Pregnancy Hypertension 13 (2018) 46–50

Contents lists available at ScienceDirect

Pregnancy Hypertension

journal homepage: www.elsevier.com/locate/preghy

MRI-derived aortic characteristics after pregnancy: The AMBITYON study

G.A. (Gerbrand) Zoet[a,*], A.K. (Anna) Sverrisdóttir[a], A.L.M. (Anouk) Eikendal[b], A. (Arie) Franx[a], T. (Tim) Leiner[b], B.B. (Bas) van Rijn[a,c]

[a] Wilhelmina Children's Hospital Birth Center, University Medical Center Utrecht, Lundlaan 6, PO Box 85090, 3508 AB Utrecht, The Netherlands
[b] Department of Radiology, University Medical Center Utrecht, Heidelberglaan 100, 3584 CX Utrecht, The Netherlands
[c] Academic Unit of Human Development and Health, University of Southampton, Princess Anne Hospital, Coxford Road, Southampton SO16 5YA, United Kingdom

A R T I C L E I N F O

Keywords:
Parity
Cardiac magnetic resonance
Arterial stiffness
Pulse wave velocity
Subclinical atherosclerosis
Aortic wall thickness

A B S T R A C T

Objectives: Pregnancy and pregnancy complications have been associated with increased arterial stiffness even at young age. In this study we assessed the impact of parity on CMR-derived aortic characteristics as early markers of atherosclerosis and arterial stiffness in healthy women between 25 and 35 years.

Study design: We studied 68 women who participated in the AMBITYON study, a prospective population-based cohort study for assessment of atherosclerotic burden by MRI and traditional CVD risk factors in healthy, young adults. Of these women, 40 (58.8%) were nulliparous, 13 (19.1%) were primiparous and 15 (22.1%) were multiparous.

Main outcome measures: Descending thoracic aortic wall thickness (AWT) and pulse wave velocity (PWV) were measured using 3.0T CMR.

Results: AWT measurements were similar between nulliparous women and primi- or multiparous women (1.6 mm ± 0.2 mm vs. 1.6 mm ± 0.2 mm; p = 0.79). Correction for age and systolic blood pressure did not change these results. Applying percentile based cut-off values showed a non-significant increase in AWT in parous women. PWV measurements did not differ between nulliparous women and parous women (4.5 m/s ± 0.7 m/s vs. 4.5 m/s ± 0.8 m/s; p = 0.78). Correction for age and systolic blood pressure did not influence these results. Using percentile based cut-off values, showed an increasing likelihood of higher PWV-values in parous women, although not statistically significant.

Conclusions: Direct measurement of aortic AWT and PWV by CMR showed no difference between nulliparous and parous women, probably indicating limited effect of pregnancy on arterial stiffness and early markers of atherosclerosis.

Trial registration: Netherlands Trial Register (NTR) number: 4742.

1. Introduction

Pregnancy is associated with cardiovascular alterations and poses a considerable challenge to the maternal cardiovascular system [1–3]. During normal pregnancy the total circulating blood volume, cardiac output and heart rate increase markedly whereas peripheral vascular resistance and mean arterial blood pressure decrease [1,3]. Some of the maternal adaptations during pregnancy, such as increased body weight and hypercholesterolemia, persist during the postpartum period and may endure for extended periods of time [4]. Women who experience such changes may exhibit an unfavorable cardiovascular disease (CVD) risk profile following parity [5,6].

Vascular dysfunction, including both arterial stiffness and subclinical atherosclerosis, has been suggested to play a key role in the development of CVD in women [7]. This has been extensively investigated in relation to hypertensive pregnancy disorders (HPD), such as preeclampsia and gestational hypertension [8,9]. HPD are associated with increased arterial stiffness and early development of atherosclerosis [8,10]. However, the influence of uncomplicated pregnancy on these early markers of CVD is less clearly understood.

Previous studies have used operator-dependent techniques to assess vascular dysfunction, such as carotid-femoral pulse wave velocity (cfPWV) by tonometry measurement and carotid intima-media thickness (cIMT) by ultrasound, both requiring trained operators and specialized equipment [8,11]. Recent advances in cardiovascular magnetic resonance (CMR) imaging provide a unique opportunity to assess aortic arterial stiffness and subclinical atherosclerosis both non-invasively and with low operator dependency [12–14]. CMR – derived PWV has been

* Corresponding author at: University Medical Center Utrecht, Room KE 04.123.1, Lundlaan 6, PO Box 85090, 3508 AB Utrecht, The Netherlands.
E-mail address: g.zoet@umcutrecht.nl (G.A. (Gerbrand) Zoet).

https://doi.org/10.1016/j.preghy.2018.04.018
Received 29 December 2017; Received in revised form 26 April 2018; Accepted 28 April 2018
Available online 30 April 2018

established as measure for arterial stiffness and aortic wall thickness (AWT) as measure for subclinical atherosclerosis [14–17]. CMR measures of vascular dysfunction have been validated and showed to be in good agreement with invasive measurements [18,19].

In this study we assessed the impact of parity on CMR – derived aortic characteristics as early markers of atherosclerosis and arterial stiffness in asymptomatic women between 25 and 35 years.

2. Methods

2.1. Population

We used data of the AMBITYON (Atherosclerosis-Monitoring-and-Biomarker-measurement-In-The-Young) study (Netherlands National Trial Register number: 4742). The AMBITYON study is a prospective mono-center cohort study, which included 131 healthy young adults [14]. The participants were recruited from Leidsche Rijn, a region in the city of Utrecht, The Netherlands. Potential participants were randomly selected from the municipality population registry and approached with an invitation letter. Healthy young adults between 25 and 35 years were considered suitable for inclusion in the AMBITYON study. Individuals with symptomatic CVD, history of CVD, cardiac arrhythmias, contra-indications to CMR (i.e. pregnancy) and use of cardiovascular protective medication were excluded from the study. CMR imaging was performed in all participants of the AMBITYON cohort.

For the current study we included all female participants (n = 68) from the AMBITYON study. The institutional review board of the University Medical Center Utrecht approved the AMBITYON study (reference number: 13/397). The AMBITYON study was carried out according to the principles expressed in the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment in the study.

3. Measurements

3.1. Demographic and clinical measurements

Details regarding demographic and anthropometric data have been published previously [14]. In short, all participants filled out a standardized questionnaire upon inclusion in the AMBITYON study. This questionnaire comprised items regarding general health, presence of CVD risk factors and obstetric history. Measurements of body mass index (BMI), waist circumference, hip circumference and blood pressure were standardized and obtained upon inclusion. In addition, a venous blood sample was drawn for assessment of blood lipid profile, glucose, C-reactive protein and white blood cell count.

3.2. CMR imaging protocol and analysis

All participants underwent CMR imaging in supine position on a 3.0T multi-transmit clinical MRI system (Achieva, Software Release 5.1.7.2, Philips Healthcare, Best, the Netherlands). Images were acquired using a 32-channel phased-array cardiac receive coil. Total CMR imaging examination time was approximately 60 min per participant.

3.3. Aortic wall thickness

Images of the descending thoracic aorta were acquired in the sagittal orientation using a non-contrast-enhanced isotropic 3 dimensional (3D) black-blood (BB), T1-weighted, turbo-spin-echo (TSE) sequence with variable flip angles (3D-T1-BB-VISTA) sequence. Spectral Attenuated Inversion Recovery (SPAIR) fat suppression was used as well as sensitivity encoding (SENSE) parallel imaging algorithm, during free breathing without electrocardiogram gating to reduce acquisition duration [20]. Blood signal suppression was achieved by intrasequence flow related dephasing. The field of view (FOV; 350 × 302 × 45 mm) ranged from the top of the aortic arch and the most distal boundary of the cardiac coil, covering approximately 35 cm of the descending thoracic aorta. Aortic wall geometry, including AWT, was assessed using a validated software program specifically designed for measuring vessel wall characteristics (Vessel Mass, release 5.1, Laboratory for Clinical and Experimental Image processing (LKEB), the Netherlands) [21]. Image analysis was carried out according to standardized protocol, which has been published previously and showed high intraclass correlation coefficient for quantifications of aortic wall characteristics [14,22].

3.4. Pulse wave velocity

To assess stiffness of the thoracic aorta, global PWV was assessed over the entire thoracic aorta. To depict the full extent of the thoracic aorta, a double oblique single-slice SENSE balanced turbo field gradient-echo survey image was acquired using retrospective ECG gating and a single end-expiratory breath-hold. This resulting image was then used to plan two velocity-encoded phase contrast acquisitions perpendicular to the center lumen line of the aorta. One acquisition was positioned in the ascending aorta at the level of the pulmonary trunk to obtain the through-plane flow velocity in the ascending and proximal descending aorta. Subsequently, a second acquisition plane was positioned in the descending aorta near the dome of the liver to obtain the through-plane flow velocity in the distal descending thoracic aorta. All flow measurements were obtained in the transverse orientation perpendicular to the center lumen line using a one-directional through-plane, segmented, gradient echo pulse sequence with velocity encoding (VE) set to 1.50 m/s, retrospective ECG gating and free breathing. Quantification of PWV was performed in two steps. First, aortic velocity maps were generated by using validated customized software (MASS version 5.1, LKEB, Leiden, The Netherlands). Subsequently, absolute PWV values for the total thoracic aorta were generated by using a validated PWV measurement software program which showed (PwvAppStatic, LKEB, Leiden, the Netherlands) [18,23].

4. Data analysis

Continuous characteristics of the participants were presented as the mean with standard deviation (SD) or medians and interquartile range. Categorical variables were expressed as frequencies and proportions. Participants were categorized according to parity (nulliparous versus primi-or multiparous). Nulliparous women were considered the reference group.

CMR – derived PWV and AWT were compared between parity groups by linear regression analysis with and without correction for age and systolic blood pressure to control for possible confounding. Based on distribution of PWV and AWT in the reference group; 50th, 75th, 90th and 95th percentile cut-off values for PWV and AWT were computed. The frequencies of both nulliparous and parous women above the pre-specified cut-off values were used for further analyses, using Pearson Chi square or Fisher's exact, where appropriate.

A two-sided probability (p) value < 0.05 was considered statistically significant. Data were analyzed using SPSS 22.0 (SPSS Inc. Chicago, IL) and GraphPad prism 5.01 (GraphPad Software Inc. San Diego, CA).

5. Results

Out of the total study population of 68 women, 40 women (58.8%) were nulliparous and 28 women (41.2%) were primi- or multiparous (see Table 1). The mean age of the study population was 31 years. Mean BMI was 23.0 kg/m^2 whereas mean blood pressure was 123/78 mmHg. The most prevalent CVD risk factor was smoking, which was reported by 17 women (25.0%). Among the parous women, three women (10.7%) reported a history of hypertensive pregnancy disorders