In-vitro assessment of coronary flow using the PressureWire® as a hot film anemometer

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A. van der Horst, M.C.F. Geven, M.C.M. Rutten, F.N. van de Vosse
Eindhoven University of Technology, Department of Biomedical Engineering

Introduction

To assess the physiological significance of coronary artery disease (CAD) and distinguish between epicardial and microvascular disease (Fig. 1) simultaneous measurement of intracoronary pressure and flow is required [1,2].

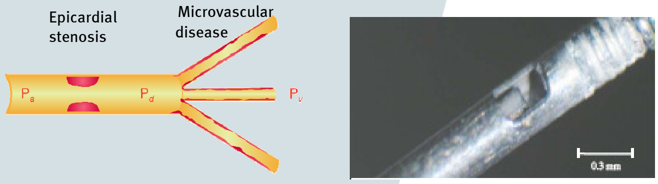

Figure 1 Left: schematic representation of epicardial and microvascular coronary disease. Right: the guidewire mounted pressure sensor of the Radi PressureWire.

Objective

The objective of this study is to enable flow measurement by adapting a commercially available pressure-sensing guidewire, the Radi PressureWire (right side of Fig. 1), so it can function as a constant temperature hot film anemometer. This will enable assessment of intracoronary pressure and flow using a single guidewire.

Material and Methods

Hot film anemometry

A small temperature sensitive resistor, which is part of the PressureWire, is electrically heated to a constant temperature. The amount of heat transferred to the surrouding fluid is influenced by the local flow rate. Therefore, the power (P) needed to keep the resistor at a constant temperature is a measure for the flow (Q). The relationship between power and flow is characterized by a power law model [3]:

$$P = P_0 + P_1\left[\frac{Q}{Q_0}\right]^n , \qquad (1)$$

where the parameters P_0, P_1, Q_0 and n depend on the geometry of the sensor, temperature and the flow signal.

Experimental set-up

The PressureWire is tested in an open loop circulation inside a temperature controlled water bath (Fig. 2). The flow through the circulation is controlled by a piston pump and measured by the PressureWire and a reference flow meter.

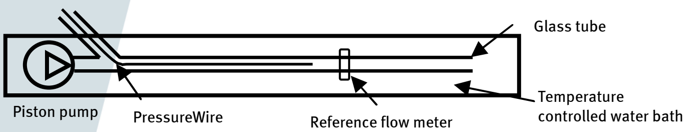

Figure 2 Schematic representation of the set-up used to test the PressureWire as a flow meter.

Results

Mean flow assessment

The left side of Figure 3 shows the relationship between mean power and mean flow for an overheat of 20 K. It is represented as the standard deviation of five measurements. A curve is fitted using a power law model. Using this curve the flow is calculated and presented with a Bland-Altman plot (right side of Fig. 3).

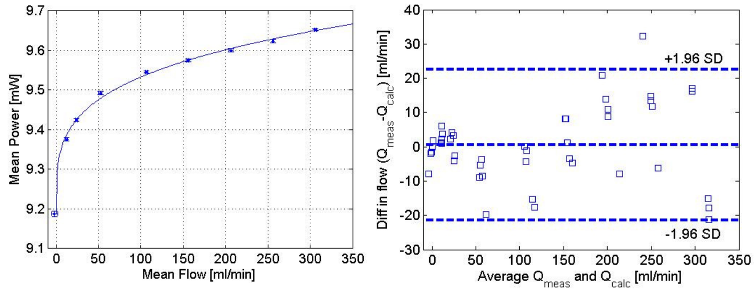

Figure 3 Left: Mean power - mean flow relationship for an overheat of 20 K. Right: Bland-Altman representation of measured flow and flow calculated with the fitted calibration curve.

Dynamic flow assessment

Figure 4 shows that a flow signal, similar to a coronary flow, can be tracked in time.

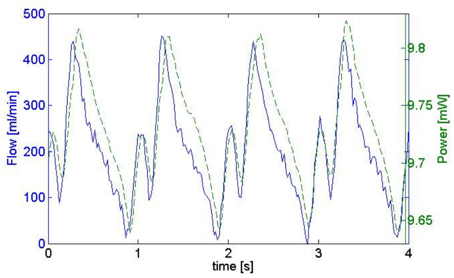

Figure 4 The reference flow (-, blue) and measured electric power (--, green) in time.

Conclusions

Reproducible calibration curves for mean flow measurement could be obtained for an overheat of 20 K. The relationship between power and flow could be described with a power law model. This method is promising for the assessment of both pressure and flow using a single guidewire. Furthermore, since the phasic pattern of the flow can be measured, this sensor might even be suitable for the search for new parameters, indicating CAD, based on dynamic pressure and flow .

References:

[1] W.H. Aarnoudse, PhD thesis, Eindhoven, 2006.
[2] M.C.F. Geven, PhD thesis, Eindhoven, 2007.
[3] H.H. Bruun. *Meas. Sci. Technol.* 7:1301-1312, 1996.