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Heat and pregnancy-related emergencies: Risk of placental abruption during hot weather

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Outdoor heat increases the risk of preterm birth and stillbirth, but the association with placental abruption has not been studied. Placental abruption is a medical emergency associated with major morbidity and mortality in pregnancy. We determined the relationship between ambient temperature and risk of placental abruption in warm seasons.

Material and methods: We performed a case-crossover analysis of 17,172 women whose pregnancies were complicated by placental abruption in Quebec, Canada from May to October 1989–2012. The main exposure measure was the maximum temperature reached during the week before abruption. We computed odds ratios (OR) and 95% confidence intervals (CI) for the association of temperature with placental abruption, adjusted for humidity and public holidays. We assessed whether associations were stronger preterm or at term, or varied with maternal age, parity, comorbidity and socioeconomic status.

Results: Compared with 15 °C, a maximum weekly temperature of 30 °C was associated with 1.07 times the odds of abruption (95% CI 0.99–1.16). When the timing of abruption was examined, the associations were significantly stronger at term (OR 1.12, 95% CI 1.02–1.24) than preterm (OR 0.96, 95% CI 0.83–1.10). Relationships were more prominent at term for women who were younger than 35 years old, nulliparous or socioeconomically disadvantaged, but did not vary with comorbidity. Associations were stronger within 1 and 5 days of abruption. Temperature was not associated with preterm abruption regardless of maternal characteristics.

Conclusions: Elevated temperatures in warm seasons may increase the risk of abruption in women whose pregnancies are near or at term. Pregnant women may be more sensitive to heat and should consider preventive measures such as air conditioning and hydration during hot weather.

1. Introduction

A growing number of studies suggest that environmental conditions can affect the risk of placental abruption (Mankita, 2012; Michikawa et al., 2017; Yackerson et al., 2007). Placental abruption is an obstetric emergency that in extreme cases can lead to severe maternal and fetal morbidity or mortality (Oyelese and Ananth, 2006; Tikkanen, 2011). Abruption occurs when the placenta separates prematurely from the wall of the uterus before delivery, causing hemorrhage (Oyelese and Ananth, 2006). Every 7–12 pregnancies per 1000 end in abruption in North America (Ananth et al., 2014), with data suggesting that rates may be increasing (Ananth et al., 2014; Broers et al., 2004; Oyelese and Ananth, 2006). Preventing placental abruption is difficult as its causes are not fully understood, and risk factors such as preeclampsia and substance abuse account for only a proportion of cases (Tikkanen, 2011). Recent studies suggest that exposure to air pollutants may increase the risk of abruption (Ibrahimou et al., 2017; Michikawa et al., 2017), and that unstable seasonal weather in semi-arid areas can contribute (Mankita, 2012; Yackerson et al., 2007). The possibility that elevated outdoor temperature could increase the risk of placental

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abruption has however not been investigated.

Elevated temperature has potential to trigger placental abruption through different routes. In normal individuals, outdoor heat stress results in diversion of blood flow to the skin surface to prevent increasing core body temperature (Wells and Cole, 2002). Pregnant women may however not be able to regulate temperature as efficiently due to the physiologic changes of gestation (Schifano et al., 2016). Heat may alter placental blood flow patterns, potentially reducing the integrity of the placenta and increasing the chance of abruption. Also, elevated temperatures have been shown to increase fetal heart rate and lead to uterine contractions (Vaha-Eskeli and Erkkola, 1991), both of which are associated with placental abruption (Tikkanen, 2011). Heat could further affect risk factors for abruption, such as preeclampsia and prolonged preterm premature rupture of membranes (Beltran et al., 2014; Yackerson et al., 2007). Related outcomes such as preterm birth, low birth weight, and stillbirth have been shown to be more frequent during high temperatures, thought to be due to the added strain that heat exerts on pregnant women (Auger et al., 2016a; Arroyo et al., 2016; Bruckner et al., 2014; Dadvand et al., 2011; Ha et al., 2017a; Ha et al., 2017b; Schifano et al., 2016). The possibility of an association with placental abruption however has not been studied, despite similarities in biologic pathways of abruption, preterm birth, and stillbirth. To fill this knowledge gap, we sought to determine the relationship between elevated outdoor temperature and the odds of placental abruption in a large population of pregnant women exposed to heat during warm months.

2. Materials and methods

2.1. Study population

We included hospital records for all women whose pregnancies were complicated by placental abruption in Quebec, Canada from 1989 to 2012, and counted multiple pregnancies only once. We obtained the data from the Maintenance and Use of Data for the Study of Hospital Clientele registry, which contains hospital discharge information for all pregnant women who delivered in a hospital in the province (Ministry of Health and Social Services, 2017). In Quebec 99% of deliveries occur in hospital, thus we captured the majority of pregnant women with placental abruption during the study (Auger et al., 2016b). We included cases of abruption that presented between May and October. The months of May through October are the hottest period of the year in Quebec, allowing us to focus on women who were most at risk of heat exposure. November through April is much cooler with temperatures frequently below 0 °C, and women are less likely to be exposed to high temperatures.

2.2. Placental abruption

We identified women with placental abruption using diagnostic codes of the International Classification of Diseases (ICD-9 641.2; ICD-10 O45). We investigated all abruptions combined, as well as abruptions according to gestational age (preterm, term) because heat may impact women differently depending on the timing of gestation (Wells, 2002). Heat may be more physically straining for women at term, when physiologic changes are particularly advanced and lower a woman's ability to dissipate heat (Wells and Cole, 2002). We defined term as 37 completed weeks of gestation or more, and preterm as 36 weeks or less.

2.3. Meteorological variables

We retrieved hourly data on temperature and humidity from Environment Canada (https://weather.gc.ca/canada_e.html). We selected 18 meteorological stations that Environment Canada previously validated were representative of the temperatures in each region of Quebec during the study period (Martel et al., 2010). Monitors in each region are located in populated areas (Martel et al., 2010). We matched the meteorological data to patients according to the region of residence recorded on the hospital chart. We used the maximum weekly temperature, defined as the highest temperature reached on the day of abruption or in the six preceding days, as the main exposure measure. We investigated the maximum daily temperature of each week day as a secondary measure in the event that associations were sensitive to the timing of exposure. We expressed temperature as both a categorical (< 15, 15–19.9, 20–24.9, 25–29.9, ≥ 30 °C) and continuous variable using splines. Splines are flexible and allow the continuous relationship of temperature with abruption to be modelled smoothly and flexibly (Durrleman and Simon, 1989).

2.4. Covariates

We accounted for average relative humidity (continuous), and public holidays (yes/no) in the analysis. We did so because humidity may exacerbate the effects of heat, and public holidays may affect personal behaviors associated with placental abruption (Davis et al., 2016). In addition, we tested the possibility that the association between heat and abruption varied with maternal age (< 25, 25–34, ≥ 35 years), parity (nulliparous, multiparous), presence of comorbidity (yes/no), and socioeconomic disadvantage measured as a binary variable (yes/no) defined as below the most socioeconomically deprived median of neighbourhoods. Socioeconomic disadvantage was estimated from a composite index based on census data on neighborhood income, education and employment (Auger et al., 2016b). We used ICD codes to identify women with comorbidity, defined as pregnancy-related hypertension, substance use (illicit drugs, alcohol, tobacco), low birth weight (< 2500 g), prolonged preterm premature rupture of membranes, chorioamnionitis, and thrombophilia (Oyelese and Ananth, 2006; Tikkanen, 2011) (Table S1).

2.5. Study design

We used a case-crossover study design. We chose this design because placental abruption is an acute condition and temperature is transient, two conditions ideal for a case-crossover approach (Levy, 2001). The case-crossover design is similar to the standard case-control study in which cases are compared with controls. In a case-crossover study, however, cases are their own controls as patients are self-matched (Maclure and Mittleman, 2000). For each case, the temperature the week before abruption is compared with the temperature of surrounding weeks when abruption did not occur. Because patients are self-matched, this method automatically adjusts for time invariant confounders such as age, multiple pregnancy, socioeconomic status, smoking and comorbidity, thus avoiding bias from such sources (Janes et al., 2005; Maclure and Mittleman, 2000). In this analysis, the date of delivery corresponded to the date of abruption.

We selected control days using a time-stratified approach. The time-stratified approach requires that control days be on the same day of the week and in the same month and year as cases (Levy, 2001). Control days were selected in the same month the abruption occurred, with each abruption case having up to 4 control days. For abruptions in the middle of the month, control days were selected both before and after the event. For abruptions the first week of the month, control days were selected in later weeks. For abruptions in the last week, control days were selected in prior weeks of the month. The time-stratified approach has the advantage of preventing bias due to weekday effects or temporal trends in temperature (Janes et al., 2005; Levy, 2001).

2.6. Data analysis

In primary analyses, we examined the association of temperature with placental abruption for the entire sample of women. We then analyzed preterm and term abruptions separately. In secondary