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Original Article

A comparison of Doppler waveform parameters versus flow-mediated vascular dilation of the brachial artery in pregnant women

Inna V. Landres [a], Maria Small [b], Adesh Sirjusingh [c], Samuel Ramsewak [c], Keith P. Williams [d,*]

[a] Stony Brook Department of Obstetrics and Gynecology, 6 Technology Drive, Suite 200, East Setauket, NY 11733, United States
[b] Department of Obstetrics and Gynecology, Duke University Medical Center, DUMC 3967, Durham, NC 27710, United States
[c] Department of Obstetrics and Gynecology, Mount Hope Maternity Hospital, University of the West Indies, Trinidad and Tobago
[d] Department of Obstetrics and Gynecology, Rowan University – School of Osteopathic Medicine, Stratford, NJ, United States

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ABSTRACT

Objective: Flow mediated dilation of the brachial artery is impaired with endothelial dysfunction. *We previously identified that brachial artery waveforms were changed in preeclamptic women.* We therefore sought to compare Doppler waveform analysis with flow mediated vascular dilation (FMVD) measurements in pregnant women.
Study design: A cross sectional study of 71 pregnant women at >20 weeks gestation comparing FMVD measurements with Doppler waveform parameters was performed. Research was conducted at three hospitals and two geographic settings; (1) Yale-New Haven Hospital in New Haven, CT, (2) Mount Hope Maternity and (3) Port of Spain General Hospital in Trinidad. Brachial artery Doppler waveform measurements were done at baseline and 90 s post cuff-release. From the Doppler waveforms we assessed percent change in Peak Systolic Velocity (% ΔPSV), systolic acceleration, acceleration time and pulsatility index and compared them with the percent change in FMVD. Statistical analysis using Student's *t* tests and correlation coefficient was done as necessary.
Results: Correlation analysis between the % change in the Doppler waveform parameters and the % change in mean FMVD identified only the waveform parameter of % ΔPSV as significantly correlated ($p = 0.040$).
Conclusion: FMVD remains the gold standard for assessment of endothelial dysfunction. A correlation was observed between the Doppler measured % ΔPSV and FMVD, which may allow it to be used to assess endothelial dysfunction changes under different conditions was identified.

Introduction

Endothelial cell dysfunction is identified as the final common pathway in preeclampsia with multiple biochemical markers of endothelial activation increased in preeclampsia [1]. A non-invasive in vivo measurement of endothelial cell dysfunction uses the brachial artery diameter (flow mediated dilation) assessed with high

* Corresponding author. Address: Department of Obstetrics and Gynecology, Rowan University – School of Osteopathic Medicine, 42 E. Laurel Road, University Doctor's Pavilion, Suite 3600, Stratford, NJ 08084, United States. Tel.: +1 856 566 7099; fax: +1 856 566 6499.
E-mail address: williakp@rowan.edu (K.P. Williams).

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resolution ultrasound in response to a hypoxemic challenge [2–4]. Previous work has shown that endothelial dysfunction assessed by brachial artery dilation is impaired in women who develop or are at risk of preeclampsia [5,6]. Although brachial artery dilation is an established test of endothelial cell dysfunction, specific changes in brachial artery Doppler waveform characteristics accompanying the dilatation which may correlate with endothelial cell dysfunction have only been assessed in limited studies [7]. Previously we identified that brachial artery waveforms were changed in preeclamptic women [8]. We therefore conducted this study to investigate the timing and correlation between the Doppler waveform analysis with flow mediated vascular dilation (FMVD) measurements in pregnancy.

Methods

Subjects

We conducted a cross sectional study at two geographic settings and three hospitals: (1) Yale-New Haven Hospital (YNHH) in New Haven, CT, (2) Mount Hope Maternity and (3) Port of Spain General Hospital in Port of Spain, Trinidad. All three hospitals were affiliated with a University academic center and potential participants were recruited from prenatal clinics and inpatient wards. The study was approved by the HIC Committee at the YNHH/Yale University School of Medicine as well as the Internal Review Boards for Mount Hope Maternity and Port of Spain General Hospitals.

Women participating in the cross sectional study had brachial artery ultrasound at gestational age $\geqslant$20 weeks. Inclusion criteria for the case control study were pregnant women at a gestational age $\geqslant$20 weeks. Exclusion criteria for the study were (1) age $\leqslant$18, (2) timing of smoking >4 h prior to the study, (3) multiple pregnancy, (4) carpal tunnel syndrome or other arm/hand disabilities.

Ultrasound assessment of the brachial artery

Each patient rested in a quiet, temperature-controlled room (22–26 °C) in either the supine or left lateral position for 10 min prior to the ultrasound exam with a manual sphygmomanometer placed on the forearm of the patient. The right brachial artery was scanned over a longitudinal section 2–15 cm above the elbow where the clearest longitudinal image of the arterial lumen was obtained using the Logiq book portable ultrasound machine (GE Healthcare). The diameter of the brachial artery was measured from high-resolution B-mode image obtained with a 7 MHz linear array transducer (GE healthcare). The depth and gain controls were set to optimize visualization of the lumen to arterial wall interfaces. A 30 s recording of the brachial artery was obtained to measure baseline diameter. To create the hyperemic state, the cuff around the forearm was inflated to a pressure of 250–300 mmHg. The pressure is held above 250 mmHg for 5 min. After 5 min, the cuff is rapidly released and brachial artery is imaged continually using the color-flow mode from the point of cuff deflation ($t = 0$) to 90 s, and again at 120 s.

Measurements of the vessel diameter were taken with ultrasonic calipers, from the leading edge of the anterior wall to the leading edge of the posterior wall of the brachial artery at the end of diastole (see Fig. 1). Each measurement was recorded as the mean of 3 different points along the length of at least 0.8 cm of lumen wall. The baseline (resting) vessel diameter was calculated as a mean of two measurements between 0 and 30 s of recording. The measurements of flow-mediated hyperemic response were calculated between 10 and 90 s at 15 s intervals and again at 120 s for a total of 7 post-cuff release measurements. Changes in diameter at each time point were calculated as percentage change relative to the resting diameter; % FMVD = ([Vessel diameter at X s. after cuff deflation − Baseline diameter]/Baseline diameter) × 100%. All measurements were done with the investigator blinded to subject identification.

Statistical analysis

The study could detect a moderate correlation ($r = .3$) with a power of 80% to discover that the correlation is statistically different from there being no correlation at the 0.05 level. Statistical analysis was done using the statistical program, SSPS, Version 12.0 statistical package. We compared the waveform characteristics and the FMVD characteristics at 75–120 s post occlusion. Continuous data was presented as mean and standard deviation and comparison was done using Student's *t*-tests. Correlation between the Doppler waveform characteristics and FMVD was done using Pearson correlation. Categorical data was compared using chi-square analysis or fisher exact test as necessary. Significance was set at $p < .05$.

Results

See Tables 1 and 2.

Discussion

FMVD remains the gold standard for assessment of endothelial dysfunction [9]. A correlation was observed in this study between the Doppler measured % change in PSV and FMVD between 75 and 120 s. The importance of assessing endothelial dysfunction lies in the fact that it is the final common pathway in the pathogenesis of preeclampsia and vascular diseases [3].

Brachial artery ultrasound imaging during reactive hyperemia is a tool used widely for establishing the presence of endothelial dysfunction in non-pregnant patients [2–4]. This technique provokes the release of NO, resulting in FMVD that can be quantified using high-frequency ultrasound. Studies in non-pregnant patients with atherosclerosis and diabetes have identified impaired brachial artery reactivity (defined as a significant reduction in FMVD) which correlated with increasing endothelial cell dysfunction [9].