3D analysis of Vessel Morphology

Imaged with ECG Gated Flow Spoiled-Fresh Blood Imaging Non Contrast-MRA

BZ Cooper[1], R Singh[1], R Griffith[1], M Grimaldi[1], PV Viswanath[2], E Wilson[1]
[1]Pocono Medical Center, [2]Pace University

Purpose: The morphologic assessment of peripheral vessels in patients suffering from peripheral arterial disease (PAD) is important in determining treatment options. Contrast and Non-Contrast MRA is becoming increasingly utilized preoperatively to assess the location and severity of vascular disease[1]. Whereas 2D quantitative angiography (QA) for the assessment of vessel diameter is standard, 3D quantitative angiography (QA) may provide more accurate measurements by minimizing inherent limitations of 2D measurements[2]. The aim of this study was to compare 3D to 2D analyses of diameter and implied area of vessels of the lower extremity arterial tree imaged with Non-Contrast MRA.

Methods: This study was approved by the Western Institutional Review Board. Five (5) healthy adult volunteers underwent Flow Spoiled-Fresh Blood Imaging **(**FS-FBI) Non-Contrast MRA (NC-MRA) of the complete arterial bed from the aorto-iliac bifurcation down to the distal run-off using a 1.5 Tesla MRI (Vantage Titan™, Toshiba) scanner. A three-station full runoff was performed on each volunteer. Image acquisition was performed at peak systole and peak diastole using auto-ECG. Appropriate flow-spoiling gradient pulses on the readout axis were used to optimize the separation of arteries and veins. 2D (McKesson Radiology Station ™) and 3D (Vitrea, Vital Images) workstations (WS) were used for uni-planar (UP) and bi-planar (BP) analysis of Maximum Intensity Projections (MIP). 15 arterial locations were assessed for each volunteer. All measurements were made at a uniform window width/level and at a uniform magnification. The transverse diameter (Tr) at each location was measured using a 2D WS (Tr2D). The transverse (Tr3D) and Anterior–Posterior (AP) diameter (AP3D) were measured using a 3D WS. The ratio of Tr2D to Tr3D, the ratio of the area implied by Tr2D (Ai2D) to the area implied by Tr3D ($Ai^{Tr}3D$), and the ratio of Ai2D to the area implied by Tr3D and AP3D ($Ai^{Tr\text{-}AP}3D$) were calculated. Under the null hypotheses of no difference between the 2D and 3D measurements, all these ratios should be equal to one. An F-test, based on an estimated linear regression model, was used to jointly test the hypotheses that the ratios are all equal to one for all 15 arterial locations. All statistical analysis were performed using STATA14.

Results: The null hypotheses of no difference between the 2D and 3D measures was easily rejected with a high degree of confidence for all ratios: Tr2D to Tr3D ($F(12, 48) = 5.59$, $Prob > F = 0.0000$), the ratio of Ai2D to $Ai^{tr}3D$ ($F(12, 48) = 3.01$, $Prob > F = 0.0033$), and the ratio of Ai2D to $Ai^{Tr\text{-}AP}3D$ ($F(12, 48) = 3.01$, $Prob > F = 0.0033$). This suggests that the 2D measurement of the blood vessel area is significantly greater than that of the 3D measurement. The evidence also suggests that this is particularly true at the Internal Iliac Artery and the DFA arterial locations.

Conclusion: This preliminary study demonstrates significant differences between 3D and 2D assessment of vessel diameter and implied vessel area of arteries imaged with NC-MRA. Whereas assessing severity of stenosis and preoperative planning is usually performed with 2D analysis, future investigative work may show a benefit to using 3D analysis tools for the assessing vessel morphology.

References: (1) Cooper BZ et al. J Surg Res. 2001 Sep;100(1):99-105. (2) Ihara T et al. Ann Vasc Surg. 2013 Feb;27(2):154-61.

We acknowledge the support of Toshiba America Medical Systems