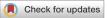
# Factors associated with early readmission for postpartum hypertension



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**BACKGROUND:** Hypertensive disorders of pregnancy are increasing in prevalence and a leading cause of early postpartum readmissions. Stricter blood pressure target goals for treatment of hypertension during pregnancy have recently been proposed, however, the treatment goals for management of postpartum hypertension are less well established.

**OBJECTIVE:** We sought to evaluate the clinical factors associated with early postpartum readmissions for hypertensive disease and to evaluate blood pressure thresholds associated with these readmissions.

**STUDY DESIGN:** We conducted a retrospective cohort study of women delivering at a tertiary care center between January 2018 and May 2022 who experienced a hospital readmission for postpartum hypertension or new onset postpartum preeclampsia. Charts were reviewed for clinical and sociodemographic data. Patients with early readmission (<72 hours after discharge) were compared with patients readmitted after 3 days of initial discharge. Data were analyzed using chi-square, Student *t* test, Mann-Whitney *U* test, and logistic regression where appropriate. The *P* value <.05 was considered significant.

**RESULTS:** During the study period, 23,372 deliveries occurred. Postpartum readmission due to worsening of a known diagnosis of hypertension or new onset postpartum preeclampsia occurred in 1.1% and 0.49% respectively. Patients with early readmission were more likely to have hypertensive disorders of pregnancy as the indication for delivery. Among patients readmitted, 93% had 2 or more systolic blood pressure  $\geq$ 140 mmHg or diastolic blood pressure  $\geq$ 90 mmHg, and 73% had blood pressure of either systolic between 130 and 139 mmHg or diastolic between 80 and 89 mmHg within 24 hours before initial discharge. Only 27 patients met criteria (blood pressure  $\geq$ 160/110 mmHg on >1 vitals check during their hospitalization) to be started on antihypertensives before initial delivery discharge; of those 25 (93%) were discharged with a new prescription for an antihypertensive. After controlling for confounding variables, predischarge blood pressure between 130–140 mmHg/80–90 mmHg (adjusted odds ratio, 2.4 [1.5–4.0]) was associated with an increased likelihood of early readmission.

**CONCLUSION:** Patients with delivery for hypertensive disorders of pregnancy and predischarge blood pressure  $\geq$ 140/90 mmHg were less likely to have an early readmission within 3 days of initial discharge, however, patients with predischarge blood pressure 130–139 mmHg/80–89 mmHg were more likely to have an early readmission for hypertensive disorders of pregnancy and postpartum preeclampsia. Further research is indicated to evaluate interventions to prevent postpartum readmission in patients at high risk for persistent hypertension or new onset postpartum preeclampsia.

Key words: Maternal cardiovascular disease, Postpartum hypertension, Postpartum readmission

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#### Introduction

Rates of postpartum readmission, defined as readmission within the first 6 weeks following delivery, range from 0.4% to 5% depending on the presence of risk factors.<sup>1-4</sup> Common causes for postpartum readmission include postoperative wound complications, infectious morbidity, psychiatric conditions, and nonobstetric medical and surgical diseases.<sup>2,4</sup> However, one of the most common indications for postpartum readmission is hypertensive disease, including preeclampsia. In a recent multistate analysis of postpartum readmissions within the United States, the most common primary diagnosis associated with readmission was hypertensive disorder (9.3%), followed by infection (8.3%)<sup>2</sup> Recent evidence suggests that rates of postpartum readmissions are increasing.<sup>2</sup> This trend is concerning and warrants an increased focus on prediction and interventions to prevent postpartum readmissions.

Risk factors for postpartum readmission for hypertension (HTN) have been well described and include persistent postpartum HTN, increasing maternal age, more severe antepartum HTN and non-Hispanic Black race.<sup>5-7</sup> Despite awareness of risk factors, evidence and guidelines for interventions to prevent readmission remain limited. There are no clear criteria for whom to treat and when to treat them and the treatment goals. In 2017, the American College of Cardiology/American Heart Association (ACC/AHA) revised their definition of HTN in adults by lowering the threshold for diagnosis from  $\geq$ 140/90 mmHg to  $\geq$ 130/80 mmHg. However, the American College of Obstetricians and Gynecologists (ACOG) did not adopt this

# AJOG Global Reports at a Glance

#### Why was this study conducted?

This study aimed to evaluate risk factors associated with postpartum hypertension hospital readmissions.

#### **Key findings**

Mildly elevated postpartum blood pressure (BP), between 130–139 mmHg/ 80-89 mmHg, within the 24 hours before discharge is associated with early readmission, however, indicated delivery for hypertensive disorders of pregnancy and BP  $\geq$ 140/90 mmHg is associated with a decreased likelihood of early readmission.

# What does this add to what is known?

Patients with mildly elevated BP may represent a group that may benefit from closer surveillance and interventions in the postpartum period to reduce hospital readmission.

classification new for pregnancy. Recently updated guidelines advocate for treating mild chronic HTN in pregnancy with a goal blood pressure (BP) of <140 mmHg systolic and 90 mmHg diastolic, representing a lower BP goal than before. However, the recommendations do not extend to the postpartum period. There are no guidelines for BP treatment goals in the postpartum period.<sup>8</sup> Early readmission was defined as admission within 3 days of discharge because these happened before the ACOG recommended BP check within 3 days of discharge. These readmissions within 3 days of discharge are most concerning for preventability and may represent a missed opportunity to prevent postpartum readmissions.

The goal of this study was to evaluate the clinical factors associated with early postpartum readmissions for hypertensive disease and to evaluate BP thresholds associated with these readmissions. We hypothesized that patients with early readmission, compared with those with readmission >3 days after initial discharge, were more likely to have abnormal BP values before delivery hospitalization discharge, representing an opportunity to prevent readmission.

## Materials and Methods Patient selection and study design

We conducted a retrospective cohort study of all patients with an initial hospitalization and delivery discharge in the study hospital between January 2018 to May 2022. We defined postpartum readmission as hospitalization within 42 days of initial delivery discharge. No participants were excluded. Early readmission was defined as an admission within 3 days of discharge from the delivery hospitalization.

Electronic medical records were reviewed to obtain patient demographic characteristics, including age, race and ethnicity, marital status, and insurance. Medical and obstetrical history was obtained, including gravidity and parity, history of diabetes mellitus, mental illness, substance use, diagnosis of chronic HTN (CHTN), delivery gestational HTN (gHTN), and preeclampsia. Delivery admission data obtained included indication for admission and delivery, mode of delivery, indication for cesarean delivery, postpartum complications, neonatal outcomes, and vital signs within 24 hours before initial discharge. Data obtained from readmission hospitalization included chief readmission complaint and diagnosis, time from discharge to readmission, vital signs on readmission, and imaging or surgery necessary on readmission. Hypertensive disorders of pregnancy (HDP) included the diagnoses of preeclampsia, gHTN, CHTN, CHTN with superimposed preeclampsia, hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome, or eclampsia. HDP was listed as the indication for delivery if the clinical diagnosis was the reason for the delivery of the patient.

Preeclampsia, gHTN, eclampsia, and HELLP syndrome were defined based on ACOG definitions.<sup>9</sup> Elevated BP before delivery hospitalization discharge was defined as BP  $\geq$ 140/90 mmHg on 2 separate occasions within 24 hours before discharge, mildly elevated BP was defined as BP between 130–139 mmHg/80–89 mmHg.

### **Hospital protocol**

During the study period, general hospital practice regarding initiation of antihypertensives was such that any patient requiring acute treatment with antihypertensives due to sustained BPs ≥160/ 110 mmHg more than 15 minutes apart or with non-sustained BPs ≥160/110 mmHg that did not necessarily require acute treatment were initiated on a maintenance BP medication. Choice of medication was left to provider discretion based on patient factors and comorbidities. For patients already on maintenance antihypertensive medications (either previously initiated during admission or due to cHTN), the same indications for initiating antihypertensives were used for up-titration of medications.

Typical discharge for uncomplicated vaginal deliveries on postpartum day 1 or 2 and postoperative day 2 or 3 for cesarean deliveries. Any patient with a severe range BP ( $\geq$ 160/110 mmHg) were monitored for an additional 24 hours from that BP such that no patient should have a severe range BP within the 24 hours before discharge. Per ACOG guidelines, hospital practice is to have any patient with any hypertensive disorder of pregnancy scheduled for a BP check within 3 days of discharge from delivery hospitalization.

During the study period, hospital practice included readmission for postpartum patients who presented to the hospital, clinic, or emergency room with BPs  $\geq$ 160/110 mmHg, symptoms of preeclampsia with severe features, superimposed preeclampsia with severe features, and/or eclampsia. For those patients with new onset preeclampsia, treatment included magnesium sulfate infusions for seizure prophylaxis, as indicated, and optimization of antihypertensive medications. Initiation of antihypertensives among patients with severe range BP was under provider discretion. Patients with new onset preeclampsia without severe features may be discharged with close outpatient surveillance. Patients who present with mild range BPs (140/90-160/110) without persistent neurologic symptoms are typically discharged without readmission after observation and after changes to their antihypertensive regimen. Patients with a prior diagnosis of preeclampsia with severe features may be admitted for an observation period to optimize medications or discharged with close outpatient surveillance.

### **Statistical analysis**

There were 2 comparative groups in the cohort: participants readmitted within 3 days of discharge from delivery hospitalization (early readmission) and those readmitted beyond day 3 after discharge. An a priori sample size was not calculated given the retrospective and descriptive nature of the study. Analyses were performed using commercially available software (IBM SPSS Statistics version 27 [IBM Corp, Armonk, NY]). Univariate analyses were used to compare demographic and clinical characteristics. The chi-square test and Fisher exact test were utilized for binomial variables. Wilcoxon rank-sum, Mann -Whitney U test, and Student t test were utilized for discrete and continuous variables where appropriate. A logistic regression was performed for the outcome measure of early readmission. The variables with at least a borderline association (P < .10)on univariate analysis were then included in a regression model to verify which was independently associated with the outcome of interest. Adjustment covariates included obesity, Black race, the delivery indication of HDP, HTN within the 24 hours before discharge defined as systolic ≥140 mmHg, diastolic  $\geq$ 90 mmHg, and hypertension within the 24 hours before discharge defined as systolic ≥130 mmHg, diastolic  $\geq$ 80 mmHg. Nominal 2-sided P

values are reported. The *P* value <.05 was considered statistically significant. A composite adverse outcome was also evaluated, and included stroke, eclampsia, HELLP syndrome, pulmonary edema, heart failure, and intensive care unit admission. This retrospective cohort study was approved by the institutional review board at the University of South Florida (IRB STUDY003943).

### **Results**

There were 23,374 deliveries at our quaternary hospital during the study period; 489 patients were readmitted within 42 days of delivery, representing a 2.1% readmission rate. Of these readmissions, 259 (53%) were due to HDP. Of patients readmitted for HDP, 130 (52.8%) had a previous diagnosis of a hypertensive disorder in pregnancy before discharge from delivery hospitalization, and 116 (47.2%) had no prior diagnosis of hypertensive disease. Overall, the cohort's new onset postpartum preeclampsia rate was 0.49% (Figure). Of those with an existing HDP diagnosis before discharge from delivery hospitalization, 53 had chronic hypertension, and 77 had a pregnancy -related hypertensive disorder, including cHTN with superimposed preeclampsia.

Of all patients readmitted for postpartum hypertension, 41% were evaluated in the clinic before their readmission. Fourteen patients had >1 readmission within 42 days after delivery. The average time to readmission among those with early readmission was  $2.29\pm0.86$ compared with  $7.7\pm4.3$  days, P<.001 in the remainder of the group.

Baseline demographic characteristics are summarized in Table. Those readmitted within 72 hours of discharge and after 72 hours of discharge were similar in sociodemographic and clinical characteristics. There was no difference in comorbidities or mode of delivery. Patients with early readmission were more likely to have a delivery indication of hypertensive disease of pregnancy, mild HTN with 1 or more elevations of either a systolic ( $\geq$  140 mmHg) or diastolic ( $\geq$  90 mmHg) BP, and 1 or more BPs of either systolic BP between 130

and 139 mmHg or diastolic BP between 80 and 90 mm Hg within 24 hours before initial discharge. However, there was no difference in the proportion of patients discharged home with antihypertensive medication, with only 9.6% of the overall cohort meeting criteria to receive a prescription. Of the 187 patients with abnormal BP in the 24 hours before initial discharge, 27 (14.4%) met the criteria to be started on antihypertensive medication, 25 (93%) of which were discharged with a new prescription. The average length of stay for those readmitted within 3 days of initial discharge and those readmitted after 3 days was not statistically different (3.43 vs 3.10 days).

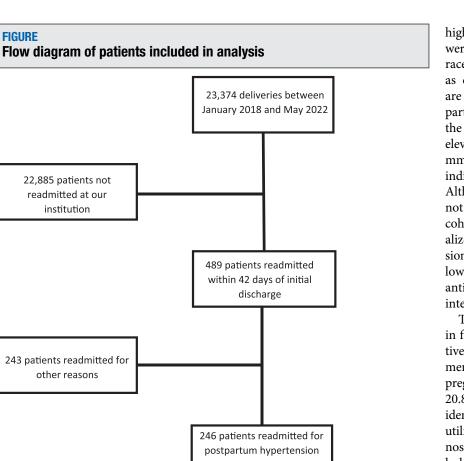
Each readmission was evaluated for a composite adverse outcome which included stroke, eclampsia, HELLP syndrome, pulmonary edema, heart failure, ICU admission. Although not statistically significant, a larger percentage of patients readmitted within 3 days had one of these adverse outcomes (15.4 vs 11.6).

After controlling for confounding variables, predischarge BP between 130 -139/80-89 mmHg (adjusted odds ratio [aOR], 2.4 [1.5-4.0]) was associated with early readmission. Delivery for the indication of HDP (aOR, 0.03 [0.007-0.125]) and a predischarge BP  $\geq$ 140/90 mmHg (aOR, 0.38 [0.23-0.64]) were associated with a decreased likelihood of early readmission. Neither obesity (aOR, 0.82 [0.52-1.3]) nor race (aOR, 0.98 [0.89-1.09]) were associated with an early readmission.

### Discussion

In our study, we found that the majority of patients who were readmitted with postpartum hypertension had mildly elevated blood pressure, defined as BP 130-139 between mmHg/80-89 mmHg, within the 24 hours before initial hospital discharge. After adjusting for confounding variables, mildly elevated BP below the threshold to initiate oral therapy within the 24 hours before discharge was associated with early hospital readmission. However, delivery for HDP and BP ≥140/90 mmHg were associated with a decreased likelihood institution

FIGURE



high proportions of individuals who were of advanced maternal age, Black race, and had comorbid conditions such as diabetes mellitus. These conditions are associated with a high risk of postpartum readmission.<sup>7,10</sup> In addition to the usual risk factors, we found that an elevated BP between 130/80-139/89 mmHg was also more common among individuals who had early readmission. Although many of the risk factors are not modifiable, they may help identify a cohort that may benefit from individualized care plans to prevent readmission. These interventions can include lower thresholds for initiation of oral antihypertensive medication or more intensive home monitoring of BP.

There is a growing body of literature in favor of using lower and more sensitive criteria for the diagnosis and treatof hypertension ment during pregnancy. Bello et al<sup>11</sup> identified a 20.8% improvement in the appropriate identification of future preeclampsia by utilizing a lower BP cutoff for the diagnosis of cHTN during pregnancy. Similarly, several groups identified increased rates of earlier gestational age at delivery, lower birthweight, increased risk of indicated preterm birth, HDP, and gestational diabetes mellitus using lower BP cutoffs.<sup>12–14</sup> A recent randomized clinical trial extended these findings to the postpartum period and investigated the impact of treatment at lower BP thresholds. Patients with postpartum HTN were randomized to initiation of antihypertensive therapy at a threshold of 140/90 mm Hg (tight control) vs 150/95 mmHg (liberal control). The authors found no difference in the composite outcome of maternal morbidity between the groups.<sup>15</sup> Another single center conducted a retrospective cohort study of 19,425 patients. Approximately 24% met the criteria for HDP, and 26.4% of those individuals were discharged on antihypertensive medications. They identified a prescription for nifedipine at the time of discharge as a protective factor that was associated with a reduced risk of readmission compared with no medication or labetalol monotherapy.<sup>16</sup> These studies and our findings highlight the need for more

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91 patients readmitted

within 3 days (early

readmission)

of early readmission. These findings highlight that patients with mildly elevated predischarge BPs are at elevated risk for readmission and postpartum hypertensive complications. Currently, those patients are treated similarly to normotensive patients. However, they may benefit from the same heightened awareness and clinical attentiveness provided to patients delivered for HDP or with demonstrated high BP in the immediate postpartum period.

Carrying a diagnosis of a HDP at the time of delivery is one of the strongest

predictors of readmission. In a study evaluating the rate of readmission in those with prepregnancy HTN or HDP, the rate of readmission in those without a history of HDP or cHTN is as low as 0.15% compared with rates as high as 4.6% in those with superimposed preeclampsia/eclampsia.<sup>1</sup> Our findings are aligned with those reports. Risk factors for admission without an existing HDP diagnosis include cesarean delivery, diabetes mellitus, asthma, and multiple gestations.<sup>3</sup> Our readmissions cohort included a high-risk population with

155 patients readmitted

after 3 days

|  | Early readmission, <3 d | Late readmission, >3 d |                                |
|--|-------------------------|------------------------|--------------------------------|
|  | n=91                    | n=155                  | Unadjusted odds ratio (95% CI) |
| Factors  |                         |                        |                                |
| Uninsured/underinsured   | 42 (46.2)               | 86 (55.5)              | .68 (.409–1.15)                |
| Black race   | 35 (38.5)               | 77 (50.3)              | .61 (.36–1.04)                 |
| Substance use  | 5 (5.5)                 | 11 (11.6)              | .44 (.15–1.23)                 |
| Obesity  | 37 (41.1)               | 90 (58.4)              | .66 (.38–1.13)                 |
| Any diabetes   | 30 (22.2)               | 32 (20.6)              | 1.09 (.58-2.06)                |
| Maternal age >35 y   | 31 (34.1)               | 68 (43.9)              | .66 (.38–1.13)                 |
| Cesarean delivery  | 55 (60.4)               | 96 (61.9)              | .93 (.55–1.59)                 |
| Hypertensive disorder chronic HTN  | 19 (20.9)               | 34 (21.9)              | .94 (.49–1.76)                 |
| Delivery for HDP   | 51 (56)                 | 44 (28.4)              | 3.21 (1.87–5.52) <sup>a</sup>  |
| Delivery hospitalization length of stay, unadjusted mean difference (95% Cl) | 3.43±1.35               | 3.10±2.06              | -0.331 (-0.760 to 0.099)       |
| Predischarge following delivery  |                         |                        |                                |
| BP 130-140/80-90 (mmHg)  | 75 (82.4)               | 106 (68.4)             | 2.17 (1.16–4.09) <sup>a</sup>  |
| SBP $\geq$ 140 or DBP $\geq$ 90 (mmHg)                                       | 58 (63.7)               | 75 (48.4)              | 1.88 (1.10–3.19) <sup>a</sup>  |
| Discharged with medication   | 13 (14.4)               | 12 (7.7)               | 2.10 (.87-4.62)                |
| Readmission course   |                         |                        |                                |
| Severe HTN   | 72 (84.7)               | 145 (95.4)             | 0.27 (0.10-0.70)               |
| Composite adverse outcome <sup>b</sup>                                       | 14 (15.4)               | 18 (11.6)              | 1.41 (0.67-3.00)               |
| Clinic evaluation  | 20 (22)                 | 87 (56.1)              | .22 (.1240) <sup>a</sup>       |
| New onset readmission HDP  | 30 (33)                 | 86 (55.5)              | .44 (.15–1.23)                 |
| Required surgery   | 0                       | 3 (1.9)                | .62 (.56–.68) <sup>a</sup>     |
| Required imaging   | 54 (59.3)               | 70 (45.2)              | 1.77 (1.04–2.9) <sup>a</sup>   |

Data are presented as number (percentage) or mean  $\pm {\rm standard}$  deviation.

*BP*, blood pressure; *CI*, confidence interval; *HDP*, hypertensive disorders of pregnancy; *HTN*, hypertension; *HELLP*, hemolysis, elevated liver enzymes, and low platelet count; *ICU*, intensive care unit; *SBP*, systolic blood pressure.

<sup>a</sup> P=.007; <sup>b</sup> Composite adverse outcome, including stroke, eclampsia, HELLP syndrome, pulmonary edema, heart failure, ICU admission.

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data on the effective use of BP thresholds and the ACC/AHA HTN criteria for diagnosing and treating hypertension during the postpartum period.

Evidence-based guidance for BP goals in the postpartum period is limited. However, experts suggest that controlling BP effectively during this time can improve short-term and long-term outcomes.<sup>9,17</sup> Data are even more limited on the role of lower BP goals in the postpartum period consistent with ACC/AHA definition of HTN (systolic  $\geq$  130 mmHg, diastolic  $\geq$  80 mmHg). Our study found that in the cohort overall, 73% of women readmitted for postpartum HTN had elevated BP by the ACC/AHA criteria within 24 hours before hospital discharge during the delivery admission. This suggests that the ACC/AHA guidelines may be a useful predictor of the postpartum population at risk of persistence and worsening of postpartum HTN and may provide guidance for the establishment of stricter BP goals postpartum.

Future research focused on management of postpartum HTN and subsequently the implications of tighter postpartum BP control are necessary to determine thresholds at which initiation of medication may be indicated.

The strengths of our study include a large and diverse cohort with individual patient-level data leading to improved generalizability. Furthermore, no patients were excluded because all patients included in the cohort had complete data as both their delivery and readmission hospitalizations were within our institution. However, our study has several limitations that should be considered. First, our data comes from a single hospital site, yet several practice groups used it as their delivery site. Although intrapartum HTN treatment is standardized, the postpartum treatment and follow-up were not standardized. We do not have access to data on ambulatory follow-up care due and cannot comment on the role of access to ambulatory care. Our analysis did not include patients with postpartum HTN who were not readmitted, which limits our ability to comment on the cohort with milder HTN. Further, we were not able to account for patients who may have had a readmission at a different area hospital.

#### Conclusions

In conclusion, our study found that most patients readmitted for postpartum preeclampsia had at least 1 elevated BP before initial discharge. In most cases, the elevated BP was not sustained during the delivery admission. Patients with mildly elevated BP may represent a group that may benefit from closer surveillance and interventions in the postpartum period to reduce hospital readmission. Further research is needed to evaluate the benefit of antihypertensive medication and other factors, such as access to follow-up care in patients with mild range BP elevation in the postpartum period.

# CRediT authorship contribution statement

Katherine Pressman: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. Jody Wellcome: Data curation. Chandni Pooran: Data curation. Daniela Crousillat: Methodology, Writing – original draft, Writing – review & editing. Mary A. Cain: Supervision, Writing – original draft, Writing – review & editing. Judette M. Louis: Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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