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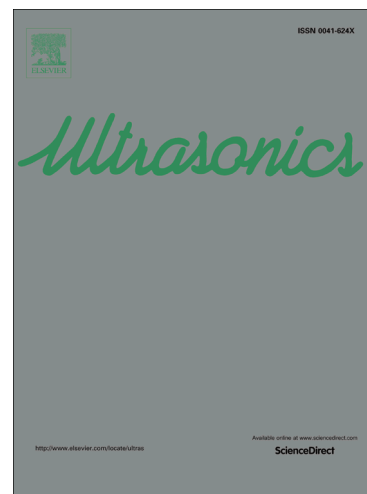
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# Vector Velocity Volume Flow Estimation: Sources of Error and Corrections Applied for Arteriovenous Fistulas

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## Abstract

A method for vector velocity volume flow estimation is presented, along with an investigation of its sources of error and correction of actual volume flow measurements. Volume flow errors are quantified theoretically by numerical modelling, through flow phantom measurements, and studied *in vivo*. This paper investigates errors from estimating volumetric flow using a commercial ultrasound scanner and the common assumptions made in the literature. The theoretical model shows, e.g. that volume flow is underestimated by 15%, when the scan plane is off-axis with the vessel center by 28% of the vessel radius. The error sources were also studied *in vivo* under realistic clinical conditions, and the theoretical results were applied for correcting the volume flow errors. Twenty dialysis patients with arteriovenous fistulas were scanned to obtain vector flow maps of fistulas. When fitting an ellipsis to cross-sectional scans of the fistulas, the major axis was on average 10.2 mm, which is 8.6% larger than the minor axis. The ultrasound beam was on average 1.5 mm from the vessel center, corresponding to 28% of the semi-major axis in an average fistula. Estimating volume flow with an elliptical, rather than circular, vessel area and correcting the ultrasound beam for being off-axis, gave a significant ( $p=0.008$ ) reduction in error from 31.2% to 24.3%. The

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