Pulse Wave Velocity in Adolescent Girls with Risk Factors for Metabolic Syndrome

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INTRODUCTION Pulse wave velocity (PWV) is the best validated measure of large vessel compliance and is well known to increase in conditions leading to cardiovascular disease (CVD), such as hypertension, diabetes mellitus, glucose intolerance and metabolic syndrome (MetS) [1]. PWV has been shown to be an independent predictor of cardiovascular mortality and stroke [2]. Furthermore, PWV is known to be a better predictor of cardiovascular mortality than traditional risk factors such as obesity, smoking, hypertension, hypercholesterolemia and diabetes mellitus [3]. Although the mechanisms by which vessel compliance decreases and subsequent CVD risk increases are not well understood, there is emerging evidence non-alcoholic fatty liver disease (NAFLD) is an important independent risk factor for future CVD risk in adults [4-6]. It is not yet known if this relationship is also present in children. However, risk factors for NAFLD in adults and children are similar and are related to MetS. The primary aim of this study was to demonstrate the feasibility of measuring PWV, hepatic fat fraction (HFF), visceral adipose tissue (VAT) volume and subcutaneous adipose tissue (SCAT) volume in girls with risk factors for MetS using quantitative non-invasive magnetic resonance imaging (MRI) techniques. A secondary aim was to study the relationship between PWV and body mass index (BMI), HFF, VAT, and SCAT.

MATERIALS AND METHODS This HIPAA-compliant study was approved by our institutional human subjects review committee and written informed consent was obtained from all subjects. MRI was performed on a 3T MR scanner (MR750, GE Healthcare, Waukesha, WI) using a 32-channel coil (NeoCoil, Pewaukee, WI) in 7 girls with risk factors for MetS (average age = 14.78±2.11 years, average body mass index (BMI) = 28.16±8.36). PWV was measured with a previously validated Fourier velocity encoding (FVE) technique (Fig. 1A) implemented at 3T [7-9]. The pulse sequence consisted of a cylindrical excitation pulse followed by a bipolar VE gradient stepped through 32 velocity-encoding steps and a readout gradient applied along the axis of the cylinder. The sequence was gated to the cardiac cycle and executed 32 times per heart cycle. Four interleaves were acquired to increase the temporal resolution to 3.5ms, resulting in 128 time frames covering the first 450 ms of the cardiac cycle. The readout field of view was 24cm with a 15mm cylindrical excitation pulse obtained with an 8-cycle spiral trajectory. HFF (Fig. 1B), VAT, SCAT and total adipose tissue (TAT=VAT+SCAT) volumes (Fig. 1C) were determined using a quantitative complex chemical shift based water-fat MRI method, based on IDEAL [10]. The sequence, as implemented, corrected for all known confounding factors including T1 bias, T2* decay, spectral complexity of fat, noise related bias, and eddy currents. Image analysis for measuring PWV was performed in MATLAB. Liver fat content was determined from the average of 6 regions of interest placed in the liver on the fat fraction images. VAT and SCAT volumes were measured using Slice-O-Matic segmentation software (v4.3 Tomovision, Magog, Quebec). Linear regression analysis was used to assess the relationship between PWV and HFF, VAT, SCAT and the ratios of VAT and SCAT to TAT.

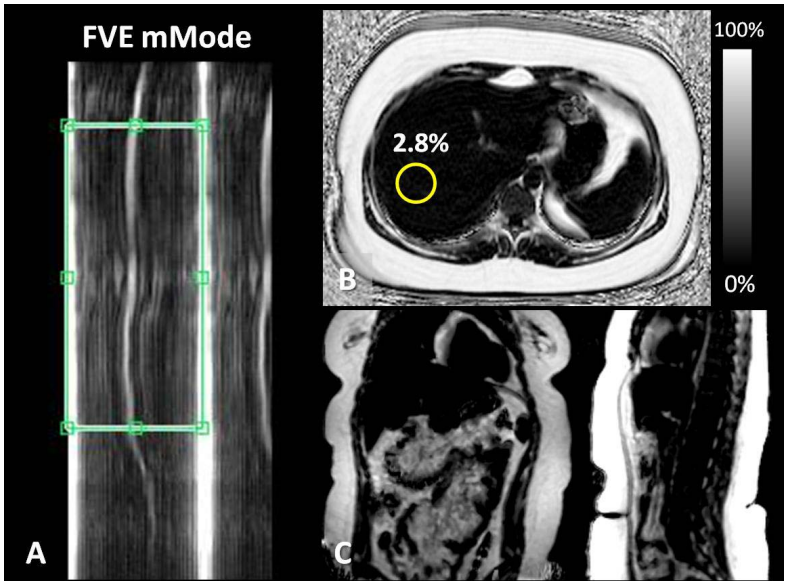

Figure 1: 17 year-old female with BMI=36.4. (A) FVE mMode is used to calculate descending aorta PWV (4.9m/s) as described in references 7-9. High isotropic spatial-resolution, single breath-hold IDEAL scans are used to quantify (B) hepatic fat fraction (2.6%) and (C) visceral and subcutaneous adipose tissue volumes (VAT = 1915mL; SCAT = 8537mL; TAT = 10452mL).

RESULTS The mean ± standard deviation (range) PWV was 4.1±0.7 (3.1-4.9) seconds. HFF was 3.8± 2.1 (2.3-8.1) %. VAT, SCAT and TAT volumes were 1497±1127 (240-2978) mL, 7099±4660 (512-12289) mL and 7732±5157 (752-12158) mL, respectively. Linear regression results are summarized in Table 1.

DISCUSSION We successfully acquired PWV, HFF, VAT, and SCAT data in 7 adolescent girls with risk factors for metabolic syndrome using simple, rapid MRI sequences. The strongest correlations were found between PWV and BMI (r=0.78) and VAT (r=0.64). The relatively strong correlation between PWV and VAT in the absence of correlation between PWV and SCAT (r=0.03) is understandable because previous studies have shown that CVD is more closely associated with VAT than SCAT. The absence of a correlation between PWV and HFF in this small study is presumably related to the lack of subjects with severely elevated HFF (none greater than 8.1%). Future, larger studies are necessary to determine if a stronger correlation between PWV and HFF can be found when subjects with higher HFF are included.

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Table 1. Linear Regression Analysis.

	PWV&HFF	PWV&VAT	PWV&SCAT	PWV&VAT/TAT	PWV&SCAT/TAT	PWV&BMI
Correlation coefficient (r)	-0.02	0.64	0.03	0.41	-0.41	0.78