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ORIGINAL ARTICLE

Prediction of pregnancy-induced hypertension by a shift of blood pressure class according to the JSH 2009 guidelines

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Elevated blood pressure (BP) at early or mid pregnancy is a known risk factor for pregnancy-induced hypertension (PIH). However, the association between BP changes during the first half of pregnancy and subsequent PIH development is unknown. We used changes in maternal BP between 16 and 20 weeks of gestation to evaluate the risk of PIH. A total of 976 pregnant women with BP estimations recorded before 16 weeks and at 20 weeks of gestation participated in this study. BPs were classified by the Japanese Society of Hypertension 2009 Hypertension Treatment Guidelines (JSH 2009). There was a significant trend for future PIH in women whose JSH 2009 BP class increased between 16 and 20 weeks of gestation, and the risk of PIH was highest among women whose BP was Class IV Hypertension (systolic BP $\geqslant$ 140 mm Hg and/or diastolic BP $\geqslant$ 90 mm Hg). The risk of PIH increased in women whose BPs shifted from Classes I Optimal (systolic BP $<$ 120 mm Hg and diastolic BP $<$ 80 mm Hg) and II Normal (systolic BP 120–129 mm Hg and/or diastolic BP 80–84 mm Hg) before 16 weeks to Class III High-Normal (systolic BP 130–139 mm Hg and/or diastolic BP 85–89 mm Hg) at 20 weeks of gestation. These shifts in BP class were significantly correlated with the risk of PIH after adjustments for variables (*P*-value for trend $<$0.05). Within JSH 2009 Classes I, II and III, a shift in BP from a low to a high class between 16 and 20 weeks of gestation predicts the subsequent development of PIH.
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INTRODUCTION

Pregnancy-induced hypertension (PIH) refers to high blood pressure (BP) during pregnancy. PIH affects 3–10% of all pregnancies[1–3] and is associated with high levels of maternal, fetal, and neonatal morbidity and mortality.[1,4,5] Furthermore, the long-term prognosis of women with a history of PIH includes increased risks of cerebrovascular disease, ischemic heart disease and renal disease.[6–12] These data indicate that the early identification, and subsequent monitoring and management of PIH are critical for maternal and fetal well-being.

In normotensive women, BP in early pregnancy decreases up to 20 weeks of gestation, and gradually increases to normal or higher than pre-pregnancy levels before delivery.[13,14] A diagnosis of PIH includes a BP $>$ 140/90 mm Hg in the late second or third trimester. Previous studies described successful screening for PIH development following a single estimation of maternal BP. However, the false positive rate and sensitivity of these studies varied widely, from 7 to 52% and 8 to 93%,[15–19] respectively, indicating that this method is not sufficient for effective PIH prediction. In contrast, systematic monitoring of changes in BP during the early to mid stages of pregnancy may predict the development of PIH more exactly. Systematic sampling with 48-h ambulatory BP monitoring indicated that PIH was associated with a stable BP in the first half of gestation and a greater increase to delivery than in healthy pregnancies.[20] In addition, the development of PIH in women with low education levels was related to the absence of a significant fall in diastolic BP at mid pregnancy compared with healthy pregnancies in women with higher education.[21] These data indicate that information describing the changes in BP during early to mid pregnancy may be more predictive of subsequent PIH development than data recorded at a single measurement.

In the present study, we examined whether BP changes from early to mid gestational age are capable of predicting the development of PIH. BP was classified according to the JSH 2009 for easy clinical use.[22]

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METHODS

Study population and design

Our investigations are part of the Tokyo-Children's Health, Illness and Development Study. This is a unicenter, longitudinal, prospective observational birth cohort study conducted at the National Center for Child Health and Development (Tokyo, Japan). The aims of this cohort study are: (1) to investigate the influence of maternal weight gain and nutrition during pregnancy on the birth weight, growth and development of infants, (2) to identify the influence of maternal environment on the development of childhood allergies, (3) to study the influence of the prenatal and perinatal environment (fetus) on the psychological and psychiatric development of the infant, (4) to study the influence of parental attitude and knowledge about child rearing on the parent–child relationship and the development of children and (5) to determine the feasibility of using an electronic medical record system to conduct a birth cohort study. The participants in the Tokyo-Children's Health, Illness and Development Study were recruited at their first antenatal visit, before 16 weeks of gestation, from October 2003 to December 2005. Institutional review boards at the National Center for Child Health and Development approved our investigations.

We used the cohort data to analyze the relationship between BP changes during the first half of pregnancy and the onset of PIH. Our inclusion criteria accepted only participants with BP estimations recorded before 16 weeks and at 20 weeks of gestation (18–22 weeks of gestation), and who delivered at our institution after 22 weeks. Subjects with multiple gestations, pre-existing hypertension and pre-existing proteinuria were excluded. A total of 1019 women were initially included, from which 43 cases were excluded because of mismatched selection criteria and loss of information; therefore, data from 976 women were used in our analyses (Figure 1).

Measurement and classification of BP

After 5 min rest, BP was measured in the sitting position with the right arm held at heart level, using an automated sphygmomanometer (Omron BP-203RVIII oscillometer; Nippon Colin, Tokyo, Japan). BP monitoring was performed at two time points: before 16 weeks and between 18 and 22 weeks of gestation. If BP was measured on several occasions before 16 weeks, the average systolic and diastolic values were evaluated.

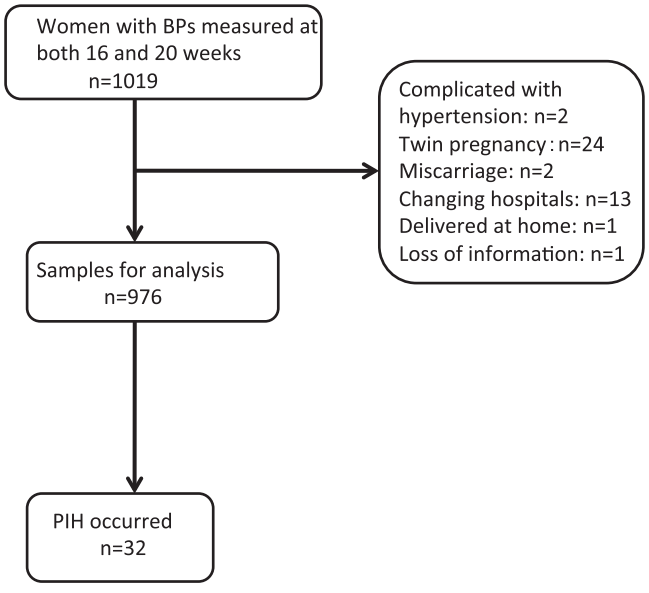

Figure 1 Flow diagram showing sample selection for our analyses. A total of 1019 pregnant women with BP estimations recorded before 16 weeks and at 20 weeks of gestation (18–22 weeks of gestation) were initially included in the study; 976 subjects were enrolled because of mismatched selection criteria and loss of information. Pregnancy-induced hypertension occurred in 32 women. BP, blood pressure; PIH, pregnancy-induced hypertension.

BPs were stratified into four groups based on Japanese Society of Hypertension 2009 Hypertension Treatment Guidelines (JSH 2009):[22] Class I (Optimal), systolic BP <120 mm Hg and diastolic BP <80 mm Hg; Class II (Normal), systolic BP 120–129 mm Hg and/or diastolic BP 80–84 mm Hg; Class III (High-Normal), systolic BP 130–139 mm Hg and/or diastolic BP 85–89 mm Hg; Class IV (Hypertension), systolic BP $\geqslant 140$ or diastolic BP $\geqslant 90$ mm Hg.

Definition of PIH

PIH was defined according to Guideline 2009 for care and treatment of hypertension in pregnancy by the Japan Society of the Study of Hypertension in Pregnancy[23] as: 'hypertension with or without proteinuria occurring after 20 weeks of gestation but resolving by twelve weeks postpartum.'. We excluded superimposed PIH, defined as: 'pre-existing hypertension with new onset of proteinuria after 20 weeks of gestation, or pre-existing proteinuria with new onset of hypertension.'

Other baseline data

Information describing sociodemographic, medical and behavioral data, past medical history, previous pregnancy complications, family history of hypertension or diabetes mellitus, smoking, education, family income and delivery were collected from the database of the cohort study.

Statistical analysis

Student's *t*-test and Mann–Whitney *U*-test were performed for analysis between two continuous variables, and χ^2-test or Fisher's exact test was used for discrete variables. The influence of BP class on the development of PIH was assessed by multiple logistic regression analysis. The probability of PIH occurrence was determined from the shifts in BP classes between 16 and 20 weeks of gestation and evaluated with odds ratios and *P*-values. All analyses were performed with the SPSS software (version 18 for Windows; SPSS, Chicago, IL, USA). $P<0.05$ was considered statistically significant.

RESULTS

Patient characteristics

Baseline patient characteristics are shown in Table 1. In 976 participants, 32 of the index pregnancies (3.3%) were eventually complicated with PIH. There were no significant differences in the gestational ages of participants at the times of BP monitoring. Maternal age, maternal pre-existing diabetes mellitus and previous history of PIH were significantly different between the PIH and non-PIH groups. Other variables (pre-pregnancy body mass index, rate of nulliparity, maternal pre-existing renal disease, previous pregnancy history of fetal growth restriction and placental abruption, rate of smoking, educational levels, distribution of family income, family history of diabetes mellitus, hypertension, ischemic heart disease, cerebrovascular stroke, chronic renal disease) were similar.

Pregnancy and delivery outcomes

Pregnancy and delivery outcomes in the non-PIH and PIH groups are shown in Table 2. The gestational age of delivery was significantly lower and the rate of preterm delivery was higher in the PIH group compared with non-PIH subjects. The rate of normal vaginal delivery was significantly lower and the rate of instrumental delivery was higher in the PIH group. The frequency of cesarean section (both planned and emergency) was similar between both groups. Placental weight and neonatal birth weight were significantly lower in the PIH group, and the number of neonates with an Apgar score of $\leqq 7$ at 5 min was significantly higher.

Analysis for PIH risk based on BP classification

Table 3 shows the crude and adjusted odds ratios, and confidence intervals of PIH occurrence according to class of BP (based on JSH

Table 1 Baseline characteristics of the PIH and non-PIH groups

Characteristics		*All* (n=*976*)	*PIH group* (n=*32*)	*non-PIH group* (n=*944*)	P-*value*
Maternal age (years)	mean (s.d.)	33.6 (4.1)	35.3 (4.5)	33.5 (4.1)	0.028
Maternal height (cm)	mean (s.d.)	159.4 (5.1)	158.7 (5.5)	159.4 (5.1)	NS
Maternal pre-pregnancy body weight (kg)	mean (s.d.)	51.3 (6.5)	52.0 (8.0)	51.3 (6.5)	NS
Pre-pregnancy BMI ($kg\,m^{-2}$)	mean (s.d.)	20.2 (2.4)	20.6 (2.4)	20.2 (2.4)	NS
Parity					
0	*n* (%)	489 (50.1)	19 (59.4)	470 (49.8)	NS
≧1	*n* (%)	487 (49.9)	13 (40.6)	474 (50.2)	
Mean gestational age before 16 weeks blood pressure	mean (s.d.)	14.3 (1.0)	14.3 (1.0)	14.2 (1.1)	NS
Mean gestational age at 20 weeks blood pressure	mean (s.d.)	20.0 (1.2)	20.0 (1.2)	20.1 (1.2)	NS
Maternal pre-pregnancy complications					
Diabetes mellitus	*n* (%)	6 (0.6)	2 (6.3)	4 (0.4)	0.014
Renal disease	*n* (%)	2 (0.2)	1 (3.1)	1 (0.1)	NS
Previous pregnancy complications					
PIH	*n* (%)	12 (1.2)	4 (12.5)	8 (0.8)	<0.001
Fetal growth restriction	*n* (%)	5 (0.5)	1 (3.1)	4 (0.4)	NS
Placental abruption	*n* (%)	2 (0.2)	1 (3.1)	1 (0.1)	NS
Smoking					
Never or former	*n* (%)	944 (96.9)	31 (96.9)	913 (96.9)	NS
Current	*n* (%)	30 (3.1)	1 (3.1)	29 (3.1)	
Education (high school or less)	*n* (%)	94 (10.1)	4 (12.9)	90 (10.0)	NS
Income (per year)					
<4 million yen	*n* (%)	55 (6.2)	3 (10.0)	52 (6.0)	NS
<6 million yen	*n* (%)	202 (22.6)	6 (20.0)	196 (22.7)	
<8 million yen	*n* (%)	198 (22.2)	9 (30.0)	189 (21.9)	
<10 million yen	*n* (%)	192 (21.5)	4 (13.3)	188 (21.8)	
over 10 million yen	*n* (%)	246 (27.5)	8 (26.7)	238 (27.6)	
Family History					
Diabetes mellitus	*n* (%)	73 (7.5)	0 (0.0)	73 (7.7)	NS
Hypertension	*n* (%)	72 (7.4)	4 (12.5)	68 (7.2)	NS
Ischemic heart disease	*n* (%)	38 (3.9)	1 (3.1)	37 (3.9)	NS
Cerebrovascular stroke	*n* (%)	18 (1.8)	0 (0.0)	18 (1.9)	NS
Chronic renal disease	*n* (%)	8 (0.8)	0 (0.0)	8 (0.8)	NS

Abbreviations: BMI, body mass index; NS, not significant; PIH, pregnancy-induced hypertension; s.d., standard deviation.

2009) before 16 weeks of gestation. Although the risk of PIH was significantly higher in Class III and IV subjects without adjustments for any variables, these risks became insignificant after variables were accounted for. However, the trend of PIH occurrence was statistically significant, regardless of any adjustments.

Table 4 demonstrates the crude and adjusted odds ratios of PIH occurrence based on BPs at 20 weeks of gestation. The risk of PIH was significantly greater in all Class II, III and IV subjects with or without adjustments for variables.

BP class shift from 16 weeks to 20 weeks gestation and the risk of PIH occurrence

Table 5 shows the shifts in BP classes between 16 and 20 weeks of gestation, and their associations with PIH occurrence. Odds ratios and 95% confidence intervals were calculated based on each BP class before 16 weeks of gestation. Women with Class IV (Hypertension) BPs before 16 or at 20 weeks of gestation were excluded, because they were already considered high risk for PIH as indicated in Tables 3 and 4.

The subjects with BPs that did not shift class between 16 and 20 weeks of gestation were referred to as baseline. The risk of PIH occurrence was significantly higher in subjects whose BP shifted from Class I at 16 weeks to Class III at 20 weeks of gestation. The risk of PIH occurrence was not statistically significant in subjects whose BP shifted from Class I to II at 16 and 20 weeks of gestation, respectively; however, the trend for PIH risk was significant (*P*-value for trend <0.05) and remained significant even after adjustments for all variables. When comparing two groups, one in which the BP class elevated to Class II or III at 20 weeks gestation and the other in which the BP class did not change, the sensitivity, false positive rate and positive predictive value of BP class elevation between 16 and 20 weeks of gestation were 33.3, 10.8 and 7.4%, respectively. The risk of PIH occurrence was significantly higher in subjects whose BP shifted from Class II at 16 weeks to Class III at 20 weeks of gestation, although this

Table 2 Pregnancy and delivery outcomes of the PIH and non-PIH groups

		All (n=*976*)	*PIH group* (n=*32*)	*non-PIH group* (n=*944*)	P-*value*
Gestational age (weeks)	mean (s.d.)	39.1 (1.8)	37.8 (1.9)	39.1 (1.7)	<0.001
<37	*n* (%)	59 (6.0)	11 (34.4)	48 (5.1)	<0.001
≧37	*n* (%)	917 (94.0)	21 (65.6)	896 (94.9)	
Stillbirth	*n* (%)	2 (0.2)	1 (3.1)	1 (0.1)	NS
Delivery mode					
Normal vaginal delivery	*n* (%)	614 (62.9)	11 (34.4)	603 (63.9)	<0.001
Instrumental delivery	*n* (%)	152 (15.6)	11 (34.4)	141 (14.9)	0.01
Total Cesarean section	*n* (%)	208 (21.3)	10 (31.3)	198 (21.0)	NS
Planned cesarean section	*n* (%)	124 (12.7)	6 (18.8)	118 (12.5)	NS
Emergency cesarean section	*n* (%)	84 (8.6)	4 (12.5)	80 (8.5)	NS
Placental weight (g)	mean (s.d.)	558.4 (104.6)	513.0 (100.9)	560.0 (104.4)	0.022
Birth weight (g)	mean (s.d.)	3003.6 (421.8)	2618.7 (538.7)	3016.6 (411.3)	<0.001
Head circumference (cm)	mean (s.d.)	33.1 (1.4)	32.4 (1.7)	33.2 (1.4)	0.007
Chest circumference (cm)	mean (s.d.)	31.5 (1.7)	30.0 (2.0)	31.6 (1.7)	<0.001
Apgar score at 5 min of ≦7	*n* (%)	18 (1.8)	3 (9.4)	15 (1.6)	0.02

Abbreviations: NS, not significant; PIH, pregnancy-induced hypertension; s.d., standard deviation.

Table 3 Unadjusted and multivariable adjusted ORs (95% CIs) of PIH occurrence classified by blood pressure before 16 weeks of gestation

	<16 weeks blood pressure OR (95% CI)				
Classification	*I*	*II*	*III*	*IV*	
n	*713*	*189*	*59*	*15*	
PIH	*18*	*7*	*5*	*2*	P *for trend*
Unadjusted	1	1.49 (0.61–3.61)	3.58 (1.28–10.00)	5.94 (1.25–28.28)	0.003
Age adjusted	1	1.51 (0.62–3.68)	3.25 (1.15–9.19)	5.15 (1.07–24.90)	0.006
Age+BMI adjusted	1	1.52 (0.62–3.71)	3.26 (1.12–9.54)	5.17 (1.03–25.94)	0.008
age+BMI+parity adjusted	1	1.51 (0.62–3.71)	3.13 (1.06–9.21)	5.59 (1.09–28.60)	0.009
Age+BMI+pre-existing DM adjusted	1	1.55 (0.63–3.83)	3.25 (1.08–9.77)	5.81 (1.16–29.16)	0.007
Age+BMI+pre-existing renal disease adjusted	1	1.62 (0.66–3.99)	3.49 (1.19–10.28)	5.56 (1.10–27.99)	0.005
Age+BMI+family history of HTN adjusted	1	1.51 (0.61–3.69)	3.22 (1.10–9.49)	5.53 (1.10–27.89)	0.008
Age +BMI+previous history of PIH adjusted	1	1.38 (0.55–3.45)	2.80 (0.92–8.47)	3.86 (0.70–21.36)	0.032
Fully adjusted (all above)	1	1.50 (0.59–3.82)	2.71 (0.85–8.63)	5.41 (0.90–32.50)	0.025

Abbreviations: BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; HTN, hypertension; OR, odds ratio; PIH, pregnancy-induced hypertension.

Table 4 Unadjusted and multivariable adjusted ORs (95% CIs) of PIH occurrence classified by blood pressure at 20 weeks of gestation

	20 weeks blood pressure OR (95% CI)				
Classification	*I*	*II*	*III*	*IV*	
n	*782*	*143*	*44*	*7*	
PIH	*14*	*7*	*9*	*2*	P *for trend*
Unadjusted	1	2.82 (1.12–7.12)	14.11 (5.72–34.81)	21.94 (3.92–122.90)	<0.001
Age adjusted	1	2.78 (1.10–7.05)	13.57 (5.45–33.78)	19.10 (3.32–109.76)	<0.001
Age+BMI adjusted	1	2.89 (1.14–7.36)	14.84 (5.76–38.37)	21.02 (3.57–123.61)	<0.001
Age+BMI+parity adjusted	1	2.84 (1.11–7.24)	14.66 (5.68–37.84)	19.34 (3.23–115.71)	<0.001
Age+BMI+pre-existing DM adjusted	1	2.94 (1.15–7.50)	13.94 (5.29–36.73)	22.76 (3.85–134.50)	<0.001
Age +BMI+pre-existing renal disease adjusted	1	2.95 (1.16–7.54)	13.94 (5.31–36.62)	21.63 (3.66–127.85)	<0.001
Age+BMI+family history of HTN adjusted	1	2.88 (1.13–7.34)	14.40 (5.53-37.46)	21.58 (3.66–127.38)	<0.001
Age +BMI+previous history of PIH	1	2.98 (1.15–7.76)	13.96 (5.22–37.31)	23.50 (3.95–140.02)	<0.001
Fully adjusted (all above)	1	3.01 (1.14–7.98)	11.72 (4.13–33.26)	24.14 (3.81–152.99)	<0.001

Abbreviations: BMI, body mass index; CI, confidence interval; DM, diabetes mellitus; HTN, hypertension; OR, odds ratio; PIH, pregnancy-induced hypertension.

Table 5 Blood pressure class shift from 16 weeks to 20 weeks of gestation and the risk of PIH occurrence

	20 weeks (no. of PIH(+)/PIH(−))			
16 weeks	*I*	*II*	*III*	P *for trend*
I	12/619	3/65	3/10	<0.001
II	2/120	2/52	3/9	0.001
III	0/26	2/15	2/13	0.081
I	*12/619*	*3/65*	*3/10*	P<*0.001*
BP Class I before 16 weeks gestation (OR (95% CI))				
Unadjusted	1	2.38 (0.65–8.65)	15.47 (3.77–63.45)	0.001
Age adjusted	1	2.40 (0.66–8.74)	16.44 (3.96–68.34)	0.001
Age+BMI adjusted	1	2.40 (0.66–8.79)	16.47 (3.85–70.56)	0.001
Age+BMI+parity adjusted	1	2.43 (0.66–8.97)	14.78 (3.38–64.73)	0.002
Age+BMI+pre-existing DM adjusted	1	2.26 (0.604–8.44)	17.06 (3.97–73.33)	0.001
Age+BMI+pre-existing renal disease adjusted	1	2.47 (0.67–9.08)	12.98 (2.70–62.32)	0.009
Age+BMI+family history of HTN adjusted	1	2.40 (0.65–8.80)	16.63 (3.84–71.99)	0.001
Age +BMI+previous history of PIH adjusted	1	2.60 (0.70–9.63)	17.81 (4.11–77.08)	0.001
Fully adjusted (all above)	1	2.35 (0.58–9.47)	13.01 (2.64–64.16)	0.010
II	*2/120*	*2/52*	*4/9*	P<*0.001*
BP Class II before 16 weeks of gestation (OR (95% CI))				
Unadjusted	0.43 (0.06–3.16)	1	8.67 (1.27–159.35)	0.002
Age adjusted	0.45 (0.06–3.28)	1	7.40 (1.04–52.35)	0.003
Age+BMI adjusted	0.43 (0.06–3.18)	1	7.73 (1.08–55.54)	0.002
Age+BMI+parity adjusted	0.38 (0.05–2.82)	1	8.13 (1.06–62.26)	0.002
Age+BMI+pre-existing DM adjusted	0.4 (0.05–3.00)	1	4.78 (0.54–42.00)	0.008
Age+BMI+pre-existing renal disease adjusted	NA	NA	NA	NA
Age+BMI+family history of HTN adjusted	0.42 (0.06–3.15)	1	13.65 (1.64–113.53)	0.001
Age +BMI+previous history of PIH adjusted	0.27 (0.03–2.55)	1	8.21 (1.12–60.07)	0.001
Fully adjusted (all above)	0.22 (0.02–2.25)	1	8.44 (0.81–87.72)	0.008
III	*0/26*	*2/15*	*2/13*	P=*0.081*
BP Class III before 16 weeks of gestation (OR (95% CI))				
Unadjusted	NA	0.87 (0.11–7.05)	1	0.114
Age adjusted	NA	0.64 (0.06–6.28)	1	0.066
Age+BMI adjusted	NA	0.71 (0.07–7.62)	1	0.079
Age+BMI+parity adjusted	NA	0.72 (0.07–7.78)	1	0.080
Age+BMI+pre-existing DM adjusted	NA	0.43 (0.04–5.33)	1	0.053
Age+BMI+pre-existing renal disease adjusted	NA	NA	NA	NA
Age+BMI+family history of HTN adjusted	NA	0.44 (0.03–6.41)	1	0.086
Age +BMI+previous history of PIH adjusted	NA	0.74 (0.07–8.08)	1	0.083
Fully adjusted (all above)	NA	NA	NA	NA

Abbreviations: BMI, body mass index; BP, blood pressure; CI, confidence interval; DM, diabetes mellitus; HTN, hypertension; NA, not available; OR, odds ratio; PIH, pregnancy-induced hypertension.

risk became insignificant after adjustment for pre-existing diabetes mellitus. The risk of PIH occurrence was not statistically significant in subjects whose BP shifted from Class II at 16 weeks to Class I at 20 weeks of gestation. However, the trend for PIH risk was significant ($P<0.05$) and remained significant even after adjustments for all variables. When comparing two groups, one in which the BP class elevated to Class III at 20 weeks gestation and the other in which the BP class did not change or decreased to Class I, the sensitivity, false positive rate and positive predictive value of BP class elevation between 16 and 20 weeks of gestation were 50.0, 5.0 and 30.8%, respectively. Subjects whose BP shifted from Class III at 16 weeks to Classes I and II at 20 weeks of gestation were not associated with a significant risk reduction of PIH (Table 5).

DISCUSSION

In this study, we classified BP in pregnant women according to JSH 2009. Our results suggested that the risk of PIH could be predicted from BP class shifts between 16 and 20 weeks of gestation. The elevation of BP over the course of pregnancy was associated with a significant risk for future development of PIH even among women with Class I (Optimal) and II (Normal) BPs before 16 weeks of gestation, who are normally recognized as low risk for PIH.

In a previous study, Hermida *et al.*[20] compared the time course of BP changes during pregnancy in normotensive and PIH women. The normotensive women had a steady decrease in BP toward 20 weeks; this was absent in patients with gestational hypertension and pre-eclampsia. Silva *et al.*[21] investigated the effect of maternal education levels on BP alterations in pregnancy. They found the absence of a mid-pregnancy fall in diastolic BP in low educational groups with a high occurrence of PIH. However, both studies failed to analyze the direct association between changes in BP during pregnancy and the risk of PIH. In this study, we clearly demonstrated a significant association between an increased BP during the first half of pregnancy and the risk of PIH.

Our results are in accordance with those previously reported, which identified normal and high-normal BPs at early and mid pregnancy as predictors of subsequent PIH development.[5,23] We used the JSH 2009 classification to show a significant trend for risk of future PIH in women whose BP class increased both before 16 (Table 3) and 20 weeks (Table 4) of gestation, even after adjustment for all variables. Thus, JSH 2009 may be a novel, more accurate system for PIH prediction based on a single estimation of maternal BP during pregnancy, particularly if the measurement is taken at early-mid pregnancy, and especially if performed at 20 weeks.

In a previous report, Duckitt *et al.*[16] conducted a meta-analysis to evaluate patient characteristics recorded at antenatal booking as risk factors of PIH. These included age, body mass index, nulliparity, previous history of PIH and diabetes mellitus, multiple gestations, family history of PIH and antiphospholipid syndrome. In our study population, age, pre-existing diabetes mellitus and previous history of PIH were also identified as significant risk factors for PIH.

There were some limitations to our study, including the retrospective design allowing the possibility of some bias and the small size of the study population.

In conclusion, the JSH 2009 classification may be used early in pregnancy to identify women at risk of PIH even in those with optimal or normal BPs. A shift in BP class at 20 weeks of gestation is predictive of subsequent PIH development. JSH 2009 has potential widespread clinical application.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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