Reduce Early Graft Failure Following CABG Surgery

Accurate Flow Measurements Help You Identify and Repair Flow Restrictions to Assure Graft Patency Prior to Closure

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Coronary Flowprobes take the guesswork out of knowing bypass flow

Transonic® Cardiovascular Flowprobes work with the Transonic® Optima Flowmeter to measure volume flow in vessels or grafts from 1.3 - 36 mm diameter. The non-constrictive perivascular Flowprobes use transit-time ultrasound technology to measure volume blood flow directly, quickly and easily, even in the low-flow range.

The surgeon now has a quantitative tool with which to objectively assess the quality of the anastomosis. Unseen blood flow obstructions can be detected intraoperatively and repaired before closing the patient. This ability to correct otherwise undetectable flow restrictions gives the surgeon with a unique opportunity to improve patient outcomes.

European Revascularization Guidelines

"Graft flow measurement, related to graft type, vessel size, degree of stenosis, quality of anastomosis, and outflow area, is useful at the end of surgery. Flow <20 mL/min and pulsatility index >5 predict technically inadequate grafts, mandating graft revision before leaving the operating theatre."[1]

1 The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) "Guidelines on Myocardial Revascularization," Eur J CardiothoracSurg 2010; 38, S1 S52

"...TTFM predicts graft failure within six months after CABG."
Jokinen et al,"Clinical value of intra-operative transit-time flow measurement for coronary artery bypass grafting: a prospective angiography-controlled study", Eur J Cardiothorac Surg 2011;39(6):918-23.

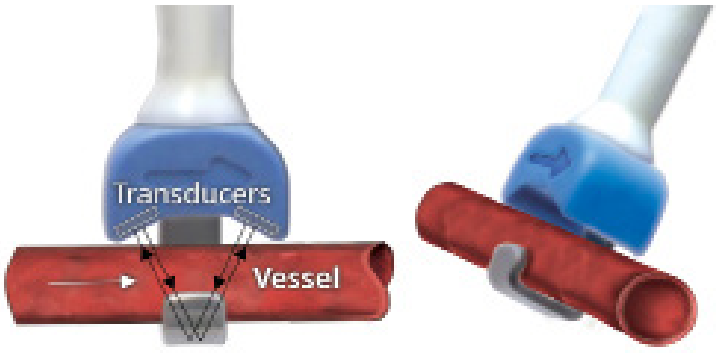
"TTFM is a reliable method to verify intraoperative graft patency."
Di Giammarco et al, "Can transit-time flow measurement improve graft patency and clinical outcome in patients undergoing coronary artery bypass grafting?" Interact Cardiovasc Thorac Surg 2010; 11(5): 635-40.

"Routinely, the use of TTFD significantly reduced the incidence of post operative VFib, post-operative CK/CK-MB fraction and angiographically detected bypass malfunction." *Bauer SF et al, "Intraoperative bypass flow measurement reduces the incidence of postoperative ventricular fibrillation and myocardial markers after coronary revascularisation," Thorac Cardiovasc Surg 2005; 53(4): 217-22.*

"The intraoperative use of flow measurements provide invaluable information in a timely, accurate, cost-effective manner allowing for the surgical correction of a surgical problem. This has signficantly reduced the complication related to early technically induced graft failure." *Mindich B, MD*

TRANSIT-TIME ULTRASOUND TECHNOLOGY

MEASURES VOLUME FLOW, NOT VELOCITY



Two transducers pass ultrasonic signals, alternately intersecting the vessel in upstream and downstream directions. The difference between the two transit times yields a measure of volume flow.

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Flow-based Patency Assurance: Illustrative CABG Case Reports

"The intraoperative use of flow measurements provides invaluable information in a timely, accurate, cost-effective manner allowing for the surgical correction of a surgical problem. This has significantly reduced the complications related to early technically induced graft failure ... and provides documentation of the *sine qua non* of the operation: patency."

Mindich BP et al, "Reduction of Technical Graft Problems Utilizing Ultrasonic Flow Measurements," NY Thoracic Society, 2001.

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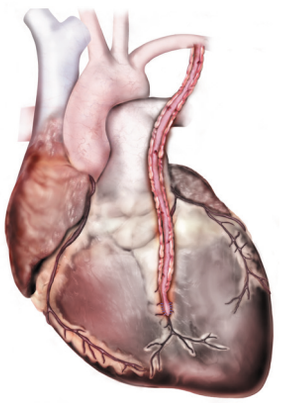
CardiacCaseStudies(CV-160-fly) RevB 2018 A4

Intraoperative Flow Measurements F

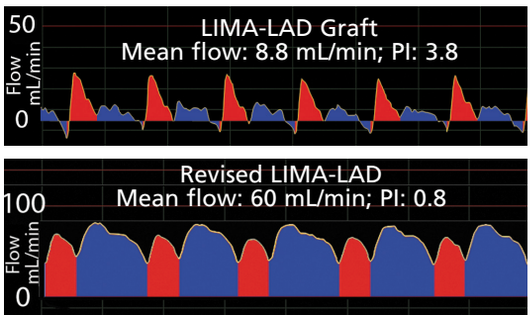
Two LIMA-LAD Cases Demonstrate that PIs <5 Can Be Misleading; Acceptable Mean Flow Is Key



These two cases demonstrate that a PI < 5 doesn't always mean that the graft has good flow. Acceptable mean flow is critical for graft patency assurance and decision making.

A 76-year-old male patient underwent coronary artery bypass grafting (CABG) surgery to bypass a lesion in the left anterior descending (LAD) artery utilizing a left internal mammary artery (LIMA) graft. Initial LIMA-LAD mean flow measured 8.8 mL/min (PI: 3.8) (top waveform).

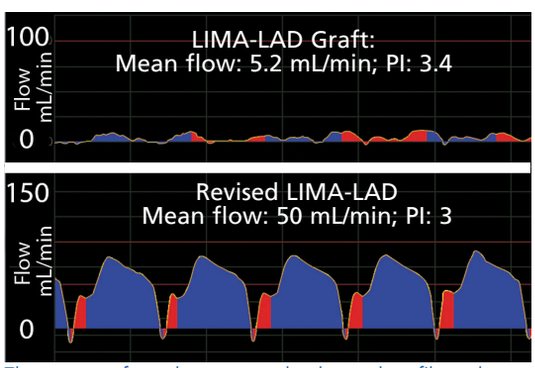
The graft was revised. Following revision, LIMA-LAD mean flow improved to 60 mL/min (PI: 0.8) and was accompanied by a classic, diastolic dominant waveform profile (bottom waveform).



The top LIMA-LAD graft waveform with a spiky systolic profile shows an initial graft flow of 8.8 mL/min (PI: 3.8). 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).

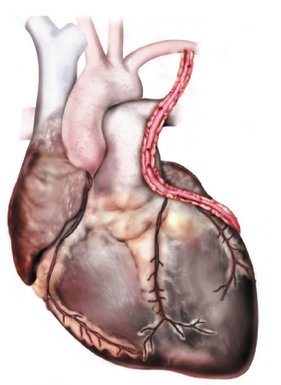
In the second case, a 67-year-old male patient with single-vessel coronary artery disease underwent off-pump CABG. LIMA-LAD graft flow first measured 5.2 mL/min (PI: 3.4). The patient's pulse and pressure appeared normal and the graft appeared functional, but the waveform exhibited a damped profile and atypical diastolization (top waveform). The surgeon decided to revise the graft.

After revision, LIMA-LAD graft flow improved to 50 mL/min (PI: 3). The flow waveform (bottom) exhibited a classic LIMA-LAD profile. Note that the first PI was 3.4, the revised PI was 3.



The top waveform demonstrated a damped profile and an atypical diastolization, and was accompanied by the 5.2 mL/min flow. This 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).

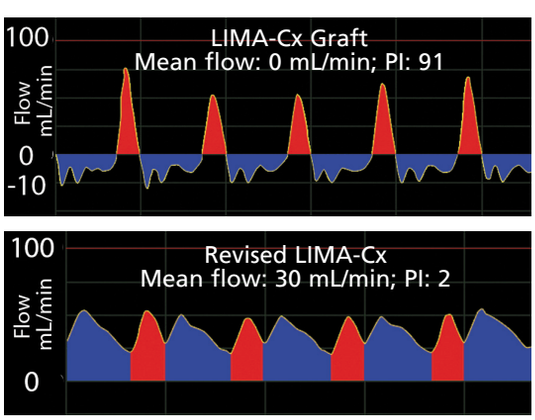
Zero Mean Flow Demands Revision of LIMA-Cx Graft



Case demonstrates serious problem with a graft when flow measures 0 mL/min.

A 78-year-old female patient underwent single coronary bypass grafting to bypass a blocked circumflex (Cx) coronary artery with the LIMA. Flow first measured 0 mL/min (PI: 91) following anastomosis of the LIMA to the Cx. The flow waveform had a spiky systolic profile (top waveform). Revision was demanded.

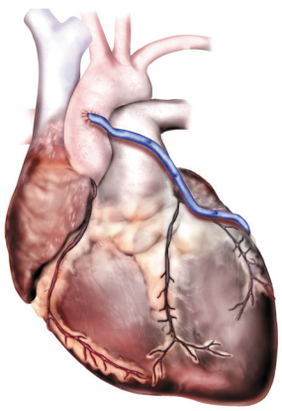
Following revision of the graft, mean graft flow improved to 30 mL/min (PI: 2), and the waveform exhibited a balanced systolic/diastolic profile (bottom waveform). Zero mean flow was the determining factor in the decision to revise the graft.



The top waveform exhibited a spiky systolic profile, which, accompanied by zero mean flow, called for the surgeon to revise the LIMA-Cx graft without hesitation. Flow improved to 30 mL/min after revision and the waveform exhibited a balanced LIMA-Cx profile (bottom waveform).

Provide Graft Patency Assurance

Zero Flow in SVG-Cx Graft Reveals Clot

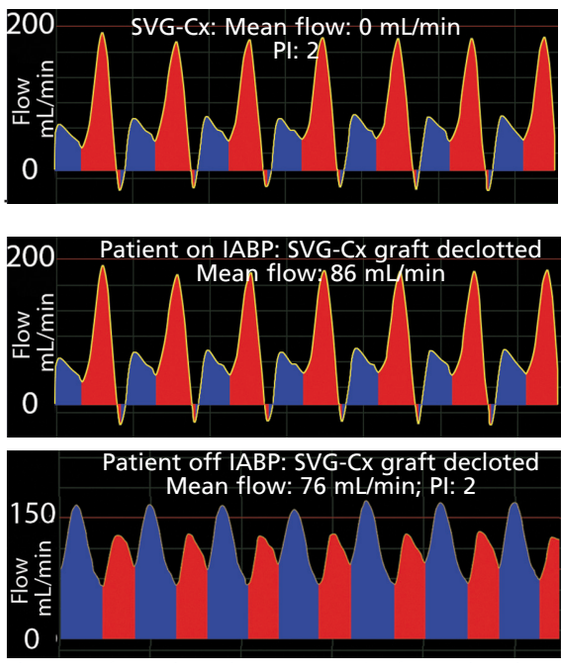


Case demonstrates that IABP support does not significantly influence flow.

An 81-year-old male patient underwent CABG surgery to bypass a blocked circumflex (Cx) coronary artery. A harvested saphenous vein graft (SVG) was used to connect the aorta to the Cx distal to the lesion (top waveform).

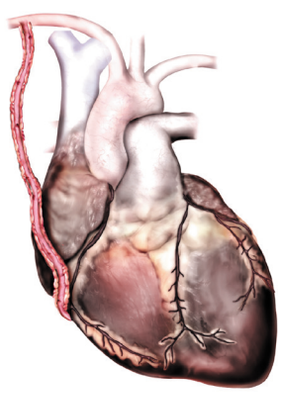
Following anastomosis of the SVG to the Cx, graft flow measured 0 mL/min, clearly indicating that there was a problem. Investigation revealed a clot in the graft. The patient was placed on IABP support. The graft was declotted and flow was remeasured with the patient still on IABP support. Flow measured 86 mL/min (middle waveform).

When the IABP support was removed, graft flow measured 76 mL/min (PI: 2) indicating that the presence of an IABP did not significantly affect graft flow (bottom waveform).



Three waveforms above show a progression from a clotted graft with zero mean flow (top waveform) to a declotted graft on IABP (mean flow, 86 mL/min) to the declotted graft with IABP removed (mean flow, 76 mL/min, bottom waveform).

RIMA-RCA Graft Flow Suppressed by Competitive RCA Flow



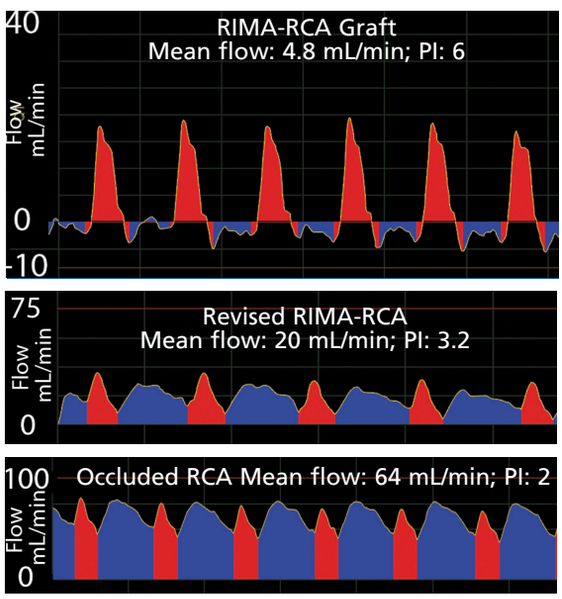
Case demonstrates that competitive flow from a native coronary can suppress graft flow.

A 60-year-old male underwent CABG to bypass a blockage in his right coronary artery (RCA) with a right internal mammary artery graft (RIMA).

Following the RIMA-RCA anastomosis distal to the blockage, flow measured 4.8 mL/min (PI: 6). Low mean flow, a high PI and a systolic dominant waveform profile indicated the need for graft revision.

After revision, flow improved to 20 mL/min (PI: 3.2), but this flow was not as high as the surgeon expected given the size of the patient. Suspecting the presence of competitive flow from the native RCA, the surgeon occluded the native RCA proximal to the anastomosis of the graft. Mean graft flow increased to 64 mL/min (PI: 2). Another graft was added, placed more distally on the RCA. Runoff improved, competitive flow decreased and graft flow was > 40 mL/min

The significant increase in mean graft flow supported the surgeon's suspicion that competitive flow was suppressing graft flow.

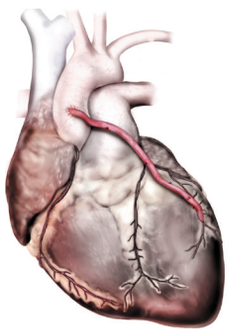


The three waveforms show the systolic dominant profile of the RIMA-RCA graft before revision (top), the systolic/diastolic flow waveform profile following revision of the graft (middle), and the similar graft waveform with the proximal RCA occluded (bottom).

Cases courtesy of B. Mindich, MD

Flow-based Patency Assurance

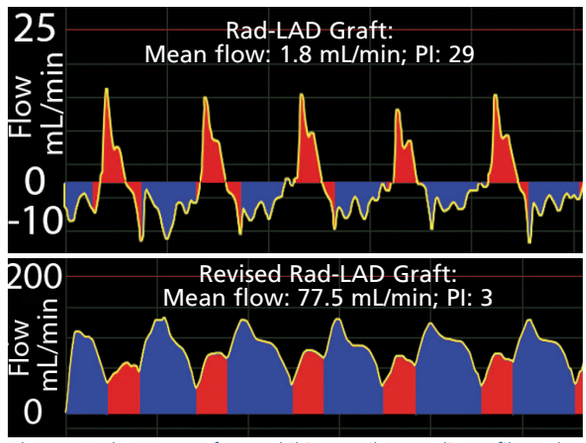
Poor Rad-LAD Graft Flow Triggers Graft Revision



Case demonstrates that poor flow signals need for graft revision.

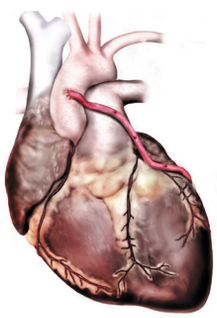
A 71-year-old male with single-vessel coronary artery disease underwent CABG surgery. A segment of the radial artery (Rad) was harvested and grafted proximally to the aorta and distally to the LAD. Initial Rad-LAD mean flow measured 1.8 mL/min (PI: 29) indicating that revision of the graft was warranted (top waveform).

After revision, graft flow improved to 77.5 mL/min (PI: 3). The flow was accompanied by a repetitive systolic/diastolic waveform profile (bottom waveform).



The top Rad-LAD waveform exhibits a spiky systolic profile and is coupled with an initial graft flow of 1.8 mL/min. Following revision of the graft, flow increased to 77.5 mL/min and was accompanied by a diastolic dominant waveform (bottom).

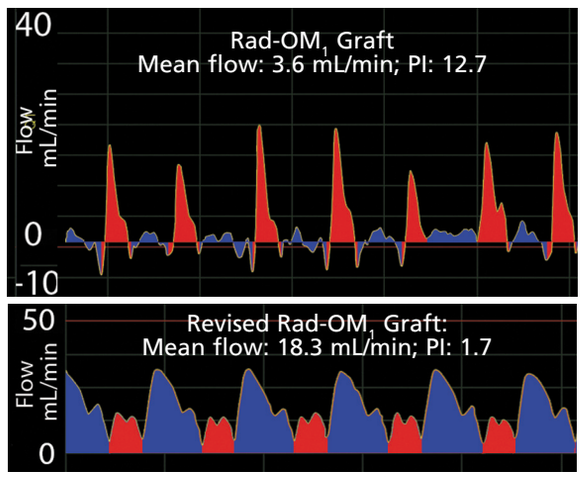
Low Mean Flow Spurs Rad-OM$_1$ Graft Revision



Case demonstrates that poor flow in one out of four grafts signals need for need for graft revision in that one graft.

A 48-year old male patient with multi-vessel coronary artery disease underwent quadruple CABG. Four grafts including a LIMA-LAD, SVG-OM, SVG-Dx and Rad-OM1 were constructed to deliver flow to the distal myocardium. Mean flows in the LIMA-LAD, SVG-OM and SVG-Dx grafts were acceptable.

However, mean Rad-OM1 graft flow measured 3.6 mL/min (PI: 12.7) signaling the need for revision of the graft. Following Rad-OM1 graft revision, mean graft flow improved to 18.3 mL/min (PI, 1.7) and was accompanied by a systolic/diastolic waveform.



The top waveform with a spiky systolic profile shows initial Rad-OM$_1$ graft flow of 3.6 mL/min. Following revision of the graft, flow increased to 18.3 mL/min and was accompanied by a diastolic dominant waveform profile (bottom waveform).

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

Drawn from the surgical expertise of BP Mindich MD, Valley Hospital, Ridgewood, NJ et al.[4-7]

*Flow-Assisted Surgical Techniques ("F•A•S•T") and Protocols are drawn from surgical experiences by transit-time flow measurement users and 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.

Why Measure Coronary Bypass Blood Flow?[1,2]

During coronary artery bypass grafting (CABG) surgery a surgeon can use coronary Flowprobes as a quantitative tool to measure blood flow through a bypass graft to objectively assess its functional quality. This provides the surgeon with a unique opportunity to improve patient outcomes through correction of otherwise undetectable flow restrictions before the patient is closed.

Measuring Bypass Blood Flow[1,2,3]

The following techniques are the result of 35 years of our users' best practices in flow measurement techniques and are necessary for proper measurement results. Flow-assisted patency tests are performed once the patient is off-pump:

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.
2. Select a Flowprobe sized so that the graft will fill at least 75% of the window of the Flowprobe. Do not to undersize the probe for the graft. Compressing a graft can cause changes in measurement accuracy.
3. Apply ultrasound couplant into the window of the Flowprobe. At this moment the meter will show the Flowprobe's 'zero offset'. Confirm that this is appropriately low (under +1mL/min for the 1.5 and 2 mm probe, under +1.5 mL/min for the 3 mm probe; under +3 mL/min for the 4 mm probe). One of the following graft patency criteria relies on the Flowprobe's capability to perform within specifications under very low flow conditions.
4. Turn on FlowSound®. A low-pitch hum flow sound indicates that the Flowprobe is properly connected to the Flowmeter, and that there is adequate ultrasound couplant within its flow-sensing window.
5. 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's display.
6. Observe the contraction of the heart while listening to FlowSound: a higher pitch indicates greater flow. Listen for a strong diastolic flow component.
   - Diastolic-dominant Left Heart Flow Sounds: Contracted muscle resists inflow. Therefore, on a good graft to the left heart, one would expect low flow (a pitch within one's vocal range) during systole, and a far higher pitched FlowSound (above one's vocal range) during diastole for a "Diastolic-dominant Flow Profile."
   - Systolic/Diastolic Balanced Right Heart FlowSounds: The right side of the heart contracts less forcefully than the left heart. Therefore, bypass graft flow to a right heart coronary is less impeded during systole. Both systolic and diastolic FlowSounds to a good right heart graft will be above one's vocal range.
7. The average (mean) flow will display on the Flowmeter screen or its front panel.
8. Graft patency must be tested at its greatest graft flow. Temporarily occlude the native coronary artery proximal to the anastomosis and note any changes in the pitch and pattern of FlowSound. An increase in FlowSound pitch or mean flow indicates the presence of competitive flow. If no competitive flow is observed, the occlusion may be released; otherwise maintain the occlusion during the patency test.
9. When flow waveform and mean flow have stabilized, press snapshot, print or export buttons on the Flowmeter.

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.

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Coronary Artery Bypass Grafting Protocol cont.

Mean Flow Assessment Is Primary[3]

Transonic's FAST Protocol for CABG is based primarily on mean graft flow. Mean flow is the most important consideration to confirm graft patency or to alert the surgeon to an undesirable condition.

Mean Flow Assessment Rules of Thumb are simply: an adequately high flow indicates a patent graft; a very low flow indicates a potential problem with the graft.

1. Mean Flow ≥ 25 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 has a potential problem and demands further investigation. (Detailed measurement steps follow.)

If competitive flow is ruled out as the cause of the low flow reading, consider the following:

- Mean graft flow can vary over a wide range. It is influenced by, and should be evaluated with respect to:
  - The patient's size, weight and physical condition;
  - 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.
- Using FlowSound to find the cause of low flow:
  - With the 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.

When Mean Flow Does Not Confirm Graft Patency or Indicates Technical Error?[3,4]

1. When flows are questionable (between 5 mL/min and 20 mL/min to 25 mL/min depending on a patient's size and physiology), check first for the presence of competitive flow. If competitive flow is not present, analysis of diastolic/systolic 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.
2. If the Flowmeter is connected to the patient's ECG (or pressure) for systolic-diastolic phase detection, conventional D/S Ratio (or DF%) is calculated to analyze the waveform of blood flow passing through a bypass graft. A D/S Ratio divides diastolic flow by systolic flow. DF% divides diastolic flow by total flow:

D/S Ratio:

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

DF%:

- A DF% >50% indicates a diastolic-dominant flow profile;
- A DF% approximating 50% indicates a balanced, diastolic-systolic, flow profile;
- A DF% <50% indicates a systolic dominant flow profile.

Note: D/S Ratio and DF% are two methods of evaluating the same criteria. D/S > 2 corresponds to DF% > 67%; D/S between 1 and 2 corresponds to DF% between 50% and 67%; D/S < 1 corresponds to DF% < 50%.

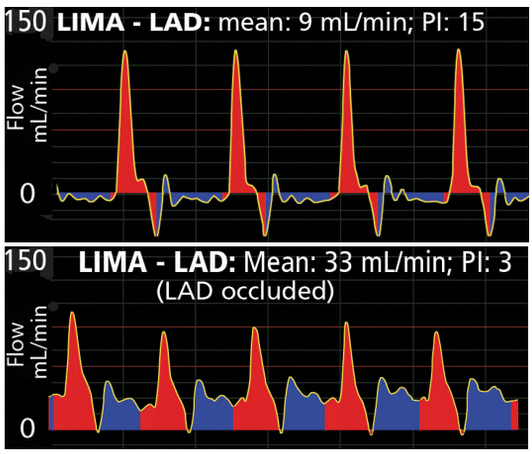
3. If the Flowmeter does not perform systolic-diastolic detection from ECG or pressure, Pulsatility Index (PI) is available as it is calculated only from the flow waveform:

Is PI greater than 5?

- A PI greater than 5 has been associated with low mean flow and systolic-dominant flow pattern indicating that the graft should be reexamined.
- A PI between 1 and 5 can be considered acceptable as long as step 4 (visual waveform analysis) is acceptable.

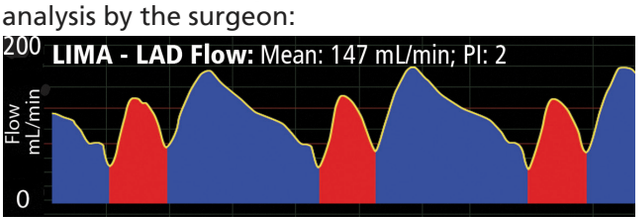
**Note* Pulsatility Index should not be relied upon as an absolute method to assess CABG graft patency; a graft can be not patent, but still have an acceptable PI or, as demonstrated in the figure at the top of the next page, a PI >5 may be the result of competitive flow which must be temporarily eliminated during a proper CABG patency test.[8]*

Coronary Artery Bypass Grafting Protocol cont.

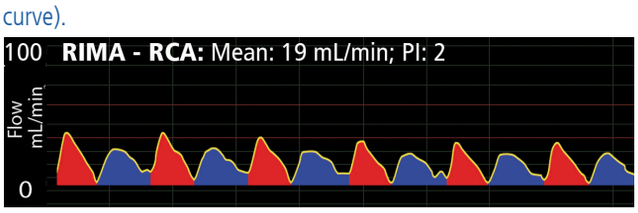


Competititve Flow in LIMA-LAD Graft: Flow increased from 9 mL/min to 33 mL/min when the LAD was occluded. The presence of competitive flow (top waveform) produced a spiky systolic profile and a PI of 15. When the LAD was occluded (bottom waveform), the waveform changed from an unacceptable negative diastolic to a more dominant diastolic phase with a PI of 3.

4. Transonic recommends that any analysis that is performed without the benefit of diastolic-systolic period detection (via ECG or Pressure) is complemented with visual systolic-diastolic waveform analysis by the surgeon:



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



Balanced Systolic Diastolic Pattern (Right-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 dominant, but is followed by a proportionally strong diastolic flow producing a systolic/diastolic waveform.

Optional: Novel New Parameter

If the Flowmeter is connected to the patient's radial artery pressure signal, you may implement Pressure/Flow (Resistance)-based diastolic-systolic graft patency assessment using DRI (Diastolic Resistance Index), a promising novel parameter indicative of the resistance of the anastomosis between the graft and the coronary vessel. DRI has not yet been thoroughly validated; the values have been arrived at through post processing of the data presented by Morota et al9 with the formula presented in Appendix A; do compare its findings with conventional DS Ratio and DF% parameters, available either off markers in the pressure or ECG waveform. (See Appendix A for more)

DRI:

- A value of DRI < 1 indicates a low diastolic flow resistance (Diastolic dominant flow).
- DRI ≈ 1.5 places the coronary anastomosis at around 50% stenosis: systolic-dominant flow.
- At higher degree of stenosis, DRI will become progressively higher as well. At 90% stenosis, DRI ≈ 3.

Transonic is providing DRI for those users interested in studing and publishing on its strength as a novel parameter for CABG Patency. DRI is not currently part of Transonic's CABG Patency Assessment Protocol nor is it factored in to the meter's Case Type: CABG Patency Assessment.

References:
1 Measuring PeriFlowprobe (CV-180-mn) RevA 2018 USltr
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.
5 Di Giammarco G, Rabozzi R, "Can transit-time flow measurement improve graft patency and clinical outcome in patients undergoing coronary artery bypass grafting?" Interact Cardiovasc Thorac Surg. 2010 Nov; 11(5): 635-40.
6 The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Kohl G (Chair), "Guidelines on Myocardial Revascularization," Eur J Cardiothorac Surg 2010; 38: S1 S52.
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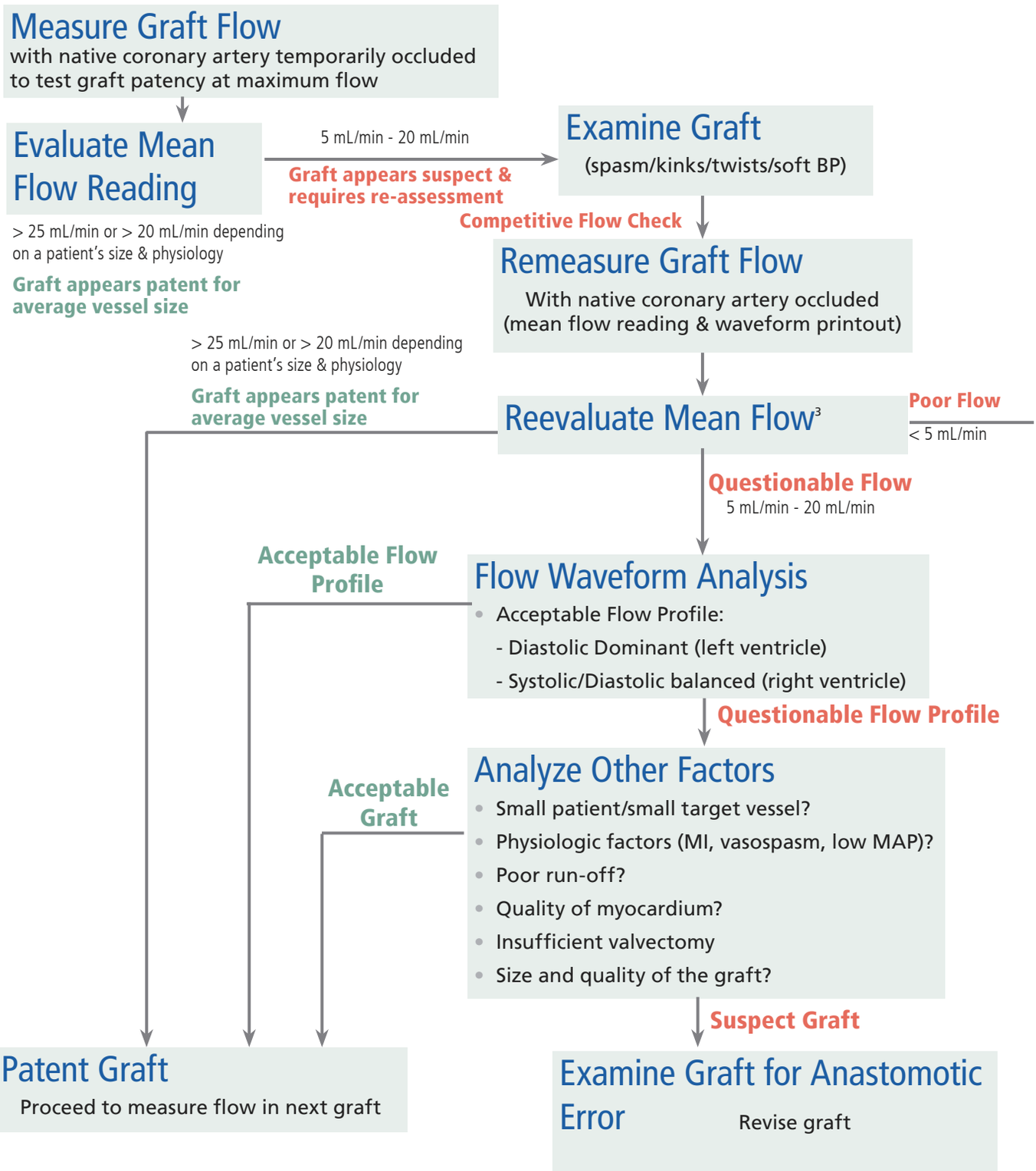
Coronary Artery Bypass Grafting Protocol cont.



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Signature CABG References

Validations

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CABG Application

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The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) Kohl G (Chair),"Guidelines on Myocardial Revascularization," Eur J Cardiothorac Surg 2010; 38, S1 S52. *"Graft flow measurement, related to graft type, vessel size, degree of stenosis, quality of anastomosis, and outflow area, is useful at the end of surgery. Flow < 20 mL/min and pulsatility index >5 predict technically inadequate grafts, mandating graft revision before leaving the operating theatre."*

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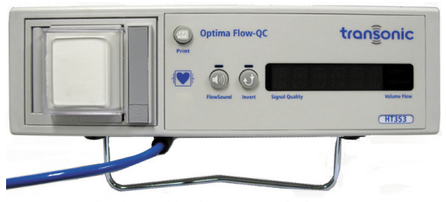
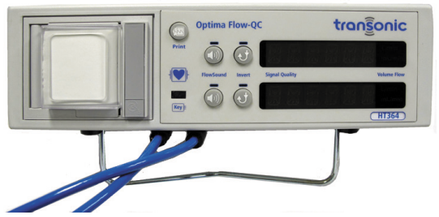


HT353 Single-channel keyless Optima® Flowmeter



HT364 Dual-channel key-activated Optima® Flowmeter permits simultaneous measurements with two Flowprobes.

Key-activated and Keyless Systems

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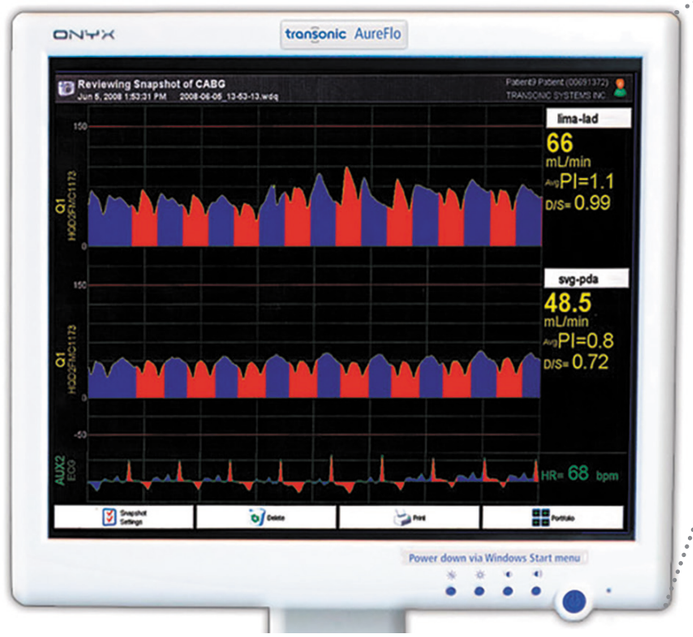
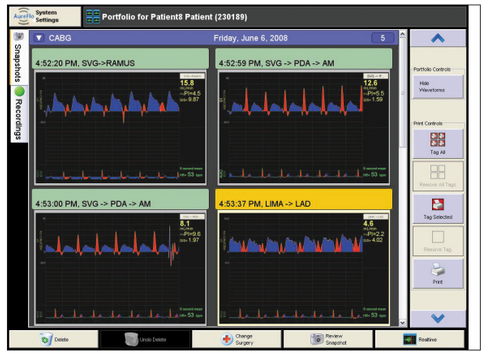
The AureFlo®



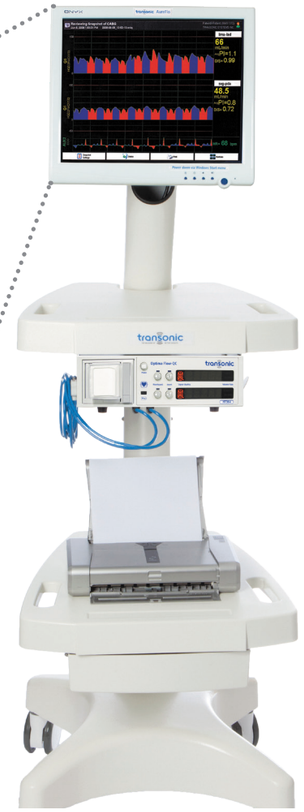
AureFlo® display of recorded LIMA-LAD volume flow waveform (systolic flow volume in red; diastolic in blue). Also displayed are mean flow in mL/min, pulsatility index (PI), D/S Ratio, ECG tracing and heart rate.

Case Portfolios: Record, Display, Create

- Recordings and snapshots can be labeled for identification before and after the procedure
- Select 8-second snapshots from recorded measurements for review or documentation
- Generous memory space allows storage of many cases



Portfolio screen can display up to four snapshots at a time



Versatile Display

- Touch-screen PC uploaded with FlowTrace® software
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- Display can be connected to an OR monitor

Intuitive Operation

- Quick and easy data entry
- Measure, capture, store and retrieve flow information

Archive & Retrieve

- Enhance operative notes and referral feedback
- Review case recordings remotely
- Print selected waveforms for reference, analyzing, teaching or documenting into the patient record

Convenient & Portable

- Small footprint, easy mobility
- Stable cart that securely holds Flowmeter, Monitor & printer
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Why rely on guesswork and intuition, and wait until postoperative conditions determine surgical success? Make intraoperative flow measurements with a Transonic Flowmeter part of your routine to verify establishement of adequate blood flow before closing your patient.

Surgical

Transonic®: The Flow Pioneer

Transonic, the recognized leader in clinical and research blood Flowmeters, is rooted in university research. The company was founded in 1983 by its current President Cornelis Drost and fellow collaborators at Cornell University's College of Veterinary Medicine to commercialize the transit-time ultrasound flowmetry devices pioneered by the group.

From its initial animal research market niche, Transonic evolved into the market leader for innovative medical flow measurement instrumentation. Examples include:

- Transonic's transit-time non-constrictive Perivascular Flowprobes, now the intraoperative quality assurance standard for beating-heart coronary bypass surgery.
- Its intraoperative bayonet-style Flowprobes help avert intraoperative stroke encountered during aneurysm clipping procedures, EC/IC bypass and other cerebrovascular procedures.
- Transonic's Clamp-on Tubing Sensors are an integral component of ventricular assist devices, organ preservation units, ECMO and cardiopulmonary bypass circuits.

"Accurate flow measurements can be of great assistance during vascular reconstructive surgery. The primary aim with these intra-operative measurements is to obtain information on the immediate result of the reconstruction, where a technical failure may jeopardize an otherwise successful operation." *A Lundell, MD, FACS*

"Not a day goes by that these flow measurements don't solve a problem for me." *B. Mindich, MD*

"...at the Medical Center here, we use the flowprobe as part of our routine monitoring the post-bypass patient. It gives us intraoperatively information about what's transpiring with each individual graft. It's not information that you could get any other way." *E. Grossi, MD*

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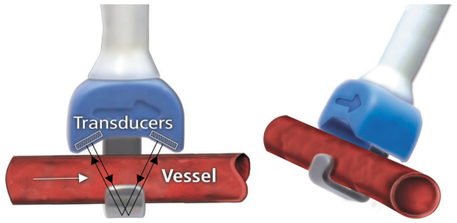
MEASURES VOLUME FLOW, NOT VELOCITY



Two transducers pass ultrasonic signals through the vessel, alternately intersecting the vessel in upstream and downstream directions. The difference between the two transit times yields a measure of volume flow.

European Revascularization Guidelines

"Graft flow measurement, related to graft type, vessel size, degree of stenosis, quality of anastomosis, and outflow area, is useful at the end of surgery. Flow <20 mL/min and pulsatility index >5 predict technically inadequate grafts, mandating graft revision before leaving the operating theatre."[1]

1 The Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) "Guidelines on Myocardial Revascularization," Eur J CardiothoracSurg 2010; 38, S1 S52

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Moreover, you can choose the flowmeter that best fits your needs. They include:

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Transonic Flowmeters(CV-53-fly) Rev G USltr 2018

Flowprobe Selection Guide

PERIVASCULAR FLOWPROBE SERIES & AVAILABLE SIZES		
SUFFIX	DESCRIPTION	SIZES (mm)
-FMC	Coronary (J-reflector, extended neck)	1.5, 2, 3, 4
-FMV	Vascular (J-reflector, standard handle)	1.5, 2, 3, 4, 6, 8, 10, 12, 14
-FME	Carotid (L-reflector, standard handle)	1.5, 2, 3, 4, 6, 8, 10
-MU	Microvascular (L-reflector, standard handle)	0.7, 1, 1.5, 2, 3
-AU	Cardiac Output COnfidence Flowprobe® (C-shaped design, no handle)	4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36
-MB; -MR	Intracranial Charbel Micro-Flowprobe® (L-reflector, long bayonet handle) -MB: single use; -MR: limited use	1.5, 2, 3
-MB-S -MR-R	Extracranial EC-IC Bypass: Micro-Flowprobe (L-reflector, short bayonet handle): -MB-S: single use; -MR-S: resposable	3, 4, 6
-P -FD	Port Access (J-reflector, long port-access handle) Port Access (J-reflector, long port-access handle)	2, 3, 4 1.5, 2, 3, 4

Recommended Sizes and/or Flowprobe Series for Specific Vessels or Applications

CARDIAC SURGERY		
CABG: ON OR OFF PUMP	Probe Size (mm)	Probe Series
Arterial conduits	1.5, 2, 3, 4	-FMC
Saphenous vein	2, 3, 4	-FMC
Port access - coronary arteries	1.5, 2, 3, 4	-FD
CARDIAC OUTPUT		
Ascending aorta	28, 32, 36	-AU
Pulmonary artery	24, 28, 32	-AU
Pediatric heart	4, 6, 8, 10, 12, 14, 16, 20	-AU

TRANSPLANT SURGERY			
LIVER	Probe Size (mm)	Probe Series	
Hepatic artery	4, 6, 8	-FMV	-AU
Portal vein	10, 12, 14	-FMV	-AU
KIDNEY			
Renal artery	4, 6	-FMV	
Renal vein	10	-FMV	
External iliac artery	6, 8	-FMV	-
Hypogastric artery	4, 6	-FMV	-
PANCREAS			
Common iliac artery	8	-FMV	-

CEREBROVASCULAR SURGERY			
ANEURYSM CLIPPING	Probe Size (mm)	Probe Series	
	mm	1 x use	limited use
Cerebral arteries	1.5, 2, 3	-MB	-MR
EC-IC BYPASS			
Extracranial	3, 4, 6	-MB-S	MR-S
Intracranial	1.5, 2, 3	-MB	-MR
AVM, TUMOR RESECTION, DURAL FISTULA			
Outflows	variable	-MB,	-MR

VASCULAR SURGERY			
CAROTID ENDARTERECTOMY	Probe Size (mm)	Probe Series	
Common carotid artery	8, 10	-FME	
External carotid artery	6	-FME	
Internal carotid artery	6	-FME	
AV FISTULAS & GRAFTS			
Radial artery	2, 3	-FMV	
Brachial artery	3, 4, 6	-FMV	
Graft venous outflow	4, 6	-FMV	-
ABDOMINAL			
Renal bypass	4, 6	-FMV	
Aorta	16, 20		-AU
Common iliac	10, 12	-FMV	-AU
Portocaval shunt	10, 12, 14	-FMV	-AU
Splenorenal shunt	10, 12, 14	-FMV	-AU
LOWER EXTREMITY BYPASS			
Profunda femoris	8	-FMV	-AU
Common femoral	8, 10	-FMV	-AU
Popliteal	4, 6	-FMV	
Tibial	3, 4	-FMV	

MICROVASCULAR SURGERY		
REATTACHMENTS/FLAPS	Probe Size (mm)	Probe Series
Microvessels in hand, wrist	0.7, 1, 1.5, 2, 3	-MU

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HQD_XL Tubing Flowsensor Selection Guide

HQD_XL-Series Clamp-on Tubing Flowsensor

STOCK TUBING			
Procedure	Cat #	TUBING (inches) Inner Diameter / Wall Thickness	Tygon Stock Tubing: If using tubing of different diameter or type, please discuss tubing with a customer service representative.
CAROTID SHUNTS	HQD 2XL	3/32 x 1/32	Tygon ND 100-65; Tygon E-3603
	HQD 3XL	1/8 x 3/32	Tygon E-3603
	HQD 4XL	1/8 x 1/16	Tygon ND 100-65; Tygon E-3603
	HQD 5XL	3/8 x 1/16	Tygon ND 100-65; Tygon E-3603
PED CPB, ECMO	HQD 6XL	1/4 x 1/16	Tygon ND 100-65; Tygon E-3603
	HQD 7XL	1/4 x 3/32	Tygon ND 100-65; Tygon E-3603
	HQD 8XL	3/8 x 1/16	Tygon ND 100-65; Tygon E-3603
ADULT CPB	HQD 9XL	3/8 x 3/32	Tygon ND 100-65; Tygon E-3603
	HQD 10XL	1/2 x 1/16	Tygon ND 100-65; Tygon E-3603
	HQD 11XL	1/2 x 3/32	Tygon ND 100-65; Tygon E-3603

HQD - XL SENSORS (INCHES)			
CATALOG #	TUBING		
	ID INCHES	WALL THICKNESS INCHES	OD INCHES
HQD2XL	IN SIZES 2XL-5XL RATIO OF TUBING WALL THICKNESS TO OD MUST NOT EXCEED 1.5 FOR PVC; 1:3 FOR SILICONE		1/8
HQD3XL			3/16
HQD4XL			1/4
HQD5XL			5/16
HQD6XL	1/4	1/16	3/8
HQD7XL	1/4	3/32	7/16
HQD8XL	3/8	1/16	1/2
HQD9XL	3/8	3/32	9/16
HQD10XL	1/2	1/16	5/8
HQD11XL	1/2	3/32	11/16
HQD12XL	1/2	1/8	3/4

HQD - XL SENSORS (METRIC)	
CATALOG #	OD MM
HQD2XL-M2	2 mm
HQD2XL-M3	4 mm
HQD3XL-M5	5 mm
HQD4XL-M6	6 mm
HQD4XL-M6	7 mm
HQD5XL-M7	7 mm
HQD6XL-M8	8 mm
HQD7XL-M9	9 mm
HQD8XL-M10	10 mm
HQD9XL-M12	12 mm
HQD10XL-M14	14 mm
HQD11XL-M16	16 mm
HQD12XL-M20	20 mm

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