Role Of Intrarenal Resistance Indices In The Renal Interlobular Arteries Measured By Doppler Ultrasound In Pre-Eclampsia

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Abstract

Pre-eclampsia is a complication of pregnancy that mainly presents as new onset hypertension and often proteinuria in the mother. Feared as one of the most dreaded complications of pregnancy, pre-eclampsia can progress to multi-organ dysfunction, including cerebral, hepatic, and renal disease. There are different explanations for the development of pre-eclampsia, which are impaired pseudo-vasculogenesis, generalized endothelial dysfunction, increased concentration of antagonists of the vascular growth factor, circulating autoantibodies and the renin-angiotensin-aldosterone system(RAAS), disorders in the relaxin-gelatinase pathway. Ultrasonography (US) facilitates the acquisition of real-time qualitative and quantitative information regarding renal vasculature. The present prospective observational (case-control) study was conducted in the Department of Radio-diagnosis and Imaging, over a period of one and a half years to evaluate the role of maternal renal interlobular Doppler ultrasound in preeclampsia and to correlate the arterial resistive indices of umbilical and uterine arteries with maternal intrarenal resistance indices in pre-eclampsia. One hundred and twenty-six women with period of gestation more than 28 weeks diagnosed as pre-eclampsia were taken as cases and 126 pregnant women with no history of disease (present and past) were taken as controls. Renal interlobular arterial Doppler parameters (EDV, PI, RI) were significantly higher in pre-eclamptic women than in healthy pregnant women. Renal Doppler indices showed a positive correlation with proteinuria and systolic blood pressure in pre-eclamptic women. Combined intrarenal Doppler parameters (IRIs) showed a high diagnostic accuracy (88.29%) for predicting pre-eclampsia. On combination of the Doppler parameters namely IRIs and RI of the umbilical and uterine arteries, the specificity and positive predictive value for predicting pre-eclampsia rises to 100% each. There exists a significant difference between the intrarenal resistance indices in healthy and pre-eclamptic women. There exists a statistically significant correlation between intrarenal resistance indices and resistance indices of umbilical and uterine arteries in women with pre-eclampsia.

Introduction

Pre-eclampsia is a complication of pregnancy that mainly presents as new-onset hypertension and often proteinuria in the mother. Feared as one of the most dreaded complications of pregnancy, pre-eclampsia can progress to multi-organ dysfunction, including cerebral, hepatic, and renal disease. It is associated with a substantial risk of maternal and fetal death. Glomerular endotheliosis also occurs in patients with an

ordinary course of pregnancy or with pregnancy-induced hypertension [1-3]. To a pronounced degree, it is typical for pre-eclampsia. However, the expression varies greatly. Risk factors for developing pre-eclampsia have been extensively studied. Major risk factors include a medical history such as previous history of preeclampsia, pregestational diabetes mellitus, chronic hypertension, antiphospholipid syndrome, and obesity.[4] Other risk factors include older maternal age >35 years, nulliparity, history of chronic kidney disease, history of stillbirth, previous placental abruption, and use of assisted reproductive technology. Less common risk factors include a mother with a fetus with trisomy 13 and a family history of pre-eclampsia There are different explanations for the development of pre-eclampsia which include impaired pseudo-vasculogenesis, generalized endothelial dysfunction, increased concentration of antagonists of the vascular growth factor, circulating autoantibodies and the renin-angiotensin-aldosterone system [5 -11] . Fetal Doppler ultrasound is already an established method of prenatal diagnosis and is recommended in the current guidelines of the ACOG working group on maternal-fetal medicine. The focus is on examining the umbilical, uterine, and cerebral arteries.

Doppler sonographic assessment of renal vasculature

Approximately 20% of cardiac output is directed to the kidneys through the paired renal arteries.[12] The right main renal artery is longer and often originates slightly superior to the left renal artery . Near the renal hilum, the main renal artery divides into segmental arteries that course through the renal sinus to supply five arterial segments of the kidney—specifically, the apical, superior, middle, inferior, and posterior segments. Segmental arteries branch into lobar arteries that supply an individual renal pyramid. Subsequent divisions of the lobar arteries include their branching into interlobar arteries, then into arcuate arteries and then into interlobular arteries; this branching area indicates the actual corticomedullary junction.

Renal Doppler Imaging Ultrasonography (US) facilitates the acquisition of real-time qualitative and quantitative information regarding renal vasculature.

Aims and objectives

To evaluate the role of maternal renal interlobular Doppler ultrasound in pre-eclampsia and correlate the arterial resistive indices of umbilical and uterine arteries with maternal intrarenal resistance indices in pre-eclampsia.

Methods

The present prospective observational (case-control) study was conducted in the Department of Radio-diagnosis and Imaging, over a period of one and a half years. One hundred twenty-six (126) pregnant women with pre-eclampsia were selected as cases and were included in group A. The selection was based on the following inclusion criteria: The age of the patient from 18 to 40 years, Last menstrual period (LMP) of the patient was known and documented or based on LMP obtained on first-trimester ultrasound, Gestational age of 28 weeks and beyond. Patients diagnosed with pre-eclampsia according to the latest ACOG guidelines. Patients with previously diagnosed diseases that affect the vascular system which include: Diabetes mellitus, Chronic kidney disease, Essential and secondary hypertension, Vasculitis are excluded from study.One hundred twenty-six (126) healthy pregnant patients were selected as controls and included in group B. Ultrasound evaluation of the patient was done in accordance with the PreConception & Pre-Natal Diagnostic Techniques Act, 1994.Evaluation of renal interlobular arterial segments was performed in a patient in decubitus position [14,15]. Doppler spectral samples were recorded during the patient's inhalation when the scanning was performed in the decubitus position[56].

Waveform analysis of the Doppler :The maximum and minimum values of the velocity waveform were calculated. The Doppler changes were analyzed by calculating

PI, RI, and the end-diastolic flow velocity (EDV). The RI was defined as the maximum flow velocity (PSV) minus the EDV, all divided by the PSV{(PSV – EDV)/PSV}. The PI was defined as the PSV minus the EDV, all divided by the mean flow velocity {(PSV – EDV)/Vmean}. The gestation outcome was noted, including the number of cesarean sections performed, the number of live births, and stillbirths.The study was analyzed by correlating the PI and RI values of the umbilical and uterine arteries with the PI and RI values of intrarenal interlobular arteries. Correlation of the intrarenal resistive indices with other symptoms of preeclampsia, mainly hypertension, and proteinuria, was also done.

Statistical analysis

The following statistical tests were applied to the results:

1. The comparison of the variables, which were quantitative in nature, was analyzed using the independent t-test and those which were qualitative in nature, were analyzed using the Chi-Square test.

2 Receiver operating characteristic curve was used to find out cut off point, sensitivity, specificity, positive predictive value, and negative predictive value of PI {Umbilical artery}, RI {Umbilical artery}, PI {Uterine artery},RI {Uterine artery}, EDV (cm/sec) {renal interlobular arteries - RIBA}, PI {RIBA}, RI{RIBA}, Urinary protein 24 hours (g/24 hours), IRIs, IRIs+UmA RI, IRIs+UmA RI+ UtA RI for predicting pre-eclampsia.

6. Univariate logistic regression was used to determine significant risk factors of pre-eclampsia. Final analysis was done using Statistical Package for Social Sciences (SPSS) software, IBM manufacturer, Chicago, USA, ver 25.0.

Results

The proportion of patients in the age group 31-40 years was significantly higher in group A compared to group B.[25.40% vs. 5.56% respectively]. The proportion of patients in the age group 18-30 years was significantly lower in group A compared to group B. [74.60% vs. 94.44% respectively]. (p-value <0.0001) The proportion of patients with primigravida was significantly higher in group A than in group B [73.02% vs. 50.79% respectively]. The proportion of patients with multigravida was significantly lower in group A compared to group B [26.98% vs. 49.21%, respectively]. The mean ± SD of gestational age (weeks) in group B was 38.27 ± 1.13, significantly higher than in group A (32.59 ± 1.7]. The proportion of patients with a history of pre-eclampsia was significantly higher in group A compared to group B. (11.11% vs. 0%, respectively). The proportion of patients with a family history of hypertension was significantly higher in group A compared to group B (39.68% vs. 20.63%, respectively) with p-value=0.001). The proportion of patients with a family history of diabetes was significantly higher in group A compared to group B (18.25% vs. 0%, respectively) with p-value <0.0001). The mean ± SD of systolic blood pressure(mmHg) and diastolic blood pressure(mmHg) in group A was 147.87 ± 5.23 and 94.79 ± 5.37, respectively, which was significantly higher as compared to group B (118.79 ± 4.93 (p-value <0.0001)).The mean of proteinuria (g/24 hours) in group A was 1.98 ± 1.23, significantly higher than in group B (0.2 ± 0.1 with p-value<0.0001).The mean of the pulsatility index of renal interlobular arteries in group A was 1.17 ± 0.12, which was significantly higher than in group B (1.01 ± 0.06). (p-value <0.0001). Mean of end-diastolic velocity(cm/sec), pulsatility index, and resistive index in group A was 13.26 ± 1.51, 1.09 ± 0.07, 0.64 ± 0.04 which was significantly higher as compared to group B (10.41 ± 0.88 (p-value <0.0001) respectively). Distribution of viability was comparable between groups A and B. (Stillbirth:- 9.52% vs. 7.14% respectively, Live birth:- 90.48% vs. 92.86% respectively) (p value=0.494).

A significant positive correlation was seen between the pulsatility index {RIBA} and the pulsatility index {Umbilical artery} with a correlation coefficient of 0.195. No

correlation was seen between pulsatility index {RIBA} and the pulsatility index {Uterine artery} with correlation coefficient of 0.014. No correlation was seen between the resistive index {RIBA} with the resistive index {Uterine artery} with a correlation coefficient of -0.039. A non-significant mild positive correlation was seen between resistive index {RIBA} with resistive index {Umbilical artery} with a correlation coefficient of 0.156.

Table 1: Correlation of Doppler indices - Pulsatility index, and Resistive index of renal interlobular arteries{RIBA} with Pulsatility index and Resistive index of the umbilical artery and uterine artery in pre-eclampsia.

Variables	Pulsatility index {Umbilical artery}	Resistive index {Umbilical artery}	Pulsatility index {Uterine artery}	Resistive index {Uterine artery}
Pulsatility index{RIBA}				
Correlation coefficient	0.195	-	0.014	-
P value	0.029	-	0.710	-
Resistive index{RIBA}				
Correlation coefficient	-	0.156	-	-0.039
P value	-	0.644	-	0.405

On univariate regression, the pulsatility index {Umbilical artery} significantly affected the Pulsatility index {RIBA}. With the increase in pulsatility index {Umbilical artery} by 1 unit, the Pulsatility index {RIBA} significantly increased by 0.026 units.

Table 2: Univariate linear regression to determine factors affecting Pulsatility index {RIBA} in pre-eclampsia

Variable	Beta coefficient	Standard error	Standardized coefficient	P value	Lower bound (95%)	Upper bound (95%)	Equation
Pulsatility index {Umbilical artery}	0.026	0.012	0.195	0.029	0.003	0.050	0.601+0.026*Pulsatility index {Umbilical artery}

Pulsatility index {Uterine artery}	0.008	0.053	0.014	0.874	-0.096	0.113	1.077+0.008*Pulsatility index {Uterine artery}

On univariate regression, none of the variables significantly affected the Resistive index{RIBA}. (p value>0.05)

Table 3: Univariate linear regression to determine factors affecting Resistive index{RIBA} in pre-eclampsia.

Variable	Beta coefficient	Standard error	SStandardized coefficient	P value	Lower bound (95%)	Upper bound (95%)	Equation
Resistive index {Umbilical artery}	0.064	0.036	0.156	0.082	-0.008	0.136	0.588+0.064*Resistive index {Umbilical artery}
Resistive index {Uterine artery}	-0.022	0.052	-0.039	0.667	-0.125	0.080	0.653-0.022*Resistive index {Uterine artery}

A significant positive correlation was seen between proteinuria(g/24 hours) with pulsatility index {Uterine artery} and resistive index {Uterine artery} with correlation coefficients of 0.359 and 0.673, respectively. A significant positive correlation was seen between proteinuria(g/24 hours) with pulsatility index{RIBA} and resistive index{RIBA} with a correlation coefficient of 0.298 and 0.227, respectively. A non-significant mild positive correlation was seen between proteinuria(g/24 hours) with pulsatility index {Umbilical artery}, resistive index {Umbilical artery} with a correlation coefficient of 0.137, 0.137 respectively.

Table 4: Correlation of proteinuria(g/24 hours) with End diastolic velocity(cm/sec), Pulsatility index, and Resistive index of renal interlobular arteries of the kidneys, umbilical artery and uterine artery in pre-eclampsia.

Variables	Pulsatility index {Umbilic--al artery}	Resistive index {Umbilic--al artery}	Pulsatility index {Uterine artery}	Resistive index {Uterine artery}	Pulsatility index{RIBA}	Resistive index{RIBA}
Correlation coefficient	0.137	0.137	0.359	0.673	0.298	0.227
P value	0.126	0.125	<0.001	<0.001	0.001	0.011

A significant positive correlation was seen between systolic blood pressure(mmHg) with pulsatility index {Umbilical artery}, resistive index {Umbilical artery}, pulsatility index {Uterine artery}, resistive index {Uterine artery}, pulsatility index{RIBA}, resistive index{RIBA} with a correlation coefficient of 0.361, 0.521, 0.595, 0.579, 0.569, 0.458 respectively.

TABLE 5: Correlation of Systolic blood pressure(mmHg) with End diastolic velocity(cm/sec), Pulsatility index, and Resistive index of renal interlobular arteries of the kidneys, umbilical artery and uterine artery Pulsatility index and Resistive index in total study subjects.

Variables	Pulsatility index {Umbilic-al artery}	Resistive index {Umbilic--al artery}	Pulsatility index {Uterine artery}	Resistive index {Uterine artery}	Pulsatility index {RIBA}	Resistive index {RIBA}
Correlation coefficient	0.361	0.521	0.595	0.579	0.569	0.458
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Interpretation of the area under the ROC curve showed that the performance of proteinuria (g/24 hours) (AUC 0.979; 95% CI: 0.953 to 0.993) was outstanding. The discriminatory power of resistive index {Umbilical artery} (AUC 0.807; 95% CI: 0.753 to 0.854), pulsatility index {Uterine artery} (AUC 0.891; 95% CI: 0.846 to 0.927), resistive index {Uterine artery} (AUC 0.872; 95% CI: 0.824 to 0.910) and pulsatility index{RIBA} (AUC 0.898; 95% CI: 0.853 to 0.932) was excellent and discriminatory power of pulsatility index {Umbilical artery} (AUC 0.725; 95% CI: 0.666 to 0.780) and resistive index{RIBA} (AUC 0.732; 95% CI: 0.672 to 0.785) was acceptable. Among all the parameters, Proteinuria (g/24 hours) was the best predictor of pre-eclampsia at a cut-off point of >0.48 with an area under a curve of 0.979 for correctly predicting pre-

eclampsia. Pulsatility index {RIBA} had a sensitivity of 86.51% followed by proteinuria (g/24 hours) (86.51%), pulsatility index {Uterine artery} (85.71%). In predicting pre-eclampsia, the Resistive index {Umbilical artery} had the lowest sensitivity of 67.46%. On the other hand, proteinuria (g/24 hours) and resistive index {Uterine artery} had a specificity of 100.00% each, followed by resistive index {Umbilical artery} (96.83%). In predicting pre-eclampsia, Resistive index {RIBA} had the lowest specificity of 65.08%. The highest positive predictive value was found in proteinuria (g/24 hours) and Resistive index {Uterine artery} (100.00% each), and the highest negative predictive value was found in Pulsatility index {RIBA} (86.3%). There is always a trade-off between sensitivity and specificity (any increase in sensitivity will be accompanied by a decrease in specificity), so we choose that variable as best in which combination of sensitivity and specificity gives the maximum predictive value, i.e., the maximum area under curve, so overall proteinuria (g/24 hours) was the best predictor of pre-eclampsia.

TABLE 6: Receiver operating characteristic curve of Pulsatility index {Umbilical artery}, Resistive index {Umbilical artery}, Pulsatility index {Uterine artery}, Resistive index {Uterine artery}, Pulsatility index{RIBA}, Resistive index{RIBA} and Proteinuria (g/24 hours) for predicting pre-eclampsia.

Variabl-es	Pulsatility index {Umbilic-al artery}	Resistive index {Umbilic-al artery}	Pulsatili-ty index {Uterine artery}	Resistive index {Uterine artery}	Pulsa-tility index{RIBA}	Resis-tive index{RIBA}	Protei-nuria (g/24 hours)
Area under the RO C curve (AUC)	0.725	0.807	0.891	0.872	0.898	0.732	0.979
Standard Error	0.0329	0.0298	0.0205	0.0235	0.0207	0.0309	0.00635
95% Confidence interva l	0.666 to 0.780	0.753 to 0.854	0.846 to 0.927	0.824 to 0.910	0.853 to 0.932	0.672 to 0.785	0.953 to 0.993
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cut off	>1.21	>0.71	>1.045	>0.67	>1.015	>0.615	>0.48
Sensitivity (95% CI)	79.37% (71.2 - 86.1%)	67.46% (58.5 - 75.5%)	85.71% (78.4 - 91.3%)	73.81% (65.2 - 81.2%)	86.51% (79.3 - 91.9%)	71.43% (62.7 - 79.1%)	86.51% (79.3 - 91.9%)
Specificity (95% CI)	66.67% (57.7 - 74.8%)	96.83% (92.1 - 99.1%)	84.92% (77.5 90.7%)	100% (97.1 - 100.0%)	84.92% (77.5 - 90.7%)	65.08% (56.1 - 73.4%)	100% (97.1 - 100.0%)

PPV(95% CI)	70.4% (62.2 - 77.8%)	95.5% (88.9 - 98.8%)	85% (77.6 - 90.7%)	100%(96.1 - 100.0%)	85.2% (77.8 - 90.8%)	67.2% (58.5 - 75.0%)	100% (96.7 - 100.0%)
NPV(95% CI)	76.4% (67.3 - 83.9%)	74.8% (67.5 - 81.3%)	85.6% (78.2 - 91.2%)	79.2% (72.1 - 85.3%)	86.3% (79.0 - 91.8%)	69.5% (60.3 - 77.6%)	84.1%(78.6 - 88.9 %)
Diagnostic accuracy	73.02%	82.14%	85.32%	86.90%	85.71%	68.25%	93.25%

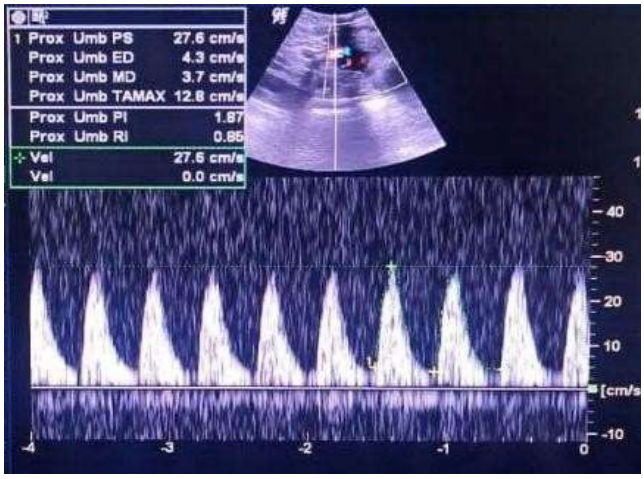
The discriminatory power of IRIs (AUC 0.858; 95% CI: 0.800 to 0.889), IRIs+UmA RI (AUC 0.887; 95% CI: 0.825 to 0.893), and IRIs+UmA RI+UtA RI (AUC 0.907; 95% CI: 0.834 to 0.916) was acceptable. Among all the parameters, the combination of IRIs and RIs of umbilical and uterine arteries was the best predictor of preeclampsia at a cut-off point of IRIs had a sensitivity of 78.57% followed by IRIs+UmA RI (76.08%) and IRIs+UmA RI+UtA RI (75.17%). In the prediction of pre-eclampsia, IRIs+UmA RI+UtA RI had the lowest sensitivity of 75.17%. On the other hand, IRIs+UmA RI+UtA RI had a specificity of 100.00%, followed by IRIs+UmA (97.34%). In the prediction of pre-eclampsia, IRIs had the lowest specificity of 96.03%. The highest positive predictive value was found in IRIs+UmA RI+UtA RI (100.00%) and the highest negative predictive value was found in IRIs (84.4%).

Table 7: Receiver operating characteristic curve of IRIs, IRIs+UmA RI, IRIs+UmA RI + UtA RI for predicting pre-eclampsia.

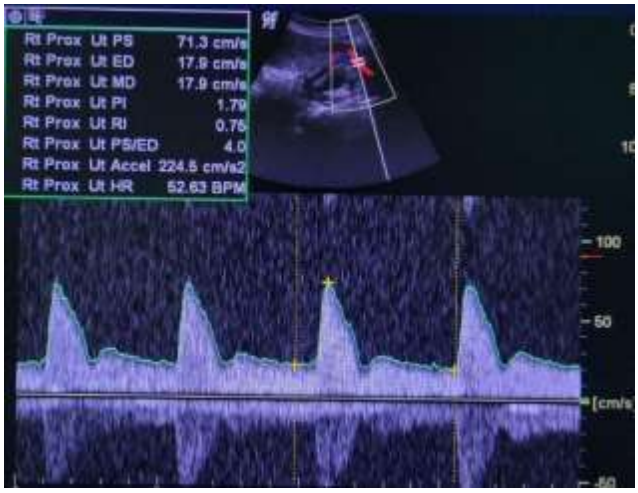
Variables	IRIs	IRIs+UmA RI	IRIs+UmA RI + UtA RI
Area under the RC curve (AUC)	0.858	0.887	0.907
Standard Error	0.0239	0.0216	0.0204
95% Confidence interval	0.800 to 0.889	0.825 to 0.893	0.834 to 0.916
P value	<0.0001	<0.0001	<0.0001
Sensitivity(95% CI)	78.57% (70.4 - 85.4%)	76.08% (56.1 - 79.4%)	75.17% (74.1 - 82.1%)
Specificity(95% CI)	96.03% (91.0 - 98.7%)	97.34 (97.1- 99.60%)	100% (97.7 -100.0%)
PPV(95% CI)	93.3% (85.1 - 97.8%)	94.20% (92.5 - 97.0%)	100% (90.5- 100.0%)
NPV(95% CI)	84.4% (78.4 - 88.0%)	84.1% (76.9 - 90.5%)	74.1% (66.9 - 79.8%)

Diagnostic accuracy	88.29%	88.04%	90.59%

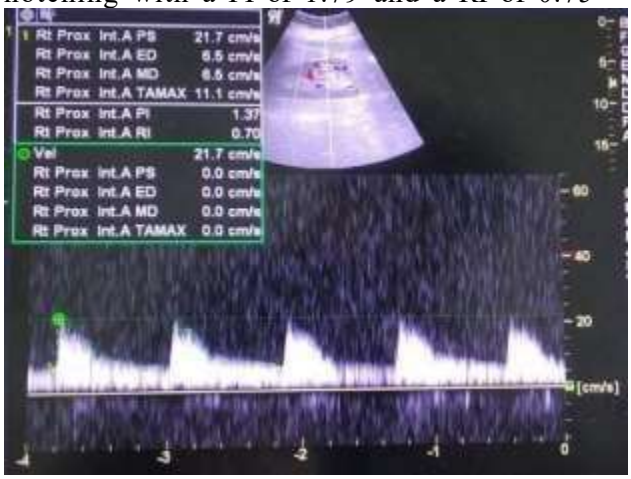
REFERENCES IMAGES



Umbilical artery Doppler utrasound showing a high resistance waveform with a PI of 1.87 and a RI of 0.85

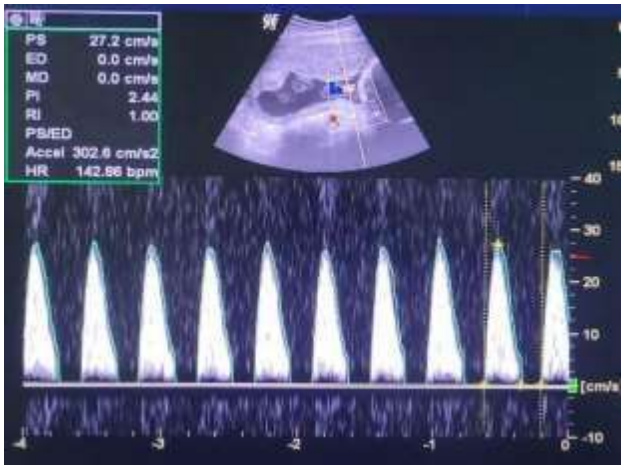


Uterine artery of the same patient showing a high resistance waveform and characteristic notching with a PI of 1.79 and a RI of 0.75

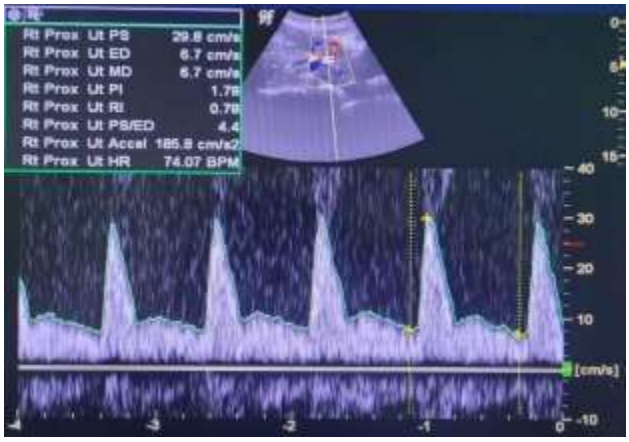


Renal Doppler ultrasound of the same patient showing a high resistance waveform in interlobular arteries with a PI of 1.37 and a RI of 0.70

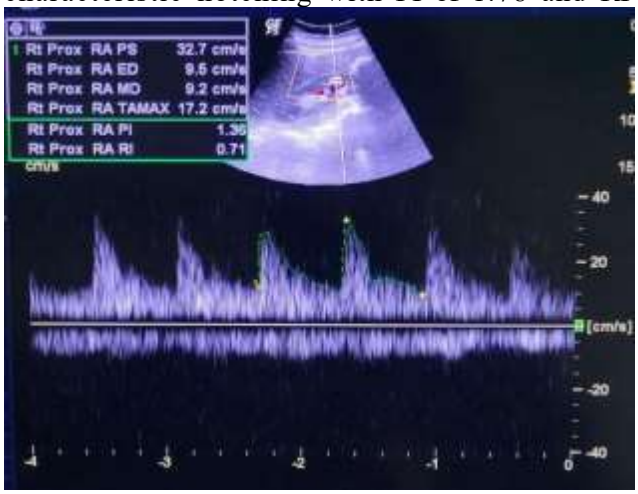
Case 2



Umbilical artery Doppler waveform showing absent end-diastolic flow with PI of 2.44 and a RI of 1.00

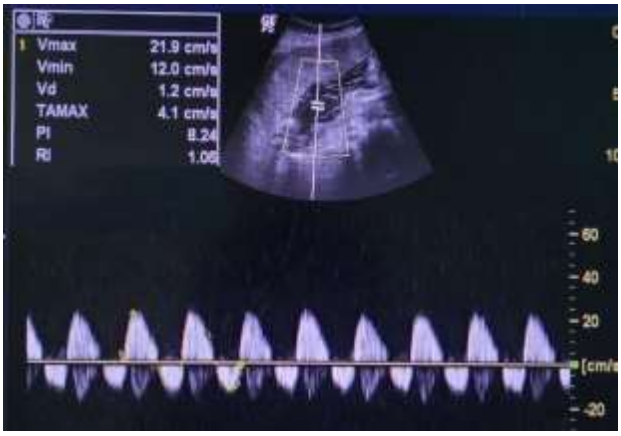


Doppler examination of uterine artery of the patient showing high resistance flow with characteristic notching with PI of 1.78 and RI of 0.78

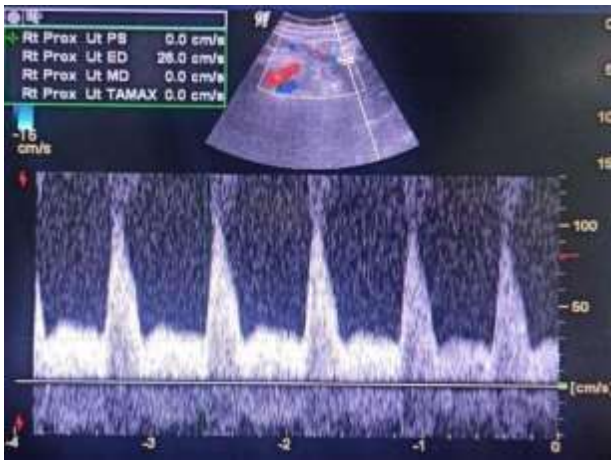


Renal Doppler ultrasound of the same patient revealing a high resistance flow in interlobular arteries with PI of 1.36 and RI of 0.71

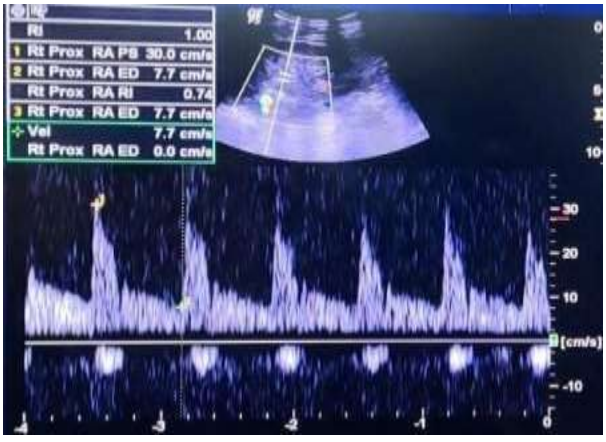
CASE3



Umbilical artery showing a triphasic waveform with reversal of end-diastolic flow with PI of 8.24 and RI of 1.06



Uterine artery of the same patient showing high resistance biphasic waveform with characteristic notching with PI of 1.81 and RI of 0.8



Renal Doppler ultrasound of the same patient showing high resistance biphasic waveform in interlobular artery with PI of 1.44 and RI of 0.74

Discussion

Pre-eclampsia is a common condition associated with increased perinatal morbidity and mortality. Our work aimed to evaluate the potential of renal Doppler ultrasonography as

a diagnostic tool for pre-eclampsia. In our study, of the 126 pre-eclamptic women, 32 were in the higher age group of 30-40 years and 94 in the age group of 18 to 30 years. The proportion of patients of age group 31-40 years was significantly higher in pre-eclamptic women than in normal healthy pregnant women. (25.40% vs. 5.56% respectively). The proportion of patients of age group 18-30 years was significantly lower in women with pre-eclampsia than in normal pregnant women. (74.60% vs. 94.44% respectively). Similar results were observed by Bustan-Nahumson N et al. In our study, there was a higher proportion of pre-eclamptic patients with an urban residence as compared to the healthy pregnant women (56.35% vs. 42.06%, respectively). The proportion of patients with a rural area of residence was significantly lower in pre-eclamptic group than in healthy pregnant group (43.65% vs. 57.94% respectively). Similar findings were reported by van Middendorp D et al.A prior history of pre-eclampsia is a known risk factor for developing preeclampsia in the present pregnancy. Our study showed that the proportion of patients with a prior history of pre-eclampsia was significantly higher in preeclamptic women compared to normal healthy pregnant women. (11.11% vs. Discussion 83 0%, respectively). Similar results were observed by Sibai BM et al.[13] The proportion of patients with a family history of hypertension in our study was significantly higher in the pre-eclamptic group compared to the healthy group. (39.68% vs. 20.63%, respectively). (p-value=0.001) Similarly, the proportion of patients with family history of diabetes was significantly higher in the pre-eclamptic group as compared to the healthy group. (18.25% vs. 0%, respectively). This is consistent with a study by Bezerra PC et al [16,17]. In our study, the umbilical artery resistance index had a sensitivity of 67.5% and a specificity of 96.8% for predicting pre-eclampsia. Similar results were observed by Bahser N et al .Our study used Doppler ultrasonography to image renal interlobular arteries which are immediately upstream of afferent vessels and glomerular capillaries. The results showed a significant difference in intrarenal resistance indices (IRI) between pre-eclamptic and healthy pregnant women. End-diastolic velocity, pulsatility index and resistive index of the renal interlobular arteries were significantly higher in the pre-eclamptic group than in the healthy group. This is clinically important because kidney function is a key factor in the prognosis of PE. In PE, inflammation of the endothelium leads to the release of vasoconstrictive substances, causing the kidneys to maintain a constricted state. This process occurs before any measurable decline in renal function. In normal pregnancy, the kidneys adapt by increasing blood flow and filtration, but this adaptation fails in PE.

The early onset of endothelial dysfunction and vasoconstriction in PE suggests that IRIs could serve as early predictors of the condition, similar to elevated PI values in uterine arteries during the first trimester in high-risk pregnancies. Similar results were observed by Bahser N et al.[13] Using the Pearson correlation coefficient in pre-eclamptic women, our study determined a significant positive correlation of proteinuria with the PI and RI of renal interlobular and uterine arteries and a mild non-significant correlation with PI and RI of umbilical arteries. Similar correlation was seen by the study done by Bahser N et al. Using Pearson correlation coefficient in pre-eclamptic women, our study determined a significant positive correlation of systolic blood pressure with PI, RI of umbilical artery, uterine artery and the end-diastolic velocity(cm/sec), PI, and RI of the renal interlobular artery with a correlation coefficient of 0.361, 0.521, 0.595, 0.579, 0.737, 0.569, 0.458 respectively (p-value < 0.0001). Similar results were also achieved by Bahser N et al.[13]Among the resistance indices of intrarenal vessels, our study found the PI of the intrarenal vessels as the best predictor with 85.71% correctly classified preeclamptic cases. Our findings are consistent with the study done by Bahser N et al.[13] , Using the combination of PI, RI and EDV of renal interlobular arteries as IRI for predicting pre-eclampsia, our study achieved a high diagnostic accuracy of 88.29% with a sensitivity of 78.57% and a specificity of 96.03%. The combination of IRIs with RI of umbilical arteries showed a sensitivity of 76.08% and a specificity of 97.34% and a diagnostic accuracy of 88.04% for predicting pre-eclampsia. Combining the IRIs, RI of umbilical and uterine arteries revealed a sensitivity of 75.17%, a specificity of 100% and a higher diagnostic accuracy of 90.59% for correctly classifying women with preeclampsia. Similar results were observed by Bahser N et al. [13]

Conclusion

Blood pressure and proteinuria was significantly higher in pre-eclamptic women than in healthy pregnant women. Doppler indices (PI and RI) of uterine and umbilical arteries were significantly higher in pre-eclamptic women than in healthy pregnant women. Renal interlobular arterial Doppler parameters (EDV, PI, RI) were significantly higher in pre-eclamptic women than in healthy pregnant women. Renal interlobular PI showed a significant positive correlation with the PI of umbilical arteries in pre-eclamptic women. Intrarenal RI showed a mild positive correlation with RI of umbilical arteries. Renal interlobular arterial Doppler indices showed a positive correlation with proteinuria and systolic blood pressure in pre-eclamptic women. From this study it may be concluded that there exists a significant difference between the intrarenal resistance indices in healthy and pre-eclamptic women. Intrarenal resistance indices can correctly classify women into pre-eclampsia and healthy groups. There exists a statistically significant correlation between intrarenal resistance indices and resistance indices of umbilical and uterine arteries in women with pre-eclampsia. Based on our data and considering that renal Doppler ultrasound is inexpensive, less stressful, and not time-consuming, we would recommend renal Doppler ultrasound for pregnant women, especially in the early stages, as a predictor and a potential clinical test.

References

1 Hogan MC, Foreman KJ, Naghavi M, Ahn SY, Wang M, Makela SM et.al. Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress towards Millennium Development Goal 5. Lancet. 2010; 375:1609–1623

2. Sajith M, Nimbargi V, Modi A, Sumariya R, Pawar A. Incidence of pregnancy induced hypertension and prescription pattern of antihypertensive drugs in pregnancy. International Journal of Pharma
Sciences and Research (IJPSR). Apr 2014; 05(04): 163-170.

3. Kooffreh ME, Ekott M, Ekpoudom DO. The prevalence of pre-eclampsia among pregnant women in the university of Calabar teaching hospital, Calabar. Saudi J Health Sci. 2014;3:133-6.

4.Bartsch E, Medcalf KE, Park AL, Ray JG; High Risk of Pre-eclampsia Identification Group. Clinical risk factors for pre-eclampsia determined in early pregnancy: systematic review and meta-analysis of large cohort studies. BMJ. 2016; 353:i1753.

5.Levine, RJ, Qian, C, Maynard SE. Serum sFlt1 concentration during preeclamp- sia and mid trimester blood pressure in healthy nulliparous women. Am J Obstet Gynecol, 2006; 194: 1034-1041.

6 .Harskamp RE. Zeeman GG. Pre-eclampsia: at risk for remotecardiovascular disease. Am J Med Sci, 2007; 334: 291-295.

7 .Levine RJ, Lam C, Qian C, Yu KF, Maynard SE, Sachs BP, Sibai BM, Epstein FH, Romero R, Thadhani R, Karumanchi SA. CPEP Study group. Soluble en- doglin and other circulating antiangiogenic factors in preeclampsia. N Eng J Med, 2006; 355: 992-1005.

8 .Lam C, Lim KH, Karumanchi SA. Circulating angiogenic factors in the pathogenesis and prediction of preeclampsia. Hypertension, 2005; 46: 1077-1085

9 .Eremina V, Sood M, Haigh J, Nagy A, Lajoie G, Ferrara N, Gerber HP, Kikkawa Y, Miner JH, Quaggin SE. Glomerular-specific alterations of VEGF-Aexpression lead to distinct congenital and acquired renal diseases. J Clin Invest,2003; 111: 707-716.

10 .Davison JM, Homuth V, Jeyabalan A, Conrad KP, Karumanchi SA, QuagginS, Dechend R, Luft FC. New Aspects in the Pathophysiology of Preeclampsia. J Am Soc Nephrol, 2004; 15: 2440-2448.

11 .Levine RJ, Maynard SE, Qian C, Lim KH, England LJ, Yu KF, Schisterman EF, Thadhani R, Sachs BP, Epstein FH, Sabai BM, Sukhatme VP, KarumanchiSA. Circulating angiogenic factors and the risk of preeclampsia. N Engl J Med, 2004; 350: 672-683.

12 .Standring S, Gray HA. Gray's anatomy: the anatomical basis of clinical practice. 40th ed. Edinburgh, Scotland: Churchill Livingstone, 2008.
13 .Bahser N, Godehardt E, Hess AP, Blume C. Examination of intrarenal resistance indices indicate the involvement of renal pathology as a significant diagnostic classifier of preeclampsia. Am J Hypertens. 2014; 27(5):742-9.
14 .Cochlin DL: Vascular disorders of the kidney In: Allan PL, Baxter GM, Weston MJ (eds.): Clinical Ultrasound. Elsevier, Amsterdam: 2011; 467–485.
15 .Jakubowski W: Standardy badań ultrasonograficznych Polskiego Towarzystwa Ultrasonograficznego. Roztoczańska Szkoła Ultrasonografii, Warszawa–Zamość 2008
16 .Sibai BM, Lindheimer M, Hauth J, Caritis S, VanDorsten P, Klebanoff M,et al. Risk factors for preeclampsia, abruptio placentae, and adverse neonatal outcomes among women with chronic hypertension. National Institute of Child Health and Human Development Network of Maternal-Foetal
Medicine Units. N Engl J Med . 1998;339(10):667–71
17 .Bezerra PC, Leão MD, Queiroz JW, et al. Family history of hypertension as an important risk factor for the development of severe preeclampsia. Acta Obstet Gynecol Scand. 2010; 89(5):612-617