Towards a Non-Invasive Ultrasound Pressure Assessment in Large Arteries

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Aim

Recently a new Particle ultrasound Image Velocimetry (PuIV) technique (Fig.1.a) was validated allowing the estimation of velocity components perpendicular to the ultrasound beam [1]; and in combination with the cosθ-integration model [2], the accurate assessment of volume flow in both straight and curved vessels (Fig.1.b), simultaneously with the vessel’s diameter. In the current study, this technique is extended to a new method, which allows a precise and simultaneous estimation of both flow and pressure waveforms via a single non-invasive ultrasound measurement, validated in a phantom setup and allowing a comparison between the estimated and the reference pressure and flow waveforms.

Methods

In the experimental setup (Fig. 2) impulse and physiologically relevant pulsating flows were applied to a straight phantom vessel, employing a shear thinning Blood Mimicking Fluid (BMF) with both acoustical and rheological properties similar to blood’s. A commercially available ultrasound scanner was operated in fast B-mode, with the linear array probe parallel to vessel’s wall, hence, scanning perpendicularly to the axial velocity component.

Pulse Wave Velocity (PWV), for large Womersley numbers (Eq.1) in the vessel was estimated during a reflection free period, i.e. a linear section in the QA-loop of the cardiac cycle (the systolic foot) as the ratio between changes in flow Q and in cross sectional area A (Eq.3). PWV estimation was used to obtain pressure waveforms from the measured distention waveforms (Eq.4). Simultaneously, flow rate and local pressure were measured directly.

\[ c_s = \frac{A}{\sqrt{PC}} \]  
\[ Z_0 = \frac{dP}{dQ} = \sqrt{\frac{\rho}{AC}} \]  
\[ c_L = \frac{dQ}{dA} \]

Results

- QA-loops
- Flow rates and local Pressure estimation

Conclusion

A good agreement was found between the estimated and the reference waveforms. An accurate beat to beat pressure estimation could be obtained, indicating that a non-invasive ultrasound pressure assessment is feasible.

References