Obstetrical and perinatal outcomes among women with gestational hypertension, mild preeclampsia, and mild chronic hypertension

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OBJECTIVE: The purpose of this study was to compare maternal and neonatal outcomes of women with gestational hypertension (GHTN), mild chronic hypertension (CHTN), and mild preeclampsia at delivery.

STUDY DESIGN: A multicenter database that contained 228,668 deliveries was used to extract data on gravid women with GHTN, preeclampsia, and CHTN and on women without hypertensive disease (control group). Univariate and multivariate logistic regression analyses were performed.

RESULTS: There were 4918 women with GHTN, 5274 women with preeclampsia, 2531 women with CHTN, and 15,221 control subjects. Women with GHTN had the greatest risk for blood transfusion (adjusted odds ratio [aOR], 4.6; 95% confidence interval [CI], 3.4–6.3), intensive care unit admission (aOR, 25.7; 95% CI, 9.8–67.3), and lowest risk for stillbirth (aOR, 0.1; 95% CI, 0.04–0.4); women with preeclampsia had the greatest risk for postpartum hypertension (aOR, 9.6; 95% CI, 7.2–12.9). Neonates with GHTN had the greatest risk for ventilator requirements (aOR, 7.5; 95% CI, 4.6–12.4).

CONCLUSION: Women with gestational hypertension and their neonates had significant risks for morbidity, compared with women with mild chronic hypertension and those with mild preeclampsia.

Key words: chronic hypertension, gestational hypertension, maternal outcome, mild preeclampsia, neonatal outcome

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Hypertension is one of the most common medical disorders in pregnancy and a major cause of maternal and perinatal morbidity and death.[1] Approximately 70% of women who are diagnosed with hypertension during pregnancy will have gestational hypertension or preeclampsia, which complicates 6-8% of all pregnancies.[2] Approximately 46% and 9.6% of women with gestational hypertension will progress to mild preeclampsia and severe preeclampsia, respectively.[3]

Most gestational hypertensive and mild preeclamptic cases occur after 36 weeks gestation, and there is conflicting evidence regarding treatment of these women. It was previously thought that women with mild hypertensive disease that occurred at ≥37 weeks' gestation have a pregnancy outcome similar to that found in normotensive women, and previous recommendations have included outpatient treatment in those who were compliant with induction of labor near term.[2] However, it has been demonstrated recently that pregnant women with mild disease (gestational hypertension or mild preeclampsia) who were allocated to expectant monitoring experienced adverse maternal outcome in 44%, compared with 31%, allocated to induction of labor (relative risk, 0.71; 95% confidence interval [CI], 0.59–0.86; $P < .0001$).[4] Thus, induction of labor now has been suggested for women with mild hypertensive disease who have achieved 37 weeks gestation. However, Koopmans et al[4] did not separate gestational hypertension from mild preeclampsia, which made it unclear whether morbidities were similar and whether recommendations should be the same for both.

The objective of this study was to compare maternal and neonatal outcomes of women with gestational hypertension,

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mild chronic hypertension, and mild preeclampsia from a large, multicenter electronic database. Main maternal outcomes included intensive care unit (ICU) admission rate, the number of postpartum days in the hospital, cesarean delivery rate, stillbirth rate, and the amount of blood loss. Primary neonatal outcomes addressed included neonatal ICU (NICU) admissions, the number of NICU days, respiratory distress syndrome (RDS), ventilator use, presence of intrauterine growth restriction, and the number of neonatal deaths. Our hypothesis was that these outcomes will be similar among pregnant women with gestational hypertension and mild preeclampsia, but greater in pregnant women with chronic hypertension.

Materials and Methods

This is a retrospective cohort study from the Consortium on Safe Labor, which was a study sponsored by the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development. The primary goal was to establish a comprehensive database from electronic medical records from multiple sites to characterize labor and delivery in a contemporary group of women who experienced current obstetric clinical practices. More detailed information regarding the Consortium on Safe Labor has been published.[5] The electronic database contained 228,668 deliveries at >23 weeks' gestation from 12 clinical centers and 19 hospitals that represented 9 American College of Obstetricians and Gynecologists districts between 2002 and 2008; most of the births (87%) occurred from 2005-2007 (which reflected the period when individual institutions initiated their electronic medical record systems). An in-house obstetrician was available 24 hours per day at 11 of the 12 participating sites. Participating institutions provided data on maternal demographics, medical history, reproductive and prenatal history, labor and delivery information, postpartum information, and newborn information. Data inquiries, cleaning, and logic checking were performed on the database. Validation studies were also performed to ensure that the electronic database was a reasonably accurate representation of the medical charts and noted to be highly consistent (97.3-99.7%).[5] Institutional Review Board approval was obtained by all participating institutions.

For the cohort of interest, we included only the first pregnancy, within the timeframe of data collection, from each subject in the database to avoid intraperson correlation, which left 206,969 deliveries, including multiples. We included all pregnant women with hypertensive disease in pregnancy that met the definition for gestational hypertension, mild chronic hypertension, and mild preeclampsia at admission for delivery. All participating institutions used standard definitions to delineate the hypertensive diseases. *Gestational hypertension* was defined as an elevation in blood pressure (BP) ≥140 mm Hg systolic or ≥ 90 mm Hg diastolic without proteinuria that developed in a woman after 20 weeks of gestation.[6] *Chronic hypertension* was defined as having a preexisting diagnosis of chronic hypertension or having a systolic BP ≥140 mm Hg or diastolic ≥90 mm Hg before 20 weeks of gestation; *mild disease* was defined as those women not taking antihypertensive medications on admission.[7] *Mild preeclampsia* was defined as diastolic BP of ≥90 mm Hg or systolic BP ≥140 mm Hg measured on 2 occasions at least 6 hours apart, combined with proteinuria (1+ protein on dipstick, ≥300 mg total protein within a 24 hour urine collection, or ratio of protein to creatinine ≥0.3 mg/mmol).[6] Only women with preeclampsia with an admitting BP of <160 mm Hg systolic and <110 mm Hg diastolic were included. Patients with the diagnosis of chronic hypertension with superimposed preeclampsia were excluded. These 3 groups were then compared with a control group, which was defined as all pregnant women with no past or current medical disease, no obstetric issues in the current pregnancy, and no tobacco, alcohol, or recreational drug use.

Maternal predictor variables included maternal characteristics: singleton vs multiple gestation, prepregnancy and delivery body mass index, admitting systolic and diastolic BP, gestational age on admission, substance use, and comorbidities (Table 1). Maternal outcome variables included length of stay, delivery mode, stillbirth, nonreassuring fetal status, abruption, uterine rupture, hysterectomy, postpartum hemorrhage, transfusion, blood loss, ICU admission, thrombosis, postpartum hypertension, seizures, and death.

Neonatal outcome variables included gestational age, birthweight, small-for-gestational-age (SGA) infants, Apgar scores <7 at 5 minutes, arterial pH and base excess in umbilical cord gases, NICU admission, NICU length of stay, ventilator use, RDS, asphyxia, surfactant use, transient tachypnea of the newborn infant, pneumonia, sepsis, intracranial bleed, necrotizing enterocolitis (NEC), neonatal seizures, and death. *SGA* was defined in 2 ways: as <3rd percentile and as <10th percentile of growth.[8]

Analysis included chi-square test for categoric descriptive variables and analysis of variance tests for continuous descriptive variables. Univariate analyses were performed for maternal and neonatal outcomes with the use of a simple logistic regression model for categoric outcomes and simple linear regression model for continuous variables. Unadjusted odds ratios (uOR) for categoric variables and unadjusted parameter estimates for continuous variables and the corresponding 95% CIs were calculated. Multivariate analyses were then conducted with the use of logistic regression and linear regression models to examine maternal and neonatal outcomes. A backward elimination model selection method was used to find potentially significant confounders ($P < .05$), such as maternal age, gestational age, race, insurance status, body mass index, parity, order of pregnancy, maternal comorbidities, and substance use. The same was performed for neonatal outcomes. Adjusted odds ratios (aORs) were then calculated for categoric variables, and adjusted parameter estimates were calculated for continuous variables, along with corresponding CIs. SAS software (version 9.2; SAS Institute Inc, Cary, NC) was used for all the analyses.

TABLE 1
Maternal characteristics

Maternal characteristics	Mild chronic hypertension (n = 2531)	Gestational hypertension (n = 4918)	Mild preeclampsia (n = 5274)	Control group (n = 15,221)	*P* value
Maternal age, y[a]	29.5 ± 6.6	26.9 ± 6.1	28.2 ± 6.7	26.7 ± 6.3	< .0001
Race, n (%)					
White	821 (32.4)	2827 (57.5)	2712 (51.4)	4443 (29.2)	< .0001
Black/non-Hispanic	1285 (50.8)	1090 (22.2)	1131 (21.4)	6160 (40.5)	
Hispanic	299 (11.8)	733 (14.9)	736 (14.0)	1925 (12.7)	
Asian/Pacific Islander	35 (1.4)	71 (1.4)	283 (5.4)	402 (2.6)	
Other	91 (3.6)	197 (4.0)	412 (7.8)	2291 (15.1)	
Parity, n (%)					
0	906 (35.8)	2876 (58.5)	3260 (61.8)	6568 (43.2)	< .0001
1	673 (26.6)	1031 (21.0)	1044 (19.8)	4729 (31.1)	
2	463 (18.3)	590 (12.0)	490 (9.3)	2435 (16.0)	
3	243 (9.6)	251 (5.1)	243 (4.6)	894 (5.9)	
≥4	246 (9.7)	170 (3.5)	237 (4.5)	595 (3.9)	
Fetuses, n (%)					
1	2462 (97.3)	4730 (96.2)	4963 (94.1)	15,039 (98.8)	< .0001
2	67 (2.7)	172 (3.5)	300 (5.7)	180 (1.2)	
≥3	2 (0.1)	16 (0.3)	11 (0.2)	2 (0.01)	
Body mass index, kg/m^2[a]					
Prepregnancy	32.9 ± 9.4	28.3 ± 7.2	27.2 ± 7.0	26.1 ± 6.3	< .0001
At delivery	37.9 ± 8.9	34.2 ± 7.1	33.5 ± 7.2	31.4 ± 6.2	< .0001
Blood pressure at admittance, mm HG[a]					
Systolic	140.9 ± 17.2	142.3 ± 15.0	137.2 ± 12.5	122.4 ± 13.4	< .0001
Diastolic	83.8 ± 13.5	87.4 ± 12.4	83.8 ± 11.9	73.2 ± 11.1	< .0001
Mean arterial	102.8 ± 13.5	105.7 ± 12.1	101.6 ± 10.9	89.6 ± 10.8	< .0001
Gestational age at delivery, wk					
Overall[a]	37.2 ± 3.2	37.4 ± 2.8	37.2 ± 3.2	39.2 ± 1.8	< .001
<30, n (%)	128 (5.1)	146 (3.0)	216 (4.1)	92 (0.6)	
30-33$^{6/7}$, n (%)	158 (6.2)	317 (6.5)	439 (8.3)	156 (1.0)	
34-36$^{6/7}$, n (%)	486 (19.2)	908 (18.5)	1010 (19.2)	713 (4.7)	
37-37$^{6/7}$, n (%)	413 (16.3)	817 (16.6)	685 (13.0)	1333 (8.8)	
38-38$^{6/7}$, n (%)	571 (22.6)	1103 (22.4)	993 (18.8)	2954 (19.4)	
39-39$^{6/7}$, n (%)	502 (19.8)	988 (20.1)	994 (18.9)	4932 (32.4)	
>40, n (%)	273 (10.8)	639 (13.0)	937 (17.8)	5041 (33.1)	
Insurance, n (%)					
Private	1154 (45.6)	2840 (57.8)	3735 (70.8)	8030 (52.8)	< .0001
Public	1240 (49.0)	1810 (36.8)	1033 (19.6)	6442 (42.3)	

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TABLE 1
Maternal characteristics *(continued)*

Maternal characteristics	Mild chronic hypertension (n = 2531)	Gestational hypertension (n = 4918)	Mild preeclampsia (n = 5274)	Control group (n = 15,221)	*P* value
Substance use, n (%)					
Smoking	264 (10.4)	262 (5.3)	212 (4.0)	0	< .0001
Alcohol	86 (3.4)	115 (2.3)	94 (1.8)	0	< .0001
Illicit drug use	116 (4.6)	59 (1.3)	69 (1.3)	0	< .0001
Maternal comorbidities, n (%)					
Gestational diabetes mellitus	178 (7.1)	248 (5.0)	299 (6.4)	0	< .0001
Pregestational diabetes mellitus	353 (14.0)	215 (4.4)	208 (4.0)	0	< .0001
Renal disease	99 (3.9)	58 (1.2)	38 (0.7)	0	< .0001
Heart disease	61 (2.4)	54 (1.1)	17 (0.3)	0	< .0001
Thromboembolic history	21 (0.8)	3 (0.07)	33 (0.7)	0	< .0001
Intrauterine growth restriction in current pregnancy[b]	225 (9.0)	415 (8.5)	553 (10.8)	875 (5.8)	< .0001

[a] Data are given as mean ± SD; [b] Defined as <tenth percentile of growth.

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Results

The electronic database included 228,668 deliveries. After exclusions, there was a total of 2531 women with mild chronic hypertension, 4918 pregnant women with gestational hypertension, 5274 pregnant women with mild preeclampsia, and 15,221 women in the control group. Table 1 shows the maternal characteristics of the study population. The group with gestational hypertension had the highest mean admitting BP (142.3 ± 15.0 mm Hg systolic/87.4 ± 12.4 mm Hg diastolic; $P < .0001$) and mean arterial BP (105.7 mm Hg ± 12.10 mm Hg; $P < .0001$). However, the maximum BP within the entire cohort of women did not exceed ≥160/110 mm Hg.

Table 2 presents the univariate analysis of maternal outcomes. Significantly more stillbirths occurred in the control group (n = 20; 0.6%). Women with gestational hypertension had the greatest risk for postpartum hemorrhage (uOR, 4.2; 95% CI, 3.2–5.3), requirement for transfusion (uOR, 9.0; 95% CI, 7.2–11.3), and ICU admission (uOR, 40.3; 95% CI, 17.6–92.6). Women with mild preeclampsia were 25 times more likely to experience hypertension during the postpartum period (uOR, 25.1; 95% CI, 21.6–29.3), but women with mild chronic hypertension were most likely to have a seizure (uOR, 6.2; 95% CI, 2.5–15.7).

Neonatal outcomes after univariate analysis are noted in Table 3. All hypertensive groups were more than twice as likely to have an SGA neonate <3% and 1.5 to 2 times more likely to have a SGA neonate <10%, when compared with the control group ($P < .0001$). The neonates of mothers with mild chronic hypertension had the greatest risk for ventilator requirements (uOR, 24.3; 95% CI, 17.7–33.3), RDS (uOR, 9.0; 95% CI, 7.5–10.9), surfactant administration (uOR, 8.9; 95% CI, 6.9–11.6), transient tachypnea of the newborn infant (uOR, 2.2; 95% CI, 1.8–2.5), pneumonia (uOR 2.9; 95% CI, 2.0–4.3), sepsis (uOR 2.2; 95% CI, 1.8–2.7), seizures (uOR, 4.9; 95% CI, 2.4–10.0) and neonatal death (uOR, 6.7 {3.4–13.2), although differences among groups were small. Of note, infants of women with mild preeclampsia and chronic hypertension had a >9-fold risk for intracranial bleeds, had the greatest risk for NEC (uOR, 11.8; 95% CI, 5.5–25.4), and were most likely to be admitted to the NICU (uOR, 3.5; 95% CI, 3.3–3.8).

After adjustment for potentially confounding factors in a regression analysis (maternal age, gestational age, race, insurance status, body mass index, parity, order of pregnancy, maternal comorbidities, and substance use), significant maternal outcomes became more apparent (Table 4). All the groups had an increased risk for induction of labor because of hypertensive disease, and women with gestational hypertension and mild preeclampsia had reduced stillbirths. Women with mild chronic hypertension were those with the greatest risk for uterine rupture (aOR, 3.8; 95% CI, 1.0–14.5) and experienced a thrombotic event (aOR, 5.4; 95% CI, 2.1–14.0). Women with gestational hypertension had the greatest risk for postpartum hemorrhage (aOR, 2.9; 95% CI, 2.1–4.0), blood transfusion (aOR, 4.6; 95% CI, 3.4–6.3), admission to the ICU (aOR, 25.7; 95% CI, 9.8–67.3), and the lowest risk for stillbirth (aOR, 0.1; 95% CI, 0.04–0.4); women with mild preeclampsia were noted to have the greatest risk for sustaining an abruption (aOR, 1.9; 95% CI, 1.2–2.9) and experiencing postpartum hypertension (aOR, 9.6; 95% CI, 7.2–12.9).

Neonatal outcomes were adjusted for the same potentially confounding factors (Table 5). Although neonates in all 3 groups had fairly similar morbidities,

TABLE 2
Univariate analysis maternal outcomes

Maternal characteristics	Mild chronic hypertension (n = 2531)		Gestational hypertension (n = 4918)		Mild Preeclampsia (n = 5274)		Control group (n = 15,221)
	Mean ± SD or n (%)	Difference: chronic hypertension vs control group, OR (95% CI)	Mean ± SD or n (%)	Difference: gestational hypertension vs control group, OR (95% CI)	Mean ± SD or n (%)	Difference: mild vs control group, OR (95% CI)	Mean ± SD or n (%)
Length of stay, d	3.7 ± 3.7	1.2 (1.1–1.4)	3.4 ± 3.5	1.0 (0.8–1.1)	4.1 ± 3.7	1.6 (1.5–1.7)	2.5 ± 2.0
Estimated blood loss, mL	529.9 ± 337.5	159.1 (145.2–173.1)	520.1 ± 267.8	149.3 (137.0–161.6)	553.1 ± 296.2	182.3 (171.5–193.1)	370.7 ± 229.8
Delivery mode							
Spontaneous vaginal	1342 (54.5)	Reference	2629 (54.0)	Reference	2546 (49.1)	Reference	12,250 (81.3)
Operative	85 (3.5)	3.1 (2.4–4.0)	407 (8.4)	7.5 (6.4–8.8)	311 (6.0)	5.9 (5.0–7.0)	254 (1.7)
Cesarean	1035 (42.0)	3.7 (3.4–4.0)	1832 (37.6)	3.3 (3.3–3.6)	2333 (44.9)	4.4 (4.1–4.7)	2561 (17.0)
Outcome							
Induction	1324 (53.0)	3.1 (2.8–3.4)	3029 (61.6)	4.4 (4.1–4.7)	2546 (49.2)	2.7 (2.5–2.8)	3650 (26.7)
Stillbirth	7 (0.5)	1.0 (0.4–2.3)	3 (0.1)	0.2 (0.1–0.6)	8 (0.3)	0.6 (0.3–1.3)	20 (0.6)
Nonreassuring fetal status	287 (12.0)	5.5 (4.6–6.4)	413 (8.4)	3.7 (3.2–4.2)	297 (10.2)	4.5 (3.9–5.3)	373 (2.5)
Abruption	35 (1.4)	2.9 (1.9–4.3)	32 (0.7)	1.3 (0.9–2.0)	67 (1.7)	3.4 (2.5–4.8)	77 (0.5)
Uterine rupture	4 (0.2)	4.9 (1.3–18.1)	2 (0.04)	1.2 (0.2–6.4)	3 (0.1)	2.0 (0.6–8.2)	5 (0.03)
Hysterectomy	2 (0.08)		0		6 (0.1)		3 (0.02)
Postpartum hemorrhage	38 (1.5)	1.8 (1.3–2.7)	123 (3.4)	4.2 (3.2–5.3)	119 (2.6)	3.1 (2.4–4.0)	126 (0.8)
Transfusion	80 (4.1)	5.7 (4.3–7.6)	277 (6.3)	9.0 (7.2–11.3)	192 (3.7)	5.1 (4.0–6.5)	112 (0.7)
Intensive care unit admission	15 (0.6)	16.1 (6.2–41.4)	77 (1.6)	40.3 (17.6–92.6)	26 (0.9)	22.8 (9.4–55.5)	6 (0.04)
Thrombosis	10 (0.5)	8.7 (3.6–21.5)	7 (0.2)	3.2 (1.2–8.7)	13 (0.3)	4.7 (2.0–11.1)	9 (0.06)
Postpartum hypertension	139 (7.1)	5.7 (4.5–7.0)	50 (1.4)	1.0 (0.8–1.4)	1330 (25.3)	25.1 (21.6–29.3)	202 (1.3)
Seizure	8 (0.4)	6.2 (2.5–15.7)	12 (0.3)	4.1 (1.8–9.6)	15 (0.3)	4.4 (2.0–9.7)	10 (0.07)
Death	1 (0.04)		1 (0.02)		1 (0.02)		0

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those of mothers with gestational hypertension had the greatest risk for ventilator requirements (aOR, 7.5; 95% CI, 4.6–12.4), RDS (aOR, 2.5; 95% CI, 1.8–3.4), surfactant use (aOR, 1.7; 95% CI, 1.1–2.6), and NEC (aOR, 3.2; 95% CI, 1.4–7.2). Neonates of mothers with mild preeclampsia had the greatest risk for being SGA <3rd percentile (aOR, 1.8; 95% CI, 1.3–2.7), <10th percentile (aOR, 1.3; 95% CI, 1.1–1.6), having pneumonia (aOR, 2.3; 95% CI, 1.2–4.3), and sustaining an intracranial bleed (aOR, 3.2; 95% CI, 2.1–5.0). Infants of mothers with chronic hypertension fared slightly better than those with gestational hypertension. Birthweight, asphyxia, sepsis, neonatal seizures, and death were no longer significant after adjustments in the regression analysis.

Comment

In this multicenter electronic database representative of pregnant women across the United States, women with gestational hypertension had the greatest risk for postpartum hemorrhage, blood transfusion, and admission to the ICU and the lowest risk for stillbirth. Neonates of these mothers had the greatest risk for ventilator requirements, RDS, surfactant use, and experiencing NEC. In contrast, mothers with mild preeclampsia had the most risk for sustaining abruption and experiencing postpartum hypertension, although their infants had the greatest risk for intrauterine growth restriction (both <3rd and <10th percentile), pneumonia, and sustaining an intracranial bleed. Women with mild chronic hypertension had the greatest risk for uterine rupture and experiencing a thrombotic event, but their infants fared better than those in the other 2 groups. Significantly more stillbirths occurred in the control group, likely because the 3 hypertensive groups had higher rates of induction before this event.

We had hypothesized that outcomes would be similar among women with gestational hypertension and mild preeclampsia but would be greater in women with chronic hypertension, based on what had been reported previously. Adverse pregnancy outcomes in women with mild gestational hypertension (such as low birthweight, SGA neonates, placenta abruption, and perinatal deaths) have been shown to be similar or to occur at greater rates than in women

TABLE 3
Univariate analysis of neonatal outcomes

Neonatal outcomes	Mild chronic hypertension (n = 2531)		Gestational hypertension (n = 4918)		Mild preeclampsia (n = 5274)		Control group (n = 15,221)
	Mean ± SD	Difference: chronic hypertension vs control group (95% CI)	Mean ± SD	Difference: gestational hypertension vs control group (95% CI)	Mean ± SD	Difference: mild vs control group (95% CI)	Mean ± SD
Gestational age, wk	37.2 ± 3.2	−2.0 (−2.2 to −1.9)	37.4 ± 2.8	−1.8 (−1.9 to −1.8)	37.2 ± 3.2	−2.1 (−2.2 to −2.0)	39.2 ± 1.8
Birthweight, g	2942.8 ± 798.0	−369.4 (−402.8 to −336.1)	2993.7 ± 735.9	−333.2 (−358.6 to −307.9)	2914.1 ± 805.6	−423.1 (−447.9 to −398.3)	3303.3 ± 509.9
Neonatal intensive care unit length of stay, d	23.1 ± 30.2	15.2 (12.4–18.1)	21.7 ± 29.2	14.1 (11.9–16.4)	20.1 ± 25.6	12.5 (10.5–14.5)	7.5 ± 14.3
Cord blood arterial pH	7.2 ± 0.1	0 (−0.01 to 0.01)	7.2 ± 0.1	0.01 (0.01–0.02)	7.2 ± 0.1	−0.002 (−0.01 to 0.01)	7.2 ± 0.1
Arterial base excess	−3.8 ± 3.6	0.8 (0.4–1.2)	−3.6 ± 3.	1.0 (0.7–1.4)	−4.2 ± 4.0	0.5 (0.02–1.0)	−4.6 ± 3.8
Small for gestational age							
<3%	68 ± 2.6	2.6 (2.0–3.5)	129 ± 2.5	2.5 (2.0–3.2)	149 ± 2.8	2.8 (2.2–3.5)	154 ± 1.0
<10%	232 ± 9.0	1.6 (1.3–1.8)	453 ± 8.9	1.5 (1.4–1.7)	600 ± 11.1	2.0 (1.8–2.2)	907 ± 6.0
Apgar <7 at 5 min	96 ± 3.8	5.5 (4.2–7.3)	108 ± 2.1	3.0 (2.4–4.0)	188 ± 3.4	4.9 (3.9–6.3)	108 ± 0.7

	n (%)	Odds ratio (95% CI)	n (%)	Odds ratio (95% CI)	n (%)	Odds ratio (95% CI)	n (%)
Neonatal intensive care unit admission	647 (25.6)	2.9 (2.6–3.2)	1018 (20.7)	2.2 (2.1–2.4)	1514 (28.7)	3.5 (3.3–3.8)	1649 (10.8)
Ventilator	182 (7.2)	24.3 (17.7–33.3)	329 (6.7)	23.5 (17.4–31.7)	262 (5.0)	17.0 (12.6–23.1)	46 (0.3)
Respiratory distress syndrome	247 (9.8)	9.0 (7.5–10.9)	407 (8.3)	8.0 (6.7–9.5)	413 (7.8)	7.3 (6.2–8.7)	179 (1.2)
Asphyxia	8 (0.3)	2.5 (1.2–5.2)	28 (0.6)	3.8 (2.2–6.5)	24 (0.5)	3.2 (1.9–5.6)	23 (0.2)
Surfactant use	133 (5.3)	8.9 (6.9–11.6)	226 (4.6)	8.0 (6.3–10.2)	190 (4.0)	7.0 (5.5–8.9)	84 (0.6)
Transient tachypnea of the newborn infant	194 (7.7)	2.2 (1.8–2.5)	222 (4.5)	1.3 (1.1–1.5)	341 (6.5)	1.9 (1.7–2.2)	556 (3.7)
Pneumonia	35 (1.4)	2.9 (2.0–4.3)	57 (1.2)	2.5 (1.8–3.6)	61 (1.2)	2.6 (1.9–3.7)	72 (0.5)
Sepsis	134 (5.3)	2.2 (1.8–2.7)	196 (4.0)	1.6 (1.4–1.9)	277 (5.3)	2.2 (1.8–2.5)	388 (2.6)
Intracranial bleeding	44 (1.7)	9.3 (5.8–14.9)	43 (0.9)	5.0 (3.2–8.0)	91 (1.7)	9.6 (6.3–14.5)	29 (0.2)
Necrotizing enterocolitis	11 (0.4)	8.9 (3.6–21.8)	23 (0.5)	10.7 (4.8–23.2)	27 (0.5)	11.8 (5.5–25.4)	7 (0.1)
Neonatal seizures	14 (0.6)	4.9 (2.4–10.0)	8 (0.2)	1.8 (0.8–4.0)	13 (0.3)	2.3 (1.1–4.6)	17 (0.1)
Death	17 (0.7)	6.7 (3.4–13.2)	22 (0.5)	4.5 (2.4–8.6)	30 (0.6)	5.5 (3.0–10.1)	14 (1.0)

CI, confidence interval.

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with normotensive pregnancies.[3,9-11] Moreover, in women with mild preeclampsia, rates of preterm delivery, SGA neonates, placental abruption, and perinatal death were similar to those reported in normotensive pregnancies.[9,12,13] In the aforementioned investigations, the number of women included ranged from 62-715, far fewer than the current investigation and possibly resulting in insufficient power to detect increased morbidities. In a cross-sectional study by Kuklina et al[14] that investigated complications of all hypertensive disorders in pregnancy, women with gestational hypertension had only a 1- to 2-fold risk for experiencing severe obstetric complications (such as acute renal failure, pulmonary edema, acute RDS, puerperal cerebrovascular disorder, disseminated intravascular coagulation, ventilation, and death); those with eclampsia/severe preeclampsia and chronic hypertension experienced most of the obstetric morbidity during delivery hospitalizations.

Contrary to what we had anticipated, mothers with gestational hypertension had greater risk for morbidity than women with mild chronic hypertension or mild preeclampsia. This outcome lends support to the recommendation by Koopmans et al[4] regarding the induction of labor in women with gestational hypertension and mild preeclampsia once 37 weeks' gestation was achieved to avoid maternal morbidity. However, in their investigation they did not separate gestational hypertension from mild pre-

TABLE 4
Multivariate logistic regression analysis of maternal outcomes (adjusted)[a]

	Mild chronic hypertension		Gestational hypertension		Mild preeclampsia	
Maternal outcomes	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI
Induction	3.6	3.1–4.0	4.5	4.1–5.0	3.0	2.7–3.4
Stillbirth	0.7	0.3–1.6	0.1	0.04–0.4	0.4	0.2–0.9
Abruption	0.8	0.5–1.4	0.8	0.5–1.3	1.9	1.2–2.9
Uterine rupture	3.8	1.0–14.5	1.2	0.2–6.4	1.8	0.4–7.4
Postpartum hemorrhage	1.7	1.1–2.5	2.9	2.1–4.0	2.7	2.0–3.7
Transfusion	3.4	2.3–5.1	4.6	3.4–6.3	3.3	2.4–4.6
Intensive care unit	6.4	2.1–19.7	25.7	9.9–67.3	11.6	4.1–32.9
Thrombosis	5.4	2.1–14.0	2.3	0.9–6.4	3.1	1.3–7.5
Postpartum hypertension	2.6	1.8–3.8	0.7	0.5–1.2	9.6	7.2–12.9
Seizure	2.1	0.7–6.3	1.0	0.3–3.1	1.6	0.7–4.1

CI, confidence interval.

[a] Multivariate maternal outcomes: adjusted for maternal age, race, insurance, body mass index, mean arterial pressure on admission, gestational age, parity, number of fetuses, pregestational and gestational diabetes mellitus, renal disease, history of heart disease, history of thrombotic event, small for gestational age, smoking, alcohol use, and recreational drug use; all comparisons are to the healthy, nonhypertensive control group.

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eclampsia as we did in the current work. Moreover, it is concerning that neonates of mothers with gestational hypertension in our study experienced the greatest risks for respiratory issues and NEC. As demonstrated by Habli et al,[15] poor neonatal outcomes such as neonatal ICU admission, SGA, and longer neonatal stay than normotensive pregnancies were noted in infants of women with either preeclampsia or gestational hypertension, regardless of the severity of the disease, who were delivered at 35-37 weeks of gestation. Although we limited our investigation to mild hypertensive disease, we did control for gestational age and still noted high rates of morbidity in these infants. Furthermore, 37-week infants, regardless of hypertensive diseases, have been documented previously to have greater respiratory morbidity such as ventilator requirements, RDS, transient tachypnea of the newborn infant, pneumonia, asphyxia, and sepsis, which lends further support to our results.[16,17]

This is a retrospective analysis of >12,000 deliveries in a multicenter database that was drawn from centers across the country and is a good snapshot of mild hypertensive disease in contemporary obstetric practice in the United States. This allowed us to assess less frequent outcomes such as maternal abruption, ICU admission rates, thrombosis, neonatal NEC, seizures, and intracranial bleeds while controlling for confounding factors. However, it is also subject to the pitfalls of retrospective analyses, such as selection bias. In the current investigation, diagnoses were assigned at admission to the hospital for delivery, and data were not collected on the progression of disease, except for the development of seizures or postpartum worsening of hypertension. Thus, we were unable to assess those women with mild preeclampsia who progressed to severe or those with gestational or chronic hypertension who progressed to preeclampsia during labor. This certainly may have underestimated those with progression of disease and could account for some of the results that we obtained. We tried to reduce this selection bias by excluding those who were being treated with antihypertensive medications or an admission BP of ≥160/110 mm Hg in women with preeclampsia. Further, on admission no patient in any group had a BP that exceeded 160/110 mm Hg, and the mean arterial BP was remarkably similar among the groups.

Surprisingly, women with gestational hypertension had the greatest risk for maternal ICU admission, and one would have expected them to have the highest incidences of life-threatening events. However, they did not have greater rates of seizures or postpartum hypertension, nor were the rates of thromboses, hysterectomies, or death greater in these women. It is possible that the greater rate of postpartum hemorrhages and need for transfusion accounts for the higher rates of ICU admission in women with gestational hypertension, especially if the clinicians were concerned for disseminated intravascular coagulation. After adjustment for confounding factors, women with mild preeclampsia were found to have the greatest risk for postpartum hypertension, more so even than women with chronic hypertension. None of the groups had increased risk for seizures after adjusted analyses, which supports the idea that mild disease infrequently progressed to this severe disorder.

Another potential weakness that is common to electronic databases is incomplete data entry at each site, which

TABLE 5
Multivariate logistic regression analysis of neonatal outcomes (adjusted)[a]

Neonatal outcomes	Mild chronic hypertension		Gestational hypertension		Mild preeclampsia	
	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI	Adjusted odds ratio	95% CI
Small for gestational age						
<3rd percentile	1.6	1.0–2.4	1.7	1.2–2.5	1.8	1.3–2.7
<10th percentile	1.1	0.9–1.5	1.1	0.9–1.4	1.3	1.1–1.6
Apgar <7 at 5 min	1.9	1.3–2.7	1.0	0.7–1.5	1.6	1.2–2.2
Ventilator use	6.8	4.0–11.6	7.5	4.6–12.4	4.0	2.5–6.6
Respiratory distress syndrome	2.2	1.6–3.2	2.5	1.8–3.4	1.9	1.4–2.6
Asphyxia	0.6	0.2–1.6	1.7	0.9–3.3	1.2	0.7–2.3
Surfactant use	1.3	0.8–2.1	1.7	1.1–2.6	1.5	1.0–2.2
Transient tachypnea of the newborn infant	1.1	0.9–1.4	0.8	0.7–1.0	1.0	0.8–1.2
Pneumonia	1.5	0.7–3.4	2.2	1.1–4.2	2.3	1.2–4.3
Sepsis	0.9	0.7–1.3	1.1	0.8–1.3	1.2	0.9–1.5
Intracranial bleed	2.8	1.7–4.6	2.0	1.2–3.2	3.2	2.1–5.0
Necrotizing enterocolitis	2.5	1.0–6.4	3.2	1.4–7.2	3.0	1.3–6.9
Neonatal seizures	2.0	0.9–4.2	0.9	0.4–2.0	1.0	0.5–2.0
Death	0.6	0.2–1.5	0.6	0.2–1.6	1.0	0.5–2.1

CI, confidence interval.

[a] Multivariate neonatal outcomes: adjusted for maternal age, race, insurance, body mass index, mean arterial pressure on admission, parity, gestational age, number of fetuses, pregestational and gestational diabetes mellitus, renal disease, history of thrombotic event, small for gestational age, smoking, alcohol use and recreational drug use; all comparisons are to the healthy, nonhypertensive control group.

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may result in type II errors. However, a strength of our work is that the electronic data were verified and correlated highly with chart review as demonstrated by Zhang et al.[5] Finally, our control subjects were highly selective. We excluded all women with medical, obstetric, or psychiatric diseases and those who used controlled substances, including cigarette smokers. These exclusion criteria were perhaps so restrictive that we ended with a small control group in comparison with the entire cohort in our database, which could introduce further bias.

The next important issue should be to address maternal and neonatal outcomes at specific gestational ages to assess the optimal timing of delivery for women with gestational hypertension as compared with women with mild chronic hypertension or mild preeclampsia. Although maternal morbidity in some respects may be increased if induction is delayed, implementing induction of labor in women with mild disease at 37 weeks' gestation has the potential for complications that are associated with higher overall induction and cesarean delivery rates and their attendant morbidities, especially in women with an unripe cervix.

In conclusion, women with gestational hypertension had the greatest risks for morbidity among women with mild hypertensive disease. Neonates of mothers with gestational hypertension and mild preeclampsia had greater morbidity compared with neonates of women with mild chronic hypertension. Weighing the risks and benefits and determining the optimal time to deliver women with mild hypertensive disease, while trying to minimize morbidity to mothers and neonates, will continue to challenge the obstetrician. ■

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