Ultrasound flow assessment in curved vessels

Citation for published version (APA):

Document status and date:
Published: 01/01/2006

Document Version:
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
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Download date: 24. Oct. 2019
Introduction
In clinical practice, ultrasound is often used as a non-invasive method to obtain local information on vessel walls and blood flow in vessels. Both flow and pressure waveforms can be assessed by ultrasound. Flow can be determined from measurements of the velocity profile and pressure can be assessed from distension waveforms and pulse wave velocity. Simultaneous measurement of flow and pressure waveforms enables the determination of global conditions of the vascular tree. Vessels can be slightly curved causing asymmetric velocity profiles (figure 1), which results in an inaccurate assessment of flow through the vessel.

Velocity estimation
Currently, velocity is determined by Doppler ultrasound. To enable simultaneous assessment of flow and wall motion by making use of a linear array ultrasound probe, positioned perpendicular to the vessel, a new algorithm is being developed. Blood flow velocity is determined by applying a 2d cross correlation algorithm to the raw ultrasound data (figure 3).

Aim
Estimate the 3d shape of a vessel from the asymmetry of velocity profiles over time, with the aid of analytic and/or numeric models. Together with the wall motion this knowledge will be used to derive the pressure distribution, flow velocity and wall shear rate in curved and tapered vessels from local properties that can be assessed using ultrasound.

Phantom setup
Ultrasound measurements are performed in a phantom setup. The phantom setup exists of a computer controlled pump which pumps fluid through a polyurethane tube terminated by a Windkessel model (figure 2). Small gas bubbles, created by electrolysis, are used as scatterers for the ultrasound. Flow and pressure are monitored simultaneously.

Computed modeling
A computational model will be used to relate the core velocity profiles measured by ultrasound to the total flow (figure 5).

Results and future work
Preliminary results using the cross correlation algorithm look promising but have to be evaluated in the phantom setup.