In vitro study of estimation of blood flow by laser technique

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Background and Aims

Failure of arterio-venous access is usually preceded by a decline of access blood flow (*Qa*). Our research aims to explore laser vibrometry as a means to measure non-invasively and contact-free *Qa*. We developed an *in-vitro* model to simulate a dialysis access circuit to evaluate whether changes in *Qa* can be assessed accurately using a laser vibrometer.

Methods

Qa was provided by a commercially available pump which delivers flow patterns comparable to arterial flow (Model 1423, Harvard Apparatus. Holliston, MA, USA). We set *Qa* by changing the stroke volume of the pump in 10 equal increments between 15 mL to 60 mL; the pump stroke rate was kept constant at 50/min, resulting in a *Qa* between 750 and 3000 mL/min. A hemodialysis blood tube was used to provide a closed circuit (Fig.1). A portable class II HeNe laser vibrometer (PDV 100,Polytec, GmbH Germany) was used to assess flow-induced tube movements with a velocity resolution of less than 0.05 µm/s (1 experiment per flow rate), each 0.004 seconds.

One series of measurements took 20 seconds per Qa step. Data were analyzed with proprietary Polytec software. The readout of the laser vibrometer was velocity of displacement (in mm/s).

Peak displacement velocity was the average of maximum velocity of displacement per cycle during 20 seconds of measurement.

Nonlinear regression analysis was used to model the relationship between the tube peak displacement velocity and *Qa*.

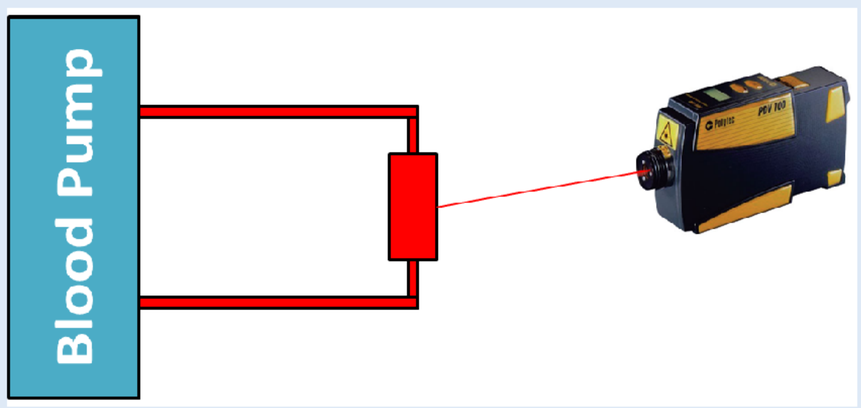

Figure 1. Circuit setup

Results

Figure 2 shows a representative example of the displacement velocity time series obtained during experiment (in this case, *Qa*=1500ml/min). The relationship between the peak displacement velocity and *Qa are shown in Figure 3.* The increase in peak velocity flattened out towards higher fluid flow rates, caused by the tubing's limited capacity for distension.

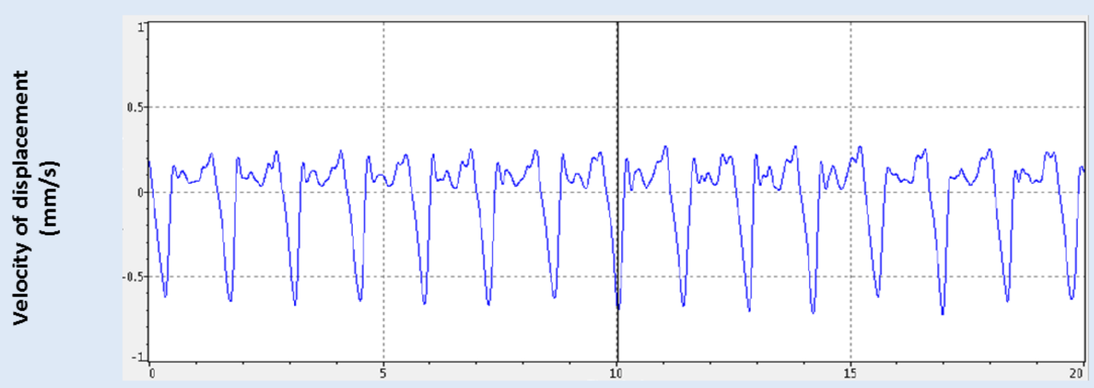

Figure 2. Velocity of displacement changes detected by laser vibrometer.

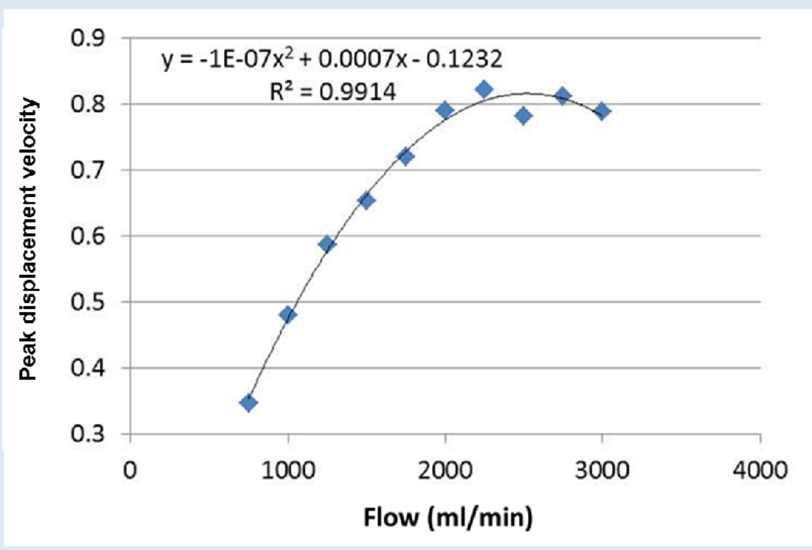

Figure 3. Correlation between peak displacement velocity and blood flow rate.

Conclusion

This in vitro proof of concept study indicates that changes in “access” *Qa* and tube (“access”) oscillation detected by laser vibrometry are linearly correlated over a wide range, in particular in the very range of greatest clinical interest. These in vitro data need clinical validation.

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