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Systolic, Diastolic and Mean Arterial Pressure at 30–33 Weeks in the Prediction of Preeclampsia

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Key Words
Third-trimester screening · Preeclampsia · Mean arterial pressure · Systolic blood pressure · Diastolic blood pressure · Pyramid of antenatal care

Abstract
Objective: To investigate the potential value of measuring mean arterial pressure (MAP), systolic (sBP) and diastolic (dBP) blood pressure at 30–33 weeks' gestation in the prediction of preeclampsia (PE) developing at or after 34 weeks. ***Methods:*** Screening study in singleton pregnancies at 30–33 weeks' gestation including 4,294 that were unaffected by PE, gestational hypertension (GH) or delivery of small-for-gestational-age neonates (normal group), 145 that subsequently developed PE [37 cases requiring delivery at 34–37 weeks (intermediate PE) and 108 delivering at or after 38 weeks (late PE)] and 161 that developed GH. The a priori risks for intermediate and late PE from maternal demographic characteristics and medical history were determined. The a posteriori risks were calculated by combining the a priori risks with the likelihood ratios for MAP, sBP and dBP, which were calculated from fitted bivariate gaussian distributions. ***Results:*** The mean multiple of median MAP, sBP and dBP were significantly higher in the intermediate and late PE groups than in the normal group. In screening by a combination of maternal characteristics and MAP, the estimated detection rates of intermediate and late PE, at a false-positive rate of 10%, were 70.3 and 62.0%, respectively. The respective detection rates for sBP were 62.2 and 59.3% and for dBP were 62.2 and 57.4%. ***Conclusion:*** Combined testing by maternal characteristics and blood pressure at 30–33 weeks could effectively identify women at high risk for subsequent development of PE.

Introduction

Preeclampsia (PE), which affects 2–3% of pregnancies, is a major cause of maternal and perinatal morbidity and mortality [1–3]. The condition has been subdivided into early PE, requiring delivery before 34 weeks, intermediate PE with delivery at 34–37 weeks and late PE delivering at or after 38 weeks [4]. Screening for PE at 11–13 weeks' gestation by a combination of maternal demographic characteristics, including medical and obstetric history, mean arterial pressure (MAP) and a series of other biophysical and biochemical markers is highly effective in identifying pregnancies that will develop early PE, but less so for intermediate and late PE [4–8].

We have recently proposed a two-stage strategy for the identification of pregnancies at risk of PE [9, 10]. The first

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stage, at 11–13 weeks, should be primarily aimed at the effective prediction of early PE, thus allowing the high-risk group to benefit from potential therapeutic interventions starting from the first trimester of pregnancy; in particular, there is evidence that the prevalence of this condition can be reduced substantially by the prophylactic use of low-dose aspirin started before 16 weeks' gestation [11, 12]. The second stage, at 30–33 weeks, should be aimed at the effective prediction of intermediate and late PE because there is good quality evidence that induction of labor for term PE results in a significant reduction of perinatal complications [13], and therefore, in the case of intermediate and late PE, the objective of antenatal care is the identification of women at high risk leading to intensive maternal monitoring for earlier diagnosis of PE and timely delivery with the potential for mitigating an adverse outcome.

The objective of this screening study is to investigate the potential value of and compare MAP, systolic blood pressure (sBP) and diastolic blood pressure (dBP) at 30–33 weeks' gestation in the prediction of intermediate and late PE.

Methods

The data for this study were derived from prospective screening for adverse obstetric outcomes in all women attending for their routine hospital visit in the third trimester of pregnancy at King's College Hospital, London and Medway Maritime Hospital, Kent between May 2011 and March 2012. This visit, which is held at 30^{+0}–33^{+6} weeks' gestation, included recording of maternal characteristics and medical history, estimation of fetal size from transabdominal ultrasound measurement of fetal head circumference, abdominal circumference and femur length, and measurement of blood pressure. Written informed consent was obtained from the women agreeing to participate in a study on adverse pregnancy outcome, which was approved by the Ethics Committee of each participating hospital.

Gestational age was determined by the measurement of fetal crown-rump length at 11–13 weeks or the fetal head circumference at 20–24 weeks [14, 15].

Measurement of Blood Pressure

Blood pressure was taken by automated devices (3BTO-A2; Microlife, Taipei, Taiwan), which were calibrated before and at regular intervals during the study [16]. The recordings were made by doctors who had received appropriate training in the use of these machines. The women were in the sitting position, their arms were supported at the level of their heart and either a small (<22 cm), normal (22–32 cm) or large (33–42 cm) adult cuff was used depending on the mid-arm circumference. After rest for 5 min, two recordings of blood pressure were made in both arms simultaneously. We calculated the final MAP, sBP and dBP as the average of all four measurements [17].

Patient Characteristics

Patient characteristics included maternal age, racial origin (Caucasian, Afro-Caribbean, South Asian, East Asian and mixed), method of conception (spontaneous or assisted conception requiring the use of ovulation drugs), cigarette smoking during pregnancy (yes or no), history of chronic hypertension (yes or no), history of preexisting diabetes mellitus (yes or no), family history of PE in the mother of the patient (yes or no) and obstetric history including parity (parous or nulliparous if no previous pregnancies at or after 24 weeks) and previous pregnancy with PE (yes or no). Maternal weight and height were also measured.

Outcome Measures

Data on pregnancy outcome were collected from the hospital maternity records or the general medical practitioners of the women. The obstetric records of all women with preexisting or pregnancy-associated hypertension were examined to determine if the condition was chronic hypertension, PE or nonproteinuric gestational hypertension (GH).

The definitions of GH and PE were those of the International Society for the Study of Hypertension in Pregnancy [18]. In GH, the sBP should be 140 mm Hg or more and/or the dBP should be 90 mm Hg or more on at least two occasions 4 h apart developing after 20 weeks of gestation in previously normotensive women. In PE, there should be GH with proteinuria of 300 mg or more in 24 h or two readings of at least ++ on dipstick analysis of midstream or catheter urine specimens if no 24-hour collection is available. In PE superimposed on chronic hypertension, significant proteinuria (as defined above) should develop after 20 weeks of gestation in women with known chronic hypertension (history of hypertension before conception or the presence of hypertension at the booking visit before 20 weeks of gestation in the absence of trophoblastic disease). PE requiring delivery at 34–37 weeks was defined as intermediate PE and PE requiring delivery at or after 38 weeks was defined as late PE.

The newborn was considered to be small for gestational age (SGA) if the birth weight was less than the 5th percentile after correction for gestation at delivery [19].

Statistical Analysis

Comparisons of maternal characteristics between outcome groups were by the χ^2 or Fisher exact test for categorical variables and by ANOVA for continuous variables, with post hoc Bonferroni correction.

The values of MAP, sBP and dBP were $\log_{10}$ transformed to make its distribution gaussian. Normality of distributions was assessed using probability plots. In the unaffected pregnancies multivariable regression analysis was used to determine which of the factors amongst the maternal characteristics and gestational age in weeks were significant predictors of $\log_{10}$ MAP, $\log_{10}$ sBP and $\log_{10}$ dBP. Gestational age at screening was centered by subtracting 32 from gestational age in weeks and maternal weight was centered by subtracting 75 kg. Each measured value in the outcome groups was expressed as a multiple of the normal median (MoM) after adjustment for those characteristics found to provide a substantial contribution to the $\log_{10}$-transformed value. ANOVA was used to compare the mean MoM values of MAP, sBP and dBP between the outcome groups. Regression analysis was used to determine the significance of association between $\log_{10}$ MAP MoM, $\log_{10}$ sBP MoM, $\log_{10}$ dBP MoM and gestational age at delivery.

Table 1. Maternal characteristics in the study population

Characteristic	Normal (n = 4,294)	PE (n = 145)	GH (n = 161)
Maternal age, years	31.0 ± 5.9	31.5 ± 6.2	31.0 ± 6.2
Maternal weight at booking, kg	69.8 ± 15.1	77.2 ± 20.3*	75.1 ± 15.0*
Maternal weight at 30–33 weeks, kg	78.7 ± 14.8	86.0 ± 19.9*	84.5 ± 15.5*
Maternal height, cm	164.7 ± 6.6	163.5 ± 6.5	165.2 ± 7.2
Gestation, weeks	32.4 ± 0.5	32.3 ± 0.5	32.3 ± 0.5
Racial origin			
Caucasian	2,710 (63.1)	60 (41.4)*	93 (57.8)
Afro-Caribbean	1,171 (27.3)	70 (48.3)*	56 (34.8)
South Asian	171 (4.0)	6 (4.1)	7 (4.3)
East Asian	109 (2.5)	3 (2.1)	1 (0.6)
Mixed	133 (3.1)	6 (4.1)	4 (2.5)
Parity			
Nulliparous	2,041 (47.5)	76 (52.4)	102 (63.4)*
Parous with no previous PE	2,123 (49.5)	52 (35.9)*	42 (26.1)*
Parous with previous PE	130 (3.0)	17 (11.7)*	17 (10.6)*
Cigarette smoker	380 (8.8)	9 (6.2)	8 (5.0)
Family history of PE	184 (4.3)	11 (7.6)	14 (8.7)*
Conception			
Spontaneous	4,185 (97.5)	141 (97.2)	157 (97.5)
Assisted	109 (2.5)	4 (2.8)	4 (2.5)
History of chronic hypertension	46 (1.1)	26 (17.9)*	0
Antihypertensive	27 (58.7)	21 (80.8)	0
No antihypertensive	19 (41.3)	5 (19.2)	0
History of preexisting diabetes mellitus	37 (0.9)	2 (1.4)	0

Data are presented as n (%) or mean ± standard deviation.

Comparisons between outcome groups were by the χ^2 or Fisher exact test for categorical variables and by ANOVA for continuous variables, with post hoc Bonferroni correction. * $p < 0.05$.

The a priori risks for intermediate and late PE were calculated from the following formula: odds/(1 + odds), where odds = e^Y and Y was derived from previously established multiple regression models that comprised of maternal characteristics and medical and obstetric history [9]. Likelihood ratios for intermediate and late PE were calculated from the fitted bivariate gaussian distributions for MAP, sBP and dBP, and these were combined with the a priori risks to produce a posteriori risks. The performance of screening for intermediate and late PE by maternal characteristics, blood pressure and their combination was determined by receiver operating characteristic (ROC) curve analysis.

The statistical software package SPSS 20.0 (SPSS Inc., Chicago, Ill., USA) and Medcalc (Medcalc Software, Mariakerke, Belgium) were used for all data analyses.

Results

Characteristics of the Study Population

Third-trimester assessment was carried out in 5,099 singleton pregnancies. We excluded 244 cases because they had missing outcome data (n = 156), PE at the time of screening or before 34 weeks (n = 25), pregnancy resulting in delivery before 34 weeks' gestation (n = 37) or the birth of babies with major defects (n = 26). In the remaining 4,855 cases there were 4,294 that were unaffected by PE, GH or SGA (normal group), 145 (3.0%) that developed PE, with 37 cases requiring delivery at 34–37 weeks (intermediate PE) and 108 cases delivering at or after 38 weeks (late PE), 161 (3.3%) that developed GH and 255 (5.3%) that were SGA in the absence of PE. In this study we present the results of the normal pregnancies and those that developed PE or GH. The findings of the group with SGA in the absence of PE are the subject of a separate publication.

The maternal characteristics and history in the outcome groups are presented in table 1. In the PE group, compared to the normal group, there was a higher mean maternal weight and prevalence of Afro-Caribbean racial origin, personal history of PE and chronic hypertension.

Table 2. Fitted regression model for $\log_{10}$ MAP, $\log_{10}$ sBP and $\log_{10}$ dBP in unaffected pregnancies

Variable	Coefficient	Standard error	95% CI	p value
MAP				
Intercept	1.93664	0.00076499	1.93514 to 1.93814	<0.0001
Gestational age – 32 weeks	0.0033973	0.00097327	0.0014892 to 0.0053054	0.0015
Weight – 75 kg	0.0011530	0.000049037	0.0010568 to 0.0012491	<0.0001
(Weight – 75 kg)^2	–0.000010259	0.0000013678	–0.000012941 to –0.0000075773	<0.0001
Afro-Caribbean	–0.012158	0.0012016	–0.014514 to –0.0098024	0.0001
sBP				
Intercept	2.067920	0.00078822	2.066375 to 2.069465	<0.0001
Gestational age – 32 weeks	0.0035640	0.00096826	0.00023540 to 0.0016657	0.0002
Weight – 75 kg	0.0012103	0.000049166	0.0011139 to 0.001113067	<0.0001
(Weight – 75 kg)^2	–0.000011271	0.0000013625	–0.0000139 to –0.0000086	<0.0001
Afro-Caribbean	–0.010977	0.0012064	–0.013342 to –0.0041668	<0.0001
South Asian	–0.0094781	0.0027092	–0.014790 to –0.0041668	0.0005
East Asian	–0.0069059	0.0033515	–0.0134767 to –0.0003351	0.039
dBP				
Intercept	1.85240	0.00092937	1.85058 to 1.85422	<0.0001
Gestational age – 32 weeks	0.0030615	0.0011824	0.00074342 to 0.0053797	0.010
Weight – 75 kg	0.0010872	0.000059574	0.00097042 to 0.0012040	<0.0001
(Weight – 75 kg)^2	–0.0000091499	0.0000016617	–0.000012408 to –0.000005892	<0.0001
Afro-Caribbean	–0.013770	0.0014598	–0.016632 to –0.010908	<0.0001

In the GH group, compared to the normal group, there was a higher mean maternal weight and prevalence of family and personal history of PE.

Distributions of Blood Pressure in Normal Pregnancies

Multivariable regression analysis in the normal pregnancies demonstrated that for the prediction of $\log_{10}$ MAP there were significant independent contributions from gestational age, maternal weight and racial origin (table 2), but not from maternal age (p = 0.051), height (p = 0.101), cigarette smoking (p = 0.964) or assisted conception (p = 0.449):

$\log_{10}$ MAP expected = 1.93664 + [0.0033973 × (gestational age – 32 weeks)] + [0.0011530 × (maternal weight – 75 kg)] – [0.000010259 × (maternal weight – 75 kg)^2] + (–0.012158 if Afro-Caribbean racial origin, 0 if any other race); $R^2 = 0.151$, $p < 0.0001$.

Multivariable regression analysis in the normal pregnancies demonstrated that for the prediction of $\log_{10}$ sBP there were significant independent contributions from gestational age, maternal weight and racial origin (table 2), but not from maternal age (p = 0.052), height (p = 0.253), cigarette smoking (p = 0.127) or assisted conception (p = 0.851):

$\log_{10}$ sBP expected = 2.067920 + [0.0035639 × (gestational age – 32 weeks)] + [0.0012103 × (maternal weight – 75 kg)] – [0.000011271 × (maternal weight – 75 kg)^2] + (–0.010977 if Afro-Caribbean, –0.0094781 if South Asian, –0.0069059 if East Asian, 0 if any other race); $R^2 = 0.168$, $p < 0.0001$.

Multivariable regression analysis in the normal pregnancies demonstrated that for the prediction of $\log_{10}$ dBP there were significant independent contributions from gestational age, maternal weight and racial origin (table 2), but not from maternal age (p = 0.885), height (p = 0.051), cigarette smoking (p = 0.210) or assisted conception (p = 0.335):

$\log_{10}$ dBP expected = 1.85240 + [0.0030615 × (gestational age – 32 weeks)] + [0.0010872 × (maternal weight – 75 kg)] – [0.000091499 × (maternal weight – 75 kg)^2] + (–0.013770 if Afro-Caribbean racial origin, 0 if any other race); $R^2 = 0.102$, $p < 0.0001$.

The mean MoM of MAP, sBP and dBP were significantly increased in the intermediate and late PE groups compared to the normal group (table 3; fig. 1). In the PE group there was an inverse correlation between $\log_{10}$ MoM values of MAP, sBP and dBP with gestational age at delivery (MAP: r = –0.334, $p < 0.0001$; fig. 2; sBP: r = –0.374, $p < 0.0001$; dBP: r = –0.250, p = 0.002). The overlapping gaussian distributions of $\log_{10}$ MoM of MAP, sBP and dBP in the normal group and the intermediate and

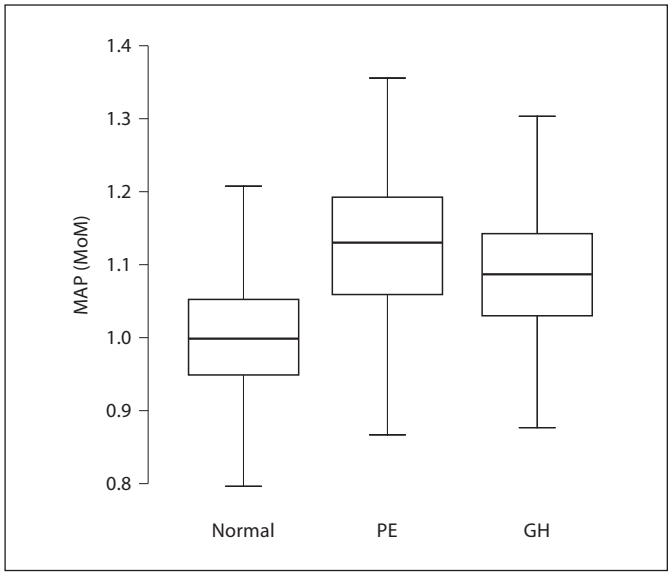

Fig. 1. Box-whisker plot of MoM values of MAP, sBP and dBP in the groups.

late PE groups were used to calculate likelihood ratios for intermediate and late PE (table 4).

Algorithms for PE

The a priori risks for intermediate and late PE based on maternal characteristics and obstetric history were determined as previously described [9]. The a posteriori risks for intermediate and late PE were derived by multiplying the a priori risks by the likelihood ratios for MAP, sBP and dBP.

Performance of Screening for PE

The areas under ROC (AUROC) and the detection rates of intermediate and late PE for false-positive rates of 5 and 10% in screening by maternal characteristics, MAP, sBP, dBP and their combinations are given in table 5 and figure 3. There was no significant difference in the AUROC for the prediction of intermediate PE by a combination of maternal characteristics with MAP compared to sBP ($p = 0.713$) or dBP ($p = 0.272$). In the case of late PE the AUROC was significantly higher with a combination of maternal characteristics with MAP than with dBP ($p = 0.040$) but not with sBP ($p = 0.096$; fig. 4). In screening by a combination of maternal characteristics and MAP the estimated positive and negative predictive values for intermediate PE were 5.8 and 99.7%. The respective positive and negative predictive values for late PE were 13.7 and 98.9%.

Table 3. Mean ± standard deviation of MAP, sBP and dBP at 30–33 weeks' gestation in the outcome groups

	Normal (n = 4,294)	Intermediate PE (n = 37)	Late PE (n = 108)
MAP			
mm Hg	86.7 ± 7.4	101.1 ± 10.9	96.7 ± 9.1
MoM	1.003 ± 0.079	1.159 ± 0.106*	1.113 ± 0.098*
sBP			
mm Hg	117.2 ± 10.0	136.7 ± 17.9	128.9 ± 11.8
MoM	1.003 ± 0.078	1.159 ± 0.135*	1.095 ± 0.089*
dBP			
mm Hg	71.4 ± 7.2	83.2 ± 9.2	80.6 ± 8.9
MoM	1.005 ± 0.097	1.162 ± 0.110*	1.129 ± 0.121*

Comparisons between intermediate PE, late PE and unaffected groups by ANOVA with post hoc Bonferroni correction. * $p < 0.05$.

Table 4. Likelihood ratios for intermediate and late PE from MAP, sBP and dBP MoM

	Likelihood ratio (95% CI)	
	intermediate PE	late PE
MAP MoM		
0.8	0.04 (0.02–0.05)	0.11 (0.07–0.13)
0.9	0.13 (0.06–0.24)	0.26 (0.15–0.43)
1.0	0.51 (0.27–1.32)	0.77 (0.47–1.63)
1.1	2.88 (1.64–9.13)	2.98 (1.93–7.31)
1.2	19.59 (12.41–67.68)	13.24 (9.28–34.74)
sBP MoM		
0.8	0.16 (0.16–0.20)	0.11 (0.05–0.14)
0.9	0.22 (0.17–0.31)	0.32 (0.16–0.51)
1.0	0.53 (0.33–1.17)	0.92 (0.56–1.81)
1.1	2.20 (1.39–7.05)	2.88 (2.07–6.14)
1.2	16.53 (10.07–71.57)	10.11 (7.60–22.10)
dBP MoM		
0.8	0.03 (0.01–0.05)	0.15 (0.10–0.19)
0.9	0.15 (0.06–0.29)	0.33 (0.20–0.48)
1.0	0.60 (0.33–1.27)	0.77 (0.52–1.31)
1.1	2.41 (1.49–5.15)	2.16 (1.48–4.10)
1.2	8.45 (6.03–17.8)	6.42 (4.72–13.2)

Discussion

This study has demonstrated that at 30–33 weeks' gestation in pregnancies which subsequently develop PE, the MAP, sBP and dBP are increased and the increase is inversely related to the severity of the disease reflected in

Table 5. Performance of screening for intermediate and late PE by maternal characteristics, MAP, sBP, dBP and their combinations

Screening test	AUROC (95% CI)			
	intermediate PE	late PE		
Maternal history	0.771 (0.758–0.783)	0.756 (0.743–0.768)		
MAP	0.878 (0.868–0.887)	0.810 (0.798–0.822)		
sBP	0.854 (0.843–0.864)	0.786 (0.774–0.798)		
dBP	0.860 (0.849–0.870)	0.792 (0.780–0.804)		
Maternal history with				
MAP	0.905 (0.896–0.914)	0.845 (0.834–0.856)		
sBP	0.898 (0.888–0.907)	0.836 (0.825–0.847)		
dBP	0.887 (0.877–0.896)	0.841 (0.829–0.851)		
	Detection rate (with 95% CI) for fixed false-positive rate of 5 and 10%			
	5%	10%	5%	10%
Maternal history	27.0 (13.8–44.1)	40.5 (24.8–57.9)	37.0 (27.9–46.9)	44.4 (34.9–54.3)
MAP	54.1 (36.9–70.5)	70.3 (53.0–84.1)	41.7 (32.3–51.5)	52.8 (42.9–62.5)
sBP	56.8 (39.5–72.9)	59.5 (42.1–75.2)	32.4 (23.7–42.1)	47.2 (37.5–57.1)
dBP	40.5 (24.8–57.9)	59.5 (42.1–75.2)	31.5 (22.9–41.1)	51.9 (42.0–61.6)
Maternal history with				
MAP	56.8 (39.5–72.9)	70.3 (53.0–84.1)	49.1 (39.3–68.9)	62.0 (52.2–71.2)
sBP	51.4 (34.4–68.1)	62.2 (44.8–77.5)	38.0 (28.8–47.8)	59.3 (49.3–68.6)
dBP	51.4 (34.4–68.1)	62.2 (44.8–77.5)	47.2 (37.5–57.1)	57.4 (47.5–66.9)

Fig. 2. MAP MoM with gestational age at delivery in pregnancies complicated by PE, plotted on the 10th, 50th and 90th percentile of the normal range.

the gestational age at delivery. The measurement of blood pressure can be combined with the maternal factor-derived a priori risks to provide effective third-trimester screening for PE. In screening for intermediate and late PE by a combination of maternal characteristics and MAP the estimated detection rates, at a false-positive rate of 10%, were about 70 and 62%, respectively. The performance of screening by the use of MAP appears to be better, but not significantly so, than by sBP or dBP.

The strengths of this screening study for PE are, firstly, the prospective examination of a large population of pregnant women attending for routine care in a well-defined gestational age range which is widely used for the assessment of fetal growth and well-being, secondly, the use of a well-defined methodology and appropriately trained doctors to measure blood pressure and thirdly, the application of a statistical approach that is widely accepted in screening for aneuploidies and pregnancy complications to examine the performance of screening and calculate patient-specific risks [10].

In the unaffected group, none of whom developed PE, GH or SGA, MAP and dBP at 30–33 weeks' gestation increased with gestational age and maternal weight and were lower in women of Afro-Caribbean racial origin than in other racial groups. Similarly, sBP increased with

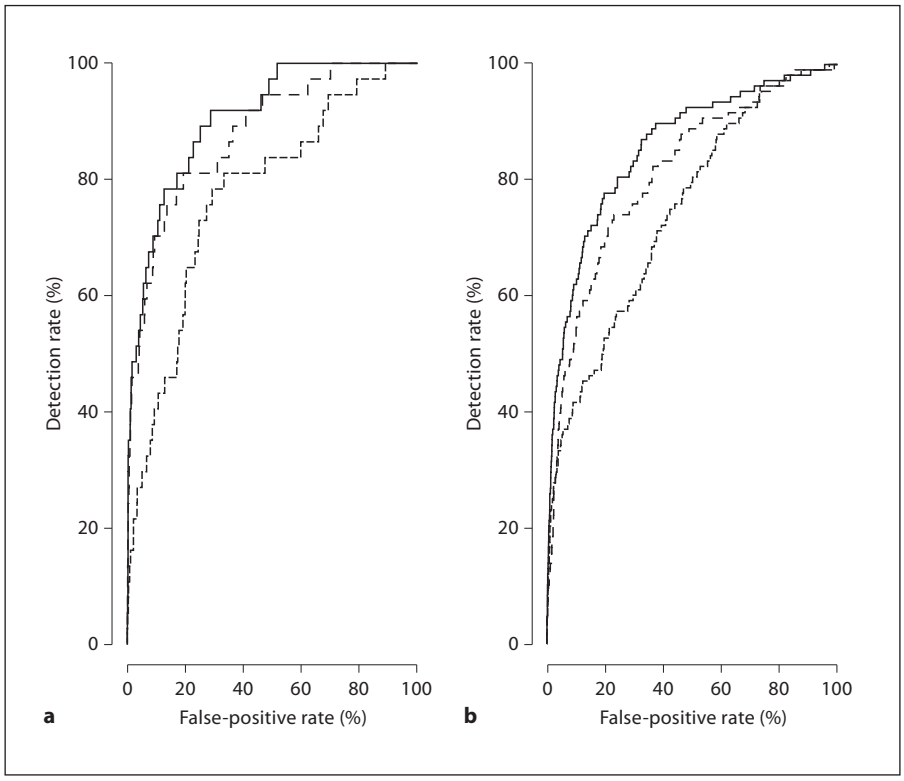

Fig. 3. ROC curves of maternal characteristics (-----), MAP (– – – –) and their combination (——) in the prediction of intermediate PE (**a**) and late PE (**b**).

gestational age and maternal weight and was lower in women of Afro-Caribbean, South Asian and East Asian racial origin than in Caucasians. Consequently, comparison of values between normal and pathological pregnancies necessitates the appropriate adjustments for the characteristics of the population under investigation. The effect of maternal weight and racial origin is similar to that described previously in a study during the first trimester of pregnancy [20]. The finding that MAP, sBP and dBP increase between 30–33 weeks' gestation is compatible with previous reports. In normal pregnancy, blood pressure begins to decrease in the first trimester as a result of the fall in systemic vascular resistance due to smooth muscle relaxation and overall vasodilatation caused by elevated progesterone [21, 22]. The blood pressure continues to decrease in the second trimester to a nadir by 22–24 weeks' gestation and increases thereafter to prepregnancy levels at term [23].

The finding that the performance of screening by the use of MAP appears to be better than by sBP or dBP is similar to that described previously in a first-trimester study [6]. sBP is determined by the stroke volume and stiffness of the aorta and large arteries [24] and dBP mainly reflects peripheral resistance which essentially depends on the tone of small arteries, but it also decreases with increasing stiffness in the aorta [25]. The stiffness of large arteries increases with advancing age and this would tend to increase sBP with an associated decrease in dBP [25, 26]. Pregnant women tend to be young and traditionally greater emphasis has been given to dBP rather than sBP as the predictor of the adverse consequences of pregnancy hypertension. However, there has been a gradual increase in the age of pregnant women with the proportion being 35 years or more increasing from 5% in the 1970s to 20% in the 2000s [27], with a consequent expected increase in the contribution of sBP in pregnancy-related hypertension. It is not surprising that MAP, a blood pressure measurement that combines sBP and dBP, is better than sBP alone or dBP alone in predicting PE. With the introduction of automated devices the measurement of MAP can be reliably and easily measured and does not necessitate complex calculation by physicians; therefore, it is the blood pressure measurement of choice for the screening of PE.

In the pregnancies that subsequently developed PE the MAP MoM at 30–33 weeks was increased and the increase was greater in those with intermediate rather than late PE. The performance of screening for intermediate

and late PE by a combination of maternal factors and MAP at 30–33 weeks is superior to that of screening at 11–13 weeks, when for a 10% false-positive rate the respective detection rates were 54 and 45% [4].

Several previous studies have examined the use of blood pressure measurement as a screening test for the subsequent development of hypertensive disorders in pregnancy [6]. The studies reported widely contradictory results in the performance of screening (detection rate: median 43%, range 5–100%; false-positive rate: median 16%, range 0–66%) as a consequence of major methodological differences [6]. The sample size ranged from 22 to 22,582 (median 348); the incidence of PE was 1–65% (median 14%); the patients screened were low, moderate or high risk, and blood pressure was measured by either mercury sphygmomanometers or different types of automated devices at a wide range of gestations (median 21 weeks, range 8–42 weeks), with some reporting on sBP, dBP or MAP. Different cutoffs were used in defining the screen-positive group, and widely different definitions of the hypertensive disorder were reported with some studies not distinguishing between PE and GH and others defining PE by the development of edema rather than proteinuria [6]. The data from these studies were somehow compiled into a systematic review which reached the conclusion that MAP is significantly better than sBP or dBP in predicting PE but in any case the measurement of blood pressure does not help predict PE [28]. There is one previous study examining the potential value of predicting PE by measuring MAP in the early part of the third trimester of pregnancy. Conde-Agudelo et al. [29] measured MAP at 31 weeks' gestation in 588 nulliparous women, including 23 who developed PE, and reported that at a cutoff MAP of 89 mm Hg the detection rate of PE was 39% at a false-positive rate of 14%.

In a proposed new approach to prenatal care the potential value of a clinic at 11–13 weeks in which maternal characteristics are combined with the results of a series of biophysical and biochemical markers to assess the risk for a wide range of pregnancy complications has been extensively documented [10]. In the context of PE the primary aim of such a clinic is to identify those cases that would potentially benefit from prophylactic pharmacological interventions to improve placentation [11, 12]. It is likely that a similar integrated clinic at 30–33 weeks will emerge for the effective prediction of pregnancy complications that develop at or after 34 weeks. The potential value of such a clinic is to improve perinatal outcome by close monitoring and timely intervention in cases identified as being at high risk of pregnancy complications. Ultimately, the effectiveness of such intervention would need to be investigated by randomized studies. However, before such studies are undertaken, it is necessary to define the best algorithms to be applied in a screening clinic at 30–33 weeks for the effective prediction of pregnancy complications. The findings of our study suggest that recording maternal characteristics and measuring MAP at this clinic can form the basis for the development of such an algorithm for the prediction of intermediate and late PE that is likely to be improved by the use of additional biophysical and biochemical markers.

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