Flow-assisted Surgical Techniques and Notes* Coronary Artery Bypass Grafting Protocol

*Flow-Assisted Surgical Techniques ("F•A•S•T") and Protocols are a summation of documented surgical experiences by transit-time flow measurement users that are being passed along by Transonic for educational purposes. They are not intended to be used as sole basis for diagnosis. Clinical interpretation of each patient's individual case is required.

Measurement results are technique dependent.[1,2]

1. If using an internal mammary artery graft, skeletonize a 1.5 cm segment of its distal end before performing the anastomosis. Vein grafts require no additional preparation.[1,2]
2. Select a Flowprobe sized so that the graft will fill at least 75% of the window of the Flowprobe. Take care not to undersize the probe for the graft. [1,2]
3. Apply ultrasound couplant into the window of the Flowprobe. [1,2]
4. Turn on FlowSound®. A low-pitch zero flow sound ("hum") indicates that the Probe is properly connected to the Flowmeter, and that there is adequate ultrasound signal coupling for a measurement.
6. Place the Flowprobe on the graft, bending its flexible neck as needed for perpendicular placement. Avoid stretching, compressing, or kinking the graft. Do not place the Flowprobe over surgical clips or sutures. The ultrasound's signal quality is indicated on the Monitor or the Flowmeter's front panel display. [1,2]
7. Observe the contraction of the heart while listening to FlowSound. Listen for a strong diastolic flow component. [1,2]
8. Note, after 10 seconds, the average (mean) flow displayed on the Flowmeter screen or the front panel of the Flowmeter. [1,2]
9. Occlude the native coronary artery and note any changes in the pitch and pattern of FlowSound. An increase in FlowSound pitch (i.e. mean flow) indicates the presence of competitive flow. If no competitive flow is observed, the occlusion may be released. [1,2]
10. When flow has stabilized in 10 to 15 seconds, press PRINT on the Flowmeter to record the next 8 seconds of flow, or tap SNAPSHOT or RECORD on AureFlo to document the previous 8 seconds of flow. Hold the probe steady on the graft until printing is completed. [1,2]

Pictured, from left to right, are 1.5 mm, 2 mm, 3 mm and 4 mm coronary Flowprobes showing their blue Probe bodies, J-style reflectors and ultrasonic sensing windows.

FMC-Series Coronary Handle Flowprobes are available in sizes 1.5 mm to 4 mm. They feature a J-style reflector, designed for spot flow checks of coronary artery bypass grafts and an extended neck with a flexible end to reach coronary grafts even behind the heart.

References:
1 Measuring PeriFlowprobe(CV-180-mn)RevA2018USltr
2 AU-QRG-Optima-EN Rev E
3 CABG Graft Patency Assessment Handbook (CV-50-hb) Rev B, 2014
4 Mindich BP *et al,* "Reduction of Technical Graft Problems Utilizing Ultrasonic Flow Measurements," NY Thoracic Society, 2001.

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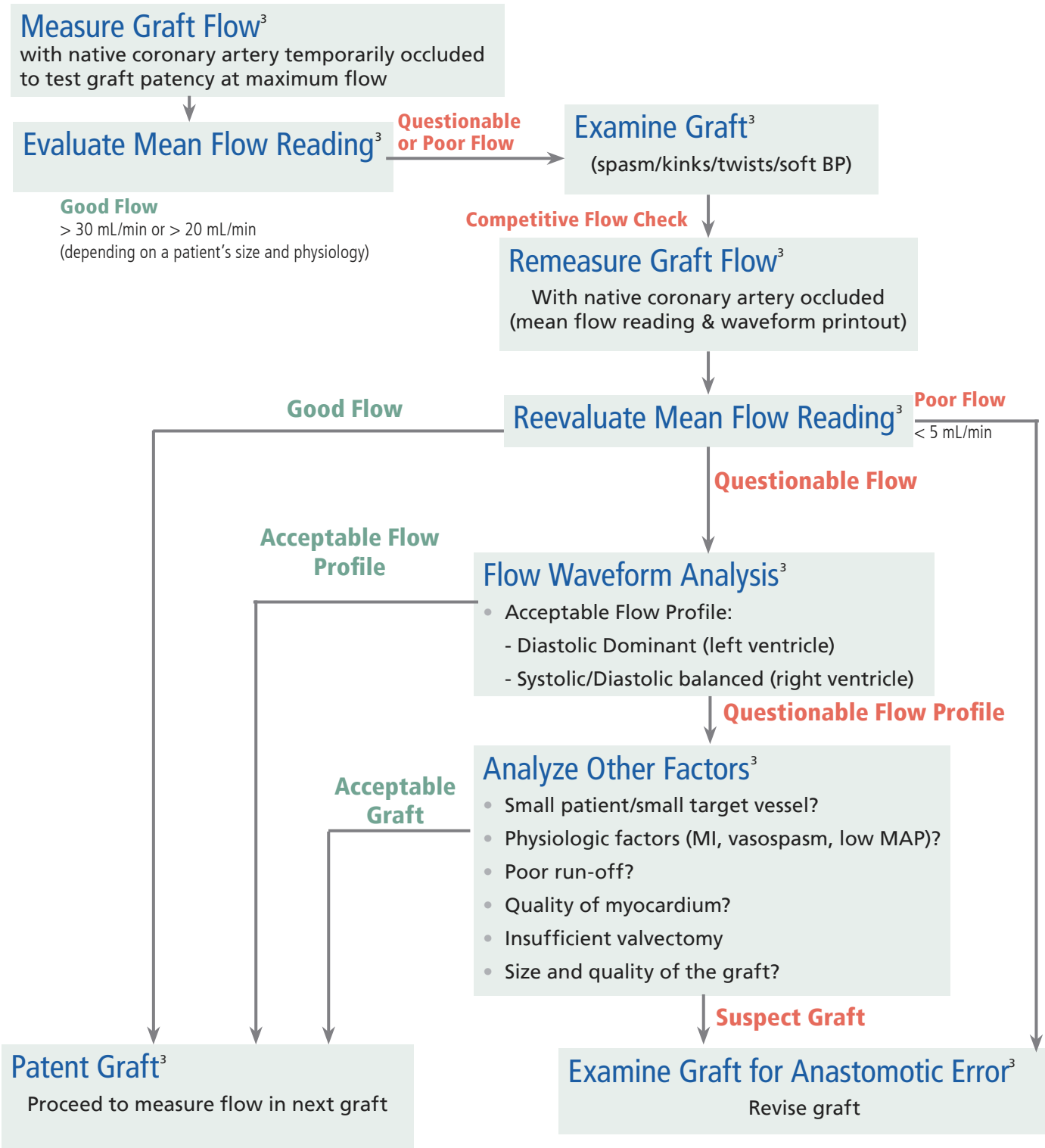

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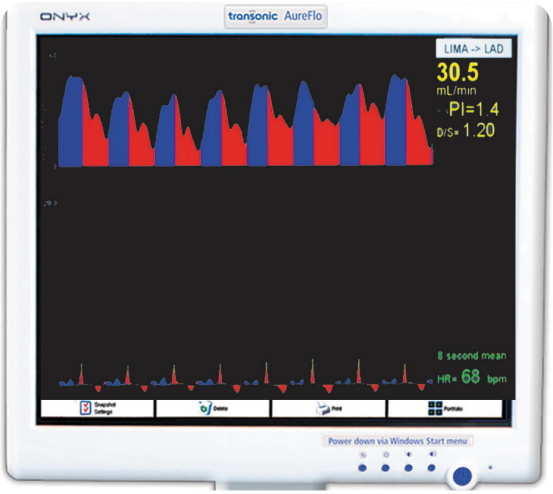
Mean Flow Assessment Is Primary[3]

Transonic's CABG Flow Assessment Protocol is based, first and foremost, on mean graft flow. It is the primary consideration to confirm graft patency or to alert the surgeon to an undesirable condition.

Mean Flow Assessment Rules of Thumb are:

1. Mean Flow ≥ 30 mL/min (small patients, >20 mL/min) = Patent Graft: If mean flow is less than expected, first consider the presence of competitive flow.
2. Mean Flow < 5 mL/min = Graft in Trouble
3. Medium Range Mean Flows (5 mL/min - 30 (20) mL/min): Analyze Graft Flow Waveforms, by D/S Ratio or DF% and PI.

(Detailed measurement steps follow.)



AureFlo® single-channel display of recorded LIMA-LAD volume flow waveform (systolic flow volume in red; diastolic in blue). Also displayed are mean flow in mL/min, pulsatility index (PI), D/S Ratio and ECG tracing.

Measuring Graft Flow[1,2]

Accurate measurements are technique dependent

- Select a Flowprobe sized so that the graft will fill at least 75% of the window of the Probe without compressing the graft.
- Fill Probe window with ultrasound gel.
- Position Probe on graft (not over metal clips or fascia).
- Occlude native coronary artery in order to assess graft at maximum graft flow.
- On AureFlo®, take snapshot or record when flow reading is stable (10-15 seconds).
- On Optima Flowmeter, press Print when flow reading is stable (10-15 seconds).

When Does Mean Flow Confirm Graft Patency?[3]

Flows greater than 20mL/min for a small patient and 30 mL/min for a normal sized patient indicate a good graft. However, mean graft flow can vary over a wide range. It is influenced by, and should be evaluated with respect to:

- The size and quality of the graft;
- The size and quality of the target vessel;
- Mean arterial pressure (MAP);
- State of disease in the myocardial run-off.

If mean flow is lower than expected, the presence of competitive flow must be considered first.

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When Do Mean Flows Not Confirm Graft Patency?[3]

Flows below 5 mL/min indicate a problem graft that demands further investigation. When flows are questionable (between 5 mL/min and 20 mL/min to 30 mL/min depending on a patient's size, examine waveforms.

1. Flows < 5 mL/min, Suspect Graft Patency[3]

- With Probe on the graft, turn on FlowSound® and listen for the change in pitch (flow) as the vessel around the anastomosis is manipulated.
- Look for kinks/twists in the graft, low MAP, flow with diminished pulsatility (dampened waveform).
- Redo anastomosis if technical error is indicated.

2. Questionable Flows: Analyze Waveforms[3]

If flow values fall in the medium range (more than 5 mL/min but less than 20-30 mL/min), flow waveform analysis of systolic/diastolic waveform properties can shed light on a possible problem. Waveforms should be first examined to see if they exhibit a repetitive flow pattern characteristic for the ventricle it is supplying (left ventricle: diastolic dominant pattern; right ventricle: systolic/diastolic balanced waveform.

Consider Other Factors: PI, D/S (or DF%) When Mean Flow Is Inadequate

D/S Ratio and DF%

Transonic Surgical Flowmeters can use ECG or pressure signals to analyze and display D/S Ratio (or DF%) to represent the amount of blood flow passing through a bypass graft. A D/S Ratio (or DF%) compares diastolic flow to systolic flow

- D/S Ratio >2 (or DF%, 67%): acceptable diastolic-dominant profile;
- D/S Ratio between 1 and 2 (or DF between 50% and 67%): indicates a diastolic-systolic balanced profile (acceptable for a right heart bypass).
- D/S Ratio <1 (or DF%, <50%): a systolic dominant flow profile which signals the need for further examination of the graft.

Is Pulsatility Index (PI) between 1 & 5?[3]

A PI greater than 5 has been associated with low mean flow and systolic-dominant flow pattern indicating that the graft should be reexamined.

Diastolic-Dominant Pattern (L-Heart Grafts)

For grafts to the left ventricle, the shorter waveform peak is usually systolic, and the higher, broader peak is diastolic (Fig. 1) except in the presence of severe tachycardia where diastole is shortened. An acceptable left ventricular waveform is "diastolic dominant" where the delivered diastolic blood volume (i.e., area under diastolic curve) exceeds delivered systolic blood volume.

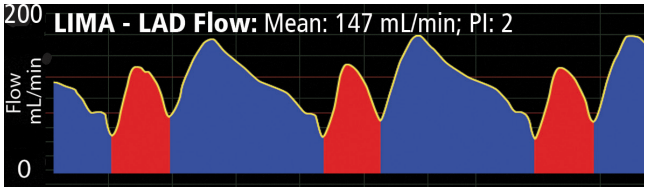

Fig. 1: LIMA-LAD: mean = 147 mL/min; diastolic dominant; PI =2.

Balanced Systolic/Diastolic Pattern (R-Heart Grafts)

In grafts to the right ventricle, flow is more equally distributed between the systolic and diastolic phases. This produces a flow waveform where the systolic peak may dominate but is followed by a proportionally strong diastolic flow producing a systolic/diastolic balanced waveform (Fig. 2).

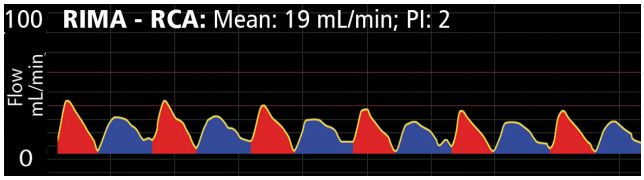

Fig. 2: RIMA - RCA: mean is 19 mL/min. systolic/diastolic balanced; PI=2

Stenotic Pattern

In stenotic grafts, the systolic phase dominates the flow profile and is associated with low or zero mean flow. Often, systolic charge flow runs backwards as a negative flow during diastole.

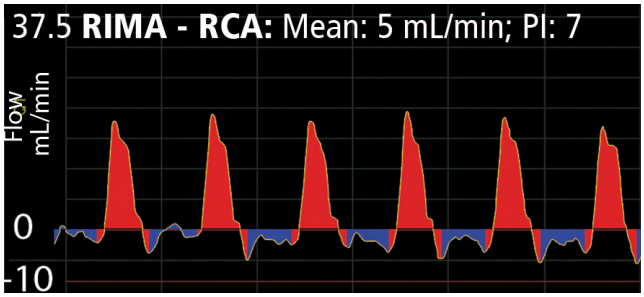

Fig. 3: The RIMA - RCA graft illustrates a graft with a stenotic flow profile. The flow waveform dips below zero which indicates the presence of competitive flow.