with the development of transplantology (the science of transplantation of tissues and organs). It is known that the successful transplantation of tissues and organs taken from a corpse is largely determined by the time elapsed from the moment of death to their collection. The shorter this time, the greater the chance of a successful transplant.

Q2. Clinical death, its symptoms.

A living organism does not die simultaneously with respiratory arrest and cessation of cardiac activity, therefore, even after they stop, the body continues to live for some time. This time is determined by the ability of the brain to survive without oxygen; it lasts 4-6 minutes, on average - 5 minutes. This period, when all the extinct vital processes of the body are still reversible, is called clinical death. Clinical death can be caused by heavy bleeding, electrical injury, drowning, reflex cardiac arrest, acute poisoning, etc.

Signs of clinical death:

1) lack of pulse on the carotid or femoral artery; 2) lack of breathing; 3) loss of consciousness; 4) wide pupils and the lack of their reaction to light.

Therefore, first of all, it is necessary to determine the presence of blood circulation and respiration in a patient or a victim.

Definition of signs of clinical death:

1. The absence of a pulse on the carotid artery is the main sign of circulatory arrest;
2. The absence of breathing can be checked by the visible movements of the chest during inhalation and exhalation or by putting the ear to the chest, hear the sound of breathing, feel (the movement of air during exhalation is felt by the cheek), and also raising a mirror, a glass or watch glass to the lips, as well as a fleece or thread by holding them with tweezers. But it’s not necessary to waste time precisely on the definition of this sign, since the methods are not perfect and unreliable, and most importantly they require a lot of precious time for their determination;
3. Signs of loss of consciousness are the lack of reaction to what is happening, to sound and pain stimuli;
4. The upper eyelid of the victim is raised and the pupil size is determined visually, the eyelid drops and immediately rises again. If the pupil remains wide and does not narrow after repeated lifting of the eyelid, then we can assume that there is no reaction to light.

If one of the first two is determined from the 4 signs of clinical death, then resuscitation must be started immediately. Since only the resuscitation started in a timely manner (within 3-4 minutes after cardiac arrest) can return the victim to life. Do not resuscitate only in the case of biological (irreversible) death, when irreversible changes occur in the tissues of the brain and many organs.

Q3 Absolute and relative signs of biological death.

Signs of biological death:

1) drying of the cornea;
2) the phenomenon of "cat pupil";
3) temperature reduction;
4) body cadaveric spots;

5) rigor mortis

Identification of signs of biological death:

1. The signs of the drying of the cornea are the loss of their original color by the iris, the eye is covered with a whitish film - "***herring shine***", and the pupil becomes cloudy.
2. The eyeball is squeezed with the thumb and forefinger, if a person is dead, then his pupil will change shape and turn into a narrow gap - the ***"cat pupil"***. In a living person, this is not possible. If these 2 signs appeared, it means that a person died at least an hour ago.
3. The ***body temperature*** drops gradually, about 1 degree Celsius every hour after death. Therefore, according to these signs, death can be certified only after 2–4 hours and later.
4. ***Cadaverous spots*** of purple color appear on the underlying parts of the corpse. If it lies on the back, then they are determined on the head behind the ears, on the back of the shoulders and hips, on the back and buttocks.
5. ***Rigid rigor mortis*** - post-mortem contraction of skeletal muscles "from top to bottom", ie face - neck - upper limbs - trunk - lower limbs.

Full development of symptoms occurs within a day after death.

Q4. Cardiopulmonary resuscitation (CPR) according to the European Resuscitation Council protocol 2015.

The European Resuscitation Council Guidelines for Resuscitation 2015 provide specific instructions for how resuscitation should be practiced. They were developed by Europeans and have been specifically written with European practice in mind.

The guidelines are based on the ILCOR 2015 Consensus on Science and Treatment Recommendations (CoSTR) for BLS/AED. The ILCOR review focused on 23 key topics leading to 32 treatment recommendations in the domains of early access and cardiac arrest prevention, early, high-quality CPR, and early defibrillation.

Guidelines 2015 highlights the critical importance of the interactions between the emergency medical dispatcher, the bystander who provides CPR and the timely deployment of an automated external defibrillator. An effective, coordinated community response that draws these elements together is key to improving survival from out-of-hospital cardiac arrest.

The time sensitivity of CPR in sudden cardiac death is emphasized in the Chain of Survival.

The Chain of Survival summarizes the vital links needed for successful resuscitation. Most of these links apply to victims of both primary cardiac and asphyxia arrest.

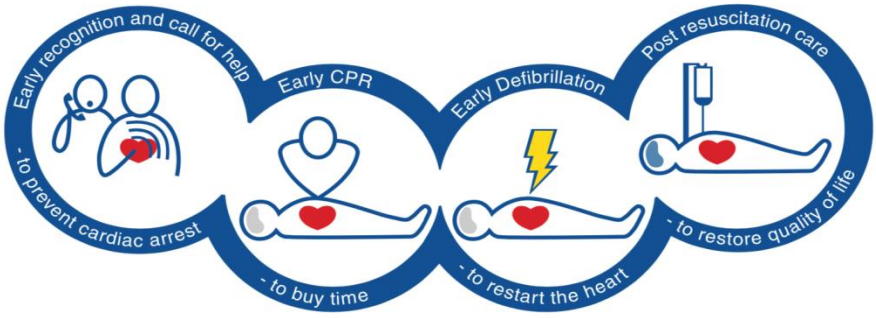

Fig. 1.2. The Chain of Survival.

Further material contains information about basic CPR for adults and children ≥8 years old, including the approach to an unresponsive patient; the physiology and mechanics of closed chest compression techniques; and basic airway opening procedures, including initial management of an obstructed airway.

12. **Q5. CPR technique**.

Sequence steps of CPR.

1. A-B-C (airway, breathing, chest compressions) is the recommended sequence for a single rescuer. Provide chest compressions before giving rescue breaths.

2. Compression rate should be 100 to 120 per minute.

3. Compression depth should be 2 to 2.5 in. (5 to 6 cm).

4. Do not lean hands on the chest between compressions to allow complete recoil between compressions.

5. Continue compression-only CPR until arrival of automated external defibrillator or rescuers with additional training.

6. If trained in rescue breathing, add rescue breaths after 30 compressions, using two breaths then and every 30 compressions until skilled help arrives.

7. Assessment of breathing and pulse checks may be done first by basic life support healthcare providers, but must be done in < 10 seconds.

Steps of CPR •

STEP 1 AND STEP 2 in basic CPR: Recognition and call for help.

Before approaching a collapsed individual, assess the scene for risks to healthcare providers. Potential risks include the presence of hazardous materials, an unstable physical environment, or personal violence.

Once the patient is reached, determine the patient's level of responsiveness to noxious stimuli.

If the patient is without normal breathing, get help first before starting chest compressions.

In a hospital, this may mean calling for the arrest team and requesting the arrest cart.

Outside the hospital, this is likely to mean asking a bystander to activate the local EMS system.

Look around to see if an automatic external defibrillator (AED) is nearby. Rapid application of defibrillation for shockable rhythms is critical for patient survival.

STEP 3 (HEALTHCARE PROVIDER ONLY): Assess circulation.

The carotid artery is generally the most reliable and accessible location to palpate a pulse. The artery is located by placing two fingers on the trachea and then sliding them down to the groove between the trachea and the sternocleidomastoid muscle.

Simultaneous palpation of both carotid arteries should not be performed because, in low-pressure states, this could obstruct cerebral blood flow and may interfere with the ability to detect a pulse.

The femoral artery may be used as an alternative site to palpate a pulse. This can be found just below the inguinal ligament approximately halfway between the anterior superior iliac spine and the pubic tubercle. If no definite pulse is felt within 10 seconds, chest compression should begin. •

STEP 4: Begin cardiac compressions.

Physiology of Closed Chest Compressions

There has been an active debate as to the exact mechanism that causes blood flow since the technique of closed chest compressions was put forth in the 1960s. In a closed system, liquid flows when pressure gradients develop. There are three basic theories for how pressure gradients and flow are produced during closed chest cardiac massage.

The conventional theory of blood flow during compressions is called the cardiac pump theory. The pump theory postulates that direct compression of the heart between the spine and the sternum leads to increased pressure in the ventricles. This causes closure of the mitral and tricuspid valves, leading to blood flow into the aorta and the pulmonary arteries.

The thoracic pump theory postulates that compressions lead to an increase in pressure throughout the thoracic cavity, leading to a pressure gradient from intrathoracic to extrathoracic arteries.

The third mechanism described is the abdominal pump theory, which has both an arterial and a venous component. The arterial component postulates blood flow into the peripheral arterial system from increased arterial pressure caused by

abdominal compressions that forces blood from the abdominal aorta against the closed aortic valve. The venous component leads to blood return via the inferior vena cava from abdominal pressure.

However, regardless of the mechanism, conventional chest compressions generate one fourth to one third of physiologic cardiac output. Lower ratios can be expected with delays in initiating compressions.

Technique of closed Chest Compression

When the lack of a pulse is confirmed, begin serial rhythmic closed chest compressions.

Place the victim supine on a firm surface, with the rescuer at the victim's side. Place the heel of one hand midline on the lower half of the sternum, 4 to 5 cm (~2 in.) cephalad of the xiphoid process.

The heel of the hand should be parallel with the long axis of the patient's body. Then place the second hand on top of the first hand, so the hands are parallel with each other.

The fingers of the two hands may be interlaced if desired, but they should not be touching the chest.

Keep the arms straight and the elbows locked.

The vector of the compression force should start from the rescuer's shoulders and be directed downward.

Lateral compressive forces will decrease the efficiency of the compressions and increase the likelihood of complications.

Depress the sternum 2 to 2.5 in. (5 to 6 cm) in an adult at a rate of 100 to 120 compressions per minute.

Rates lower than this are inadequate.

The compression-release phases should be roughly equal in length. With a single rescuer or with two rescuers if the patient is not intubated, give two ventilations after every 30 compressions.

With two rescuers assisting an intubated patient, ventilate at a rate of 8 to 10 per minute, without interrupting chest compressions.

Of note, although assisting ventilation is important, not everyone is willing to perform mouth-to-mouth breathing due to concerns over infectious disease transmission.

Chest compressions alone can be effective and should be provided even if rescue breathing is not being performed.

STEP 5: Defibrillate

Purpose.

Defibrillation is the therapeutic use of electricity in cardiac arrest to depolarize the entire myocardium to eliminate ventricular fibrillation or

nonperfusing ventricular tachycardia so that coordinated contractions can resume. It should be performed in close coordination with CPR of the cardiac arrest patient.

Patient selection.

The indications for defibrillation include ventricular fibrillation and pulseless ventricular tachycardia (shockable rhythms). Defibrillation is not "jumpstarting the heart". It is contraindicated for sinus rhythm, conscious patients with a pulse, or when there is danger to the operator or others (e.g., from a wet patient or wet surroundings).

Equipment.

The energy used for defibrillation is delivered as a wave and may be monophasic or biphasic. Monophasic waveforms are found in older defibrillators and deliver the energy in a single direction, while biphasic waveforms deliver the energy forward and back in two phases within the same amount of time. The amount of energy required for successful defibrillation is typically lower with biphasic waveforms. Most current defibrillators employ biphasic waveforms, with some manufacturers using their own proprietary waveforms.

Automated external defibrillators may be fully or semi-automated. Fully automated external defibrillators will analyze the rhythm automatically, and if indicated, charge and deliver the shock, whereas semi-automated external defibrillators will require an operator to manually deliver the shock after analysis and charging. Manual shocks may be delivered using paddles or self-adhesive defibrillator pads.

Safety must be ensured.

Adhesive pads are single-use and come in disposable packaging. When applying the pads, ensure that they do not overlap and there are no air pockets between the pads and the skin. Good contact ensures maximal shock efficacy. In automated external defibrillators, if contact is insufficient for the defibrillator to operate, a "Check Electrodes" message may also be heard. Pads are considered advantageous over paddles because of ease of placement, self-retaining nature, improved transmission of current, safety, and hygiene. In addition, they may be used as electrical leads for monitoring of the rhythm or in cardiac pacing. Due to their thinner profile, they can be easily placed in antero-apical (antero-lateral), anteroposterior with greater ease. They are preferred, if available. Defibrillators and their accessories should be properly maintained and kept in a constant state of readiness.

Patient positioning and skin preparation.

Ensure that the scene is safe for performing defibrillation, including water and environmental scene dangers such as traffic.

The patient should be in the supine position with ongoing CPR.

Expose the chest to apply the pads or paddles.

To avoid skin burns, remove all metallic objects, jewelry, or medication patches (wipe off any residue). If there is excessive chest hair over the areas where the pads or paddles are to be placed, quickly shave the hair off to ensure a good contact with the skin. If the patient is on a wet or conducting surface, move the patient to a safe area and dry the body before delivering any shocks. Sweat or moisture on the chest will conduct the current and may reduce the adhesion of pads. Remove all direct sources of oxygen to avoid fire.

Placement of pads.

There are several possible positions for the placement of the pads:

1. *Anteroapical (antero-lateral) position*: Place one pad to the right of the upper half of the sternum, just below the patient's right clavicle, and place the other pad just below and to the left of the left nipple. With a female patient, place the paddle/pad just below and to the left side of the breast. Do not place it over the breast. This is the preferred position for a supine patient, such as in cardiac arrest, and when using defibrillation paddles. The idea is to maximize current flow across the cardiac chambers rather than along the chest wall.

2. *Anteroposterior position*: Place one pad/paddle at the left lower sternal border and the posterior pad/paddle below the left scapula.

3. Pacemakers, automated implantable cardiac defibrillators, and other implants: such devices are implanted under the skin and palpable on examination. Ensure that the placement of the pads is at least four fingerbreadths away from such devices.

STEP 6 in basic CPR: Continue high-quality cardiac compressions.

Continuing high-quality compressions as much as possible while minimizing interruptions is critical to increase the chances of achieving return of spontaneous circulation and optimizing the chance of survival.

Interruptions can be minimized by continuing compressions between pulse checks, while applying the AED, and immediately restarting CPR after defibrillation.

STEP 7: open the airway and rescue breathing.

The seventh step is to assess the upper airway of the victim and its management. More closely it is discussed in the Topic 2 "Airway management".

Q6 Duration and termination of CPR.

Efforts at resuscitation should be continued until the patient recovers spontaneous respirations and cardiac output, the rescuer becomes exhausted, or the patient is pronounced dead.

An atraumatic individual who recovers spontaneous respirations and circulation should be placed on his or her side—the recovery position (See Topic 2).

Recovery from cardiac arrest depends on time to CPR and rhythm-specific intervention.

Resuscitation and long-term outcome in normothermic patients with arrest times of 20 minutes or more are very poor.

Q7 Complications that occur during CPR

Ventilations can cause insufflation of the stomach, leading to regurgitation and aspiration and possibly to gastric rupture.

Closed chest compressions can lead to fractures of the sternum or the ribs, separation of the ribs from the sternum, pulmonary contusion, pneumothorax, myocardial contusion, hemorrhagic pericardial effusions, splenic laceration, or liver laceration.

Proper techniques can minimize these complications but cannot totally prevent them.

Late complications include pulmonary edema, GI hemorrhage, pneumonia, and recurrent cardiopulmonary arrest.

Anoxic brain injury can occur in a resuscitated individual subjected to prolonged hypoxia; it is the most common cause of death in resuscitated patients.

Q8 Ethical issues of CPR.

During the initiation of resuscitation attempts, try to discover whether or not the victim has advance directives that prohibit CPR. Family members may wish to be present during resuscitation attempts, and support from social services and clergy should be sought early.

Appendix 1

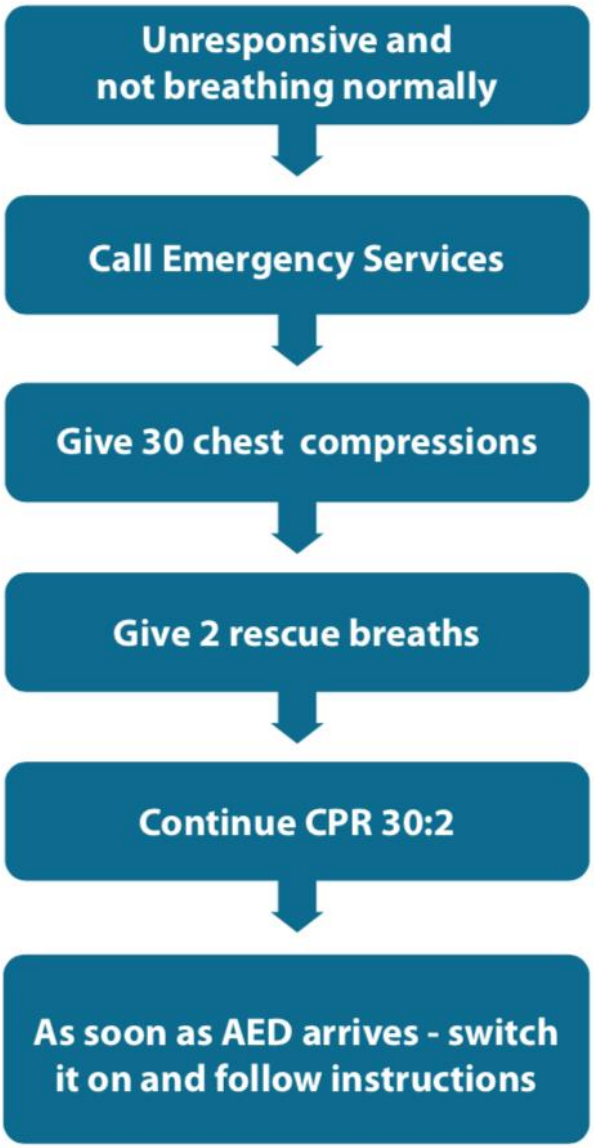

Fig. 1.3. The basic life support/automated external defibrillation (BLS/AED) algorithm.

Appendix 2

SEQUENCE / Action		Technical description
SAFETY **Make sure you, the victim and any bystanders are safe**		
RESPONSE **Check the victim for a response**		Gently shake his shoulders and ask loudly: "Are you all right?" If he responds leave him in the position in which you find him, provided there is no further danger; try to find out what is wrong with him and get help if needed; reassess him regularly
AIRWAY **Open the airway**		Turn the patient onto his back if necessary Place your hand on his forehead and gently tilt his head back; with your fingertips under the point of the victim's chin, lift the chin to open the airway
BREATHING **Look, listen and feel for normal breathing**		In the first few minutes after cardiac arrest, a victim may be barely breathing, or taking infrequent, slow and noisy gasps. Do not confuse this with normal breathing. Look, listen and feel for **no more** than 10 seconds to determine whether the victim is breathing normally. If you have any doubt whether breathing is normal, act as if it is they are not breathing normally and prepare to start CPR
UNRESPONSIVE AND NOT BREATHING NORMALLY **Alert emergency services**		Ask a helper to call the emergency services (112) if possible otherwise call them yourself Stay with the victim when making the call if possible Activate speaker function on phone to aid communication with dispatcher
SEND FOR AED **Send someone to get AED**		Send someone to find and bring an AED if available. If you are on your own, do not leave the victim, start CPR

CIRCULATION

Start chest compressions

Kneel by the side of the victim

Place the heel of one hand in the centre of the victim's chest; (which is the lower half of the victim's breastbone (sternum))

Place the heel of your other hand on top of the first hand

Interlock the fingers of your hands and ensure that pressure is not applied over the victim's ribs

Keep your arms straight

Do not apply any pressure over the upper abdomen or the bottom end of the bony sternum (breastbone)

Position yourself vertically above the victim's chest and press down on the sternum approximately 5 cm (but not more than 6 cm)

After each compression, release all the pressure on the chest without losing contact between your hands and the sternum

Repeat at a rate of 100-120 min^{-1}

IF TRAINED AND ABLE

Combine chest compressions with rescue breaths

After 30 compressions open the airway again using head tilt and chin lift

Pinch the soft part of the nose closed, using the index finger and thumb of your hand on the forehead

Allow the mouth to open, but maintain chin lift

Take a normal breath and place your lips around his mouth, making sure that you have a good seal

Blow steadily into the mouth while watching for the chest to rise, taking about 1 second as in normal breathing; this is an effective rescue breath

Maintaining head tilt and chin lift, take your mouth away from the victim and watch for the chest to fall as air comes out

Take another normal breath and blow into the victim's mouth once more to achieve a total of two effective rescue breaths. Do not interrupt compressions by more than 10 seconds to deliver two breaths. Then return your hands without delay to the correct position on the sternum and give a further 30 chest compressions

		Continue with chest compressions and rescue breaths in a ratio of 30:2
IF UNTRAINED OR UNABLE TO DO RESCUE BREATHS **Continue compression only CPR**		Give chest compressions only CPR (continuous compressions at a rate of 100-120 min^{-1})
WHEN AED ARRIVES **Switch on the AED and attach the electrode pads**		As soon as the AED arrives: Switch on the AED and attach the electrode pads on the victim's bare chest If more than one rescuer is present, CPR should be continued while electrode pads are being attached to the chest
Follow the spoken/visual directions		Ensure that nobody is touching the victim while the AED is analysing the rhythm
If a shock is indicated, **deliver shock**		Ensure that nobody is touching the victim Push shock button as directed (fully automatic AEDs will deliver the shock automatically) Immediately restart CPR 30:2 Continue as directed by the voice / visual prompts
If no shock is indicated, continue CPR		Immediately resume CPR. Continue as directed by the voice/visual prompts

IF NO AED IS AVAILABLE CONTINUE CPR

Continue CPR

Do not interrupt resuscitation until:

- a health professional tells you to stop
- the victim is definitely waking up moving, opening eyes and breathing normally
- you become exhausted

IF UNRESPONSIVE BUT BREATHING NORMALLY

If you are certain the victim is breathing normally but is still unresponsive, place in the recovery position (see First aid chapter).

It is rare for CPR alone to restart the heart. Unless you are certain the person has recovered continue CPR

Signs the victim has recovered

- waking up
- moving
- opens eyes
- normal breathing

Be prepared to restart CPR immediately if patient deteriorates

APPENDIX 3. **COVID-19 recommendations referred to CPR technic**.

Because of the heightened awareness of the possibility that the victim may have COVID-19, Resuscitation Council offers this advice:

- Recognize cardiac arrest by looking for the absence of signs of life and the absence of normal breathing. Do not listen or feel for breathing by placing your ear and cheek close to the patient's mouth. If you are in any doubt about confirming cardiac arrest, the default position is to start chest compressions until help arrives.
- Make sure an ambulance is on its way. If COVID 19 is suspected, tell them when you call 103.
- If there is a perceived risk of infection, rescuers should place a cloth/towel over the victims mouth and nose and attempt compression only CPR and early defibrillation until the ambulance (or advanced care team) arrives. Put hands together in the middle of the chest and push hard and fast.
- Early use of a defibrillator significantly increases the person's chances of survival and does not increase risk of infection.
- If the rescuer has access to any form of personal protective equipment (PPE) this should be worn.
- After performing compression-only CPR, all rescuers should wash their hands thoroughly with soap and water; alcohol-based hand gel is a convenient alternative. They should also seek advice from coronavirus advice service or medical adviser.