Technical Note

Pulsatility Index (PI) Examined

Why?

Pulsatility Index (PI) is one of the available metrics in flow-based intraoperative CABG patency assessment. It quantifies the pulsatility of the flow waveform with respect to the mean flow rate:

$$PI = \frac{\text{maximum flow rate - minimum flow rate}}{\text{mean flow rate}}$$

A high PI may be indicative of a critically occuded graft. Understanding the physical and physiological background of PI is essential for medical professionals to interpret measurement results and make informed decisions during the CABG procedure.

How?

If a graft is critically occluded, for example, by a misplaced stitch in the distal anastomosis, little to no blood can pass through it. Blood is still pushed into the graft by the high pressure during systole, but this mostly causes the graft to "inflate." During diastole, when pressure falls, the graft "deflates," and blood flows back toward the aorta.

A flow probe placed on a graft some distance upstream of an occlusion will register this proccess of inflation and deflation as a so-called purely capacitive flow waveform (Figure 1), with a positive peak in systole, a negative peak in diastole, and low, perhaps even zero, mean flow rate. This combination results in a high value of PI in a severely occluded graft.

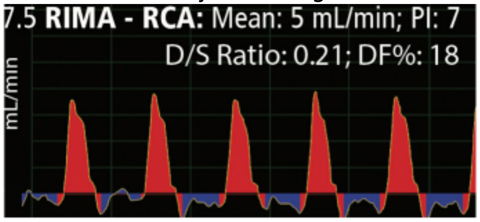

Figure 1: Stenotic flow waveform example in RIMA-RCA; flow is almost purely capacitive, with mostly antegrade flow in systole, mostly retrograde flow in diastole, and very low mean flow rate. As a result PI is high.

What?

Users may see a difference between PI values displayed on Transonic and Medistim flow monitors. This is mostly caused by differences in how the computation of PI is implemented. Medistim computes PI based on a 2-second signal interval filtered at 20 Hz, whereas Transonic uses an 8-second interval as soon as this is available, updates the displayed value every second, and uses 10 Hz filtering. These design choices may in some cases lead to differences, with a lower filtering frequency tending to decrease PI, and a longer signal section tending to increase PI.

Apart from this, PI is influenced by a number of other factors that are also not necessarily related to graft quality. The most important of these are the position of the flow probe on the graft and the presence of retrograde flow (Figure 2). Finally, PI tends to identify only a severe occlusion, leaving subcritical stenosis unnoticed.

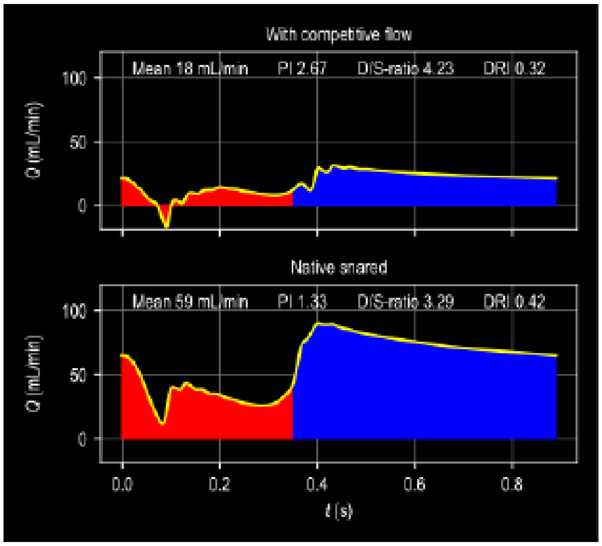

Figure 2: Example of competitive flow in a LITA-LAD graft, resulting in increased PI (top). Snaring the native coronary blocks competitive flow, and improves the graft flow waveform, with higher mean flow rate, and lower PI.

Conclusion

Transonic recommends a holistic approach to evaluating graft flow, considering mean flow rate as the primary indicator of graft quality. When mean flow rate is not decisive, additional metrics, such as D/S-ratio, DF%, or PI, may be used to obtain a more complete picture.

Understanding the physical and physiological aspects of PI and the influence of algorithm design choices by medical device manufacturers facilitates interpretation and decision making. The information presented in this Technical Note should clarify these aspects and give the user confidence in the correct use of PI.

References:

1 Jelenc M, *et al,* Understanding coronary artery bypass transit time flow curves: role of bypass graft compliance. Interact Cardiovasc Thorac Surg. 2014 Feb;18(2):164-8.

2 Nordgaard HB, *et al,* Pulsatility index variations using two different transit-time flowmeters in coronary artery bypass surgery. Eur J Cardiothorac Surg. 2010; 37(5):1063-7.

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