Acta Biomed 2018; Vol. 89, N. 3: 370-377 DOI: 10.23750/abm.v89i3.6359

Original article

Relation of the frequency and mortality of pulmonary thromboembolism with meteorological parameters

Gökhan Perincek[1], *Osman Nuri Hatipoğlu*[2], *Erhan Tabakoğlu*[2], *Sema Avcı*[3]

[1] Department of Chest Diseases, Kars Harakani State Hospital, Kars, Turkey; [2] Department of Chest Diseases, Trakya University, Edirne, Turkey; [3] Department of Emergency Medicine, Kars Harakani State Hospital, Kars, Turkey

Summary. *Objective:* The objective of this study is to find the relationship between incidence rate and mortality of acute pulmonary thromboembolism (PTE), and seasonal and meteorological factors. *Materials and methods:* The data from 234 patients who were hospitalized due to acute PTE in the emergency service or policlinics between 2001 and 2008 were investigated retrospectively. Cases that developed APE (acute pulmonary embolism) in the hospital were excluded. Seasons and months in which acute PTE was diagnosed were recorded. Mortality rates by months and seasons were evaluated. The mean pressure, temperature and humidity values were evaluated for periods of three days, seven days and one month before the day of presentation. The effects of meteorological factors on the severity (massive or non-massive) and mortality of APE were investigated. *Results:* The incidence rate of acute APE showed a significant difference according to seasons (p=0.000). APE was diagnosed most commonly in spring and winter. The mean pressure values for three days, seven days and one month and the mean humidity values for three days for the dead patients were found to be significantly lower than those of the survived ones (p<0.05). The mortality rate for patients admitted in summer was significantly higher than the rates for other seasons (p=0.02). There were no seasonal differences among the massive APE incidences. Mortality rates were higher in summer because of the nonmassive APE patients rather than the massive patients. *Conclusion:* Acute PE is a disease whose incidence and mortality rates are affected by meteorological factors. (www.actabiomedica.it)

Key words: pulmonary thromboembolism, meteorological parameters

Introduction

Barometric pressure is the pressure that is formed by gravity acting upon the atmosphere. Normal pressure at sea level, at a temperature of 15°C, is 760 mmHg or 1013.25 millibars (1). Barometric pressure is affected by changes in altitude and temperature. When altitude and temperature increase, barometric pressure decreases, and it increases at sea level and when temperature decreases (2).

It has been found that thromboembolic events such as pulmonary embolism, acute myocardium infarct, temporary ischemic attack, paralysis and retinal vein occlusion show chronobiological differences and occur more frequently in specific seasons and months (3-5). An autopsy study revealed that deaths from PTE are more common in some seasons (6). Other studies in the literature show no associations between meteorological factors and PTE (7, 8). When we looked closer at the literature we saw that studies to identify the relationship between PTE and meteorological factors are not numerous, and the case has not yet been made clear.

We observed clinically that the number of patients with acute PTE increases in some periods. We planned to find out whether this observation was correct, and if so, to investigate its relationship with meteorological factors. Within this study we also investigated the association between meteorological factors and the severity of PTE.

Materials and methods

Data from 234 patients who were with diagnosed PTE by the Chest Diseases Clinic of Trakya University Medical Faculty between May 2001 and April 2008 were investigated retrospectively. Patients who developed acute PTE in the hospital were excluded from the study.

Patients with high probability V/P scintigraphy and low or medium probability V/P scintigraphy, together with DVT diagnosed through Doppler USG or thrombus diagnosed through spiral thoracic CT, were included in the study.

Addresses and demographic features of the patients, dates of their admissions to ER, types of PTE – massive or nonmassive – treatments applied and the results (discharge from hospital, death) about the patients, were all recorded. Months and seasons of admission dates were defined. Daily meteorological pressure, humidity and temperature values were obtained electronically from the general directorate of meteorology. Based on these data, the meteorological parameters (pressure, humidity and temperature) were defined for three days, seven days and one month before the day of presentation of the patients and the mean values were calculated.

Data were analyzed with the SPSS 15 program. Descriptive statistics, Kolmogorov-Smirnov test, X^2 test, correlation analysis and T test for the independent samples were used. Values of $p<0.05$ were deemed statistically significant.

Results

234 patients with PTE were included in the study. Of the patients 113 were female (48.3%), 121 were male (51.7%) and the mean age was 59.43±15.9, with the youngest being 19 and the oldest 93. The demographic features of the patients according to seasons and co-morbidities are summarized in Table 1.

When we examined the seasonal distribution of patients, we determined that most of the patients that treatment procedures applied were in spring (n=67, 28.6%) and the least in autumn (n=47, 20.1%). Differences among seasons were found to be statistically significant (p=0.000).

When we looked at the monthly distribution of the patients treated due to PTE, we established that most patients were followed in March (n=28, 12.0%) and the least in November (n=12, 5.1%). Differences among months were found to be statistically significant (p=0.02).

Table 1. Demographic features of the patients according to seasons and co-morbidities

	Spring (n=67)	Summer (n=56)	Autumn) (n=47	Winter (n=64)
Female / Male	37/30	24/32	21/26	31/33
Age	59±15	60±15	57±17	60±15
Undergone PTE	3	2	0	3
Cardiovascular Disease	35	28	25	33
DM	5	7	4	5
KBY	1	2	1	1
Hematological Disease	0	2	0	1
DVT	2	4	2	4
Varix	3	0	3	5
Cerebrovascular Disease	3	4	5	9
COPD	9	6	2	6
Lung Carcinoma	2	4	2	2
Extrapulmonary Malignity	2	5	4	4

Table 2. Results about patients according to seasons

Seasons	Discharged n (%)	Mortality n (%)	p value
Spring	60 (25.9)	7 (3.0)	0.47
Summer	44 (18.9)	12 (5.2)	**0.02**
Autumn	43 (18.6)	4 (1.7)	0.24
Winter	55 (23.7)	7 (3.0)	0.69

When we evaluated the rates of discharge from hospital and mortality after treatment, we obtained the figure of 232 patients out of 234. We determined that 30 (12.8%) of the patients died and 202 (%87.2) were discharged. 14 of the dead patients were female and 16 were male; 97 of the patients discharged were female and 105 were male. The mean age for the dead patients was 67.7±13.6, while for the discharged patients it was 58.2±15.9 (p=0.01).

When the mortality rates were compared according to seasons, it was found that the mortality rate increased in summer (n=12, 5.2%) although the number of patients was relatively less (n=56, 24.1%) in summer. This increase was statistically more significant than the other seasons (p=0.02). The results about patients according to seasons are shown in Table 2.

When the rates of discharge and mortality were evaluated according to months, it was found that the mortality rate increased in August (n=5, 2.1%) although the number of patients decreased (n=14, 5.9%). This increase was statistically more significant than the other months (p=0.00).

When the mean temperature, pressure and humidity values were compared, summer was the season with the lowest pressure and humidity values but the highest temperature, while winter had the highest pressure and humidity values but the lowest temperature. Seasonal differences among pressure, temperature and humidity were statistically significant (p=0.00). There was an "inverse" correlation between temperature and pressure and humidity. When we compared the mortality rates according to seasons, we found that the mortality rate was highest in summer during which pressure and humidity were lowest and temperature highest (p=0.02) (Figure 1).

When the number of patients and mortality rates were compared according to months, the mortality rate was found to be significantly higher in August during which pressure and humidity were the lowest and temperature the highest (p=0.02) (Table 3).

The results about patients and pressure, humidity and temperature values for three days, seven days

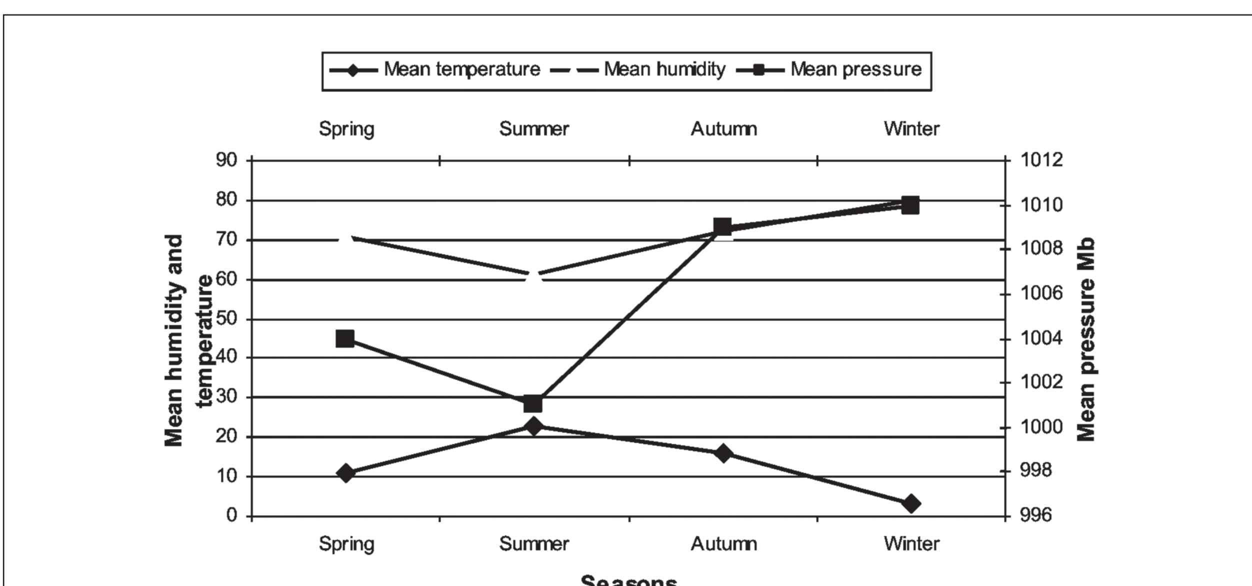

Figure 1. Mean pressure, temperature, humidity values according to seasons

Table 3. Mean pressure, temperature, humidity values, number of patients and mortality rates according to months

Month of diagnosis	Patients (n)	Mortality (n)	Mean pressure (Mb)	Mean temperature (°C)	Mean humidity (%)
January	24	2	1011.0	1.68	81.1
February	20	1	1010.1	4.8	78.2
March	28	2	1005.0	8.4	74.8
April	21	3	1003.1	11.8	69.2
May	18	2	1004.3	16.8	68.2
June	20	5	1004.6	22.2	62.5
July	20	2	999.4	24.2	56.8
August	14	5	998.1	25.0	62.1
September	16	1	1010.8	20.1	65.9
October	22	2	1007.2	16.6	72.8
November	12	1	1011.1	10.4	78.5
December	17	4	1011.0	4.3	81.1

Mb: Millibars; °C: Degree centigrade

and one month before the presentations of the patients were compared. The mean pressure values for three days (1001.4±10.9 Mb), seven days (1001.8±11.3 Mb) and one month (1002.8±102 Mb), and the mean humidity values for three days (67.8±11.9%) before the presentation of the patients who later died were significantly lower than those values of the patients who were discharged from hospital. As for the temperature, no significant effects were detected on mortality or discharge rates ($p<0.05$) (Table 4).

When patients with PTE were grouped as massive and nonmassive, then of the 234 patients 53 were massive and 181 were nonmassive. The mean age was found to be 58.6±16.3 for the massive PTE patients and 62.5±14.3 for the nonmassive PTE patients ($p=0.12$). Of 53 patients with massive PTE, 29 were female and 24 were male; of the patients with nonmassive PTE 84 were female and 97 were male ($p=0.28$). In their follow up period we determined that 17 (32%) of the massive and 13 (7%) of the nonmassive PTE patients died. The higher rate of mortality in massive PTE was statistically significant ($p=0.00$).

The mean age for the patients who expired due to massive PTE was 64.2±14.6 and that of the discharged patients was 61.3±14.3. The association between mortality due to massive PTE and age was statistically insignificant ($p=0.49$). The mean age for the patients who expired due to nonmassive PTE was 72.2±11.1 and that of the discharged patients was 57.6±16.2. We found the association between mortality due to nonmassive PTE and age statistically significant ($p=0.00$).

When we investigated the incidence of 53 patients with diagnosed massive PTE according to seasons and the results about them, we found that the

Table 4. Association between the results about the patients with pulmonary thromboembolism and meteorological factors

Meteorological feature	Deceased patients	Discharged patients	p value
Mean pressure for three days±SD	1001.4±10.9	1006.3±10.4	**0.03**
Mean pressure for seven days±SD	1001.8±11.3	1006.5±9.8	**0.02**
Mean pressure for one month	1002.0±10.2	1007.3±9.6	**0.01**
Mean humidity for three days±SD	67.8±11.9	73.2±12.6	**0.04**
Mean humidity for seven days±SD	69.1±11.2	72.7±12.1	0.16
Mean humidity for one month±SD	70.3±9.8	72.6±10.2	0.31
Mean temperature for three days±SD	13.6±9.1	12.8±8.1	0.62
Mean temperature for seven days±SD	14.2±8.4	12.5±7.9	0.33
Mean temperature for one month±SD	13.4±8.4	12.4±7.8	0.55

SD: Standard Deviation

most of the patients were treated in winter (n=16), and the fewest were followed in spring and autumn (n=11). The difference between seasons was found to be statistically significant (p=0.01). Concerning the mortality rates according to seasons, we determined that the highest mortality was in spring and summer (n=5) and the lowest in autumn (n=3), which meant a statistically insignificant difference between seasons in terms of mortality (p>0.05).

We obtained the results of 179 nonmassive patients and investigated the incidences according to seasons and the results about them. We saw that the maximum number of patients were followed in spring (n=56) and the minimum number in autumn (n=38), and the difference between the seasons was significant (p=0.00). The results about the patients according to seasons were examined, and an increase in mortality rates was observed in summer although there was a decrease in the number of patients. The highest mortality was detected in summer (n=6) and the lowest in autumn (n=1). The rise in the mortality rate in summer was statistically significant (p=0.03).

When we looked at the monthly distribution of patients with massive PTE, we saw that the maximum number of patients were admitted in January and June (n=6) and the minimum number of patients were admitted in November (n=2). There were no significant differences in this monthly distribution (p=0.58). Concerning the mortality rates according to months, it was determined that most of the deaths were in May (n=3) and the differences in mortality rates was not significant (p>0.05).

When we considered the months of diagnosis, we determined that most of the nonmassive PTE patients were followed in March (n=24) and the least were followed in November (n=10). The difference among the months was found to be statistically significant (p=0.003). With respect to mortality rates of patients according to months, we found that the maximum number of patients died in June and August (n=3). The rise in August was considered statistically significant (p=0.03).

Our investigation concerning the association between the development of massive and nonmassive PTE and the values of pressure, temperature and humidity for three and seven days and one month revealed that these meteorological parameters have no effects on the incidence of massive and nonmassive PTE (Table 5).

When we investigate the correlation between the outcomes of patients with massive PTE and the values of pressure, temperature and humidity for three and seven days and one month, we found that the mean pressure value for one month was lower in the period that patients mostly died, and this was statistically significant (p=0.04). Temperature and humidity values did not have any effects on the results for massive PTE patients.

When the results of patients with nonmassive PTE and the values of pressure, temperature and humidity for three and seven days and one month were investigated, the mean pressure value for three days was found to be lower in the period patients died and this was statistically significant (p=0.03). Temperature

Table 5. Effects of meteorological factors on the development of massive and nonmassive pulmonary thromboembolism

Meteorological feature	Massive PTE Mean±SD	Non massive PTE Mean ±SD	p value
Pressure for three days	1004.7±10.9	1006.1±10.6	0.46
Pressure for seven days	1005.0±10.3	1006.3±10.0	0.46
Pressure for one month	1005.6±9.4	1007.0±9.9	0.42
Humidity for three days	70.6±12.8	73.1±12.5	0.25
Humidity for seven days	70.7±12.3	72.7±11.9	0.34
Humidity for one month	70.6±10.0	72.8±10.2	0.21
Temperature for three days	13.4±9.1	12.6±8.0	0.59
Temperature for seven days	13.8±8.6	12.3±7.8	0.30
Temperature for one month	13.1±8.6	12.3±7.7	0.55

SD: Standard Deviation

and humidity values were established to have no effects on mortality and discharge in those patients with nonmassive PTE.

Discussion

In our study we identified that most of the patients with PTE were followed in spring (n=67), then in winter (n=64), and the least in autumn (n=47) and summer (n=56). When we investigated the two studies carried out in our country about the seasonal distribution of patients with PTE, we saw that in the study of Meral et al. (3) involving 91 patients, similar results had been obtained, with more PTE cases being observed in the spring.

Boulay et al. (9) investigated PTE and DVT cases in all the hospitals in France by using ICD codes. 62,237 patients with PTE and 65,081 patients with DVT were included in their study.

As a result they found that the number of both PTE and DVT patients markedly increased in winter and decreased in summer.

The second study made in our country about this subject was made by Ercan et al. (10) and included a limited number of patients (n=49). This study revealed a decreased number of PTE cases in winter. Similar results were obtained in the studies made by Gallerani et al. (11) and Manfredini et al. (12). The study of Gallerani et al. (11) included 22,436 patients diagnosed in the hospitals of the Emilia-Romegna region in Italy. This large-scale study established that the number of PTE patients increase markedly in winter.

In the study of Masotti et al. (13), patients were grouped into internal and surgical patients, and the incidence rates according to seasons were investigated. When all patients were evaluated in general, an increase in the number of patients in winter months was discovered and this increase was more prominent in the surgical patient group. Sharma et al. (14) evaluated 248 PTE patients and found that PTE incidences were 2.9 times higher in the autumn and winter months.

Beside the studies indicating the seasonal differences in PTE incidences, other studies show no differences. Stein et al. (15) evaluated 2,475,000 PTE and 5,767,000 DVT patients in the USA between 1979 and 1999. This large-scale study revealed no differences in the incidences of PTE and DVT according to seasons and months. Bilora et al. (16) investigated the seasonal association of nonmassive PTE and DVT. In their study, although there were differences in the winter and summer months, these differences were not statistically significant. An increase in PTE and DVT development was determined on Saturdays and in the mornings. Scott et al. (17) investigated incidences of PTE development according to seasons and barometric pressure and found that PTE development was not associated with the seasons.

When we evaluated the PTE incidences according to months, we saw that most of the patients were followed in January (n=24) and March (n=28). Masotti et al. (13) similarly determined that PTE patients were mostly admitted in January and March. Likewise, Gallerini et al. (11) and Ercan et al. (10) established in their studies that PTE cases were most common in January.

When we investigated the mortality rates of PTE patients, we determined a significant increase in mortality due to PTE in the summer, especially in August. In the literature, however, there are few studies about the subject and they lead to different results. In an autopsy study by Green and Edwards (6), a higher mortality rate due to massive PTE was established for spring and autumn. When we made an evaluation according to seasons, the rise in October was found to be statistically significant. Masotti et al. (13) evaluated PTE and mortality rates in their study. Their study concluded that there was an increase in the number of patients with PTE and mortality rates in the winter months. In their study covering a period of 18 years, Stein et al. (18) found that PTE mortality was not associated with seasons.

When we investigated PTE development and barometric pressure, temperature and humidity values, we observed an inverse correlation between temperature and values of pressure and humidity. During the period when the pressure was low the number of patients increased; the changes in temperature and humidity values did not have any effects on the number of patients. When we looked at the association between mortality rates and pressure, temperature and humidity values, we found that in the period when patients died due to PTE the mean rates of pressure for three days, seven days, one month and humidity rates for three days were low, and temperature had no effect.

Of the studies made about our subject, the one by Masotti et al. (13) established that the number of patients with PTE increased when barometric pressure was low. In their study about the development of PTE, Scott et al. (17) determined an increase in the number of PTE patients when barometric pressure decreased. Clauss et al. (19) found in their study that humidity and rain affected PTE development positively, but temperature and pressure had no effects.

In our country the study of Meral et al. (3) determined that the number of patients with PTE increased during the periods when the pressure was low; on the other hand they could not find a relation between mortality and pressure. Ercan et al. (10) found in their study, which they made with a limited number of patients, that PTE was associated with pressure and temperature.

In our study we established that seasons and meteorological parameters do not have any effects on the development of massive and nonmassive PTE. Meral et al. (3) also reached similar results in their study and reported that pressure was not associated with the development of massive and nonmassive PTE.

The most important factor restricting these two studies made in our country is the limited number of patients. Our study is the largest one made in our country about this subject.

The effects of seasonal variability on PTE development are associated with hematological reasons. It has been shown that changes in blood viscosity and coagulation (20) and the development of red blood cells and the rise in the number of platelets due to slight surface cooling (21) cause spontaneous thrombosis. This state of hypercoagulability is supported by increased fibrinogen levels. In the cold months of the year fibrinogen levels rise a lot (22). Fibrinogen level is a major risk factor for cardiovascular diseases (23). Another effect of cold weather is that it raises blood pressure levels (24). A rise in sympathetic activity and a decline in liquid and sodium loss can explain the high levels of blood pressure in winter months (25). Low temperatures increase cardiovascular and respiratory morbidity and mortality. A short term exposure to temporary air pollution is effective on cardiorespiratory mortality and morbidity (26). Cold wind alone can determine mortality more than temperature can. In some studies this subject was investigated and it was stated that moving air causes physiological changes in a few hours and increases blood viscosity at the rate of 20% (21).

Consequently, this study confirmed our observation about the increase in the incidence and mortality of pulmonary thromboembolism in some periods. Our findings indicating that low atmospheric pressure can affect the variability of mortality need to be supported by large- scale studies.

References

1. Erol O. Hava küre. Genel kliminoloji.6. Ankara: Çankaya Kitabevi; 2004: 15-25.
2. Erol O. Hava basıncı ve rüzgarlar. Genel kliminoloji.6. Ankara: Çankaya Kitabevi; 2004: 112-97.
3. Meral M, Mirici A, Aslan S, Akgun M, Kaynar H, Saglam L, et al. Barometric pressure and the incidence of pulmonary embolism. Chest 2005; 128: 2190-4.
4. Astrid MF, Wolfgang M, Andreas S. Seasonal variations of deep vein thrombosis and its influence on the location of the thrombus. Thromb Res 2002; 106: 97-100.
5. Wilmshurst P. Temperature and cardiovascular mortality. BMJ 1994; 309: 1029-30.
6. Green J, Edwards C. Seasonal variation in the necropsy incidence of massive pulmonary embolism. J Clin Pathol 1994; 47: 58-60.
7. Bounameaux H, Hicklin L, Desmarais S. Seasonal variation in deep vein thrombosis. BMJ 1996; 323: 284-5.
8. Fink AM, Mayer W, Steiner A. Seasonal variations of deep vein thrombosis and its influence on the location of the thrombus. Thromb Res 2002; 106: 97-100.
9. Boulay F, Berthier F, Schoukroun G, Raybaut C, Gendreike Y, Blaive B. Seasonal variations in hospital admission for deep vein thrombosis and pulmonary embolism: Analysis of discharge data. BMJ 2001; 323: 601-2.
10. Ercan I, Coskun F, Cangur S et al.An analysis of patients diagnosed with pulmonary embolism in terms of clinical and meteorological data. Saudi Med J 2006; 27(4): 555-7.
11. Gallerani M, Boari B, Smolensky MH et al. Seasonal variation in occurrence of pulmonary embolism: analysis of the database of the Emilia-Romagna region, Italy. Chronobiol Int 2007; 24(1): 143-60.
12. Manfredini R, Gallerani M, Boari B, Salmi R, Mehta RH. Seasonal variation in onset of pulmonary embolism is independent of patients' underlying risk comorbid conditions. Clin Appl Thromb Hemost 2004; 10(1): 39-43.

13. Masotti L, Ceccarelli E, Forconi S, Cappelli R. Seasonal variations of pulmonary embolism in hospitalized patients. Respir Med 2005; 99(11): 1469-73.
14. Sharma GV, Frisbie JH, Tow DE, Yalla SV, Khuri SF. Circadian and circannual rhythm of nonfatal pulmonary embolism. Am J Cardiol 2001; 87(7): 922-4.
15. Stein PD, Kayali F, Olson RE. Analysis of occurrence of venous thromboembolic disease in the four seasons. Am J Cardiol 2004; 93(4): 511-3.
16. Bilora F, Manfredini R, Petrobelli F, Vettore G, Boccioletti V, Pomerri F. Chronobiology of non-fatal pulmonary thromboembolism. Panminerva Med 2001; 43(1): 7-10.
17. Scott JA, Palmer EL, Fischman AJ, Strauss HW. Meteorologic influences on the frequency of pulmonary embolism. Invest Radiol 1992; 27(8): 583-6.
18. Stein PD, Kayali F, Beemath A, et al.Mortality from acute pulmonary embolism according to season. Chest 2005; 128(5): 3156-8.
19. Clauss R, Mayes J, Hilton P, Lawrenson R. The influence of weather and environment on pulmonary embolism: pollutants and fossil fuels. Med Hypotheses 2005; 64(6): 1198-201.
20. Bull GM, Brozovic M, Chakrabarti R et al. Relationship of air temperature to various chemical, haematological, and haemostatic variables. J Clin Pathol 1979; 32(1): 16-20.
21. Keatinge WR, Coleshaw SR, Cotter F, Mattock M, Murphy M, Chelliah R. Increases in platelet and red cell counts, blood viscosity, and arterial pressure during mild surface cooling: factors in mortality from coronary and cerebral thrombosis in winter. Br Med J (Clin Res Ed) 1984; 289(6456): 1405-8.
22. Elwood PC, Beswick A, O'Brien JR et al.Temperature and risk factors for ischaemic heart disease in the caerphilly prospective study. Br Heart J 1993; 70(6): 520-3.
23. Qizilbash N, Jones L, Warlow C, Mann J. Fibrinogen and lipid concentrations as risk factors for transient ischaemic attacks and minor ischaemic strokes. BMJ 1991; 303(6803): 605-9.
24. Kunes J, Tremblay J, Bellavance F, Hamet P. Influence of environmental temperature on the blood pressure of hypertensive patients in Montréal. Am J Hypertens 1991; 4: 422-6.
25. Sharma BK, Sagar S, Sood GK, Varma S, Kalra OP. Seasonal variations of arterial blood pressure in normotensive and essential hypertensives. Indian Heart J 1990; 42(1): 66-72.
26. Keatinge WR, Donaldson GC. Mortality related to cold and air pollution in London after allowance for effects of associated weather patterns. Environ Res 2001; 86(3): 209-16.

Received: 11 April 2017
Accepted: 18 October 2017
Correspondence:
Sema Avcı
Kars Harakani Devlet Hastanesi
İsmail Aytemiz Bulvarı 36200 Merkez/Kars
E-mail: dnzlsema@gmail.com