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Original Article

Do atmospheric pressure and air pollution affect the incidence of primary spontaneous pneumothorax?

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ABSTRACT

Background: Primary spontaneous pneumothorax (PSP) occurs as a result of rupture of bullae or blebs adjacent to the visceral pleura. In our study, we retrospectively reviewed the weather information of PSP patients admitted to our clinic and aimed to investigate the relationship between meteorological changes and the development of PSP.

Materials and Methods: A total of 5051 patients were included in the study. Weather records between January 2020 and March 2023 were recorded day by day. The data obtained from Istanbul Regional Meteorological Measurement Center, Fatih Air Monitoring Center, and Atatürk Airport Air Monitoring Center within the provincial borders were recorded and accepted as the daily weather data of the city.

Results: NO2 and PM10 were shown to have a significant effect on the risk of pneumothorax. Curve estimation regression analysis showed that the mean NO2 level for Istanbul was 50 ± 12.4 picograms/m^3, and a significant increase ($p = 0.035$) in the risk of pneumothorax occurred when the level reached 30 picograms/m^3. PM10 concentrations above this value significantly increased the risk of pneumothorax, and this increase was statistically significant ($p = 0.018$).

Conclusions: In our study, the frequency of pneumothorax increased significantly as the concentration of NO2 and P10 particles in the air increased. This indicates that the risk of pneumothorax increases with the increase in particulate matter in air pollution. This highlights the importance of environmental factors on health and the need to improve air quality, which may be important in developing public health policies and prevention strategies.

Keywords: primary spontaneous pneumothorax, microparticle number, nitrogen dioxide, meteorological conditions

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Introduction

Primary spontaneous pneumothorax (PSP) occurs as a result of rupture of bullae or blebs adjacent to the visceral pleura. Poor body type, smoking, and young age are among the most commonly accepted risk factors [1-3]. There is no consensus on other factors associated with PSP formation. Many studies have investigated the role of meteorological conditions, air pollutants, and weather events in the development of PSP [2-7].

In this study; we aimed to analyze the relationship between weather conditions and pneumothorax occurrence in patients without pulmonary parenchymal disease. Therefore, we retrospectively reviewed the weather information of PSP patients admitted to our clinic and investigated the relationship between meteorological changes and the development of PSP.

Materials and Methods

Patients admitted to the emergency department/polyclinic of Yedikule Chest Disease and Thoracic Surgery Thoracic Surgery Training and Research Hospital between January 2020 and March 2023 were reviewed retrospectively. Patients with code J93 (pneumothorax) in the ICD-10 coding system were screened in the patient tracking system (n = 8173). Patients with secondary spontaneous pneumothorax, traumatic pneumothorax, iatrogenic pneumothorax, and 3122 patients with insufficient data in the registry system were excluded from the study. None of the included patients have pulmonary parenchymal disease. A total of 5051 patients were included in the study.

Weather records between January 2020 and March 2023 were recorded day by day from the official websites www.havaizleme.gov.tr and mgm.gov.tr/site/urunler.aspx of the Ministry of Environment, Urbanization, and Climate Change. The data obtained from Istanbul Regional Meteorological Measurement Center, Fatih Air Monitoring Center, and Atatürk Airport Air Monitoring Center within the provincial borders were recorded and accepted as the daily weather data of the city. The recorded data were mean air pressure (hPa), PM10 (microparticle number) (μg/m3), SO2 (sulfur dioxide) (μg/m3), CO (carbon monoxide) (μg/m3), NO2 (nitrogen dioxide) (μg/m3), NOX (nitrogen gas derivatives) (μg/m3), NO (nitrogen monoxide) (μg/m3).

In the study, the relationship between the patients diagnosed with pneumothorax for each day and the weather data and mean air pressure on the same day was investigated. The study was conducted in accordance with the principles of the Declaration of Helsinki. This study was approved by Health Sciences University Ethics Committee no: 2023-435.

Statistical Analyses

SPSS 26.0 for Windows program was used for statistical analysis. Descriptive statistics were given as numbers and percentages for categorical variables and mean, standard deviation, minimum, maximum, and median for numerical variables. Curve estimation regression analysis was performed to find the daily incidence of PSP and the safety interval of each parameter in terms of pneumothorax risk. P value lower than 0.05 was accepted as statistically significant.

Results

In the demographic evaluation of 5051 patients included in the study, 81.12% (n = 4097) were male, 18.88% (n = 954) were female, and the mean age was 26.56 years (min: 13, max: 68).

Among the meteorological data analyzed, especially NO2 and PM10 were shown to have a significant effect on the risk of pneumothorax. Curve estimation regression analysis showed that the mean NO2 level for Istanbul was 50 ± 12.4 picograms/m^3, and a significant increase ($p = 0.035$) in the risk of pneumothorax occurred when the level reached 30 picograms/m^3 (Table 1).

It was determined that PM10 concentrations above 10 picogram/m^3 caused an increase in the risk of pneumothorax, and the threshold value for PM10 was 30 picogram/m^3. PM10 concentrations above this value significantly increased the risk of pneumothorax, and this increase was statistically significant ($p = 0.018$) (Table 2).

Besides, the mean values of other meteorological parameters such as SO2, NO, NOX, and CO were 55 ± 13.2, 50.99 ± 12.7, 85.36 ± 22.2, 679.99 ± 165.2 30 picograms/m^3, respectively, however, no significant correlation was found between these variables and the incidence of pneumothorax. These findings reveal that especially NO2 and PM10 have the strongest relationship with the risk of pneumothorax among air pollution parameters.

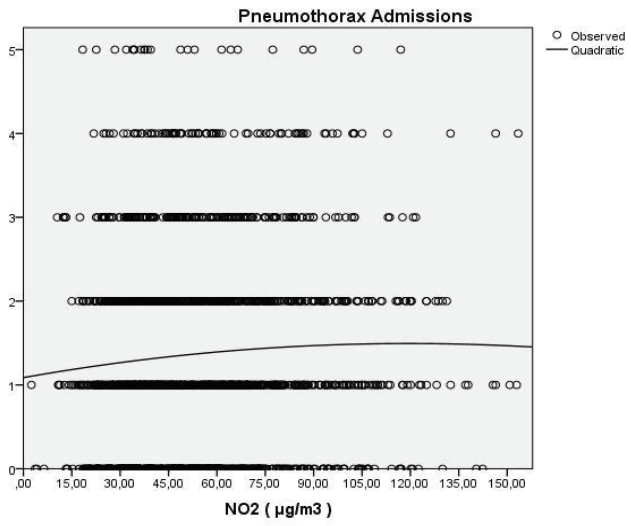

Table 1. There is a significant increase in the incidence of pneumothorax with increasing NO2 (p = 0.035).

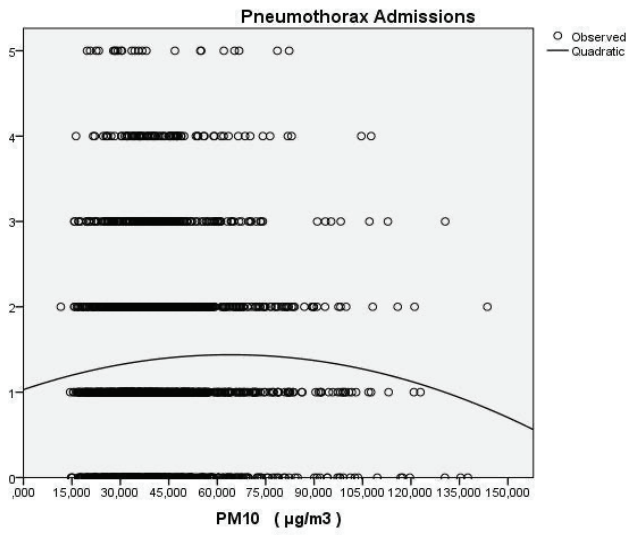

Table 2. The incidence of pneumothorax increases with the increase in PM10, and it is seen to be a risk factor for PSP, especially after 30 (p = 0.018).

Discussion

Primary spontaneous pneumothorax (PSP) develops as a result of rupture of bullae or blebs adjacent to the visceral pleura. A thin body type, smoking, and young age are among the most commonly accepted risk factors [1]. There is no consensus on other factors associated with PSP formation.

Many studies have investigated the role of meteorological conditions, air pollutants, and weather events in the development of PSP. Air pollutants are a mixture of chemical species from various sources, and some may also be produced through atmospheric photochemical processes. The respiratory system is more affected by air pollution than other organs in the human body due to its direct contact with air [2-4]. Small-sized air pollutants pass through small airways into the alveoli and cause activation of pro-inflammatory mediators [5,6]. This then causes systemic autonomic imbalance, leading to sudden cardiac arrest as well as exacerbation of respiratory diseases such as asthma, chronic obstructive pulmonary disease, and pneumothorax [6]. Air temperature and atmospheric pressure (AP) have been the most frequently reported meteorological factors affecting the occurrence of PSP [5-8].

In this study, it was revealed that NO2 reaching a level of 30 picograms/m3 significantly increased the risk of pneumothorax. For PM10, a mean level of 10 picograms/m^3 was found to start the risk of pneumothorax, and 30 picograms/m3 was found to increase the risk of PSP statistically significantly. In conclusion, NO2 and PM10 values were found to be associated with the incidence of primary spontaneous pneumothorax (PSP). Our findings suggest that certain air pollutants may be a potential increased risk factor for pneumothorax. These results are partially consistent with but differ from, a large number of studies focusing on this issue worldwide. Several studies in the literature have reported varying associations between air pollutants and meteorological data, such as air pressure changes, wind speed, temperature, and PSP, emphasizing the complexity of the health effects of environmental factors.

A retrospective analysis conducted by Bartolaccini et al in Turin, Italy, showed that short-term NO2 exposure may increase the risk of PSP [9]. Another study conducted in Seoul, South Korea, showed that O3, NO2, PM10, and sudden pressure changes increased the risk of PSP [1]. In the literature, there are studies presenting similar findings that NO2 increases the risk of PSP [10-11]. The number of studies investigating the relationship between PM10 level and PSP is less and statistically significant results were obtained in the existing publications [10-13]. However, there are also literature data in which no relationship between NO2 and PM10 and PSP was found [10]. In our study, an increase in NO2 and PM10 levels was associated with an increase in the incidence of PSP.

Meteorological factors, especially air temperature and atmospheric pressure changes, are among the impor-

tant factors in the formation of primary spontaneous pneumothorax (PSP). In particular, sudden atmospheric changes may pave the way for PSP formation by bringing risks such as rupture of alveoli or bullae/bleb walls. Some theories suggest that repetitive pressure changes may lead to weakening and subsequent rupture of these structures [14,15]. Furthermore, by a mechanism similar to asthma, air may be trapped in bullae or blebs by a check valve mechanism as a result of rapid pressure gradient changes, which has also been associated with PSP [14]. Many studies have shown that abnormal changes in atmospheric pressure (AP), together with other meteorological factors such as temperature, humidity, wind speed, and storms, may increase the risk of pneumothorax. For example, Bense et al [16] reported a significant increase in the number of PSP patients within two days following a 10 hPa decrease in AP within 24 hours. Scott et al [17] examined 192 cases of PSP with abnormal changes in AP four days before the PSP increase and found that 72% of cases had an increased risk of PSP after exposure to sudden pressure change. In a study of 337 PSP patients over three years, a statistically significant correlation was found between low AP and increased risk of PSP [10]. However, these associations have not been consistently reported in all studies, with some studies showing no specific relationship between AP and the development of pneumothorax [15,18]. In summary, there are various findings on the impact of atmospheric pressure and air temperature changes on the occurrence of PSP, but these effects are still not fully understood. In our study, air temperature data were not included, and no significant relationship was found between air pressure and the incidence of PSP.

Many studies have found a statistically significant increase in the number of pneumothorax cases on certain days and focused on clusters in the number of cases. In an analysis of 115 patients over two years, clusters in pneumothorax admissions were examined, and 73% were found to be included in clusters [4]. In an analysis of 294 PSP cases over four years in Italy, 86% of patients showed clustering and atmospheric pressure difference, which was found to be associated with PSP [10]. There are studies indicating that the difference between the pressures of the days when only PSP was detected and the previous days is a significant predisposing factor [19]. Özpolat et al [20] analyzed 669 patients admitted within ten years. Days with spontaneous pneumothorax were clustered, and reported that low AP was associated with an increased risk of PSP.

In all of these studies, clustering required either a relatively small number of patients or a longer period of time. Since PSP cases were admitted to our hospital on almost all of the dates included in the study, clustering could not be established. Similar to studies using clustering, a significant association with AP was not detected in our study, however, a significant association between PM10 and NO2 and PSP was revealed.

In another study examining the relationship between air pollutants and pneumothorax, Abul et al [19] reported that spontaneous pneumothorax was observed more frequently at high ozone levels. In some studies, the relationship was not revealed, and statistically significant results could not be reached [10]. When the relationship between SO2 CO and PSP is examined, the number of studies with statistically significant results in this regard is even lower [10-13]. In our study, no statistically significant relationship was found between O3, SO2, and CO levels and the incidence of PSP.

Although there are some controversies, seasons and weather changes are also reported to be risk factors in the occurrence of PSP. Numerous studies have reported that seasonal and weather changes are important factors associated with increased incidence of PSP [10,21,22]. Factors such as temperature and wind may also contribute to seasonal factors. Increased wind speed may lead to bronchiolar spasms, mucus retention, and coughing by directly carrying air pollutants [21]. This mechanism may increase the risk of bubble or bullae rupture. In our study, no significant relationship was found between the incidence of PSP and seasons. In addition, wind and long-term temperature monitoring data were not included in our study due to lack of data.

The differences in the above-mentioned results point to the role of study design, climate, and the demographic conditions in which the study was conducted.

Our study revealed that an increase in NO2 and PM10 significantly increased the risk of PSP. This finding sup-

ports our preliminary thesis that an increase in air pollutants may increase the risk of PSP.

The main limitation of this study is its retrospective, single-center design and the fact that patients were not admitted to the hospital on the days of onset of clinical symptoms, which makes these analyses based on diary data misleading. This study include the inability to distinguish the effects of other environmental and personal factors fully. Furthermore, the influence of other variables that may affect the association between air pollution and PSP (e.g., air temperature, humidity) was not examined in detail in this study

However, it also has several important strengths. Firstly, the data were recorded in one of the most populous cities in the world, and secondly, accurate meteorological data were obtained from the national meteorological agency. This study suggests that air pollution may have a significant impact on the risk of pneumothorax. Thus, our study has important clinical and epidemiologic information to guide air pollution levels and to advise patients at high risk of vulnerable PSP (poor body type, smoking, and young age) on the need to stay indoors when air quality is poor. This result is particularly important for emergency departments because it shows that the possibility of primary spontaneous pneumothorax should be considered among the priority diagnoses on days when NO2 and PM10 levels increase in atmospheric measurements.

In conclusion, this study is based on a large series of patients and includes a wide range of geographical and epidemiologic data since it was conducted in one of the largest cities in the world. These features provide an important advantage in terms of the generalizability of our results. Furthermore, comparing the results of our study with studies from various geographical regions and different air quality conditions allows a global perspective to be gained. The frequency of pneumothorax increased significantly as the concentration of NO2 and P10 particles in the air increased. This indicates that the risk of pneumothorax increases with the increase in particulate matter in air pollution, highlighting the importance of environmental factors on health and the need to improve air quality, which may be important in developing public health policies and prevention strategies. Future research may further elucidate the relationship between air pollution and pneumothorax, contributing to the development of interventions to reduce this health risk.

Declaration of conflicting interests

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Ethics approval

This study was approved by Health Sciences University Ethics Committee no: 2023-435.

Authors' contribution

AC; designed the analysis, wrote the paper, ME; collected data, performed the analysis, YS; collected data, AMA; collected data, NC; contributed data, LC, MAB; editing.

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