Barometric Pressure Drops and Premature Rupture of Membranes

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ABSTRACT

Introduction: Many patients and health care providers believe that barometric pressure drops increase the incidence of premature rupture of membranes (PROM). To test this, we studied high risk women living near a weather station.

Methods: This cohort chart review study investigated 189 PROMs, diagnosed between 24 and 42 weeks gestation, at Wheaton Franciscan-St Joseph Campus, Milwaukee, Wisconsin. National Oceanic and Atmospheric Administration (NOAA) data from the 24 hours preceding each PROM occurrence were analyzed. The sample provided 91% power to detect a two-fold increase in the PROM rate.

Results: The PROM rate, 9.5%, within the 24 hours following a NOAA-defined substantial pressure drop, was similar to that predicted using the percentage of the total study period time within 24 hours after a substantial pressure drop, 10.8%, (P= .64). The findings for within 3, 6, and 12 hours after a substantial pressure drop were similar.

Conclusions: The incidence of PROM does not increase following substantial atmospheric pressure drops.

INTRODUCTION

Certain beliefs are widely held among obstetrical patients and health care providers working on labor and delivery units. One of the most common—and perhaps strongest—is that a drop in barometric pressure, often associated with the onset of stormy weather, quickly leads to an increase in the number of women presenting with premature rupture of membranes (PROM). A small number of studies, many conducted 30 to 40 years ago, reported a statistically significant association between a declining barometric pressure and an increased incidence of PROM.[1,2] As climate change intensifies and severe weather intensifies, if stormy weather increases the incidence of PROM, labor and delivery units may need to increase staffing to prepare for a patient influx during severe weather forecasts.

We studied a geographically concentrated, inner-city population near a United States National Oceanic and Atmospheric Administration (NOAA) weather station to reexamine the potential relationship between PROM and a drop in barometric pressure.

METHODS

This retrospective chart review study was conducted at Wheaton Franciscan-St Joseph Campus (WF-SJ) in Milwaukee, Wisconsin, a safety-net hospital that serves an economically disadvantaged population. Data were collected initially for a resident research project; the manuscript was completed later, after climate change was widely recognized and severe weather became more common, highlighting the importance of this investigation.

This study was approved with waiver of consent by both the Wheaton Franciscan Health Care and the Medical College of Wisconsin Institutional Review Boards. Women aged 18 years and older with gestational ages between 24 and 42 weeks who presented with PROM during July 5, 2005, through November 24, 2006, were included, except those who presented during August 3, 2005 through September 9, 2005, for whom data were unavailable.

PROM was defined as ruptured chorioamniotic membranes

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without contractions, based on patient report and tocodynameter evaluation. Rupture was diagnosed clinically by obvious pooling with a positive nitrazine test and/or ferning of the vaginal fluid. Patients with known polyhydramnios or uterine anomalies were excluded. The time of PROM reported by the patient was recorded.

Hourly barometric pressure data from Milwaukee's General Mitchell International Airport weather station, starting 24 hours before the study period, were obtained from the NOAA National Climatic Data Center. The weather station is 8.8 miles from WF-SJ. NOAA designated episodes of pressure falling rapidly (PFR), which are defined as a decrease of at least 0.06 inches of mercury per hour and a total change of 0.02 inches or more of mercury at the time of the observation.[3] For each PROM occurrence, barometric pressure readings for the preceding 24 hours were analyzed to determine whether a PFR episode had occurred. The start of the PFR episode was the time immediately before the required pressure drop began (eg, if pressure was stable before 1 PM and >0.06 inches of mercury lower at 2 PM, the PFR began at 1 PM).

Table 1. Descriptive Statistics

Characteristic	PROM Within 24 Hours of Rapidly Falling Pressure Event (n=18)	PROM Without Corresponding Rapidly Falling Pressure Event (n=171)	Test Statistic
Maternal age (years)	22.2 **26.0** 28.5 (25.8±) 5.0[a]	21.0 **26.0** 310.0 (26.9±6.4)	F=0.22, *P*=.64[b]
Maternal weight[c] (lb)	164 **178** 201 (186±48)	153 **181** 210 (186±46)	F=0.03, *P*=.87[b]
Gravida	1.2 **3.0** 5.0 (4.2±5.5)[d]	1.0 **2.0** 3.5 (2.7±2.3)	F=0.17, *P*=.17[b]
Race			
Black	8 (44%)[e]	85 (50%)	$\chi_2^2=0.23$, *P*=.89[f]
White	7 (39%)	63 (37%)	
Other	3 (17%)	23 (13%)	
Gestational age (days)	226 **242** 267 (244±25)	228 **251** 271 (246±29)	F=0.24, *P*=.62[b]
Infant sex: female	7 (39%)	78 (46%)	$\chi_1^2=0.3$, *P*=.58[f]
Infant weight (g)	1831 **2600** 3078 (2482±956)	2038 **2687** 3208 (2573±836)	F=0.14, *P*=.71[b]
Apgar score			
1 min	7.25 **8.00** 8.00 (7.78±0.88)	7.00 **8.00** 8.00 (7.30±1.74)	F=0.67, *P*=.41[b]
5 min	9.00 **9.00** 9.00 (8.72±0.75)	9.00 **9.00** 9.00 (8.65±0.98)	F=0.29, *P*=.59[b]
Twins	2 (11%)	12 (7%)	$\chi_1^2=0.4$, *P*=.53[f]

Abbreviations: PROM, premature rupture of membranes; lb, pounds.
[a]X**Y**Z: X=lower quartile, **Y**=median, Z=upper quartile for continuous variables; (m±s)=mean ± 1 SD.
[b]Wilcoxon rank sum test.
[c]Data available for only 178 subjects. For all other characteristics, data were available for all 189 subjects.
[d]Mean and standard deviation were driven by 1 subject reporting gravida of 25.
[e]Numbers after percents are frequencies.
[f]Pearson chi-square test.

The primary analysis compared the proportion of PROM occurrences within 24 hours after a PFR (P_1) with the proportion of the total study period within 24 hours after a PFR (P_0). Using the Bayes theorem, the odds ratio, $[P_1/(1-P_1)]/[P_0/(1-P_0)]$ equals the relative risk of PROM within 24 hours after a PFR compared with no PFR within the preceding 24 hours. For the binomial test, at a 5% significance level, the sample size of 189 PROM cases provided 91% power to detect a twofold increase in risk.

The study population lived very close to both the hospital and the weather station: 80.9% within 10 miles of the hospital and 77.3% within 15 miles of the weather station. Strobe reporting guidelines for cohort studies were followed.

RESULTS

During the study period, 189 PROM cases occurred. The mean gestational age was 245.7 days (35 weeks), the median was 250 days (35 weeks), and the range was 168 to 290 days (24-41 weeks). The PROM rate among labor and delivery admissions was 3.3%.

Table 1 summarizes patient and infant demographics. For twin gestations, data from the first-born infants were used. No significant differences were observed between women experiencing PROM within 24 hours after a PFR and those without a corresponding PFR. Overall, 83 PFR episodes occurred, averaging 1.24 PFRs per week. Because episodes were unevenly spaced, 10.8% of the study time fell within 24 hours after a PFR and 1.9% within 3 hours after a PFR.

Table 2. Portion of the PROM Events and the Total Study Time Within the Specified Interval Following a Rapidly Falling Pressure

	≤3 hours	≤6 hours	≤12 hours	≤24 hours
PROM events	1.1%	1.6%	4.8%	9.5%
Total study time	1.9%	3.4%	6.1%	10.8%

Abbreviation: PROM, premature rupture of membranes.

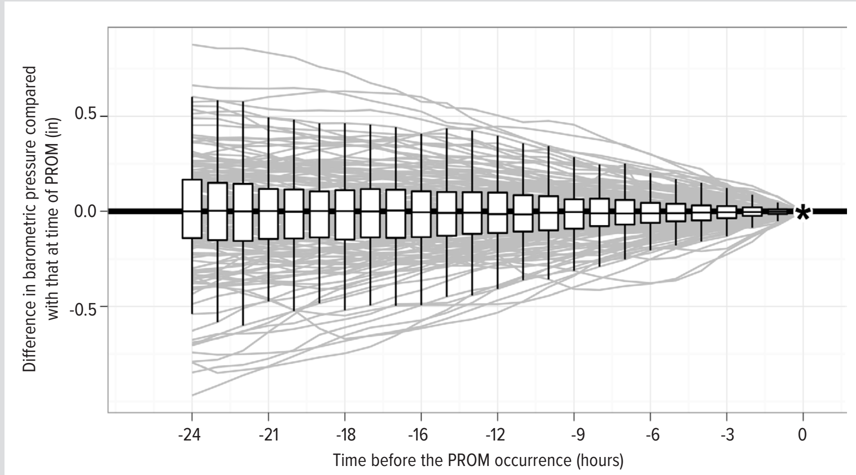
The Figure illustrates the barometric pressures during the 24 hours preceding PROM occurrences. Pressure differences were symmetrically distributed around the line labeled 0.0, indicating the pressure at PROM onset. This suggests that the barometric pressure before PROM was as likely to rise as fall.

Table 2 shows the proportion of PROM occurrences preceded by a PFR event. In the primary analysis, based on 24-hour periods after such a pressure drop, fewer PROM cases occurred than predicted by the percentage of study time within 24 hours after a PFR. That is, the observed proportion was 9.5% (95% CI, 5.7%–14.6%), consistent with the expected 10.8% (binomial test, *P*=.64). The odds ratio comparing observed and expected proportions yielded a relative risk of 0.87 (95% CI, 0.50–1.41) for PROM within 24 hours after a PFR versus periods greater than 24 hours after the latest PFR. Findings for other intervals—within

3, 6, and 12 hours following a PFR—were similar, with relative risk estimates of 0.56, 0.46, and 0.77, respectively.

Analysis of the rate of PROM across time intervals revealed similar findings. The overall rate was 0.4 PROMs/day; during periods within 24 hours after a pressure drop, the rate was 0.35 PROMs/day. During periods within 24 hours after a sudden pressure rise, the rate was also 0.35/day.

Figure. Barometric Pressures in the 24 Hours Preceding Premature Rupture of Membranes Occurrences



A difference of zero corresponds to a barometric pressure equal to that at the time of the premature rupture of membranes (PROM) occurrence. For each hour, a box plot contains the middle 50% of the values. The horizontal bar within each box indicates the median.

*Indicates the time of the PROM occurrences.

DISCUSSION

No increased incidence of PROM was observed within the 24-, 12-, 6-, or 3-hour periods after a PFR; in fact, fewer PROMs occurred than expected.

Strengths of this study include the relatively high latitude and relatively flat topography of Southeastern Wisconsin, the highly geographically concentrated patient population, and use of the accepted meteorological definition of a substantial pressure change. Latitude is important because frontal passages in midlatitudes occur regularly, typically every 3 to 5 days. Both cold fronts and warm fronts produce noteworthy pressure fall/rise couplets, with cold fronts generally associated with the most pronounced pressure changes and significant weather impacts, including precipitation. Because of the relatively high latitude of Milwaukee, it is exposed to more of these cold fronts than lower latitudes within the United States. The relatively flat topography is advantageous because frontal passage characteristics are often more sharply delineated in flat versus complex terrains, where significant surface topographical features, such as mountains and valleys, can disrupt frontal movement. The absence of such features increases the likelihood that our patient population experienced the weather conditions recorded at the weather station.

Another strength of this study is proximity: the study group lived very close to the hospital, which was near the weather station. At Milwaukee's latitude, the most significant prefrontal pressure falls and postfrontal pressure rises routinely occur within approximately 50 km (31 miles).[4] Most patients, (>77%) lived within half this distance of the weather station, again increasing the likelihood they experienced the recorded conditions. Finally, use of NOAA's definition of PFR enabled evaluation of meteorologically significant pressure drops on PROM incidence.

Weaknesses of this study include limitations inherent to chart review studies and the decision to combine preterm and term PROM cases, which likely have different etiologies. However, if barometric pressure changes exert stress on the membranes, predisposed membranes—regardless of the etiology—should be more likely to rupture. Additionally, this study focused on a high-risk population, limiting generalizability to lower-risk populations.

Our findings contradict some previous studies, possibly due to more rigorous study design. Steinman and Kleinerl[1] reported lower mean barometric pressure at PROM compared with a reference standard calculated from readings at noon over 6 days in June 1975. Their study included 32 PROM cases and 227 controls without PROM. Polansky et al[2] found a significant increase in PROM within 3 hours after any pressure drop among term patients at the University of Iowa Hospitals. Their 109 PROM subjects lived within 100 miles of the weather station at the Cedar Rapids (Iowa) Municipal Airport. One hundred nine women experiencing the spontaneous onset of labor, matched for age, served as their control group. Because their patient population was less concentrated, it is more likely that they experienced weather conditions different from those recorded at the weather station. Finally, Akutagawa et al[5] studied 547 Tokyo women who experienced PROM at an average gestational age of 39 weeks, 5 days. They divided this population into 2 groups: those delivering while the barometric pressure was above the mean and those delivering while the barometric pressure was below the mean. They found a significant increase in PROM occurrence at lower absolute barometric pressures but did not assess pressure changes or geographic proximity to the weather station.

Two studies agree with our findings. Marks et al[6] found that PROM occurred randomly among women >36 weeks gestation who gave birth at the University Hospital of Jacksonville, Florida, with no clustering of ruptures around barometric pressure or lunar phase. Trap et al[7] studied 254 PROM cases that occurred in Denmark and found no relationship between PROM frequency and the absolute barometric pressure or pressure changes up to 9 hours before rupture. They also reported that the average changes in barometric height in the 4 time periods investigated within the 9 hours preceding PROM did not significantly differ from zero, and there was no association between the time of the year and PROM frequency. Neither study included a control population, evaluated defined pressure drops, or commented on the geographic distribution of their population with respect to the weather station.

Another study examined barometric pressure changes and the onset of labor among term deliveries at the Medical Center of Central Massachusetts-Memorial Hospital.[8] They reported a significant deficit in spontaneous labor onset after continuous 3-hour pressure decreases but did not use NOAA's PFR definition and included a less concentrated population, living within a 50-mile radius of their hospital.

Previous investigators[2] hypothesized that sudden barometric pressure changes create a gradient across chorioamniotic membranes, making rupture of membranes more likely. This explanation is not biologically plausible. The amniotic sac can be modeled as a balloon: a drop in atmospheric pressure decreases pressure on the abdomen, reducing pressure on the cervix and, theoretically, making rupture less likely. The vagina is a potential space: when there is nothing inside the vagina, the walls collapse together; it is closed to barometric pressure changes. So, at most, a drop in atmospheric pressure should decrease overall pressure on the ballon. Based on anatomy, atmospheric pressure drops should decrease the PROM risk, consistent with our finding that PFR episodes were not associated with increased PROM risk and the trend toward lower-than-expected risk after PFR episodes.

CONCLUSIONS

Episodes of rapidly falling barometric pressure were not associated with increased PROM incidence in this geographically concentrated, high-risk population. These findings suggest that labor and delivery units do not need to increase staffing in anticipation of severe weather. Further research in diverse populations may clarify whether these results are generalizable.

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