Blood Pressure Monitoring for Intrauterine Growth Restriction

1. Home blood-pressure monitoring in a hypertensive pregnant population.

Author(s): Perry, H.; Thilaganathan, B.; Khalil, A.; Sheehan, E.

Source: Ultrasound in Obstetrics & Gynecology; Apr 2018; vol. 51 (no. 4); p. 524-530

Publication Date: Apr 2018

Publication Type(s): Academic Journal

PubMedID: 29468771

Available at Ultrasound in Obstetrics & Gynecology - from Wiley Online Library Science, Technology and Medicine Collection 2017

Abstract: Objective: The majority of patients with chronic or gestational hypertension do not develop pre-eclampsia. Home blood-pressure monitoring (HBPM) has the potential to offer a more accurate and acceptable means of monitoring hypertensive patients during pregnancy compared with traditional pathways of frequent outpatient monitoring. The aim of this study was to determine whether HBPM reduces visits to antenatal services and is safe in pregnancy.

Methods: This was a case-control study of 166 hypertensive pregnant women, which took place at St George's Hospital, University of London. Inclusion criteria were: chronic hypertension, gestational hypertension or high risk of developing pre-eclampsia, no significant proteinuria (≤ 1+ proteinuria on dipstick testing) and normal biochemical and hematological markers. Exclusion criteria were maternal age ≥ 155 mmHg or diastolic blood pressure > 100 mmHg, significant proteinuria (≥ 2+ proteinuria on dipstick testing or protein/creatinine ratio > 30 mg/mmol), evidence of small-for-gestational age (estimated fetal weight < 10th centile), signs of severe pre-eclampsia, significant mental health concerns or insufficient understanding of the English language. Pregnant women in the HBPM group were taught how to measure and record their blood pressure using a validated machine at home and attended every 1-2 weeks for assessment depending on clinical need. The control group was managed as per the local protocol prior to the implementation of HBPM. The two groups were compared with respect to number of visits to antenatal services and outcome.

Results: There were 108 women in the HBPM group and 58 in the control group. There was no difference in maternal age, parity, body mass index, ethnicity or smoking status between the groups, but there were more women with chronic hypertension in the HBPM group compared with the control group (49.1% vs 25.9%, P = 0.004). The HBPM group had significantly fewer outpatient attendances per patient (6.5 vs 8.0, P = 0.003) and this difference persisted when taking into account differences in duration of monitoring (0.8 vs 1.6 attendances per week, P < 0.001). There was no difference in the incidence of adverse maternal, fetal or neonatal outcome between the two groups.

Conclusion: HBPM in hypertensive pregnancies has the potential to reduce the number of hospital visits required by patients without compromising maternal and pregnancy outcomes. Copyright © 2018 ISUOG.

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Database: CINAHL

Author(s): Eguchi, K; Ohmaru, T; Ohkuchi, A; Hirashima, C; Takahashi, K; Suzuki, H; Kario, K; Matsubara, S; Suzuki, Mitsuaki

Source: Journal of human hypertension; Jan 2016; vol. 30 (no. 1); p. 62-67

Publication Date: Jan 2016

Publication Type(s): Journal Article

PubMedID: 25787779

Abstract: The significance of ambulatory blood pressure (ABP) monitoring during pregnancy has not been established. We performed a prospective study to elucidate whether ABP measures are associated with small-for-gestational-age birth weight (SGA). We studied 146 pregnant women who were seen for maternal medical checkups or suspected hypertension. ABP monitoring was performed for further assessment of hypertension. The outcome measure was SGA. The subjects were classified by their medical history and ABP as having preeclampsia or gestational hypertension (n=68 cases), chronic hypertension (n=48) or white-coat hypertension (n=30). There were 50 (34.2%) cases of SGA by the fetal growth reference standard. In multivariable logistic regression analyses adjusting for age, body mass index, the presence of prior pregnancy, current smoking habit and the use of antihypertensive medications, 24-h SBP (per 10 mm Hg (odds ratio (OR): 1.74; 95% confidence interval (CI): 1.28-2.38; P<0.001)) was more closely associated with SGA than clinic BP (OR: 1.40; 95% CI: 0.92-2.13; P=0.11). The results were essentially the same if 24-h BP was replaced by awake or sleep SBP. Ambulatory diastolic BP showed the same tendency. However, abnormal circadian rhythm was not associated with the outcome. In conclusion, ambulatory BP monitoring measures performed during pregnancy were more closely associated with SGA than clinic BP.

Database: Medline

3. Serial hemodynamic monitoring to guide treatment of maternal hypertension leads to reduction in severe hypertension.

Author(s): Stott, D; Papastefanou, I; Paraschiv, D; Clark, K; Kametas, N A

Source: Ultrasound in obstetrics & gynecology : the official journal of the International Society of Ultrasound in Obstetrics and Gynecology; Jan 2017; vol. 49 (no. 1); p. 95-103

Publication Date: Jan 2017

Publication Type(s): Journal Article Observational Study

PubMedID: 27800645

Abstract: OBJECTIVE To examine whether treatment for hypertension in pregnancy that is guided by serial monitoring of maternal central hemodynamics leads to a reduction in the rate of severe hypertension, defined as blood pressure ≥ 160/110 mmHg; and to assess the distinct longitudinal hemodynamic profiles associated with beta-blocker monotherapy, vasodilator monotherapy and dual agent therapy, and their relationships with outcomes, including fetal growth restriction. METHOD This was a prospective observational study at a dedicated antenatal hypertension clinic in a tertiary UK hospital. Fifty-two untreated women presenting with hypertension were recruited consecutively and started on treatment, either with a beta-blocker or a vasodilator. The choice of initial antihypertensive agent was determined according to a model
constructed previously to predict the response to the beta-blocker labetalol in pregnant women needing antihypertensive treatment. At presentation, the demographic and maternal hemodynamic variables associated with a therapeutic response to labetalol, defined as blood pressure control < 140/90 mmHg with labetalol monotherapy throughout pregnancy, were ascertained and analyzed with logistic regression to create a model to predict sustained blood pressure control as described above. The women were reviewed regularly until delivery and underwent serial hemodynamic monitoring throughout pregnancy. If their blood pressure was elevated, the prediction model was referred to again to determine if alternative antihypertensive therapy, either with additional beta-blocker or a vasodilator, should be added.

RESULTSTreatment by referring to results of serial hemodynamic monitoring reduced the rate of severe antenatal hypertension from 18% to 3.8%. Seventy-seven percent of women were initially prescribed a beta-blocker and 23% a vasodilator. The group that maintained good blood pressure control with beta-blocker monotherapy had the best fetal and maternal outcomes. They had lower blood pressures at presentation and throughout gestation, demonstrated well-maintained cardiac output and had the lowest rates of fetal growth restriction. The groups that required dual therapy to control their blood pressure had persistently higher blood pressure and rate of fetal growth restriction. The groups that required vasodilator therapy due to high levels of peripheral vascular resistance, either at presentation or later in pregnancy, accounted for 81% of cases with fetal growth restriction.

CONCLUSIONUsing serial hemodynamic monitoring in pregnancy to guide treatment of hypertension significantly reduces the rate of severe hypertension and allows identification of high-resistance, low-output hypertensive pregnancies that are associated with an increased rate of fetal growth restriction. Copyright © 2016 ISUOG. Published by John Wiley & Sons Ltd.

Database: Medline

4. Antenatal blood pressure for prediction of pre-eclampsia, preterm birth, and small for gestational age babies: development and validation in two general population cohorts.

Author(s): Macdonald-Wallis, Corrie; Silverwood, Richard J; de Stavola, Bianca L; Inskip, Hazel; Cooper, Cyrus; Godfrey, Keith M; Crozier, Sarah; Fraser, Abigail; Nelson, Scott M; Lawlor, Debbie A; Tilling, Kate

Source: BMJ (Clinical research ed.); Nov 2015; vol. 351 ; p. h5948

Publication Date: Nov 2015

Publication Type(s): Research Support, Non-u.s. Gov't Research Support, N.i.h., Extramural Journal Article Validation Studies

PubMedID: 26578347

Available at BMJ (Clinical research ed.) - from BMJ Journals - NHS

Abstract: STUDY QUESTION Can routine antenatal blood pressure measurements between 20 and 36 weeks' gestation contribute to the prediction of pre-eclampsia and its associated adverse outcomes? METHOD This study used repeated antenatal measurements of blood pressure from 12,996 women in the Avon Longitudinal Study of Parents and Children (ALSPAC) to develop prediction models and validated these in 3005 women from the Southampton Women’s Survey (SWS). A model based on maternal early pregnancy characteristics only (BMI, height, age, parity, smoking, existing and previous gestational hypertension and diabetes, and ethnicity) plus initial mean arterial pressure was compared with a model additionally including current mean arterial pressure, a model including the deviation of current mean arterial pressure from a stratified normogram, and a model including both at different gestational ages from 20-36 weeks. STUDY ANSWER AND LIMITATIONS The addition of blood pressure measurements from 28 weeks onwards improved prediction models compared with use of early pregnancy risk factors alone, but they contributed little to the prediction of preterm birth or small for gestational age. Though multiple
imputation of missing data was used to increase the sample size and minimise selection bias, the validation sample might have been slightly underpowered as the number of cases of pre-eclampsia was just below the recommended 100. Several risk factors were self reported, potentially introducing measurement error, but this reflects how information would be obtained in clinical practice. WHAT THIS STUDY ADDSThe addition of routinely collected blood pressure measurements from 28 weeks onwards improves predictive models for pre-eclampsia based on blood pressure in early pregnancy and other characteristics, facilitating a reduction in scheduled antenatal care. FUNDING, COMPETING INTERESTS, DATA SHARINGUK Wellcome Trust, US National Institutes of Health, and UK Medical Research Council. Other funding sources for authors are detailed in the full online paper. With the exceptions of CM-W, HMI, and KMG there were no competing interests.

Database: Medline

5. Is there a role for ambulatory blood pressure monitoring in pregnancy?

Author(s): Brown M.A.

Source: Clinical and Experimental Pharmacology and Physiology; Jan 2014; vol. 41 (no. 1); p. 16-21

Publication Date: Jan 2014

Publication Type(s): Article

PubMedID: 23651133

Available at Clinical and experimental pharmacology & physiology - from Wiley Online Library Science, Technology and Medicine Collection 2017

Abstract: Summary: Ambulatory blood pressure monitoring (ABPM) has been used in pregnancy for just over 20 years now and is generally well tolerated. Normal values have been established for different gestations; these are slightly higher than conventional blood pressure (BP) in normal pregnancy, presumably reflecting greater activity during the 24 h of ABPM recordings. Ambulatory blood pressure monitoring is a better predictor than conventional BP for the development of pre-eclampsia and fetal growth restriction, but it is not sensitive or specific enough to be recommended for these purposes in routine practice. Studies of ABPM have shown that sleep hypertension is common in women with gestational hypertension or pre-eclampsia, but detecting this in routine clinical practice does not aid usual decision making in the pregnancy, including timing of delivery. Studies using ABPM have found that pregnant women who are working outside the home have higher BP than non-working women, but these data should not be interpreted to mean that not working during pregnancy will prevent gestational hypertension or pre-eclampsia. The best role for ABPM is to determine whether women with office hypertension in early pregnancy have true (usually essential) hypertension or white-coat hypertension. The latter can be managed without antihypertensives and pregnancy outcomes appear good, although possibly with a slightly increased incidence of pre-eclampsia. Women who have had pre-eclampsia are at greater life-time risk for cardiovascular diseases; several years postpartum these women have slightly higher ABPM-measured BP than women who had normal pregnancies and a greater propensity to metabolic syndrome. © 2013 Wiley Publishing Asia Pty Ltd.

Database: EMBASE
6. Ambulatory blood pressure monitoring around the 28th week of gestation is associated with small for gestational age

**Author(s):** Eguchi K.; Ohkuchi A.; Ohmaru T.; Hirashima C.; Takahashi K.; Suzuki H.; Kario K.

**Source:** Journal of Clinical Hypertension; Apr 2012; vol. 14

**Publication Date:** Apr 2012

**Publication Type(s):** Conference Abstract

**Abstract:** The significance of ambulatory blood pressure monitoring (ABPM) during pregnancy is not established. We performed this study to evaluate which ambulatory BP (ABP) measures are associated with a pregnancy-associated outcome. We studied 366 pregnant women who were seen for maternal medical checkup or suspected hypertension, and delivered in Jichi Medical University Hospital or International University of Health and Welfare Hospital. The mean age was 32.6 +/- 5.1 years; there were 96 hypertension and 270 normotensives when defined by clinic SBP >= 140 or DBP >= 90 mmHg (either). Subjects with essential hypertension prior to pregnancy (n = 37) was also included in this study. Ambulatory BP monitoring was performed predominantly around the 28th week of gestation (average: 27.7 +/- 6.3 weeks), and the outcome measures were small for gestational age (SGA). White-coat hypertension (WCH) was defined when clinic BP was high but normal awake BP level; masked hypertension (MHT) when normal clinic BP level but high awake BP; sustained HT (SHT), and normotensives (NT group) when both clinic and awake BP were hypertensive, and normotensive levels, respectively. There were 60 (16.4%) cases of SGA. In multivariable logistic regression analyses adjusting for age, BMI, history of smoking, and the presence of pregnancy induced hypertension (either preeclampsia or gestational hypertension), WCH was not significantly associated with SGA [Odds ratio (OR): 2.05; 95% CI: 0.53-7.93, P = 0.30], but SHT (OR: 5.95; 2.37-14.94, P < 0.001) and MHT (OR: 7.93; 2.30-27.35, P = 0.001) were significantly associated with the presence of SGA compared to the NT group. When the same analysis was performed by DBP, the results were the same. In conclusion, in pregnant women with possible hypertension, ABPM around the 28th week was useful in predicting SGA, especially masked hypertension may have the same impact of sustained hypertension.

**Database:** EMBASE
7. Prediction of gestational hypertension or intrauterine fetal growth restriction by mid-trimester 24-h ambulatory blood pressure monitoring.

**Author(s):** Tranquilli, A L; Giannubilo, S R; Dell'Uomo, B; Corradetti, A

**Source:** International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics; May 2004; vol. 85 (no. 2); p. 126-131

**Publication Date:** May 2004

**Publication Type(s):** Journal Article

**PubMedID:** 15099773

Available at International journal of gynaecology and obstetrics: the official organ of the International Federation of Gynaecology and Obstetrics - from Wiley Online Library Science, Technology and Medicine Collection 2017

**Abstract:** OBJECTIVE To investigate clinical impact of 24-h ambulatory blood pressure monitoring (ABPM) on the prediction of hypertensive disorders of pregnancy and IUGR. METHODS ABPM was performed in 334 normotensive non-proteinuric nulliparous women at 20 weeks' gestation. Arterial blood pressure patterns were analyzed by chronobiometry. RESULTS Women who developed idiopathic IUGR (21) or PIH (33) showed a 24-h diastolic blood pressure mean significantly higher than the controls (69.2+/-1.8 mmHg and 73.5+/-6.2 vs. 62.2+/-1.5). Women with subsequent IUGR also showed a modification in BP rhythm. The most effective cut-off levels of 24-h diastolic blood pressure mean proved to be 67 for IUGR and 68 for hypertension. CONCLUSIONS ABPM in the second trimester reliably predicts idiopathic IUGR and PIH. Both patients destined to develop gestational hypertension and those destined to develop IUGR show similar elevations in 24-h diastolic mean at 20 weeks' gestation.

**Database:** Medline

8. Serial hemodynamic measurement in normal pregnancy, preeclampsia, and intrauterine growth restriction

**Author(s):** Rang S.; Wolf H.; van Montfrans G.A.

**Source:** American Journal of Obstetrics and Gynecology; May 2008; vol. 198 (no. 5); p. 519

**Publication Date:** May 2008

**Publication Type(s):** Article

**PubMedID:** 18279824

**Abstract:** Objective: The study hypothesis was that hemodynamic measurements in conjunction with uterine artery Doppler could enable selection of women at risk for the development of preeclampsia or fetal growth restriction. Study Design: Systolic (SBP) and diastolic blood pressure, heart rate (RR), cardiac output (CO), total peripheral resistance (TPR), phase difference of SBP and RR interval were measured serially before, during, and after pregnancy. At 20 weeks, uterine artery Doppler measurement was performed. Outcome was classified as preeclampsia (PE) or gestational hypertension (GH) with or without fetal growth restriction (FGR), FGR without PE or GH, and normal pregnancy (NP). Differences between these groups were assessed by 1-way analysis of variance and discriminant analysis. Results: In early pregnancy, in comparison with NP (n = 28), PE/GH had a higher SBP and phase difference of SBP-RR interval. CO was higher in PE/GH without FGR (n = 5) but not PE/GH with FGR (n = 5). FGR, either with or without PE/GH (n = 4), was associated with higher TPR. Conjunction with uterine Doppler allowed selection of 93% of women with an abnormal outcome with a specificity of 100%. Conclusion: The study supports our hypothesis that in early pregnancy, hemodynamic parameters differ from normal in women predisposed to develop preeclampsia or fetal growth restriction. © 2008 Mosby, Inc. All rights reserved.
9. Ambulatory blood pressure monitoring in pregnancy

**Author(s):** Shennan A.H.; Halligan A.W.F.

**Source:** Fetal and Maternal Medicine Review; May 1998; vol. 10 (no. 2); p. 69-89

**Publication Date:** May 1998

**Publication Type(s):** Review

**Database:** EMBASE

**Abstract:**

BACKGROUND Retarded growth in utero has been linked with high blood pressure and other risk factors for cardiovascular disease in adult life. However, the influence on fetal growth of the maternal blood pressure during pregnancy is not well defined. In a prospective study, we examined the relation between maternal ambulatory blood pressure during pregnancy and indices of fetal growth.

**METHODS**

We studied 209 healthy nulliparous pregnant women referred to an inner-city district general hospital (86% of 244 consecutively referred women who met the study criteria). 24 h ambulatory blood-pressure recordings were obtained in early (median 18 weeks [IQR 17-18]) mid (28 weeks [28]), and late (36 weeks [36]) gestation. Eight infants delivered before 32 weeks' gestation were excluded from the analysis.

**FINDINGS**

A 5 mm Hg (1 SD) increase in mean 24 h diastolic blood pressure at 28 weeks' gestation was associated with a 68 g (95% Cl 3-132) decrease in birthweight; a similar change in diastolic pressure at 36 weeks' gestation was associated with a 76 g (24-129) decrease in birthweight. These associations were independent of potential confounders (maternal age, height, weight, cigarette smoking, alcohol intake, ethnic origin, pregnancy hypertension syndromes, and preterm birth). Maternal mean 24 h diastolic blood pressure at 28 weeks' gestation was also inversely associated with the infant's ponderal index at birth in multivariate analysis (p = 0.06). Higher maternal ambulatory blood pressure at 28 weeks' and 36 weeks' gestation also predicted lower head circumference, although these associations were dependent on birthweight. Associations between ambulatory systolic blood pressure and indices of fetal growth were weak and inconsistent and ambulatory blood pressure at 18 weeks' gestation did not predict fetal growth.

**INTERPRETATION**

There is a continuous inverse association between fetal growth and maternal blood pressure, throughout the range seen in normal pregnancy. Maternal blood pressure may be an important confounding factor in the reported associations between fetal growth retardation and adult hypertension and cardiovascular disease.

**Database:** Medline

10. Ambulatory blood pressure in pregnancy and fetal growth.

**Author(s):** Churchill, D; Perry, I J; Beevers, D G

**Source:** Lancet (London, England); Jan 1997; vol. 349 (no. 9044); p. 7-10

**Publication Date:** Jan 1997

**Publication Type(s):** Research Support, Non-u.s. Gov't Journal Article

**PubMedID:** 8988114

Available at [Lancet (London, England)](https://www.proquest.com) - from ProQuest (Hospital Premium Collection) - NHS Version

**Abstract:**

BACKGROUND Retarded growth in utero has been linked with high blood pressure and other risk factors for cardiovascular disease in adult life. However, the influence on fetal growth of the maternal blood pressure during pregnancy is not well defined. In a prospective study, we examined the relation between maternal ambulatory blood pressure during pregnancy and indices of fetal growth.

**METHODS**

We studied 209 healthy nulliparous pregnant women referred to an inner-city district general hospital (86% of 244 consecutively referred women who met the study criteria). 24 h ambulatory blood-pressure recordings were obtained in early (median 18 weeks [IQR 17-18]) mid (28 weeks [28]), and late (36 weeks [36]) gestation. Eight infants delivered before 32 weeks' gestation were excluded from the analysis.

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**INTERPRETATION**

There is a continuous inverse association between fetal growth and maternal blood pressure, throughout the range seen in normal pregnancy. Maternal blood pressure may be an important confounding factor in the reported associations between fetal growth retardation and adult hypertension and cardiovascular disease.

**Database:** Medline
11. How to assess and manage hypertension during and after pregnancy

**Author(s):** McKenna L.A.; Freeman D.J.; Jarvie E.; Huda S.S.

**Source:** Clinical Practice; Jul 2013; vol. 10 (no. 4); p. 455-470

**Publication Date:** Jul 2013

**Publication Type(s):** Review

Available at Clinical Practice - from ProQuest (Hospital Premium Collection) - NHS Version

Available at Clinical Practice - from Unpaywall

**Abstract:** Hypertensive disorders of pregnancy are increasingly important complications of which clinicians should have an up-to-date knowledge to facilitate prompt recognition, diagnosis and management. These disorders affect a growing number of pregnancies worldwide, with incidence rates likely to increase in the future commensurate with increasing maternal age and maternal comorbidities independent of age, with consequent effects on maternal and fetal/neonatal morbidity and mortality rates. This article mainly focuses on management within the UK of these disorders, examining their current working definitions, detection methods and recent developments in screening tool development. The current NICE-recommended strategies for treating these disorders and minimizing their occurrence in pregnancy are also explored. In addition, the association between adverse pregnancy outcome and increased risk of future maternal and offspring cardiovascular disease is described, with comments on future strategies to help minimize these potential risks. © 2013 Future Medicine Ltd.

**Database:** EMBASE

12. Screening pregnant women at 22-24 weeks for gestational hypertension or intrauterine growth retardation by Doppler ultrasound followed by 24-hour blood pressure recording

**Author(s):** Valensise H.; Tranquilli A.L.; Arduini D.; Garzetti G.G.; Romanini C.

**Source:** Hypertension in Pregnancy; 1995; vol. 14 (no. 3); p. 351-359

**Publication Date:** 1995

**Publication Type(s):** Article

**Abstract:** Objective: To improve the efficacy of screening patients at increased risk of hypertension or intrauterine growth retardation, we combined the assessment of increased uteroplacental resistance with a second-line screening using 24-h blood pressure monitoring. Methods: Doppler assessment of uterine artery flow (resistance index, diastolic notch) at 20 and at 24 weeks gestation and 24-h ambulatory blood pressure were determined in 48 consecutive patients. Mean 24-h diastolic blood pressure (M24-h DBP) was used as a measure to describe the overall pressure regimen for each patient. Based on a cutoff of 68 mm Hg, the series was divided into two groups: 18 high-risk patients with abnormal M24-h DBP (higher than 68 mm Hg), and 30 low-risk patients (equal to or lower than 68 mm Hg). The results were blinded to clinicians. Main Outcome Measures: The development of gestational hypertension, pre eclampsia, and intrauterine growth retardation (IUGR). Results: None of the 18 pathological M24-h DBP as compared to 25/30 in the normal DBP group had a normal pregnancy outcome. The group with abnormal 24-h DBP monitoring delivered earlier and smaller infants than did the normal 24-h DBP group. Sensitivity of combining these two methods to detect gestational hypertension was 79% and positive predictive value was 83%, whereas the respective indices for IUGR were 90% and 50%. Conclusions: Screening patients with increased uteroplacental resistance with 24-h blood pressure recording improves the efficacy of the Doppler screening to identify patients at risk of an abnormal outcome of pregnancy.

**Database:** EMBASE
13. Influence of non-dipping pattern of blood pressure in gestational hypertension on maternal cardiac function, hemodynamics and intrauterine growth restriction.

**Author(s):** Ilic, A.; Ilic, DJ.; Tadic, S.; Stefanovic, M.; Stojsic-Milosavljevic, A.; Pavlovic, K.; Redzek, A.; Velicki, L.; Ilic, D J

**Source:** Pregnancy Hypertension; Oct 2017; vol. 10 ; p. 34-41

**Publication Date:** Oct 2017

**Publication Type(s):** Academic Journal

**PubMedID:** 29153687

**Abstract:** Background: An association between gestational hypertension (GH) and changes of maternal cardiac function was previously reported. Aim: The study assessed the effect of non-dipping pattern of blood pressure (BP) in GH on haemodynamic function and intrauterine growth restriction (IUGR). Methods: This study included 126 women (91 with GH and 35 normotensive controls). Based on the BP values measured by ambulatory blood pressure monitoring (ABPM), all hypertensive women were classified in dipper (46 women) or in non-dipper group (45 women). All participants underwent echocardiography and ABPM during the third trimester. Results: Participants with GH and non-dipping pattern had significantly lower velocity of longitudinal systolic function (s') (p<0.0005), and cardiac output index (COi) compared to dippers (p<0.0005) and controls (p=0.002). Diastolic velocities at the mitral valve annulus were also lower in non-dippers e’s (non-dippers vs dippers p=0.023; non-dippers vs controls p<0.0005) and e’l (non-dippers vs dippers p=0.048; non-dippers vs controls p<0.0005). There were significant differences in the index of the left ventricle filling pressure E/e' and myocardial mass index between women with GH and controls, but with no significant difference among dippers and non-dippers. Total vascular resistance was increased in non-dipping group compared to normotensives and dippers (p<0.0005). Multivariate regression analysis revealed that the peak night-time diastolic BP, left ventricular mass index and CO index were identified as independent predictors of IUGR. Conclusion: Changes in maternal hemodynamics, as well as IUGR, are strongly related to the non-dipping pattern of BP.

**Database:** CINAHL

**Author(s):** Starling, A P; Shapiro, A L B; Sauder, K A; Kaar, J L; Ringham, B M; Glueck, D H; Galan, H L; Dabelea, D

**Source:** Journal of Perinatology; May 2017; vol. 37 (no. 5); p. 502-506

**Publication Date:** May 2017

**Publication Type(s):** Academic Journal

Available at Journal of Perinatology - from ProQuest (Hospital Premium Collection) - NHS Version

Available at Journal of Perinatology - from Unpaywall

**Abstract:**

**Objective:** The objective of this study is to estimate associations between changes in maternal arterial pressure during normotensive pregnancies and offspring birth weight and body composition at birth.

**Study Design:** Prospective study of 762 pregnant normotensive Colorado women, recruited from outpatient obstetrics clinics. Repeated arterial pressure measurements during pregnancy were averaged within the second and third trimesters, respectively. Multivariable regression models estimated associations between second to third trimester changes in arterial pressure and small-for-gestational-age birth weight, fat mass, fat-free mass and percent body fat.

**Results:** A greater second to third trimester increase in maternal arterial pressure was associated with greater odds of small-for-gestational-age birth weight. Greater increases in maternal diastolic blood pressure were associated with reductions in offspring percent body fat (−1.1% in highest vs lowest quartile of increase, 95% confidence interval: −1.9%, −0.3%).

**Conclusion:** Mid-to-late pregnancy increases in maternal arterial pressure, which do not meet clinical thresholds for hypertension are associated with neonatal body size and composition.

**Database:** CINAHL

15. Maternal blood pressures during pregnancy and the risk of delivering a small-for-gestational-age neonate.

**Author(s):** Block-Abraham, Dana M.; Adamovich, Dasha; Turan, Ozhan M.; Doyle, Lauren E.; Blitzer, Miriam G.; Baschat, Ahmet A.

**Source:** Hypertension in Pregnancy; Aug 2016; vol. 35 (no. 3); p. 350-360

**Publication Date:** Aug 2016

**Publication Type(s):** Academic Journal

**PubMedID:** 27003637

**Abstract:**

**Objective:** To determine the relationship between maternal blood pressures throughout pregnancy and the risk of delivering a small-for-gestational-age (SGA) neonate.

**Methods:** Women were prospectively enrolled at 9-14 weeks and had serial blood pressure measurements throughout pregnancy. SGA prevalence was compared to maternal blood pressure at enrollment, average blood pressure during each trimester, and blood pressure trends throughout gestation. Blood pressure was categorized as normotension, prehypertension, or hypertension using Joint National Committee on Hypertension-7 (JNC-7) definitions. Information on preeclampsia prevalence was also obtained due to its frequent concurrence with SGA.

**Results:** A total of 758 women had 8438 blood pressure measurements taken (average 11.1, range 3-14) and 65 (8.6%) delivered an SGA neonate. Forty-two of 514 (8.2%) normotensive women at enrollment and 23/244 (9.4%) women with enrollment prehypertension or hypertension delivered an SGA neonate. Women with elevated enrollment blood pressures did not have an increased SGA rate if their blood pressures improved throughout pregnancy. Logistic regression identified enrollment uterine artery Doppler, pregnancy-associated plasma protein-A.
levels, and ethnicity as primary contributors to SGA. Conclusion: Blood pressure improvement throughout pregnancy decreases the preeclampsia rate without increasing SGA frequency. Theoretical risks of fetal growth delay should not prevent investigations into improved maternal blood pressure control, possibly at thresholds lower than commonly used in obstetric practice, beginning in the first trimester of pregnancy.

Database: CINAHL

16. The association between maternal blood pressures and offspring size at birth in Southeast Asian women.

Author(s): Lim, Wai-Yee; Lee, Yung-Seng; Tan, Chuen-Seng; Kwek, Kenneth; Chong, Yap-Seng; Gluckman, Peter D; Godfrey, Keith M; Saw, Seang-Mei; Pan, An

Source: BMC pregnancy and childbirth; Dec 2014; vol. 14 ; p. 403

Publication Date: Dec 2014

Publication Type(s): Research Support, Non-u.s. Gov't Journal Article

PubMedID: 25444649

Available at BMC pregnancy and childbirth - from ProQuest (Hospital Premium Collection) - NHS Version

Available at BMC pregnancy and childbirth - from BioMed Central

Abstract: BACKGROUND Maternal blood pressures in pregnancy is an important determinant of offspring size at birth. However, the relationship between maternal blood pressures and offspring’s size at birth is not consistent and may vary between ethnic groups. We examined the relationship between maternal peripheral and central blood pressures and offspring size at birth in an Asian multi-ethnic cohort, and effect modifications by maternal ethnicity and obesity. METHODS We used data from 713 participants in the Growing Up in Singapore Towards Healthy Outcomes study consisting of pregnant Chinese, Malay and Indian women recruited from two tertiary hospitals between 2009 to 2010. Peripheral systolic and diastolic blood pressures (SBP and DBP), and central SBP and pulse pressure (PP) were measured around 27 weeks of gestation. Biometric parameters at birth were collected from medical records. RESULTS After adjusting for maternal and fetal covariates, each 1-SD increase (10.0 mmHg) in central SBP was inversely associated with birth weight (-40.52 g; 95% confidence interval (CI) -70.66 to -10.37), birth length (-0.19 cm; -0.36 to -0.03), head circumference (-0.12 cm; -0.23 to -0.02) and placental weight (-11.16 g; -20.85 to -1.47). A one-SD (11.1 mmHg) increase in peripheral SBP was also associated with lower birth weight (-35.56 g; -66.57 to -4.54). The inverse relations between other blood pressure measures and offspring size at birth were observed but not statistically significant. Higher peripheral SBP and DBP and central SBP were associated with increased odds of low birth weight (defined as weight <2500 g) and small for gestational age (defined as <10(th) percentile for gestational age adjusted birth weight). Maternal adiposity modified these associations, with stronger inverse associations in normal weight women. No significant interactions were found with ethnicity. CONCLUSIONS Higher second-trimester peripheral and central systolic pressures were associated with smaller offspring size at birth, particularly in normal weight women. Findings from this study reinforces the clinical relevance of antenatal blood pressure monitoring.

Database: Medline
Associations of blood pressure change in pregnancy with fetal growth and gestational age at delivery: findings from a prospective cohort.

Author(s): Macdonald-Wallis, Corrie; Tilling, Kate; Fraser, Abigail; Nelson, Scott M; Lawlor, Debbie A

Source: Hypertension (0194911X); Jul 2014; vol. 64 (no. 1); p. 36-44

Publication Date: Jul 2014

Publication Type(s): Academic Journal

PubMedID: 24821945

Available at Hypertension - from Ovid (Journals @ Ovid) - Remote Access

Available at Hypertension - from Unpaywall

Abstract: Hypertensive disorders of pregnancy are associated with intrauterine growth restriction and preterm birth. However, the associations of patterns of blood pressure change during pregnancy with these outcomes have not been studied in detail. We studied repeat antenatal blood pressure measurements of 9697 women in the Avon Longitudinal Study of Parents and Children (median [interquartile range], 10 [9-11] measurements per woman). Bivariate linear spline models were used to relate blood pressure changes to perinatal outcomes. Higher systolic, but not diastolic, blood pressure at baseline (8 weeks of gestation) and a greater increase in systolic and diastolic blood pressure between 18 and 36 weeks of gestation were associated with lower offspring birth weight and being smaller for gestational age in confounder-adjusted models. For example, the mean difference (95% confidence interval) in birth weight per 1 mm Hg/wk greater increase in systolic blood pressure between 18 and 30 weeks was -71 g (-134 to -14) and between 30 and 36 weeks was -175 g (-208 to -145). A smaller decrease in systolic and diastolic blood pressure before 18 weeks and a greater increase between 18 and 36 weeks were associated with a shorter gestation (percentage difference in gestational duration per 1 mm Hg/wk greater increase in systolic blood pressure between 18 and 30 weeks was -0.60% [-1.01 to -0.18] and between 30 and 36 weeks was -1.01% [-1.36 to -0.74]). Associations remained strong when restricting to normotensive women. We conclude that greater increases in blood pressure, from the 18-week nadir, are related to reduced fetal growth and shorter gestation even in women whose blood pressure does not cross the threshold for hypertensive disorders of pregnancy.

Database: CINAHL
18. OS083. Fetal growth and maternal vascular function in early pregnancy.

Author(s): Iacobaeus, C; Jörneskog, G; Kahan, T; Thorsell, M; Andolf, Ellika

Source: Pregnancy hypertension; Jul 2012; vol. 2 (no. 3); p. 223

Publication Date: Jul 2012

Publication Type(s): Journal Article

PubMedID: 26105298

Abstract: INTRODUCTION Increasing evidence indicates that the rate of fetal growth is partly determined already in the first half of pregnancy. A number of authors have reported that if the fetus is smaller than expected at dating, the risk for a small for gestational age fetus increases. OBJECTIVES To investigate if maternal vascular function in early pregnancy reflects fetal growth in the first trimester. METHODS Fifty healthy women with singleton viable pregnancies were included in the study that were recorded the ultrasound department of UltraGyn Stockholm, Sweden for ultrasound dating in gestational week 11-14. Of these, 25 women had their estimated date of delivery postponed ≥7 days at ultrasound dating compared to last menstrual period in gestational week 11-14. As controls 25 women were fetal size were in accordance with the last menstrual period (defined as expected date of delivery moved less than six days) were recruited. The dating examinations were performed by specially trained midwives. To assess gestational age, biparietal diameter was used. Exclusion criteria were the use of oral contraceptives within three months before conception, uncertain date of the last menstrual period, irregular menstrual periods, fetuses that were ≥21 days larger or smaller than expected, and fetal anomalies. Women that smoked were also excluded. Blood pressure was measured in the upper arm in a conventional way. The central blood pressure was calculated with a validated algorithm. Changes in skin microcirculation were measured using laser Doppler fluxmetry (LDF). Both endothelial dependent dilatation using assessment of acetylcholine (Ach) and local warming of skin to 44°C for maximum micro vascular hyperaemia (MMH) and non endothelial dilatation using assessment of sodium nitroprusside (SNP) was examined. RESULTS Fetuses that were smaller than expected at ultrasound dating compared to last menstrual period in gestational week 11-14, had an increased change in maximum micro vascular hyperaemia (p=0.034). There was no significant correlation between Ach-response (p=0.59) and SNP-response (p=0.23). No differences were seen in blood pressure. CONCLUSION In the first trimester, changes in vascular function might reflect important adaptations that are required to facilitate normal fetal growth. This was highlighted by the findings of a positive correlation between fetal growth at 11-14 weeks gestation and changes in endothelial dependent microcirculation. Vascular function of these women will be followed longitudinally during pregnancy and related to obstetric outcome. If changes in microcirculation in the first trimester correlates to an increased risk for complications such as hypertensive disorders during pregnancy or intrauterine growth restriction this gives new insights into the early phase of these complications.

Database: Medline

Author(s): Bakker R.; Jaddoe V.W.V.; Hofman A.; Steegers E.A.P.

Source: American Journal of Epidemiology; Oct 2011; vol. 174 (no. 7); p. 797-806

Publication Date: Oct 2011

Publication Type(s): Article

PubMedID: 21859836

Available at American journal of epidemiology - from Oxford Journals - Medicine
Available at American journal of epidemiology - from Unpaywall

Abstract: Researchers have suggested that maternal hypertensive disorders during pregnancy affect fetal growth. The authors examined the associations between systolic and diastolic blood pressures in different trimesters of pregnancy and both repeatedly measured fetal growth characteristics and the risks of adverse birth outcomes. The present study (2001-2005) was performed in 8,623 women who were participating in a population-based prospective cohort study from fetal life onwards. Blood pressure and fetal growth characteristics were assessed in each trimester of pregnancy. Information on hypertensive complications and adverse birth outcomes was obtained from medical records. The results suggested that higher blood pressure was associated with smaller fetal head circumference and femur length, as well as lower fetal weight from the third trimester onward. An increase in blood pressure from the second trimester to the third trimester was associated with an increased risk of adverse birth outcomes. Compared with women who did not experience hypertension during pregnancy, women with preeclampsia had increased risks of having children who were preterm (odds ratio = 5.89, 95% confidence interval: 2.63, 13.14), had a low birth weight (odds ratio = 8.94, 95% confidence interval: 6.19, 12.90), or were small for their gestational age (odds ratio = 5.03, 95% confidence interval: 3.31, 7.62). The present results suggest that higher maternal blood pressure is associated with impaired fetal growth during the third trimester of pregnancy and increased risks of adverse birth outcomes. © The Author 2011.

Database: EMBASE

Author(s): Prefumo, F; Muiesan, M L; Perini, R; Paini, A; Bonzi, B; Lojacono, A; Agabiti-Rosei, E; Frusca, T

Source: Ultrasound in obstetrics & gynecology : the official journal of the International Society of Ultrasound in Obstetrics and Gynecology; Jan 2008; vol. 31 (no. 1); p. 65-71

Publication Date: Jan 2008

Publication Type(s): Journal Article Evaluation Studies

PubMedID: 18157797

Abstract: OBJECTIVE To investigate maternal cardiovascular function in pregnancies complicated by intrauterine growth restriction (IUGR). METHODSMaternal echocardiography and ambulatory blood pressure monitoring were performed in pregnancies complicated by IUGR (n = 12) and controls (n = 12), all of whom were normotensive at enrollment. RESULTS Compared to controls, maternal blood pressure (P = 0.016) and total vascular resistance (P = 0.008) were higher in IUGR pregnancies. Heart rate was lower (P = 0.003), as was systolic function expressed by midwall fractional shortening (P = 0.04). No significant differences between the two groups were observed for left atrial or left ventricular dimensions, nor for left ventricular geometry. Assessment of diastolic function by means of transmitral Doppler flow measurements revealed a significantly longer isovolumetric relaxation time in pregnancies with IUGR (P = 0.006). CONCLUSIONS In normotensive pregnancies complicated by IUGR, as compared to controls, there is decreased diastolic and systolic maternal cardiac function, and a higher blood pressure.

Database: Medline

21. Circadian rhythm of maternal blood pressure and fetal growth

Author(s): Maggioni C.; Consonni D.; Nicolini U.; Cornelissen G.; Halberg F.; Otsuka K.

Source: Biomedicine and Pharmacotherapy; Oct 2005; vol. 59

Publication Date: Oct 2005

Publication Type(s): Article

PubMedID: 16275513

Abstract: This study aimed at examining any relation between the circadian variation in blood pressure (BP) in human pregnancy and fetal growth. A prospective study included 52 pregnant women monitored during the third trimester of pregnancy. There were 33 uncomplicated pregnancies with normal fetal growth (Group 1) and 19 pregnancies complicated by intrauterine growth retardation (IUGR), confirmed at birth (Group 2). Ten women (five in each group) had pregnancy-induced hypertension. All women were hospitalized and followed a similar daily routine. BP was recorded with an automatic wearable device. Measurements were obtained every 20 min for 24 +/- 1 h. BP profiles were analyzed by conventional statistical methods and by cosinor, involving the least squares fit of cosine curves with an anticipated period (24 h) to the data. BP parameters, fetal outcome, demographic and obstetric characteristics were compared between the two groups. Logistic regression and multivariate analyses were used to assess factors putatively associated with fetal outcome. The circadian amplitude of diastolic BP was found to be larger in normotensive women with IUGR. As gauged by odds ratios (OR), the circadian amplitude of diastolic BP (OR = 1.7, 95% CI: 1.1-2.8; P = 0.03) and hematocrit (OR = 1.4, 95% CI: 1.0-1.9; P = 0.04) were the only variables
positively and independently associated with IUGR. In the presence of maternal hypertension, the circadian amplitude of systolic BP was negatively associated with IUGR (OR = 0.7, 95% CI: 0.5-1.0; P = 0.03). A larger circadian variation in diastolic BP, rather than a difference in the mean value of systolic or diastolic BP, was found to be statistically significantly associated with IUGR. This study adds another condition in which the circadian BP amplitude constitutes a harbinger of elevated risk, apart from an association with a shortened lifespan in the absence or presence of malignant hypertension and with an increased risk of stroke and nephropathy reported earlier. © 2005 Elsevier SAS. All rights reserved.

Database: EMBASE

22. Blood pressure is elevated in normotensive pregnant women with intrauterine growth restriction.

Author(s): Tranquilli, Andrea Luigi; Giannubilo, Stefano Raffaele

Source: European journal of obstetrics, gynecology, and reproductive biology; Sep 2005; vol. 122 (no. 1); p. 45-48

Publication Date: Sep 2005

Publication Type(s): Journal Article

PubMedID: 16154038

Abstract: OBJECTIVE To assess the relationship between blood pressure pattern and intrauterine growth restriction in normotensive pregnant women. STUDY DESIGN Twenty-four-hour ambulatory blood pressure was consecutively performed between 32 and 34 weeks in 139 normotensive, non-proteinuric, primigravidae with intrauterine growth restriction (IUGR) and in 140 primigravidae, matched for age and gestation, who were and remained normotensive throughout pregnancy and whose fetuses had regular fetal growth, who served as controls. RESULTS Although all measures were within the normotensive range, blood pressure of mothers with IUGR were significantly higher than controls. Twenty-four-hour mean, daytime, and nighttime systolic were 119.9+/-11.9, 122.6+/-11.7, 114.4+/-13.3 mmHg, in women with IUGR and 108.0+/-7.4, 109.2+/-7.3, 102.1+/-8.5 mmHg, in controls. Twenty-four-hour diastolic average, daytime, and nighttime diastolic (mean+/-S.D.) 78.1+/-9.3, 69.2+/-10.6, 67.2+/-9.0 mmHg, in women with IUGR and 64.1+/-5.7, 66.0+/-5.7, 58.2+/-6.3 mmHg, in normal pregnant women. All differences p<0.0001. CONCLUSIONS Pregnant women with idiopathic IUGR have blood pressure higher than normal. Although within clinic normotensive range, slightly higher levels of blood pressure can alter uterine and placental perfusion and determine fetal growth restriction.

Database: Medline
23. Intrauterine growth and blood pressure: What causes the relationship?

**Author(s):** Melander O.

**Source:** Journal of Hypertension; Jul 2003; vol. 21 (no. 7); p. 1245-1247

**Publication Date:** Jul 2003

**Publication Type(s):** Editorial

**PubMedID:** 12817166

Available at Journal of Hypertension - from Ovid (LWW Total Access Collection 2015 - Q1 with Neurology)

Available at Journal of Hypertension - from Unpaywall

**Database:** EMBASE

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**Author(s):** Hermida, Ramón C; Ayala, Diana E

**Source:** Hypertension (Dallas, Tex. : 1979); Sep 2002; vol. 40 (no. 3); p. 298-303

**Publication Date:** Sep 2002

**Publication Type(s):** Research Support, Non-u.s. Gov't Comparative Study Controlled Clinical Trial Clinical Trial Journal Article

**PubMedID:** 12215470

Available at Hypertension (Dallas, Tex. : 1979) - from Ovid (LWW Total Access Collection 2015 - Q1 with Neurology)

Available at Hypertension (Dallas, Tex. : 1979) - from Unpaywall

**Abstract:** With the objective to assess the prognostic value of office values as compared with ambulatory monitoring in pregnancy, we analyzed 2430 blood pressure series systematically sampled from 403 untreated pregnant women for 48 consecutive hours every 4 weeks from the first visit to the hospital until delivery. Women were divided into 5 groups: "detected" gestational hypertension, women with office blood pressures >140/90 mm Hg after 20 weeks of gestation and hyperbaric index (area of blood pressure excess above the upper limit of a time-specified tolerance interval) consistently above the threshold for diagnosing hypertension in pregnancy; "undetected" gestational hypertension, office values <140/90 mm Hg but hyperbaric index above the threshold for diagnosis; normotension, both office values and hyperbaric index below the thresholds for diagnosis; white coat hypertension, women with recorded diagnosis of gestational hypertension but hyperbaric index consistently below the threshold for diagnosis; and preeclampsia, defined as gestational hypertension and proteinuria. Results indicate small and nonsignificant differences in 24-hour mean of ambulatory pressures between "detected" and "undetected" gestational hypertension at all stages of pregnancy, in contrast with highly significant differences between these two groups and normotensive pregnancies. Average office blood pressure values were similar for preeclampsia, "detected," and "undetected" gestational hypertension. The hyperbaric index was, however, significantly higher for women with preeclampsia after 20 weeks of gestation as compared with all other groups and higher for women with either "detected" or "undetected" gestational hypertension as compared with normotensive pregnant women. The incidence of preterm delivery and intrauterine growth retardation were similar for "detected" and "undetected" gestational hypertension but significantly lower for normotensive women. In pregnancy, the hyperbaric index derived from ambulatory monitoring is markedly superior to office measurements for diagnosis of what should be truly considered gestational hypertension, as well as for prediction of the outcome of pregnancy.
25. Analysis of ambulatory blood pressure monitor data using a hierarchical model incorporating restricted cubic splines and heterogeneous within-subject variances.

**Author(s):** Lambert, P C; Abrams, K R; Jones, D R; Halligan, A W; Shennan, A

**Source:** Statistics in medicine; Dec 2001; vol. 20 (no. 24); p. 3789-3805

**Publication Date:** Dec 2001

**Publication Type(s):** Comparative Study Journal Article

**PubMedID:** 11782034

Available at Statistics in medicine - from Wiley Online Library Science, Technology and Medicine Collection 2017

**Abstract:** Hypertensive disorders of pregnancy are associated with significant maternal and foetal morbidity. Measurement of blood pressure remains the standard way of identifying individuals at risk. There is growing interest in the use of ambulatory blood pressure monitors (ABPM), which can record an individual's blood pressure many times over a 24-hour period. From a clinical perspective interest lies in the shape of the blood pressure profile over a 24-hour period and any differences in the profile between groups. We propose a two-level hierarchical linear model incorporating all ABPM data into a single model. We contrast a classical approach with a Bayesian approach using the results of a study of 206 pregnant women who were asked to wear an ABPM for 24 hours after referral to an obstetric day unit with high blood pressure. As the main interest lies in the shape of the profile, we use restricted cubic splines to model the mean profiles. The use of restricted cubic splines provides a flexible way to model the mean profiles and to make comparisons between groups. From examining the data and the fit of the model it is apparent that there were heterogeneous within-subject variances in that some women tend to have more variable blood pressure than others. Within the Bayesian framework it is relatively easy to incorporate a random effect to model the between-subject variation in the within-subject variances. Although there is substantial heterogeneity in the within-subject variances, allowing for this in the model has surprisingly little impact on the estimates of the mean profiles or their confidence/credible intervals. We thus demonstrate a powerful method for analysis of ABPM data and also demonstrate how heterogeneous within-subject variances can be modelled from a Bayesian perspective.

**Database:** Medline


**Author(s):** Goldenberg, R L; Cliver, S P; Cutter, G R; Davis, R O; Hoffman, H J; Wen, S W

**Source:** International journal of technology assessment in health care; 1992; vol. 8

**Publication Date:** 1992

**Publication Type(s):** Journal Article

**PubMedID:** 1428651

**Abstract:** The effect of various levels of both diastolic and systolic blood pressure at various times during pregnancy on the rates of intrauterine growth retardation (IUGR) and preterm delivery (PTD) were determined. Low systolic and diastolic pressures were associated with both IUGR and PTD, as were high pressures. Low pressures tended to be associated with spontaneous preterm deliveries, whereas high pressures were associated with more indicated preterm deliveries.

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