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Uterine Artery Doppler Sonography in Predicting Preeclampsia and IUGR at 14-16 Week Gestation

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Abstract: Preeclampsia is a heterogeneous disorder with variable maternal and fetal manifestations. Several studies have been performed to assess the validity of uterine artery. Doppler examination screening tool for pre-eclampsia. The purpose of this study was to evaluate the predictive value of Doppler investigations of the uterine circulations during 14-16 weeks of gestation with regard to the development of preeclampsia and/or IUGR in study population. This prospective observational study was carried out at university hospital. All 456 pregnant women referred to hospital from October 2011 to october2012, ultrasound sonography was done at 14-16 weeks of gestation. In all Doppler measurements, the mean peak systolic (S) to end-diastolic (D) ratio of 3-5 cardiac cycle was computed by electronic capilers and the RI calculated as (S-D/S). A total of 456 pregnant women with mean age of 26.8±5.3 years were recruited during the study. The uterine artery RI at 14-16 weeks was significantly higher in 27 women subsequently developed preeclampsia (mean RI=0.7526±0.039) than in 429 pregnancy with a normal outcomes (mean RI=0.6440±0.059, P=0.001).The uterine artery RI also was significantly higher in 36 women developed IUGR (RI=0.7244±0.04730) compared with 420 women with normal pregnancies (RI=0.6505±0.06043, P=0.001). Conclusion: RI=0.69 to predict preeclampsia and RI=o.7 to predict IUGR as mentioned are optional cut-off value for RI of the uterine artery in our study which are congruent with other studies.

Key words: Preeclampsia · IUGR · Doppler sonography

INTRODUCTION

Preeclampsia is a heterogeneous disorder with variable maternal and fetal manifestations. Although the diagnosis of the condition relies on the demonstration of hypertension and proteinuria in the mother, the clinical outcome depends primarily on the presence of multisystem dysfunction in the mother and impairment of growth and oxygenation in the fetus. There is evidence that the severity of the fetal compromise is mainly related to the gestational age at the onset of pre-eclampsia [1,2].

Preeclampsia during the latter half of pregnancy are believed to result from impaired placentation in early gestation [4]. Deficient placentation is characterized by inadequate trophoblast invasion into the maternal spiral arteries and failure to develop low-resistance uteroplacental circulation. In the past 20 years, Doppler ultrasonographic studies of uteroplacental circulation have shown that high impedance to flow is associated with subsequent preeclampsia, IUGR and related complications [5]. secondary hypothesis is that pre-eclampsia may apparently occur after normal placentation, as a consequence of placental deterioration with increased placental mass (twins and diabetes) or a deteriorating placenta (fetal hydrops and term or prolonged pregnancy [6].

Doppler examination of the uterine arteries is a non-invasive tool that can be used to indirectly assess trophoblast development and uteroplacental perfusion. Several studies have been performed to assess the validity of uterine artery Doppler examination as a screeningtool for pre-eclampsia [5, 7-9].

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The purpose of this study was to evaluate the predictive value of Doppler investigations of the uterine circulations during 14-16 weeks of gestation with regard to the development of preeclampsia and/or IUGR in study population.

METHODS AND MATERIALS

This prospective observational study was carried out at university hospital. All 456pregnant women referred to hospital from october2011 to October 2012 ultrasound sonographywas done at 14-16 weeks of gestation. The data were examined for significant associations using SPSS version 11.0 for windows. The chi-square was used for comparison of categorical variables. P<0.05 was considered to indicate statistically significant.

Mothers were asked to complete a questionnaire on maternal age, medical history (included chronic hypertension, diabetes mellitus, antiphospholipid syndrome, thrombophilia), obstetric history (including previous pregnancy with preeclampsia) and family history of preeclampsia.

Doppler examinations were performed by experienced sonographers. Using a duplex pulsed wave Doppler ultrasound scanner (ALOKA SSD-650) with a 3.5 MHZ convex transducer, we measured blood velocity waveforms from both main uterine arteries. The main uterine artery was located at the uterocervical junction close to the cross-over point of the uterine and external iliacarteries on both sides.

In all Doppler measurements, the mean peak systolic (S) to end-diastolic (D) ratio of 3-5 cardiac cycle was computed by electronic capilers and the RI calculated as (S-D/S) [10].

The primary outcome measure was preeclampsia, defined according to the guidelines of International Society for the Study of Hypertension in Pregnancy. This requires two recordings of diastolic blood pressure of 90 mmHg and proteinuria of 300mg or more in 24 h, or two reading of at least one plus on dipstick analysis of mid-stream or catheter urine specimens if no 24 h collection is available [11].

IUGR was defined as a birth weight below the 10^{th} centile for the normal Finnish population as reported by Yla-Outinen [12].

Receiver Operating Characteristics (ROC) was calculated separately for the main uterine artery to obtain suitable cut-off value for RI for prediction of preeclampsia and IUGR. In the main uterine arteries the highest RI, usually registered at the ‘’non-placental side’’ was used.

The study was approved by the Shahid-Sadoughi Hospital’s Ethical committee, Yazd, Iran. Informed consent was obtained from each patient.

The data were examined for significant associations using SPSS version 11.0 for windows. The chi-square was used for comparison of categorical variables. P<0.05 was considered to indicate statistically significant.

RESULTS

A total of 456 pregnant women with mean age of 26.8±5.3 years were recruited during the study. The uterine artery RI at 14-16 weeks was significantly higher in 27 women subsequently developed preeclampsia (mean RI=0.7526±0.039) than in 429 pregnancy with a normal outcomes (mean RI=0.6440±0.059, P=0.001).

The uterine artery RI also was significantly higher in 36 women developed IUGR (RI=0.7244±0.047) compared with 420 women with normal pregnancies (RI=0.6505±0.060, P=0.001).

99 pregnancies (21.7%) had an either RI>0.7 and 125 pregnancies (27.4%) had bilateral RI value of >0.69.

A total number of 27 patients showed abnormal Doppler finding to develop preeclampsia of the uterine artery. 23 pregnancies (85.2%) of them with preeclampsia had only RI of more than 0.7 and only 4 of them (14.8%) with proceeding preeclampsia had RI<0.7 (P=0.001) (Table 3).

26 (96.3%) of patients with RI>0.69 developed preeclampsia and only 1 patients (3.7%) with RI<0.69 developed preeclampsia (Table 4).

A total number of 36 patients showed abnormal Doppler finding for IUGR in the uterine artery. 27 pregnancies (75%) of them with IUGR had only RI of more than 0.69 and only 9of them (25%) with preceding IUGR had RI<0.69 (Table 5).

27 (75%) of patients with RI>0.7 developed IUGR and only 9 patients (25%) with RI<0.7 developed IUGR (Table 6).

If RI>0.7 were used to predict preeclampsia, the test achieved the sensitivity of 85.25%, specificity of 82.3%, positive predictive value of 23.2%, negative predictive value of 98.9% and accuracy of 82.4%; while RI>o.69 were used the sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 96.3%, 76.9%, 20.8%, 99.7% and 78.1% respectively (Table 3,4).

There were significant association between Doppler sonography findings and preeclampsia and IUGR, the association being stronger for high risk population with development of preeclampsia (p-value=0.001) (Table 7,8).

Table 1: Mean RI according to preeclampsia condition

Preeclampsia	Numbers	Mean RI	SD	Minimum	Maximum
Yes	27	0.75	0.039	0.69	0.85
No	429	0.64	0.059	0.53	0.80
Total	456	0.65	0.063	0.53	0.85

Table 2: Mean RI according to IUGR condition

IUGR	Numbers	Mean RI	SD	Minimum	Mximum
Yes	36	0.72	0.047	0.59	0.85
No	420	0.64	0.060	0.53	0.81
Total	456	0.65	0.063	0.53	0.58

Table 3: preeclampsia if RI=0.7 was cut-off value in study

		Preeclampsia		
		Yes	No	Total
RI>0.7	Yes	23	76	99
		85.2%	17.7%	21.7%
	No	4	353	357
		14.8%	82.3%	78.3%
Total		27	429	456
		100%	100%	100%

Table 4: Preeclampsia if RI=0.69 was cut-off value in study.

		Preeclampsia		
		Yes	No	Total
RI>0.69	Yes	26	99	99
		96.3%	23.7%	27.4%
	No	1	330	331
		3.7%	76.9%	72.6%
Total		27	429	456
		100%	100%	100%

Table 5: IUGR if RI=0.69 was cut-off value in study.

		IUGR		
		Yes	No	Total
RI>0.69	Yes	27	72	99
		75%	17.7%	21.7%
	No	9	348	357
		25%	82.9%	71.3%
Total		36	420	456
		100%	100%	100%

Table 6: IUGR if RI=0.7 was cut-off value in study.

		IUGR		
		Yes	No	Total
RI>0.7	Yes	27	28	125
		75%	23.3%	27.4%
	No	9	322	331
		25%	76.7%	72.6%
Total		36	420	456
		100%	100%	100%

Table 7: Preeclampsia by considering of risk factors.

		Preeclampsia		
		Yes	No	Total
Risk Factors	No	9	336	345
		33.3%	78.3%	75.5%
	Yes	18	93	11
		66.7%	21.7%	24.3%
Total		27	429	456
		100%	100%	100%

Table 8: IUGR by considering of risk factors.

		IUGR		
		Yes	No	Total
Risk Factors	No	23	322	345
		63.9%	76.7%	75.7%
	Yes	13	98	111
		36.1%	33.3%	24.3%
Total		36	420	456
		100%	100%	100%

As shown in table 7, preeclampsia developed in patients with high risk factors. 18 out of 27 preeclampsia (66.7%) had risk factors, while 336 (78.3%) of 429 normal pregnancies had no history of risk factors (P=0.001).23(66.7%) out of 36 patients with IUGR had risk factors, while 322 (76.7%) of 420 normal pregnancies had no history of risk factors (P=0.08) (Table 8).

CONCLUSION

Uterine artery resistance index of Doppler ultrasonography was measured in 456 pregnant women with mean age of 26.5±5.3 years at 14-16 gestational age of pregnancy.

The uterine artery RI at 14-16 weeks was significantly higher in 27 women subsequently developed preeclampsia (mean RI=0.7526±0.039) than in 429 pregnancies with a normal outcomes (mean RI=0.6440±0.059, p=0.001). The uterine artery RI also was significantly higher in 36 women developed IUGR (RI=0.7244±0.047) compared with 420 women with normal pregnancies (RI=0.6505±0.060, P=0.001).This confirmed the value of one-stage screening of preeclampsia and IUGR at 14-16 weeks using Doppler sonography of uterine arteries to screen the high risk women.

The optional cut-off value for RI of the uterine artery has been discussed widely in the literature. Attempts have been made to overcome this problem by calculating average values of different vessels of the uterine circulation or using highest RI or even the lowest RI as the variable of interests.

When RI=0.7were used as cut-off point in our study, 99 pregnancies (21.7%) had an either RI>0.7 and when RI=0.69 chosen as cut-off point, 125 pregnancies (27.4%) had bilateral RI value of >0.69.

Bewely and co-workers studied pregnant women at the 16-24 weeks of gestational age, reported a cut-off value 0f 0.65 for both the average of four points of measurement in four quadrants of the uterus and for the worst RI, which is quite close to 0.69 in our study, calculated by ROC analysis [13].

Schulman and colleagues recruited women with gestational age of 20 weeks and reported 0.63 and Fleischer and coworkers 0.62 for the average RI from both uterine arteries, which also are close to our criteria value [14,15].

Capucci et al on their study on women with gestational age of 16-18 weeks, pointed cut-off point of 0.58 in their study as predictive criteria [16].Steel and colleagues found 0.58 as the cut-off point for the arcuate arteries [17].

If RI>0.7 were used to predict preeclampsia, the test achieved the sensitivity of 85.25%, specificity of 82.3%, positive predictive value of 23.2%, negative predictive value of 98.9% and accuracy of 82.4%; while RI>o.69 were used the sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 96.3%, 76.9%, 20.8%, 99.7% and 78.1% respectively (Table3, 4). It should be considered that when we used 0.69 as cut-off point for RI, sensitivity increased 11.05% (p=0.001).

If RI>0.69 were used to predict IUGR, the test achieved the sensitivity of 75%, specificity of 82.9%, positive predictive value of 37.3%, negative predictive value of 97.5% and accuracy of 82.3%; while RI>o.7 were used the sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 75%, 76.7%, 24.6%, 97.3% and 76.5% respectively. The sensitivity of both tests was similar.

The value of screening studies is its high sensitivity to predict disease in all high risk patients; RI=0.69 as cut-off value to predict preeclampsia increased sensitivity considerably significant but this was not significant to predict IUGR, so appointing RI=0.69 to predict preeclampsia and RI=o.7 to predict IUGR as mentioned is a optional cut-off value for RI of the uterine artery in our study which are congruent with other studies.

Coleman and his colleagues studied pregnant women at the gestational age of 24-24 weeks. The sensitivity, specificity, positive predictive value of test with cut-off value of RI=0.58 were 91%, 425 and 37%, respectively, while in our study when we used RI=0.69 as cut-off the sensitivity was 96.3%. Higher sensitivity of our study compared with Coleman et al studies, confirmed the better predictive value of our selection [18].

Fleinder et al [19] have considered RI=o.58 as cut-off value to predict preeclamsia and IUGR with sensitivity of 67%, which was lower to compared with the sensitivity of our study.

Both studies confirmed the accuracy of our cut-off value selection to predict preeclampsia and IUGR.

The problem with most Doppler screening studies is its low positive predictive values and as gestational age advances, the specificity and positive predictive value increase significant and the sensitivity decrease [20].

In our study, we preferred to postpone the study of the uterine artery to 14-16 weeks, because we believed that placental implantation is completed by 14-18 weeks [4, 21]

Our study showed that by detecting abnormal uterine artery Doppler indices (high RI) between 14-16 weeks of pregnancy, we can identify women at risk for development of preeclampsia.

This screening study demonstrates the feasibility of Doppler assessment of uterine arteries into the routine scan. Our study examined the value of one-stage screening at 14-16 weeks using Doppler sonography of uterine arteries.

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