Annals of the University of Oradea, Fascicle: Ecotoxicology, Animal Husbandry and Food Science and Technology, Vol. XVI/B 2017

Analele Universitatii din Oradea, Fascicula: Ecotoxicologie, Zootehnie si Tehnologii de Industrie Alimentara, Vol.XVI/B 2017

THE INFLUENCE OF ENVIRONMENTAL FACTORS ON THE HUMAN BODY - CRYOAGRESSION

Perju-Dumbrava Dan*, Ureche Daniel*, Maxin Marius*, Radu Casandra Maria, Radu Carmen****

*University of Medicine and Pharmacy „Iuliu Haţieganu" Cluj-Napoca, str. Victor Babeş nr.8, cod postal 400012, Cluj, România, email: ureche.daniel@umfcluj.ro
*University Of Oradea – Faculty of Medicine and Pharmacy, str: Piaţa 1 Decembrie, nr 10, 410067, Oradea, România, e-mail: raducarmencorina@yahoo.com;

Abstract

Even though industrialization is permanent in our days and decent human comfort is provided when it comes to exposure to environmental conditions, there are some factors predisposing especially in the cold season to the occurrence of death by hypothermia or cryoaggression. The study of death due to environmental conditions, including prolonged exposure to cold, belongs to legal medicine, most of the time being a violent death.

Factors favoring cryoagression may be exogenous with reference to environmental, temperature, humidity, wind, or clothing and endogenous conditions. We consider endogenous factors as having a major contribution to the production of hypothermia death because as a result of their systemic exposure, exposure to an ambient temperature around 0 degrees Celsius may lead to death. Endogenous changes of major importance in the production of systemic cryoaggression are primarily the preexisting pathologies, medication and toxic consumption, hormonal and constitutional variations.

Among the pre-existing pathologies, the cardiovascular, neurological, psychiatric and systemic metabolic antecedents are the most common, followed by alcohol consumption. From forensic practice, we can say that in such pathologies exposure to low ambient temperatures can lead to insufficient cardio-respiratory and death.

Thus environmental factors, particularly low temperatures, can be criminalized as a cause of death. Death often occurs not by exposure to very low temperatures but by prolonged exposure to average temperatures around 0 degrees Celsius which decompensates the endogenous factors listed above. Environmental conditions are thus only a variable that can be analyzed in the tanatogenesis of systemic cryoaggression, especially in people who fall within the notion of endogenous factors.

Key words: cryoagression, hypothermia death, cold environment, forensic death

INTRODUCTION

Death through cryoagression is a physically-violent death with legal implications and sometimes with social impact. Most of the time it is accidental, but it can also hide the elements of a dissimulation under certain circumstances. Legal medicine by the nature of the field of activity has to determine the cause of death, from where the correlation with the environment arises because there are tanatogenerator situations induced by

natural events. Fetching, drowning, hypothermia and industrial electrocution are the most common among them. On-site research, reconstitution, exclusion of other causes of death, and analysis of the socio-economic factors involved in hypothermic death are extremely important. (Perju-Dumbrava Dan, 1999) Most cases of hypothermia death were recorded in the urban area and were due to environmental cold exposure in close association with alcohol, drug abuse or the presence of other pre-existing pathological diseases. In this article we will present a study on hypothermia death and the implications of some well known adjuvant factors. (James Li et all 2016)

THE PHYSIOLOGY OF HYPOTHERMIA

The term hypothermia is attributed to a situation where body temperature drops below 35 ° C as a result of heat loss that goes beyond the limits of compensatory mechanisms. (Turk EE, 2016) The human body is more resistant to cold than to elevated temperature, so acclimatization at low temperatures is made easier. (Iftenie Valentin 2002) As a result of intense metabolic activity, heat is produced, but at the same time the heat is lost, the loss being explained by the three fundamental phenomena: irradiation, conduction and evaporation. As long as this mechanism is in balance, the body temperature maintains its consistency as previously described. The nervous system denotes a primordial involvement in body temperature regulation, knowing that the hypothalamus is the center of thermoregulation. A complex consisting of peripheral and hypothalamic receptors is formed with feedback control mechanisms. The pulse discharge rate is achieved directly with the temperature change, increasing the temperature increases the pulse discharge rate and vice versa.(Guyton, 1996)

To accomplish this, compensatory mechanisms are activated when exposed to low temperature in order to limit heat loss and to stimulate production. Thus, the stress caused by cryoaggression triggers the adrenaline, noradrenaline and cortisol secretion by the adrenal gland by performing a peripheral vasoconstriction and a centralization of circulation to the vital territories, their vessels lacking alpha receptors. Increases metabolism rate, muscle tremor occurs, and blood glucose levels increase by glycogenolysis initially. Acidification of lipid metabolism increases ketoneemia. If the cryoaggression continues, by the above mentioned mechanism, by acute prerenal renal insufficiency, the rate of glomerular filtration decreases, so diuresis occurs in the cold. Generalized swelling may occur in cold by migration of plasma into the extracellular space. Due to volume depletion and exposure persistence, hydroelectrolytic and acido-

basic disorders occur, compensatory mechanisms are exceeded and metabolic acidosis is iminent with impaired cardiorespiratory function. (Turk EE, 2016)

Regarding the central nervous system, its damage is initiated when the central temperature reaches 33 ° C, with confusion, and at the central temperature of 30 ° C the loss of consciousness occurs. The central temperature of 24 ° C is incompatible with life.(Turk EE 2016, Gheorghiu 2005)

Death occurs through ventricular fibrillation or sudden death, which is associated with increased levels of catecholamines, electrolyte disturbances and myocardial oxygen depletion. Sudden death occurs by sudden skin cooling and rapid vascular constriction, with reflex stimulation of the heart followed by increased blood pressure and heart work, all of which suggesting the cardiovascular etiology of death.(Turk EE 2016, DiMaio 2001)

Atrial and ventricular arrhythmias are common in the first few minutes of immersion in cold water, but they sometimes disappear in minutes by adapting the skin receptors to the low-temperature. These mechanisms may be responsible for the sudden deaths of swimmers at first cold water contact. .(Turk EE 2016, Gheorghiu 2005, DiMaio 2001)

CLASSIFICATION OF CRYOAGRESSION

From this point of view, we have in the first instance a legal classification that determines the way in which the incident occurs. Hypothermia death can be accidental, most commonly encountered, homicide in exceptional situations or suicide - in people with severe psychiatric disorders, with psychotic syndrome or under the influence of alcohol or drugs. (Perju-Dumbrava Dan, 1999)

Regarding the mechanisms implicated in hypothermia, death often can occur by prolonged exposure to low temperature environments. Persons who survive for a period of time and do not die immediately by hypothermia may develop some organic changes like hemorrhagic pancreatitis, gastric, ileal and colonic mucosal hemorrhages, bronchopneumonia, renal tubular acidosis, and myocardial degeneration. Another more aggressive method of inducing hypothermia is by immersion in low temperature water. In cases of cold water immersion, the most important factor involved in maintaining the body survival resistance is the subcutaneous fat layer.

For children, the ratio of body surface area to body weight is higher than that of adults, concluding that faster body cooling is achieved. It has been observed that in very cold water, physical exercise accelerates the rate of decrease in central temperature by exaggerating the heat used by the

muscles for physical effort, which consumption is exceeded by the heat output resulting from the effort itself. [7] A brief review also focuses on local anatomopathological changes when talking about frostbite. These are classified in grade I frostbite, warm and swollen tegument, second degree froshes in the form of serum or haemorrhagic vesicles, grade III frostbite with ulcerative necrosis zones, and grade IV frostbite represented by severe wet or dry gangrene. (Beliș V. 1995)

FACTORS FAVORING CRYOAGRESSION

Crioagression refers not only to the action against the body of some low temperatures. Therefore, death can be influenced by certain factors, which have an adjuvant role in addition to a relatively low temperature, temperature which in ordinary circumstances would not have caused the person's death. Among these factors we mention the exogenous factors with reference to wind and moisture or inappropriate, inadequate, wet clothing. The temperature at which the body can maintain its thermal balance at rest is 24-28 ° C in air, respectively 33-35 ° C in water. At lower temperatures or with the addition of another wind-favouring factor, in order to maintain constant central temperature, the body must activate its intrinsic thermoregulatory mechanisms or increase physical activity. Protective equipment plays a crucial role in body resistance to cryoaggression, inadequate clothing increasing the risk of hypothermia. (Turk EE 2016)

Endogenous factors refer to constitutional and health changes of the body undergoing cryoagression. Among these factors involved in fast installation of hypothermia changes we mention age, fatigue, alcohol or medication, preexisting pathological conditions, and even fat and muscle mass. Elderly suffer a decrease in muscle mass and, due to bone pathology, reduced mobility, so the heat output resulting from muscle activity is very low. Moreover, older people, especially females, have a decrease in thyroid function that significantly influences the body's vulnerability to cryoaggressive disease by delayed response to shock. Elderly patients often have an associated cerebrovascular pathology with consecutive cerebral dysfunction leading to poor central thermoregulation and depressive disorders followed by an apathetic state of feeding, self-care, and well-being. In the case of children, because the area of the body surface is large and the light weight, heat loss is made easier. (Saukko P. Et all 2004)

Although the antiarrhythmic effect of alcohol in hypothermia was discussed, which would reduce the possibility of sudden death, alcohol leads to significant pathophysiological changes that entrust its role as a major risk factor for hypothermia. It performs a peripheral vasodilatation which, together with stimulation of sweat secretion, leads to an increased

temperature loss in the periphery with hypovolaemia and the decrease in the amount of oxygen transported into the blood. Moreover, the anesthetic effect of alcohol and some medications such as benzodiazepines, tricyclic antidepressants, chlorpromazine reduces the perception of low temperature and the risk of hypothermia increases substantially. Alcohol inhibits shivers by relaxing muscles, and in high concentrations it can act directly act at the hipotalamic thermoregulatory center by inhibiting it. By its effects, alcohol also leads to an increased risk of trauma by injuring the cephalic extremity with loss of consciousness, or fractures of the extremities, followed by the inability of the individual to protect himself from the weather. (Turk EE 2016)

Pre-existing pathology of the individual plays an important role in the reactivity of the organism subjected to cryoaggressive activity. Organ failure, psychiatric disorders, cardiovascular disease, anemia, endocrine disease (hypothyroidism) and perhaps the most important condition, diabetes, are some very important risk factors. During treatment of diabetes mellitus with insulin, incorrect dosing may induce hypoglycaemia, an extremely important condition, affecting the whole metabolism and especially the production of heat. Other risk factors include traumas, hepatic or renal failure, Parkinson's disease, infections or malnutrition.(Brändström H. 2013)

FORENSIC ISSUES

As we mentioned at the beginning of this article, death through hypothermia or cryoaggressive death is a violent one that necessarily implies the conduct of a forensic autopsy, or if post-cryoaggressive sequelae have been established, an expert report on the state of the person's health, post-hypothermia post-sequela, infirmity or disability. (Iftenie Valentin 2002) Both the forensic autopsy and the expertise report are governed by the New Criminal Procedure Code, Articles 172-185, which also cover the objectives to which the forensic practitioner has to answer or to clarify.

In case of deaths by hypothermia some specific cadaveric changes appear represented by lively-red lividities, visible especially at the knee joint, called erythema of freezing. Their pathogenesis is not fully known but is believed to arise from the destruction of capillaries and plasma extravasation in tissues. (Dolinak D. et all 2005, Madea B. et all 2004) The cadaveric rigidity is of woody hardness and quickly disappears after defrosting, when the putrefaction is accelerated.(Morar S. 2006) By defrosting the body, hemolysis occurs, leading to a red coloration of the intima of the vessels, of the serous tissue, respiratory mucosa and endocardium. At the gastric level, there may be dark-brown lesions of the

mucosa with a diameter of a few millimeters and a number of tens to 100 called Wischnewski spots. (Vishnevski). Although not considered pathognomonic, Vischnewski spots are the most reliable indicator of death by hypothermia. It has been shown that they occur by the action of hydrochloric acid on hemoglobin in the interstitial area of the gastric mucosa with chlorhemin formation, thus explaining the dark-brown color. (Bright F. et all 2013) The histological suggestive elements of Vichnewski stains are mucosal necrosis and hematin formation. (Tsokos M. et all 2008) Similar lesions can be found in other areas of the digestive tract, such as the colon or esophagus. (Palmiere C. 2014)

Summarizing, the microscopic anatomopatological changes are represented at the liver by glycogen loss, pancreatic cell necrosis, gastric tissues with pronounced hyperemia, infarctions in various regions of the digestive tract, cytoplasmic vacuolization of anterior pituitary cells, hypoxic cardiac changes and vacuolizar degeneration of myocardial and hepatic cells and degenerative lesions in the brain. (Turk EE 2016, Palmiere C. 2014) The Armanni-Ebstein phenomenon frequently encountered is being considered the most reliable histological indicator of hypothermia, is represented by subnuclear vacuolization of renal tubule epithelial cells. In a study of 46 fatal hypothermia cases, 15 of them (33%) had renal tubular vacuolization, 9 of the 15 cases had a history of pathological diabetes, which indicates the involvement of diabetic ketoacidosis in the pathogenesis of the Armanni-Ebstein phenomenon. (Zhou C, Byard R. 2011) Another change is the blood coloration of the synovial fluid and the synovial membrane of the knee joint. In another study of a population of 36 fatal cryoaggressive patients, synovial fluid bleeding was noted in 27 cases (75%).(Hejna P. et all 2012)

MATERIAL AND METHOD

Regarding cryoagression we conducted a study consisting of a retrospective statistical analysis of 24 cases of death by refrigeration recorded in the archives of the Cluj-Napoca Forensic Institute during the period 2014-2016. In order to carry out this study, we used the forensic expertise reports found in the archives of the Institute of Forensic Medicine Cluj-Napoca. From these documents were extracted data on the circumstances of death, some personal data, the external examination of the corpse, respectively the internal and toxicological examination.

The analyzed parameters were gender, background, age group, favoring factors, associated pathologies, central temperature, alcohol level, elements of the external examination (appearance of lividity, signs of hypothermia, rotting changes, stiffness) or internal (changes of gastric

mucosa, presence of Vischnewski stains in the gastric mucosa) from the forensic autopsy.

RESULTS AND DISCUSSION

There was a decrease in the violent deaths by hypothermia, so that in 2014, of the total number of violent deaths of 285, 10 were due to cryoagression, in 2015 - 8 cases were documented with hypothermia, and in 2016 only 6 cases. Maximum incidence of hypothermia deaths was found in December (10 cases) and January (6 cases), but cases were reported in period March - November (1-2 cases/month), especially in mountain areas or regarding people with different pathologies associated. According to the sex distribution of the cases under study, there is a slight predominance of male sex with a proportion of 54% compared to female sex of 46%. By analizing the deaths by hypothermia with the age, the maximum incidence at 50-65 years (11 cases) was observed, followed by the age group of 65-80 years (8 cases) over those three years (2014-2016). Analyzing the distribution of deaths by cryoagression according to the environment of origin, the predominance of the rural population was 58%, compared to 42% in the urban environment.

Analyzing the impact of factors favoring death by hypothermia, it was observed that a major role is the presence of comorbidities (20 subjects) and acute ethanol poisoning (14 subjects). Inappropriate clothing (10 subjects) and advanced age (10 subjects) were also factors contributing to hypothermia death. The majority of cardiac pathology was present with a weight of 41% of the total subjects enrolled in the study. This is followed by liver disease with a weight of 32%. Also, renal changes, cerebral diseases, and even pancreatic and haematological pathology have been reported. Analyzing the color of the lividity detected on the external examination, it was observed that with the decrease of the temperature, their color varies from violet to intense red, so that in subjects with violet lividity we have detected an average temperature of 26.3 ° C compared to the lividities of a red color at which the average recorded temperature was 24.1 ° C and the intense red color at which the average temperature was the lowest, namely 21.3 ° C.

The examination of the gastric mucosa revealed Vischnevski spots in only 21% of all subjects included in the statistical analysis, in 79% of cases they were not detected. Of the total group of subjects included in the study, 58% had a positive toxicology test for the detection of alcohol, while the remaining 42% had a negative test. And for those with positive alcohol the majority (14 subjects) showed a blood alcohol concentration in the range 0-1.0g ‰, followed by the range of 1.01-2.0g ‰ and 3.01-4.0g ‰ with the

same number of cases, respectively 4 subjects. Testing the influence of alcohol intake over 1g ‰ on the average temperature value using F-Test Two-Sample for Variances resulted in a result of F = 0.697 and F critical one-tail = 0.314. F> F critical one-tail, resulting in data being statistically significant.

CONCLUSIONS

After analyzing the data from the study, the following conclusions were reached: the number of deaths by cryoagression is decreasing. Male individuals are more prone to cryogression, possibly because of their daily activities. The maximum age incidence is 50-65 years associated with pathological modifications, especially cardiac by damaging the circulatory physiology or hepatic by impairment of glycogen levels. The lividity color varies with temperature, and those found at low temperatures are intense red. The alcohol concentration is inversely proportional to the value of the detected temperature. Alcohol causes additional temperature loss in hypothermia. Alcohol influences the detected central temperature, but only at an alcohol level above 1 g ‰.

REFERENCES

1. Beliș V. 1995, Tratat de Medicină Legală Vol. II, Ed.Medicală, București;
2. BRÄNDSTRÖM H. 2013, Accidental hypothermia and local cold injury: physiological and epidemiological studies on risk [internet] Jan. [accesat ianuarie 2017]; Disponibil la: URL:http://onlinelibrary.wiley.com/doi/10.1111/aas.12000/abstract;jsessionid=44775EFCD3FB9AC6B40119C9E64BE878.f02t01
3. Bright F, Winskog C, Walker M, Byard R. 2013, Why are Wischnewski spots not always present in lethal hypothermia? The results of testing a stress-reduced animal model. Journal of Forensic and Legal Medicine. Jun; 20:785-787.
4. DiMaio VJ, DiMaio D. 2001, Forensic Pathology. 2nd ed. CRC Press LLC.Florida;
5. Dolinak D, Matshes E, Lew E. Environmental Injury. In: Dolinak D, Matshes E, Lew E, editors. 2005, Forensic Pathology Principles and Practice. ed.Elsevier;.p.248-250.
6. Gheorghiu V. 2005, Medicină legală-note de curs. ed. Universitară Carol Davila. București;
7. Guyton AC. 1996, Fiziologia umană și mecanismele bolilor; ediția în limba română sub redacția Cârmaciu R, Ed. Medicală Amaltea, București;
8. Hejna P, Zátopková L, Tsokos M. 2012, The diagnostic value of synovial membrane hemorrhage and bloody discoloration of synovial fluid (“inner knee sign”) in autopsy cases of fatal hypothermia. Int J Legal Med () 126:415–419.
9. Iftenie V. 2002, Medicină Legală, Ed.Științelor Medicale, București;
10. James Li, Silverberg MA, Decker W, Edelstein JA. 2016, Hypothermia Epidemiology [internet] Medscape Sept. [accesat ianuarie 2017]; Disponibil la: URL: http://emedicine.medscape.com/article/770542-overview#a6

11. Madea B, Preuß J, Henn V, Lignitz E 2004, Morphological findings in fatal hypothermia and their pathogenesis. In: Oehmichen M (ed) Hypothermia. Clinical, pathomorphological and forensic features. Schmidt-Ro¨ mhild, Lu¨ beck, p.181–204.
12. Madea B, Tsokos M, Preuß J. 2008, Death Due to Hypothermia. In: Tsokos M, editor. Forensic Pathology Reviews. Volume 5 ed. Humana Press Inc. New Jersey; p.3-21.
13. Morar S. 2006, Medicină Legală curs. ed. Universității „Lucian Blaga" din Sibiu;
14. Palmiere C, Teresiński G, Hejna P. 2014, Postmortem diagnosis of hypothermia. Int J Legal Med . Feb; 128:607–614.
15. Perju-Dumbrava Dan. 1999 Expertiza medico-legală în practica juridica, Ed. Argonaut, Cluj-Napoca;.
16. Saukko P, Knight B. Knight's 2004, Forensic Pathology. 3rd ed. Edward Arnold. London;
17. Turk EE. 2010, Hypothermia. Forensic Sci Med Pathol. Feb.; 6:106–115.
18. Zhou C, Byard R. 2011, Armanni-Ebstein phenomenon and hypothermia. Forensic Science International 206-82–84