Best Practices for Managing Postpartum Hypertension

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Accepted: 6 June 2022 / Published online: 20 June 2022
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Abstract

Purpose of Review  Patients remain at risk for persistent and de novo postpartum hypertension related to pregnancy. This review aims to summarize the current definitions, clinical practices, and novel systems innovations and therapies for postpartum hypertension.

Recent Findings  Recent changes to the definitions of hypertension outside of pregnancy have not yet impacted definitions or management of hypertensive disorders of pregnancy (HDP), though research examining the implications of these new definitions on risks of developing HDP and the resultant sequelae is ongoing. The administration of diuretics has been shown to reduce postpartum hypertension among women with HDP. Widespread implementation of telemedicine models and remote assessment of ambulatory blood pressures has increased data available on postpartum blood pressure trajectories, which may impact clinical management. Additionally, policy changes such as postpartum Medicaid extension and an increasing emphasis on building bridges to primary care in the postpartum period may improve long-term outcomes for women with postpartum hypertension. Prediction models utilizing machine learning are an area of ongoing research to assist with risk assessment in the postpartum period.

Summary  The clinical management of postpartum hypertension remains focused on blood pressure control and primary care transition for cardiovascular disease risk reduction. In recent years, systemic innovations have improved access through implementation of new care delivery models. However, the implications of changing definitions of hypertension outside of pregnancy, increased data assessing blood pressure trajectories in the postpartum period, and the creation of new risk prediction models utilizing machine learning remain areas of ongoing research.

Keywords  Hypertensive disorders of pregnancy · Obstetrics · Postpartum care · Telemedicine · Health disparities · Maternal mortality and morbidity

Introduction

Hypertensive disorders of pregnancy (HDP) affect approximately 10% of pregnancies in the USA and are one of the leading causes of maternal morbidity and mortality [1, 2•] and poor perinatal outcomes. They are also a leading cause of postpartum readmissions and associated healthcare costs [3•, 4•, 5, 6].

Theories regarding the pathophysiology of HDP include chronic uteroplacental ischemia, immune maladaptation and genetic imprinting leading to imbalances of angiogenic factors [7••, 8•, 9]. Definitive treatment of antenatal HDP requires delivery. It is now well known that patients with HDP subsequently are at increased risk of chronic hypertension and cardiovascular disease long term [10••, 11, 12]. Prevalence of long-term complications may potentially be related to timing of onset of HDP, as small studies have shown increased prevalence of chronic hypertension among patients with early onset preeclampsia compared with late onset preeclampsia or gestational hypertension [13•].

Postpartum hypertension, which affects approximately 2% of pregnancies, typically refers to hypertension occurring after delivery through 6 weeks postpartum [14, 15••]. This includes patients with both persistent or worsening hypertension following a pregnancy complicated by antenatal HDP and de novo disease following a normotensive pregnancy and delivery. Gestational hypertension and preeclampsia account for the majority of these cases, while
worsening chronic hypertension and superimposed preeclampsia account for the remainder [16]. Postpartum hypertension due to worsening antenatal HDP is typically easier to diagnose because antenatal disease is a clear risk factor for postpartum disease and patients with antenatal HDP are typically subject to increased surveillance postpartum. Other risk factors for postpartum readmission for hypertension include advanced maternal age, multiparity, elevated body mass index, and longer length of labor [17–19]. While more challenging to diagnose, patients with de novo postpartum hypertension have similar clinical risk factors and antepartum plasma angiogenic profiles to patients with antenatal HDP [20•]. Most cases of de novo postpartum hypertension occur within 5–7 days after delivery, when blood pressures peak during the postpartum period and up to 80% of these cases resolve by 6 weeks postpartum [21, 22].

For patients with persistent hypertension past 6 weeks postpartum, small studies have indicated a variety of disease phenotypes. Notably, in an ambulatory blood pressure monitoring study of 115 patients with preeclampsia, 11.6% had masked hypertension after 6 weeks postpartum compared with none of the patients in control groups [23•]. Among women with either a blood pressure available from a postpartum visit or a reported home blood pressure measurement after 3 weeks postpartum, 53.9% met the criteria for stage 1 hypertension and 19.9% met the criteria for stage 2 hypertension. Though race is a social rather than biologic construct—and thus examination of differences by race demonstrate the impact of racism upon health outcomes rather than any biologic factors—study has also shown that persistence of higher blood pressures postpartum was more common in Black women compared to White women [24]. These differences in phenotype and trajectory illustrate potential opportunities for population-based interventions in the postpartum period.

**Current Definitions of Hypertensive Disorders of Pregnancy**

The definitions of hypertensive disorders of pregnancy (HDP) have evolved rapidly in the past decade. Historically, the term “preeclampsia” was used when patients had elevated blood pressures during pregnancy as well as evidence of end organ damage, specifically proteinuria. Since 2013, HDP has been separated into disease without severe features (i.e., elevated systolic blood pressures 140–159 mm Hg or diastolic blood pressures below 90–109 mm Hg) and disease with severe features (i.e., systolic blood pressures above or equal to 160 mm Hg or diastolic blood pressures above or equal to 110 mm Hg or evidence of significant organ damage such as pulmonary edema, neurologic signs or symptoms, or severe laboratory derangements demonstrating acute kidney or hepatic injury or thrombocytopenia) [25••]. The most recent guidelines developed by the American College of Obstetricians and Gynecologists (ACOG) in 2019 no longer require proteinuria to be part of the definition of preeclampsia [26••]. In addition, severe range blood pressures alone can constitute preeclampsia with severe features without other evidence of end organ damage.

It is also important to note that outside of pregnancy, definitions of hypertension have also been changing. In 2017, the American College of Cardiology (ACC) and the American Heart Association (AHA) published stricter guidelines defining class I hypertension, where systolic blood pressures range 130 to 139 mm Hg or diastolic blood pressures range 80–89 mm Hg [27••]. In 2019, updated guidelines from ACOG on chronic hypertension in pregnancy noted that it was reasonable to continue blood pressure treatment for patients previously diagnosed with chronic hypertension outside of pregnancy based on the stricter parameters for class I hypertension but did not redefine the parameters for HDP [28••]. Several studies including a large retrospective cohort of more than 18,000 patients demonstrated an association between class I hypertension and increased risk of HDP, preterm birth, and adverse perinatal outcomes [29•, 30]. Unsurprisingly, a larger proportion—up to 20%—of pregnant patients previously considered normotensive in the postpartum period by older guidelines would be diagnosed with postpartum hypertension if the stricter ACC/AHA guidelines were applied, though the long-term implications of class I hypertension in the postpartum period are not known [31].

**Clinical Management of Postpartum Hypertension**

The clinical management of postpartum hypertension focuses primarily on blood pressure control via use of anti-hypertensive medications both prior to discharge and after discharge, risk reduction for patients with antenatal HDP via use of diuretics postpartum, consideration of magnesium administration for seizure prophylaxis, and clinical surveillance to improve diagnosis during the postpartum period, particularly after discharge.

Postpartum hypertension is diagnostically challenging as it can be quite difficult to predict which patients will develop either worsening hypertension following antenatal HDP or de novo postpartum hypertension, though multiple studies have sought to identify risk factors for postpartum hypertension [5, 32, 33]. Given the challenge in predicting at-risk patients, it is prudent for all patients to receive blood pressure monitoring during the early postpartum period when most cases of postpartum hypertension occur. Innovative healthcare delivery models for remote blood pressure
monitoring, which will be discussed more extensively later in this review, provide a cost-effective solution for widespread surveillance to optimize diagnosis and timely management of postpartum hypertension [34].

Among patients with antenatal HDP, who have a known risk of worsening hypertension in the postpartum period, effective therapies for risk reduction have been an area of ongoing research. Several studies have found that administration of diuretics postpartum can reduce the prevalence of postpartum hypertension among patients with antenatal HDP [35, 36•, 37]. In particular, among patients with antenatal HDP who received a 5-day course of 20 mg furosemide daily, there was a 60% reduction in the prevalence of persistently elevated blood pressure at 7 days, though no difference in postpartum readmissions or need for antihypertensive medications compared to patients who received placebo [36•]. Data from this same trial demonstrates that there were significant differences in blood pressure trajectories among patients who received furosemide compared to placebo; peak blood pressures were noted 3 to 4 days postpartum among patients with severe HDP and 6 to 8 days postpartum among patients with HDP without severe features. We administer 20 mg of oral furosemide nearly universally among patients with HDP, unless there are absolute or relative contraindications which include, but are not limited to allergy to furosemide, specific cardiac lesions, creatinine > 1.2, advanced diabetes (White class C or higher), hypokalemia (K < 3 mEq/L), or preexisting diuretic use. This 5-day postpartum course is usually initiated on the day after delivery.

Acute onset hypertension during pregnancy and postpartum significantly increases the risk of severe maternal morbidity [2•]. In 2019, ACOG published guidelines for the emergent treatment of acute onset, severe hypertension, based on the safety bundle established by the National Partnership on Maternal Safety through the Alliance for Innovation on Maternal Health [38•, 39••]. Both intravenous hydralazine and labetalol are reasonable choices for treatment of severe hypertension in both the antepartum and postpartum period; randomized controlled trials have demonstrated similar efficacy for both agents in terms of resolution of hypertension [40]. When intravenous access is not available or is unlikely to be available in a timely fashion, immediate release oral nifedipine is an effective choice [41, 42]. Ensuring timely treatment, particularly in the postpartum period where patients remain at high risk of cerebrovascular complications though they are no longer pregnant, has been a focus of significant efforts by perinatal quality collaboratives in the USA in the past decade [43]. In 2021, the Society of Maternal Fetal Medicine proposed a hospital-level quality improvement metric for time to treatment of acute onset severe maternal hypertension with target treatment time of less than 60 min [44]. This metric applies to severe hypertension that presents both before and after delivery.

Recommendations regarding initiation of oral medications for management of elevated, but not severe range blood pressures, are more varied. Generally, the goal for blood pressure management with oral medications is to reduce or eliminate the incidence of severe range blood pressures requiring rapid, intravenous treatment, thus reducing risk of severe maternal morbidity and preventable postpartum readmission for blood pressure management and medication titration. ACOG’s Taskforce on Hypertension in Pregnancy recommends initiation of oral medications with systolic blood pressures greater than or equal to 150 mm Hg or diastolic blood pressures greater than or equal to 100 mm Hg. This lower target for the postpartum period is recommended, as there are no fetal concerns of growth with aggressive hypertension treatment after delivery. The choice of oral agent can also be challenging in the postpartum period (Table 1). Typically, obstetricians are comfortable with calcium channel blockers such as nifedipine or amlodipine or beta blockers such as labetalol, which are commonly used in pregnancy. These drugs vary widely in the dosing frequency, where the calcium channel blockers are typically administered once daily and the beta blockers

### Table 1 Summary of oral medications used for postpartum blood pressure management

| Medication                  | Mechanism of action                  | Advantages                                                                 | Disadvantages                        |
|-----------------------------|--------------------------------------|-----------------------------------------------------------------------------|--------------------------------------|
| Labetalol                   | Dual alpha (α1) and beta (β1/β2) blocker | • Safe for lactation, low levels in breast milk                             | • Frequent dosing                    |
| Nifedipine or amlodipine    | Calcium channel blocker               | • Safe for lactation, low levels in breast milk                             | • Once daily dosing                  |
| Enalapril                   | Angiotensin converting enzyme (ACE) inhibitor | • First line medication in non-pregnant adults                              | • Can only be initiated postpartum   |
| Hydrochlorothiazide         | Thiazide diuretic                     | • Acceptable for lactation at doses 50 mg or less                           | • Can only be initiated postpartum   |

Higher doses may decrease breast milk production.
may be administered up to three times per day. Studies have shown that both beta blockers and calcium channel blockers can effectively control blood pressures postpartum [45]. However, first-line medications outside of pregnancy typically include angiotensin converting enzyme inhibitors and angiotensin receptor blockers, for which there are generally limited data for breastfeeding mothers. Of these drugs, the secretion of enalapril may be selectively restricted in breast milk and is not thought to be harmful [46]. Thiazide diuretics are also widely used outside of pregnancy. They do not seem to have adverse neonatal effects but may suppress lactation when used at high doses [47].

Intravenous magnesium is recommended for seizure prophylaxis among patients with antenatal HDP with severe features, but there are limited guidelines dictating administration during the postpartum period in patients with persistent or worsening hypertension or de novo HDP, both in terms of indications and duration of treatment. Specifically, the seizure risk, in patients with de novo postpartum HDP, is unclear. Does a patient with new onset severe blood pressure 7 days from delivery carry the same seizure risk warranting magnesium that a patient with antenatal HDP with severe features does? The answer to this question is unknown thereby leading to significant management variation in patient with presenting with either de novo postpartum hypertension or representing with persistent or worsening severe postpartum hypertension. There is limited data examining the impact of magnesium administration on the incidence of eclampsia among patients with postpartum hypertension [48]. In a meta-analysis of seven randomized controlled trials including 1124 participants and two eclampsia events, a shortened duration of magnesium postpartum was as effective for seizure prophylaxis as the traditional 24-h administration [49]. There is scant data to guide magnesium administration for patients with antenatal disease that demonstrate worsening postpartum hypertension, though the utility is likely limited. Postpartum hypertension in these patients is a worsening of antecedent disease and thus the risk of eclampsia in the postpartum period is likely reduced from the time of their initial diagnosis and per-delivery, thereby not warranting magnesium prophylaxis. This is in clear contrast to patients with de novo postpartum hypertension, as noted above, whose seizure risk at time of new postpartum presentation is unknown. At our institution, we typically initiate magnesium for 12 h for patients with de novo postpartum hypertension with severe features, extending to 24 h if there are other concerning features such as laboratory derangements or persistent neurologic symptoms, as there is data associating prodromal neurologic symptoms with eclampsia [50]. Magnesium dosing should be adjusted based on renal function as the medication is renally cleared; strategies for adjustment include but are not limited to utilizing intermittent serial boluses or decreasing the infusion rate as well as serial magnesium levels.

**Paradigm Shifts in Management of Postpartum Hypertension**

Recently, the clinical management and research surrounding HDP has shifted drastically in response to several key factors (Fig. 1). The advent of the COVID-19 pandemic has accelerated changes in blood pressure monitoring and outpatient management of HDP [51••]. Novel research techniques such as machine learning also demonstrate promise in helping clinicians to better understand patients’ risks related to HDP in the postpartum period [52••]. The prioritization of work aiming to reduce disparities in maternal morbidity and mortality in the USA has shifted policy and clinical paradigms governing the postpartum period along with an increased focus on improving interpregnancy health by augmenting bridges to primary care following pregnancy.
The COVID-19 pandemic augmented ongoing efforts to integrate telemedicine into prenatal and postpartum care [53, 54]. For HDP in particular, the practice of remote blood pressure monitoring either via home blood pressure monitoring – where patients check blood pressures at prescribed intervals themselves and keep a log - or ambulatory blood pressure monitoring – where a machine automatically obtains blood pressures, usually at much shorter intervals, for a 24–48 h period – has been proven to be safe, efficacious, and cost-effective even before the pandemic [55•, 56]. As previously discussed, it can be challenging to identify or predict patients who may develop postpartum hypertension. In the postpartum period, remote blood pressure monitoring holds significant promise for improving rapid diagnosis and effective, low-cost intervention (Table 2). Use of remote blood pressure monitoring increases engagement with postpartum care and reduces racial disparities in postpartum blood pressure ascertainment [57, 58••, 59]. Essential aspects of ensuring an efficacious intervention include (1) utilization of a validated blood pressure cuff, and (2) patient education prior to discharge regarding critical parameters for communication or intervention. At our institution, all patients with antenatal HDP are enrolled in a remote blood pressure monitoring program, where patients submit blood pressures via text messaging for review by providers during the postpartum period [58••]. We have also recently started enrolling low risk patients without antenatal HDP in a separate remote blood pressure monitoring program, with less frequent requests for blood pressure measurements. In addition, postpartum follow-up visits for HDP are predominantly performed via telehealth to maximize access to care. Finally, data on the incidence of postpartum hypertension and trajectories of blood pressures postpartum have historically been limited by loss to follow-up in the postpartum period [60]. Remote blood pressure monitoring serves as a rich new source of data on blood pressure trajectories postpartum, which may facilitate more nuanced research on the true incidence, phenotypes, and management of postpartum hypertension [24, 32].

Table 2 Summary of recent studies examining remote blood pressure monitoring programs for hypertensive disorders of pregnancy

| Article                      | Findings                                                                 |
|------------------------------|--------------------------------------------------------------------------|
| Hirsberg et al. [58••]       | • 92.2% of patients reported a blood pressure postpartum when using a text-based program compared to 43.7% using office-based care |
|                              | • 84% of patients enrolled in the text-based program met ACOG recommendations for reporting blood pressures at specific postpartum timepoints |
|                              | • There was a statistically significant increase in postpartum readmissions for patients utilizing office-based care |
| Hauspurg [24]                | • 83% continued the program beyond 3 weeks postpartum and 74% continued the program beyond 4 weeks postpartum |
|                              | • 88% of patients enrolled in the program attended a 6-week postpartum visit, compared with 66% attendance among women with a hypertensive disorder of pregnancy in the year before implementation |
|                              | • 94% of patients were satisfied with their experience in the remote monitoring program |
|                              | • 93% would recommend the program to others |
|                              | • 96% reported they were comfortable using new technology |
|                              | • 88% did not worry about their privacy |
|                              | • 82% expressed feeling more comfortable knowing a nurse was checking their health daily |
| Hoppe et al. [59]            | • Patients enrolled in a telehealth model with remote blood pressure monitoring had significantly fewer postpartum readmissions than patients enrolled in office-based care |
|                              | • More patients in the telehealth model reported at least one blood pressure in the first 10 days postpartum |
| Quinn and McLaughlin [57]    | • 90% of patients returned for their postpartum visit |
|                              | • More than 30% of enrolled patients received outpatient management of medications, resulting in decreased readmissions |
|                              | • Coordination of care beyond the episode of pregnancy to primary care providers doubled for enrolled patients |
| Niu et al. [34]              | • Telehealth monitoring significantly reduced postpartum readmissions, 3.7% (8/214) versus 0.5% (1/214), and resulted in higher quality-adjusted life years |
|                              | • Average cost of telehealth per patient was $309 and was cost-effective up to a cost of $420 per patient |
|                              | • Telehealth monitoring remained cost-effective down to a readmission cost of $10,999 (compared to baseline estimate of $14,401) |
after delivery, and having antenatal HDP are all predictive of postpartum readmission.

Increased attention to maternal morbidity and pregnancy-related mortality, in which more than half of maternal deaths occur past 42 days postpartum, has led to increased public health campaigns around postpartum health issues and the reconceptualization of the postpartum period by professional organizations and policymakers. These significant changes to the postpartum care paradigm will expand care for patients with postpartum hypertension. Healthcare organizations such as the Preeclampsia Foundation have run national public health campaigns (“Still at Risk”) emphasizing the warning signs and risk factors for postpartum hypertension, recognizing the importance of patient education and advocacy in reducing maternal morbidity. In 2018, ACOG published a committee opinion formally redefining the postpartum period from an arbitrary 6 weeks to an ongoing, individualized process over the fourth trimester [62•]. Attention has also been paid to improving the quality of postpartum care via health system interventions such as the use of patient navigators [63•]. Supplementing the changing definition of postpartum care, ACOG and SMFM have dedicated sustained political support to efforts to extend Medicaid coverage to 12 months postpartum; an increasing number of states, including some Southern states that did not support Medicaid expansion through the Patient Protection and Affordable Care Act, have passed legislation or applied for Centers for Medicare and Medicaid Services waivers for postpartum Medicaid extension [64, 65]. This extended coverage will significantly improve ongoing care beyond the early postpartum period to ensure prioritization on improving long-term health.

Growing understanding of the long-term implications of HDP and other medical complications of pregnancy have led to an increasing focus on building transitions from postpartum care to primary care, which will be essential for the long-term wellbeing of women with postpartum hypertension [66•, 67]. For HDP specifically, researchers have identified risk factors for loss to follow-up postpartum [33] and for persistent hypertension, as previously described. Implementation of transition clinics, where patients with HDP are followed for a longer period of time with services tailored to their specific clinical problem, may significantly improve patients’ acquisition of resources such as home blood pressure monitors [68•]. Generally, populations in these clinics demonstrated high completion of preventive measures such as nutritionist referrals and primary care follow-up appointments, though their rate of triage visits and postpartum readmissions may be higher due to increased engagement with care [68•, 69]. These data highlight the importance of utilizing caution when choosing quality metrics for postpartum care; while postpartum readmissions are a frequently reported metric in health services research, readmissions for HDP are not necessarily all preventable and therefore are not always an indicator of poor quality of care. In fact, heightened surveillance, leading to a necessary readmission, may reflect improved quality of care. Though the long-term cardiovascular disease (CVD) risks associated with HDP are now well known, research has identified significant gaps in postpartum cardiology care for these women [70]. At our institution, we refer all patients with severe preeclampsia in pregnancy who were delivered preterm or were started on an antihypertensive agent to cardiology for follow-up to facilitate more detailed counseling and additional workup given the significantly elevated long-term cardiovascular risk in these patients. While a cardiology referral may not be feasible at all institutions, a referral to primary care with deliberate CVD surveillance and prevention strategies for women with HDP, particularly those with severe disease, should be considered. Use of telemedicine may improve postpartum visit attendance rates, transition to primary care, cardiology follow-up rates as well.

Conclusions

Postpartum hypertension, which affects approximately 2% of pregnancies, typically refers to hypertension occurring after delivery through 6 weeks postpartum, which includes patients with worsening hypertension after antenatal diagnosis of HDP and patients with de novo postpartum hypertension after a normotensive pregnancy and intrapartum course. As of now, changing definitions of hypertension outside of pregnancy has not impacted definitions of hypertensive disorders of pregnancy (HDP). The clinical management of postpartum hypertension remains focused on accelerated diuresis, blood pressure control, and seizure prophylaxis when appropriate. In recent years, systemic innovations have improved access to postpartum blood pressure monitoring through implementation of new care delivery models and new research utilizing machine learning has led to the development of new risk prediction models for postpartum hypertension. The long-term risks of cardiovascular disease related to HDP are now well understood, and legislation expanding insurance coverage has allowed for an increasing focus on postpartum transitions to primary care. Overall, these recent developments in healthcare delivery models, policy reform, and novel therapeutics have significantly improved care for hypertensive disorders of pregnancy in the postpartum period. Continued efforts in this area hold the potential to significantly reduce maternal morbidity and mortality in the USA.
Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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