Weather and chinook winds in relation to spontaneous pneumothoraces

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Background: Spontaneous pneumothorax (SP) results from the rupture of blebs or emphysematous bullae. Rapid changes in weather may precipitate this process. The city of Calgary is well suited to examine the effects of weather and specifically the rapid changes in weather associated with a chinook event and the occurrence of SP.

Methods: We performed a retrospective chart review of all cases of SP in the Calgary Health Region from 2001 to 2005. We obtained local hourly weather data over the same period from Environment Canada. We then compared the rates of SP on chinook and nonchinook days. Further, we compared mean daily temperature, humidity, wind speed and atmospheric pressure on chinook and nonchinook days.

Results: In all, 220 SP events from 149 patients occurred during the 4,5-year study period. There was no significant difference in the rate of SP on chinook days versus nonchinook days (p = 0.80). Similarly, there was no significant difference in the rate of SP in each of the 4 seasons (p = 0.30). We observed significantly higher average wind speed and lower mean atmospheric pressure on days with SP versus days without (p = 0.009, p = 0.020, respectively). There was no difference in mean temperature or mean relative humidity when comparing days with SP versus days without.

Conclusion: We found no association between SP and chinook events. We observed significantly higher wind speeds and lower atmospheric pressures on days with SP versus days without.

Contexte : Le pneumothorax spontané (PS) est causé par la rupture de boursoufflures ou de bulles emphysémateuses. Les changements rapides de température peuvent précipiter ce phénomène. La ville de Calgary est un bon endroit où étudier les effets de la température, et plus précisément des changements rapides de température associés à un chinook, et l’occurrence de PS.


Résultats : Au total, il y a eu 220 PS chez 149 patients au cours de l’étude de 4,5 ans. Il n’y avait pas de différence importante au niveau du taux de PS les jours de chinook par rapport aux autres jours (p = 0.80). De même, il n’y avait pas de différence importante au niveau du taux de PS au cours de chacune des 4 saisons (p = 0.30). Par ailleurs, nous avons observé une vitesse du vent très supérieure à la moyenne et une pression atmosphérique moyenne inférieure les jours où il y a eu des PS par rapport aux autres jours (p = 0.009, p = 0.020, respectivement). Il n’y avait pas de différence au niveau de la température moyenne ou de l’humidité relative moyenne si l’on comparait les jours où il y a eu PS par rapport aux autres.

Conclusion : Nous n’avons trouvé aucun lien entre le PS et le chinook. Nous avons observé des vitesses du vent beaucoup plus élevées et des pressions atmosphériques plus basses les jours où il y a eu PS par rapport aux autres jours.

There is general agreement that spontaneous pneumothorax (SP) results from rupture of blebs or emphysematous bullae beneath the visceral pleura.1,2 It is believed that rupture occurs when a large transpulmonary pressure gradient exists and an equilibrium between surrounding structures...
and air trapped in blebs/bullae cannot be reached. Rapid changes in environmental conditions may be a precipitating factor in this process. Previous studies have suggested that changes in weather, specific meteorological parameters and storm events may be related to the occurrence of SP. This association is further supported by the observation that SPs occur in clusters. Unfortunately, these findings are not consistently demonstrated in the literature, and broad consensus concerning the role of atmospheric factors in SP does not exist.

The city of Calgary is a unique and ideal centre to examine the effects of weather changes and specifically chinook events on SP occurrence because of its location in the so-called chinook belt. The chinook winds of southern Alberta belong to a family of warm winter mountain winds, including the Fohn winds of Southern Europe, the Zonda in Argentina and the Northwesterners in New Zealand, that occur in locations where long mountain ranges lie perpendicular to the prevailing wind. During a chinook, there are defined rapid changes in wind speed and direction, rises in temperature and decreases in relative humidity. Our aim was to examine the relation between SP and the weather in Calgary, with a particular focus on chinooks. We hypothesized that there would be a significant relation between chinook and SP events. To our knowledge, the relation between SP and chinook has not been studied previously.

**Methods**

**Patient identification**

The Calgary Health Region serves Calgary’s population of 1 million people and provides tertiary care to all of southern Alberta. Using International Classification of Diseases (ICD)-9 codes as well as surgeon records, we identified all cases of SP within the health region over a 5-year period between Oct. 1, 2001, and Mar. 31, 2005. Inclusion was restricted to those patients who experienced their SP in Calgary. We excluded patients with secondary pneumothoraces such as traumatic and iatrogenic pneumothoraces or those with known underlying lung disease (e.g., chronic obstructive pulmonary disease, pulmonary fibrosis, asthma, lung cancer). We considered the time of onset of SP to be the time at which the patient first experienced symptoms, not the time of admission or presentation to hospital. We excluded patients in whom a time of onset could not be determined. We considered SPs occurring in the same individual at different times to be separate events. We confirmed all cases of SP radiographically.

**Weather analysis**

Environment Canada provided highly detailed hourly meteorological data recorded from the Calgary International Airport over the study period. The parameters included hourly temperature (in 0.1°C), hourly relative humidity (in percentages), wind speed (km/h), wind direction (increments of 10°) and hourly barometric pressure (in 0.1 mm Hg).

We required a detailed weather analysis. This involved plotting hourly grafts for the 5 weather variables listed for all days during the chinook season (October–March) for a total of 4555 grafts. A chinook was defined according to Nkemdirim’s description. Accordingly, a chinook required the combination of

1. winds from the south–southwest and west–northwest;  
2. strong winds (> 16.4 km/h);  
3. a sharp rise in temperature, with the eventual daily mean exceeding the normal for the day;  
4. a marked drop in relative humidity; and  
5. occurrence during the Chinook season (October–March; Fig. 1).

If an author was uncertain whether a chinook had occurred, Dr. Nkemdirim personally reviewed the specific day. A chinook day was a calendar day in which a chinook was present.

**Statistical analysis**

We determined the rate of SPs/day. Because the number of SPs/day did not assume a normal distribution according to the Shapiro–Wilks test, we used nonparametric Mann–Whitney U tests to test the hypothesis that the number of SPs/day on chinook days was greater than on nonchinook days and to compare the number of SPs/day on chinook day ±1, chinook day ±2 and chinook day ±3 versus non-chinook days.

To examine whether any specific meteorological variables were predictive of SP, we compared days with SPs versus days without SPs with respect to mean daily temperature, relative humidity, wind speed and atmospheric pressure for all days in the study period using the Mann–Whitney U test. Next, we compared the rate of SPs/day across the 4 seasons using 1-way analysis of variance (ANOVA). Lastly, we compared the rate of SPs/day on days with a large change in atmospheric pressure (increase or decrease > 1 kPa in a 24-hour calendar day) versus days without.

**Results**

We identified 220 SPs during the study period occurring in 149 patients, with 32% of patients experiencing multiple SPs. The mean age of patients was 29 years, and 76% of patients were male.

**Chinooks**

The study period included 1643 days, with 911 occurring
during the chinook season. During chinook season, there were 345 chinook days (38% of the chinook season), with an average of 58 chinook days/year. Fifty-six percent of all SPs occurred during the chinook season. There was no significant difference in the rate of SPs on chinook days versus nonchinook days ($p = 0.80$), with an SP occurring

![Graphs showing temperature, wind speed, and relative humidity during a chinook day in Calgary, Alta.](image)

Fig. 1. Graphs showing the (top) temperature, (middle) wind speed and (bottom) relative humidity during a chinook day in Calgary, Alta.
on 13% of chinook days (47 SPs/345 d) and 13% on nonchinook days (77 SPs/566 d). Chinooks ranged from 1 to 9 days in length, with most being single-day runs (34%), followed by 2-day runs (33%). Overall, we observed no pattern for the distribution of SPs within a chinook run. Similarly, we observed no relation between the rate of SPs on nonchinook days versus chinook days +1 ($p = 0.60$), chinook days +2 ($p = 0.70$) or chinook days +3 ($p = 0.40$). In addition, there was no significant difference in the rate of SPs in each of the 4 seasons ($p = 0.30$).

**Spontaneous pneumothorax and weather parameters**

When analyzing the entire study period, there was a significantly higher average wind speed and lower mean atmospheric pressure on days with an SP versus days without (Table 1). There was no demonstrable difference in mean temperature or mean relative humidity when comparing days with SP versus days without (Table 1). A large daily shift in atmospheric pressure (increase or decrease > 1 kPa in a 24-h calendar day) occurred on 19% of the days (264) within the 1643-day study period. There was no significant difference in the rate of SPs when comparing days with large shifts in atmospheric pressure (45 SPs/264 d with a large change > 1 kPa) versus days without (175 SPs/1379 d without; $p = 0.30$).

**DISCUSSION**

We found no significant correlation between SP occurrence and a specific season of the year. The literature investigating seasonal variations in SP rates is unclear. In the earliest related study, Accard and colleagues$^{13}$ demonstrated the frequency of SPs was highest from October to March. More recently, Bulajich and colleagues$^{10}$ found an equal distribution of SP occurrence through the seasons. It is possible that the occurrence of SPs is related more to rapid changes in specific meteorological variables than to gradual seasonal changes.

Our study did not confirm a significant relation between SP occurrence and chinook weather events. To our knowledge, this relation has not been previously investigated. Studies have demonstrated a relation between chinooks and a variety of illnesses, including migraine headaches, chronic pain and irritability; however, the causal mechanisms are unknown. Authors have postulated various triggers to these illnesses, including changes in wind speed, temperature, pressure and concentrations of positive ions in the air.$^{14,16}$ More research concerning the impact of chinooks and weather on human illness is required.

When studying specific meteorological variables, we did not find a significant difference in mean temperature on SP days versus non-SP days. There is little published on the relation between temperature and SP. Smit and colleagues found a significant rise in temperature on the day before an SP versus non-SP days. However, several other studies have failed to show a relation.$^{7,10}$ Similarly, we found no significant difference in relative humidity on SP days versus non-SP days. The limited literature regarding SP and relative humidity is conflicting. The only study demonstrating a relation between humidity and SPs is a small series by Ozenne and colleagues$^{17}$ wherein they found lower relative humidity on days with SPs compared with days without. Like our study, most reports fail to demonstrate any relation.$^{10,19}$

To our knowledge, our study is the first to demonstrate a correlation between wind speeds and SPs. We found significantly higher mean wind speeds and lower mean atmospheric pressures on days with SPs versus days without. To offer an explanation for these coexistent phenomena is difficult. We believe the 2 factors are likely related to one another, and both contribute to the increased rate of SPs. Fundamentally, wind is simply air movement between 2 areas of different pressure along a gradient. In Calgary, when local air pressures are lowest, the prevailing wind speeds travelling east from a westerly direction off the Rocky Mountains are highest. It is unlikely that increased wind speed directly causes SPs by changing a patient’s transpulmonary pressure gradient leading to bleb or bullae rupture. Rather, as has been described elsewhere, the strong winds act as a pathogenic trigger by increasing pollen, allergen and pollutant exposure producing bronchiolar spasm, mucous retention and coughing. It is possible these changes increase the possibility of bleb/bullae rupture and SPs. This same hypothesis has been suggested to explain the association between asthma and thunderstorms.$^{20,21}$

Lastly, we found no significant relation in the rate of SPs on days with large shifts in atmospheric pressure versus days without. Pathophysiologically it makes sense that when atmospheric pressure changes, any air trapped within a bleb/bullae is unable to equilibrate and could rupture.$^{7}$ There are a number of papers addressing this topic specifically, as most studies relating occurrence of SPs to weather have focused on atmospheric pressure, but again these studies have conflicting results. Recently Alifano and colleagues$^{7}$ described significantly larger drops in atmospheric pressure on the days preceding a cluster of SP events versus days without SPs. They defined a cluster as 2 or more patients
with SPs admitted to hospital within a 3-day period. Similarly, Bense\textsuperscript{5} found a higher rate of SPs following a fall in atmospheric pressure of at least 10 millibars over 24 hours. On the contrary, Bulajich,\textsuperscript{10} Smit\textsuperscript{3,8} and Suarez-Varel\textsuperscript{22} and their respective colleagues found no correlation between pneumothoraces and variations in atmospheric pressure. Despite the seemingly logical hypothesis and common conception that atmospheric pressure changes relate to the development of SP, this relation remains unproven in the literature and is not supported by our study.

**CONCLUSION**

There was no significant relation between SPs and chinook weather events. Likewise, there was no significant correlation between temperature, relative humidity and large changes in atmospheric pressure and SP occurrence. There was a significantly higher mean wind speed and lower mean atmospheric pressure on days with SPs than days without.

**Competing interests:** None declared.

**Contributors:** Drs. Shieman and Grondin and Ms. Tiruta designed the study and together with Dr. Hill, acquired the data and wrote the article. Drs. Shieman, Graham, Gelfand, McFadden, Hill and Grondin and Ms. Tiruta analyzed the data and reviewed the article. All authors approved article publication.

**References**