ЗМІСТ

Anesthesiology and intensive care: textbook

Про книгу

The textbook has been developed according to the new curriculum. The course of anesthesiology and intensive care lays the foundation for mastering emergencies that require the use of anesthesia and intensive care techniques. The study of these disciplines integrates the knowledge of internal medicine, pediatrics, and pharmacology, as students need to know the clinical physiology of the respiratory and cardiovascular systems, liver, kidneys, etc. In the third edition, the authors updated several chapters of the textbook taking into account the significant changes that have occurred in the medical field in recent years. According to the new curriculum, the textbook includes the chapter Sepsis, Rational -Antimicrobial Therapy. For students of higher medical education institutions.

Anesthesiology and intensive care

TEXTBOOK

THIRD edition, updated and revised

Edited by
Professor F.S. HLUMCHER,
Professor S.O. DUBROV

RECOMMENDED
by the Ministry of Public Health of Ukraine
as a textbook for students of higher medical education institutions

RECOMMENDED
by the Academic Board of the Bogomolets National Medical University as a textbook for students and internship doctors of higher medical education institutions

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Authors:
F.S. Hlumcher , Yu.L. Kuchyn, S.O. Dubrov, L.V. Usenko, Yu.Yu. Kobeliatskyi, O.V. Oliynyk, N.O. Voloshyna, O.V. Tsariov, S.M. Yaroslavska, K.Yu. Belka, Ye.Yu. Diomin

Reviewers:
V.I. Cherniy — Correspondent Member of the NAMS of Ukraine, Doctor of Medical Science, Professor;
J.M. Pidhirnyy — Head of the Department of Anesthesiology and Intensive Care FPGE of Danylo Halytsky Lviv National Medical University, Doctor of Medical Science, Professor

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CARDIOPULMONARY AND CEREBRAL RESUSCITATION

INTRODUCTION TO RESUSCITATION

There are three historical titles of this section of medicine:
1) intensive care (1950);
2) resuscitation (1961);
3) critical care medicine (1970).

Historically, the term "intensive care" came first; it emerged after the establishment of postanesthetic recovery chambers, with clock duty nurses, by neurosurgeons Dandy and Cushing before the Second World War. Further, the term entrenched since the establishment of the first intensive care unit (ICU) in Denmark (1952) during the polio epidemic. In 1965 Peter Safar proposed the term "intensivist" denoting a doctor (anesthesiologist, surgeon, therapist) working in the ICU. Later P. Safar substantiated the need for special training of doctors to work in intensive care. In 1964 M. Weil and H. Shubin first introduced the term "critical condition". In subsequent discussions between P. Safar, W. Shoemeker, M. Weil, H. Shubin et al., Critical Care Medicine (CCM) was born, which had the objective of "improving care for patients with acute life-threatening conditions and injuries, as well as facilitating the development of optimal technology of such assistance". And it should be noted that P. Safar always viewed CCM as a synonym of the term "resuscitation".

Urgency of the problem stems from the fact that about 1/4 of all deaths among people is not connected with incurable diseases, senile illnesses, or destructive changes in the brain. In the United States about 400 000 and in Europe, 700 000 cases of sudden death are registered each year. In the late 1950s during pathological studies the lack of morphological causes of death in much of the lethal cases was noted. In C.S. Beck's figurative expression, "The hearts of those patients were too good to die, and it was necessary to enable them to resume their work". This principle, later rehashed by P. Safar — "heart and brains too good to die" — formed the basis of the modern concept of cardiopulmonary and cerebral resuscitation (CPR). Philosophy of resuscitation addresses the individuals, whose life was suddenly interrupted by any cause, where there has been an unjustified death of the viable and healthy body, in the absence of a fatal incurable disease or severe senile dementia (Fig. 1). In this case the determining criterion of CPR success is restoration of the brain complete function. In case of a persistent vegetative state, which must be considered as a defect of CPR, such people should be allowed to die with dignity, as senseless prolongation of the dying process is unethical. Certainly, cardiopulmonary and cerebral resuscitation will always be one of the central points of intensive care.

The picture reflects the philosophy of resuscitation, focused on the personal life of man. In the given arc of the life, the body is denoted in black, and the human mind is

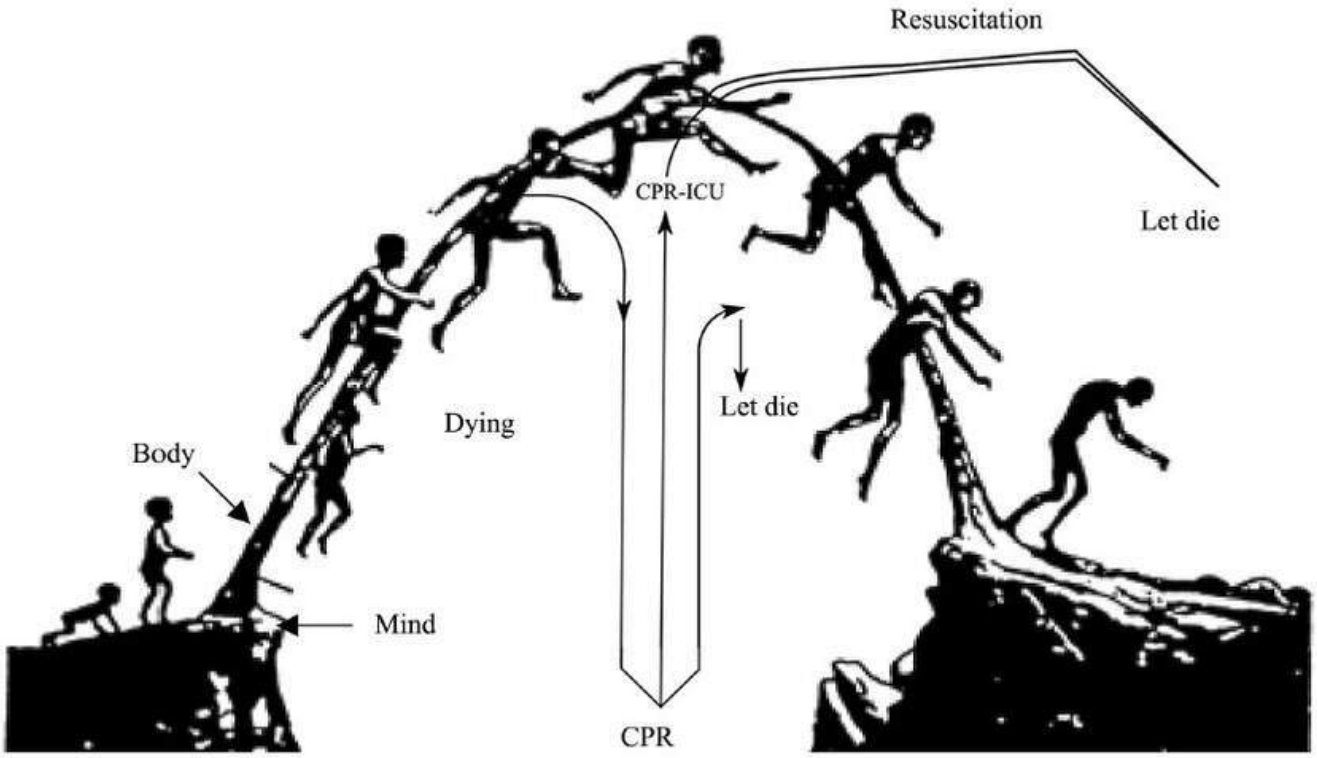


Fig. 1. **The nine ages of man** (R.N. Johnston)

white. As life experiences accumulate, white becomes larger. At an advanced age, the mind continues to evolve towards the development of senile dementia. The end of life is at a higher level than the one from which it started.

In late 2015, the new recommendations of the European Resuscitation Council (ERC) were published, in which several significant changes in the algorithm of CPR were introduced.

BASIC CONCEPTS AND DEFINITIONS

Resuscitation — the science of the mechanisms of extinction, methods of management, artificial replacement and restoration of vital functions of the organism, which is in the conditions of aggression of so degree that exceeds the possibilities of autoregulation. The subjects of the study of resuscitation are critical and terminal conditions.

Critical state is an extreme degree of any pathology in which disorders of physiological functions and disorders of individual systems cannot spontaneously be corrected by self-regulation and require partial or complete correction or artificial replacement.

Terminal states — the last stages of life (the boundaries between life and death); preagony, agony, clinical death.

The use of both terms as successive steps, signify the transition from disease pathogenesis to tanatogenesis.

The basic methodological principle of resuscitation is a systematic approach, which follows from the idea of the non-specificity of the syndrome as a clinical phenomenon.

One can completely agree with G.A. Ryabov's (1999) opinion that the formation of syndromology is the philosophy of critical state medicine, which explains the essence of

the disease, makes it possible to find common ground and may suggest rational ways of medical decisions.

Resuscitation (lat. reanimation — recovery) — a complex of therapeutic measures aimed at restoring of vital functions of the body in the case of cardiac and respiration arrest.

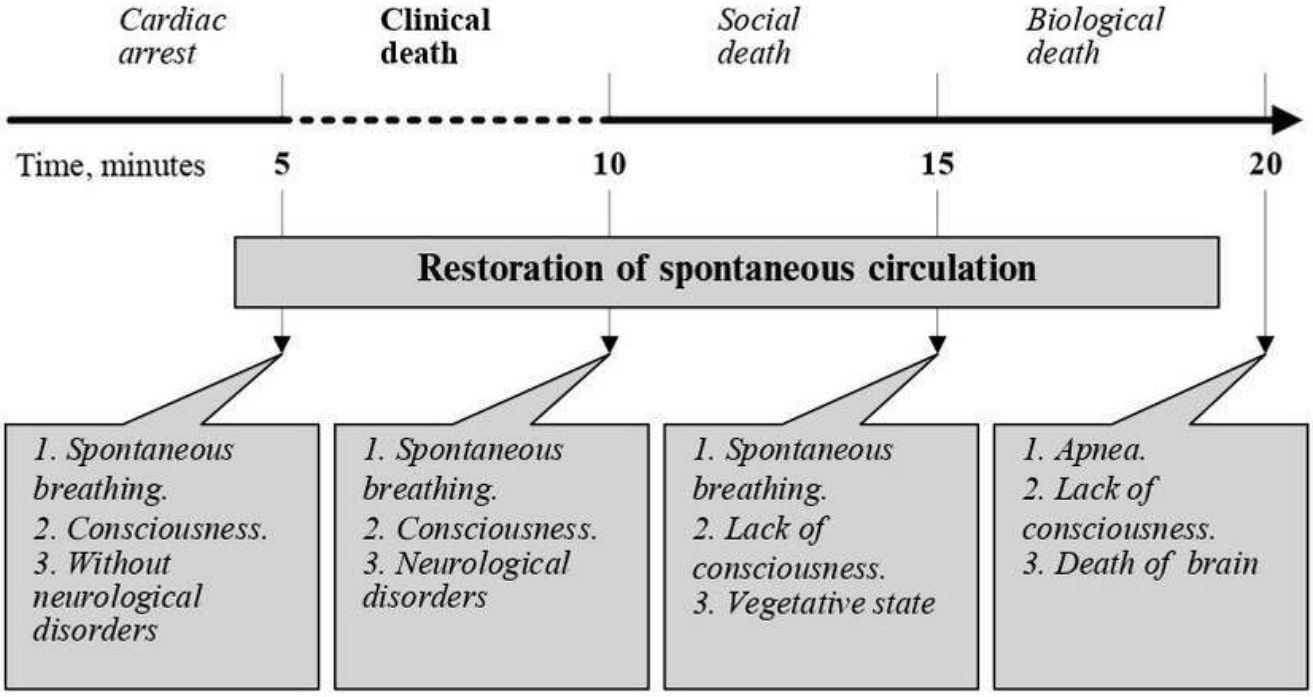
Dying — the process of decaying of vital functions of the body; not only the qualitative transition from life to death, but also the consistent and regular disturbances of the body's functions and systems, which result in their shutdown. Even the sequencing and gradual shutdown of functions gives time and makes it possible to intervene to restore life.

The main stages of attenuation of vital functions of the body

Preagonia, terminal pause and agony — the stages of dying by V.A. Negovsky, now they have more historical significance and are not considered in detail.

Clinical death is a reversible condition, beginning with the cessation of vital functions (circulation, respiration) until the onset of irreversible changes in the cerebral cortex. In other words, it is time when neurons of the cerebral cortex maintain their viability in anoxia (since the content of O_2 in the brain tissue is reduced to zero within 1 min from the moment of cardiac arrest).

The duration of clinical death primarily depends on the temperature of the body: as temperature increases, the period of clinical death is reduced to 1—2 min by increasing the oxygen consumption of tissues due to the prevalence of dissociation of oxyhemoglobin over its production. On the contrary, when the temperature lowers (in case of hypothermia), the clinical death lengthens to an average of 12 min by reducing the oxygen consumption of tissues (in exceptional cases, such as drowning in icy water, this period can be 30—60 or more minutes). At normal temperature the period of clinical death is 3—5 min, being a limiting factor in resuscitation (Scheme 1).



Scheme 1. **Time limits for resuscitation**

Thus, on average, when CPR is started within 5 min after cardiac arrest and ends with restoration of spontaneous circulation and respiration, there is a high chance of full mental restoration without neurological deficit. If CPR started within 10 min after cardiac arrest, the recovery of consciousness will be accompanied by neurological disorders of different severity, and if after 15 min, it is possible to restore only the vegetative functions, whereas the recovery of consciousness is impossible (i.e. in most cases there will be a so-called social death, a synonym of vegetative state). CPR started within 20 min or more after cardiac arrest is associated with total loss of all sections of the brain, including the stem structures (decerebration), when it becomes impossible to restore even the vegetative functions.

Social death is a partly reversible condition characterized by irreversible loss of the cerebral cortex function (decortication), while maintaining the vegetative functions.

Biological death is an irreversible state of the cells of vital organs, when the revival of the organism as an integrated system is impossible.

Brain death is a total and irreversible cessation of all the brain functions, while the heart is working, during mechanical ventilation, infusion and drug therapy.

In contemporary understanding, brain death is a juridical equivalent of a person's death.

Symptoms of clinical death

1. Absence of pulse on the carotid arteries. Pulse on the carotid arteries is determined with a use of palpation, by slowly shifting the index and middle fingers from the angle of the thyroid cartilage (Adam's apple) to the inner edge of the sternocleidomastoid muscle (Fig. 2).

2. Absence of respiration. Presence of respiration is evaluated by listening to the movement of air around the person's airways, and monitoring chest excursion.

3. Pupil dilation in the absence of reaction to light (emerges after 1 min after cardiac arrest).

Diagnosis of clinical death must be carried out as quickly as possible (within 10—15 sec) for the immediate start of resuscitation, because if the critical period of 3—5 min of clinical death is overlooked, an irreversible damage to the brain begins.

Fig. 2. **Clinical signs of cardiac arrest:**
a — lack of pulse in the carotid arteries; *b* — apnea; *c* — dilated pupils without reaction to light

Indications to cardiopulmonary resuscitation

All cases of clinical death, regardless of its causing factors.

Contraindications to cardiopulmonary resuscitation

All cases when it is known that resuscitation is absolutely useless and hopeless:

1. The onset death due to a long debilitating disease, in which all modern methods of treatment have already been used and death is not a surprise (in this case, resuscitation will not prolong life, but only extend the process of dying that is not humane).
2. The onset death of patients with incurable diseases (oncopathology in the terminal stage, terminal stages of brain circulatory violations — strokes).
3. If there are signs of biological death.

STAGES OF CARDIOPULMONARY AND CEREBRAL RESUSCITATION

The cardiopulmonary resuscitation algorithm — ABC (A — Airway, B — Breathing, C — Circulation), initiated by P. Safar, since the recommendations of ERC 2010, was modified in the CAB algorithm:

C— artificial maintenance of blood circulation;

A — control and restoration of airway patency;

B — artificial respiration support.

Thus, after diagnostics of a stop of blood circulation it is necessary to start chest compression immediately and only after that provide airway patency and hold artificial respiration and cerebral resuscitation. P. Safar divided the whole CPR complex into 3 stages, each with its purpose and steps:

Stage I. Basic life support:

Purpose — emergency oxygenation.

Steps:

C. Artificial maintenance of circulation.

A. Airway examination and management.

B. Artificial maintenance of respiration.

Stage II. Advanced life support:

Purpose — restoration of spontaneous circulation.

Steps:

D. Drug therapy.

E. Electrocardiogram.

F. Defibrillation.

Stage III. Prolonged life support.

Purpose — cerebral resuscitation and postresuscitation intensive care.

Steps:

G. Assessment (establishing the causes of cardiac arrest and its therapy) of the chance to fully rescue the patient considering the possible degree of central nervous system (CNS) damage.

H. Complete mental restoration.

I. Correction of the disturbed functions of other organs and systems.

"The chain" of survival

American Heart Association (AHA) proposed an algorithm of first aid organization called the *chain of survival*, which includes:

1. Early activation of emergency medical services.
2. Early basic life support (steps A—B—C).
3. Early defibrillation with automated external defibrillators (AED).
4. Early beginning of further life support, including intubation and use of drugs (Fig. 3).

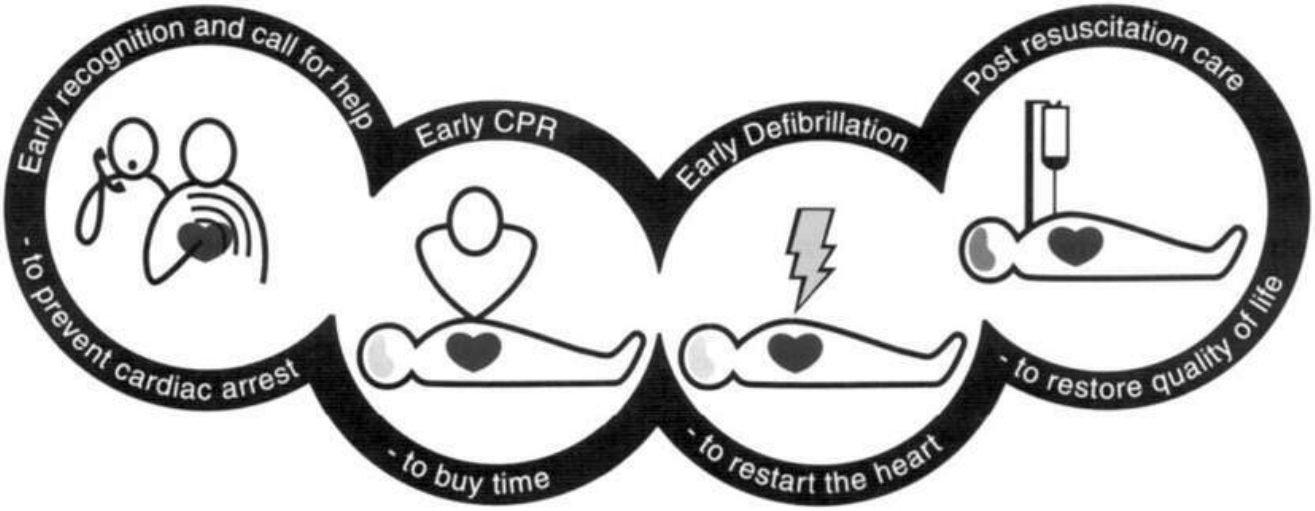


Fig. 3. **The chain of survival** (ERC'2015)

Stage I. BASIC LIFE SUPPORT

Step C: Artificial maintenance of circulation

Chest compressions. The fundamental problem of the artificial maintenance of blood circulation is very low (less than 30 % of normal) cardiac output (CO) generated during chest compression. The correctly performed compression maintains the level of systolic blood pressure at 60—80 mm Hg, while diastolic blood pressure rarely exceeds 40 mm Hg, and, consequently, causes a low level of brain (30—60 % of normal) and coronary (5—20 % of normal) blood flow. During chest compressions coronary perfusion pressure increases only gradually and therefore with each pause needed for mouth-to-mouth breathing it is rapidly declining. However, a few extra compressions lead to restoration of the initial level of cerebral and coronary perfusion. In this regard, significant changes have occurred in the algorithm of chest compression.

According to the research the ratio of compressions to the respiratory rate 30 : 2 is more effective than 15 : 2, providing the most optimal balance between blood flow and oxygen delivery, and therefore the ratio of compressions and artificial breaths number for one or two rescuers should be 30 : 2 (Fig. 4).

Chest compression technique. Then the point of compression should be determined with the next method: using the palpation find the end metasternum and place two

Fig. 4. **Compression — ventilation ratio**

transverse fingers (Fig. 5, *a*). The upper edge of them would be the place where the compressions should be performed. Then place one hand between the middle and lower thirds of the sternum (the fingers along the ribs), and the other hand — on it's top (Fig. 5, *b*). The "lock" position of palms may be used (Fig. 5, *c*). Compressions are carried out with the hands straightened in the elbows, using part of the body weight (Fig. 5, *d*).

Chest compressions should be carried out with a frequency of 100—120/min (about 2 compressions per sec) at a depth not less than 5 and not more than 6 cm, pausing for artificial respiration (it is not acceptable to conduct air insufflation at the time of chest compressions in unintubated patients — the danger of getting air into the stomach exists).

Modern models of defibrillators have implemented technology to check the quality of chest compression according to the frequency and depth of compression, and the

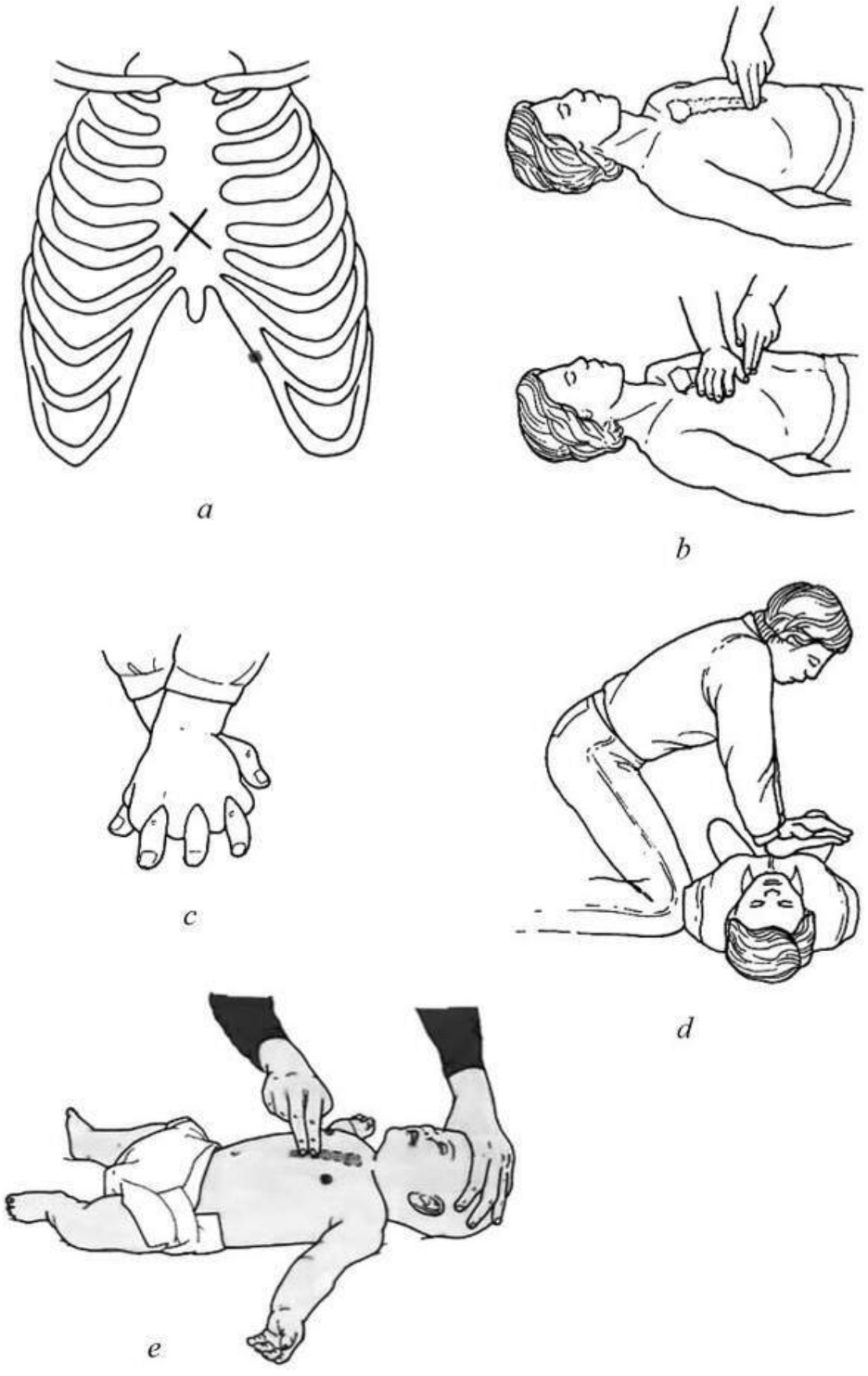


Fig. 5. **Chest compression (explanation in the text)**

quality of ventilation according to the frequency and volume. This device is placed on the chest of the patient (Fig. 6). The parameters of compression and ventilation are displayed on the screen of defibrillator, which has a function of the voice feedback to control the correctness of the resuscitation measures.

This device allows you to control the optimum depth (not less than 5 and not more than 6 cm), the frequency of compression and prevent hyperventilation.

Signs of chest compression correctness and effectiveness are the presence of pulse wave on the main and peripheral arteries.

To determine the possible restoration of spontaneous circulation every 2 min of CPR a pause (for 5 sec) is made to check the pulse on the carotid arteries.

For children aged 10—12 years chest compressions are carried out with one hand, and the ratio of compressions and breathing should be 15 : 2. For neonates and infants — with the tips of two fingers with a frequency of 100—120 rpm (Fig. 5, *e*).

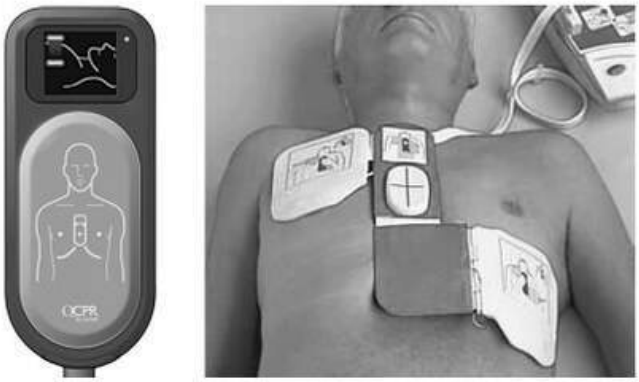


Fig. 6. **Device for controlling the correctness of chest compression**

Step A: Airway management

The main arising problem of the unconscious patients, is obturation of the respiratory tract by the tongue and epiglottis in the laryngopharyngeal area due to the development of muscular atony (Fig. 7). Obturation occurs at any position of the patient (even in the prone one), and during the tilt of the head (chin to chest), it occurs in virtually 100 % of cases. So the first thing that must be undertaken is to find out if the person is unconscious — to call out (loudly ask: What happened? Open your eyes!), pat on the cheeks, gently shake the shoulders. Once it's obvious that the victim is unconscious, it is necessary to manage the airways.

The "gold standard" for airway management is P. Safar's triple airway maneuver and tracheal intubation.

Triple airway maneuver

P. Safar developed the triple airway maneuver which includes tilting the head, opening of the mouth and thrusting the lower jaw. When this technique is carried out, the tongue is pulled forward, rising above the posterior wall of the pharynx, and the entrance to the trachea opens.

During the manipulations on the respiratory tract one should be aware of

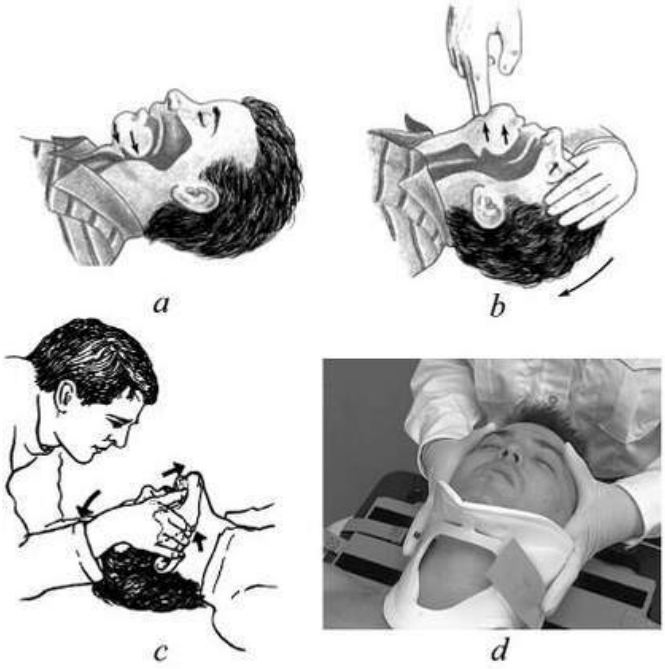


Fig. 7. **Basic airway management:**
a — airway obstruction with the root of the tongue and epiglottis; *b* — head tilt and chin lift; *c* — mouth opening and extending of the lower jaw; *d* — example of manipulation of probable spinal injury in the cervical region

possible damage to the cervical spine. The highest probability of injury of the cervical spine may occur in two groups of victims:

1) in car accidents (a person was struck by a car or was in a car during a crash);

2) when falling from a height (including "divers").

So in such patients you cannot tilt (bend the neck forward) and turn the head to the side. In these cases it is necessary to conduct a mild traction of the head and then, holding the head, neck and chest in the same plane, exclude neck overextension, with minimum tilting of the head and simultaneous opening of the mouth and thrusting of the lower jaw. During first aid the neck-fixing Schantz collar should be used.

Forced opening of the mouth and finger sweep

Head tilt by itself does not guarantee restoration of airways patency. Thus, in 1/3 of unconscious patients due to muscular atony the nasal passages during exhalation are closed by the soft palate moving like a valve. Also, it may be needed to remove foreign bodies from the oral cavity (blood clots, vomit, fragments of teeth, etc.). Therefore, especially for people with injuries, it is necessary to examine the oral cavity and if necessary, conduct a finger sweep. To open the mouth, one of the following methods is used.

1. The maneuver with crossed fingers is appropriate for a moderately relaxed lower jaw. A resuscitator stands at the head end or one side of the patient's head (Fig. 8, *a*). The index finger is placed into the corner of his mouth and the resuscitator presses the victim's upper teeth, then the thumb is placed opposite to the index finger on the lower teeth (Fig. 8, *b*) and the mouth is forced to open. Thus, significant transcending power can be achieved, allowing to open the mouth and examine the oral cavity. If foreign bodies are present, they should be immediately removed. To do this, one must turn the patient's head to the right, without altering the position of the fingers of his left hand (Fig. 8, *c*). The right index finger pulls the right corner of the mouth down, making it easier to drainage the oral cavity of the liquid contents (Fig. 8, *d*). With one or two fingers, wrapped with a handkerchief or other cloth, clean the mouth and pharynx (Fig. 8, *e*).

2. Lifting the tongue and jaw maneuver. In the case of a fully relaxed jaw the left thumb is put in the victim's mouth and the fingertip lifts the tongue root. Other fingers grasp the lower jaw on the chin and thrust it forward (Fig. 9).

In order to restore airway patency, I-gel laryngeal mask, which has a cuff made in the form of a larynx from a thermoplastic elastomer gel, is widely used, which ensures reliable airway sealing. Installing this laryngeal mask requires minimal use of skills that are easy to master during medical training (Fig. 10). The size of the laryngeal mask is selected depending on the weight of the patient.

Stable position on the side

If the victim is unconscious, but has a pulse and maintains adequate spontaneous respiration, it is necessary to give a stable position on the side to prevent aspiration of gastric contents due to vomiting or regurgitation and to manage the airway (Fig. 11). To do this, bend the person's leg on the side of the rescuer (Fig. 11, *a*), put the victim's hand under his buttock on the same side (Fig. 11, *b*). Then carefully turn the victim on the same side (Fig. 11, *c*), simultaneously tilt the head and keep the victim's face down (Fig. 11, *d*). Put the victim's upper hand under the cheek to keep the head position and to avoid the face turning down. In this case the victim's hand behind the back would not allow him to take a supine position.

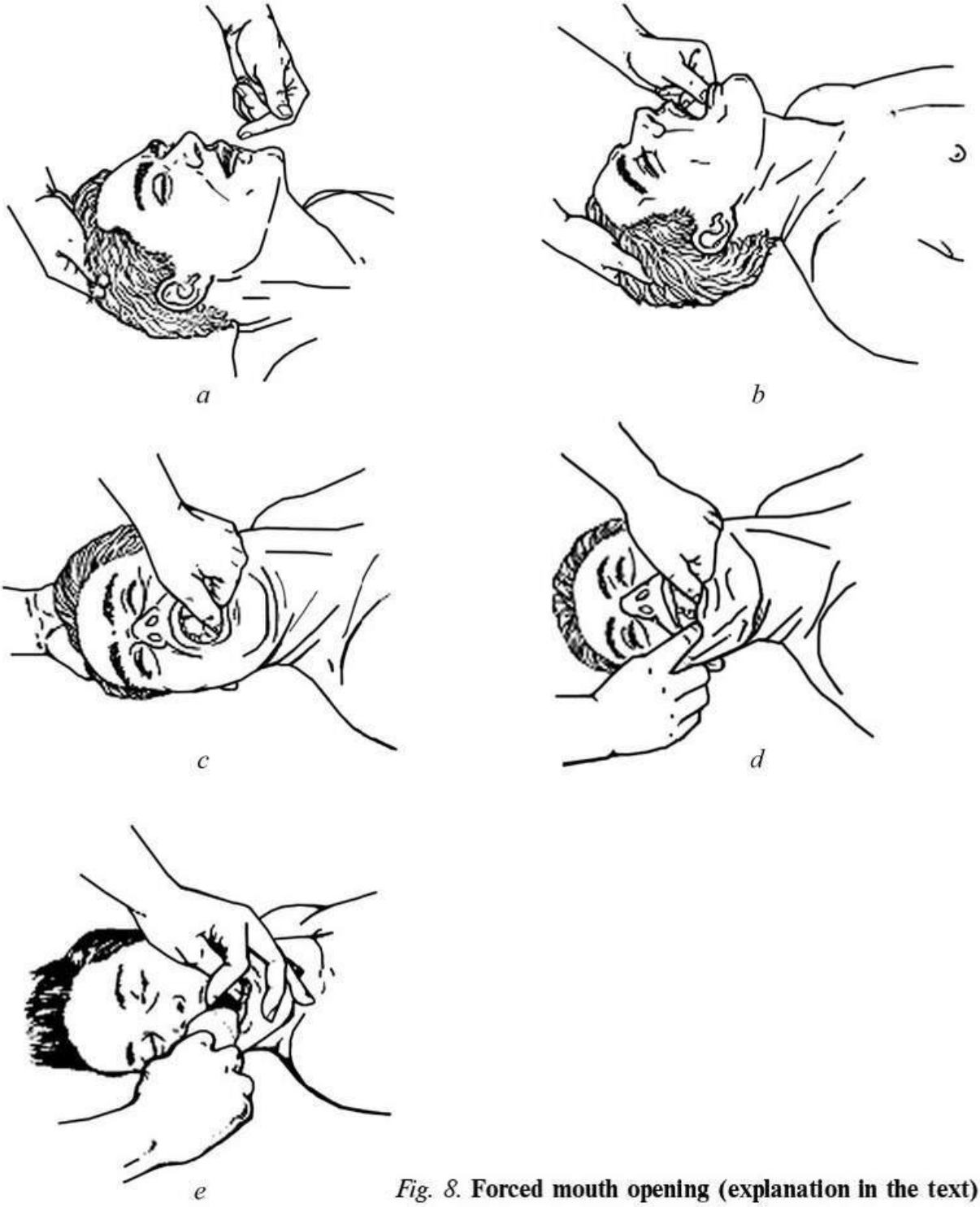


Fig. 8. **Forced mouth opening (explanation in the text)**

Algorithm of help during obstruction of the respiratory tract by a foreign body

In the case of partial airway obstruction (maintaining normal color of the skin, patient's ability to speak and effectiveness of cough), immediate intervention is not indicated.

In the case of complete airway obstruction (if the patient is unable to speak, cough is ineffective, there is an increasing difficulty in breathing, cyanosis) the following assistance is recommended, depending on whether the patient is conscious or not: