Influence of Weather Conditions on the Onset of Primary Spontaneous Pneumothorax: Positive Association with Decreased Atmospheric Pressure

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Purpose: Primary spontaneous pneumothorax is believed to result from blebs, or from other abnormalities of the pleural surface. There is no consensus as to whether a change in weather conditions can precipitate spontaneous pneumothorax. The aim of the present study was to investigate the influence of weather conditions on the onset of primary spontaneous pneumothorax.

Methods: The case histories of 1051 inpatients with primary spontaneous pneumothorax treated at Nissan Tamagawa Hospital between January 2006 and December 2011 were analyzed retrospectively. Data on weather conditions were collected daily throughout the 6-year period. The data were analyzed to determine differences in weather conditions between days on which primary spontaneous pneumothorax occurred and those on which it did not.

Results: Primary spontaneous pneumothorax occurred on 819 (37.3%) of 2191 study days. On days before and the day of primary spontaneous pneumothorax onset, the difference in mean atmospheric pressure was 0.6 hPa lower than on days in which no primary spontaneous pneumothorax occurred. This difference was statistically significant (P = 0.015). There was no statistical difference in mean, maximum, and minimum temperature, hours of sunshine, amount of precipitation, and mean and minimum humidity between days with and those without primary spontaneous pneumothorax.

Conclusion: This largest study of the literature showed decreased atmospheric pressure might play an important role in the occurrence of primary spontaneous pneumothorax.

Keywords: atmospheric pressure, spontaneous pneumothorax, weather

Introduction

Spontaneous pneumothorax (SP) is defined as the presence of air within the thoracic cavity in the absence of trauma and is associated with symptoms such as chest pain and breathing difficulties. Despite recent advances in the treatment of SP, the precise mechanism of onset remains unclear. Primary SP (PSP) is caused by the rupture of a bulla or a bleb (hereafter referred to generically as blebs), or from other abnormalities of the pleural surface. Research has suggested that rupture of the blebs may be influenced by changes in airway pressure. It has been hypothesized that one cause of this change in airway pressure is a change in weather conditions. However, the results of previous studies to investigate the influence of weather conditions on the onset of primary PSP have been inconsistent. The aim of the present study was to elucidate the influence of weather conditions on the onset of PSP by...
Investigating a large population of PSP patients.

**Materials and Methods**

**Patients**

The case histories of all PSP patients admitted to Pneumothorax Research Center at Nissan Tamagawa Hospital between January 2006 and December 2011 were analysed retrospectively. Only the patients lived in Tokyo or the Kanagawa Prefecture were included. Pneumothorax was diagnosed on the basis of a physical examination and chest radiography. The onset of PSP was defined as the timepoint at which symptoms such as chest pain, back pain, dyspnea, and respiratory discomfort commenced. A cluster of PSP cases was defined as the occurrence of at least two cases of SP within a period of 3 days. The study was approved by the institutional review board of the Nissan Tamagawa Hospital.

**Collection of meteorological data**

Meteorological data were obtained from Tokyo District Meteorological Observatory of Japan Meteorological Agency. Measurements were made on a total of 2191 days over the 6-year study period. Topographical analysis revealed that all of the patients resided within 50 km of Tokyo District Meteorological Observatory and at the same elevation above sea level. All study participants were thus assumed to have experienced identical atmospheric pressure conditions. Daily measurements were made of the mean atmospheric pressure; mean, maximum, and minimum temperature; number of hours of sunshine; amount of precipitation; and mean and minimum humidity. The occurrence of lightning was also recorded. A series of calculations were performed to determine the influence of the sequential change in atmospheric pressure on the occurrence of PSP. On days with and without PSP, differences in the mean atmospheric pressure were measured between each study day and the preceding day. Similar calculations were made for the other weather variables.

**Statistical analysis**

Quantitative data were reported as the mean ± SD. Differences between days with and without PSP were analyzed using the chi-square test for categorical variables and Student’s t-test for quantitative variables. A P value of <0.05 was considered to be significant. All analyses were performed using a statistical software package (Statview, version 5.0; SAS Institute; Cary, NC, USA).

**Results**

A total of 1051 cases of PSP occurred during the 6-year study period. The sample included 899 males (85.5%) and 152 females (14.5%), and the mean age was 29.3 ± 12.8 years (range 14 to 90 years). A total of 226 patients (21.5%) presented with a first episode of PSP, and 825 (78.5%) presented with a relapse. Eight (0.8%) patients recovered with rest only, 287 (27.3%) patients recovered with tube thoracostomy, and 756 (71.9%) patients underwent thoracoscopic surgery. PSP occurred on 819 (37.3%) of the 2191 study days. The mean period from the onset of PSP to hospitalization was 10.7 ± 10.1 days. A total of 597 clusters of PSP were observed. These involved 923 of the 1051 PSP cases (87.8%).

On days with PSP, a mean decrease of 0.4 ± 5.5 hPa in the mean atmospheric pressure was observed between the days before and the day of PSP. On days without PSP, a mean increase of 0.2 ± 4.9 hPa was observed between these timepoints. On days with PSP, the difference in mean atmospheric pressure between the days before and the day of PSP was 0.6 hPa lower than on days without PSP. This difference was statistically significant (P = 0.015) (Table 1).

There was no statistical difference in mean, maximum, and minimum temperature, hours of sunshine, amount of precipitation, and mean and minimum humidity between days with and those without PSP.

Lightning occurred on 41 of the 2191 study days. No association was found between lightning and the occurrence of PSP.

**Discussion**

Previous research has suggested that a change in airway pressure influences blebs rupture. Cran et al. reported an increased incidence of PSP in Air Force personnel. In a study of pulmonary barotrauma in divers, Raymond et al. identified a case of PSP occurring secondary to rapid surfacing. Dermksian et al. reported a case of in-flight PSP, and Noppen et al. described a case of PSP that resulted from a change in air pressure due to exposure to loud music. The present authors have experience of the management of patients who developed PSP while playing a wind instrument, holding their breath, sneezing, or coughing.

A change in atmospheric pressure can cause a slightly change in airway pressure. Thus, a change in atmospheric pressure can influence blebs rupture. SP has
been reported to occur in clusters,\(^7,8\) and this tendency was confirmed in the present study. It is thus reasonable to hypothesize that environmental factors are implicated in blebs rupture.

Several studies have investigated the influence of a change in atmospheric pressure on the onset of SP (Table 2).\(^7\)\(^-\)\(^14\) There are 4 reports demonstrating positive relationship on the atmospheric pressure and the onset of pneumothorax. Bense et al. reported a significant increase in the number of hospitalizations for SP within the 2-day period following a decrease of 10 hPa or more in the atmospheric pressure within a time-period of 24 hours.\(^9\) Scott reported a significantly higher incidence of SP in individuals exposed to four abnormal changes in atmospheric pressure over a 4-day period.\(^10\) Alifano et al. reported a significant association between SP clusters and wider differences in atmospheric pressure between the first day of the cluster and the preceding day.\(^8\) Ozpolat et al. reported the atmospheric pressure on one day before and two days before SP days were significantly lower than the atmospheric pressure on the non SP days.\(^11\) Each research shows the positive relationship by a separate method.

However, these studies used the day of hospitalization rather than the day of SP onset to study, and the day of SP onset cannot be determined accurately from those data. It is questionable when patients are hospitalized on the day of SP onset. When the day of SP onset and the hospitalization day are different, an accurate examination cannot be done. In the present study, the period between the onset of PSP and hospitalization was 10 days or more, since a small drainage unit (consisting of a flexible 9Fr silicone drainage catheter, a one-way valve, and a small plastic chamber) was used for the first-line outpatient management of all cases of PSP.

Our study demonstrated that on days with PSP, the difference in mean atmospheric pressure between the days before and the day of PSP was 0.6 hPa lower than on days without PSP. As the small difference is statistically significant, we believe a change in atmospheric pressure can influence blebs rupture.

Smit et al. reported a significantly higher incidence of SP on the 2 days following the occurrence of lightning.\(^7\) Alifano et al. reported a significantly higher incidence of PSP on the day of a storm.\(^8\) Although several studies have reported this finding, it was not replicated in the present study.

The present study had several important strengths. Firstly, it was conducted in the largest sample. When investigating the relationship of weather conditions and disease, the patient population tends to be small because patients must be recruited within a relatively small area. Because the Pneumothorax Research Center is specialized in the treatment of pneumothorax, we can collect a

| Table 1 | Comparison of mean atmospheric pressure on days with and without pneumothorax |
|----------------|--------------------------------------------------|-----------------------------|---------------|
| Mean atmospheric pressure (hPa) | Days with pneumothorax onset; \(n = 819\) | Days without pneumothorax onset; \(n = 1372\) | p value |
| D | 1009.5 ± 6.6 | 1009.3 ± 6.7 | 0.675 |
| D-1 | 1009.8 ± 6.7 | 1009.1 ± 6.6 | 0.022 |
| D-(D-1) | -0.4 ± 5.5 | 0.2 ± 4.9 | 0.015 |

D: onset day; D-1: one day before

| Table 2 | Results of studies reporting the influence of atmospheric pressure on the occurrence of pneumothorax |
|----------------|--------------------------------------------------|-----------------------------|---------------------|
| Author (ref) | Study period(year) | No of patients | Object of study | Association of SP and AP | Year |
| Besnse (9) | 1 | 282 | Day of hospitalization | S | 1984 |
| Scott (10) | 6 | 685 | Day of hospitalization | S | 1989 |
| Smit (7) | 2 | 115 | Day of onset | NS | 1999 |
| Suarez-Varela (12) | 2 | 62 | Day of hospitalization | NS | 2000 |
| Bujajich (13) | 5 | 659 | Day of onset | NS | 2005 |
| Alifano (8) | 4 | 294 | Day of hospitalization | S | 2007 |
| Celik (14) | 3 | 175 | Day of onset | NS | 2009 |
| Ozpolat (11) | 10 | 669 | Day of hospitalization | S | 2009 |
| Haga | 6 | 1051 | Day of onset | S | 2012 |

SP: spontaneous pneumothorax; AP: atmospheric pressure; NS: not significant; S: significant
large patient population from a small area. Secondly, accurate meteorological data were collected from national meteorological agency. The main limitation of this study was the retrospective analysis of clinical records, the lack of detail on clinical histories, and condition of the patients. This prevented us from confirming the diagnosis, especially ruling out underlying pulmonary disease.

**Conclusion**

In conclusion, this largest study of the literature showed decreased atmospheric pressure might play an important role in the occurrence of PSP.

**Disclosure Statement**

We have no financial or other interest in the manufacture or distribution of the device.

**References**