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Are Sonographically Measured Vascular Haemodynamic Parameters Reproducible Using Magnetic Resonance Imaging?

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WHAT THIS PAPER ADDS

The venous-arterial flow index (VAFI) is defined as the ratio of venous to arterial volume flow measured in the common femoral vein and artery by duplex sonography. The VAFI is significantly increased in patients with varicose veins and/or chronic venous disease in comparison with that of healthy subjects. The cut off to define hemodynamically relevant venous disease by the VAFI is $\geq$1.2. Varicose vein surgery and/or compression therapy reduces the VAFI to that seen in healthy controls (i.e., $<$1.2). The VAFI can be used to determine the severity of chronic venous disease and additional research is needed to help to identify patients requiring surgical interventions or conservative treatment. In this study, VAFI measurements performed by duplex sonography were compared with those obtained by phase contrast magnetic resonance imaging. This comparison confirms the value of the VAFI as a non-invasive technique to determine the presence and severity of chronic venous disease, including venous insufficiency.

Objective/Background: Hemodynamic measurements of blood flow in the common femoral vein and artery can be performed readily using duplex sonography. The ratio of venous to arterial volume flow in these vessels, the venous arterial flow index (VAFI), is increased in patients with varicose veins and/or chronic venous disease. The objective was to determine the reproducibility of sonographically measured hemodynamic flow parameters using phase contrast magnetic resonance imaging (MRI).

Methods: Based on hemodynamic volume flow measurements from the common femoral vein and artery the VAFI was calculated in seven patients with varicose veins (C2, Ep, As, Pr) and 32 healthy controls using standard duplex sonography and MRI.

Results: Based on duplex sonography, the average VAFI ($VAFI_{\_d}$) was 1.05 $\pm$ 0.17. The same ratio, using MRI ($VAFI_{\_mri}$) was 1.05 $\pm$ 0.19. There was a significant correlation between the $VAFI_{\_d}$ and the $VAFI_{\_MRI}$ ($p = .0021$). In patients with venous disease, the average $VAFI_{\_d}$ and $VAFI_{\_mri}$ were 1.36 $\pm$ 0.21 and 1.36 $\pm$ 0.20, respectively. In contrast, in the healthy cohort the $VAFI_{\_d}$ was 1.00 $\pm$ 0.12 and the $VAFI_{\_mri}$ measured 1.01 $\pm$ 0.15. As expected, there was a significant difference between the VAFI measured in those with venous disease when compared with that of healthy controls ($p < .0001$).

Conclusion: There is a significant correlation between the VAFI measured using sonography and MRI. The study confirmed the elevation of VAFI in patients with chronic venous disease.

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INTRODUCTION

Duplex sonography is an integral part of the diagnostic work up in patients with suspected chronic venous disease (CVD). In addition to facilitating visualization of the relevant anatomical structures, duplex sonography also permits the measurement of hemodynamic parameters.[1–4] An important example is the ratio of the volume flow in the common femoral vein and artery, termed the venous arterial flow index (VAFI). A former research group at the University of Heidelberg collected a series of data pertaining to the validity and utility of the VAFI.[5–7] Indeed, elevation of the VAFI has been described in patients with venous disease when compared with healthy controls,[5,6] and treatment of venous vascular disease, both operative and conservative, resulted in a reduction of the VAFI.[7] Therefore, the VAFI is a potentially useful tool with which to identify which patients with CVD may benefit from operative or conservative

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intervention, although this requires confirmation in further research studies. A VAFI $\geq$ 1.2 is associated with clinically relevant venous vascular disease, while a VAFI $<$ 1.1 is seen in the absence of venous vascular disease.[5–7] The aim of this study was to determine whether the VAFI could be measured accurately using phase contrast magnetic resonance imaging (MRI), and the extent to which the measurement correlated with the sonographically determined VAFI.

PATIENTS AND METHODS

Patients

Patients were recruited from the phlebology outpatient clinic (Department of Dermatology, University of Schleswig Holstein Campus Lübeck) after routine investigation and having provided written informed consent. Thirty-nine patients were recruited (20 females, 19 males), 32 of whom showed CVD stage C0 and C1, and seven of whom had CVD with clinical classification C2 or C3. Contraindications to MRI and cardiac arrhythmias served as exclusion criteria. Patients with severe peripheral arterial occlusive disease were also excluded.

Duplex sonography

Duplex sonography was performed using the HDI 5000 (Philips Medical Systems DMC GmbH, Hamburg, Germany), with the patient in a relaxed supine position and the leg slightly abducted. The target vessel was identified in cross section and the diameter was measured. Thereafter, the vessel was viewed in the longitudinal plane and the diameter was confirmed and the volume flow was measured. The mean blood flow velocity (Vm) was determined in the target vessel while the patient was comfortable and at rest. Using a screenshot and integrated software, the vessel diameter, and its relation to the Vm, was measured in longitudinal section in order to determine the volume flow. The venous volume flow (VVF) was measured in the common femoral vein (CFV) cephalad to the saphenofemoral junction (Fig. 1). The arterial volume flow (AVF) was measured at the same level, proximal to the bifurcation of the common femoral artery (CFA) (Fig. 1).

Phase contrast MRI

Phase contrast MRI was performed in the Clinic for Radiology and Nuclear Medicine, University of Schleswig-Holstein Campus Lübeck, using a 1.5 T whole body scanner (Achieva; Philips, Best, the Netherlands). By MRI, venous and arterial volume flow were measured using cross sectional phase contrast sequences that encode flow velocity in each acquired image pixel. The through-plane slices were placed perpendicular to the flow direction in the common femoral vein and artery. To get a mean flow, venous measurements were performed by acquiring data over 45 seconds during free breathing. Arterial flow was measured by electrocardiogram-triggered image acquisition to measure flow during three cardiac cycles. In both scenarios, flow was calculated as mL/min. By manually placing regions of interest over the vessel, flow was measured. Phase contrast MRI was performed without the use of contrast media. In our setting, the VAFI measurement using MRI was performed independently and the operator was unaware of the sonographic VAFI data recorded for each patient.

Statistical methods

Gnu R open-source software version 3.2.2 was used for statistical analysis together with the package *car* for improved ANOVA calculation (http://www.r-project.org; last accessed 22 February 2016). To evaluate the correlation between two variables, the non-parametric Spearman's rank correlation coefficient was used. One-way ANOVA was used to analyze the VAFI depending on the venous disease score (CEAP classification). XY plots and combined scatter and box plots were used to present the data as raw as possible, with each dot representing one separate individual.

p-values $<$ 0.05 were considered significant.

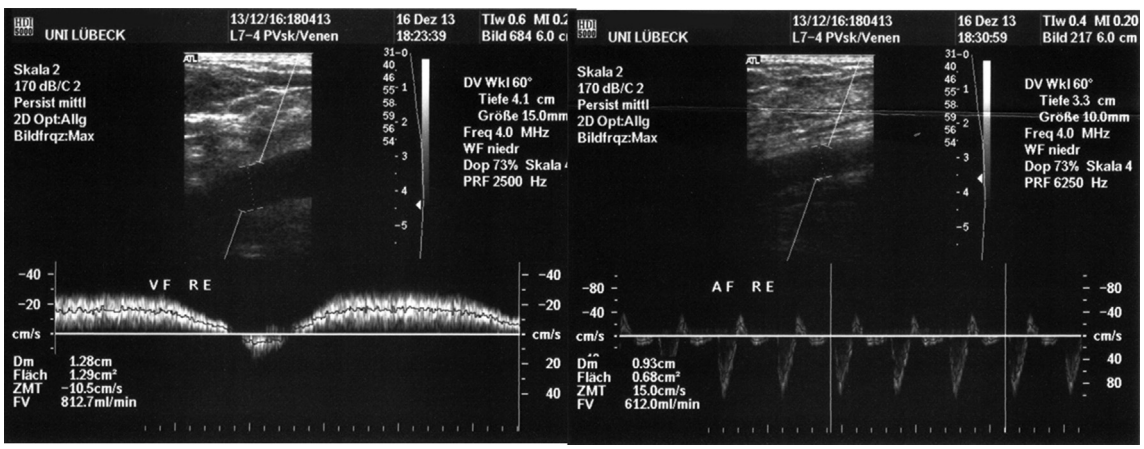

Figure 1. Volume flow measurement using duplex sonography in varicose veins. VFV_d = 821.7 mL/min and VFA_d = 612.0 mL/min; VAFI = 1.32.

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