Comparison of Pulsatility Index and Notching of Uterine Artery Doppler on Normotensive Pregnancy and Established Pre-eclampsia

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Abstract

Objective: The aim is to assess the pulsatility index of the uterine artery (UtA-PI) and the presence of notching, then compare them between normotensive pregnancy and pre-eclampsia.

Methods: This cross-sectional study was conducted at dr. Sardjito Hospital and Harapan Kita Maternal Children Hospital as a tertiary referral hospital. The study involved 220 women, this includes pregnant women who are at risk of illness and mortality during pregnancy, parturition, and postpartum periods, specifically those with chronic hypertension and a history of pre-eclampsia. The inclusion criteria comprised of women aged ≥18years, gestational age 28-40 weeks, singleton pregnancy, normotensive pregnant women, and pregnant women diagnosed with pre-eclampsia. The exclusion criteria included women with intrauterine fetal death, pregnant women with heart disease, acute fatty liver of pregnancy, chronic kidney disease, autoimmune disorders like systemic lupus erythematosus or antiphospholipid, and type 1 or type 2 diabetes. STATA 14.2 program was used for statistical analysis.

Result: There were 188 pregnant women normotensive pregnancy (85.5%) and 32 pre-eclampsia cases (14.5%). Body mass index, blood pressure, mean arterial pressure, chronic hypertension, history of pre-eclampsia, birth weight, UtA-PI and notching showed an significant association with pre-eclampsia. The receiver operating characteristic curve (ROC) analysis was used. The ROC analysis result of UtA-PI was found as sensitivity 87.50% and specificity 98,94% (AUC: 0.9963, 95% CI: 0.99-1) with cutoff 1,22. and notching was found as sensitivity 46,88% and specificity 87,23% (AUC: 0.6705, 95% CI: 0.57-0.76).

Conclusion: There are differences in the accuracy between UtA-PI and notching. UtA-PI has better performance the notching.

Keywords: Pulsatility index, notching, normotensive, pre-eclampsia

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INTRODUCTION

Hypertension in pregnancy remains the major cause of maternal death. Pre-eclampsia results in the deaths of 76,000 women and 500,000 infants annually, affecting 3-5% of pregnancies worldwide[1]. In Indonesia, the maternal mortality rate due to pre-eclampsia is approximately 2.2%, and at Cipto Mangunkusumo Hospital, it remains a significant cause of maternal deaths. To address this issue, quality antenatal care services are essential[2,3].

Pre-eclampsia is caused by abnormal uteroplacental circulation, which is a result of imperfect remodeling of the spiral arteries during trophoblast invasion[4]. This condition can be assessed using a

non-invasive method, namely, Doppler ultrasonography, which examines the UtA-PI and notching[5]. The UtA-PI is the difference between systolic and diastolic flow velocities divided by the average velocity, providing information about the impedance index[6]. Notching is associated with endothelial damage in the mother, resulting in increased vascular resistance[7]. The objectives of this study are to assess the UtA-PI and the presence of notching, then compare them between normotensive pregnancy and pre-eclampsia.

METHODS

A cross sectional study was conducted between March to August 2024. The inclusion criteria comprised of women aged ≥18years, gestational age 28-40 weeks, singleton pregnancy, normotensive pregnant women, and pregnant women diagnosed with pre-eclampsia. The exclusion criteria included women with intrauterine fetal death, pregnant women with comorbidities, such as heart disease, acute fatty liver of pregnancy, chronic kidney disease, autoimmune disorders like systemic lupus erythematosus or antiphospholipid, type 1 or type 2 diabetes and those unable to provide informed consent. This research used a consecutive sampling method.

The study was conducted in dr. Sardjito Hospital and Harapan Kita Maternal Children Hospital. The study had 227 participants and 7 of them were excluded, that only 220 research samples were analyzed, this includes pregnant women who are at risk of illness and mortality during pregnancy, parturition, and postpartum periods, specifically those with chronic hypertension and a history of pre-eclampsia. Pre-eclampsia is defined as a hypertensive condition that appears after 20 weeks of pregnancy, accompanied by end-organ damage, including proteinuria[8]. Chronic hypertension refers to hypertension that exists prior to pregnancy. A history of preeclampsia indicates that the pregnant woman experienced pre-eclampsia in a previous pregnancy. Superimposed pre-eclampsia refers to women with chronic hypertension accompanied by proteinuria after 20 weeks of gestation represents a significant complication[9]. Diagnosing pre-eclampsia using the guidelines of the International Society for the Study of Hypertension in Pregnancy (ISSHP)[8]. Superimposed pre-eclampsia is not included in analysis. Data analyzed using STATA version 14.2.

The pregnant woman undergoes an interview covering her previous pregnancy and medical history. The physical examination includes vital signs and an obstetric examination. An ultrasound examination is performed using a Voluson S8 ultrasound machine produced by General Electric Healthcare in Milwaukee, United States. The machine is equipped with a convex transducer probe operating at 1-5MHz for transabdominal scanning.

The operator of this study was two sonographers certified by the Fetal Medicine Foundation. Inter-Observer Agreement were also conducted to assess the reliability between two observers using intraclass correlations. The uterine artery examination and assessment of the notching were carried out according to the guidelines of the International Society of Ultrasound in Obstetrics and Gynaecology (ISUOG)[10].

RESULT

In Table 1, the total number of women who completed the study was 220 of these, 188 (85,5%) had normotensive pregnancy, while 32 (14,5%) of them developed pre-eclampsia. The analysis was carried out using t test and chi-square test. The table shows a significant association between pre-eclampsia and several variables are body mass index, blood pressure, mean arterial pressure, chronic hypertension, history of pre-eclampsia, birth weight, UtA-PI and notching. In contrast, other variables are age and parity showed no significant correlation.

Tabel 1. Distribution of pre-eclampsia cases based on characteristics and chi-square test

| Variables	Total (N=220)			P value
	Normotensive(n=188)	Pre-eclampsia(n=32)	ALL	
Age, years*	32.088 (4.939)	32.035 (5.479)	32.080 (5.008)	0.956
Age				
<35 years old	134 (71.3%)	23 (71.9%)	157 (71.4%)	0.945
35+ years old	54 (28.7%)	9 (28.1%)	63 (28.6%)	
Body Mass Index, Kg/M^2	27.138 (4.529)	31.317 (4.585)	27.746 (4.761)	<0.001
Blood Pressure, mmHg				
Systolic	113.287 (10.610)	159.719 (19.069)	120.041 (20.415)	<0.001
Diastolic	69.963 (7.701)	97.125 (11.316)	73.914 (12.684)	<0.001
Mean Arterial Pressure, mmHg	84.404 (6.834)	117.990 (13.176)	89.289 (14.328)	<0.001
<90	146 (77.7%)	3 (9.4%)	149 (67.7%)	<0.001
90+	42 (22.3%)	29 (90.6%)	71 (32.3%)	
Parity				
Nulli/Primigravida	150 (79.8%)	24 (75.0%)	174 (79.1%)	0.538
Multigravida	38 (20.2%)	8 (25.0%)	46 (20.9%)	
Chronic Hypertension				
No	185 (98.4%)	23 (71.9%)	208 (94.5%)	<0.001
Yes	3 (1.6%)	9 (28.1%)	12 (5.5%)	
History of Pre-eclampsia				
No	188 (100.0%)	21 (65.6%)	209 (95.0%)	<0.001
Yes	0 (0.0%)	11 (34.4%)	11 (5.0%)	
Birth Weight, gram	2,900.005(564.238)	2,421.625 (693.284)	2,830.423(607.006)	<0.001
<2500	32 (17.0%)	17 (53.1%)	49 (22.3%)	<0.001
2500+	156 (83.0%)	15 (46.9%)	171 (77.7%)	
UtA-PI, score*	0.670 (0.141)	1.376 (0.178)	0.773 (0.289)	<0.001
Notching			181 (82.3%)	
Absent	164 (87.2%)	17 (53.1%)		<0.001
Presents	24 (12.8	15 (46.9%)	39 (17.7%)	

*) t test , all other using chi-square
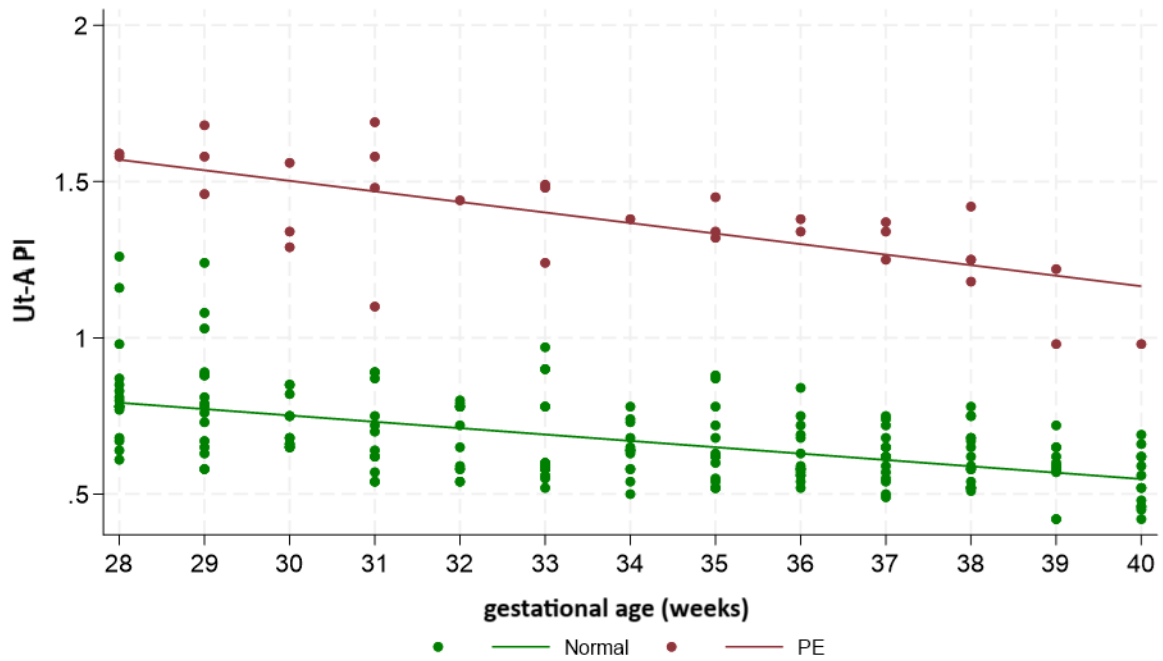
Figure 1. Uterine Artery Pulsatility Index on normotensive pregnancy (normal) and pre-eclampsia (PE)

Figure 1, they analysis was carried out using regression test, showed higher baseline UtA-PI values in pre-eclampsia compared to normotensive pregnancy. In another study, an increase in the UtA-PI ratio >95th percentile was reported in women with pre-eclampsia compared to normotensive pregnancy [11].
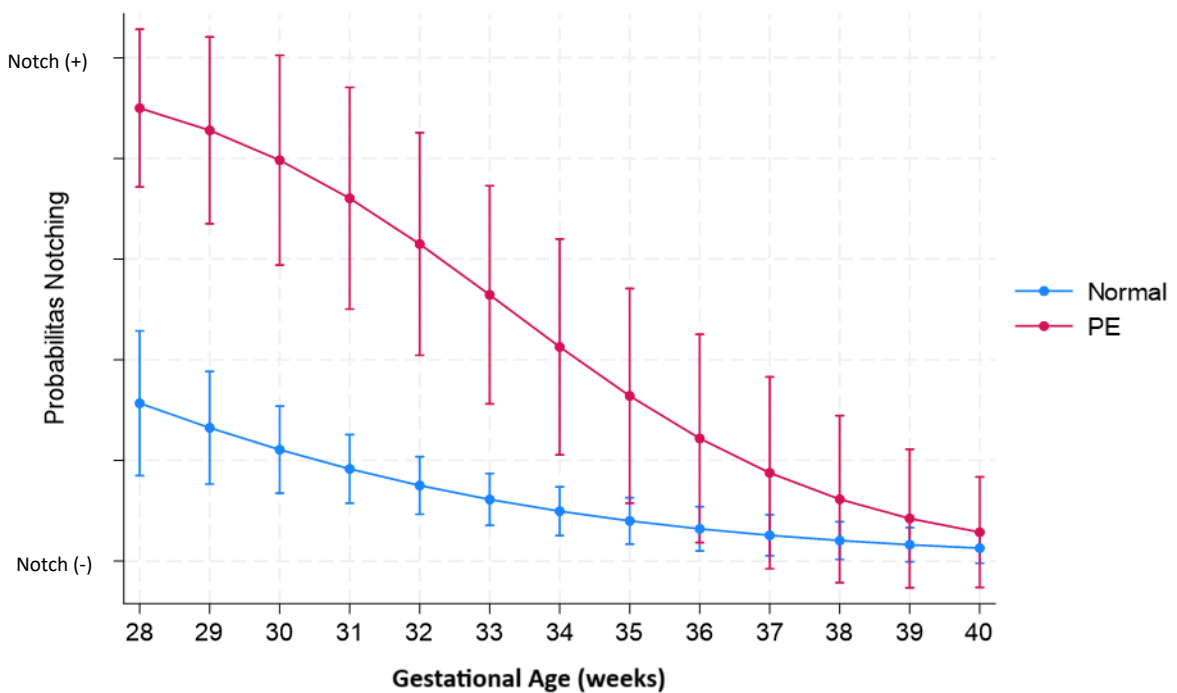
Figure 2. Notching in Normotensive Pregnancy and Pre-eclampsia

Figure 2, they analysis was carried out using regression test, showing notching is more often present in pregnant women with pre eclampsia compared to pregnant women with normotensive. Whereas other research, notching appears more often in pre eclampsia compared to pregnant women with normotensive [12].
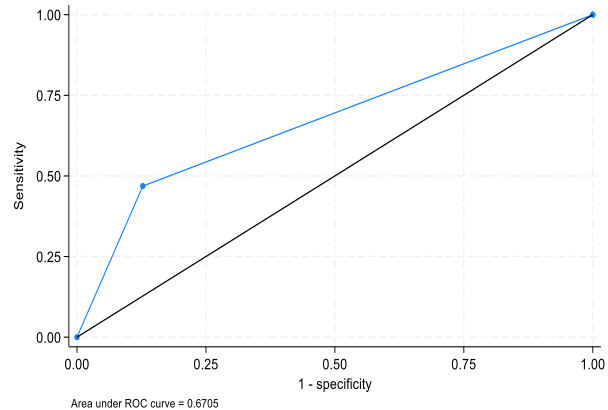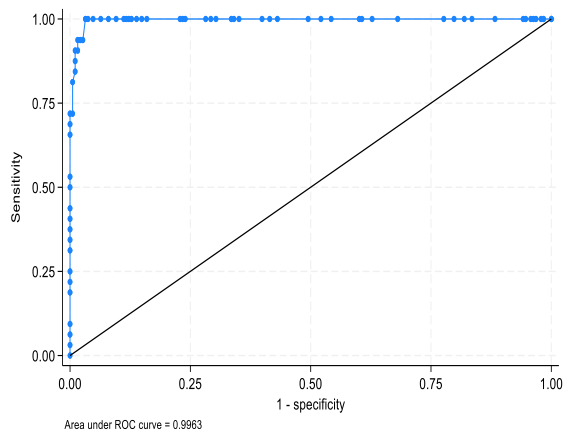
a

b

Figure 3. Receiving Operator Curve (ROC) Pulsatility Index Analysis (a) and ROC for notching (b)

Figure 3a shows the logistic model analysis, performed with a Receiver Operating Characteristic (ROC) curve value of 0.99 to evaluate the screening method's performance. Figure 3b shows the logistic model analysis for the notching yielding under the ROC curve value of 0,67.

Table 2. Sensitivity and Specificity Notching and UtA-PI

Variable	Sensitivity (%)	Specificity (%)	Cut off
Notching	46,88	87,23	-
UtA-PI	87.50	98.94	1.22

Table 2 compares the sensitivity and specificity of the UtA-PI and notching. The logistic regression model for the pulsatility index shows an area under the ROC curve (AUC) of 0.99, with a chosen cut-off 1,22 yielding 87.50% sensitivity and 98.94% specificity. The notching model has an AUC of 0.67, with 46.88% sensitivity and 87.23% specificity. After performing a one-way analysis using F-tests, the notching shows a power of 0,98 ($\alpha = 0,05$), while the UtA-PI demonstrates a power of 1 ($\alpha = 0,05$). Whereas other research the UtA-PI has defined the cut-off value as 2.51 AUC of 0,93 in the 1st trimester, 1,32 AUC of 0,93 in the 2nd trimester and 1,91 AUC of 0,96 in the 1st and 2nd trimesters [13].

DISCUSSION

This research identified 14,5% pre-eclampsia cases. The high rate of pre-eclampsia is consistent with previous report from Indonesia [14]. Globally, the incidence ranges from 2-8% and is increasing in developing countries [15]. Therefore, early screening of pre-eclampsia are essential. Given this, ultrasonography is a viable approach that can be implemented in Indonesia, even with limited resources.

Cytotrophoblasts invade the spiral arteries that supply blood to the basal decidua, establishing contact between the fetus and mother. The placenta functions to regulate oxygen and nutrients for the fetus. Disruptions in

perfusion and oxygen flow can lead to placental insufficiency. This condition is believed to be associated with the failure of spiral arteries to undergo vascular remodeling. The spiral arterial invasion, which should normally penetrate the medial elastic, muscular, and neural tissues and replace the endothelial layer, only penetrates superficially, resulting in blood vessels with high resistance. This leads to increased vascular resistance, which results in notching and causes increased blood flow, ultimately leading to elevated pulsatility index. In normotensive pregnancy, perfect spiral artery remodeling leads to decreased vascular resistance and reduced blood flow[4,16,17]. This explains why in this study, there was an increased UtA-PI in pregnant women with pre-eclampsia compared to normotensive pregnant women, and notching was more frequently observed in women with pre-eclampsia compared to women with normotensive pregnancies. These findings are supported by previous research: the presence of bilateral notching in pregnancy is associated with the occurrence of pre-eclampsia[18], bilateral notching has a significant relationship with increased risk of pre-eclampsia in the 2nd and 3rd trimesters and increased mean UtA-PI occurs in pregnant women with preeclampsia[7], there is a difference in the average value of UtA-PI in pregnant women with preeclampsia compared to normotensive pregnant women[19].

In this study, The UtA-PI has a sensitivity of 87.50% and a specificity of 98.94% with a cutoff of 1.22. While the notching had a sensitivity of 46.88% and a specificity of 87.25%. A previous study found that the UtA-PI has a sensitivity of 65% and a specificity of 88%, while notching has a sensitivity of 54% and a specificity of 89%.[20] This is due to UtA-PI over notching is that UtA-PI provides information about vascular impedance, which is related to vascular resistance, preload, heart rate, and cardiac contractility throughout the cardiac cycle. Meanwhile, notching only indicates the occurrence of high vascular resistance[6].

CONCLUSION

The mean UtA-PI increases in pregnant women with pre-eclampsia. Notching is more commonly found in pregnant women with pre-eclampsia compared to normotensive pregnant women. The sensitivity of the UtA-PI is higher than that of notching, while the specificity of the UtA-PI is comparable to notching.

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