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The Effects of Atmospheric Changes on Spontaneous Pneumothorax

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Background: Inconsistent results were reported in studies on the relationship between pneumothorax and meteorological conditions.
Aim: We aimed to investigate whether meteorological variables increase the incidence of pneumothorax applications in a region with intense southwestern winds.
Methods: The study was conducted retrospectively using the hospital records of patients diagnosed with spontaneous pneumothorax at the emergency department or thoracic surgery outpatient clinics between January 2016 and December 2018. The admissions were grouped according to the months and seasons. Meteorological data, including daily mean temperatures (°C), atmospheric pressure (millibars), moisture (%), and wind (m/s), were obtained from the local meteorological directorate. The meteorological data on the days with and without spontaneous pneumothorax were compared.
Results: Total 264 patients diagnosed as pneumothorax included to this study. Of the patients, 27 (10.2%) were female, and 237 (89.8%) were male. The mean age was 36.71±17.95 years (between 18-92). Of these patients, 185 (70.0%) had primary SP, while 79 (29.9%) had secondary SP. During the study period, lower atmospheric pressure, humidity and higher temperature were detected in July, August and September (<0.05). Secondary spontaneous pneumothorax was significantly higher in August and September ($p<0.05$). While southwestern winds were recorded in 703 days (74.5%), there were 214 days (22.7%) without such winds. Regarding the daily number of pneumothorax patient admissions, there was no statistically significant relationship between southwestern winds and SP.
Conclusions: Secondary spontaneous pneumothorax was significantly higher in August and September due to lower atmospheric pressure, humidity and higher temperature.

Keywords: Pneumothorax, temperature, atmospheric pressure, wind, thoracic surgery

Short Title in English: Atmospheric Changes and Spontaneous Pneumothorax

INTRODUCTION

Pneumothorax is described as a pathological accumulation of air between the pleural leaves, causing lung collapse (1). Spontaneous pneumothorax (SP) is classified under two main headings as 'primary' and 'secondary.'

Primary spontaneous pneumothorax (PSP) usually occurs in young, tall, smoking men who do not have any lung disease. Sub-pleural blisters or blep ruptures are blamed in the etiology. The incidence is highest around the 20s. In the past, it was about 6-times more common among men. However, today, this ratio has become around 3, possibly due to the increase in smoking among women (2).

There is underlying lung pathology in patients with secondary spontaneous pneumothorax (SSP) (3). Thus, the process may be more severe in patients whose lung function is already impaired due to existing disease. SSP affects the elderly more frequently, chronic obstructive pulmonary disease (COPD) being the most common cause. Its incidence in these patients is approximately 26/100 thousand/year (4).

Atmospheric pressure, temperature, humidity, or sudden weather changes are blamed for being involved in the etiology of SP (5,6). Due to conflicting literature between the relationship of atmospheric changes and SP, there is a need for further clarifying studies.

This study aimed to investigate the effects of weather and atmospheric pressure changes on SP hospital admissions in XXX, a XXX city where southwestern winds are prevalent.

MATERIALS AND METHODS

Study Design

This study was designed as descriptive-analytical cross-sectional research. Survey reporting was done per the STROBE guideline (7).

Setting

The study was conducted retrospectively using the hospital records of patients diagnosed with spontaneous pneumothorax in the emergency department or thoracic surgery outpatient clinics between January 2016 and December 2018. This hospital is the largest and most

comprehensive health center in XXX of XXX with a capacity of 1370 beds. The daily number of patients served is approximately 10,000. Approximately 3500 patients are seen each day in the emergency department.

Ethics Committee Approval

Ethics committee approval was received for this study from the Medical Ethics Committee of XXX Hospital (approval no.2011-KAEK-25 2019/06-20).

Participants

In this study, the data of 264 (2.1 per 1000) adult persons diagnosed with pneumothorax from among 1 203 339 patients who applied to the hospital throughout the 944 days between 01.06.2016 and 31.12.2018 (Figure 1), and the climatic data between these dates were analyzed.

The diagnosis of SP was made from the patient's history, physical examination findings, posterior-anterior (PA) chest radiography, and thorax computed tomography (CT). PSP and SSP were differentiated using clinical examination and radiological imaging.

The patient admissions were grouped according to the days, months, and seasons. Meteorological data, including daily average temperature (°C), atmospheric pressure (millibars), moisture (%), and wind (meters/second), were obtained from Bursa meteorological directorate. The meteorological data on the days with and without SP were compared.

Variables

The primary outcome variable of the study was “the presence of pneumothorax.” The independent variables were age, sex, type of pneumothorax, affected lung side, presence of southwestern winds (lodos), season, mean daily atmospheric pressure, mean daily humidity, mean daily temperature, and the total number of emergency applications.

Study Size

Without sampling, all patients diagnosed as pneumothorax between 01.06.2016 and 31.12.2018 were included in the study.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0 software (SPSS Inc., Chicago, IL, USA). The results of the study were presented as

frequencies and percentages for categorical variables and as means and standard deviations for numerical variables. The normal distribution of the numerical variables was evaluated by checking the skewness coefficients. The independent samples t-test, Mann-Whitney U test, Kruskal-Wallis test or one-way ANOVA were used to compare the groups. Multivariate comparisons were examined by logistic regression analysis. The statistical significance threshold was taken as $p<0.05$.

RESULTS

The median number of daily emergency admissions during the study period was 1263 (minimum: 875, maximum: 1643). Total 264 patients diagnosed as pneumothorax included to this study. Of the patients, 27 (10.2%) were female, and 237 (89.8%) were male. The mean age was 36.71±17.95 years (minimum 18, maximum 92). 185 (70.0%) patients had PSP, while 79 (29.9%) had SSP. Out of 1 203 339 emergency applications, 264 cases of spontaneous pneumothorax were encountered (2.1 cases per 10 000 emergency admissions).

PSP vs. SSP distribution among males and females (males: 165 (69.6%) vs. 72 (30.4%), females: 20 (74.1%) vs. 7 (25.9%), respectively) was not significantly different (Chi-square=0.229, p=0.632). However, the mean age was significantly higher among patients with SSP (61.08±11.42 years) compared to PSP patients (26.30±6.46 years) (Mann-Whitney U Z=12.855, $p<0.001$).

At the time of the study, the min.-max. values of daily temperature, atmospheric pressure, and humidity in XXX were reported as -3.6-30.9 ˚C, 749.5-1024.6 millibar, and 31.3%-98.8%, respectively. At least one pneumothorax application was made to the hospital in 214 (22.7%) of 944 days included in the study.

All patients were hospitalized. Tube thoracostomy was applied in 94.7% (n=250) of the patients, and medical therapy (oxygen inhalation, analgesia, and observation) was performed in 5.2% (n=14) of the patients. Fifty-six (22.4%) patients who underwent tube thoracostomy required surgical intervention. During the follow-up, one patient died due to severe chronic obstructive pulmonary disease (COPD) and respiratory failure. Hence, the mortality rate was 0.3%.COPD was the most common etiology in patients with SSP.

The highest rate of SP was seen in autumn (24.9%, n=68), followed by summer (23.9%, n=66), spring (20.7%, n=38), and winter (19.9%, n=42). There was no difference concerning the seasons (Chi-Square=2.371, p=0.499).

Although southwestern winds were reported during 703 days (74.5%), these winds were not present in 241 days (25.5%). Regarding the daily number of pneumothorax patient admissions, there was no statistically significant relationship between southwestern winds and SP (Table 1).

Statistical significance was determined in the One way ANOVA test conducted to determine whether there was a difference in the distribution of atmospheric pressure (mb), humidity (%) and temperature (C) according to months ($p<0.05$). In the post-hoc tukey test conducted to determine the months of the difference, lower atmospheric pressure and humidity and higher temperature were detected in July, August and September. In the Kruskal-Wallis test conducted to determine whether there is a difference between the distribution of PSP, SSP and TSP by months, it was seen that SSP was significantly higher due to the month of August and September ($p<0.05$) (Table 2 and Figure 2).

Although the mean atmospheric pressure was slightly lower during the days with SP admissions, there was no statistically significant difference between the number of pneumothorax cases and the meteorological variables (Table 3).

DISCUSSION

This study demonstrated a prevalence of 2.1 spontaneous pneumothorax (SP) cases per 10,000 emergency admissions. There was a decrease in the mean atmospheric pressure during July, August, and September. The presence of southwestern winds, daily atmospheric pressure, daily humidity, and daily temperature do not increase the number of diagnoses of total spontaneous pneumothorax. However, secondary spontaneous pneumothorax cases presented most commonly during August and September when the atmospheric pressure was relatively low.

SP is a relatively rare disease, but it is one of the most common pathologies encountered in thoracic surgery. It is often seen as a PSP, and there is no underlying etiological cause. The annual incidence of PSP was reported as 7.4-18/100,000 for men and 1.2-6/100,000 for women.

In SSP cases, the yearly rate is given as 6.3/100,000 for males and 2.0/100,000 for females (8). In this study, we could calculate only the incidence of SP among emergency applications.

We did not record the presence of concomitant diseases or the history of previous pneumothorax. However, the most frequent concomitant lung diseases are reported as COPD, tuberculosis, cystic fibrosis, lung cancer (5). Although it is more common in PSP patients, recurrent pneumothorax can be seen in various proportions ranging from 16 to 52% (9,10).

The influence of climatic conditions on human health was extensively studied. There are reports that temperature, humidity, and atmospheric pressure changes may play a role in hospital admission, hearing loss, asthma, myocardial infarction, and joint problems (11–15). In our study, lower atmospheric pressure and humidity and higher temperature were detected in July, August and September. It is known that as the temperature increases, the air pressure decreases. We found that secondary spontaneous pneumothorax was significantly higher in August and September. These are the hottest and driest months of Bursa (16). Perhaps the temperature-dependent air pressure has a threshold; when it falls below a certain level, it may give rise to an increase in the incidence of pneumothorax.

Studies reporting the relationship of seasonal changes and SP rates are inconsistent. Earlier in 1972, it was mentioned that the frequency of SPs was highest between October and March (17). However, this could not be confirmed by later studies (18,19). Although our study did not reveal a significant difference in the number of total SP applications, there was a seasonal variation concerning SSP, which was more common during the months with relatively low atmospheric pressure. On the other hand, we could not demonstrate a relationship between the atmospheric pressure and the number of SP. Thus, we infer that this finding may be due to secondary factors affecting pneumothorax. It may be postulated that the higher rate of SSP during the days with low atmospheric pressure may be due to the worsening of COPD during these days (20). Besides, it was argued that that atmospheric ozone was higher in the spring season, which allegedly causes pleural blep and blister rupture (21).

According to a study conducted in the northeast of Turkey, the wind speed was lower on the days with spontaneous pneumothorax compared to the other days (22). On the other hand, no significant difference was found in a study investigating the effect of weather and Chinook winds on spontaneous pneumothorax (19). In our research, most of our cases with SP were PSP, and

most of these cases occurred in southwestern winds days and autumn. However, we could not find a statistically significant between the number of pneumothorax and southwest winds per previous studies.

In a study to investigate whether atmospheric pressure changes played a role in the formation of SP, no effect could be demonstrated (23). Other studies could not confirm a significant impact of daily temperature, humidity, and atmospheric pressure changes on SP formation (24,25). However, some studies claimed a substantial relationship between PSP and climatic changes with an increased incidence of PSP in case of low atmospheric pressure (26,27). Another study stated that increased air pollution and sudden atmospheric pressure change increased the frequency of PSP (28). As to a report from Japan, the incidence of SP increases significantly when atmospheric pressure drops (27). Also, in a study conducted in Tunisia, where the Mediterranean climate is dominant, it was found that there was a significant relationship between the seasons with high average air temperature and SP (29). In our study, no statistically significant difference was found between the incidence of pneumothorax and daily atmospheric pressure.

Limitations

The absence of data from other hospitals in XXX city was considered as a limitation of the study. Since SP is a rare condition, including other health centers could yield more significant results by increasing the sample size. Addition, other potentially substantial factors and confounders such as air pollution and co-morbidities deserved attention in this study.

Conclusion

Secondary spontaneous pneumothorax was significantly higher in August and September due to lower atmospheric pressure, humidity and higher temperature.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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TABLES

TABLE 1. The relationship between the numbers of patients with pneumothorax admitted daily and the presence of southwestern winds

		Presence of southwesternwinds					
		Absent		Present			
		n	%	n	%	χ^2	p
Number of PSP	0	197	81.7	586	83.4	0.655	0.884
	1	39	16.2	101	14.4		
	2	4	1.7	14	2.0		
	3	1	0.4	2	0.3		
Numberof SSP	0	225	93.4	647	92.0	0.705	0.703
	1	15	6.2	50	7.1		
	2	1	0.4	6	0.9		
Total SP	0	182	75.5	548	78.0	3.552	0.470
	1	52	21.6	122	17.4		
	2	6	2.5	25	3.6		
	3	1	0.4	7	1.0		
	4	0	0.0	1	0.1		
Presence of SP	Absent	182	75.5	548	78.0	0.606	0.436
	Present	59	24.5	155	22.0		

SP: Spontaneous pneumothorax. PSP: Primary Spontaneous pneumothorax SSP: Secondary Spontaneous pneumothorax.

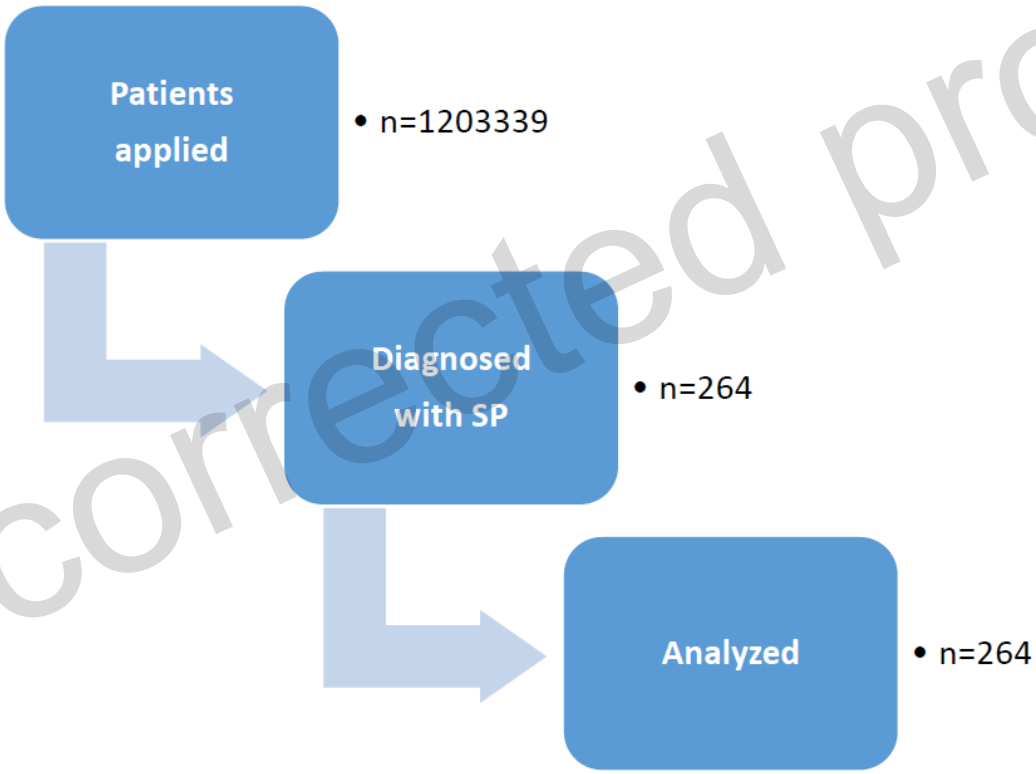
TABLE 2. Comparison of climate indicators by months

	Atmosphericpressure (mb)		Humidity (%)		Temperature (C)		PSP cases		SSP cases		Total SP	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	1002,51	19,88	77,41	10,84	5,1	3,68	0.29	0.55	0.03	0.18	0.32	0.57
2	989,95	35,74	74,24	13,61	8,68	3,94	0.20	0.44	0.05	0.23	0.25	0.58
3	998,65	11,57	74,07	14,15	11,75	3,82	0.15	0.36	0.10	0.30	0.24	0.47
4	1002,41	8,15	70,17	9,8	14,35	3,27	0.22	0.52	0.05	0.22	0.27	0.61
5	999,4	8,04	74,72	9,22	18,9	2,61	0.16	0.37	0.03	0.18	0.19	0.40
6	999,57	3,56	67,85	9,84	23,67	2,74	0.13	0.34	0.10	0.37	0.23	0.54
7	973,6	51,61	61,97	7,72	25,97	1,65	0.25	0.56	0.05	0.23	0.30	0.66
8	979,81	46,55	63,75	6,79	26,09	1,82	0.24	0.58	0.17	0.43	0.41	0.71
9	967,29	70	65,45	8,93	22,02	3,19	0.19	0.42	0.16	0.39	0.34	0.56
10	994,64	34,83	75,01	7,69	15,86	2,81	0.24	0.52	0.08	0.27	0.31	0.63
11	1003,15	19,31	76,34	11,47	11,4	4,07	0.19	0.39	0.06	0.27	0.24	0.55
12	994,59	33,8	81,06	10,12	6,16	4,16	0.12	0.39	0.08	0.30	0.19	0.49
F	9.333*		31.193*		44.854*			8.406**		20.197**		11.956**
p	<0.001		<0.001		<0.001			0.677		**0.043**		0.367

*One way ANOVA. **Kruskal-Wallis test. PSP: primary spontaneous pneumothorax. SSP: secondary spontaneous pneumothorax. mb: millibars.

TABLE 3. Distribution of climate indicators according to the state of pneumothorax applications

	Presence of pneumothorax			
	Absent (mean±SD) (number of days: 730)	**Present (mean±SD) (number of days:214)**	**t**	**p**
Daily atmosphericpressure (millibar)	992.00±38.01	987.92±38.90	1.373	0.170
Daily humidity (%)	71.80±11.44	70.31±11.95	1.657	0.098
Daily temperature (°C)	16.31±7.92	17.19±8.03	-1.419	0.156



SP: Spontaneous pneumothorax.

FIG. 1. Participant flow diagram.

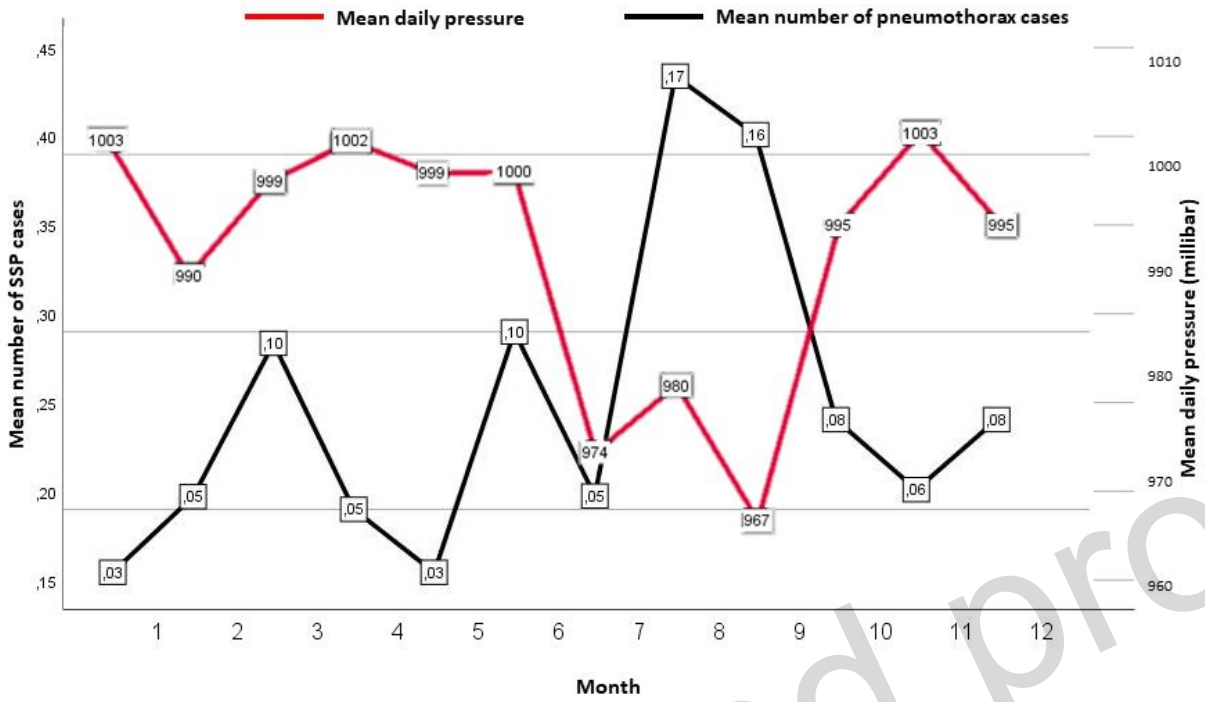


FIG. 2. Mean number of secondary spontaneous pneumothorax (SSP) cases admitted and the mean atmospheric pressure changes over months