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Hemodynamic changes of renal main arteries in pregnancy-induced hypertension

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Abstract

Objective: To detect Doppler ultrasonographic velocimetry alterations of renal main arteries in pregnancy-induced hypertension (PIH).
Study design: The peak systolic and end-diastolic velocities (Vs, Vd), resistivity and pulsatility indices (RI, PI), systolic/diastolic ratio (S/D ratio), acceleration time (AT) and systolic acceleration (SA) of renal main arteries were obtained in 17 PIH women and 15 age- and gestation week-matched normal pregnant (NP) women. The data between the two groups were compared with unpaired student's *t*-test.
Results: The AT was much longer and SA much lower in PIH than those in NP, while no significant differences were found in Vs, Vd, RI, PI and S/D ratio.
Conclusions: AT and SA could be better used than Vs, Vd, RI, PI or S/D for detection of hemodynamic changes of renal arteries in patients with PIH. It may also imply that larger arteries proximal to the renal main artery be significantly affected.

Keywords: Pregnancy-induced hypertension; Renal artery; Doppler ultrasonography; Normal pregnancy; Hemodynamics

1. Introduction

Pregnancy is often accompanied by significant changes in renal hemodynamics that could be impaired in women with pregnancy-induced hypertension (PIH). The basic pathophysiological change of PIH is the spasm of small arteries all over the body, which causes increased peripheral vascular resistance [1–3]. Many studies have been performed to explore the renal arterial hemodynamics, but the differences in renal arterial indices between normotensive and hypertensive pregnant women are still controversial at present. Some studies adopted the parameters that describe the renal arterial downstream vascular resistivity, such as the systolic peak velocity, the end-diastolic velocity and their ratio, the resistivity index and pulsatility index, but no significant differences were found in these parameters between PIH patients and normal pregnant women. Other studies employed the parameters of acceleration time and systolic acceleration that describe the upstream vascular resistivity, and significant differences were found in these two parameters between PIH patients and normal pregnant women, while most of these studies were restricted to the study of interlobar renal arteries [4–6]. This study was conducted to detect the renal main arterial hemodynamic changes in patients with PIH and to further investigate the mechanism and clinical implication.

2. Methods

Seventeen women with PIH and 15 age- and gestation week-matched (mean: 26.6 years versus 26.5 years; 38.3 weeks versus 39.1 weeks) NP women were recruited for this study. PIH was defined as a blood pressure elevation higher than 140/90 mmHg in both systole and diastole after 20 weeks gestation in at least two measurements obtained 6 h apart according to Miyake [1]. The blood pressure elevation of the PIH women was higher than 140/90 mmHg when they received the ultrasound scan. Approval of the Hospital Ethics Committee was obtained, and written informed consent was collected from all patients. All the subjects in

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Table 1
Comparison of blood flow parameters of renal main artery in PIH with those in NP ($x \pm$ S.D.)

Group	Vs (cm/s)	Vd (cm/s)	PI	RI	S/D (Vs/Vd)	AT (ms)	SA (m/s^2)
PIH	64.96 ± 17.00	23.33 ± 7.04	1.02 ± 0.18	0.62 ± 0.07	2.79 ± 0.31	116.59 ± 43.21	6.67 ± 3.46
NP	70.61 ± 19.20	23.87 ± 6.14	0.99 ± 0.16	0.60 ± 0.06	2.61 ± 0.40	76.79 ± 18.28	9.08 ± 3.20
P	0.42	0.80	0.62	0.53	0.28	0.007	0.009

Abbreviations: Vs, peak systolic velocity; Vd, end-diastolic velocity; PI, pulsatility index; RI, resistivity index; S/D, peak systolic velocity/end-diastolic velocity; AT, acceleration time; SA, systolic acceleration.

this study denied having a history of renal disease or essential hypertension.

2.1. Doppler ultrasonography

The right kidney was examined in order to maintain the pregnant women in a comfortable position throughout the Doppler ultrasonographic examination.

Each subject was examined in the left lateral decubitus position and the longitudinal plane of the right kidney was obtained to rule out abnormalities in renal size, shape and echogenicity with two-dimensional ultrasonography. With pulsed Doppler ultrasonography directed by color Doppler ultrasonography, the spectra of the renal main artery (proximal to the renal interlobar arteries) were recorded over five cardiac circles while the subjects held their breath, and the best spectra obtained in each artery were analyzed. The Doppler angle was less than 60°. The peak systolic velocity (Vs), end-diastolic velocity (Vd), time-averaged velocity (TAV), resistivity index (RI), pulsatility index (PI), systolic/diastolic ratio (S/D ratio), acceleration time (AT) and systolic acceleration (SA) of renal main arteries were obtained with Acuson Sequoia 512 ultrasonograph (Siemens Medical Solutions, Mountain View, CA) with the transducer of 4V1.

The Vs and Vd were measured at the apex of the highest systolic peak and at the end of diastole, respectively. RI, PI and S/D were calculated as follows: RI = (Vs − Vd)/Vs, PI = (Vs − Vd)/TAV. S/D = (Vs/Vd). The AT was measured as the interval from the start of the systolic forward phase to the maximal peak velocity in systole. The SA was calculated by dividing the Vs during this same interval by the AT.

2.2. Statistical analysis

The statistics on Excel package were used. Results were expressed as mean ± S.D. The data between the PIH and NP groups were compared with unpaired student's *t*-test. A value of $P < 0.05$ was considered statistically significant.

3. Results

3.1. Patient population

The systemic arterial pressures in women with PIH were significantly higher than those in NP women (120 ± 10 mmHg versus 76 ± 6 mmHg, $P = 0.0001$). No significant differences were found in age (26.4 ± 3.3 years versus 26.5 ± 3.1 years, $P = 0.83$), gestational age (38.3 ± 2.2 weeks versus 39.1 ± 1.2 weeks, $P = 0.09$) and heart rate between the two groups (88.1 ± 11.3 bpm versus 89.0 ± 13.5 bpm, $P = 0.098$).

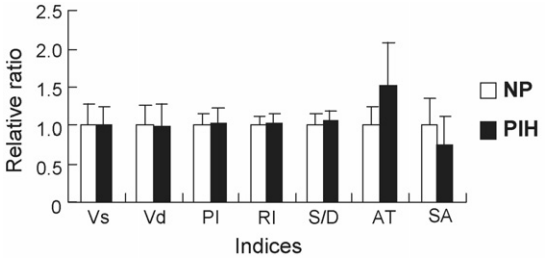

Fig. 1. Comparison of blood flow parameters of renal main artery in PIH with those in NP. The mean value was normalized as 1 for all the indices. Vs, peak systolic velocity; Vd, end-diastolic velocity; PI, pulsatility index; RI, resistivity index; S/D, peak systolic velocity/end-diastolic velocity; AT, acceleration time; SA, systolic acceleration.

3.2. Differences of blood flow parameters of renal main artery between PIH and NP

The AT was much longer and SA was much lower in PIH than those in NP (AT: 116.59 ± 43.21 ms versus 76.79 ± 18.28 ms, $P = 0.007$; SA: 6.67 ± 3.46 m/s^2 versus 9.08 ± 3.20 m/s^2, $P = 0.009$). No significant differences were found in Vs, Vd, RI, PI and S/D ratio between the two groups ($P > 0.05$) (Table 1, Fig. 1).

4. Discussion

Pregnancy-induced hypertension (PIH) is estimated to affect 8–10% of all pregnancies [2]. Despite being one of the leading causes of maternal death and a major contributor of maternal and prenatal morbidity, the mechanisms responsible for the pathogenesis of PIH have not yet been fully elucidated. The initiating event in PIH appears to be reduced uteroplacental perfusion as a result of abnormal cytotrophoblast invasion of spiral arterioles. Placental ischemia is thought to lead to widespread activation/dysfunction of the maternal vascular endothelium that results in enhanced formation of endothelin and thromboxane, increased vascular sensitivity to angiotensin