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EFFECTS OF LACTATION ON POSTPARTUM BLOOD PRESSURE AMONG WOMEN WITH GESTATIONAL HYPERTENSION AND PREECLAMPSIA

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Abstract

BACKGROUND—Women with a history of hypertensive disorders of pregnancy are at increased risk of hypertension and cardiovascular disease in later life. Lactation has been associated with reduced risk of maternal hypertension, both in the postpartum period and later life. However, little is known about whether lactation is also cardio-protective in women with hypertensive disorders of pregnancy such as preeclampsia or gestational hypertension.

OBJECTIVES—This study aimed to characterize the relationship between lactation and postpartum blood pressure among women with preeclampsia and gestational hypertension.

STUDY DESIGN—Data were obtained from women who participated in the Prenatal Exposures & Preeclampsia Prevention study (n=379; 66% African American; 85% overweight or obese). Women enrolled during pregnancy and attended a postpartum visit (on average, 9.1 months after delivery) where data on lactation duration and blood pressure were collected. The significance of associations between postpartum blood pressure and lactation among women who remained normotensive during pregnancy, developed gestational hypertension, or developed preeclampsia

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were assessed with analysis of variance. Linear regression models were used to adjust for maternal age, race, education, pre-pregnancy weight, and time since delivery.

RESULTS—Gestational hypertension affected 42 (11%) and preeclampsia affected 33 (9%). Lactation was reported by 217 (57%) with 78 (21%) reporting ≥ 6 months of lactation. Women who lactated were somewhat older, more educated, and had higher socioeconomic status. Among women who had gestational hypertension, lactation was associated with lower systolic blood pressure (p=0.02) and diastolic blood pressure (p=0.02). This association persisted after adjustment for age, race, education, pre-pregnancy weight, and time since delivery. However, for women who had preeclampsia and women who remained normotensive during pregnancy, lactation was not associated with postpartum blood pressure in either bivariate or multivariate analyses.

CONCLUSIONS—This study found that lactation is associated with lower postpartum blood pressure among overweight women who develop gestational hypertension, but not among women who develop preeclampsia. Future studies are needed to explore association of lactation and blood pressure in later life for women with hypertensive disorders of pregnancy.

Keywords

Gestational Hypertension; Hypertension; Lactation; Postpartum blood pressure; Preeclampsia

INTRODUCTION

Hypertensive disorders of pregnancy are increasingly common in the United States[1-345,6] and women who develop preeclampsia or gestational hypertension are at increased risk of hypertension and cardiovascular disease in later life[7-9]. In particular, women with a history of preeclampsia have approximately double the risk of cardiovascular events in the 5 to 15 years after pregnancy compared to women who are normotensive during pregnancy[7]. Similarly, women with a history of gestational hypertension are at increased risk for hypertension, ischemic heart disease, and stroke in later life[10].

The American Heart Association (AHA) Guidelines for Prevention of Cardiovascular Disease (CVD) in Women suggest that women with hypertensive disorders of pregnancy should receive ongoing post-delivery and life-long care from a primary care physician or cardiologist to monitor and control risk factors for CVD such as hypertension, diabetes, and hyperlipidemia[11]. Women with a history of preeclampsia may also benefit from lifestyle interventions such as exercise, changes in dietary habits, and smoking cessation[12]. Less attention has been given to the role breastfeeding may play in improving women's cardiovascular health.

Increased lifetime duration of lactation has been associated with reduced CVD risk in women and lower rates of hypercholesterolemia, diabetes, and the metabolic syndrome[13-15]. Lactation affects multiple hormones which impact blood pressure, including oxytocin[16], prolactin[17], cortisol[18], estrogen, and progesterone. Among normal weight women, lactation has been associated with lower blood pressure at 1 month postpartum[19,20]. There have now been at least 9 studies,[14,19-26] examining the association between lactation and maternal

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blood pressure after menopause, which have consistently shown that mothers who do not breastfeed are more likely to develop hypertension. However, whether lactation may differentially affect women with preeclampsia or gestational hypertension is not well understood.

We therefore characterized the relationship between lactation and postpartum blood pressure among women who did or did not develop preeclampsia or gestational hypertension. We hypothesized that participants who did not lactate would have higher postpartum blood pressure than mothers who lactated, whether or not they had developed gestational hypertension or preeclampsia, after adjustment for relevant confounders.

MATERIALS AND METHODS

Participants

The study population was derived from the Prenatal Exposures & Preeclampsia Prevention (PEPP3) study, a prospective study of the impact of obesity on preeclampsia risk in women who received antepartum, delivery, and postpartum care at Magee-Womens Hospital of University of Pittsburgh Medical Center (UPMC)[27]. Eligibility criteria included age 18-40 years, singleton pregnancy, and gestational age of 6-16 weeks at enrollment. Overweight and obese women (BMI>25kg/m^2) were preferentially recruited to comprise 85% of the study population to examine mechanisms linking obesity to preeclampsia and gestational hypertenstion; a small a group of lean women were enrolled for comparison. Women with BMI <18, pre-existing hypertension, diabetes, seizure disorders, liver, heart, or kidney disease, collagen vascular disorder, drug or alcohol abuse, major fetal anomaly, or fetal demise were excluded.

As part of the study protocol, women were asked to attend a postpartum visit at least 3 months after delivery. Of the initial cohort (N=651), 437 women completed a postpartum visit 3-24 months after delivery. There were 55 women who became pregnant in the follow-up period and thus were ineligible for a postpartum visit and excluded from our analyses. For this study, we excluded women who had a postpartum visit < 6 months after delivery as these women would not have had data regarding whether they lactated for up to 6 months and those who had a postpartum greater than 24 months after delivery. Additionally, 3 participants attended a postpartum visit, but did not have recorded blood pressure data and were thus excluded. Our final analyses included 379 women (mean postpartum visit at 9.1 months, median 7.0 months, standard deviation (SD) 4.3 months). All women provided written informed consent and this study received exempt approval by the University of Pittsburgh's Institutional Review Board (IRB approval number PRO14080003).

At enrollment, participants completed a questionnaire which included demographic information (age, race, parity, marital status, education, income, occupation, smoking history, and plans for breastfeeding) as well as self-reported pre-pregnancy height and weight. The correlation between the first study weight measure and the self-reported pre-pregnancy weight was high (>0.97). Pre-pregnancy BMI (kg/m^2) was calculated with self-reported weight and height and categorized based on World Health Organization guidelines as normal weight (BMI 18.5 to 24.9 kg/m2), overweight (BMI 25 to 29.9), obese class I

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(BMI 30-34.9), class II (BMI 35 to 39.9) and class III (BMI ≥40). Trained research personnel measured participant weight and blood pressure by standardized methods (measured twice after participants had been sitting for 5 minutes at rest and a third time if the first two measurements varied by more than 10mmHg).

Delivery data including gestational age at delivery, delivery type, and pregnancy complications were abstracted from delivery medical records. Gestational hypertension (two or more BP measurements >140/90) and preeclampsia (gestational hypertension plus proteinuria) were defined based on American College of Obstetricians and Gynecologists (ACOG) guidelines in 2002[28] and adjudicated by the PEPP3 research team based on chart reviews using strict research criteria. Five women who attended a postpartum visit had a history of chronic hypertension, however none of these women developed superimposed preeclampsia.

At the postpartum visit, weight and blood pressure data were again gathered by trained research personnel. A variable to assess weight change postpartum compared to prepartum depending on follow-up time was defined as [postpartum weight (pounds)-prepartum weight (pounds)]/follow-up month postpartum.

Lactation History

At the postpartum visit, particpants completed a questionnaire which assessed their breast feeding practices. To assess duration of breastfeeding, participants were initially asked “Did you ever breastfeed or pump breast milk to feed your new baby after delivery, even for a short period of time?” Those who answered “no” were placed in the never breastfed category. Those who answered “yes”, were subsequently categorized by duration depending on their answers to two additional questions: “Are you currently breastfeeding or feeding pumped milk to your new baby?” and “How many weeks or months did you breastfeed or pump milk to feed your baby?” Based on these questions, participants were categorized into four groups: never lactated, lactated <3 months, lactated 3-6 months, and lactated > 6 months.

Statistical Analysis

Maternal characteristics [mean±SD or n(%)] were compared according to lactation history using analysis of variance (ANOVA) for continuous variables and chi-squared tests for categorical variables. We then tested the relationship between lactation and postpartum blood pressure for participants with (a) normotensive pregnancies, (b) preeclamptic pregnancies, or (c) gestational hypertensive pregnancies. We used ANOVA to compare differences in both postpartum systolic blood pressure (SBP) and diastolic blood pressure (DBP) between each of the four lactation groups. Linear regression was used to adjust for potential confounding and mediating variables including maternal education (the SES indicator that has been most strongly related to pregnancy complications and to CVD risk in women[29,30]), age, race, time since delivery, preterm birth, and pre-pregnancy BMI with women who never lactated as the reference category.

Potential confounders were identified as those that varied significantly by lactation category and those known to be related to blood pressure. Models that adjusted for insurance or

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income in place of education did not alter the primary result of relationship between lactation and postpartum BP. We performed sensitivity analyses restricting the sample to nulliparous women only and obese women only (BMI>30) to confirm that the observed relationships were consistent with all approaches. Statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC) and Stata version 13.0.

RESULTS

Participants

The initial cohort was comprised of 651 predominantly obese and overweight women. Of these, 437 (67%) attended the postpartum study visit and 379 who had a follow-up visit between 6 and 24 months were included in this study. In general, women who attended the postpartum visit were more likely to be African American and of low income compared to those who did not (Supplemental Table 1). Women who lactated for longer durations tended to be older, more educated, have higher income, and were more likely to report that they had planned to breastfeed , with over 90% of women who lactated for more than 3 months reporting that they had planned to breastfeed at delivery (Table 1). There were 33 women (9%) with preeclampsia and 42 (11%) with gestational hypertension; the prevalence of preeclampsia and gestational hypertension was similar in each of the lactation groups. Weight change and weight change over time in the postpartum period did not change with duration of lactation.

Postpartum Blood Pressure by Lactation Duration

Among the participants who had gestational hypertension, postpartum SBP was significantly lower with longer lactation as was DBP (Table 2). However, there were no significant differences in postpartum SBP or DBP among women who remained normotensive during pregnancy across lactation groups. Similarly, among women who had preeclampsia, there were no significant differences in postpartum SBP or DBP across lactation groups. Combined analyses including women with gestational hypertension and women with preeclampsia showed no change in postpartum blood pressure.

In fully adjusted models (Table 3), women who developed gestational hypertension had significantly lower postpartum SBP if they lactated for >6 months (β=−16.1 mm Hg, 95% CI [−27.7, −4.5]) compared to those who never lactated. Similarly, in the adjusted models women with gestational hypertension had significantly lower postpartum DBP if they lactated for >6 months (β=−16.9 mm Hg, 95% CI [−27.8, −6.0]). Among women who remained normotensive throughout and among women who had preeclampsia, fully adjusted models did not identify any significant associations between lactation duration and postpartum blood pressure.

COMMENT

In this study of maternal blood pressure assessed, on average, 8 months after delivery, women with gestational hypertension had significantly lower BP if they had lactated for more than 6 months compared to those who did not lacate; this did not extend to women who lactated for 3-6 months or for <3 months. Among women who had gestational

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hypertension, the difference in postpartum BP between women who did and did not lactate was similar in magnitude to the 12-15 mmHg drop in BP expected among hypertensive patients who start a first line anti-hypertensive agent[31].

These findings are consistent with previous studies that have suggested that lactation is associated with lower blood pressure in the immediate postpartum period,[19,20] as well as in later life[14,19-26]. In a prospective study of 71 healthy women, systolic blood pressure declined across the immediate postpartum period (1-5 months) and was significantly lower in women who lactated compared to those who did not, independent of pre-pregnancy BMI[20]. Similarly, a retrospective chart review of Japanese women who had normal pregnancies showed a small, but significant reduction in postpartum blood pressure at 1 month postpartum among women who were lactating compared to those who did not[19]. Importantly, an experimental murine study found that systolic blood pressure was lowered at 1 and 2 months postpartum in mice that were allowed to lactate compared to those that were prevented from nursing their pups[32]. Endocrine pathways involved in lactation may contribute to lower postpartum blood pressure by decreasing inflammatory markers. Specifically, oxytocin may play a role in reducing inflammation[16] and has some cardioprotective benefits. In addition, lactation may affect factors that influence systolic blood pressure such as arterial stiffness and compliance[33].

Surprisingly, in this study, lactation was not associated with postpartum BP among participants who had preeclampsia, nor among those who remained normotensive throughout pregnancy. This may reflect underlying differences in the pathophysiology of gestational hypertension and preeclampsia. Although both gestational hypertension and preeclampsia share many risk factors[34], they have distinct differences in pathophysiology. In preeclampsia, antiangiogenic peptides originating in the placenta are elevated, resulting in endothelial dysfunction and ultimately reduced blood flow through the spiral arteries that supply the placenta[35,36]. Newer studies also suggest that women with preeclampsia have persistent postpartum cardiovascular changes including left ventricular systolic dysfunction, diastolic dysfunction, and ventricular hypertrophy[37]. Murine models of preeclampsia have shown a lack of reduction in postpartum BP with lactation as well[38]. In comparison, gestational hypertension has been described as latent hypertension revealed temporarily by pregnancy[35], with increased risk of progression to essential hypertension. Women with gestational hypertension do not have systemic findings of proteinuria nor cardiovascular changes suggesting that gestational hypertension and preeclampsia are in fact two distinct processes. Thus, it is plausible that lactation may have more of an effect on postpartum BP among women with gestational hypertension than those with preeclampsia as evidenced in our results.

Our study also found no relationship between lactation and reduced postpartum blood pressure among women who remained normotensive during pregnancy. This finding differs from what has been previously reported on lactation effects on blood pressure in the more immediate postpartum period and may be due to the fact that most participants in this study were followed for a mean of 9.1 months postpartum and median of 7.0 months in comparison to only 1 to 5 months post partum in previous studies. Additionally, it should be noted that the majority of women in this study, by design, were overweight or obese before

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pregnancy (mean BMI 32.5). Some studies have identified an interaction between pre-pregnancy obesity and the relationships between lactation and weight retention[39]. Although lactation has been associated with less postpartum weight retention for mothers who were normal weight before pregnancy, lactation has been associated with increased postpartum weight retention for mothers who were obese before pregnancy[40]. As few participants in this study had normal pre-pregnancy BMI, we may have missed an effect of lactation on postpartum blood pressure that could be visible among a larger sample of normal weight women.

Prior studies have shown that the prenatal period offers important opportunities to educate women about lifestyle changes that may affect their health in the future[41]. By participating in this study, women may have received prenatal counseling that increased their intention to breastfeed since participants' reports of intending to breastfeed were higher than might be expected among lower income African American women in Pennsylvania. Notably, most of the predominantly overweight and African American participants in this study who planned to breastfeed prior to delivery succeeded in lactating for >3 months, which supports the idea that prenatal counseling about breastfeeding, especially for women with gestational hypertension, may be particularly important.

Strengths of this study include that blood pressure was measured at the same time that lactation history was collected and both were measured in a standardized fashion shortly after delivery, reducing the possibility of recall bias. In addition, detailed information on hypertensive disorders of pregnancy was collected from medical records using a formal research adjudication protocol, thus ensuring that preeclampsia and gestational hypertension were distinguished. However, there are limitations that warrant mention. When dividing participants by duration of lactation and specific hypertensive disorders of pregnancy, the sample sizes became small and would need more participants to be adequately powered. Additionally, although participants in this study were followed up to 24 months postpartum, longer follow up is needed to fully assess the relationships between lactation and maternal cardiovascular health in later life. During our study, ACOG definitions of gestational hypertension and preeclampsia were used, however these definitions have since been updated[42]. The definition for preeclampsia now includes women without proteinuria who have other systemic findings consistent with preeclampsia; with the newer definitions, some women we categorized as having simply gestational hypertension may have shifted to the pre-eclampsia group. Further classification of subtypes of preeclampsia including mild versus severe were not recorded nor were data on NICU stay. Another limitation is the lack of a measure of exclusivity of lactation, although this construct may be more relevant when considering the infant feeding than maternal health. In particular, women were not asked specifically about breast pumping versus breast feeding. By receiving prenatal counseling about breastfeeding, results about intention to breasfeed and success of lactation may have increased. Additionally, we chose not to adjust for both prepregnancy and postpartum BMI due to concern for colinearity. Lastly, there were significant socioeconomic differences between women who lactated and those who did not. Although we adjusted for socioeconomic status using education, concurrent adjustment for other socioeconomic variables was precluded by the small numbers of participants in each categetory which created model instability.

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In conclusion, this study suggests that lactation may lower postpartum blood pressure, especially among women with pregnancies affected by gestational hypertension. Long term follow up is needed to assess relationship of lactation to later life blood pressure among women with hypertensive disorders of pregnancy. Additionally, future studies are needed to fully understand the pathophysiology of blood pressure changes during pregnancy and the postpartum period, particularly among those who have experienced hypertensive disorders of pregnancy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Baseline Characteristics by Lactation Group (n=379)

	Total (N=379)	Never Lactated (N=162)	Lactated <3 mos (N=88)	Lactated 3-6 mos (N=51)	Lactated ≥ 6 mos (N=78)	p-value
Age, mean in years, sd	23.8, 4.2	23.1, 4.3	23.7, 3.9	24.5, 3.6	25.0, 4.2	<0.01
Race (%)						0.19
Black	251 (66)	119 (73)	57 (65)	31 (61)	44 (56)	
White	119 (31)	41 (25)	29 (33)	18 (35)	31 (40)	
Other	9 (2)	2 (1)	2 (2)	2 (4)	3 (4)	
Married (%)	150 (40)	55 (34)	39 (44)	21 (42)	35 (45)	0.26
Education (%)						<0.01
Less than HS	31 (8)	20 (12)	8 (9)	0 (0)	3 (4)	
HS or GED	184 (49)	100 (62)	39 (44)	18 (36)	27 (35)	
College +	163 (43)	42 (26)	41 (47)	32 (64)	48 (62)	
Income (%)						<0.01
< $20,000	209 (55)	94 (58)	51 (58)	23 (46)	41 (53)	
$20,000-$49,999	80 (21)	28 (17)	21 (24)	15 (30)	16 (21)	
> $50,000	24 (6)	4 (3)	5 (6)	3 (6)	12 (15)	
Unknown	65 (17)	36 (22)	11 (12.5)	9 (18)	9 (12)	
Insurance (%)						<0.01
Private	35 (9)	5 (3)	9 (10)	6 (12)	15 (20)	
Medicaid	231 (62)	116 (73)	50 (57)	30 (59)	35 (46)	
None at enroll	104 (28)	34 (21)	29 (33)	15 (29)	26 (34)	
Smoking (lifetime) (%)	164 (43)	78 (48)	35 (40)	21 (42)	30 (38)	0.43
Nulliparous (%)	291 (77)	120 (74)	71 (81)	40 (78)	60 (77)	0.68
Parity, mean, sd	0.37, 0.80	0.47, 0.95	0.30, 0.66	0.24, 0.47	0.35, 0.75	0.19
Pre-pregnancy BMI (%)						0.64
Normal	56 (15)	24 (15)	11 (13)	7 (14)	14 (18)	
Overweight	88 (23)	34 (21)	16 (18)	16 (31)	22 (28)	
Class I Obese	115 (30)	47 (29)	33 (38)	12 (24)	23 (29)	
Class II Obese	63 (17)	29 (18)	15 (17)	10 (20)	9 (12)	
Class III Obese	57 (15)	28 (17)	13 (15)	6 (12)	10 (13)	
Preterm Birth (<37wks) (%)	43 (11)	16 (10)	9 (10)	9 (18)	9 (12)	0.48
Preeclampsia (%)	33 (9)	15 (9)	7 (8)	6 (12)	5 (6)	0.74
Gestational HTN (%)	42 (11)	19 (12)	9 (10)	7 (14)	7 (9)	0.84
Gestational diabetes (%)	12 (3)	2 (1)	6 (7)	1 (2)	3 (4)	0.11
Planned breastfeeding (%)	226 (63)	44 (29)	65 (79)	45 (92)	72 (97)	<0.01
Δ weight / follow-up time, mean in pounds/month	1.6	1.5	1.9	1.4	1.4	0.57
Follow-up, mean month, sd	9.1, 4.3	9.2, 4.3	8.7, 4.2	9.9, 4.9	8.6, 4.1	0.30

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	Total (N=379)	**Never Lactated (N=162)**	**Lactated <3 mos (N=88)**	**Lactated 3-6 mos (N=51)**	**Lactated ≥ 6 mos (N=78)**	**p-value**
Postpartum, mean weight change, sd	12.2, 18.4	12.3, 18.9	13.8, 20.1	11.0, 16.5	11.2, 16.6	0.77

sd=standard deviation; HS=high school; GED=general educational development; BMI=body mass index; HTN=hypertension

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Table 2

Associations between Lactation Duration and Mean Postpartum Systolic and Diastolic Blood Pressure

	Never Lactated	Lactated <3 mos	Lactated 3-6 mos	Lactated ≥ 6 mos	p-value
Normotensive	N=128	N=72	N=38	N=66	
Postpartum Systolic BP, sd	110.9, 9.3	112.0, 9.9	111.4, 9.1	113.1, 11.9	0.56
Postpartum Diastolic BP, sd	70.6, 7.5	71.5, 7.6	72.3, 7.4	72.0, 9.5	0.49
Preeclampsia	N=15	N=7	N=6	N=5	
Postpartum Systolic BP, sd	118.1, 13.9	122.6, 14.3	119.0, 9.0	127.9, 8.7	0.48
Postpartum Diastolic BP, sd	75.6, 11.8	77.7, 12.7	75.7, 5.4	83.4, 3.9	0.52
Gestational Hypertension	N=19	N=9	N=7	N=7	
Postpartum Systolic BP, sd	125.7, 15.3	113.7, 12.6	118.0, 8.0	109.0, 6.11	0.02
Postpartum Diastolic BP, sd	80.0, 13.1	73.7, 10.0	74.3, 9.9	64.4, 2.1	0.02

BP=blood pressure; sd=standard deviation

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Table 3

Associations between Lactation Duration and Postpartum Systolic and Diastolic Blood Pressure in Adjusted Models (N=379)

	Postpartum Systolic Blood Pressure				Postpartum Diastolic Blood Pressure			
	Unadjusted		Fully Adjusted*		Unadjusted		Fully Adjusted*	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
Gestational HTN								
Lactated < 3 mos	−12.0	(−22.4, −1.6)+	−13.0	(−24.2, −1.9)+	−6.3	(−15.2, 2.6)	−8.0	(−18.6, 2.6)
Lactated 3-6 mos	−7.7	(−19.0, 3.7)	−4.1	(−15.6, 7.3)	−5.7	(−15.4, 4.1)	−4.6	(−15.5, 6.2)
Lactated > 6 mos	−16.7	(−28.0, −5.3)†	−16.3	(−28.3, −4.4)†	−15.5	(−25.3, −5.8)†	−16.8	(−28.1, −5.5)†

HTN=hypertension

*Adjusted for age, race, education, time since delivery, and pre-pregnancy BMI with never lactated as reference category

+p-value < 0.05

†p-value < 0.01