ORIGINAL ARTICLE

Hypothermia Deaths in Van Province, Turkey

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ABSTRACT

Objective: *To evaluate autopsy findings in hypothermia-related deaths in Van Province, Turkey, a city near the Turkey–Iran border.*

Methods: *Autopsy reports on 43 hypothermia fatalities were retrospectively reviewed. Data regarding age, gender, nationality of the cases, seasonality of the deaths, crime scene findings, autopsy findings, manner of deaths, risk factors for hypothermia, other traumatic lesions, and toxicology were obtained from autopsy records and scene investigation records.*

Results: *There were 36 males and 7 females. The mean age was 20.5 years. More than half of the cases died or were found dead in the spring months. All but one of the cases was found dead outdoors. There were common red-coloured livor mortis in 33 cases (76.7%), antemortem traumas in 16 cases (37.2%), cold erythema in 26 cases (60.5%), myxedema in 1 case, bloody discolouration in the synovial fluid in 11 (84.6%) cases, and Wischnewski spots in 32 cases (74.4%).*

Conclusion: *The study showed that illegal refugees are an important social problem in Turkey. Hypothermia should be considered as a cause of death for refugees when they are found, especially in the cold provinces. In the diagnosis of hypothermia, bloody discolouration of the synovial fluid is confirmed to be a valuable finding. Wischnewski spots remain valuable for positive identification.*

Keywords: Autopsy findings, crime scene findings, hypothermia, synovial fluid, Wischnewski spots.

INTRODUCTION

Systemic hypothermia is a decrease in core body temperature below 35°C (1). When the human body is exposed to hypothermia, it protects itself from possible damages due to hypothermia by triggering different responses against different stages of cold stress. The most important responses are shivering, stimulation of chemical thermogenesis and peripheral vasoconstriction (2–4).

Deaths due to hypothermia are often seen under certain conditions and in communities with a low socioeconomic level. The risk groups were defined as babies, elders, drug addicts, patients with mental illness, athletes, individuals exposed to substances that cause heat loss such as water, and persons who are immobilized due to drug abuse and acute or chronic illnesses (2, 5, 6).

Despite the general opinion that 'hypothermia can be seen in only colder climates', the fact is that it can be seen in almost all climates (5, 7–11). According to a 2004 report by the National Center for Health Statistics of the United States (8), 16 555 persons died due to hypothermia between 1979 and 2002 in the United States. This is 689 cases per year. In 2002, most hypothermia deaths occurred in Alaska, which is close to the North Pole region. This is expected; but the second most common location for hypothermia deaths is New Mexico, which has an arid or semi-arid, continental climate with desert climate in some regions (3).

In recent studies, the rate of deaths due to hypothermia was high in states that had a climate with a sudden temperature change and low evening temperatures (8, 12).

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Elbaz *et al* reported 169 hypothermia cases in Soroka University Medical Center in Israel, which has a desert climate characterized with low night temperatures in winter (5°C) and 18°C in summer from 1999 to 2005 (5).

In a study reported by Brändström *et al* (9), 150 (72%) of the 207 deaths due to hypothermia occurred in rural areas and 57 (28%) in urban areas. The incidence of these fatalities in North Sweden was 6.1/100 000 in rural areas and 0.4/100 000 in urban areas.

Despite all of the advances in medicine, the number of hypothermia-related deaths is still high, and hypothermia is often underestimated in forensic applications. Hypothermia is diagnosed at a postmortem period by excluding the other causes of death because of a lack of any pathognomonic and specific findings. Clues obtained in the crime scene investigation may arouse suspicion of a postmortem diagnosis of hypothermia. During scene investigations of hypothermia-related deaths, the existence of alcohol or drugs, lack or inadequacy of heaters and the existence of features suggestive of psychiatric disorders (clutter, decreasing self-care, *etc*) are common (13).

The number of studies regarding hypothermia-related deaths and their medico-legal autopsy findings are limited. The aims of this study were to define the incidence of hypothermia-related deaths that occurred in Van Province, Turkey and to describe some features such as age, gender, nationality, seasonality of deaths, crime scene findings, autopsy findings, manner of deaths, risk factors for hypothermia-related deaths, other traumatic lesions, and toxicology.

SUBJECTS AND METHODS

This study is a retrospective review of autopsy reports and crime scene investigation data from 43 hypothermia-related fatalities in Van Province, Turkey from June 1, 2010 to May 31, 2015.

Data regarding age, gender, nationality of the cases, seasonality of deaths, crime scene findings, autopsy findings, manner of deaths, risk factors for hypothermia, other traumatic lesions and toxicology were obtained from autopsy records and scene investigation records.

According to statistical data between 1950 and 2014 from the Turkish State Meteorological Service (14), the low temperature was –28.7°C in winter and –2.6°C in the summer. The mean temperature in January (the coldest month) was –3.4°C in Van Province (Table 1). The resulting data were statistically assessed by the Chi-square test, Kolmogorov–Smirnov test and Student's *t*-test. The statistical significance levels were set at 5%.

RESULTS

Of 1699 deaths, 43 (2.53%) were evaluated by medico-legal autopsy in Van Province between June 1, 2010 and May 31, 2015. There were 4 cases between 2010 and 2011, 5 cases between 2011 and 2012, 9 cases between 2012 and 2013, 13 cases between 2013 and 2014, and 12 cases between 2014 and 2015. The average annual incidence of fatal hypothermia during the study period in Van Province was calculated as 0.8/100 000 persons for all cases and 0.2/100 000 persons for residents.

Of these cases, 36 (83.7%) were males and 7 (16.3%) were females ($p < 0.05$). The mean age was 20.5 years (standard deviation [SD]: 9.9; median: 22; min: 1; max: 47) in males, 14.6 years (SD: 10.6; median: 17; min: 2; max: 25) in females, and 19.6 (SD: 10.2; median: 22; min: 1; max: 47) in all cases. The majority of cases (n = 23; 53.5%) was between the 21 and 30 years age range ($p < 0.05$) (Table 2). More than half of cases (n = 28; 65.1%) died or were found dead in the spring months

Table 1: The highest and lowest monthly temperatures in Van Province between 1950 and 2014 (Turkish State Meteorological Service)

Months	Mean temperature (°C)*	Lowest temperature (°C)	Mean of lowest temperature (°C)	Highest temperature (°C)	Mean of highest temperature (°C)
January	–3.5	–28.7	–7.7	12.6	1.8
February	–2.9	–28.2	–7.2	14.3	2.5
March	1.4	–22.7	–2.8	22.7	6.6
April	7.8	–17.5	2.8	27.2	12.9
May	13.1	–1.5	7.0	28.3	18.3
June	18.1	–2.6	10.8	33.2	23.8
July	22.2	3.6	14.6	37.5	28.0
August	21.8	6.6	14.6	36.7	28.2
September	17.2	–0.1	10.8	35.0	24.1
October	10.7	–7.5	5.7	28.8	17.2
November	4.3	–20.5	0.2	20.1	10.0
December	–0.8	–21.3	–4.6	15.5	4.4

($p < 0.05$), especially in April (n = 14; 32.6%) (Fig. 1). All but one of the cases (n = 42; 97.7%) was found dead outdoors ($p < 0.05$), especially in the mountainous region near the Turkey–Iran border (n = 23; 53.5%) ($p < 0.05$) (Table 3).

Table 2: The distribution of cases according to age groups and genders

Age groups	Males (n = 36)	%	Females (n = 7)	%	Total (n = 43)	%
1–10	7	19.4	3	42.9	10	23.3
11–20	5	13.9	1	14.2	6	13.9
21–30	20	55.6	3	42.9	23	53.5
31–40	3	8.3	0	0.0	3	7.0
≥ 41	1	2.8	0	0.0	1	2.3

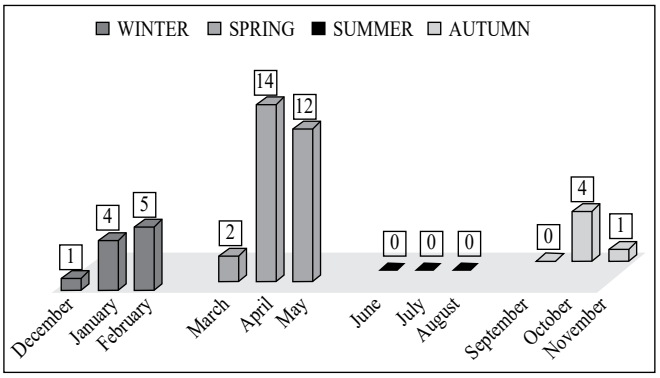

Fig. 1: The distribution of cases according to season.

Table 3: The distribution of cases according to death scenes

Death scene		n	%
Mountainous region near Turkey–Iran border	Valleys and foothills	21	53.5
	The bottom of cliff	2	
Rural areas	Plains and pastures	9	44.2
	The edges of rivers and lakes	6	
	Roadsides	3	
	Dumping ground	1	
Indoor	Prefabricate container	1	2.3

Of all the cases, eight (18.6%) were Turkish citizens and the rest (n = 35; 81.4%) were citizens of other countries. All of the cases that were found dead in the mountainous region near the Turkey–Iran border were foreigners. In evaluating external autopsy findings of all the cases, the rectal temperature was not recorded in any case, but there were common, red livor mortis in 33 cases (76.7%) (Fig. 2). There were antemortem traumas in 16 cases (37.2%). Of these 16 cases, 2 were found at the bottom of a cliff, but these trauma findings did not cause deaths alone. The traumatic findings in other cases were also not lethal. There was cold erythema in 26 cases (60.5%) (Fig. 3), and myxedema in one 17-year-old female resident (2.3%) who died outdoors.

Fig. 2: Livor mortis in two cases of hypothermia-related deaths.

Fig. 3: Cold erythema on the nose in a case of hypothermia-related death.

In the internal examination, there was bloody discolouration in the synovial fluid in 11 (84.6%) of the 13 cases investigated on this subject (Fig. 4), Wischnewski spots in 32 cases (74.4%) (Fig. 5), haemorrhage, congestion, and/or oedema in the lungs in 22 cases (51.2%), enzymatic fat necrosis of the pancreas in 7 cases (16.3%), and congestion of the liver and/or spleen in 20 cases (46.5%).

There was pancreatitis and haemorrhage in the psoas muscle, pectoralis minor muscle and the first intercostal muscle. There was congestion of the vena cava. There were differences in the left and right heart blood colour. Studies of acute heart failure showed that there was dilatation of the right atrium and ventricle of the heart. There were also bronchopneumonia, acute tubular necrosis and lipid deposits in the glomeruli, liver, heart, and skeletal muscle. Focal myocardial degeneration and necrosis in the heart muscle were not reported in any autopsy.

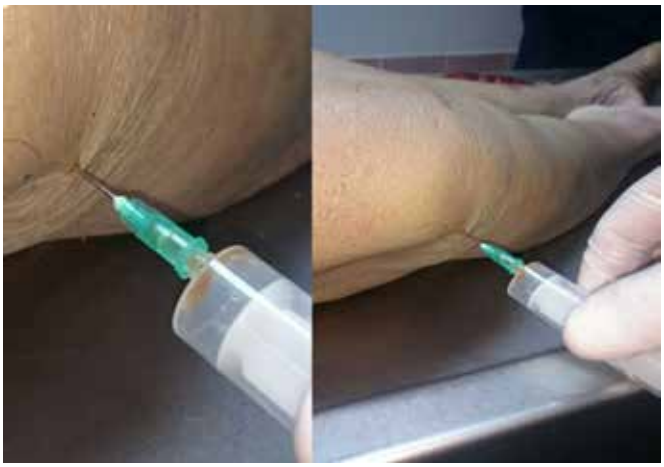

Fig. 4: Bloody discolouration in the synovial fluid in a case of hypothermia-related death.

Fig. 5: Wischnewski spots in a case of hypothermia-related death.

Because the majority of the cases were foreign nationals, they had little medical history. These cases were not evaluated for psychiatric illnesses. Ethyl alcohol was detected in only one case who died in a prefabricated container; drugs were not detected in any case.

DISCUSSION

The climate of the east and middle regions of Turkey is inclined to cause hypothermia. We encountered only one article on hypothermia-related deaths in Turkey in the literature. This article mentioned 12 cases (15). Literature reports regarding autopsies in hypothermia-related deaths were limited worldwide.

In many studies, the annual incidence of fatal hypothermia was reported as between 0.2/100 000 and 6.1/100 000 persons (8–12). The average annual incidence of fatal hypothermia during the study period in Van Province was 0.8/100 000 persons for all cases, including foreigners, and 0.2/100 000 persons for residents. These are the first recorded incidences due to hypothermia-related deaths in Turkey; there was no prior recorded incidence on this subject (15).

We estimated that these rates will be lower than the values in this study if a study on this issue is carried out in other parts of Turkey. The Van Province region of Turkey is adjacent to the border with Iran and near the border with Iraq. Thus, this region is mountainous and is filled with illegal immigrants. During illegal immigrant crossings, some refugees have died in the cold mountains due to hypothermia. Also, immigrant deaths from hypothermia were four times greater than that of Turkish citizens. All of the cases in the mountainous region near the Turkey–Iran border were foreigners. Recently, the acceleration of the civil war in Syria and Iraq, as well as the ongoing civil war in Afghanistan, has increased the illegal passage of refugees in this region.

Various studies on the age of death from hypothermia showed similar results. Bright *et al* (10) showed that the age ranged from 30 to 86 years, with a mean of 67 years for 62 cases. Other studies have shown mean ages ranging between 62 and 68 (5, 10, 16–18). Dogan *et al*, in their study involving 12 Turkish citizens (15), reported that the ages of the patients ranged from 41 to 85 years, and the mean age was 57.0 ± 15.4 years. Here, the mean age (19.6 ± 10.2 years) was very low when compared to the results of the above-mentioned studies. This difference can be explained in that both the populations of refugees and residents are young. However, 19 refugees in 2002 (not included in this study) and 7 refugees in 2015 died from hypothermia in Van Province. Nearly all of them were young men and women and their little children (19, 20). In a study on demographics about refugees in Van Province, 90% of the refugees were under 40 years of age (21).

In previous studies, the majority of hypothermia-related deaths occurred in men (5, 9, 15, 18, 22–24). Ishikawa *et al* reported that of 162 cases (17), 114 (70.4%) were males. Here, the majority of cases were males (83.7%). Females are more resistant to hypothermia than males because they have thicker subcutaneous fat layers that protect against hypothermia (2, 25).

Deaths from hypothermia increase in winter (15, 22). Tanaka *et al* showed that 117 (74.6%) of 157 cases of fatal hypothermia died during the winter months (22). Dogan *et al* showed that 41.7% of hypothermia-related deaths occurred in January (15). We found that most cases (n = 28; 65.1%) died or were found dead in the spring months, especially in April (n = 14; 32.6%). This is likely because the corpses were covered with snowdrifts and were only visible once the snow melted in the

spring. There is also increased migration in the spring. While there was evidence of scavenging by wild animals, there was no evidence of decay (Fig. 6).

Fig. 6: (A) An Afghan refugee who died due to hypothermia in mountains in the border area. (B) In a corpse of a person who died from hypothermia in the mountains, postmortem defects formed by wild animals in the parts of the body not covered by the snow.

Despite the general belief that fatal hypothermia occurs outdoors, many studies have shown that it can happen indoors at a rate of 7% to 79% (9, 16, 18, 26–29). This study is odd in that all except one died outdoors.

One of predisposing factors of hypothermia is trauma (1, 2, 6, 26, 27). It was reported that there were trauma findings in 75% of fatal hypothermia cases in the study of Lim and Duflou (28), 20.1% in the study of Elbaz *et al* (5), and 4% in the study of Brändström *et al* (9). We found 16 cases (37.2%) with trauma at the autopsy stage.

Türk *et al* found that rectal temperature is an important diagnostic tool for establishing the diagnosis of fatal hypothermia despite the presence of information about 'the significant limitation of the usefulness of rectal temperature determination for the estimation of the time since death is very limited due expecting of dropping in rectal temperature in surviving individuals' in literature (29). Here, most cases died outdoors, and rectal temperature was not recorded. One postmortem finding is that hypothermia-related deaths were defined by a common bright pink or red lividity, similar to the lividity of carbon monoxide or cyanide, due to the binding of haemoglobin oxygen antemortem and preventing the passage to poor tissue (13, 25, 29, 30). This finding was seen in 33 cases (76.7%). Frostbite may be seen on the peripheries in individuals who are exposed to subzero temperatures in dry conditions (6, 27). Cold (frost) erythema was another autopsy finding in hypothermia-related deaths (9, 13, 25, 27, 28, 30). In 36 cases studied by Hejna *et al*, the rate of cold erythema was 80% (16). This rate was 60.5% in our study.

Endocrine diseases, including hypothyroidism, hyperglycaemia and hypoaldosteronism, are possible risk factors for hypothermia (5). Hypothyroidism, especially, is a major reason for hypothermia in elderly women (25, 27). We found myxedema in one 17-year-old female resident who died outdoors.

Paradoxical undressing and the 'hide and die' syndrome involves undressing and hiding in small places such as pantries or wardrobes. This is a special case seen in some cases of hypothermia (2, 25–29). The rate of paradoxical undressing was stated as between 20% and 30% in various articles (7, 9, 10, 28, 29). We did not note this or "hide and die syndrome" in other studies (15, 16, 18).

Haemorrhages of the synovial membrane and bloody discolouration of the synovial fluid are named as 'inner knee signs' (16, 25, 26, 30), and were defined in all hypothermia cases studied by Hejna *et al* (16). This finding was found in 11 (84.6%) of the 13 cases. We think that it is one of the most valuable findings for positive identification of hypothermia. Although it has been stated that immersion foot may be seen as a result of prolonged exposure to cold, this finding was not found in the presented cases (2, 31).

Haemorrhagic spots of the gastric mucosa are known as Wischnewski spots or Wischnewski ulcers and are one of the lesions commonly described in autopsy findings of hypothermia-related deaths (3, 7, 16, 26). Similar ulcers were described in the ileum and colon (25). The possible reasons for these lesions were defined as mucosal hypoxia due to declining metabolic rates caused by cold as well as peripheral and splanchnic vasoconstriction associated with stress and a leftward shift of the oxyhaemoglobin dissociation curve (2, 4). In an animal study, Wischnewski spots did not occur in Sprague-Dawley rats who died of hypothermia under anaesthesia. Researchers suggested that stress may be a significant effect modifier in the development of Wischnewski spots in lethal hypothermia (32). The incidence of Wischnewski spots (and/or ulcers) was 43.5% (7), 65.7% by Brändström *et al* (9), 66.7% by Dogan *et al* (15), 79% by Lim and Duflou (28), 83% by Hejna *et al* (16), 92% and 100% by Bright *et al* (10). We found the rate of Wischnewski spots to be 74.4% in accordance with the literature. We think that Wischnewski spots are useful for positive identification.

In the literature, some non-specific findings of hypothermia-related deaths (haemorrhage in the psoas muscle, pectoralis minor muscle and first intercostal

muscle; dilatations of the right atrium and ventricle of heart; acute heart failure; focal myocardial degeneration and necrosis of the heart muscle; differences in the left and right heart blood colour; dilatation of the right atrium and ventricle; haemorrhage, congestion and/or oedema in the lungs; bronchopneumonia; congestion of the vena cava; congestion of the liver and/or spleen; acute tubular necrosis; lipid deposits in the glomeruli, liver, heart and skeletal muscle, *etc*) were reported (15, 25, 26, 30).

Enzymatic fat necrosis of the pancreas or pancreatitis is another finding in some autopsies on hypothermia-related deaths (15, 25, 26, 30). However, this finding is controversial due to haemorrhages into the pancreas and possible autolysis, along with pre-existing conditions such as alcohol intake (26, 28, 33). In this study, we found haemorrhage, congestion and/or oedema in the lungs in 22 (51.2%) cases, enzymatic fat necrosis of the pancreas in 7 cases (16.3%) and congestion of the liver and/or spleen in 20 cases (46.5%). Other non-specific findings were not defined in any of the autopsy reports.

Psychiatric disorders such as schizophrenia, substance abuse and personality disorders are important risk factors for fatal or non-hypothermia, and the rate of psychiatric disorders in hypothermia was defined as between 6.3% and 36.7 in various studies (5, 9, 18, 28, 30, 34). We did not evaluate cases for psychiatric illnesses because the majority of cases were foreign nationals who lacked medical history.

Drug and alcohol abuse are predisposing factors (2, 6). Alcohol is the most common intoxicant associated with hypothermia because of its ability to cause cutaneous vasodilation, impairment of shivering and impairment of adaptive behaviour (6). Leikin *et al* reported that more than 150 drugs are also predisposing factors for hypothermia (6). In various studies, the rate of alcohol in blood in hypothermia cases is between 11.6% and 63.7% (9, 10, 16, 18, 22). We found antemortem alcohol intake in only one case who died in a prefabricated container, but no case of drug intake. This is probably because these persons are from Muslim-majority countries such as Turkey, Afghanistan, Iraq and Syria (35).

Due to the lack of post-mortem immunohistochemistry and biochemistry laboratories in Turkey, laboratory tests that define hypothermia, such as ubiquitin, hippocampal microtubule-associated protein 2 (MAP2), calcium and sodium, chromogranin A, and adrenocorticotropic hormone (25), were not studied and are lacking in this study.

CONCLUSION

Illegal refugees are an important social problem in Turkey. Hypothermia should be considered as a cause of death for refugees when they are found in the cold provinces.

The difficulty of the autopsy diagnosis of fatal hypothermia and relative non-specificity of morphological findings are important problems for forensic pathologists and other death investigators. In this study, we submitted one of the largest series of autopsy findings ever for hypothermia-related deaths. We noted bloody discolouration of the synovial fluid, which is the most valuable finding for the positive identification of hypothermia and was previously reported in a few articles. Finally, we also found that Wischnewski spots still have value for positive identification.

AUTHORS' NOTE

YH conceived paper, oversaw data collection, conducted data analysis, wrote manuscript, and approved final version. YE participated in the study design and interpretation of the data, critically revised the manuscript and approved the final version. OG participated in the study design and interpretation of data, critically revised the manuscript and approved the final version. EK participated in study design, interpretation of data and revision of manuscript and approved final version. UD participated in study design, data analysis, and interpretation of data and revision of manuscript and approved final version. MA provided oversight of the study; participated in the study design, data analysis and interpretation; critically revised the manuscript and approved the final version. The authors declare that they have no conflicts of interest.

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