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Emergency Medicine

# First aid in cases of wounds, fractures, as well as thermal and chemical burns

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## Summary:

In this work classification and characteristics of wounds are given. Subsequently, different types of treatment of patients during different individual stages of medical evacuation are briefly discussed, taking into consideration gas gangrene. Issues concerning the case of tetanus, as well as the rules of surgical aid administration to children, are also discussed.

**Key words:** wounds, wounds classification, primary delayed suture, qualified medical aid, gas gangrene, tetanus, surgical aid.

## 1. Wound management procedures

A wound (*vulnus*) is defined as a break in the body covering. The continuity of skin is broken and the inner tissues are in contact with the surrounding environment, thus a portal of infection is formed, through which pathogenic microorganisms may enter the body. During visual wound examination, special attention is paid to the location, size, shape, margin, channel and bottom of the wound. Wound margin may be smooth, nonlacerated, uneven, lacerated, contused, etc. Wound bottom is a part of the wound located between the margins. The bottom may be even or uneven, lacerated, and may have recesses and pockets. Those two characteristics, i.e. the margin and the bottom, are of high importance for the course of wound healing.

Wound, as any injury, induces local and general symptoms, even including circulatory shock. Intensity of pain related to the wound depends on the object which caused it and innervation of the injured body part. A sharp, fast-acting object induces less pain than a blunt one, e.g. a knife or razor blade cut is less painful than a contused wound caused by a hammer blow. Some areas of the body are particularly sensitive to pain due to high density of nerve endings, e.g. fingertips, eyeballs, surroundings of sexual organs. Breaking the continuity of tissues also causes blood vessel damage. Incised wounds usually induce a more intense bleeding, whereas contused wounds bleed to a lesser extent.

Depending on the type of damaged vessels, arterial, venous and mixed bleeding may be distinguished. Once skin is incised, the contraction of elastic fibres causes wound margins to retract and the wound to open. The intensity of this phenomenon is highly dependent on the direction of elastic fibre incision.

## 2. Classification of wounds

Depending on the cause and characteristics of the injury, several types of wounds may be listed:

1) **Incised wound (*vulnus sectum*)**—caused by a sharp, cutting object, e.g. knife, razor blade, glass shard. Incised wound margin is smooth and has no recesses or pockets. Haemorrhaging is intense due to wide open blood vessels. Blood leaving the wound mechanically removes any impurities. The wound usually heals well and the risk of infection is low.

2) **Slicing wound (*vulnus lobatum*)**—occurs when the cutting object (e.g. knife) is not applied perpendicularly to the skin, but inclined. The characteristics are similar to those of incised wound.

3) **Chopped wound (*vulnus caesum*)**—formed by a forceful action using a heavy cutting object (e.g. axe, sabre, cleaver). Often results in total amputation of the affected body part.

4) **Puncture wound (*vulnus ictum s. punctum*)**—has similar characteristics to incised wound and is caused by a sharp object with a very small cutting surface, e.g. pin, splinter, nail, fork, dagger, bayonet. Puncture wound often induces internal bleeding, while wound secretion accumulating at the bottom has no appropriate drainage due to the narrow and uneven wound channel, which may facilitate the development of infection. Penetrating puncture wounds of the chest and abdomen are particularly dangerous due to the possibility of heart and lung, or intestine damage, respectively.

5) **Contused wound (*vulnus contusum*)**—induced by a blunt or blunt-edged object (e.g. stone, stick, hammer). Wound margin is contused, crushed, the bottom is uneven and has recesses and pockets. Bleeding is scarce, as crushed blood vessels are not open. Contused tissue undergoes necrosis easily and the necrotic tissue constitutes a base for the development of infection.

6) **Crush wound (*vulnus conguasatum s. Guassum*)**—defined as a particularly vast and deep tissue contusion caused by a forceful trauma, e.g. in the victims of mine wall collapse, people covered with earth after mine explosion, run over, or crushed between train cars. The lesions are often accompanied by post-traumatic shock. Moreover, advantageous conditions for the development of vulnar infections, e.g. gas gangrene, are created.

7) **Lacerated wound (*vulnus laceratum*)** – has uneven, torn margin, while the bottom has recesses and pockets. The bottom exposes ragged adipose tissue and muscles. Loss of skin and deeper tissues is often experienced, as the blunt object causing the wound operates at a certain angle and tears some tissue off.

8) **Bite wound (*vulnus morsum*)** – those caused by a dog, cat, horse, or human belong to lacerated-contused wounds. Those caused by a horse are particularly dangerous, as the animal's strong mandible often tears off large fragments of soft tissues. The risk of infection of those wounds is high, since the bacterial flora residing in the animal or human oral cavity is abundant and composed of opportunistic strains.

9) **Gunshot wound (*vulnus sclopetarium*)**—has similar characteristics to lacerated and contused wounds, however, lesions originating from the kinetic energy of the bullet also apply in this case and include overpressure and underpressure wave effects, mechanical injuries and resonance inducing tissue and organ breakage around the wound channel. Tissue and organ water content increases the force of the bullet impact, as the mechanical reactions are accompanied by hydrodynamic phenomena: the bullet's energy is transferred to water molecules which tear the organ apart. Such explosive processes take place when the bullet hits a urine-filled bladder or a full stomach. Gunshot wound has the following characteristic features: inlet (small, with a diameter equal to the bullet calibre, even margin, and scorched skin around the inlet with incorporated gunpowder remains), channel (narrow, straight or sinuous), outlet (often not located opposite to the inlet, large surface, considerable bleeding, bottom and margin lacerated with visible bone shards).

## 3. Wound treatment during medical evacuation

Treatment of the victims of catastrophes and natural disasters requires clear and detailed injury identification, allowing a precise assessment of the necessary therapeutic actions and evacuation of the wounded. Anatomical identification of the wound type and functional impairment caused by the injury should be thoroughly reported in medical documentation (Evacuation Card).

Three basic types of injury-related risks may occur: haemorrhage, potential entrance of pathogenic microorganisms through damaged body covering, as well as general anatomical and functional impairment of tissues and organs. Therefore the essential aims of the therapy cover: stopping the haemorrhage, combating potential infection along with anatomical and functional reconstruction of the affected tissues and organs.

**First aid comprises** covering the wound with aseptic bandage and using tourniquets in the case of intense arterial bleeding, impossible to stop by other means. In the case of concurrent bone fracture or massive damage to soft tissues, the damaged limb should be immobilized.

**Premedical aid** comprises control and, if needed, correction of bandage covering, tourniquet or limb immobilization.

**Medical aid** involves changing the bandage only if it is too loose or too tight, soaked with blood, or if the patient reports strong pain or oedema around the wound. Before placing a fresh bandage, the skin around the wound should be washed with petrol, ether, or alcohol, then sterilized with iodine. Wound surface should be freed from any foreign bodies using forceps and gauze pads damped with hydrogen peroxide solution. Since a longer use of a tourniquet is disallowed, it has to be released and the bleeding vessel along with the surrounding tissue has to be grasped using Kocher's haemostatic forceps or Pean's forceps, or blocked by applying a tamponade.

All the wounded should be administered anatoxin and antitetanus serum, as well as antibiotics, while the wounded potentially at risk of gas gangrene should be administered antigangrene serum. Serum administration should be noted in the Evacuation Card. Shock prevention therapy may also be introduced (analgesics, Novocaine block, immobilization in the cases of massive damage to soft tissues).

**Qualified medical aid** involves wound segregation into two groups: requiring and not requiring surgical intervention.

**The latter group comprises:**

1) small superficial skin wounds,
2) multiple, blind, superficial wounds caused by small grenade or mine debris,
3) gunshot exit wound with smooth inlet and outlet wounds, no signs of serious tissue damage along the wound channel, and no bone fractures or large blood vessel damage.

Optimal conditions for wound treatment are provided by a single surgery leaving no need for further interventions. However, in the case of massive inflow of victims, medical services will be forced to limit **early** surgical interventions to deep wounds, complicated by the damage to internal organs, blood vessels, bones and joints.

Postponed surgical aid applies to the cases of wounds limited in area and covering tissues well-supplied with blood, mainly those of the limbs. The postponement requires antibiotic and immune serum administration, in order to prevent the development of wound infection.

**Surgical wound treatment** involves performing one the following actions: incision, partial excision or complete excision of the wound.

**Wound incision** is performed in the cases of infected wounds to facilitate the drainage of purulent secretion. These are particular wounds, as they are caused by debris which produces small wound inlet but seriously damages deeper tissues. The aim of the incision is relieving tissue tension and exposure of its recesses and pockets. The surgery involves cutting through the skin in both directions from wound ends and parallel fascial incision.

**Partial excision of fresh wounds** is used when complete excision is impossible. Most of all it regards contused, crush and lacerated wounds,

when the assessment of the degree of tissue damage is difficult due to the shock induced by bullet penetration and when it is impossible to determine the border of the area indicated for complete excision. Foreign bodies are removed only when easily accessible. Bleeding must not be stopped using gauze strips, but only by precise ligation of blood vessels. The wound should be finally shaped so that efficient secretion drainage is possible without the use of a filter. Bandages wrapped around the wound should be loose in order not to cause circulatory problems and accumulation of wound secretion.

**Complete excision** involves the removal of wound margin and bottom so that a new surgical wound is formed. Bleeding sites are temporarily tamponed and wound wiping using gauze should be avoided. The surgery is performed in fully aseptic conditions. The instruments should be changed as often as possible, after every contact with the contaminated areas of the wound.

The operation begins with the skin, whose strips are radically excised approx. 1 cm beyond the visible border of the damaged area. Subdermal tissue is excised to a large extent due to its low resistance to infection. Holes in fasciae and aponeuroses should be cut with oval incisions, with subsequent cuts at both ends. This is to widely expose muscles and remove any haematomas or foreign bodies, at the same time relieving the tension caused by oedema and obstructing proper circulation. The muscles should be removed parallel to their direction, while bearing in mind that ruptured fibres may shrink considerably and may be located outside the wound channel. On muscle excision, it is necessary to pay attention to blood vessel and nerve localization, so that their potential rupture does not cause problems in local circulation and trophic innervation, which might lead to insufficient oxygen and nutrient supply to the muscle, resulting in failure or even necrosis. The most difficult aspect of the surgery is the deformation of regular anatomical structures by the trauma and the sinuous shape of wound channel. On wound excision, the channel should be strictly followed, which is facilitated by the presence of thrombuses and damaged tissue. In deeply penetrating wounds, a channel spanning through the entire wound should be formed, starting from the wound inlet and reaching the wound outlet. A healthy muscle may be recognized by a normal, red colour of the remaining fibres, their shortening or fibrillary contractions. Small blood vessel haemorrhages are managed by applying ligatures or inducing coagulation. If larger vascular trunks are damaged, vascular suture or ligation of both ends of the vessel should be applied.

If the wound contains damaged tendons, their ends should be reformed and joined. This prevents excessive recession of tendon ends and facilitates their later joining in case of suture loosening. Ruptured nerves should be joined once their crushed sections are removed. To prevent their adhesion to the surrounding tissues, sutured nerves should be placed between muscle fibres and covered with adipose tissue grafts. In the case of bone fracture, the intervention is limited to removing lose bone shards lacking periosteum. If the wound penetrates a joint, it should be opened after previous excision of the surrounding tissue, while the margin of the joint wound should be excised carefully, along with the removal of blood, small bone, and cartilage fragments. Joint wound should then be closed tightly, whereas the damaged soft tissue should be left with open wounds. Surgical intervention performed on the second day of the trauma is called **postponed**, while that performed after more than 48 hours of the trauma is called **late,** however, it is based on the same rules as the early type of intervention.

The last step in surgical wound treatment is wound closing. It may be performed:

- concurrently with the operation, by applying the so-called primary suture or using the cyanoacrylate surgical glue,
- by postponing wound closing (delayed primary suture, early and late secondary suture),
- closing of the body covering using dermatoplasty, necessary in the case of a large skin loss.

**Primary suture** may be applied, when no impurities or necrotic tissue remains after the removal of damaged tissues. After the surgery, the patient cannot be evacuated, requires constant observation by the surgeon,

and the suture should be removed immediately after the occurrence of inflammatory symptoms. An absolute contraindication to applying primary sutures are:

- no possibility of careful tissue excision throughout the wound channel,
- massive haematomas in muscles
- ligation of artery supplying blood to the surrounding tissues of the wound,
- generally grave condition of the patient.

Primary suture, commonly applied in wound surgeries, may be used only in specific cases during war time. Usually the wound remains open after surgical intervention and is drained using filters.

**Delayed primary suture** is applied to the wound during the primary intervention and aimed to place wound margins close to each other before granulation occurs in those cases, in which no necrotic tissue, infection of inflammation is observed. This condition of wounds may be seen after a careful primary intervention concurrently with antibiotic administration. Sutures are placed directly after the surgery and tied 4 or 5 days afterwards. Stratified suture is indicated in the case of deep wounds.

If pain and inflammation symptoms occur after secondary suture application, the reaction may be relieved by removing 1-2 stitches and freeing the secretion. In every case of acute inflammation, returning to an open-type treatment method is necessary.

**Early secondary suture** is used for treating wounds with necrotic tissue, applied after the wound's self-cleaning and extinction of inflammatory processes. The suture is usually applied between the 8$^{th}$ and the 12$^{th}$ days of healing, during the granulation process and before scar formation. The stitches may be placed directly after the surgery and tied to join wound margins 4-5 days later.

**Late secondary suture** is applied in slowly healing wounds caused by maturating purulent inflammation which prevents the placement of stitches in the course of wound healing. The surgery is performed after scar formation and is preceded by the excision of wound margin along with scar tissue throughout its depth. Introduction of antibiotics was a giant step forward in wound treatment; yet they support, but do not substitute surgical therapy. Administration of broad-spectrum antibiotics is necessary in such case. Their local application should be conducted with caution, as they may negatively affect wound healing.

## 4. Prevention and therapeutic procedures in the cases of gas gangrene during medical evacuation

All activities performed as **first aid** and **premedical aid** involving wound dressing, such as bandage application, immobilization, administration of antibiotics and analgesics (along with a pharmacological kit for individual radiation protection), play a protective role against the development of anaerobic bacterial infection.

**Medical aid** in the cases of crush or lacerated wounds of lower limbs, buttocks or crotch, thus particularly predisposed areas, as well as in the cases of wounds caused by debris, high doses of broad-spectrum antibiotics are used.

Polyvalent anti-gas gangrene serum is a specific preventive agent, which contains antitoxins protecting against *C. perfringens* (10,000 IU), *Vibrio septica* (10,000 IU); *C. oedematiens* (1,500 IU) and *C. histolyticum* (5,000 IU) in one ampoule.

Prophylactic use of this serum is limited to the cases of wounds containing soil, especially that well-fertilized, with antibodies detectable in the wound and delayed antibiotic administration. According to many authors, polyvalent serum against gas gangrene has no therapeutic effect and has been removed from the index of medications used by the United States Armed Forces. Serum dosage depends on the type of injury and general condition of the wounded. In small wounds and good general condition, 20,000-40,000 IU of serum is sufficient, while in massive crush wounds, 40,000-80,000 IU are administered. Moreover, specific aid should provided at this stage and, depending on the type of damage, the wounds should be washed with oxidizing agents.

At the sites where aid is provided, gas gangrene patients are placed in dedicated isolation chambers. Therapy is administered by surgeons using separate instruments and scrubs.

A surgical intervention is first performed, comprising not only wound excision or incision, but also liberation of muscles and blood vessels to minimize oedema and pressure. To this end, longitudinal fascial incisions are performed in the area of affected muscles and oedema. Then the areas are covered with loose gauze strips soaked with hydrogen peroxide solution. The wound is left wide open with a local administration of antibiotics and anti-gas gangrene serum. In the case of immobilization with a plaster splint or bandaging, drainage tubes are used to deliver antibiotics and the serum. To allow exotoxin binding, high doses of the serum (40,000-60,000 IU every 4-6 hours) are administered until clinical improvement occurs.

In order to obtain higher blood concentrations, the serum should be administered along with blood and electrolytes. On serum administration, performing skin allergy tests is obligatory. Antibiotics used in this procedure are penicillin (up to 20 million IU) and tetracycline (2.0-4.0 g daily).

In case no improvement is visible and infection advances, or when the gangrene process covers the entire circumference of the limb, amputation is indicated. It is conducted by performing a circular cut in one plane (guillotine amputation) and leaving the wound completely open. Before the surgery, 500-1000 ml of blood, antibiotics, and oxygen are administered.

On the whole, provided aid involves general intensive therapy: constant monitoring of blood pressure, heart rate, respiratory rate, as well as auxiliary examinations. Small quantities of blood or blood substitutes with electrolytes (to combat acidosis), colloids (dextran), vitamins, and cardiac medications are administered. Gas gangrene patients require protein-rich food and large quantities of liquids taken orally. Secondary stitches are applied once general and local symptoms have receded; plastic surgery may also be performed.

A novel and significant achievement in gas gangrene therapy is the administration of overpressurized oxygen. The treatment is conducted in a dedicated chamber, in which the patient is placed together with medical personnel for 1-2 hours. Once the pressure is increased to 3 atmospheres, the patient breathes with pure oxygen. Such a high partial pressure of oxygen causes its blood plasma levels to increase 20-fold compared to those in standard atmospheric conditions, enabling a therapeutic role of oxygen in insufficiently oxygenated tissues. The above sessions are performed 2-3 times a day until a significant improvement is obtained. Thus conducted therapy has increased the survival rate to 75%, with the most recent studies reporting even better results.

**Tetanus**

Tetanus has been a serious wound complication since ancient times. A detailed description of tetanus may be found even in the works of Hippocrates, who claimed that spasms occurring as a result of wounds are fatal. The relation between some soils and tetanus has been noticed quite a long time ago.

During the Franco-Prussian War, the mortality rate due to tetanus in the Prussian Army reached 91%. According to many researchers, the incidence of tetanus was predominantly related to war injuries. The toxic character of the disease was ultimately proved in 1889 r. by Kitarato, who obtained cultures of tetanus bacilli.

The recent major wars were fought in the areas, where large-scale animal breeding and soil fertilization for grapevine crops were used. According to the British Army statistics, among the l,720,000 wounded on the Western Front of World War I, 2,529 (1.47%) of them were infected with tetanus. Concurrently, among the 286,000 wounded on other fronts, only 20 cases of tetanus (0.07%) were reported. Other sources report that tetanus incidence rate on the Western Front was 21 times higher that in the Eastern Front. In World War I and, partially, World War II, seroprophylaxis was the basic preventive measure against tetanus. It was active mass immunization using antitetanus anatoxin which provided effective protection against tetanus infections. In the armies which

used anatoxin, the cases of the disease were extremely rare.

Tetanus is caused by the spore-forming bacterium *Clostridium tetani*, which belongs to anaerobic bacteria. The disease may develop once the bacteria or spores arrive deep into the tissue through an open wound, or rarely in patients who did not sustain an open wound.

Tetanus bacilli may be found in bovine, equine, and sometimes human faeces. This way the bacteria get into the soil. The cells and especially the spores are very resistant and retain the ability to develop up to one year. The portals of infection are wounds, insect bites, burns and frostbite. Tetanus bacilli multiply only in the wound and its surroundings. Host organism is affected only by neurotoxins, rapidly penetrating the central nervous system through the myelin sheath, blood and lymph. Tetanus toxin binds to ganglion cells of the anterior horn of the spinal cord and medulla oblongata. Administered anatoxin is unable to dissociate or neutralize the toxin. Tetanospasmin causes tonic contractions of skeletal muscles and increases muscle contractility leading to clonic spasms.

Proper tetanus identification is extremely important. Incubation period of the infection ranges from l to 60 days, usually lasting 7-11 days. A short incubation period lasting a few days is prognostic of a more severe course of the disease. If the initial point is a head, neck or trunk wound, the course of tetanus is more rapid and severe. The occurrence of tetanus in ⅓ of all cases is preceded by a period of initial symptoms. Jaw paraesthesia occurs along with pain around the wound much stronger than expected, occurring mainly at night, painful spasms around the wound, pain when applying pressure to the nerve trunks serving the wound area, increased muscle excitability, excessive tendon and periosteal reflexes, often covering larger areas. Among general symptoms, excitation or somnolence, increased sensitivity to light and sound, hydrophobia, increased body temperature, headache, or abundant vomiting may be observed.

The symptoms of developed tetanus may represent two forms. The generalized form occurs when the disease develops over a short period of time and tonic spasms regard different muscle groups without any order. The patient is constantly conscious. In the discerning pattern, several muscle groups are affected in the following order: muscles of mastication *(trismus),* mimic muscles *(risus sardonicus)*, neck and back muscles *(opisthotonus),* diaphragm and respiration muscles.

In both of those forms superficial sensation is retained, tendon reflexes are more pronounced, and Babinski's sign may occur. Due to the excitation of the central nervous system, tonic and clonic spasms occur, while the gaps between the spasms may be as short as a few minutes.

In the fully developed disease, the patient lies on his/her back with the head inclined backwards, the trunk heavily bent forward, lower limbs extended in the knees, feet dropped. Upper limbs lie freely. During the spasms, the patient moans, sweats and bends the neck and the trunk to a greater extent. The spasm of arm flexors causes elbow flexion and closes the hand into a fist. Due to increased contraction of the glottis, intercostal muscles, and diaphragm, breathing difficulties occur followed by cyanosis and apnoea. Strong spasms may lead to abdominal muscle rupture, as well as rib, sternal, and vertebral fractures. The cause of death may be central nervous system ischaemia, as a result of recurring periods of apnoea. Secondary causes of death may include bronchial pneumonia and heart exhaustion.

In a catastrophe, every burn or frostbite is at risk of tetanus contraction and requires preventive measures which may only be applied during medical aid.

It is assumed that all victims with wounds, burns and frostbite should receive 3,000 IU of antitetanus serum (antitoxin), which induces passive immunity. The serum should be administered as soon as possible after the injury. Protective role of serum administration becomes doubtful after 12 hours of the injury and pointless after 24 hours. Equine or bovine antitoxin is used for injections. In the case of wounds potentially at risk of tetanus or if some more time passed after the injury, 6000 IU should be administered.

In the case of decreased immunity response (due to radiation), the dose should be 3-4 times higher. Reserve in using antitetanus serum lightly may be due to the possibility of allergic reaction induced by specific antibodies (anaphylactic reaction, serum sickness). The frequency of those complications increases with the serum dose and when a 100 ml dose is administered, serum sickness occurs in 90% cases.

Antitetanus serum should only be administered after an intradermal or intraconjunctival sensitivity test. When allergy is suspected, fractionated administration should be applied, which involves intradermal injection of 0.1 ml serum diluted 1:20 with 0.9% saline. If no local reaction visible as a vesicle with reddening or oedema appears within 30 minutes, the entire serum dose may be administered. In the case of a visible reaction, the appropriate dose is divided and slowly injected during 0.5 to l hour in the following sequence: 0.05 ml of 1:20 dilution, 0.05 ml of 1:10 dilution, then 0.5 ml and l ml subcutaneously. If no clearly visible symptoms appear, the remainder should be administered intramuscularly.

Once an allergic reaction occurs, the administration should be abolished and desensitizing agents should be used *(calcium chloratum,* adrenalin, ephedrine).

Serum sickness usually occurs after 7-10 days. Passive immunity is retained for 14 days after serum administration. Negative consequences of the use of antitoxin are eliminated by the prophylactic use of human antitetanus serum. Using relatively small doses a high level of antitoxin is obtained, which remains in blood serum for longer periods. Difficulties in obtaining human serum limit its use in everyday practice.

The most effective, the simplest, and the cheapest agent inducing active immunity is tetanus anatoxin which contains no protein, therefore its use poses no risk of negative consequences.

It was demonstrated during World War II that thanks to active immunization no case of tetanus due to sustained wounds was reported. Anatoxin is administered intramuscularly in several doses. Two types are used: formol anatoxin and the type adsorbed to aluminium hydroxide or phosphate. Aluminium anatoxin is used at the quantity of 0.5 ml, while the formol type at 1.0 ml. Adsorbed anatoxin is administered in two doses, while the formol type in three doses, with 4-6-week gaps.

In order to retain a high titre of antibodies after the primary immunization, the so-called maintenance dose is administered every 4-6 years. In most cases, actively immunized people have sufficient immunity to tetanus.

If the injury occurs after more than 6 months of immunization, a maintenance dose has to be administered. Some authors advise, however, to keep the patient under observation for 10 minutes after anatoxin administration.

A mixed type of immunization, both active and passive, is used in the cases of wounds potentially at risk of tetanus in nonimmunized or improperly immunized patients. Antitoxin is to provide passive immunity until the organism produces its own antibodies. Anatoxin is injected in a different body part than serum and with a different syringe.

Antibiotics used in tetanus prophylaxis are of dubious use, but in the cases of massive wounds they constitute a form of protection against the development of additional bacterial flora.

As a part of qualified aid provided to the wounded infected with tetanus, apart from previous surgeries, surgical wound treatment is performed. The administration of tetanus serum and anatoxin is obligatory in those who have not received them.

Contemporary tetanus treatment procedures should be performed in separate, dedicated rooms or even separate hospitals. The therapy should be conducted by a surgeon in collaboration with an anaesthetist and using all the available equipment.

**Tetanus therapy involves:**

- local therapy,
- specific general therapy,
- nonspecific general therapy,
- thorough patient care.

**Local therapy** is based on surgical wound treatment. One hour before the planned

surgery, the serum should be evenly injected into the wound. The surgery involves opening the wound wide, removal of foreign bodies, damaged tissue, and recesses. Then the wound is washed with hydrogen peroxide solution, or alternatively covered with zinc powder. If the intervention concerns a limb with a concurrent fracture, tight plaster bandaging should be used for limb immobilization. In the case of damage exclusively to soft tissues, only a plaster splint is used.

In order to sequester circulating toxins, 50,000-100,000 IU of equine or bovine antitetanus serum should be injected intravenously and intramuscularly. The injections are performed for 8 days, depending on the course of infection. It is also recommended to inject antitetanus serum intrathecally every two days or, in severe cases, every day. Intrathecal administration should be obligatorily performed in general anaesthesia and with the removal of a volume of cerebrospinal fluid equal to the volume of introduced serum. To this end, concentrated serum containing 30,000-50,000 IU in 20-25 ml is used, previously heated to the body temperature.

During intramuscular serum administration, the injection site should be located above the wound and the injected volume should not exceed 50 ml per site. Intravenous injection poses a risk of allergic reaction, therefore it should be used only in exceptional cases and once protective measures have been taken. The latter involve the following sequence of actions: subcutaneous injection of 0.25-0.5 ml, 4 hours later 0.1 ml is administered intradermally, after another hour the subcutaneous injection site is examined for an allergic reaction. If oedema or reddening occurs, no intravenous administration is performed.

If an allergic reaction appears, 0.2 ml of 1:100 adrenalin solution should be administered subcutaneously, as well as 20 ml of 10% *calcium chloratum* (intravenously) and antihistamine preparations. The quantity, duration and routes of antitetanus serum administration depend on the clinical image of the disease and medical indications.

In all cases, the serum should be combined with 1 ml of antitetanus anatoxin and repeated on days 2 and 4 (3 doses altogether). Depending on the intensity of spasms and the severity of clinical signs, general anticonvulsive therapy should be applied. Mild and moderately severe tetanus therapy may include neuroplegic medications or chloral hydrate up to 3-4 g/day *(chlorali hydrati* 1.0-1.5; *Decocti amyli* 50.0 d.t.d. no. 3), administered intra-anally after heating to 40°C.

The administration of lytic mixture (l amp Dolargan (pethidine) + l amp chloropromazine — pipolphen (promethazine) — and 0,9% NaCl solution brought to 10 ml or l amp Dolargan (pethidine) + l amp. chloropromazine + l amp. promethazine and l% lignocaine brought to 20 ml) depends on patient status and age. The mixture is used every 3-4 hours depending on the spasm occurrence and intensity.

Another recommendable spasm therapy is concurrent neuroplegic and barbiturate administration at 0.5-1.0 g in 1 L of 5% glucose solution.

In a severe course of tetanus, tracheotomy is performed and controlled respiration is conducted using a tube with sealing cuff after the administration of curare preparation. D-tubocurarine may also be used as repeated intramuscular injections, adjusted to every patient individually. Gaps between the injection are gradually extended. Succinylcholine I.V. may be used instead of d-tubocurarine due to higher procedural flexibility.

When neuroplegic agents are used, special attention needs to be paid to maintaining proper blood pressure levels, as a decrease to 80-75 mm Hg is a strong contraindication for further use.

During controlled respiration, air passage through the airways has to be secured by correct body positioning, suction and drainage of airway secretion, air humidification, changing the tracheostomy tube and local antibiotic administration.

Moreover, general therapy involves the administration of antibiotics (2-3 million IU of penicillin/day and tetracycline), liquids and electrolytes. The diet should be fluid, rich in calories and proteins, delivered using a feeding tube during

periods without spasms. Adrenal hormones should be used in severe cases, as adrenal cortex depletion occurs.

Tetanus patient care involves strict isolation, keeping the patient calm, careful and frequent (every 1-1.5 hours) repositioning to prevent pressure ulcers, proper feeding, keeping free the passage of urine in the catheter, controlling fluid balance. It is also necessary to control body temperature, blood pressure and respiratory rate.

## 5. Principles of providing surgical aid to children

Children constitute approx. ⅓ of the population of Poland, therefore it is vital to protect them against harmful consequences of modern warfare. One of preventive measures is their dispersal. During war time, children typically sustain injuries similar to those of adults. For humanitarian reasons, it is necessary to provide them better conditions of treatment and more carefully segregate them to the expectant category. It is also recommended to provide separate rooms for the treatment of children.

The reaction of a child's organism to harmful factors is different according to age. From the anatomical and physiological point of view, a child is not a miniature of an adult, but an immature organism undergoing dynamic tissue transformations. This explains their high sensitivity to dehydration, insufficient protein supply and electrolyte imbalance. The greatest differences in the reactions to harmful stimuli occur in the early stages of life, while in the later development those changes are less pronounced. High instability of a child's organism makes the differentiation between physiological and pathological state difficult.

Treating wounded children requires applying the same procedures as in adults. However, vulnar infections in children easily become generalized and spread rapidly, often causing sepsis. This requires early surgical wound treatment, more frequent wound drainage and antibiotic administration.

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