RESEARCH ARTICLE

Hemodynamic Profile and Cardiac Morphometry in Normotensive and Severe Preeclamptic Pregnant Women

Peby Lestari[1], Noroyono Wibowo[2], Edo Alexander[3]

Abstract

Objective: To identify the differences in hemodynamic profile and morphometric changes of maternal heart in normotensive pregnant women and severe preeclampsia.

Materials and methods: Cross-sectional study was conducted on 34 pregnant women divided into three groups: normotensive ($n = 12$), early-onset ($n = 11$), and the late-onset ($n = 11$). Subjects were patient from ER and inpatient unit of the Department of Obstetrics and Gynecology, Faculty of Medicine, Sriwijaya University/Dr Mohammad Hoesin Hospital, Palembang, during April–June 2015.

Results: CO values of the early onset group was lower (3.4 + 0.27, $p < 0.001$) with higher SVR (3100.2 + 261.3, $p < 0.001$) than the other two groups. SVR in preeclamptic group was higher compared to the control, the early onset presenting higher SVR than the late-onset group (3100.2 + 261.3 vs 2217.1 + 407.8, $p < 0.001$). Cardiac index variables between groups were also different, except in the early onset group and controls ($p = 0.045$). In blood pressure and MAP variable, we only noticed difference between the early onset group and control ($p < 0.001$) as well as late-onset group and controls ($p < 0.001$). LVMi, LVID and LVPWT in control group was lower than the others ($p < 0.001$; $p = 0.049$; $p = 0.009$), but were similar for the early onset and late-onset groups [98.7 (86.5–203) vs 132 (77.7–17.6); 4.7 (0.4) vs 4.8 (0.5); 1.1 (0.7–1.3) vs 1.1 (0.8–1.6)]. RWT was relatively similar across the three arms of the study ($p = 0.264$).

Conclusion: In severe preeclampsia, there are changes in hemodynamic, ventricular morphometry, and left ventricular function, which is more evident in the group of early-onset preeclampsia than late-onset preeclampsia.

Keywords: Cardiac morphometry, Early onset PE, Hemodynamic profile, Late-onset PE, Normotensive.

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Introduction

Preeclampsia is the most frequent medical complications in pregnancy. Preeclampsia occurs in about 2–8% of pregnancies worldwide, and its incidence is likely to increase, especially in developing countries.[1–4] Preeclampsia contributes to 16% of peripartum death, nevertheless the cause still unknown.[1,2]

Pregnancy is characterized by the changes in hemodynamic function. Hemodynamic function in normotensive pregnant women is expected to be different from pregnant women with preeclampsia, especially severe preeclampsia. Preeclampsia has been reported to be associated with cardiac output (CO) which is low or otherwise increased depending on the type of preeclampsia. CO differences are also believed to be associated with the changes in systemic vascular resistance (SVR) and morphometric of the maternal heart (especially the left ventricle), as well as maternal arteries and veins, which are also parallel to the clinical manifestations of preeclampsia itself.[1,4]

As we know, preeclampsia is differentiated by its degree of severity (mild preeclampsia and severe preeclampsia) and based on the time of onset, i.e., early-onset preeclampsia (gestational age <34 weeks) and late-onset preeclampsia (gestation >34 weeks). Early onset preeclampsia is associated with abnormal uterine artery Doppler, fetal growth restriction, and poor maternal-neonatal outcomes.[5,6] Late-onset preeclampsia is usually associated with normal or slightly elevated uterine artery resistance index, with little involvement of the fetus and better neonatal outcome than the early onset preeclampsia.[7]

Therefore, this study tried to compare the hemodynamic and cardiac morphometry changes in normotensive pregnant women, early and late onset severe preeclampsia using echocardiography–ultrasound Doppler.

Although there have been several studies conducted on hemodynamics in preeclampsia, only very few studies about the relationship between hemodynamic and cardiac morphometry with uterine artery. In Indonesia, there has been no research on this, which is why authors are interested to learn about the changes of hemodynamic and cardiac morphometry in preeclampsia and its relationship to the image of the uterine arteries, as well as the birth weight and Apgar score of newborns more comprehensively.

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Materials and Methods

Cross-sectional study was conducted on 34 pregnant women who were enrolled consecutively and were divided into three groups: normotensive ($n = 12$), early-onset ($n = 11$), and late-onset ($n = 11$). Subjects were patient in RSMH inpatient unit and ER of Obstetrics and Gynecology Department, Faculty of Medicine, University of Sriwijaya, from April to June 2015. Inclusion criteria included gestational age >20 weeks, single live intrauterine pregnancy, normal body temperature for case group. While the control group, among others, were gestational age >20 weeks, normotensive, no history of cardiovascular disease, no history of other medical disorders. Exclusion criteria included the history of heart disease, renal disease, impaired liver function, hematologic disease, coagulation disorders, DIC, usage of anticoagulants and thrombolytics, and refusal to participate in the research.

All patients who met the inclusion criteria continued with basic data collection: identity, obstetric history, past medical history, history of drug use; physical examination (temperature, blood pressure); urine protein examination, followed by biometric measurement of the fetus and uterine artery using Voluson E8 ultrasound. Subjects were then allowed to rest for 30 minutes, followed by measurement of hemodynamic profile and maternal heart morphometry using Doppler echocardiography Philips IE-33, probe S5-3 in the left lateral recumbent position and head elevation of 15°. All ultrasound and Doppler echocardiography examinations were performed by the same person to ensure accuracy and consistency. The examination was conducted on the subject who has not been in labor.

After the birth process was completed, variable assessed were outcomes of the baby, including the baby's weight and Apgar score of the newborn. Data were processed using Statistical Package for Social Sciences (SPSS) version 20.0.

Results

Characteristics of Subjects

Table 1 shows that mean age in the group of early-onset preeclampsia was older than the control group and late-onset preeclampsia. Height, weight and body surface area were indifferent. Gestational age was divided into early onset preeclampsia for gestational age <34 weeks and late-onset preeclampsia gestational age >34 weeks. Gestational age for the control group varied between 30–41 weeks.

Hemodynamic Profile

There were differences between the three groups for CO, SVR, stroke volume and cardiac index. In the early onset preeclampsia, CO values were lower while SVR was higher than the other two groups. There was alsoincreasedSVR in the preeclampsia group compared to the control, SVR in early-onset preeclampsia being higher than the late-onset group (Table 2).

To see the differences between the two groups statistically, *post hoc* analysis was conducted with a Tukey test. CO and SVR variables differed among the three groups, but the difference of BP and MAP were only noticeable between the early onset groups compared with control and late-onset preeclampsia compared with control. Differences of a cardiac index between groups were observed, except for early-onset preeclampsia and controls (Table 3).

Maternal Heart Morphometry

The maternal cardiac morphometric examination was conducted after the subject rested for 15–30 minutes in the left lateral position. In this study, LVMi, LVID, and LVPWT were significantly different among the three groups, in which the control group tends to be lower

Table 1: Characteristics of subjects

Characteristics	*Early onset*	*Late onset*	*Control*	*p*
Age (years)	31.6 ± 6.0	27.8 ± 5.2	28.8 ± 3.8	0204[a]
Height (cm)	153.0 ± 4.3	153.3 ± 4.8	154.3 ± 5.9	0813[a]
Body weight (kg)	58.9 ± 3.5	66.6 ± 8.3	63.8 ± 8.9	0062[a]
Body surface area (m^2)	1.5 ± 0:09	1.6 ± 1	1.6 ± 0.1	0193[a]
Gravid	3.0 (1–4)	1.0 (1)	1.5 (1–4)	0036[b]
Gestational age (week)	32.4 ± 1.1	37.6 ± 1.1	36.2 ± 2.3	<0.001[a]
EFW (g)	1981.8 ± 315.6	2995.4 ± 343.1	2775.0 ± 485.9	<0.001[a]

Data are presented as mean ± SD. $p < 0.005$
[a]Analysis with one-way ANOVA test; [b]Analysis by Kruskal–Wallis

Table 2: Hemodynamic profile of research subjects

Hemodynamic profile	*Early onset*	*Late onset*	*Control*	*p*
Systolic BP (mm Hg)	166.3 + 8.1	165.4 + 12.1	114.1 + 9.0	<0.001
Diastolic BP (mm Hg)	113.6 + 5.0	111.8 + 6.0	73.3 + 4.9	<0.001
MAP	131.0 + 4.6	129.5 + 7.9	86.6 + 5.3	<0.001
Heart rate (x/minute)	85.2 + 8.8	91.3 + 19.6	86.9 + 9.0	0508
SVR (dyne seconds cm^{-5})	3100.2 + 261.3	2217.1 + 407.8	1739.2 + 165.6	<0.001
Cardiac output (L/minute)	3.4 + 0:27	4.9 + 0.9	4.0 + 0.4	<0.001
Cardiac index	2.1 + 0.1	2.9 + 0.5	2.4 + 0.3	0001
SV (mL/minute)	44.4 + 7.5	59.7 + 13.0	46.5 + 7.2	0001
Ejection fraction	68.7 + 7.6	69.6 + 5.6	64.0 + 7.1	0128

Data are presented as mean ± SD. $p < 0.005$ (one way ANOVA test)
BP, blood pressure; MAP, mean arterial pressure; SVR, systemic vascular resistance

Table 3: *Post hoc* analysis of the hemodynamic profile of research subjects

						95% CI	
Variable bound	*(I) Group*	*(II) Group*	*Mean difference (I–II)*	*Std. error*	*Sig.*	*Lower bound*	*Upper bound*
Systolic BP (mm Hg)	Early onset	Late onset	0.909	4208	0.975	–9.45	11:27
		Control	52,197*	4119	0.000	42.06	62.34
	Late onset	Early onset	–0.909	4208	0.975	–11.27	9:45
		Control	51,288*	4119	0.000	41.15	61.43
Diastolic BP (mm Hg)	Early onset	Late onset	1,818	2,278	0.707	–3.79	7:43
		Control	40,303*	2,230	0.000	34.81	45.79
	Late onset	Early onset	–1818	2,278	0.707	–7.43	3.79
		Control	38,485*	2,230	0.000	33.00	43.97
MAP (mm Hg)	Early onset	Late onset	1.4727	2.6163	0.841	–4967	7912
		Control	44.4121*	2.5613	0.000	38 108	50 716
	Late onset	Early onset	–1.4727	2.6163	0.841	–7912	4967
		Control	42.9394*	2.5613	0.000	36 636	49 243
Heart rate (x/minute)	Early onset	Late onset	–6,455	5,712	0.503	–20.51	7.60
		Control	–1,644	5,592	0.954	–15.41	12:12
	Late onset	Early onset	6,455	5,712	0.503	–7.60	20:51
		Control	4,811	5,592	0.669	–8.95	18:57
SVR (dyne second cm^{-5})	Early onset	Late onset	883.09091*	124.62731	0.000	576.3596	1189.8222
		Control	1361.02273*	122.00328	0.000	1060.7496	1661.2958
	Late onset	Early onset	–883.09091*	124.62731	0.000	–1189.8222	–576.3596
		Control	477.93182*	122.00328	0.001	177.6587	778.2049
Cardiac output (L/minute)	Early onset	Late onset	–1.4091*	0.2548	0.000	–2036	–0.782
		Control	–0.6250*	0.2495	0.045	–1239	–0.011
	Late onset	Early onset	1.4091*	0.2548	0.000	0.782	2036
		Control	0.7841*	0.2495	0.010	0.170	1398
Stroke volume (mL/minute)	Early onset	Late onset	–15.2818*	4.0898	0.002	–25 348	–5216
		Control	–2.1561	4.0037	0.853	–12 010	7698
	Late onset	Early onset	15.2818*	4.0898	0.002	5216	25 348
		Control	13.1258*	4.0037	0.007	3272	22 980
Ejection fraction (%)	Early onset	Late onset	–0.8455	2.9333	0.955	–8065	6,374
		Control	4.7076	2.8716	0.245	–2360	11 775
	Late onset	Early onset	0.8455	2.9333	0.955	–6374	8065
		Control	5.5530	2.8716	0.146	–1514	12 620
Cardiac index	Early onset	Late onset	–0.72182*	0.17127	0.001	–1.1434	–0.3003
		Control	–0.29295	0.16767	0.204	–0.7056	0.1197
	Late onset	Early onset	0.72182*	0.17127	0.001	0.3003	1.1434
		Control	0.42886*	0.16767	0.040	0.0162	0.8415

*The mean difference was significant at 0.05

than the other two groups, but for the early onset and late-onset preeclampsia, those values were relatively similar. As for RWT, results were relatively similar in the three study groups (Table 4).

Post hoc analysis was also performed on maternal heart morphometry variables. There was no difference in maternal heart morphometry of early-onset and late-onset PEB (Table 5).

Diastolic Function Research Subjects

In theory, it was said that the value of E should be greater than A, in other words, the value of E/A should be >1. The occurrence of the opposite indicates diastolic dysfunction. In this study, the early-onset group value of E/A was 0.9, meaning that diastolic dysfunction have occurred in the group of early-onset

Table 4: Heart morphometry of the research subjects

Morphometry	*Early onset*	*Late onset*	*Control*	*p*
LVM (g)	154.0 (146–294)	227.0 (124–318)	112.5 (93.4–173)	<0.001[a]
LVMi (g/m^2)	98.7 (86.5–203)	132.0 (77.7–176)	70.7 (54.6–97.2)	<0.001[a]
LVID (cm)	4.7 (0.4)	4.8 (0.5)	4.4 (0.4)	0049[b]
LVPWT (cm)	1.1 (0.7–1.3)	1.1 (0.8–1.6)	0.9 (0.7–1.7)	0009[a]
IVST (cm)	0.8 (0.6–1.6)	1.0 (0.6–1.3)	1.1 (0.6–1.5)	0151[a]
RWT	0.43 (0.02)	0.46 (0.06)	0.48 (0.09)	0264[b]

Data are presented in median (min–max)
[a]Analysis by Kruskal Wallis; [b]Test one-way ANOVA
LVM, left ventricular mass; LVMi, left ventricular mass index; LVID, left ventricular interdiameter; LVPWT, left ventricular posterior wall diameter; IVST, interventricular septal thickness; RWT, relative wall thickness
Measurements were taken at the diastolic phase

Table 5: *Post hoc* analysis of maternal cardiac morphometry

Morphometry vs control	*Early onset vs late onset*	*Early onset vs control*	*Late-onset*
LVM	0151[a]	0001[a]	<0.001[a]
LVMi	0332[a]	<0.001[a]	<0.001[a]
LVID	0928[b]	0127[b]	0059[b]
LVPWT	0652[a]	0032[a]	0002[a]
IVST	0519[a]	0118[a]	0104[a]
RWT	0720[b]	0234[b]	0661[b]

[a]Mann–Whitney test; [b]Tukey test
LVM, left ventricular mass; LVMi, left ventricular mass index; LVID, left ventricular inter-diameter; LVPWT, left ventricular posterior wall diameter; IVST, interventricular septal thickness; RWT, relative wall thickness

Table 6: Maternal cardiac diastolic function

Diastolic function	*Early onset*	*Late onset*	*Control*	*p*
E wave velocity (ms)	89.4 (11–98.7)	105.0 (67.5–107.0)	72.5 (68.6–89.9)	0014[a]
A wave velocity (ms)	87.1 (22.6)	77.8 (15.5)	53.4 (14.3)	<0.001[b]
E/A	0.9 (0.7–1.8)	1.2 (1.0–1.7)	1.40 (0.9–2.5)	0039[a]
DTE (ms)	146.1 (14.4)	123.7 (38.2)	144.0 (31.1)	0163[b]

Data are presented in median (min–max)
[a]*n* analysis by Kruskal Wallis; [b]Test one-way ANOVA
DTE, deceleration time of the E wave

Table 7: *Post hoc* analysis of diastolic function

Diastolic function	*Early onset vs late onset*	*Early Onset vs control*	*Late-onset vs control*
Wave velocity	0076[a]	0211[a]	0004[a]
A wave velocity	0445[b]	<0.001[b]	0007[b]
E/A	0065[a]	0027[a]	0288[a]
DTE	0196[b]	0983[b]	0247[b]

[a]Mann–Whitney test; [b]Tukey test

preeclampsia. Table 6 shows the diastolic function that occurs in all three study groups.

Table 8: Characteristics of the uterine artery

The uterine artery	*Early onset*	*Late onset*	*Control*	*p*
Unilateral notching				
Positive	6 (54.5%)	3 (27.3%)	0.00 (0.0%)	0033
Negative	5 (45.5%)	8 (72.7%)	12 (100.0%)	
Bilateral notching				
Positive	7 (63.6%)	2 (18.2%)	0 (0.0%)	0002
Negative	4 (36.4%)	9 (81.8%)	12 (100.0%)	–
Right RI	0.68 (0.00)	0.57 (0.021)	0.60 (0.03)	<0.001
Left RI	0.70 (0.05)	0.57 (0.022)	0.59 (0.04)	<0.001
Right PI	1.47 (0.32)	1.04 (0.145)	1.02 (0.22)	<0.001
Left PI	1.49 (0.31)	1.04 (0.145)	1.03 (0.22)	<0.001

Post hoc analysis did not reveal any difference between the diastolic function of early onset and late-onset preeclampsia (Table 7).

Characteristics of the Uterine Artery

On the study of the uterine artery, notching occurred more frequently in the early onset compared with the late-onset group and was not found in the control group, as seen in Table 8. Meanwhile, the value of RI and PI of the uterine artery in the early onset group seemed higher than the late onset and control group. In contrast, RI and PI of the uterine artery appeared to be lower than the control.

Characteristics of Newborn

No significant difference was found in infant outcomes in all three research groups, as seen in Table 9.

Relationship between a Maternal Hemodynamic and Uterine Artery

In this study, we tried to look at the relationship between maternal hemodynamic, in this case, the CO and SVR against RI and PI of the uterine artery, which all showed significant correlations. Table 10 shows a negative correlation between CO with RI and PI of the uterine artery. In contrast, a positive correlation occurred between SVR with RI and PI (Table 10).

Meanwhile, the relationship between CO with newborn birth weight was found to be uncorrelated, but there was a relationship between SVR with newborns birth weight only in the late-onset group (Table 11).

Relationship between RI and PI of the Uterine Artery with a Newborn Birth Weight

For the correlation between RI and PI with newborn birth weight, this study did not found any correlation between groups, as seen in Table 12.

Discussion

Hemodynamics in Severe Preeclampsia

Some studies suggest that preeclampsia creates a hyperhemodynamic condition (characterized with high CO and low SVR), but other studies have also demonstrated the existence of hypohemodynamic conditions (characterized by low CO and increasing SVR) in preeclampsia.[2] 8.9 this may be related to the onset of preeclampsia itself. Low CO with high

Table 9: Characteristics of neonates

Characteristics	*Early onset*		*Late onset*		*Control*		*p*
Birth weight (g)	2009.1	(465.7)	3022.7	(319.6)	3201.2	(501.5)	<0.001[a]
Gestational age (week)	33.2	(1.9)	37.6	(1.1)	38.8	(1.7)	<0.001[a]
Method of delivery							
SC	5	(45.5%)	4	(36.4%)	6	(50.0)	1000[b]
Vaginal	6	(54.5%)	7	(63.6%)	6	(50.0)	
Apgar <7 minutes 1							
Yes	1	(9.1%)	0	(0.0%)	0	(0.0%)	0324[b]
No	10	(90.9%)	11	(100.0%)	12	(100.0%)	
Apgar <7 minutes 5							
Yes	1	(9.1%)	0	(0.0%)	0	(0.0%)	0324[b]
No	10	(90.9%)	11	(100.0%)	12	(100.0%)	

Data are presented in the form *n* (%) and the mean (SD)
[a]Analysis with a one-way ANOVA test; [b]Analysis by test of Fisher after merging cells

Table 10: Relationship between CO and SVR against uterine artery RI and PI

		Right RI	*Left RI*	*Right PI*	*Left PI*
CO (mL/minute)	The correlation coefficient (r)	–0.6**	–0.6**	–0.3*	–0.4*
	p	<0.001	<0.001	0.020	0.013
SVR (dyne second cm^{-5})	The correlation coefficient (*r*)	0.6**	0.6**	0.6**	0.6**
	p	<0.001	<0.001	<0.001	<0.001

To view the strength of the correlation, the correlation coefficient were: * 0–0.3 (low), **0.3–0.7 (medium), ***> 0.7 (high)

Table 11: Relationship between CO and SVR with newborn birthweight

		Newborn birth weight		
		Early onset	*Further onset*	*Control*
CO (mL/minute)	The correlation coefficient (*r*)	–0.1	0.5	0.4**
	p	0.588	0.087	0.152
SVR (dyne second cm^{-5})	The correlation coefficient (*r*)	–0.0	–0.6*	–0.2
	p	0.979	0.019	0.424***

To view the strength of the correlation, the correlation coefficient were: * 0–0.3 (low), ** 0.3–0.7 (medium), *** >0.7 (high)

Table 12: Relationship between RI and PI of the uterine artery with a newborn birth weight

		Newborn birth weight		
		Early onset	*Late onset*	*Control*
Right RI	The correlation coefficient (*r*)	0.4	0.2	0.1
	p	0.142	0.513	0.570
Left RI	The correlation coefficient (*r*)	0.5	0.1	0.0
	p	0.060	0.576	0.863
Right PI	The correlation coefficient (*r*)	0.3	–0.3	0.0
	p	0.247	0.320	0.981
Left PI	The correlation coefficient (*r*)	0.4	–0.3	0.0
	p	0.163	0.330	0.977

To view the strength of the correlation, the correlation coefficient were: 0–0.3 (low), 0.3–0.7 (medium), >0.7 (high)

SVR as seen in the early onset group, is possibly related to the failure of the placental vascular system to do the remodeling. While the late onset characterized by increased CO and low SVR may be associated with maternal constitutional factors.

In this study, both before and after the *post hoc* analysis, we obtained sufficient contrast difference SVR between early onset and late-onset group. Easterling et al.[8] and Valensise et al.[9] stated that at 24–25 weeks' gestation, the value of SVR was higher in early-onset preeclampsia. While Bosio et al. suggested that in patients with preeclampsia, after 36 weeks, the SVR will increase, with a mean of 1687 dynes seconds cm^{-5} (range 1383–2451, $p < 0.001$), this is consistent with the study. At the end of pregnancy, SVR was shown to be high; this may be due to differences in the population (in this case the body surface area may influence).

What needs to be highlighted is there were few subjects in the early onset preeclampsia group who showed low SVR, otherwise there were few subjects in the late-onset group showed high SVR, which indicated the existence of other factors that plays a role in the complex pathophysiology of preeclampsia and was influential in different clinical course of early-onset and late-onset preeclampsia itself.

Because CO is a dynamic value, which is influenced by various factors at the time of measurement, we tried to minimize the bias of CO by measuring cardiac index. Cardiac index was calculated as the ratio between CO and body surface area. In this study, we used a body surface area as a parameter to eliminate the bias of the subjects' body. For a variety of medical purposes, measurements of body surface area are a better indicator than body mass index, due to the influence of adipose mass which will be minimized with certain calculations. The normal value of the cardiac index is said to be 2.1–4.0 L/minute/m.[2,10,11] But this value is based on research conducted on European populations. It is not known whether the same value can be applied to the Asian population, because there has been no research on it.

Visser and Wallenburg reported that in patients who haven't received preeclampsia treatment, low *cardiac index* and high SVR were observed before treatment.[12] This is consistent with our results. Higher SVR in the group of preeclampsia may be caused by vasoconstriction occurring in the vascular system and also an increase in CO.

Diastolic Function in Pregnancy

There was a significant difference in diastolic function between the groups. Generally, wave velocity and deceleration time (DTE) showed increased contributions of the atrium at the preeclampsia group compared to the control group of early onset and late-onset preeclampsia. In theory, the value of E wave velocity should be greater than the A wave velocity; thus the value of E/A must be greater than 1. In this study, the early-onset group had a value of E/A <1 that indicated diastolic dysfunction. The late-onset group had E value greater than A indicating the ability of achieved left ventricular filling in the diastolic phase. A reversed E/A (A > E speed) is often referred as a marker of diastolic dysfunction, wherein left ventricular wall becomes stiff and cannot meet the filling need, which can lead to heart failure later in life. This could occur, for example in the state of untreated hypertension.[13]

In early-onset preeclampsia, the diastolic function is more affected than in late-onset preeclampsia. In late-onset preeclampsia, left ventricular filling during the diastolic were compensated by ventricular hypertrophy, which is unlikely in early-onset preeclampsia. This is in accordance with the results of this research.

DTE is the time required of the peak value of the E wave to reach the *baseline*. The normal value of DTE varies from 120 to 200 ms. Theoretically, in the case of diastolic dysfunction, the DTE value should be elongated. This is in contrast with the results of this study, where the results showed normal DTE value in all research groups. This may be due to differences in tools and measurement bias, as well as a few sample number.

Left Ventricular Morphometry

In this study, we used LVM index to minimize bias. Early-onset and late-onset preeclampsia showed a higher index of LVM and LVM than the control group. The late onset group showed mild-moderate left ventricular hypertrophy (normal LVM: 88-222, normal LVM index: 49–112). Valensise et al. found that by the age of 24 weeks' gestation, there had been changes in LVM and LVMi in both preeclampsia groups, late-onset preeclampsia being slightly higher than the early onset preeclampsia.[9] This seemed to be continued with increasing gestational age. This is similar to the findings of this study, in late-onset preeclampsia left ventricular filling during ventricular diastolic was compensated by hypertrophy mass, whereas in the early onset preeclampsia this did not happen.[7] Muscle hypertrophy of the left ventricle is more advanced in late-onset preeclampsia, which may be associated with increased left ventricular end diastolic pressure.[14] For RWT, we found an insignificant difference among the groups. According to its LVMi data, it seemed that most of the control group were in the category of concentric remodeling, while the early onset and late-onset preeclampsia experienced concentric hypertrophy. Concentric hypertrophy occurs due to excess pressure, that is in line with severe preeclampsia which SVR increase also happens.

Uterine Artery Doppler

RI and PI measurement of the uterine artery as a predictor of preeclampsia has been debated. In theory, RI reflects better of the changes in uterine arteries caused by changes in microvascular bed in the distal uterine artery, while PI is more influenced by hemodynamic. In this study, we tried to assess both, as well as to see whether severe preeclampsia affects the RI or PI of the uterine artery and whether changes in the uterine artery RI and PI affect the outcome of the baby. Late-onset preeclampsia has been reported to be related to normal or slightly increased uterine artery PI, while the early onset preeclampsia has more changes in the uterine artery.[9] The results of this research together with research conducted by Valensise Huppert et al.[9,15] showed that the percentage, either unilateral or bilateral *notching,* was more numerous in the early-onset group compared with late-onset group and controls.

RI and PI values were higher in the early onset than the other groups. Nevertheless, this study did not observe any relationship between RI, PI, and infant outcomes. This contradicted with a variety of other longitudinal studies, which was likely due to the small research sample.

Baby Outcome

In this study, when subjects were diagnosed with severe preeclampsia, they were proceeded with fetal biometry examination. The purpose of the examination with ultrasound fetal biometry was to determine the estimated weight of the fetus and later to determine the mode of delivery. It was seen that there was no correlation between the hemodynamic changes in preeclampsia with infant outcomes. We also found no correlation between RI and PI of the uterine artery and infant outcome.

In theory, stunted fetal growth occurs in the early-onset preeclampsia, which contradicts with the results of this study. This might be due to direct pregnancy termination at the time of early preeclampsia was diagnosed, so that the fetus did not suffer hypo-perfusion condition for a long time that might affect fetal weight.

Research Limitations

In this study, the number of samples in the three research groups were relatively small, and it could have an impact on the power of the study. To evaluate the results of this study, a larger sample size with higher research methods are needed.

The definition of severe preeclampsia used in this study did not fit the definition of severe preeclampsia issued by the American College of Obstetrics and Gynecologists stating that proteinuria is no longer key condition preeclampsia diagnose.[16]

Another limitation of this study is the measurement was carried only in the third trimester so that the measurement results could not be compared with the previous condition of the mother (trimesters 1 and 2).

Conclusion

Based on this research, it appears that there was a difference between the hemodynamic profile (primarily CO and SVR) in pregnant women with normotension and preeclampsia (both early-onset and late-onset).

Based on RWT and LVMi, the control group in the study had *concentric remodeling,* while most subjects in the early onset and late-onset group experienced *concentric hypertrophy.*

Early-onset preeclampsia group demonstrated dysfunction of maternal cardiac diastolic function.

There was a significant relationship between CO and SVR with RI and PI of the uterine artery, but there was no correlation between RI and PI of the uterine artery with newborn outcomes. No relationship between CO and SVR with newborn outcomes was observed.

This research demonstrated that there were hemodynamic, morphometry ventricular and left ventricular function change in preeclampsia. But the changes that occurred seemed to be more evident in the group of early-onset preeclampsia compared with the late-onset preeclampsia.

It appears that hemodynamic assessment of maternal and uteroplacental during pregnancy may be useful to predict gestational hypertension, severe preeclampsia (early-onset and late-onset) as well as restricted fetal growth.

Suggestion

To determine the relationship between the CO and SVR with RI and PI of the uterine artery and the relationship between CO and SVR with infant outcomes, further research with a larger sample is needed.

It is necessary to perform a prospective study with the same sample to reveal whether the changes in the hemodynamic system and morphometric maternal heart is temporary or permanent.

Early-onset preeclampsia, which indicates diastolic dysfunction, should be monitored closely (up to a few years postpartum), due to diastolic dysfunction which can lead to heart failure.

There is a need to educate the clinician for echocardiography screening, at least once during pregnancy, especially in cases of high risk to take appropriate prevention or pharmacological interventions to preeclamptic women, both early-onset and late-onset, to prevent the occurrence of cardiovascular disease in later life.

Further research is needed to determine what factors can be used as predictors of cardiovascular events in women with preeclampsia history.

References

1. Eiland E, Nzerue C, et al. Preeclampsia 2012. J pregnancy 2012;2012: 1–7.
2. Sibai BM. Maternal and Uteroplacental hemodynamics for the classification and prediction of preeclampsia. Hypertension 2008;52(5):805–806. DOI: 10.1161/HYPERTENSIONAHA.108.119115.
3. Tomsin K, Mesens T, et al. Characteristics of heart, arteries, and veins in low and high cardiac output preeclampsia. Eur J Obstet Gynecol Reprod Biol 2013;169(2):218–222. DOI: 10.1016/j.ejogrb.2013.03.016.
4. Oana S, Ruxandra J, et al. Morphological and functional adaptation of the maternal heart during pregnancy. Circulation: Cardiovascular Imaging 2012;5:289–297. DOI: 10.1161/CIRCIMAGING.111.970012.
5. Ghulmiyyah L, Sibai B. Maternal mortality from preeclampsia/eclampsia. Semin Perinatol 2012;36(1):56–59. DOI: 10.1053/j.semperi.2011.09.011.
6. Murphy DJ. Mortality and morbidity associated with early-onset preeclampsia. Hypertens Pregnancy 2000;19:221–231. DOI: 10.1081/PRG-100100138.
7. Ness RM, Sibai BM. Sgared and disparate components of the pathophysiologics of fetal growth restriction and preeclampsia. Am J Obstet Gynecol 2006;2006(195):40–49. DOI: 10.1016/j.ajog.2005.07.049.
8. Easterling TR, Benedetti TJ, et al. Maternal hemodynamics in normal and preeclamtic pregnancies: a longitudinal study. Obstet Gynecol 1990;76:1061–1069.
9. Valensise H, Vasapollo B, et al. Early and late preeclampsia: two different maternal hemodynamic states in the latent phase of the disease. Hypertension 2008;52(5):873–880. DOI: 10.1161/HYPERTENSIONAHA.108.117358.
10. DuBois D, DuBois EF. A formula to estimate the approximate surface area if height and weight be known. Arch Intern Med 1916;17:863–871. DOI: 10.1001/archinte.1916.00080130010002.
11. Normal hemodynamic parameters. Diunduh dari: http:/www/lidco.com/normal hemodynamic parameters.
12. Bosio PM, McKenna PJ, et al. Maternal central hemodynamics in hypertensive disorders of pregnancy. Obstet Gynecol 1999;94: 978–984. DOI: 10.1097/00006250-199912000-00014.
13. Carolyn Y, Solomon SD. A Clinician's guide to tissue doppler imaging. Circulation 2006;113:396–398.
14. Dennis AT, Castro J, et al. Haemodynamics in women with untreated preeclampsia. Anaesthesia 2012;67:1105–1118. DOI: 10.1111/j.1365-2044.2012.07193.x.
15. Huppertz B. Placental Origins of Preeclampsia Challenging the Current Hypothesis. Hypertension 2008;51:970–975. DOI: 10.1161/HYPERTENSIONAHA.107.107607.
16. Cnossen JS, Morris RK, et al. Use of uterine artery Doppler ultrasonography to predict preeclampsia and intrauterine growth restriction: a systemic review and bivariable meta analysis. CMAJ 2008;178(6):701–711. DOI: 10.1503/cmaj.070430.