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ORIGINAL RESEARCH

Seizing the Window of Opportunity Within 1 Year Postpartum: Early Cardiovascular Screening

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BACKGROUND: Our objective was to assess new chronic hypertension 6 to 12 months postpartum for those with hypertensive disorder of pregnancy (HDP) compared with normotensive participants.

METHODS AND RESULTS: We performed a prospective cohort study of participants with singleton gestations and no known preexisting medical conditions who were diagnosed with HDP compared with normotensive women with no pregnancy complications (non-HDP). Participants underwent cardiovascular risk assessment 6 to 12 months after delivery. Primary outcome was onset of new chronic hypertension at 6 to 12 months postpartum. We also examined lipid values, metabolic syndrome, prediabetes, diabetes, and 30-year cardiovascular disease (CVD) risk. Multivariable logistic regression was performed to assess the association between HDP and odds of a postpartum diagnosis of chronic hypertension while adjusting for parity, body mass index, insurance, and family history of CVD. There were 58 participants in the HDP group and 51 participants in the non-HDP group. Baseline characteristics between groups were not statistically different. Participants in the HDP group had 4-fold adjusted odds of developing a new diagnosis of chronic hypertension 6 to 12 months after delivery, compared with those in the non-HDP group (adjusted odds ratio, 4.60 [95% CI, 1.65–12.81]), when adjusting for body mass index, parity, family history of CVD, and insurance. Of the HDP group, 58.6% (n=34) developed new chronic hypertension. Participants in the HDP group had increased estimated 30-year CVD risk and were more likely to have metabolic syndrome, a higher fasting blood glucose, and higher low-density lipoprotein cholesterol.

CONCLUSIONS: Participants without known underlying medical conditions who develop HDP have 4-fold increased odds of new diagnosis of chronic hypertension by 6 to 12 months postpartum as well as increased 30-year CVD risk scores. Implementation of multidisciplinary care models focused on CVD screening, patient education, and lifestyle interventions during the first year postpartum may serve as an effective primary prevention strategy for the development of CVD.

Key Words: chronic hypertension ■ hyperlipidemia ■ hypertensive disorders of pregnancy ■ maternal cardiovascular disease ■ metabolic syndrome ■ postpartum screening

Cardiovascular disease (CVD) is the leading cause of death among women.[1] Pregnancy offers an opportunity for early detection of CVD because it is a physiological vascular stress test. Women with preeclampsia are at increased risk for short-term and long-term CVD. They have a 2-fold increased risk of coronary heart disease and death decades after the pregnancy.[2,3] They also have a significantly increased risk of cardiovascular morbidity 1 to 5 years after a complicated delivery and even as early as the delivery hospitalization.[4–6] Therefore, the American Heart Association (AHA) now recognizes preeclampsia as a

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CLINICAL PERSPECTIVE

What Is New?

- Hypertensive disorder of pregnancy can accurately predict chronic hypertension as early as 6 to 12 months postpartum.
- Women with hypertensive disorder of pregnancy have 4-fold increased odds of new chronic hypertension 6 to 12 months postpartum.
- Women with hypertensive disorder of pregnancy are also at increased risk for elevated fasting blood glucose level, a diagnosis of metabolic syndrome, hyperlipidemia, and elevated 30-year cardiovascular risk score.

What Are the Clinical Implications?

- There is a pressing need for a maternal health assessment during the first year after delivery that should include blood pressure, lipid, and glucose monitoring.
- Structured formal programs via collaboration with cardiologists and obstetricians should be considered as standard of care for all patients with hypertensive disorder of pregnancy.
- Because women are still engaged in care during the postpartum period, it is an ideal window of opportunity to not only screen high-risk women for long-term cardiovascular disease but also to educate patients on their increased cardiovascular disease risk and implement prevention strategies including lifestyle interventions.

Nonstandard Abbreviations and Acronyms

ACOG	American College of Obstetricians and Gynecologists
AHA	American Heart Association
cHTN	chronic hypertension
HDP	hypertensive disorder of pregnancy

risk-enhancer to optimize this unique opportunity for CVD prevention.[7,8] The AHA recently issued a call to action to both providers and health care systems to implement more vigorous primary prevention of CVD during the fourth trimester for women with a history of adverse pregnancy outcomes to mitigate maternal mortality from preventable CVD.[8,9]

Currently, the American College of Obstetricians and Gynecologists (ACOG) recommends that women with hypertensive disorder of pregnancy (HDP) have a 6- to 12-month postpartum CVD risk assessment.[10,11] Canadian data demonstrate that women with preeclampsia have higher 30-year risk for CVD at 1 year postpartum, but limited data exist in the United States on details of postpartum CVD screening strategies.[12] Postpartum CVD screening data in the United States are critical in light of the recent advocacy to expand Medicaid coverage to a year postpartum. Because 80% of CVD is preventable, a postpartum risk assessment has the potential to save lives by identifying risk factors and implementing corrective strategies.[9,13]

Our primary objective was to determine if patients with HDP were at a higher risk of developing chronic hypertension (cHTN) 6 to 12 months postpartum in a diverse US population. We aimed to assess early indicators for cardiovascular morbidity and mortality and to understand CVD risk trajectory within the first year after a pregnancy complicated by hypertension.

METHODS

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

We conducted a prospective cohort study of both multiparous and nulliparous participants with singleton gestations and no known preexisting medical conditions who were diagnosed with HDP compared with normotensive healthy women with no pregnancy complications (non-HDP) at Yale New Haven Health from December 2017 to March 2020 (prepandemic). Participants were recruited from multiple practice groups across the hospital system including private practice groups and university-based groups. Women with cHTN, defined by the ACOG as a systolic blood pressure ≥140 mm Hg and/or a diastolic blood pressure ≥90 mm Hg, before 20 weeks of gestation, were excluded.[14]

HDP was defined as 1 or more of the following diagnoses: gestational hypertension, preeclampsia without severe features, preeclampsia with severe features, or eclampsia. Diagnoses were made by the clinical care team according to ACOG criteria[15] (Table S1). These participants in the HDP group were recruited during contact with the health care system from delivery until 6 months postpartum in a sequential fashion. The electronic health record was reviewed by authors H.S.L. and C.M.A-B. to determine that the participants did not have cHTN diagnosed prepregnancy or within the first 20 weeks of gestation (as per the ACOG definition).

The non-HDP group included participants without hypertension as defined by the ACOG, or any other antenatal obstetrical complication, who delivered at 37 weeks gestation or later. These participants in the non-HDP group were recruited in a similar fashion to the HDP group. The electronic health record of the non-HDP group was also reviewed before inclusion to confirm that they did not develop HDP during the

6 weeks postpartum and did not have cHTN diagnosed prepregnancy or within the first 20 weeks of gestation. At Yale New Haven Health, there are private obstetrics/gynecology practices and university-based practices that include both low-risk and high-risk patients. Recruitment methods were the same for all practice models, and patients in both the HDP and non-HDP cohorts were recruited from both practice models.

Exclusion criteria for both groups included maternal age <18 years, multiple gestations, or non-English primary language, because the informed consent forms were only available in English. In addition, all participants recruited into the study had no evidence of pregestational or gestational diabetes, cardiac disease, renal disease, or autoimmune disease. Because we aimed to compare participants with HDP with a healthy nonexposed group, and patients with placental syndromes have a known increased risk of subsequent CVD, patients with placental syndromes from non-HDP causes were excluded from the non-HDP group (preterm delivery <37 weeks gestation, fetal growth restriction, and placental abruption).[4]

At the study visit 6 months after delivery, metrics collected included measurements of resting blood pressure using an OMRON professional digital blood pressure monitor and performed by trained study staff, weight using a Tanita digital scale, abdominal circumference using a standardized technique, and a fasting blood test to measure glucose, lipid profile, and hemoglobin A1c. Following a standard protocol, research personnel recorded 3 standardized blood pressure measurements using calibrated automatic devices. With the participant seated, blood pressure measurements were recorded, and the average of the blood pressure measurements was used for analysis. All laboratory tests were assessed in the Yale New Haven Health Laboratory. Quality control at the hospital laboratory to assure accuracy of assessments include frequent monitoring of each test by running controls and inspections by a variety of agencies to monitor laboratory quality.

In addition, family history, demographic factors, and other comorbid conditions were collected by the patient's self-report. Because prior literature notes an association of family history of hypertension or cardiovascular disease with subsequent preeclampsia, family history included any first- or second-degree relatives with hypertension, diabetes, and CVD including myocardial infarction or stroke.[16] Participants completed a survey on nutritional status, exercise frequency, sleep activity, and other lifestyle habits. For self-reported race and ethnicity, patients identifying as Hispanic ethnicity (regardless of race) were categorized as Hispanic. Patients self-identifying as Black and of non-Hispanic ethnicity were categorized as Black. All participants were offered a follow-up visit after study participation to review their results, personally discuss their cardiovascular risk, and receive health information from a maternal fetal medicine specialist (authors H.S.L. and C.M.A.-B) after participation. The discussion was performed either in person or by phone as per the subject's preference.

Maternal demographics, socioeconomic status, and pregnancy-specific medical variables were examined as covariates and potential confounders. Clinical data on the index pregnancy and delivery were retrospectively extracted from the electronic health record and supplemented by self-report from a patient survey. Preexisting cardiovascular risk factors obtained from the electronic health record included prepregnancy body mass index (BMI), smoking status, and family history.

The primary outcome was new-onset cHTN (systolic blood pressure >130 or diastolic blood pressure >80), as defined by the 2017 *American College of Cardiology/AHA Task Force Guidelines* (Table S2) or use of an antihypertensive medication for blood pressure control at the 6- to 12-month postpartum study visit.[17] Secondary outcomes include fasting lipid values, metabolic syndrome, prediabetes (hemoglobin A1c ≥5.7% and <6.5%), diabetes (hemoglobin A1c >6.5%), and 30-year risk of cardiovascular disease. Definitions for abnormal results for the secondary outcomes were based on *National Lipid Association Recommendations* and the *International Diabetes Federation Consensus of the Metabolic Syndrome Definition*. (Table S3).[18,19] The 30-year Framingham risk estimate for CVD is a validated and clinically useful calculation using standard risk factors including age, lipid levels, and smoking status, among others. It predicts risk of hard CVD including myocardial infarction, atherosclerotic stroke, and death.[20]

Statistical Analysis

We examined bivariate associations between maternal characteristics and HDP status using a χ^2 test or Fisher exact test, when appropriate, for categorical variables, and Wilcoxon nonparametric test for continuous variables. Multivariable logistic regression was performed to assess the risk of a new diagnosis of cHTN and 30-year CVD risk adjusting for potential confounders chosen a priori because of clinical relevance including BMI, parity, insurance, and family history of CVD. Outcome measures were presented as odds ratios (ORs) and 95% CIs to quantify the risk of cHTN in participants with and without HDP. Analyses were conducted using SAS 9.3 software.

The Yale University School of Medicine Human Investigation Committee approved this study. All patients signed an informed consent before enrollment.

RESULTS

A total of 109 participants participated in the study. Of those, 58 (53.2%) had HDP, and 51 (46.7%) had

no HDP. In the HDP group, 13 (22.4%) had gestational hypertension, 12 (20.6%) had preeclampsia without severe features, 31 (53.4%) had preeclampsia with severe features (severe preeclampsia), and 2 (3.4%) had eclampsia. There were no statistically significant differences in age, race and ethnicity, parity, household income, education level, current smoking status, or marital status between the HDP group and non-HDP group. There were statistically significant differences in BMI and family history for participants with HDP compared with participants with non-HDP ($P<0.05$) (Table 1).

At the 6- to 12-month assessment, participants with HDP were more likely to have a higher fasting blood glucose level, diagnosis of metabolic syndrome, and higher low-density lipoprotein cholesterol. (Table 2). In addition, participants in the HDP group had significantly increased adjusted 30-year CVD risk estimates compared with the non-HDP group ($P<0.001$) (Table 2).

Two participants in the non-HDP group had a hemoglobin A1c of 6.5% or higher without a history of gestational diabetes. One of these participants had a hemoglobin A1c of 8.5% and passed her gestational diabetes screening with an elevated 1-hour glucose challenge test but a normal 3-hour glucose tolerance test. Her family history was significant for cHTN and preeclampsia in her mother and an aunt with diabetes. The other patient had a hemoglobin A1c of 6.5% and also passed her gestational diabetes screening with a normal 1-hour glucose challenge test. Her family history is significant only for diabetes in her mother.

When looking at hypertension at the 6- to 12-month postpartum medical assessment, 46 participants (42.2%) had a new diagnosis of cHTN. Of those 46 participants, 34 (74%) had HDP. For the 34 patients with an HDP who developed new cHTN at 6 to 12 months postpartum, 8 had gestational hypertension, 7 had preeclampsia, and 19 severe preeclampsia. Twelve (26%) women had no HDP during the pregnancy but developed a new diagnosis of cHTN at their postpartum medical evaluation. No patients had a hypertensive crisis, defined as systolic blood pressure >180 or diastolic blood pressure >120, at the 6- to 12-month postpartum medical assessment; however, 1 week after her postpartum medical assessment visit, a patient with HDP and new diagnosis of cHTN went to the emergency department with severely elevated blood pressures consistent with hypertensive crisis.

After adjusting for BMI, parity, and insurance, participants with HDP had almost 4-fold increased odds of a new diagnosis of cHTN 6 to 12 months postpartum compared with normotensive participants (adjusted OR [aOR], 3.98 [95% CI, 1.55–10.22]). When adjusting for BMI, parity, insurance, and maternal age, participants with HDP continued to have 4-fold increased odds of a new diagnosis of cHTN 6 to 12 months postpartum compared with normotensive participants (aOR, 4.09 [95% CI, 1.55–10.79]). When including family history of first- or second-degree relatives with myocardial infarction or cerebrovascular accident into the model, participants with HDP had almost 5-fold increased odds of

Table 1. Participant Characteristics for the HDP Group and the Non-HDP Control

Characteristic	HDP, n=58	Healthy, no HDP, n=51	*P* value
Maternal age, y, n (%)			0.21
<30	9 (15.5)	12 (23.5)	
30-34	28 (48.3)	28 (54.9)	
≥35	21 (36.1)	11 (21.6)	
Maternal age, y, median (IQR)	33.5 (30–35)	32 (30–34)	0.10
Self-reported race and ethnicity, n (%)			0.65
Non-Hispanic White	38 (65.5)	32 (62.7)	
Non-Hispanic Black	13 (22.4)	11 (21.6)	
Hispanic	7 (12.1)	6 (11.8)	
Asian	0 (0.0)	2 (3.9)	
BMI, n (%)			0.04
BMI <30	26 (44.8)	35 (68.6)	
BMI 30-39	20 (34.5)	10 (19.6)	
BMI ≥40	12 (20.7)	6 (11.8)	
Nulliparity, n (%)			0.08
Nulliparous	37 (63.8)	24 (47.1)	
Multiparous	21 (36.2)	27 (52.9)	
Insurance status, n (%)			0.82
Private or hospital health plan	41 (70.7)	35 (68.6)	
Medicaid	17 (29.3)	16 (31.4)	
Education level, n (%)			0.74
High school or less	7 (12.3)	4 (7.8)	
Some college/trade/ BA degree	27 (47.4)	26 (51.0)	
Masters, PhD, and MD degree	23 (40.3)	21 (41.2)	
Household income, n (%)			0.91
<$30 000	8 (13.8)	9 (17.6)	
$30 000-$59 999	7 (12.1)	6 (11.8)	
$60 000-$89 999	6 (10.3)	6 (11.8)	
≥$90 000	28 (48.3)	25 (49.0)	
Declined to answer	9 (15.5)	5 (9.8)	
Smoking, n (%)	4 (6.9)	3 (5.9)	>0.99
Marital status, n (%)			0.35
Married	36 (62.1)	36 (70.6)	
Single	22 (37.9)	15 (29.4)	
US born, n (%)	49 (84.5)	39 (78.0)	0.39
Family history of CVD, n (%)	29 (50)	5 (9.8)	0.03

BMI indicates body mass index; CVD, cardiovascular disease; HDP, hypertensive disorder of pregnancy; and IQR, interquartile range.

Table 2. Incident Hypertension and Fasting Serum Assessment and CVD Risk Assessment at 6 to 12 Months Postpartum for HDP and No HDP

	HDP, n=58, n (%)	Healthy, no HDP, n=51, n (%)	*P* value
Chronic hypertension, 130≤SBP, or 80≤DBP, or antihypertensive medication, n (%)	34 (58.6)	12 (23.5)	0.0002
Hemoglobin A1c, n (%)*			0.08
<5.7%	36 (63.2)	38 (74.5)	
5.7%<6.5%	21 (36.8)	11 (21.6)	
≥6.5%	0 (0.0)	2 (3.9)	
Fasting glucose, mg/dL, n (%)			0.04
<100	51 (87.9)	49 (96.1)	
100<125	7 (12.1)	1 (2.0)	
≥125	0 (0.0)	1 (2.0)	
Metabolic syndrome 6–12 months postpartum, n (%)	12 (20.7)	2 (3.9)	0.01
Total cholesterol, mg/dL, n (%)			0.47
<180	32 (55.2)	35 (68.6)	
180<200	14 (24.1)	8 (15.7)	
200<240	9 (15.5)	7 (13.7)	
≥240	3 (5.2)	1 (2.0)	
HDL cholesterol, mg/dL, n (%)			0.14
<50	20 (34.5)	11 (21.6)	
≥50	38 (65.5)	40 (78.4)	
LDL cholesterol, mg/dL, n (%)			0.04
<100	24 (41.4)	31 (60.8)	
≥100	34 (58.6)	20 (39.2)	
Triglycerides, mg/dL, n (%)			0.21
<150	53 (91.4)	50 (98.0)	
≥150	5 (8.6)	1 (2.0)	
Framingham 30-year CVD risk based on lipids, median (IQR)	7 (5–10)	4 (3–7)	<0.0001

CVD indicates cardiovascular disease; DBP, diastolic blood pressure; HDL, high-density lipoprotein; HDP, hypertensive disorder of pregnancy; IQR, interquartile range; LDL, low-density lipoprotein; and SBP, systolic blood pressure.

*One person missing.

a new diagnosis of cHTN 6 to 12 months postpartum compared with normotensive participants (aOR, 4.60 [95% CI, 1.65–12.81]).

Per the patient survey results, 56% of participants with new cHTN at 6 to 12 months postpartum watched >1 hour of television per day, and 81.8% exercised for <1 hour per day. There were no significant differences in daily exercise, hours spent watching TV, or fruit/vegetable intake for those with new cHTN at 6 to 12 months postpartum compared with participants who were normotensive postpartum. (Table S3).

In addition to the 109 patients who presented to follow-up, 42 signed informed consent but did not present for follow-up. Thus, our non-adherence rate was 27.8%, with 42 out of the 151 initially enrolled patients lost to follow-up. Of the 42 patients who were lost to follow-up, 33% were non-Hispanic White, 27% were Hispanic, 36% were non-Hispanic Black, and 4% were Asian. This represents a higher proportion of non-Hispanic Black and Hispanic women than the group of patients that presented to care. In addition, 62% had Medicaid insurance in the no-show group compared with 30% in the group that presented to care.

DISCUSSION

This prospective cohort study demonstrated that HDP is significantly associated with new cHTN 6 to 12 months postpartum. The participants with HDP were also more likely to have an elevated fasting blood glucose level, a diagnosis of metabolic syndrome, hyperlipidemia, and elevated 30-year cardiovascular risk score.

Our findings are similar to a Canadian prospective cohort study that noted increased blood pressure, total cholesterol, and BMI by 1 year postpartum for patients with preeclampsia.[21] It is also consistent with

data from the US Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-be (nuMoM2b) cohort that note an association of preeclampsia with cHTN 2 to 7 years postpartum.[22] In our study, 12 (23.5%) of the patients with non-HDP had cHTN; this is higher than the 18.9% prevalence of cHTN in the general population of reproductive-aged women.[23] Our study showed that these cardiovascular risk factors can be identified at an earlier time point and that rates within our community may be even higher than previously thought. Recently, the AHA issued a call to action to implement more vigorous, individualized primary prevention of CVD during the fourth trimester through long-term blood pressure monitoring and lipid and glucose assessment.[9] Our results confirm the significant need to improve the current paradigm of fourth-trimester care for women at risk for further hypertension, myocardial infarction, heart failure, and stroke by implementing individualized preventive and corrective strategies.

There is no standardized approach for CVD risk assessment in pregnancy; however, our proposal for a postpartum cardiovascular risk assessment mirrors that of the Maternal Health Clinic, which serves as a model for a primary prevention strategy.[21] In addition, our study responds to the AHA and ACOG call to action by providing novel insight into the application of a formal, structured postpartum risk assessment clinic in an urban academic medical center in the United States.[8,9] As CVD among women increases and threatens their lives, it is crucial to take advantage of opportunities to improve transitions of care for postpartum women at risk of CVD risk and to implement strategies to reduce this risk into both clinical recommendations and health care policy. Women with HDP deserve ongoing individualized care beyond the typical 6 to 8 weeks postpartum time period with blood pressure, lipid, and glucose monitoring.[9] Therefore, advocacy efforts to support federal legislation to extend Medicaid expansion throughout the country is crucial to improve access to preventative and life-saving care for women at high risk of CVD and death.[9]

Our results highlight the importance of optimizing this window of opportunity during the first year postpartum and begins the discussion about how and when to implement clinical and policy changes. Because pregnancy functions as a cardiovascular stress test, pregnancy complications, such as HDP, can accurately identify participants with unrecognized cardiovascular risk factors.[8,22,24,25] Our findings suggest that this known association of HDP and CVD may be evident as early as 6 to 12 months postpartum, as evidenced by the increased incidence of cHTN, metabolic syndrome, elevated fasting glucose, and low-density lipoprotein cholesterol in the HDP group. Because women are still engaged in care during this time period, it is an ideal window of opportunity to not only screen high-risk women for long-term cardiovascular disease but also to educate patients on their increased CVD risk and implement prevention strategies including lifestyle interventions.

Further work to predict who would most benefit from screening in the postpartum period is crucial, especially to assess possible predictors such as family history and social determinants of health. Initial studies demonstrate significant health care disparities among Black, Asian, and Hispanic women who are more likely to experience an adverse pregnancy outcome such as HDP.[8] Thus, future health care implementation improvements and prediction models must incorporate how to better address these health disparities.[8] Development of a prediction model of people at greatest risk of developing cHTN at 6 to 12 months postpartum is clinically useful and can be incorporated into the standard of care to expand recommendations for postpartum CVD screening beyond current recommendations of women with pregnancies complicated by preterm birth, gestational diabetes, or HDP.[9]

In addition to implementing a prediction model while women remain engaged in care during the postpartum period, it is crucial to address many of the current barriers to access to care. For example, the 6-week postpartum visit is historically poorly attended, leaving a major gap in necessary care during the fourth trimester and significantly contributing to staggering obstetric disparities.[26] Recent studies have quoted the no-show rate at about 33% to 40% with postpartum visit nonattendance disproportionately impacting vulnerable patients who are part of a minority racial and ethnic background and depend on state-funded health insurance.[27,28] This trend is also reflected in our results, where there was a higher proportion of patients with Medicaid insurance and a minority racial and ethnic background than the patients who presented to care. This illustrates the racial and socioeconomic disparities of our current health care system. Our colleagues in the Canadian Mothers' Health Education, Research & Screening (MotHERS) Program similarly noted a high canceled or no-show rate within 6 months of 54%.[21] We worked to address this while implementing the Yale Hearts Moms study by enrolling patients around the time of delivery and including a free health assessment, compensation, text messaging services, and individualized education about future risks. This yielded a 28% canceled or no-show rate. In addition, as we are learning from the COVID-19 pandemic, programs that use smart devices and telehealth may be more successful in improving care during this time period, because there are many burdens on newly postpartum patients.[29,30] The Health Hearts 4 Moms randomized trial of an online intervention to reduce CVD risk after a pregnancy complicated by preeclampsia noted

improved CVD risk knowledge and decreased physical inactivity among those who completed the online intervention.[31] Thus, creative solutions to improve outreach services will likely be critical in reducing health care disparities and CVD risk.

Our study included several strengths. Primarily, it is a prospective cohort study with a robust study design. Our study provides novel insight into our population of patients in an urban academic medical center in the United States and confirms the association of cardiovascular risk factors with HDP found with Canadian patients. Furthermore, our study cohort includes a racially and ethnically, and socioeconomically diverse population Although our population was small, it does emphasize the need to perform further analysis on other urban populations.

Our study has several limitations such as the single-center study design and selection bias. Our groups were well balanced in respect to age, race and ethnicity, education level, household income, and insurance; however, there is a concern for selection bias in that women who sought to participate in the study were more concerned about their health risks. Although we included patients in both private practices and university-based high-risk and low-risk practices to minimize the limitation of selection bias, it was impossible to completely eliminate the impact of selection bias. Thus, our results should be interpreted with that limitation in mind. In addition, we found that the rate of developing cHTN was relatively high at 23.5%, and our prevalence of severe hypertension was high at 53.4% of patients in the HDP cohort. This may have biased our results, because we recruited from a large, tertiary-care center. It serves as a referral center for many surrounding states; therefore, there is a higher prevalence of patients with severe preeclampsia and other complications. Even if our population was biased, there could be justification for not only considering cardiovascular risk evaluation in those who had experienced HDP, but rather for all postpartum women.

These significant results demonstrate that HDP can accurately predict cHTN as early as 6 to 12 months postpartum in an urban cohort in the United States, and that there is a pressing need for a maternal health assessment during the first year after delivery. Structured formal programs including risk assessments, patient education, and lifestyle interventions should be considered as standard of care for all patients with HDP. This early postpartum intervention has great potential to alter the trajectory of cardiovascular disease and prevent cardiovascular morbidity and mortality for women. Development of the ideal risk assessment, prediction models, and intervention strategies are critical, as are advocacy efforts to expand access to this care in the first year postpartum.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Table S1–S3

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SUPPLEMENTAL MATERIAL

Table S1. Diagnostic Criteria for Preeclampsia.

New onset hypertension:	Systolic Blood Pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg on 2 occasions at least 4 hours apart after 20 weeks gestation	**OR**	Systolic Blood Pressure ≥ 160 mmHg or diastolic blood pressure ≥ 110 mmHg
AND			
Proteinuria:	Protein ≥ 300 mg in 24 hour urine	**OR**	Protein/creatinine ratio ≥0.3
OR **in the absence of proteinuria, new onset hypertension and one or more of the following**:	Thrombocytopenia	Renal Insufficiency	Impaired liver function
	Pulmonary edema	New, refractory headache	

Table S2. Diagnostic Criteria for Primary and Secondary Outcomes.

Blood Pressure Category*	**Systolic Blood Pressure (mm Hg)**		**Diastolic Blood Pressure (mm Hg)**
Normal	< 120	And	<80
Elevated	120-129	And	<80
Stage 1 Hypertension	130-139	Or	80-90
Stage 2 Hypertension	>139	Or	>90
Hypertensive Crisis	>180	And/or	120
Metabolic Syndrome**			
	Central Obesity	**AND**	**At least 2 of the following:**
	BMI > 30 kg/m^2		triglycerides $\geq$ 150 mg/dl
	Or		HDL cholesterol <50 mg/dl
	Waist circumference >80 cm		systolic blood pressure > 129 mmHg or diastolic blood pressure > 84 mmHg

			fasting glucose ≥ 100 mg//dl.
Classifications of cholesterol and triglyceride levels in mg/dl* **			
LDL-C			
Desirable	<100		
Above Desirable	100-129		
Borderline High	130-159		
High	160-189		
Very High	≥190		
Triglycerides			
Normal	<150		
Borderline High	150-199		
High	200-499		
Very High	≥500		

*As defined by ACC/AHA[17]
** As defined by International Diabetes Federation[19]
***As defined by the National Lipid Association Recommendations[18]

Table S3. Exercise and lifestyle and HTN at 6-12 months postpartum.

	HTN at 6 months (stage 1 and higher)	Normotensive or elevated at 6 mos	p-value
	N (%)	N (%)	
Lifestyle Score – median (IQR)*	23 (21-26.5)	25 (23-26)	0.45
Hours of TV per day*			0.11
<1 hr	19 (43.2)	37 (58.7)	
>1 hr	25 (56.8)	26 (41.3)	
Hrs of video/computer/day*			0.90
<=1hr	26 (56.1)	38 (60.3)	
2+ hrs	18 (40.9)	25 (39.7)	
How much daily exercise?*			0.75
<1 hr	36 (81.8)	53 (84.1)	
>1 hour	8 (18.2)	10 (15.9)	
Where do you eat most meals?*			0.57
Bedroom (1) or living room (2)	17 (38.6)	21 (33.3)	
Kitchen/dining room (3)	27 (61.4)	42 (66.7)	
Do you watch TV while eating?* (Y or N)	25 (56.8)	36 (57.1)	0.97
How often do you eat daily meals together? †			0.50
None or once	27 (61.4)	42 (67.7)	

2-3 times	17 (38.6)	20 (32.3)	
Vegetable Servings per day?*			0.46
None or 1	17 (38.6)	20 (31.8)	
2+	27 (61.4)	43 (68.2)	
Sugary Drinks Servings per day?*			0.72
None	25 (56.8)	38 (60.3)	
1+	19 (43.2)	25 (39.7)	

*n=3 missing

†n=2 missing