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Blood pressure medication use and postpartum hospital readmission among preeclampsia patients

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ABSTRACT

Background: Blood pressure medication is often prescribed to patients with preeclampsia. We are not aware of any study on readmission of those with preeclampsia to the hospital that considers blood pressure medication use or dose.

Methods: This was a retrospective study of 440 preeclampsia patients diagnosed during the antepartum, intrapartum, or immediate postpartum period prior to discharge from the hospital. The outcome was hospital readmission. One analysis compared blood pressure medication (oral labetalol and oral extended release nifedipine) use and nonuse. Another analysis compared low-dose and high-dose blood pressure medication use.

Results: Blood pressure medication use was not significantly associated with readmission (OR: 0.79, 95% CI: 0.39, 1.63, $p = 0.53$). Low dose of blood pressure medication was significantly associated with increased odds for readmission (OR: 2.29, 95% CI: 1.00, 5.25, $p = 0.05$).

Conclusion: We found that low dose of blood pressure medication was associated with increased odds for readmission within 6 weeks among those with preeclampsia. We recommend that clinicians balance the preference to reduce a blood pressure medication dose with the possible concern that too low a dose may place certain patients on track for hospital readmission after discharge.

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KEYWORDS
Preeclampsia; patient readmission; labetalol; nifedipine

Introduction

Preeclampsia occurs in approximately 2–8% of pregnancies and contributes to maternal and neonatal morbidity and mortality (1). Women diagnosed with preeclampsia are at increased risk of developing severe complications that include stroke, cardiac failure, and renal failure (2). It is estimated that US$2.18 billion dollars a year are spent by hospital systems for managing preeclampsia and its complications (3).

The American College of Obstetricians and Gynecologists (ACOG) treatment recommendations for blood pressure and preeclampsia management in the acute inpatient setting include clearly defined algorithms for the administration of intravenous labetalol, oral nifedipine, and intravenous hydralazine (1). Magnesium sulfate is recommended for the management of inpatient preeclampsia (4,5). However, unlike inpatient settings, the prescription of oral management for preeclampsia after delivery lacks a clearly defined protocol for outpatient management from ACOG (1).

A systematic review of 39 studies comparing the efficacy of different postpartum blood pressure management approaches was unable to recommend a preferred approach for outpatient medical management of preeclampsia (6). In oral management of blood pressure issues in pregnancy while an outpatient, the two most common medications used are labetalol and nifedipine (7). A study of postpartum management of hypertensive issues including preeclampsia found that both labetalol and nifedipine were efficacious for blood pressure control with nifedipine being slightly more effective in achieving tight blood pressure control (8).

When studying preeclampsia, it is important to consider certain demographic and medical variables. Increased age, specifically those of advanced maternal age, is associated with increased complications from preeclampsia (9). Those of black race/ethnicity are more at risk for preeclampsia complications associated with severe morbidity and mortality (10). Increased body mass index is associated with increased complications from preeclampsia (11). Patients diagnosed with pregestational diabetes have greater complications from preeclampsia than those without diabetes (12).

To our knowledge, we are not aware of any study on readmission of those with preeclampsia to the hospital

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that considers medication use or dose. In this study, we evaluate the association between blood pressure medication use and dosage with hospital readmission.

Materials and methods

Setting

This was a retrospective study of 440 patients from January 2016 to January 2022 who received the diagnosis of preeclampsia, either with or without severe features, in the antepartum, intrapartum, or immediate postpartum period prior to discharge from the hospital. The setting was a public county hospital that serves lower-income patients in a suburb of New York City. Inclusion criteria were any patients who were discharged from the hospital with a diagnosis containing preeclampsia and received monotherapy of either oral labetalol or oral nifedipine. Providers did not consider older age as a reason for a lower dose. Dose was based upon provider's decision regarding overall blood pressure control. Readmission to the hospital only considered those who were readmitted within 6 weeks with a primary diagnosis of preeclampsia. The reason for readmission was a hypertensive crisis of elevated blood pressure. Patients were typically seen weekly after hospital discharge by an obstetrics/gynecology physician if there were concerns about blood pressure control. None of the patients had their blood pressure medications adjusted before requiring hospital readmission. Patients were excluded if they had gestational hypertension, chronic (essential) hypertension, or were on dual therapy with a combination of labetalol and nifedipine. We excluded those with dual therapy as we wanted to study the individual impact of each medication, there were too few patients receiving dual therapy, and it would be challenging to place those on dual therapy into either a low-dose or high-dose blood pressure group since some had low dose for one blood pressure medication and high dose for another blood pressure medication. For patients with multiple deliveries that included a diagnosis of preeclampsia, only the first delivery was included. Ethical approval was obtained from the Nassau Health Care Corporation Institutional Review Board (IRB#21–400). A waiver for informed consent was obtained due to the retrospective nature of this study.

Variables

Demographic variables were age, race (white, Hispanic, black, and other), and body mass index (kg/m^2). Pregnancy related variables were gravida and parity. Past medical history consisted of pregestational diabetes and gestational diabetes. Preeclampsia history from a previous pregnancy and current pregnancy preeclampsia with severe features as defined by ACOG (1) were recorded. Systolic (mm Hg) and diastolic (mm Hg) blood pressure were from blood pressure taken on the day of discharge from the hospital. Blood pressure medication use was measured as no versus yes. The medications studied were oral labetalol, a beta blocker, and oral extended release nifedipine, a calcium channel blocker. Each medication was also a priori before analyses divided into a high-dose or low-dose category based upon clinical experience for considering dosages. Low dose for labetalol was any combined daily dose less than 599 mg (daily dose totals included 200, 300, and 400 mg), while high dose was any combined daily dose of 600 mg or greater (daily dose totals included 600, 800, 900, 1200, and 1,500 mg). Low dose for nifedipine were those that received 30 mg. High dose for nifedipine were those that received any combined daily dose of 60, 90, or 120 mg. The outcome variable of readmission to hospital within 6 weeks was measured as no versus yes.

Statistical analysis

Mean and standard deviation were used to describe the continuous variables. Frequency and percentage were used to describe the categorical variables. Analysis of variance compared the continuous variables with a normal distribution while the Mann–Whitney test compared the compared the continuous variables with a skewed distribution. The Pearson chi-square test compared the categorical variables except when expected cell size was <5 and where the Fisher's exact test was used. All variables significantly differing in these analyses between the readmission groups were included as covariates in the multivariate logistic regression analyses for the outcome of readmission (Model 1). Exploratory analyses were also conducted for the main predictor variables of no/yes blood pressure medication and high/low blood pressure medication dose. All variables significantly differing in these analyses were included as additional covariates in the multivariate logistic regression analyses that included the main predictor variable when analyzing for the outcome of readmission (Model 2). Receiver operating characteristic analyses were conducted for the multivariate logistic regression models. All p-values were two tailed. Alpha level for significance was $p \leq 0.05$. IBM SPSS Statistics version 28 (IBM Corporation, Armonk, New York, 2021) and Stata SE version 17 (Stata, College Station, Texas, 2021) were used for the analyses.

Results

The sample included 141 (32.0%) patients with no blood pressure medication and 299 (68.0%) patients with blood pressure medication. The blood pressure medications consisted of labetalol ($n = 266$, 89.0%) and nifedipine ($n = 33$, 11.0%). There were 135 (45.2%) patients with high doses of blood pressure medication and 164 (54.8%) patients with low doses of blood pressure medication. There were 44 (10.0%) patients who were readmitted within 6 weeks of their initial hospital discharge. Table 1 shows comparisons for the sample characteristics. Mean age significantly differed ($p = 0.003$) where there was a greater mean for the yes readmission group ($M = 33.6$, SD = 6.31) as compared to the no readmission group ($M = 30.2$, SD = 7.00). Race/ethnicity significantly differed ($p = 0.002$) where the yes readmission group had a greater percentage of blacks (50.0%) and the no readmission group had a greater percentage of Hispanics (63.1%). Systolic blood pressure and diastolic blood pressure mean values and also categorical values showing controlled blood pressure status did not significantly differ between the readmission groups.

We conducted exploratory analyses between the blood pressure medication groups. Preeclampsia with severe features significantly differed between the groups (no: 36.2%, 51/141, yes: 83.6%, 250/299, $p < 0.001$). There were no significant differences between the groups for body mass index (no: $M = 33.4$, SD = 7.21, yes: $M = 34.6$, SD = 6.98, $p = 0.11$) or gestational diabetes (no: 8.5%, 12/141, yes: 13.0%, 39/299, $p = 0.17$).

We conducted exploratory analyses between the dose categories of the blood pressure medication groups. Age significantly differed between the groups (high: $M = 32.4$, SD = 6.43, low: $M = 30.7$, SD = 7.14, $p = 0.03$). Preeclampsia with severe features significantly differed between the groups (high: 90.4%, 122/135, low: 78.0%, 128/164, $p = 0.004$). There were no significant differences between the groups for body mass index (high: $M = 35.0$, SD = 6.80, low: $M = 34.2$, SD = 7.12, $p = 0.30$), gestational diabetes (high: 11.9%, 16/135, low: 14.0%, 23/164, $p = 0.58$), systolic blood pressure controlled (high: 54.8%, 74/135, low: 44.5%, 73/164, $p = 0.08$), or diastolic blood pressure controlled (high: 51.9%, 70/135, low: 45.1%, 74/164, $p = 0.25$).

Table 2 shows the multivariate logistic regression analysis for readmission with the main predictor variable of use of blood pressure medication. Use of blood pressure medication was not significantly associated with readmission in either Model 1 (OR: 0.79, 95% CI: 0.39, 1.63, $p = 0.53$) or Model 2 (OR: 0.73, 95% CI: 0.33, 1.63, $p = 0.45$). Also, increased age was significantly associated with increased odds for readmission in both Model 1 and Model 2 (OR: 1.08, 95% CI: 1.02, 1.13, $p = 0.01$). The area under the receiver operating characteristic curve was 0.70 in both Model 1 and Model 2.

Table 3 shows the multivariate logistic regression analysis for readmission with the main predictor variable of dose category of blood pressure medication. Low dose of blood pressure medication was significantly associated with increased odds for readmission in Model 1 (OR: 2.29, 95% CI: 1.00, 5.25, $p = 0.050$) and approached significance in Model 2 (OR: 2.30, 95% CI: 0.99, 5.36, $p = 0.054$). Also, increased age was significantly associated with increased odds for readmission in both Model 1 and Model 2 (OR: 1.10, 95% CI: 1.03,

Table 1. Comparisons of Sample Characteristics to Readmission.

Variable	No readmission M (SD) or # (%) ($n = 396$)	Yes readmission M (SD) or # (%) ($n = 44$)	p value
Age (years) [mean]	30.2 (7.00)	33.6 (6.31)	0.003
Race/ethnicity			0.002
White	25 (6.3)	3 (6.8)	
Hispanic	250 (63.1)	17 (38.6)	
Black	93 (23.5)	22 (50.0)	
Other	28 (7.1)	2 (4.5)	
Body mass index (kg/m^2) [mean]	34.3 (7.18)	33.3 (5.94)	0.40
Gravida [mean]	2.6 (1.72)	2.9 (1.86)	0.32
Parity [mean]	1.1 (1.30)	1.3 (1.56)	0.69
Diabetes (yes)	15 (3.8)	1 (2.3)	1.00
Gestational diabetes (yes)	47 (11.9)	4 (9.1)	0.59
Preeclampsia history (yes)	51 (12.9)	6 (13.6)	0.89
Preeclampsia severe features (yes)	268 (67.7)	33 (75.0)	0.32
Systolic blood pressure [mean]	125.8 (11.74)	127.8 (9.47)	0.26
Diastolic blood pressure [mean]	76.3 (9.12)	78.1 (7.65)	0.21
Systolic blood pressure ≥130	155 (39.1)	21 (47.7)	0.27
Diastolic blood pressure ≥80	171 (43.2)	24 (54.5)	0.15

Note: M=mean, SD=standard deviation. The skewed variable of parity was analyzed with the Mann–Whitney test. Due to expected cell size < 5, race/ethnicity and diabetes were analyzed with the Fisher's exact test.

Table 2. Multivariate Logistic Regression Analyses for Readmission with a Predictor Variable of Use or Nonuse of Blood Pressure Medication.

Variable	Model 1 OR (95% CI) ($n = 440$)	p value	Model 2 OR (95% CI) ($n = 440$)	p value
Blood pressure medication				
No	1.00		1.00	
Yes	0.79 (0.39, 1.63)	0.53	0.73 (0.33, 1.63)	0.45
Age (years)	1.08 (1.02, 1.13)	0.01	1.08 (1.02, 1.13)	0.01
Race/ethnicity				
White	1.00		1.00	
Hispanic	0.52 (0.14, 1.94)	0.33	0.52 (0.14, 1.95)	0.33
Black	1.78 (0.49, 6.53)	0.39	1.77 (0.48, 6.51)	0.39
Other	0.52 (0.08, 3.43)	0.50	0.54 (0.08, 3.58)	0.52
Preeclampsia severe features (yes)	—	—	1.21 (0.53, 2.77)	0.65

Note: OR=odds ratio, CI=confidence interval.

Table 3. Multivariate Logistic Regression Analysis for Readmission with a Predictor Variable of Low or High Dose of Blood Pressure Medication.

Variable	Model 1 OR (95% CI) ($n = 299$)	p value	Model 2 OR (95% CI) ($n = 299$)	p value
Blood pressure medication				
High dose	1.00		1.00	
Low dose	2.29 (1.00, 5.25)	0.050	2.30 (0.99, 5.36)	0.054
Age (years)	1.10 (1.03, 1.17)	0.01	1.10 (1.03, 1.17)	0.01
Race/ethnicity				
White	1.00		1.00	
Hispanic	0.53 (0.11, 2.71)	0.45	0.54 (0.11, 2.71)	0.45
Black	2.15 (0.44, 10.54)	0.35	2.15 (0.44, 10.56)	0.35
Other	0.39 (0.03, 5.01)	0.47	0.40 (0.03, 5.24)	0.48
Preeclampsia severe features (yes)	—	—	1.02 (0.31, 3.10)	0.97

Note: OR=odds ratio, CI=confidence interval.

1.17, $p = 0.01$). The area under the receiver operating characteristic curve was 0.73 in Model 1 and 0.74 in Model 2.

Discussion

We found that 10.0% were readmitted within 6 weeks of their initial hospital discharge. We found that use of blood pressure medication did not impact the rate of readmission. However, when focusing on dose of blood pressure medication, low medication dose was significantly associated with increased odds for readmission. Also, higher age was significantly associated with increased odds for readmission.

We did not find any association of use versus nonuse of blood pressure medication impacting readmission. Previous research reports that untreated hypertension in pregnancy is associated with increased risk for readmission to the hospital (13). Our findings differ from this pattern. Our study mean for both the untreated and treated groups had systolic blood pressure below 130 mm Hg and diastolic blood pressure below 80 mm Hg while the previous study mean (13) had systolic blood pressure below 140 mm Hg and diastolic blood pressure below 90 mm Hg. It is possible that as our sample was healthier with lower blood pressure that there was no association with readmission to the hospital.

We found that low medication dose was significantly associated with increased odds for readmission. In the additional model based upon the exploratory analysis that included preeclampsia with severe features as a predictor variable, preeclampsia with severe features was not significant and low medication dose approached significance with increased odds for readmission. We are not aware of any literature on blood pressure medication dose level and readmission for pregnant patients. In a study of hospital readmissions due to adverse drug events for patients treated by many disciplines of cardiology, gastroenterology, general surgery, internal medicine, neurology, psychiatry, and pulmonology under prescribing medications was the most common prescribing error associated with increased hospital readmission within 30 days (14). Our findings for preeclampsia and low dose of blood pressure medication are similar to this pattern of under prescribing medications placing patients at increased risk for hospital readmission. We suggest that the low dose of the blood pressure medication did not facilitate adequate control and resulted in the preeclampsia patients being readmitted to the hospital.

We found that higher age was significantly associated with increased odds for readmission. It is well known that increased age in pregnancy increases complications during pregnancy (9,15). Our finding of increased mean age for those readmitted is consistent with what is known about older age as a risk factor for preeclampsia diagnosis and complications in general. Our data suggest that age is an independent risk factor for hospital readmission.

We found that 10.0% were readmitted. The mean all-cause hospital readmission rate in the United States is 15.0% (16). Our findings for preeclampsia indicate that this readmission rate is slightly lower than the all-cause readmission rate.

A strength of this study is that we are the first to study blood pressure medication use among women with preeclampsia and readmission to hospital. This study has several limitations. First, there were only a small number of people treated with nifedipine and therefore we analyzed a combined medication group. Future research should include a larger number of people treated with nifedipine to separately study each medication of labetalol and nifedipine. Second, adherence to medication relied on patient self-report and it is possible that patients readmitted were not adhering to the prescribed medication regimen.

In conclusion, we found that low dose of antihypertensive medication was associated with increased odds for hospital readmission within 6 weeks among those with preeclampsia. We recommend that clinicians balance the preference to reduce a blood pressure medication dose with the possible concern that too low a dose may place certain patients on track for hospital readmission after discharge. We recommend from a public health perspective that ACOG provides outpatient guidelines for the prescription of oral management for preeclampsia after delivery.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [LB], upon reasonable request.

References

[1] Gestational hypertension and Preeclampsia: aCOG practice bulletin summary, number 222. Obstet Gynecol. 2020;135(6):1492–1495. doi:10.1097/AOG.0000000000003892

[2] Sibai B. Etiology and management of postpartum hypertension-preeclampsia. Am J Obstet Gynecol. 2011;206(6):470–475. doi:10.1016/j.ajog.2011.09.002.

[3] Stevens W, Shih T, Incerti D, et al. Short-term costs of preeclampsia to the United States health care system. Am J Obstet Gynecol. 2017;217(3):237–248.e16. doi:10.1016/j.ajog.2017.04.032

[4] Magpie Trial Follow-Up Study Collaborative Group. The Magpie trial: a randomised trial comparing magnesium sulphate with placebo for pre-eclampsia. Outcome for women at 2 years. Br J Obstet Gynaecol. 2007;114(3):300–309. doi:10.1111/j.1471-0528.2006.01166.x

[5] Stefanovic V. International Academy of Perinatal Medicine (IAPM) guidelines for screening, prediction, prevention and management of pre-eclampsia to reduce maternal mortality in developing countries. J Perinat Med. in press. doi:10.1515/jpm-2021-0636

[6] Cairns A, Pealing L, Duffy JMN. Postpartum management of hypertensive disorders of pregnancy: a systematic review. BMJ Open. 2017;7(11):1–14. doi:10.1136/bmjopen-2017-018696.

[7] Webster LM, Myers JE, Nelson-Piercy C, et al. Labetalol versus nifedipine as antihypertensive treatment for chronic hypertension in pregnancy: a randomized controlled trial. Hypertension. 2017;70(5):915–922. doi:10.1161/HYPERTENSIONAHA.117.09972

[8] Ainuddin J, Javed F, Kazi S. Oral labetalol versus oral nifedipine for the management of postpartum hypertension a randomized control trial. Pak J Med Sci. 2019;35(5):1428–1433. doi:10.12669/pjms.35.5.812.

[9] Lamminpää R, Vehviläinen-Julkunen K, Gissler M, et al. Preeclampsia complicated by advanced maternal age: a registry-based study on primiparous women in Finland 1997–2008. BMC Pregnancy Childbirth. 2012;12(1):47. doi:10.1186/1471-2393-12-47

[10] Gyamfi-Bannerman C, Pandita A, Miller EC, et al. Preeclampsia outcomes at delivery and race. J Matern Fetal Neonatal Med. 2020;33(21):3619–3626. doi:10.1080/14767058.2019.1581522

[11] Shao Y, Qiu J, Huang H, et al. Pre-pregnancy BMI, gestational weight gain and risk of preeclampsia: a birth cohort study in Lanzhou, China. BMC Pregnancy Childbirth. 2017;17(1):400. doi:10.1186/s12884-017-1567-2

[12] Weissgerber TL, Mudd LM. Preeclampsia and diabetes. Curr Diab Rep. 2015;15(3):9. doi:10.1007/s11892-015-0579-4.

[13] Lovgren T, Connealy B, Yao R, et al. Postpartum management of hypertension and effect on readmission rates. Am J Obstet Gynecol MFM. 2022;4(1):100517. doi:10.1016/j.ajogmf.2021.100517

[14] Uitvlugt EB, Janssen MJA, Siegert CEH, et al. Medication-related hospital readmissions within 30 days of discharge: prevalence, preventability, type of

medication errors and risk factors. Front Pharmacol. 2021;12:567424. doi: 10.3389/fphar.2021.567424

[15] Glick K, Rottenstreich M. Management of pregnancy in women of advanced maternal age: improving outcomes for mother and baby. Int J Womens Health. 2021;13:751–759. doi: 10.2147/IJWH.S283216

[16] Definitive Healthcare. Average hospital readmission rate by state. 2022. [cited Apr 28, 2023]. Available from: https://www.definitivehc.com/resources/healthcare-insights/average-hospital-readmission-state#:~:text=What%20is%20the%20average%20hospital,from%209.9%25%20to%2022.5%25.