

Drowning

"Drowning" is asphyxiation after immersion in a liquid environment' with or without aspiration into the lungs. The term is reserved for deaths within 24 hours of immersion.

'Drowning' is a condition where a child **survives > 24 hours after drowning** with subsequent **asphyxia** that required emergency treatment. The age category **1-4 years** is the most risky. Drowning is the single most common reason why emergency resuscitation is initiated in children in pre-hospital care.

- smaller children – drowning most often in garden ponds and swimming pools,
- adolescents – drowning most often in natural bodies of water^[1].

Pathophysiology

■ **Anoxic-ischemic damage:**

- Most drowning people go through a stage of *panic and struggle* on the surface, followed by *transient laryngospasm and apnea*. Finally, there are strenuous, **deep and irregular breaths**, *during which aspiration of vomit and water occurs*. In about 10% of those who drown, the laryngospasm persists and aspiration does not occur - "*dry drowning*".
- Profound hypoxemia leads to **terminal apnea** and the duration of hypoxia before irreversible brain cell damage varies between 3-5 minutes. At the same time, there are **cardiovascular changes** related to **catecholamine washout**. This explains the initial tachycardia, severe hypertension, arrhythmias. After only 3-4 minutes, circulation can fail despite a temporary increase in flow through the brain and myocardium due to the action of cold water on the face = "*diving reflex*".
- '*Total ischemia stops all cellular metabolic activity, alters calcium channel activity, and increases the production of free oxygen radicals. "Cerebral hypoperfusion" together with the described "hyperglycemia" affects the reduced production of adenosine - an endogenous neuroprotector. The complex of the mentioned events leads to the deepening of irreversible ischemic damage to the brain. Brain anoxia* is the most serious pathophysiological consequence of heating. The degree of damage depends on the duration of anoxia, which leads to **cytotoxic brain edema**, loss of cerebral autoregulation and thus to **intracranial hypertension** with subsequent deepening of anoxia. A severe anoxic episode can induce **multiorgan failure = MODS** by the mechanism of reperfusion syndrome.
- Laryngospasm → hypoxia,
- Face sinking → **centralization of blood circulation** with reduced perfusion of skin and GIT ("*diving reflex*").
- **Ingestion of water → hypovolemia and ionic changes in serum.**
 - The amount of fluid swallowed can be significant. These fluids, along with fluids administered during resuscitation, can lead to changes in intravascular fluid volume and electrolyte changes. With the exception of '*pulmonary edema*', most drowning survivors have no clinically apparent signs of volume changes and electrolyte abnormalities, only about 15% of those who drowned in both fresh and salt water.
 - Due to the high sodium content, massive aspiration or swallowing of *sea water* leads to the osmotic absorption of fluids into the lungs and GIT with subsequent reduction of intravascular fluid with *hypovolemia*.
 - Massive aspiration and ingestion of **fresh water**, on the other hand, leads to symptoms of "water poisoning" with severe *hyponatremia* and *hemodilution*. In addition to cell edema, sudden hypoosmolality leads to *hemolysis with subsequent hyperkalemia and hemoglobinuria*, which can cause acute renal insufficiency. In addition, hemodilution can also occur with SIADH, which in a certain percentage of cases can accompany pulmonary and neurological impairment during drowning and leads to brain cell edema. The resulting hyponatremia is the cause of brain edema.
- **Aspiration of water → damage to surfactant and pneumocytes,**
 - 90% of heaters aspirate water, but **in an amount that does not significantly affect the electrolyte balance. Massive water aspiration → circulatory changes and electrolyte abnormalities. Severe aspiration leads to surfactant inactivation with alveolar collapse**, *[[atelectasis/atelectases]*, **increase in** intrapulmonary shunts, decreased lung compliance, *to the increase in resistance of small airways and finally to the ventilation/perfusion disproportion with the resulting hypoxemia. ARDS develops. Profound arterial hypoxemia develops only after aspiration of at least 2.2 ml/kg. The development of primary lung infection is directly related to aspiration. Secondary infection is then related to endotracheal intubation and UPV. Fortunately, lung damage is mostly reversible, so the patient's fate depends largely on the length of brain damage caused by anoxia.*
 - The difference commented on in the literature between aspiration of sea and fresh water does not lead to significantly different clinical pictures in most cases either. Fresh water induces bronchospasm with swelling of the bronchial mucosa and ventilation/perfusion imbalance. With massive aspiration of water, hypervolemia with hyponatremia occurs with subsequent cell edema, erythrocytes are subject to osmotic hemolysis with subsequent hemoglobinuria. A more serious electrolyte imbalance may develop. Salt water directly damages the bronchial mucosa and alveoli with the development of pulmonary edema. Hypertonic seawater inactivates, fresh water washes out the surfactant. In both cases, the change in alveolar surface tension results in an unstable alveolus prone to atelectasis.
- **Hypothermia,**
 - skin temperature < 35 °C" **generally accompanies every drowning/drowning of children mainly**

because of the relatively larger body surface and smaller insulating layer of subcutaneous fat. Compensation mechanisms and spontaneous warming are applied when the skin temperature is above 30 °C. At lower temperatures, thermoregulation is no longer present. Severe hypothermia simultaneously leads to apnea due to respiratory center depression with prior hypoventilation.

- During resuscitation and initial warming of the patient, there may currently be a further drop in skin temperature before rising. This is because there is a return of cold blood from the limbs to the circulation with a corresponding impact on myocardial, respiratory and neurological functions, including the induction of malignant arrhythmias. After rescue, the so-called **'rewarming shock' can be observed with the development of hypotension, MAC** and signs of tissue ischemia.
- Modifications of neurological functions are described after prolonged immersion in ice water, when hypothermia preserves cerebral perfusion pressure through vasoconstriction in the entire organism except the CNS. This explains the "protection" of brain cells from hypoxia. However, a number of literature data indicate hypothermia as a generally unfavorable prognostic moment (> 90% of surviving children have a skin temperature at drowning > 34 °C).

- **Hypoxia → circulatory arrest**^[1].

Clinic

The length of immersion and the method of initial resuscitation give the resulting clinical picture. Short heating is usually avoided without signs of clinical damage. Apneic patients require assisted ventilation, usually leading to rapid adjustment of ventilation. A small number of children arrive at the hospital in critical condition with neurological signs of prolonged hypoxia, cardiac and respiratory dysfunction requiring urgent resuscitation procedures.

Therapy

- Rescue a drowning victim,
- airway management, cardiopulmonary resuscitation,
- heat, dryness,
- transport to hospital,
- ensuring venous access,
- oxygen therapy, intubation, overpressure ventilation with positive end-expiratory pressure (PEEP),
- treatment of edema in the brain (elevation of the upper body, hyperventilation)^[1],
- NG probe – it is necessary to assume that a larger volume of liquid will be swallowed with the subsequent risk of aspiration,
- possible CNS and spinal cord injuries must be ruled out (jumping into water),
- ECG monitoring for early detection of malignant arrhythmias is standard.

The principle is a 6-12 hour hospitalization for observation with monitoring of vital functions for any significant evidence of heating, regardless of good clinical condition. There is a real risk of delayed respiratory decompensation. This is the so-called **'secondary heating syndrome'**, which is related to the destruction of the surfactant.

Prognosis

- Prognosis depends on duration of hypoxia and extent of hypothermia. With severe hypothermia, the patient's chance of survival without long-term consequences is higher^[1].
 - Children after drowning with normal sinus rhythm, pupillary reaction and neurological findings have a very good prognosis in 99%.
 - Children after drowning, where the immersion lasted > 10 minutes and who required CPR, have a much worse prognosis - in 93% they die or show severe neurological impairment.
 - If immersion or resuscitation lasts > 25 minutes there is no hope of survival.
- A good prediction of the patient's prognosis is also determined by GCS when the patient is admitted:
 - GCS ≥ 6 b. → generally good development and prognosis,
 - GCS ≤ 5 b. → high probability of poor development.

Complications

- ARDS,
- brain edema,
- ARF = acute tubular necrosis,
- DIC.

Links

Related Articles

- Clogged nose and mouth
- Cheering
- Strangling
- Hanging (hanging)

External links

- Template:Acute
- Template:Acute
- Template:Acute

References

- HAVRÁNEK, Jiří: Drowning.

References

1. MUNTAU, Ania Carolina. *Pediatrics*. 4. edition. Prague : Grada, 2009. pp. 540-541. ISBN 978-80-247-2525-3.

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