ABSTRACT

Burns represent a significant percentage of injuries amongst trauma patients. The risks from a burn wound depends on the causative factor, time and place of exposure, extent and severity of the burn. Classification according to the American Burn Association indicates that severe burns should be diagnosed from as low as 10% of Third-degree total body surface burn. The burn disease develops progressively through shock, catabolic and anabolic phases until the development of Multiple Organ Dysfunction Syndrome (MODS).

Actions performed in the pre-hospital phase are crucial for the effectiveness of the therapeutic process. Wrongful first aid performed by a witnesses of the event may worsen the patient's condition and lead to secondary infection. Studies available in the literature indicate the use of egg whites, yoghurts and ice as means of first aid. Educational projects to promote good practice, using products such as hydrogel dressings, seem therefore necessary.

Medical personnel should quickly assess the extent and severity of burns. Furthermore, one ought to implement volume-calculated fluid therapy, protect the respiratory tract and strive to ensure thermal comfort. It seems mandatory to assess the extent of pain and administer appropriate pharmacological measures to perform analgosedation. Due to the limited number of specialist burn treatment centres, paramedics should consider indications for hospitalization and the use of Medical Air Rescue (MAR) enabling rapid patient allocation.

KEY WORDS: burns, burn disease, injuries, medical emergency, first aid.
INTRODUCTION

Thermal, chemical, electrical and ionizing factors constitute the most common causes of burn injury which usually results in damage to the skin and subcutaneous tissue [1]. Depriving the body of protection against harmful factors from the external environment entails a cascade of possible complications. The body homeostasis is disturbed, which may even pose a threat to the patient's life.

Exposed areas such as the face, hands - as a result of a burn may limit subsequent functioning of the burned person. Children and elderly people constitute the highest at-risk group. Burn injuries are a serious issue in Central Europe, as in Poland alone up to 300-400,000 such injuries are reported on an annual basis. Children between the first and second year of life remain most at risk [2]. The most common place of occurrence in these cases is the patient's home, and the factors causing the injury include hot liquids and corrosive cleaning agents. In case of adults, burns are most often caused by accidents at work, but also at home [3]. In Poland, approximately 12,000 people suffer burns that require treatment every year. The mortality rate in this group is about 600 people. First, the burns go to the general surgery ward, and only about 30% are hospitalized in specialist burn treatment centres. These are patients with severe and critical burns [1].

CHARACTERISTICS OF BURNS

Burn injuries can be divided according to several parameters. This includes, for example, differentiation of burns according to the triggering factors or the severity associated with the triggered symptoms.

Causing factors

- **Thermal burns** - this type of burns is caused by contact of skin and mucous membranes with hot liquids, solids or flames, among other things. Skin heat burn is caused by the flow of energy in the form of heat from the source through the skin to its deeper layers. The heat exchange takes place due to temperature differences. Damage occurs when the skin is exposed to a temperature higher than the temperature tolerated by the body, which does not cause injury. Temperatures exceeding 44°C are considered to cause local cell damage which doubles with every degree upwards [4].
**Chemical burns** - the main mechanism of chemical burn injury is the hydrolysis reaction caused by changes in pH. It can last as long as the chemical is present. There are many ways in which chemicals can enter the human body and cause burns. Harmful substances, upon damaging the layer of the epidermis and skin, allow them to get into the general circulation and cause a toxic effect. Another way of absorption can be the lungs, which burn as a result of inhaling free gases. Another way is the digestive tract. Drinking e.g. corrosive substances, may result in burns of the oral cavity and esophagus. Acids burns are characterized by limited coagulation necrosis, while alkaline burns are characterized by melting necrosis, which makes them deeper and heavier.

**Electric burns** - electric energy moving through the body changes into thermal energy and most often causes damage to muscles, blood vessels and nerves, thus significantly deepening the injury. It runs through tubular organs, so it can also cause, for example, intestinal necrosis. Additional symptoms may include loss of consciousness, respiratory arrest as a result of electrocution of the respiratory centre or cardiac arrest, especially in case of exposure to alternating current. This poses a real risk to the emergency services on site if the power source has not yet been disconnected [5]. According to Lee and Frame, electrical burns can be divided into:

- **Low voltage** - induced by current of up to 1,000V;
- **High voltage** - induced by current of voltage equal to or higher than 1,000V.

Every year about 20,000 people become victims of lightning strikes, which leads to about 1,000 deaths. In the USA, about 150-300 people die of this cause every year. Lightning is an electrostatic discharge phenomenon naturally occurring in the atmosphere that accompanies thunderstorms. It is also manifested by an acoustic phenomenon, which is thunder, and lightning strike, which is a light phenomenon. The temperature of lightning reaches 20,000°C and its speed is approx. 1 million times faster than the speed of sound [1].

**Burn degrees**

A four-point scale is used to assess the depth of burns. Each step features its own burn characteristics, which take into account the specific symptoms.
First-degree burns - superficial skin burns. Characterized by redness, slight swelling and painful feeling of burning. An example is sunburn, e.g. caused by sunbathing. Symptoms usually persist for 5 to 10 days and, after exfoliation, the skin heals without leaving a scar [6].

Second-degree A burns - not applicable to full skin thickness. Includes epidermis and the outer layer of dermis. The deeper layers, containing sweat glands and hair follicles, do not burn. In addition to redness and swelling, bladders filled with yellowish serum fluid are typical. There is also local tissue pain. If the wound is not infected, the healing process takes about 14 days and small scars remain [6].

Second-degree B burns - the epidermis and the dermis layer of different depths are destroyed. The burn also damages blood vessels. Blisters filled with raw fluid on the skin are usually not noticeable as in second-degree A burns. The wound is white, grey or pink brick-red. Intense pain dominates, but it happens that there is a lack of feeling in the centre of the wound. This damage to the skin prevents the launch of the healing process before surgical intervention. Healing lasts from 21 to 35 days and scars remain. If the infection develops in the wound, it may worsen to the third degree [6].

Third-degree burns - the full thickness of the skin is damaged. This is often accompanied by the destruction of deeper tissues such as nerves, vessels, subcutaneous tissue or adipose tissue. The skin in place of the injury is hard, looks like etched. The dominant color is brown, dark-brown or black. The injury can also be covered with white and grey scabs. Pressing the burn area causes severe pain, but the burn surface is insensitive to touch because the pain receptors in the skin have been damaged [6].

Fourth-degree burns - characterized by a complete carbonization of tissues. Its range covers the full thickness of the skin, sometimes also with muscles, fascias and bones [6].

Extent

In order to determine the severity of burns or to undertake appropriate liquid resuscitation in case of burns, it is necessary to determine the extent of the injury. The “Rule of Nines” applies to adults and children over 15 years of age. This method assumes that the relevant parts of the body account for 9% of the total body surface. It is the most commonly used method in medical emergency services. The “Rule of Five” has been applied in the case of infant burns. It says that for each limb there is a value of 10% of the body surface, while the head, front and back of the torso constitute 20% of the total body surface (Figure 1).
Figure 1. Extent of burns in adults and children [7].

Burn severity classification

The current classification of the severity of burns was developed by American Burn Association (ABA), accepted by the Polish Burn Treatment Society [4]. Burns are divided into light, medium and severe (Table 1).

Table 1. Burn severity scale [6].

<table>
<thead>
<tr>
<th>Severity of the burn:</th>
<th>I degree</th>
<th>II degree</th>
<th>III degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>&lt; 15%</td>
<td>&lt; 15%</td>
<td>&lt; 2% (does not apply to the face, eyes, ears, hands, perineum)</td>
</tr>
<tr>
<td>Medium</td>
<td>15-20%</td>
<td>15-20%</td>
<td>2-10% (does not apply to the face, eyes, ears, hands, perineum)</td>
</tr>
<tr>
<td>Heavy</td>
<td>&gt; 25%</td>
<td>&gt; 25%</td>
<td>&gt; 10% (applies to: face, eyes, ears, hands, crotch, electric burns, chemical and respiratory tract)</td>
</tr>
</tbody>
</table>
Burn disease occurs when thermal injury affects 15-20% of the body surface area in adults and 10% of the body surface area in children. It is divided into 3 phases [5]:

- **Shock phase** - during the first 48-72 hours. It is caused by significantly increased permeability of capillaries, which leads to fluid loss occurring through the burn wound, but also through accumulation in the form of swelling in healthy tissues. The shock is manifested by a decrease in the amount of circulating blood, hypoxia of tissues, decrease in the volume of urine excreted, decrease in cardiac output, increase in systemic vascular resistance.

- **Catabolic phase** - lasts from a few days to a few weeks. It is associated with the disintegration of dead tissues at the injury site and mobilization of the entire body to self-clean the wound. This leads to a deep metabolic disorder, because the patient experiences a fever, weight loss, lack of appetite, and the work of internal organs is disturbed. Infection also constitutes a common symptom.

- **Anabolic phase** - lasts over four weeks. This phase is related to the healing process of wounds, scarring and balancing of any disorders.

These phases lead to a full-scale Multiple Organ Dysfunction Syndrome (MODS) [8]. Clinical symptoms of MODS include: acute circulatory, liver, kidney, and lung failure; neurological disorders; gastrointestinal bleeding; homeostatic disorders; and intravascular coagulation syndrome.

**TREATMENT**

**First aid**

The mandatory first aid recommendation for burns is immediate active cooling of the burned area, which leads to a reduction in the local tissue temperature. Cooling the tissues reduces the depth of burns, which can reduce the number of people in need of hospital care. Other benefits of cooling include reduced pain, swelling, infection frequency and faster healing of wounds. The currently recommended method is to cool the burns for 10-15 minutes. However, care should be taken when cooling extensive burns or burns in newborns, children and the elderly. Remember not to lead to hypothermia, i.e. lowering the body temperature below normal values. First aid includes actions such as [9]:

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● Take care of your own safety (special safety must be ensured in the event of burns caused by electricity, the power supply must be switched off as it also poses a danger to the person providing assistance);
● Isolate the injured person from the burning agent (in case of chemical burns, toxic substances should be removed as soon as possible by rinsing the skin with water until the substance is completely removed);
● Determine the source and time of the burning agent's action;
● Protect the airway patency;
● Cool the wound under running water at 20°C;
● Take off any rings and from the patient's hands;
● Take care of concomitant injuries;
● Apply a sterile dressing to burns;
● Call for professional help;
● Cover the injured person with a blanket to prevent excessive heat loss;
● Administer drinking fluids to the patient, if conscious.

During first aid, it is often the case that the witnesses of an incident perform improper activities. The use of egg whites, yoghurt or ice on a fresh burn wound may cause deterioration of the patient's condition [9]. Therefore, the following should be avoided:

● Tearing off the clothing of the injured person;
● Applying pastes, oils, ointments and fatty substances;
● Applying ice;
● Opening burn blisters by cutting or puncturing;
● Applying materials that may be the source of infection to the burn wound;
● Oral administration of fluids in case of nausea, vomiting or disturbances of consciousness.
Hydrogel dressings

Hydrogels and hydrogel dressings are included in the group of first-aid dressings. The products constitute a group of natural and/or synthetic polymeric materials with a hydrophilic structure that makes them capable of retaining large quantities of water. They are used for immediate treatment of thermal, electrical and chemical burns. They can be used for both surface wounds (abrasions, scratches, cuts) and deep wounds. The preparations have a cooling effect, reduce swelling and pain and protect wounds against infection. When applied immediately after a burn, they significantly reduce its negative effects. Hydrogel bandages do not adhere to burns and can be painlessly removed from the burned area without causing any pain to the patient. Natural hydrogels are now being replaced by synthetic materials which have a long lifespan, high water absorption capacity and high gel durability [10]. The availability of hydrogels enables their use by both medical personnel and witnesses of the event.

![Figure 2. Hydrogel dressing](topserw.com.pl)

Fluid therapy and pharmacotherapy

By obtaining access to veins it is possible to administer drugs and infusion fluids. Each patient with a burn of more than 20% of the body surface area requires fluid transfusion. After protecting the airways, if necessary, and treating life-threatening injuries, an intravenous access should be established. This should be a thick cannula (at least 16G) placed in the peripheral vein. If the extent of the burn makes it impossible to place the cannula in an untreated area, the most accessible vein should be used, even via the burned skin.
Upper extremity veins are more recommended because of the higher risk of thrombosis and inflammation of lower extremity veins. An alternative is to use an external jugular vein or an interosseous access. Early implementation of liquid resuscitation (e.g. according to the Parkland formula) is essential for medical staff. Proper vascular bed filling can prevent the development of hypovolemic shock.

The pain factor is strongly related to the patient's condition and the development of burn shock. Analgesia should be implemented by medical staff as soon as possible. The severity of the pain should be taken into account in the choice of the proper agent. The Numerical Rating Scale (NRS) can be used to evaluate this. On this scale, pain severity is ranked between 0 and 10, where 0 means that the patient does not feel pain at all, and 10 is the worst pain the victim can only imagine [11]. In patients with pain severity ≤ 5 points, Metamizol, Paracetamol and or Ketoprofen are proposed. In patients with pain severity > 5 points, opioids (Morphine, Fentanyl) and Ketamine should be implemented. Benzodiazepines (Relanium, Midazolam) should be considered for the elimination of anxiety reactions.

**Transport to the hospital**

The number of specialist burn treatment centres in Poland is growing, but it is still insufficient and amounts to 10 centres nationwide. This is why patients with burns are often taken to Hospital Emergency Departments and then to general surgery departments. Hospitalisation is necessary in the case of [4,5]:

- Superficial burns affecting >10% in an adult and >5% in a child;
- Deep burns, affecting >2% regardless of age;
- Inhalation burns with or without skin burns;
- Patients with skin burns around shock-absorbing areas, joints or burns covering the entire circumference of the limb;
- Patients with chemical and electrical burns;
- Children under 10 years of age or adults over 50 years of age with either Second- or Third-degree burns over 10%;
- Children under 2 and adults over 60 years of age;
- Patients with concomitant diseases of other diseases such as diabetes mellitus, cardiopulmonary insufficiency, using immunosuppressive drugs, or with other diseases that delay the healing process.
Medical Air Rescue (MAR) [12,13] is a solution for transporting patients from distant regions of the country to a burn treatment centre. The use of helicopters and PMARs is the right way to transport severely burned patients. Most of the patients transported include small children and adults over 60 years of age. The majority of them are transported from the place of the accident directly to the treatment facility. Since 2005, there has been an agreement between the Polish Burn Treatment Association and the Polish Medical Air Rescue (PMAR), which significantly improves the coordination of the choice of treatment centre.

CONCLUSIONS

Burns constitute a significant problem in the trauma patient group. The burn disease develops in stages, leading to a life-threatening condition. On-site management by witnesses and medical staff is a key stage in the therapeutic process. Consideration should be given to the implementation of educational programs on how to provide first aid to patients with burns, using commonly available products. Medical personnel should immediately implement appropriate fluid therapy and pharmacotherapy, and then select the appropriate treatment facility and means of patient transportation.

Disclosure statement

The authors did not report any potential conflict of interest.
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