PATHOPHYSIOLOGY, PREVENTION AND TREATMENT OF DROWNING SYNDROME

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[Fisiopatologia, prevenzione e trattamento nella sindrome da annegamento]

SUMMARY

The Authors after reporting the cellular changes caused by a prolonged immersion, dwell on the pathophysiological effects due to drowning in freshwaters and sea waters. They pay attention to the importance of hypotonicity or hypertonicity of water that leads to alveolar damage. They conclude saying that, towards in front of a clinical presentation of drowning resulting in hemolysis and severe hypoxia that may trespass to cerebral anoxia and cardiac arrest, it would be appropriate to adopt a rapid and adequate assistance

Key words: Immersion, cellular changes, hypoxia, hemolysis, cardiac arrest.

RIASSUNTO

Gli autori dopo avere riportato le modificazioni cellulari che si vengono a determinare in seguito ad una immersione prolungata, si soffermano sugli effetti fisiopatologici legati all'annegamento in acque dolci ed in acque litoranee. Prestano l'attenzione sull'importanza dell'ipotonicità o dell'ipertonicità dell'acqua nel determinare i danni a livello alveolare. Concludono affermando che di fronte ad un quadro clinico di annegamento con conseguente emolisi e grave ipossia, che può sconfinare nell'anossia cerebrale e nell'arresto cardiaco, si deve adottare un soccorso tempestivo ed adeguato.

Parole chiave: *Immersione, modificazioni cellulari, ipossia, emolisi, arresto cardiaco*

Introduction

In the case of drowning, the pathophysiological changes in the lung appear to be very different in relation to water chemistry. The faster is the flooding of the lungs by the fresh water, more rapid is the onset of ventricular fibrillation, in less than 3 minutes. With salt water, instead, there is a transudation of fluid from the bloodstream into the alveoli, which causes hypovolemia (less of about 30% of blood volume) and a demage to the alveolar-capillary membrane, leading to acute pulmonary edema. It is also clear that the amount of salty water required to determine a cardio-circulatory arrest is almost twice that in fresh water.

Cellular changes and membrane diffusion

In the cells there are many changes that can be nored. The cell is surrounded by a membrane that separates the contents of the cell and regulates the exchange with the environment. The cell membrane works as a very selective filter that regulate the entry and exit of substances. Water can freely cross the membrane by simple diffusion: this shift is called osmosis. Instead the mineral salts and many other substances do not normally cross the cell membrane. The movement of water through the sides of the membrane depends on the concentration of salt (for example sodium chloride) on both sides of the membrane itself. The isotonic solution has the same salt concentration present inside red blood cell so the flow of incoming water in the red blood cell is equal to the leaving water and the cellular volume does not change. The water will spread from low solute concentration compartment to the high solute concentration compartment. Regarding blood, which has a concentration of 0,9% of NaCl, solutions with lower salt content are called hypotonic, instead the solutions with higher concentration are called hypertonic. Of course freshwaters (lakes, rivers, swimming pools) is hypotonic than blood, instead of seawater, which has an average content of NaCl 3,5%, is strongly hypertonic.

The different salt concentration between freshwater and seawater cause several effects in relation to drawing in one or in the other. The freshwater, especially chlorinated swimming pools, seriously damages the alveoli with consequential disruption, thus decreasing the possibility to oxygenate the blood (even after rescue).

Pathophysiological effects

The main consequence of a prolonged immersion in a liquid is hypoxemia: increased peripheral airway resistance, laryngospasm, hypoxic pulmonary vasoconstriction, reduced lung compliance, alteration of ventilation/ perfusion, acute pulmonary edema. The Mammalian diving reflex is actived by dipping the face in cold water approximately at 21 ° C (70 ° F). This reflex protects the body by putting it in a energy saving mode to optimize the time of apnea. The strength of this reflex is greater in colder water and has three main effects: bradycardia (slow heart rate up to 50% in humans), peripheral vasoconstriction (reduced blood flow to the extremities to increase the perfusion of vital organs, particularly the brain), displacing blood to the thoracic cavity, to prevent the collapse of the lungs under increased pressure during diving. Immersion in a liquid usually causes an immediate feeling of panic and leads the subject to wriggle and to hold breath.

These feelings can lead to ingestion of variable amounts of water (usually approximately 22 ml/kg), vomiting and endotracheal inhalation. If there is an alteration of consciousness the liquid can enter passively in to the lungs and cause a condition of hypoxemia that may persist even after the resumption of regular ventilation. Instead in the case of laryngeal spasm the inhalation of the liquid can be prevented. With asphyxia there is reduced or absent blood oxygenation with failed supply of O_2 to the brain (cerebral anoxia) that causes respiratory arrest. The accumulation of carbon dioxide and lactic acid respectively determines respiratory acidosis and metabolic acidosis. The anoxia, acidosis, electrolyte and haemodynamic imbalances cause rhythm disturbances until the cardiac arrest.

Differences between drowningin fresh water or in sea waters

The drowning in fresh water leads to the rapid passage of large quantities of water from the lungs to the blood (even more than 50% of the water sucked in after a few minutes). This is due to the fact that fresh water is hypotonic compared to the blood and then passes into the bloodstream by osmosis. This passage through the alveolar-capillary membrane occurs quickly and leads dilution of the blood (hemodilution), hyponatremia, and an increase of its total volume (hypervolemia). The diluted blood becomes hypotonic compared to the cells and leads the diffusion of water in the cells, mainly red blood cells, causing hemolysis, hyperkaliemia and, in more serious cases, hemoglobinuria with acute renal glomerular damage. Hemolysis is usually so important that the oxygen-carrying capacity is strongly impaired (severehypoxia).

The decreased concentration of salt (mostly sodium chloride and calcium) and plasma proteins, together with reduced availability of oxygen to the fact of hemolysis, may be responsible for severe anoxic brain damage and atrial fibrillation leading immediately to death. Drowning in sea waters determines various physiological phenomena depending on the fact that sea water is hypertonic compared with blood. The pulmonary flooding lads to the rapid transition of large quantities of water by osmosis from the vascular district to the lung parenchyma (diffuse pulmonary edema). At the same time a certain amount of salt moving from the lung to the blood is the cause of tissue damage. The removal of water and the gain of salts with a rapid increase in the concentration of salts themeselves cause hypernatriemia and hyperchloremia with consequential plasmolysis (wrinkling of red blood cells). Plasma volume decreases (hypovolemia) and blood pressure drops rapidly and severe hypoxia occurs. At first there is tachycardia, which is followed by a pronounced bradycardia (until cardiac arrest) and then damages caused by cerebral anoxia begin to appear. r

Conclusions

Because of these two different mechanisms of absorption of water drawn, if the relief is not timely, death occurs in a few minutes: 2 to 6, when it comes to fresh water, 6 to 8 in the case of sea water.

The fatal drowning in fresh water is therefore faster than in salt water. The time difference is relatively small, but of great practical importance because it indicates that drowning in the sea, relatively more numerous than those in fresh water, have more chances of be saved, provided that the assistance is promptly. It is therefore evident that the attempt to bring out fresh water from the lungs is useless, because this, being hypotonic, quickly enters into the circulation; instead sea water is hypertonic and recalls plasma into the lungs, so it should droped drainage: for this purpose can be useful Trendelenburg position. The key-factors that allow to survive to immersion are: dive time, water temperature, age of the subject and the quickness of the resuscitation.

The latter fact is of great importance when we face a clinical case of freshwater drowning where there is, as a result of lower concentration of salts than blood, a rapid passage of large quantities of water from the lungs to the blood compartment resulting in hemolysis and then severe hypoxia.

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