Arm Position Alters the Geometry of Brachial Artery and Basilic Vein

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Purpose
The brachial artery and basilic vein are two vessels commonly used for arterio-venous fistula creation in patients with end stage renal disease. Advantages are that it produces superficial fistula with a high flow rate and offer good long term patency [2]. Few studies have assessed the impact of vessel geometry on the internal haemodynamics of these vessels. Certain geometric parameters such as the curvature and tortuosity of the blood vessels are known to affect the blood flow profiles inside the vessel, and thus influence levels of wall shear stress (WSS) - the driving force in vascular remodeling [1]. This study aims to estimate the impact of two different arm positions (supine and ‘superman’) on significant geometrical features associated with haemodynamics.

Methods
The group of volunteers consisted of eight healthy men and women (Age 32.7 years, range 27 - 42 years). Magnetic Resonance (MR) images were obtained with a 3T MR unit (Siemens MAGNETOM Trio) using a surface coil (8 Channel, Siemens) wrapped around the participant’s arm of interest. Images were taken using a high-resolution sequence called Multi Echo Data Image Combination (MEDIC). The pulse sequence implemented a TE of 16 ms, a TR of 29 ms and a flip angle of 8°. The solid surface models were constructed from the MR images, using a semi-automatic segmentation technique in ITK-Snap and then post-processed in vascular modeling toolkit (VMTK). All properties were determined according to relevant published definitions. Figure 1 shows the bifurcation angle, generated from space vectors on the centerline, calculated in VMTK.

Results
Figure 2 (left) shows the changes of basilic vein bifurcation angle. The changes of the brachial artery curvature for both arm positions and for each volunteer independently represented on the right histogram. To test the reproducibility of our study between analysts, the models of a volunteer were created by two members of our team. Results showed small changes: a) in the bifurcation angle (12%) and b) on the models volume (3.7%). A change in arm position influenced the bifurcation angle, with six out of eight volunteers showing an increased angle in the supine position. The mean change corresponded to a 15% change. The results were not statistically significant (P>0.05) likely due to the large amount of variance in the results and the small sample size.

Razavi et al. [4] investigated a range of angles for an idealised coronary bifurcation using computational flow dynamics found that WSS values increased with angle at the outer, lower and upper boundaries of the bifurcation. Using these models in similar simulations are expected to reproduce these effects. Few studies have investigated the effect of curvature on haemodynamics. It is accepted that the vessel geometry has an effect on the flow field inside the vessel. Friedman et al. [3], suggested that the geometry of the vessel may have an effect on the likelihood of developing atherosclerosis, proposed the idea of ‘geometric risk factors’. We can see from these results that arm position clearly affects the curvature of the brachial artery, inferring that the haemodynamics of the vessel will change with arm position.

References

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