Technical Note

Pulsatility Index (PI) Is Not A Reliable Sole Indicator of Graft Patency

Intraoperative Flow Measurements during CABG Surgery

Intraoperative flow measurements during Coronary Artery Bypass Grafting (CABG) surgery help surgeons detect technical problems at the time of surgery when correction is immediately available.

Transonic champions Absolute Mean Flow (>30 mL/min; 20 mL/min in smaller patients) as the primary indicator of bypass graft patency. In cases of questionable flows between 5 mL/min and 20 mL/min, additional waveform analysis is advised. Calculation of a Pulsatility Index (PI) can then be used to substantiate a poor graft after assessment of a graft’s mean flow and waveform profiles. A poor flow value (under 5 mL/min) combined with a poor graft profile and an abnormal Pulsatility Index may indicate that a bypass graft is in trouble.

Pulsatility Index was first presented by D’Ancona et al in 20001,2 as a simple patency assessment calculation. It represents a single number that increases in value as the flow resistance in the distal anastomosis of the bypass graft increases. Pulsatility Index is calculated as the difference between the maximum flow and the minimum flow divided by the mean value.

Although a PI between 1 and 5 has been widely used by Medistim to indicate acceptable bypass graft flows, Transonic has not adopted PI as a major indicator of graft patency because it produces, in some instances, both false positives and false negative results. A false positive (PIs > 5 or < 1) suggests to a surgeon that a graft needs revision; a false negative (PIs between 1 and 5) could give the surgeon a false sense of security with a problematic bypass graft.

This Technical Note that revisits Pulsatility Index presents:
1. Case examples (page 2) where spiky turbulent waveform profiles can result in false positives (PIs > 5; < 1);
2. Cases (page 3) where PIs are in the acceptable range, but still the mean flow and flow waveforms of the grafts are poor creating false negatives (page 3);
3. Why the differing styles of Medistim and Transonic flow probes produce different waveforms (page 4).
4. A Reference List of publications for Pulsatility Index.
Best Practices

Poor Waveform Quality Can Cause False Positive PIs

The case examples below illustrate differences in waveform quality between the Medistim and Transonic systems. The spiky Medistim waveforms (top) can produce questionably high PIs, giving a false positive, that would suggest to the surgeon that the graft should be revised. On the other hand, the clean lower Transonic waveforms (bottom) for the same graft produce lower PIs. This “true” PI, when combined with the mean flow and good diastolic profile, indicates that graft is patent and doesn’t need revision.

SVG-PDA False Positive Case Examples

Both these examples illustrate the differences between Medistim’s calculation of a Pulsatility Index and Transonic’s calculation of the same index from their respective waveform profiles.

The spikiness of a Medistim waveform creates misleading high and low points, affecting the area under the curve, which can alter the mean flow dramatically and create a false positive index of over 5 as shown in both these examples. The Transonic PIs are 3.5 and 2.9 respectively, well within the 1-5 range of acceptable PIs for graft patency.

Additional False Positive Case Examples

SVG-OM Case Example

For this SVG-OM bypass, the Medistim waveform trace (at the top left) exhibits sharp spikes or motion artifacts caused by the flowprobe’s constrictive design. Such a design alters the waveform profile, and may give rise to high PI as it has in this case.

In the RIMA-RCA traces on the right, the Transonic flowprobe picks up a very repeatable flow signal (bottom trace), while motion artifacts in the Medistim trace results in a higher (5.3) false positive PI.

Arterial Case Example

Waveforms courtesy of Robert Poston, MD, Walter Wakwe, BS, Univ. MD, Division of Cardiac Surgery
In CABG Surgery

False Negative PIs Can Also Be Misleading

Even though the PI of the a LIMA-LAD graft was 3.8 the waveform had a spiky systolic profile. Mean flow measured 8.8 mL/min. Following revision of the graft, flow increased to 60 mL/min (PI: 0.8) and was accompanied by a diastolic dominant waveform profile (bottom waveform).

Even though the PI of a LIMA-LAD graft was 3.4, its waveform (top) had a damped profile and an atypical diastolization. Flow measured only 5.2 mL/min flow. The poor mean flow supported the surgeon’s decision to revise the LIMA-LAD graft. Flow improved dramatically after revision and the waveform exhibited a classic LIMA-LAD profile (bottom waveform).

Mean flow should always be the primary indicator of anastomotic patency, not the PI.

Why Medistim & Transonic Flow Waveforms Differ?

Constrictive Versus Non-constrictive Flowprobes

Two styles of Flowprobes are illustrated by the pictures on the right. A 4mm Transonic flowprobe, pictured on the left, illustrates a probe with a J-style reflector that creates the iconic Transonic non-constrictive sensing window of the flowprobe. It is recommended that a vessel or bypass graft fill between 75-100% of the sensing window of the flowprobe. To measure flow, the probe is simply slipped around the vessel with couplant gel and flow is measured without compressing the vessel within the sensing window.

Medistim Flowprobes in the pictures, on the right side, illustrate a flat face with an L-style reflector that fits snugly around the vessel or bypass graft. This snug or tight fit results in motion artifacts that cause spiky flow profiles resulting in misleading PIs. Compression of the vessel or graft under study also causes turbulence and constriction that can alter the waveform as well as the amount of flow being measured.
REFERENCES


