ORIGINAL ARTICLE

Use Doppler imaging of uterine arteries for predicting preeclampsia in women with risk factors

Utilização do doppler de artérias uterinas para predição da pré-eclâmpsia em portadoras de fatores de risco

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ABSTRACT

Introduction: Hypertensive disorders represent the most frequent and serious complications of pregnancy and childbirth. Abnormal findings upon uterine artery Doppler, including altered values of pulsatility index and average persistence of bilateral diastolic notch, have been proposed as suitable predictors of preeclampsia in screening tests. **Objectives:** To evaluate the usefulness of uterine artery Doppler in predicting the occurrence of preeclampsia in a group of women at clinical and epidemiological risk for its development. **Patients and methods:** 81 pregnant women, all of which with risk factors for developing preeclampsia were selected. The average pulsatility index exams were performed on gestational intervals of 16+0 and 19+6 weeks and 24+0 and 27+6 weeks. In the latter range, the persistence of bilateral diastolic notch was also assessed. **Results:** Bilateral diastolic notch between 24+0 and 27+6 weeks of gestation could predict the diagnosis of preeclampsia with 75% sensitivity, 82% specificity, positive predictive value of 50% and negative predictive value of 93%. The analysis of data obtained between 16+0 and 19+6 weeks and between 24+0 and 27+6 weeks demonstrated that high values of mean pulsatility index were found in patients affected by preeclampsia compared with those found in the group of normotensive patients. **Conclusion:** pregnancies complicated by preeclampsia had significantly higher prevalence of bilateral notches and higher mean pulsatility indexes in each of the ranges studied. Since no specific treatment is currently available, the ability to predict the disease at its onset, in the first half of pregnancy, can facilitate early monitoring, increased support, and the ability to intervene at the appropriate time so as to reduce the maternal-fetal morbidity and mortality observed in preeclampsia.

Key words: Pre-eclampsia; Pre-eclampsia/prevention & control; Laser-Doppler Flowmetry; Hypertension; Arteries; Uterus.

RESUMO

Introdução: *os distúrbios hipertensivos representam as intercorrências mais frequentes e graves do ciclo grávido-puerperal. Achados anormais no doppler de artérias uterinas, como valores alterados do índice de pulsatilidade médio e persistência da incisura protodiastólica, têm sido propostos como testes de rastreamento adequados para a predição da pré-eclâmpsia.* ***Objetivos:*** *avaliar a capacidade de predizer a ocorrência de pré-eclâmpsia pelo doppler das artérias uterinas em grupo de risco clínico e epidemiológico para o seu desenvolvimento.* ***Pacientes e métodos:*** *foram selecionadas 81 gestantes, todas portadoras de fatores de risco para pré-eclâmpsia. As avaliações do índice de pulsatilidade médio foram realizadas nos intervalos gestacionais compreendidos entre 16^{+0} e 19^{+6} semanas e 24^{+0} e 27^{+6} semanas. Neste último intervalo, foi também avaliada a persistência da incisura protodiastólica bilateral.* ***Resultados:*** *a incisura protodiastólica bilateral entre 24^{+0} e 27^{+6} semanas de gestação foi capaz de predizer o diagnóstico de pré-eclâmpsia com 75% de sensibilidade, 82% de especi-*

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ficidade, valor preditivo positivo de 50% e valor preditivo negativo de 93%. A análise dos dados obtidos entre 16^{+0} e 19^{+6} semanas de gestação e entre 24^{+0} e 27^{+6} semanas de gestação demonstrou que elevados valores de índice de pulsatilidade médio foram encontrados no grupo de pacientes acometidas pela pré-eclâmpsia quando comparado aos encontrados no grupo de pacientes normotensas. ***Conclusão:*** *as gestações complicadas pela pré-eclâmpsia mostraram prevalência significativamente maior de incisura bilateral e medidas de índice de pulsatilidade médio maiores em cada um dos intervalos estudados. Como nenhum tratamento específico está atualmente disponível, a possibilidade de se predizer a doença, com início ainda na primeira metade da gestação, pode facilitar a monitorização precoce, a instituição de medidas de suporte e a intervenção em momento apropriado para reduzir a morbimortalidade materno-fetal observada na pré-eclâmpsia.*

Palavras-chave: *Pré-eclâmpsia; Pré-eclâmpsia/prevenção & controle; Fluxometria por Laser-Doppler; Hipertenção; Útero; Artérias.*

INTRODUCTION

Preeclampsia (PE) represents the main cause of maternal mortality in developed countries.[1] Worldwide, 10 to 15% of maternal deaths are associated to PE and eclampsia.[2] In Brazil[3], PE is responsible for 23% of direct maternal deaths.

It is considered that the placental tissue is sufficient and necessary for the development of PE because its removal at the time of delivery results in improved clinical symptoms.[4,5] The increase in blood pressure during pregnancy is associated with increased risk of premature placenta separation (PPS), disseminated intravascular coagulation (DIC), cerebral hemorrhage, liver failure, and acute renal failure.[2]

The normal gestation is characterized by systemic inflammation, oxidative stress, changes in the levels of angiogenic factors, and vascular reactivity. This process is exacerbated in PE with associated loss of compensatory mechanisms, eventually resulting in vascular and placental dysfunction. The hypoxic and ischemic placenta seems to represent the physiopathological basis of PE. The placenta and maternal vasculature are sources of reactive oxygen and nitrogen species that can interact and produce oxidants that are possibly responsible for changes in the vascular function observed in PE. The interaction between placental hypoxia and maternal vascular dysfunction appears to occur through fragments of syncytiotrophoblast or angiogenic factors secreted by the placenta into maternal circulation.[5]

Considering its significant incidence and severity, an effective tracing test is essential in the early identification of PE.[6] Because no specific treatment for PE is currently available, its prediction may facilitate early monitoring such as the imposition of measures of support and intervention at the appropriate time to reduce maternal-fetal morbidity and mortality associated with PE.[7]

The traditional method for tracking PE consists in the evaluation of maternal history, allowing the identification of approximately only 30 and 20% of cases that will develop into early and late PE, respectively.[8] Blood pressure and proteinuria are also not good predictors of adverse fetal or maternal outcomes, thus, the development of additional markers is necessary.[9]

The uterine artery dopplerfluxometry allows the identification of women at risk for the development of PE, in particular the early type, facilitating the timely use of antiplatelet prophylaxis to prevent or slow down the development of the severe form of this disease.[7] Abnormal findings in uterine artery doppler in the first and second trimesters have been proposed as tracing tests suitable to predict PE [2, 6, 10, 11], restricted intrauterine growth (RIUG), PSP, and pre-term labor.[10]

The aim of this study was to evaluate the ability to predict the occurrence of PE using a uterine artery doppler in a clinical and epidemiological risk group for PE development.

MATERIAL AND METHODS

A longitudinal and prospective study was conducted from January 2011 to March 2012 in the High Risk Prenatal service from the General Clinic Hospital from the Federal University of Minas Gerais (UFMG). A total of 81 pregnant women over the age of 18 years old were included, without fetal malformations, with risk factors for PE, and evaluated between the 16^{+0} 19^{+6} and 24^{+0} and 27^{+6} gestational weeks. The risk factors considered were those already described in the literature.[12] Patients with incomplete medical records, questionable diagnostic criteria for PE, loss of follow-up, and development of gestational hypertension were excluded. The study was approved by the Committee of Ethics in Research (COEP) from UFMG. All included patients read and signed a volunteer informed consent.

The following parameters were evaluated: maternal age; parity; IMC; gestational age according to the date of last menstruation with confirmation by ultrasound in the first half of the gestation; mean arterial pressure (MAP); and uterine artery doppler for the calculation of average pulsatility index (average PI),

and evaluation of persistent bilateral protodiastolic notch. The PE group of patients was compared to the group of patients who did not develop the disease and, within the PE cases, the group that developed the early form was compared to the group that developed the late form.

Dopplerfluxometric study of uterine arteries

The uterine artery doppler was performed with a 7.5 mHz linear probe (SONOACE 8800® – Medison Co., Ltd). The right and left uterine arteries were visualized in a longitudinal lateral to the uterus incision and flow velocity waves (FVW) were obtained with the patient supine and head slightly elevated in both studied moments. The proximal third of uterine arteries was always probed and the pulsatile doppler was used to obtain three consecutive waves of flow velocity (FVW). PI from each artery was measured for the calculation of the average PI and the morphology of FVW in the search for protodiastolic notches was evaluated.

The evaluation of the protodiastolic notch was performed in both studied moments. However, whereas in pregnancies with normal evolution, the protodiastolic notch disappeared until the 26th week of gestation[13.14], the examination of altered persistence of bilateral notch in the second studied moment was considered.

Diagnostic criteria for preeclampsia

The PE diagnosis was based on the clinical classification of the disease in mild and severe forms[15] and the classification based on the beginning of clinical manifestations, i.e. early PE (patients with onset of symptoms before 34 gestational weeks) and late PE (patients in which symptoms begin after 34 gestational weeks).[16-18]

Statistical analysis

The alpha error (α) of 5% and beta error (β) of 20% were considered for sample calculation. The estimated sample was over 52 patients, similar to that reported by Bujoldet al.[19] and Teixeira et al.[20] The SHAPIRO-WILK normality test was used to verify normality in all quantitative variables. The Pearson Chi-square asymptotic test was used for categorical variables when 20% of cells, in the contingency table, presented expected values between one and five and 80% above five. When more than 20% of the cells exhibited expected values between one and five, the Pearson Chi-square exact test was adopted. The Student t test was used for quantitative variables when they showed normal distribution, and the Mann Whitney test for non-normal distribution variables. The average PI values were described by box-plot. The paired t-test was used for quantitative variables of normal distribution and the Wilcoxon test for quantitative variables of non-normal distribution in comparisons of variables between the two moments of evaluation in each group. The comparisons of variables differences in the two moments of evaluation between the groups were performed using the Student t test for normal distribution variables and the Mann Whitney test for non-normal distribution variables. The significance level was set at 0.05. Calculations of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were made in the evaluation of protodiastolic notch as a method to predict PE between 24^{+0} and 27^{+6} gestational weeks. The test diagnostic analysis via the ROC curve, calculations of sensitivity, specificity, PPV, and NPV were used for the evaluation of the average PI as a method to predict PE between 16^{+0} and 19^{+6} and 24^{+0} and 27^{+6} gestational weeks. Sensitivity, specificity, PPV, and PNV were calculated in the combined evaluation between the average PI in the second evaluation moment and protodiastolic notch.

RESULTS

Eleven out of the 81 patients were excluded for loss of follow up and 8 for not presenting all the necessary criteria for PE diagnosis. Out of the 62 included patients, 50 did not develop PE and 12 did. Of these, five showed the early form and seven the late form.

The characteristics of the selected pregnant women were evaluated in the first studied moment, i.e. during the evaluation between the 16^{+0} and 19^{+6} gestational weeks. In the analyzed qualitative variables, 25 patients were nulliparous (40.3%), the majority showed brunette skin (27, 43.5%), and 28 presented altered body mass index (BMI) (45.2%) featuring overweight or obesity. In the analyzed quantitative variables, the mean maternal age was 29.8 years, median BMI was 23.2 kg/m^2, and the average MAP was 90.8 mmHg.

A history of PE represented most of the cases (22.6%), followed by nulliparity (17.7%) in the evaluation of risk factors presented by the patients.

The demographic and gestational characteristics and systemic blood pressure values were similar in the groups with and without PE when patients were evaluated in the period of 16^{+0} to 19^{+6} gestational weeks. The average PI values were significantly higher in the group of patients that developed PE (p = 0.010) (Table 1).

Table 1 - Comparison between variables obtained in the first evaluation of patients with and without PE

Variables	No PE	PE	p value
Pregnancies *			
1	19(90,5)	2(9,5)	0,336[3]
≥ 2	31(75,6)	10(24,4)	
Skin complexion *			
Brunette	22(81,5)	5(18,5)	1,000[3]
Leucoderma	14(82,4)	3(17,6)	
Melanoderma	14(77,8)	4(22,2)	
Maternal age	29,8 ± 6,6	30,0 ± 4,4	0,921[1]
Mean arterial pressure (MAP)**	90,0 ± 8,3	93,8 ± 5,5	0,130[1]
Average Pulsatility Index **	1,11 ± 0,24	1,31 ± 0,17	0,010[1]
Body Mass Index (BMI) ***	23,2 ± 9,0	24,6 ± 7,9	0,219[2]
Gestational age***	17,5 ± 3,0	16,5 ± 1,0	0,059[2]

* n (%); ** average ± standard deviation; *** median ± interquartile interval.
[1]t-Student test. [2] Mann-Whitney test. [3] Pearson exact Chi-square test.

The evaluation of patients in the period between 24^{+0} and 27^{+6} gestational weeks (Table 2) did not allow the identification of differences in gestational age and MAP. The average PI was significantly higher in the group of patients with PE (p < 0.0001). Bilateral uterine arteries notch was observed in 18 out of 62 followed up patients (29%) being present in 50% of PE cases and absent in 93.2% among those who did not develop the disease. Considering these data, the bilateral protodiastolic notch verified at the time of the second assessment, i.e. between 24^{+0} and 27^{+6} gestational weeks, predicted the onset of PE clinical manifestations with 75% sensitivity, 82%specificity, 50% PPV, and 93% NPV.

Table 2 - Comparison between variables obtained in the second evaluation of patients with and without PE

Variables	No PE	PE	p value
Gestational age***	26,0±2,0	25,0±1,0	0,508[2]
Mean arterial pressure (MAP)**	83,3±10,0	91,7±16,7	0,064[2]
Average Pulsatility Index **	0,86±0,15	1,16±0,19	<0,0001[1]
Bilateral notch			
Yes *	9 (50,0)	9 (50,0)	< 0,0001[3]
No *	41(93,2)	3(6,8)	

* n (%); ** average ± standard deviation; *** median ± interquartile interval.
[1]t-Student test. [2] Mann-Whitney test. [3] Pearson exact Chi-square test.

There was no statistical significance difference between the average values of average PI observed in the two moments of evaluation in patients with and without PE (p = 0.099).

A significant reduction in the average PI was observed between the average PI from the two moments of evaluation (Table 3) in patients with and without PE (p 0.009 and < p 0.0001, respectively) (Table 3). A significant MAP reduction was obtained from the first to the second moment in the study, only in patients without PE (Table 3).

Figure 1 presents a graph with the average PI behavior in the two moments of evaluation (16^{+0} to 19^{+6} and 24^{+0} to 27^{+6} gestational weeks) between the two groups of pregnant women (with and without PE). In both groups the average of average PI value was higher in the period between 16^{+0} and 19^{+6} gestational weeks than in the other moment.

The ROC curve built from data obtained in the first moment of evaluation (16^{+0} to 19^{+6} gestational weeks) presents an area of 0.767 with 95% confidence interval from 0.643 to 0.890 and p value = 0.004 (Figure 2, Table 5). According to the statistical definitions (Table 4), the result of the area under the ROC curve (AUC) reveals that the average PI performed in the first moment of the study can be classified as a regular method of PE diagnosis because the area lies in the range from 0.7 to 0.8.

Table 3 - Comparison between clinical variables between the two studied moments

	PE			No PE		
Variables	1st evaluation	2nd evaluation	p value	1st evaluation	2nd evaluation	p value
Average PI *	1,31±0,17	1,16±0,19	0,009[2]	1,11±0,24	0,86±0,15	<0,0001[2]
MAP **	93,3±5,8	91,7±16,7	0,067[1]	90,8±13,3	83,3±10,00	<0,0001[1]

* average ± standard deviation; ** median ± interquartile interval; MAP: mean arterial pressure ; Average IP: Average Pulsatility Index; [1] Wilcoxon test; [2] Paired t-Student test; [A] 16^{+0} to 19^{+6} gestational weeks; [B] 24^{+0} to 27^{+6} gestational weeks.

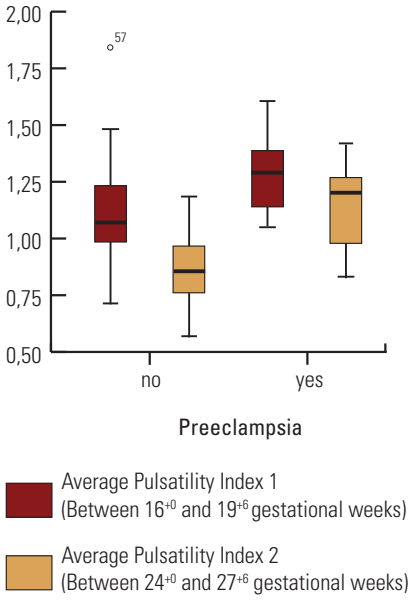

Figure 1 - Average Pulsatility Index in uterine arteries; behavior in the two studied moments among normotensive pregnant women with development of preeclampsia.

Table 4 - Values used in the interpretation of areas under the ROC curve in the statistical efficiency

Area (AUC)	Quality of diagnosis
0,9 a 1,0	Excellent
0,8 a 0,9	Good
0,7 a 0,8	Regular
0,6 a 0,7	Bad
0,5 a 0,6	Insignificant

Source: Martinez *et al.* [21]

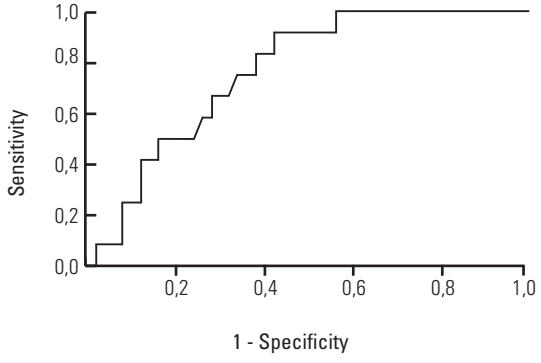

Figure 2 - ROC curve with the average PI values obtained between 16+0 and 19+6 gestational weeks in PE patients.

Table 5 - Data from the ROC curve in the first studied moment

AUC	CI 95% AUC	p value
0,767	0,643-0,890	0,004

AUC – Area under the ROC curve; CI – Confidence Interval.

The determination of average PI values, considered as cut-off points for PE's prediction, was performed based on five criteria: high specificity; high sensitivity; high PPV; high NPV; and high sensitivity and specificity. Two cut-off points were obtained for this last criterion. The cut-off point with the best result in the high specificity criterion (98%) was 1.59; in the high-sensitivity (91.7%) and high NPV (96.7%) criteria, 1.12; in the criterion high PPV, no point was found; and in the criterion high sensitivity (91.7 and 83.3%) and specificity (58 and 62%) cut-off points of 1.12 and 1.14 were found, respectively.

Regarding the data obtained in the second moment of evaluation (24+0 to 27+6 gestational weeks), the ROC curve presents an area of 0.890 with 95% confidence interval from 0.788 to 0.992 and p-value < 0.0001 (Figure 3, Table 6). According to Table 4, the result of the area under the ROC curve (AUC) reveals that the average PI performed in the second moment of the study can be classified as a good method to predict PE because the area lies in the range from 0.8 to 0.9.

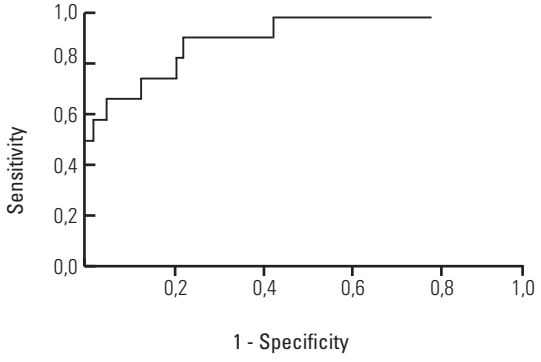

Figure 3 - ROC curve with the average PI values obtained in the second moment of evaluation (24+0 to 27+6 gestational weeks).

Table 6 - Data from the ROC curve in the second studied moment

AUC	CI 95% AUC	p value
0,890	0,788 - 0,992	< 0,0001

AUC – Area under the ROC curve; CI – Confidence Interval.

The determination of average PI values in this range of gestational moment, considered as cut-off points for PE's prediction, was performed using the same criteria. The cut-off point with the best result in the criteria of high specificity (98%) and high PPV (87.5%) was 1.17; in the high-sensitivity criteria (91.7%) and high NPV (97.3%) 0.95; and in the criterion high sensitivity (91.7% for the two points) and

specificity (70% and 72%) cut-off points of 0.95 and 0.93 were found, respectively.

Considering the cut-off point for the average PI conducted between 24^{+0} and 27^{+6} gestational weeks, which proved to be more sensitive (≥ 0.95), the use of the association of the average PI and protodiastolic notch as methods to predict PE showed reduced sensitivity when compared to the isolated use of the average PI (Table 7).

Table 7 - Analysis of prediction of preeclampsia associated to exams

Cut-off points	Sensitivity	Specificity	PPV	NPV
Present bilateral protodiastolic notch and average PI * ≥0.95	0,889	0,667	0,727	0,857

* Índice de pulsatilidade médio realizado entre 24^{+0} e 27^{+6} semanas de gestação.

DISCUSSION

PE is one of the most intriguing and challenging conditions in medical science. In spite of intense research and rapid advancement of knowledge its etiology is still not completely understood. Furthermore, the fact that it is a unique disease during human gestation limits the development of animal models. Currently, the search for pathophysiological understanding about this disease points to a tracing pathway of early and more effective prediction and monitoring minimizing or even slowing its aggravation.

The uterine artery doppler has been investigated as a marker that reflects the development or perfusion of the placental vascular bed.[7,14,21-24] The use of the uterine artery doppler in various moments of the gestation may represent a great opportunity for an early detection of PE.[6] There are no current prophylactic interventions that can substantially reduce the risk of this disease.[24] Therefore, the possibility of stratification in the prenatal care is probably the greatest benefit of the uterine artery doppler tracing in the second trimester of gestation.[25]

In this study, we prospectively followed up a group of pregnant women at risk for PE, in moments that correspond to the process of trophoblastic invasion. The selection of a group of patients at risk for developing PE was performed considering that this would be the group that would benefit from the proposed examination.

In this study, the first gestational period using the uterine artery doppler was defined based on the most likely moment for admission of pregnant women in high-risk prenatal services in the Brazilian public health system. The pathophysiology of the disease in question was considered for the definition of the second period dopplerfluxometry evaluation of gestational uterine arteries, that is, the likely moment of completion in the process of trophoblastic invasion of spiral arteries as well as the evaluation of data already presented in the literature by studies that used doppler evaluation of uterine arteries in the second trimester of gestation.[24,26]

The data presented here show that the bilateral protodiastolic notch at the moment of the second evaluation, i.e. between 24^{+0} and 27^{+6} gestational weeks predicted the PE diagnosis with 75% sensitivity, 82% specificity, 50% PPV, and 93% NPV. The bilateral notch in the second study moment suggests an increased risk of PE development. These data corroborate those reported by Espinoza et al.[27] who, after the dopplerfluxometric evaluation performed between 23 and 25 gestational weeks concluded that the protodiastolic notch represents an independent risk factor for the development of the disease.

Conversely, the data from this study also suggest that between 24^{+0} and 27^{+6} gestational weeks the absence of protodiastolic notch of uterine arteries gives patients 93% probability of not developing PE throughout their pregnancies. Comparatively, de Aguiar et al.[14], after assessing the association between maternal uterine arteries protodiastolic notch and histopathological changes in uteroplacental vessels recommended that the proper trophoblastic invasion of the placental bed, revealed by typical histology of physiological changes, results in the absence of maternal bilateral protodiastolic notch uterine arteries. These data reinforce the pathophysiological mechanisms of the disease, namely, the possible role of inadequate trophoblastic invasion in the development of PE.

In relation to uterine artery perfusion, the data analysis from the first moment in the study (16^{+0} to 19^{+6} gestational weeks) demonstrates that high average PI values were found in patients who developed PE (1.31 average) when compared to the values found in patients who have not developed the disease (1.11 average; $p < 0.05$). Therefore, patients who had high PI levels in uterine arteries presented higher incidence of PE. These results were similar to those previously reported by Llurba et al.[23] and Onwudiwe et al.[24] The study by

Llurba et al.[23] performed dopplerfluxometry between 19 and 22 gestational weeks. These authors observed that the average PI in uterine arteries was able to identify 70.6% of pregnancies that subsequently developed early PE and 23.5% of those that developed late PE. Onwudiwe et al.[24] analyzed pregnant women between 22 to 24 gestational weeks and observed average PI values significantly higher in patients who developed PE and gestational hypertension when compared to the group that did not develop the disease.

According to the statistical definitions (Table 4), the result for the area under the ROC curve (AUC 0.767) reveals that the average PI performed in the first moment of the study can be classified as a regular method of PE diagnosis because the area lies in the range from 0.7 to 0.8. However, during this same period of evaluation, a high positive predictive value was not found for the average PI. An average PI value greater than or equal to 1.12 was coincidental with three of the six criteria assessed in the ROC curve: high sensitivity, high NPV, and high sensitivity and specificity. This data suggests that patients with risk factors for PE evaluated during the moment from 16^{+0} to 19^{+6} gestational weeks and presenting average PI values greater than or equal to 1.12 require more frequent prenatal follow up for an adequate monitoring of blood pressure and possible early diagnosis of this disease.

In the second studied moment (24^{+0} to 27^{+6} gestational weeks), the average PI values identified were higher in the group of patients affected by PE (average of 1.16) when compared to those found in the group of healthy patients (average of 0.86; $p < 0.0001$). Similarly, Plasencia et al.[26] investigated the uterine artery doppler as a method to predict PE in two gestational periods (11^{+0} to 13^{+6} and 21^{+0} to 24^{+6} weeks) and found PI logarithm averages significantly higher in the group of patients who developed PE when compared to the group of patients not affected by the disease.

The data obtained in the second moment of evaluation (24^{+0} to 27^{+6} gestational weeks) showed that the area under the ROC curve (AUC 0.890) reveals that the average PI performed in the second moment of the study can be classified as a good method to predict PE because the area lies in the range from 0.8 to 0.9. Comparatively, Espinoza et al.[27], studying pregnancies between 23 and 25 gestational weeks, showed that the average PI of uterine arteries was above 95 percentile and/or the bilateral notch presented AUC of 0.619 for the prediction of PE and AUC of 0.821 for the prediction of early PE. In the second moment in the study, the average PI values (≥ 0.95) were coincidental to the same three criteria registered in the first moment of evaluation: high sensitivity, high NPV, and high sensitivity and specificity. Therefore, the data suggest that the women with PE risk factors evaluated during the gestational period between 24^{+0} and 27^{+6} weeks, who showed average PI values greater than 0.95, deserve proper surveillance and special attention for early diagnosis of PE.[28]

Between 24^{+0} and 27^{+6} gestational weeks, more sensitivity for the prediction of PE with the isolated use of average PI was observed for PI values greater than or equal to 0.95 compared to the sensitivity observed for the association of average PI and protodiastolic notch (88.9%), which can be explained by the small number of patients with notch persistence (n = 18).

CONCLUSION

The uterine artery doppler represents a useful and non-invasive method that allows early and indirect access to changes induced by the pregnancy in the uteroplacental circulation. Compared to pregnancies with normal results, pregnancies complicated by PE showed significantly higher prevalence of bilateral notch and higher average PI values in each of the studied moments. Therefore, for women with risk factors for the development of PE, the persistence of bilateral notch between 24^{+0} and 27^{+6} gestational weeks and the observation of average IP values greater than the cut-off points evidenced by the ROC curves in both moments in the study (16^{+0} to 19^{+6} and 24^{+0} to 27^{+6} weeks) represent good markers for the prediction of this hypertensive disorder in the course of these pregnancies.

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