
VII. Frequently Asked Questions



1. *I'm reading a low graft flow. How do I know that this is accurate, and not a problem in the meter?*

With FlowSound turned on, occlude the graft approximately 1 cm below the flowprobe with thumb and index finger. By occluding and releasing your fingers, you can now “pump” the graft to send flow back and forth through the probe. The high-pitched FlowSound you hear indicates that the probe is measuring flow — when there is flow.

2. *I am used to palpating the graft. What advantage is there to measuring flow?*

Palpation gives a qualitative indication of the presence of a pulse, but does not detect an occlusion downstream from the point of palpation (i.e., the distal anastomosis). Some surgeons have developed a “feel” for flow by occluding the graft partially: the thrill of turbulence provides a sense that something is passing through the graft. Flow measurement provides a unique intraoperative opportunity to “look inside” the graft and make a quantitative, not qualitative, assessment of graft patency. The best testimony for measuring flow in intraoperatively comes from the pioneers of beating heart surgery: these surgeons with ample case experience continue to rely on intraoperative flow measurement to test the quality of their work.

3. *Are there any studies demonstrating better long-term outcomes when graft flows are measured routinely?*

The goal of CABG surgery is to produce positive outcomes for the patient: non-functional grafts will sabotage this goal. Many studies report that intraoperative flow measurement can indeed detect technical error¹⁻⁴; this flow-based intraoperative patency was confirmed 100% by post-op angiography and/or Doppler^{5,6}.

¹Canver et al., Ann Thorac Surg 1994

²Canver et al., J. Cardiovasc Surg 1997

³D'Ancona et al, Futura Publ, Armonk, NY 2001

⁴Mindich et al, NY Thorac Soc 2001 (p. A5)

⁵Zenati et al, J Thorac Cardiovasc Surg 1998

⁶Boyd et al, Ann Thorac Surg 1999

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3. *Studies? cont.*

Intraoperative graft patency assessment serves a short-term purpose of helping the surgeon accomplish his immediate goals: the construction of patent grafts. Long-term outcomes are determined by many more factors than just graft patency at the end of surgery. Jaber et al reported that intraoperative graft flow assessment can only detect stenoses over 75%¹; grafts constructed with partial stenosis not detectable with intraoperative flow measurement have a likely influence on long-term outcomes as well.

4. *Should I bother fixing one graft if all the others are working OK?*

If it was worth taking your time to construct this graft, then it is also worth taking the time to make sure the graft is patent. Patients have better prognosis for full recovery if all the grafts are patent.

5. *How often does following the Flow-QC protocol detect a technical error?*

Early proponents of intraoperative flow measurement during beating heart surgery have reported technical problems in 13.2%.² With experience, this percentage reduces to 5%.^{3,4} Similar rates have been reported for technical errors in on-pump cases. To put this percentage in perspective: at 3.2 grafts per patient, a 5% technical error rate would mean that one in six patients would leave the OR with a correctable graft problem that may well create a complication during patient recovery.

6. *The mean flow table on p. 21 lists only a small sampling of all coronary graft possibilities. Are there mean flow rules for other grafts?*

Although we have not analyzed a sufficiently large number of reported flows in other grafts to yield a statistically significant number, the picture that begins to emerge is the following: for most grafts, flow over 30 ml/min indicates acceptable patency. For small patients or small target vessels, this number can be reduced to 20 ml/min. For very large coronary arteries, such as the CX, the acceptable flow margin is higher (50 ml/min).

¹Jaber et al, Ann Thorac Surg 1998

²Possati et al, J. Thorac Cardiovasc Surg 1998

³D'Ancona et al, Heart Surgery Forum 2000

⁴Mindich et al, NY Thorac Soc 2001 (Appendix C)

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7. *What if mean graft flows are lower because of small target vessel or poor runoff?*

Even if flow is low, you will still have a good flow waveform in a patent graft.

8. *How do you explain a strong flow waveform but mean zero flow?*

A highly pulsatile waveform but near-zero mean flow indicates an occlusion near the distal anastomosis. In this instance, flow pulsates forward through the flowprobe during systole and backward during diastole as the graft segment between the flowprobe and the distal anastomosis expands and contracts during the cardiac cycle (see Charge Flow, p.4-5). Transonic FlowSound has the same pitch for forward and reverse flow, but between strong flow peaks one can hear flow going down to zero. Mean flow is the primary determinant for graft patency in the Transonic Flow-QC protocol. Zero mean flow indicates a technical error. In this case, the high pulsatility of flow indicates an obstruction downstream of the probe rather than upstream.

9. *I see a good (over 30 ml/min) graft flow without proximal occlusion of the native coronary. Should I still occlude the native coronary to measure without potential competitive flow?*

With the 30 ml/min mean flow reading, this graft passes the primary Flow-QC patency test; a higher flow reading with competitive flow occluded will not alter surgical course. One could, therefore, proceed without a measurement while occluding the native coronary artery. Nevertheless, it is good practice to take this measurement as a matter of course: this will avoid searching for causes of low flow in other grafts when an occluded measurement is overlooked.

10. *I've heard that you only need to check for Pulsatility Index > 5 to determine graft patency. Why should I also do mean flow and waveform analysis?*

PI combines mean flow and waveform properties into one number; however, the PI does not tell the complete story for each and every graft in each and every condition. For instance, competitive flow will reduce mean flow and increase pulsatility. A blind reliance on PI could yield false positives (see bottom example, Fig. 3-13) and unnecessary corrective procedures. A proximal stenosis or a partial distal stenosis (see Case Study VI-A) may greatly reduce pulsatility and mean flow. In these instances, sole reliance on PI would now yield a false negative and obscure a correctable technical error.

VII. Frequently Asked Questions *cont.*

10. Pulsatility Index? cont.

In the presented Flow-QC protocol, mean flow is considered first, and flow waveform analysis second (if needed). This analysis reveals all conditions where mean flow is low and pulsatility is high, plus other indications of technical error. Once you are comfortable with mean flow and waveform analysis, review of PI may be omitted.

11. When I move the flowprobe from one location on the graft to another, my readings vary. How is this possible?

Indeed, if flow through one portion of a conduit is 50 ml/min, it is 50 ml/min at other places of the same flow conduit until a branch or leak is encountered. The observed variability in flow measurements comes from the measurement accuracy of the flowprobes. A 10% variability (e.g., 45 ml/min on one site, 55ml/min on another in the above example) while using correct techniques is not unusual. Such variations will not alter the systolic/diastolic profile. Factors that may increase the measurement error are: improper probe size, misalignment of the vessel, air bubbles, clips or adipose tissue within the ultrasound window. Application of a flowprobe, too small for the vessel being measured, produces errors in mean flow and flow waveform (see p. 20-21).

12. Will flow measurement detect an air bubble in a vein graft or in the distal vessel?

If the probe is placed over an air bubble, it will not measure flow and indicate "NO SIGNAL" on the Transonic flowmeter display for air obstructs ultrasound transmission. Air bubbles elsewhere, as do stenoses, reduce mean flow and produce abnormal flow patterns. If such measurements are unacceptable, they will be spotted in the standard Flow-QC protocol.

13. How do you know the direction of graft flow?

Measuring graft flow does not reveal the direction of flow inside the native coronary artery. This is not an issue if the distal anastomosis is placed downstream from the coronary stenosis. Under these conditions, graft flow can only flow towards the distal myocardium. If a question exists in a mid-vessel anastomosis, occlude proximally, then distally, and measure both flows. The ratio between these two readings establishes the distribution of graft flow.