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Sudden cardiac arrest in special circumstances. Part I: hypothermia, drowning

Radosław Ziemba

Military Centre for Pharmacy and Medical Technology in Celestynow, Poland

Author's address:
Radosław Ziemba, Military Centre of Pharmacy and Medical Technique, ul. Wojska Polskiego 57, 05–430 Celestynów, Poland; e–mail: zx11@op.pl

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Summary:

The subject of the paper are some issues associated with sudden cardiac arrest in special circumstances, such as hypothermia, drowning, poisoning, pregnancy, electric shock, anaphylactic reaction, acute attack of severe asthma, injuries.

Key words: ABC Safar scheme, resuscitation course, rescue procedure course, procedures for treating an unconscious person.

Cardiopulmonary resuscitation is the most difficult rescue procedure and it is deemed an element of the first aid (undoubtedly provided at the greatest stress of a rescuer). The first four minutes are crucial for the life-saving.

During these resuscitation procedures the patient's survival directly depends on the skills of the rescuer.

Within the four minutes from the cardio-respiratory arrest there occur irreversible hypoxic changes in the brain (in normal ambient conditions). This process is biologically ultimate and irreversible.

Without external help forcing the blood circulation and restoring breathing such a patient dies before the rescue team arrives. Although during hypothermia (cooling) the brain deprived of blood supply can sustain for longer than four minutes (slower metabolism), further resuscitation of a hypothermic patient is very complicated.

The concept of life support assumes restoring (resuscitation) the functioning of cardiovascular, respiratory and nervous systems. A popular literature uses both those terms interchangeably.

Safar ABC procedure

The recommended methods (standards) of resuscitation have been set out in the guidelines of the previously mentioned European Resuscitation Council and are in force in Poland. The most important information for an accidental rescuer without professional training is so called Basic Life Support procedure.

Advanced Life Support is the responsibility of the professional rescuers, and thus they need to be called at the earliest possible opportunity (the so-called priority of calling the emergency services).

How to cope with a person with a direct life threatening condition? The ABC scheme proposed by an American anesthesiologist Peter Safar is easy to remember.

The ABC procedure involves:
- opening the airways (Airway),
- breathing control (Breathing) and
- blood circulation control (Circulation).

First we need to check whether the victim is conscious, breathing and whether the blood circulation is maintained, i.e. the presence of the most important vital signs.

Dealing with an unconscious person

Never shake the victim, pat him on the face of pinch the ears to quickly assess his condition. To check the consciousness it is enough to see his response to simple stimuli.

A deeply unconscious person does not react to sound or to touch. His reaction to pain can be suppressed or eliminated. Approaching the probably unconscious ask loudly: "Are you all right? – – Can you hear me? ... ". If there is no reaction to your voice, touch his/her face with your hand. If there is also no response to the touch – this person is definitely unconscious.

- He may experience circulatory and respiratory disorders!
- Is he breathing? Can you hear his breathing while putting your ear against his mouth and nose?
- Can you see the breathing movements of the chest and abdomen?

Putting the unconscious person in the recovery position

If the victim is breathing (you can feel him breathing), but he is unconscious, try to put him on the side in the recovery position (provided there are no other injuries requiring immediate treatment).

The lateral position allows natural opening of the upper airway (the tongue and the soft palate do not collapse on the posterior pharyngeal wall), and prevents possible aspiration of the stomach contents while vomiting. The turning technique was developed with a weak rescuer and a heavy victim in mind.

The procedure is as follows. Place the arms of the unconscious, e.g. left arm up, right across his chest; bend the right leg in the knee. Using the leg as a lever, (shove to the left), roll over the victim's body. Then tilt his head back and adjust the far (right) hand under the cheek. This position provides stability and prevents aspiration and airway obstruction in the unconscious person. If the unconscious victim has to be kept in this position for a long time he should be turned to the opposite side every 1 – 2 hours (mirror image of the initial position). Prolonged laying in the recovery position may lead to the arm ischemia or even temporary paralysis of the brachial plexus nerves.

Dealing with an unconscious and not breathing person

Before beginning the resuscitation check if the victim's airway is open. A person who aspirated a foreign body into the upper respiratory tract loses consciousness due to the suffocation if the first aid is not provided quickly enough.

When the victim's airway is obstructed by a foreign body (a candy, a cigarette, a dental prosthesis), do not pat him on the back in an upright position, but lean him well forwards, so that the vibrations make the obstructing object come out of the airway.

In extreme situations, we may attempt to dislodge the "plug" out of the trachea giving the victim the abdominal thrusts. Stand behind the choking person, put both your arms around his body so as to join your hands on his abdomen, then squeeze sharply his stomach and chest to remove the plug.

If the victim is lying (unconscious) we can strongly squeeze his abdomen with both hands. After removing a foreign body from the airway using abdominal thrusts the casualty should always be examined by a doctor (there is a possibility of accidental breaking of the ribs!). Due to a significant risk of fatal complications the so-called field tracheotomy (incision of the trachea using any random sharp tool) must not be used.

If the airway is free, check to see if the breathing is restored. If the unconscious victim is not breathing — start the resuscitation immediately!

The casualty is in a state of the clinical death, without our intervention the process of dying

will continue, leading to the biological death of the organism.

You should not worry that your actions may cause any complications, it is difficult to harm a person who is already dead.

In order to carry out a coordinated chest compressions and respiratory resuscitation the casualty should be put on the back on a hard, even surface. Expose the chest (always!), find the suprasternal notch and the subcostal angle – the center of the chest. The rescuer puts his hands on the lower half of the sternum and rhythmically compresses the chest so that it declines about 3-5 cm without loosing contact between the hands and the sternum.

Give 2 rescue breaths after each 30 compressions. The chest should be compressed 100 times per minute, while the compression and hand release rate should be 1:1.

Figure 1:

While maintaining the patency of the upper airway, the rescuer blows his exhaust air into the mouth of the unconscious victim, so that the victim's chest rises. This takes about 0.5 l of air per breath. Do not breathe too fast (too deep and fast breaths may lead to a loss of consciousness in the rescuer). The oxygen concentration in the exhaust air is sufficient to provide the gas exchange in the lungs of a not breathing person.

Continue the rescue activities until the breathing is restored or the emergency service arrives.

If the first aid kit contains an isolated resuscitation device protect yourself against infection while providing the artificial breathing. If you have a self-inflating bag for the mechanical ventilation (so called AMBU bag), use it to ventilate the casualty.

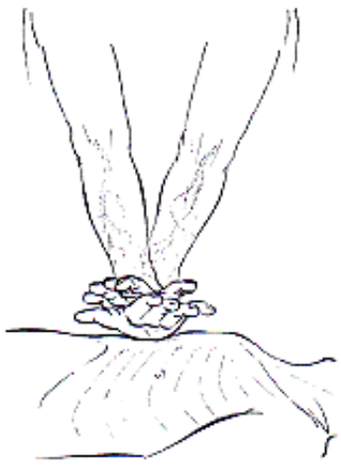

Figure 2:

Drowned people should be provided the respiratory support without removing water from the airway. The amount of water remaining in the airways is not relevant for the mechanical ventilation. Continue these activities until the arrival of the rescue team, the movements of the patient (breathing restoration) or the exhaustion of the rescuers.

Direct cardiac massage (after opening the chest), described in some handbooks, is reserved exclusively for the hospital and operational circumstances (cardiac surgery).

This paper will discuss the situations in which the resuscitation team should modify their actions according to the specific circumstances in which they operate. In many cases, early detection of the symptoms and early implementation of the resuscitation activities may prevent the cardiac arrest. The situations described below concern a high percentage of sudden cardiac arrests in the younger age group, where there are usually none coexisting cardiovascular and respiratory diseases. Early and effective resuscitation can produce good outcomes, especially if it prevents the cardiac arrest.

Hypothermia – definition

The hypothermia is a condition in which the core temperature drops below 35°C. Hypothermia can be classified as mild (35° to 32°C), moderate

(32° to 30°C) and severe (below 30°C). It may occur in patients with normal thermoregulation, when they are exposed to cold, especially accompanied by high humidity, or wind, or after immersion in cold water. In people with impaired thermoregulation, such as the elderly and very young children, hypothermia can occur even after exposure to slight cold. The risk of hypothermia increases after the intake of certain drugs or alcohol, due to an illness, trauma or negligence. Hypothermia occurs in all seasons of the year and it seems that its frequency depends not only on the ambient temperature. Hypothermia may be suspected on the basis of an interview or after a quick examination of an unconscious patient, but to measure the core temperature to confirm the diagnosis a special low-reading thermometer must be used (the temperature is measured in the esophagus, the rectum or on the tympanic membrane).

Decision to resuscitate

Distinguishing severe hypothermia and death is often not easy. You have to beware of stating a death in a hypothermic person, because lowering of the body temperature can considerably slower the pulse which is then poorly palpable and irregular, and the blood pressure can be undetectable. Hypothermia may protect the brain and the vital organs, and the associated arrhythmias are potentially reversible, both before and after warming the body up. The brain can withstand up to 10 times longer cardiac arrest when the body temperature is 18°C, compared with the temperature of 37°C. Dilated pupils may be a symptom of various conditions and must not be regarded as the sign of death.

It is not always easy to determine whether the hypothermia in a patient with the sudden cardiac arrest (SCA) and staying in a cold environment is of a primary or a secondary nature. The cardiac arrest may be a result of the primary hypothermia or the hypothermia can be secondary to the cardiac arrest in a patient with normal body temperature (e.g. cardiac arrest following myocardial infarction in an individual exposed to cold).

Death should not be stated until the patient is warmed up or until the efforts to raise the core temperature fail; it means that the resuscitation should last for a long time. In a pre-hospital circumstances resuscitation can be stopped only if the patient's injuries are clearly fatal, or if the body is completely frozen, making it impossible to attempt resuscitation. The decision to stop resuscitation attempts in a hypothermic person is based on a clinical assessment.

CPR procedure

All BLS and ALS procedures can be applied in a hypothermic patient. Follow the below procedure:

1) Clean, open and maintain the patency of the airway, if there is no spontaneous breathing begin the patient's ventilation with high-flow oxygen. Alternatively, careful tracheal intubation can be performed if recommended by the ALS algorithm. Oxygen should preferably be warmed (40°-46°C), and humidified.

2) Control the pulse on a large artery, and when possible assess the ECG within 1 minute and check whether there are any signs of life, before deciding that there is no cardiac output. If the A&E department provides the possibility of carrying out the Doppler echocardiography it can be used to determine whether there is a peripheral blood flow.

3) Confirm hypothermia during resuscitation using a low-reading thermometer.

It seems that the best way for the monitoring the core temperature is placing a permanent thermometer sensor in the esophagus, particularly during warming the intubated patient. The ventilation and chest compression rate is the same as for a patient in normothermia. Hypothermia can cause chest wall rigidity, which makes ventilation and compressions more difficult. The aim of these activities is the lung ventilation with the amount of air enough to see the chest raise, and chest (sternum) compressions to a depth of 4-5 cm. Particularly important procedure in the hypothermic patient is the cannulation of one of the central veins or a large peripheral vein. The hypothermic heart may be unresponsive to drugs, attempted electrical pacing and defibrillation The metabolism of pharmacological agents is slowed and they can accumulate within the peripheral circulation up to the toxic levels, particularly when administered

repeatedly to a person in deep hypothermia. The effectiveness of drugs in their target site is also reduced. For this reason adrenaline and other medications are often not used until the body is warmed up and the core temperature exceeds 30°C. After reaching this temperature normal intervals between doses should be doubled and the lowest recommended doses should be used. As the patient's body temperature comes back to normal the standard patterns of drug administration can be followed.

Arrhythmias

As the body core temperature decreases, sinus bradycardiatends to give way to atrial fibrillation followed by ventricular fibrillation (VF) and finally asystole. Standard procedures should be implemented. Ventricular fibrillation may not respond to defibrillation if the core temperature is lower than 30°C. If the first three shocks are ineffective, delay further attempts until the core temperature is above 30°C. However, CPR must be continued and the defibrillation attempts can be made again after warming the patient.

Arrhythmias other than VF tend to revert spontaneously as the coretemperature increases, and usually do not require immediate treatment. Bradycardia may be physiological in severe hypothermia, andcardiac pacing is not indicated unless bradycardia persists after rewarming. All treatments in patients with hypothermia require special care. Brutal treatment of the patient, too hard chest compressions, or even such procedures as tracheal intubation, may trigger ventricular fibrillation. These risks, however, should not delay the decision to begin resuscitation or careful intubation.

Rewarming

General recommendations for all victims of hypothermia include removal from the cold environment, prevention of further heat loss and rapid transfer to hospital. If only possible take the cold or damp clothing off the patient provided, however, that it is warm outside (25°C) and there is no wind. The victim should be dried and covered with blankets.

Rewarming can be passive, active external, or active internal (core rewarming). The rewarming rate should correspond to the rate of hypothermia progressing, which in fact is often difficult to assess. Passive rewarming involves wrapping in blankets and providing warm environment, but this method is useful only in conscious patients with mild hypothermia. In severe hypothermia, especially combined with cardiac arrest, active rewarming is necessary, but it must not delay transfer to a hospital, where more effective rewarming methods are available. A number of rewarming approaches have been described, but so far there are no published clinical studies showing a direct link between the final outcome and a particular rewarming method. Some of them include using heated and humidified gases and rinsing the stomach, the peritoneal or pleural cavity or the bladder with warm (40°C) fluids.

In a hypothermic patient with cardiac arrest, extracorporeal rewarming is the preferred method of active internal rewarming, as it provides sufficient circulation and oxygenation while the core body temperature is gradually increased. Unfortunately, the applicability of extracorporeal circulation is limited and a combination of the above methods can be used. Alternative extracorporeal warming may involve continuous veno-venous haemofiltration and heated fluids that top up the volume. Active external rewarming with heated air may also prove effective.

During rewarming it is necessary to give large volumes of fluidsas vasodilation causes expansion of the intravascular space. All intravenous fluids should be warmed before administration. Careful haemodynamic monitoring (continuous measurement of arterial blood pressure and central venous pressure) is essential, and thus the patients should preferably be placed in the intensive care unit. Additional tests include regular measurement of blood gases and electrolyte levels, because these parameters can change rapidly during rewarming.

Rewarming may be associated with hyperkalemia. Some patients may require administration of glucose containing fluids during warming to prevent hypoglycaemia. Devices measuring the blood gases measure them at 37°C. Therefore the blood gas values must be corrected for the temperature, as gases are more soluble in blood at lower temperatures.

In order to interpret the corrected values, the results should be compared with the normal values for specific body temperature. Thus, it is easier to interpret the blood gas results without correction and compare them only with the well known normal range values for 37°C. This is also easier to compare consecutive blood gas results during rewarming the patient.

Hypothermia in the elderly individuals is often associated with the underlying disease or injury. After successful resuscitation the thyroid function should be assessed at an early stage.

Prognosis

Complete recovery without neurological defects is possible even after prolonged cardiac arrest due to hypothermia, as hypothermia protects the brain. An unfavorable result can be expected when the core temperature is very low, and the victim suffers from other co-morbidities.

Immersion and drowning – definition

Usually the problem concerns immersion of near-drowning in water. Immersion means that the victim's head is above water, and the main problem is hypothermia and the instability of the circulatory system. The main problems in the victim of near-drowning in water (when the head is under the surface) are the consequences of asphyxia and hypoxia. Cardiac arrest is usually a secondary phenomenon. Drowning is defined as death within 24 hours from the submersion. Death after this period is referred to as "drowning-related death."

Decision to begin the resuscitation

The literature describes a successful resuscitation with complete recovery of neurological functions after prolonged submersion in very cold water. Under these conditions, the cerebral circulation may be retained for some time, especially in children. Therefore resuscitation should be started at the scene if there are no obvious fatal injuries or putrefactive changes or rigor mortis. BLS and ALS should be continued for longer than usual. If hypothermia is diagnosed, the activities following the previously discussed guidelines are implemented. A report was published on the survival of a 2-year-old child after 66 minute submersion in 5°C water. A 29 years old woman regained full neurological function after resuscitation from prolonged cardiac arrest due to accidental cooling to 13.7°C. Immersion or submersion in water colder than 25°C is associated with a high risk of hypothermia. Drowning-induced hypothermia can be of primary or secondary nature.

If the submersion occurs in icy water (below 5°C), hypothermia may develop rapidly and provide some protection against hypoxia. This protective effect is usually observed only in young children. Hypothermia can also develop as a secondary complication. The initial cardiac arrest may be due to other factors (e.g. myocardial ischemia during swimming), and hypothermia follows the submersion and SCA. In some patients the submersion may be related to the epileptic seizure or drinking alcohol. The key information that facilitates making an informed decision, is the duration of the submersion, water temperature and the initial ECG rhythm.

Rescue activities

It is extremely important that the rescuers first take care of their safety and minimize the risk during approaching the victim or pulling him out of the water. The rescuers should attempt to use a boat, a raft, a surfboard or any other floating device to reach the victim. Spinal cord injury must always be suspected and thus utmost care is necessary. Head or neck injuries are common, especially in accidents related to water sports or diving. Therefore, spinal immobilization is recommended during the rescue operation. Pulling the victim out in an upright position after prolonged immersion in water may result in the circulatory collapse. Ideally, the victim should be placed horizontally or upside down. This can be done by putting the victim on his back on a hard board before removing him from water.

Resuscitation

A key to survival is immediate resuscitation at the scene. No BLS modifications are required, but it is necessary to stress the importance of certain elements. The procedure is the same for submersion in sea or fresh water.

If the spinal cord injury is suspected, open the airway by jaw thrust and not by the head and jaw tilt. The patient's spine should be immobilized by a special collar and a board or equivalent.

Giving rescue breaths to a person without support, submerged in deep water is almost impossible. Only very experienced rescuers can perform rescue breath using special techniques, but this should not delay the removal of the victim from the water. Rescue breaths can be initiated as soon as the rescuer reaches the shallow water or pulls the victim out of the water. It is often difficult to pinch the victim's nose, support his head and open the airway the usual way, so mouth-to-nose ventilation may be used as an alternative to mouth-to-mouth ventilation.

Check the victim's airway immediately after bringing him to the land and remove any foreign bodies with your hand or a sucker if possible. There is no need to remove water from the airway before starting the BLS. In some victims respiratory arrest and glottic spasm occur just after submerging ("dry drowning"), and there is no aspiration of water. At the worst, only a small amount of water enters the lungs and it is quickly absorbed into the systemic circulation. Tilting the patient's head down does not facilitate the removal of water or lung secretion and it can induce vomiting. Moreover, abdominal thrusts to remove water from the stomach or lungs are not recommended.

Resuscitation of a drowned victim is very often associated with vomiting. If that happens tilt the victim's head to one side and remove the vomit by hand or with a sucker. If spinal injury is suspected turn the patient to his side using the spine immobilization or tilt him on a spine board. Unconscious patients should be intubated at an early stage. All patients require early administration of 100% oxygen, as profound hypoxemia is very likely.

Drowning is often accompanied by hypothermia, so the circulatory assessment should last a bit longer (1 minute). Patients with drowning-induced hypothermia are treated as described in the previous section. Chest compressions are not possible while the victim remains in the water, but it should be initiated in the usual way, as soon as possible. Arrhythmias are treated according to the guidelines.

Drowning disturbs functioning of many systems of the body, so these patients should be treated in intensive care units. They are at a significant risk of acute lung injury, and the acute respiratory distress syndrome (ARDS) may develop. Initiating the respiratory support with continuous positive airway pressure (CPAP) or assisted ventilation may be necessary to protect the lungs. During prolonged immersion, victims may become hypovolaemicfrom the hydrostatic pressure of the water on the body. The loss of this hydrostatic pressure following the removal from the water can cause hypovolemia-induced circulatory collapse.
Administration of intravenous fluids should be careful and guided by clinical assessment and hemodynamic monitoring, to prevent pulmonary edema gastric tube is introduced and the stomach is decompressed and emptied. The additional procedures include chest X-ray examination, 12-lead ECG and arterial blood gases. Blood glucose and electrolytes should also be determined.

Treatment options and prognosis

The best final outcome is usually achieved in patients with spontaneous circulation and breathing, if they reach the hospital in time. Very small percentage of patients survive prolonged resuscitation (lasting even up to three hours). There is no evidence that using steroids or barbiturates improves the final neurological outcome. Antibiotics are used only when the symptoms of infection are observed. Patients without the cardiac arrest may be discharged home after a 6-hour observation, provided that:

1) The physical examination does not reveal any problems, there is no fever, cough or breathing problems.
2) When breathing atmospheric air the oxygen pressure in the arterial blood is normal;
3) No chest abnormalities are found during examination, and the chest X-ray is normal;
4) No other troubling symptoms are reported.

The patient is discharged home with a recommendation to report to his doctor in case of any symptoms of respiratory distress.

Acknowledgements:

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