# Real-time Intraoperative Flow Data to Help Surgeons Enhance Outcomes

- Check the Quality of Inflow
- Quantify Flow Improvement
- Confirm Conduit Patency


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# Volume Flow Measurements Add Quantitative Dimension to Vascular Surgery

Vascular surgeons seek to perform the best possible operations tailored to the specific needs of each patient. To this end, intraoperative blood flow measurements provide a quick assessment that may confirm what appears to be an acceptable surgical result, or they may alert the surgeon to potential problems at a time when they can be addressed before closing the patient.

Transonic® volume flow measurements provide on-the-spot feedback about key surgical revascularization/reconstruction components:

- Inflow: checks the quality of flow of a newly constructed fistula or bypass.
- Flow Conduit: quantifies the carrying capacity of the bypass; checks for kinks or twists in a graft.
- Outflow: quantifies flow augmentation and confirms the patency of an anastomosis.

This rapid flow data offers functional information to the vascular surgeon who values real-time data to assess the quality of the surgery. No other flow technology produces flow information so quickly, accurately, and non-intrusively during vascular surgeries as do Transonic® intraoperative Flowmeters.

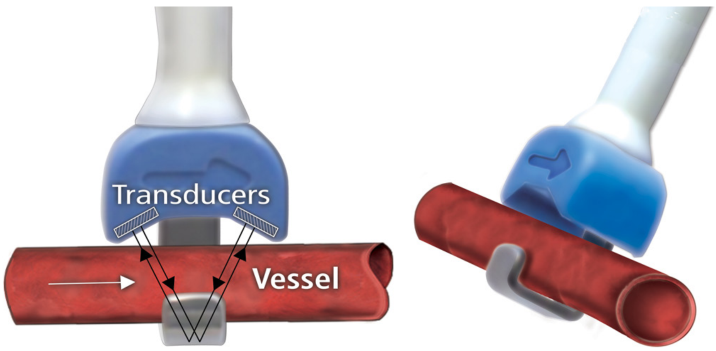
*"Accurate flow measurements can be of great assistance during vascular reconstructive surgery. The primary aim with these intraoperative measurements is to obtain information on the immediate result of the reconstruction, where a technical failure may jeopardize an otherwise successful operation."*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

*Transonic Flow-QC provides a measurable improvement in the quality of care you can extend to your patients. With Transonic Flow-QC you can: improve patient outcomes; reduce or delay the need for future interventions and document surgical results."* T. Wolvos, MD, FACS

*"Intraoperative blood flow measurements obtained at the time of autologous AVF construction can identify fistulas that are unlikely to mature; and therefore, that require immediate revision or abandonment which will ultimately expedite the establishment of a useful access in the HD patient."* Berman et al, J Vasc Access. 2008;9(4):241-7.

## 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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# Medical Note

## Intraoperative Blood Flow Measurements during Carotid Endarterectomy

Courtesy of Ian Gordon, MD, PhD, Professor, Dept. of Surgery, Univ. of CA, Irvine

### Surgical Approach

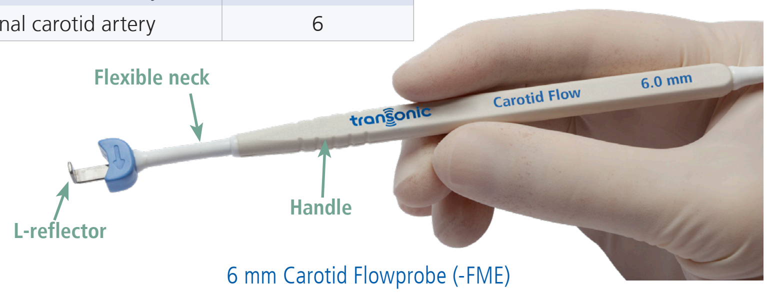
No special adjustment in surgical technique is necessary for measurement of blood flow during carotid surgery. The sites on the carotid arteries skeletonized by dissection for vascular clamp placement are identical to those employed for Flowprobe placement. A 10 mm Flowprobe (sometimes an 8 mm Flowprobe is used) is employed for the distal common carotid artery and 6 mm Flowprobes for the origin of the internal and external carotid arteries.

The Flowprobe on the external carotid is placed just distal to the origin of the superior thyroid artery. We perform the pre-endarterectomy flow measurements immediately after administration of systemic heparin. Measurement of all three arteries (Fig. 1) only requires a few minutes.

After the first measurement, vascular clamps are placed and the endarterectomy is performed. After finishing the endarterectomy, removing all clamps, and establishing hemostasis, a repeat flow measurement is performed. Occasionally, a low flow or turbulent flow waveform is detected indicating the presence of a significant stenosis which requires immediate revision. As a consequence, we try not to reverse heparin with protamine until completion of the flow measurements.

| TYPICAL FLOWS OBSERVED | | |
|---|---|---|
| **Conduit** | **Pre-Endarterectomy** | **Post-Endarterectomy** |
| Common carotid a | 287 ± 17 | 329 ± 18 |
| External carotid a | 126 ± 10 | 104 ± 8 |
| Internal carotid a | 135 ± 10 | 178 ± 11 |

| Carotid Endarterectomy | Probe Size (mm) |
|---|---|
| Common carotid artery | 8, 10 |
| External carotid artery | 6 |
| Internal carotid artery | 6 |




6 mm Carotid Flowprobe (-FME)

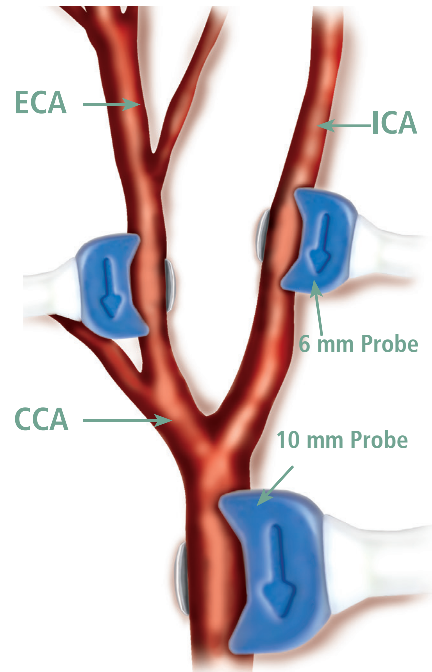



Fig 1: Flowprobe Positions: Pre and Post Endarterectomy.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# Medical Note

## Intraoperative Blood Flow Measurements during Lower Extremity Bypass Grafts

Courtesy of Ian Gordon, MD, PhD, Professor, Dept. of Surgery, Univ. of CA, Irvine

### Introduction

After completing a lower extremity arterial bypass anastomosis, flow is measured immediately before closure of the wound. We do not reverse heparinization.

Three methods are used to measure flow depending on the graft material used. Method A is suitable for saphenous vein or dacron grafts and Methods B and C are useful for PTFE grafts.

### 1: Saphenous Vein/Dacron Bypass Grafts

**Proximal Flow:** To measure flow in a saphenous vein or dacron bypass graft, the Flowproberobe is placed just distal to the proximal anastomosis (Fig. 1: A). Flow is documented and a representative flow waveform is generated. An artifact in the flow versus time waveform indicates the presence of a hemodynamically significant stenosis causing turbulence.

**Distal Flow:** The distal anastomosis is similarly assessed for turbulence by placing the Flowprobe on the target vessel for the bypass just distal to the distal anastomosis (Fig. 1: B).

**Bypass Flow:** If there are no technical problems requiring graft revision, we perform our definitive flow measurement by positioning the Flowprobe on the bypass at any convenient position (Fig. 1: C) and measuring flow. We customarily measure flow, first with the graft temporarily clamped to confirm an accurate zero flow. Then graft flow [$F_{graft}$] is measured with the clamp released, and recorded.

**Resistance:** To calculate resistance of graft flow in the distal run-off vessels, we measure the pressure drop across the graft. A 26 gauge needle, connected to a three-way stopcock, is connected by plastic extension tubing to a sterile pressure transducer (usually the anesthetist's radial artery catheter transducer) and is introduced onto the surgical field. The bypass graft is punctured by the needle several centimeters distal to the proximal anastomosis (Fig. 2). Mean pressure is measured first, with the graft open [$P_{open}$], and then, with a clamp proximal to the needle, occluding the graft [$P_{clamp}$]. The pressures are recorded. After completing the measurements, the needle is withdrawn and the needle hole is closed with a 6-0 suture.

Flow resistance (R) is calculated as:

$$R = F_{graft} / (P_{open} - P_{clamp})$$

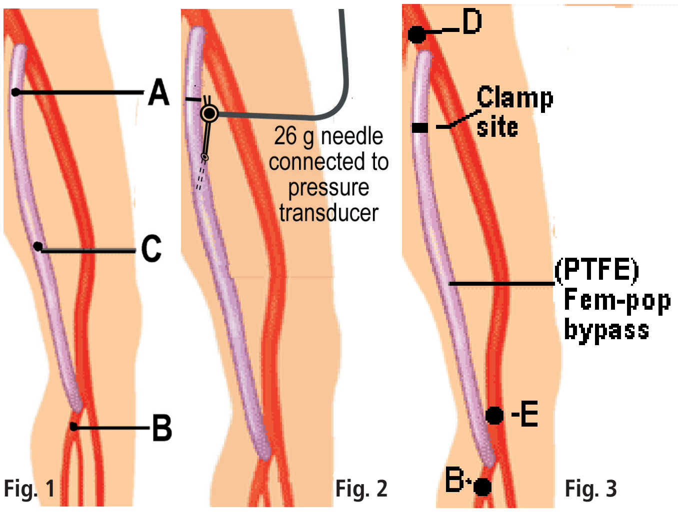


Fig. 1: Flow measurement sites for fem-pop saphenous vein or dacron grafts.
Fig. 2: To calculate resistance, the pressure drop across the bypass graft is measured, first with the clamp on the bypass opened [Popen] and then with the clamp closed [Pclamp].
Fig. 3: Method B: PTFE bypass grafts: flow is measured proximal to the bypass with the bypass open [Fopen] and then closed [Fclosed]. To measure flow distribution beyond the distal anastomosis, either antegrade or retrograde, flows are measured at points B and E with the bypass open and clamped.

### 2: PTFE Femoropopliteal Bypass

In a typical PTFE femoropopliteal bypass, the graft origin is from the common femoral artery. An 8 or 10 mm Flowprobe is placed on the common femoral artery just proximal to the bypass (Fig. 3, D). Flow in the common femoral artery is then measured with the graft open [Fopen] or clamped [Fclamp]. Net graft flow is equal to ($F_{open}$ - $F_{clamp}$). Resistance is measured as above.

Method B is also used whenever placement of the Flowprobe on both sides of the distal anastomosis is difficult due to poor exposure of the distal vessel receiving the bypass.

> Note: Dacron grafts, rarely used distal to the femoral artery, allow direct measurement of flow by transit-time Flowprobes. Expanded PTFE grafts cannot be studied immediately by a Flowprobe placed on the graft, as air trapped in the graft interstices interferes with ultrasound transmission, and an accurate measurement is not possible until this gas is expelled.

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# Intraoperative Blood Flow Measurements during Lower Extremity Bypass Grafts Cont.

## 3: Antegrade & Retrograde Flow Distribution

Method C is used to measure the distribution of flow beyond the distal anastomosis in retrograde and antegrade directions. A 4 or 6 mm probe is placed on the target vessel just distal to the distal anastomosis [position B].

Antegrade Flow: Antegrade flow is measured with the bypass graft open [$F_{ao}$] and clamped [$F_{ac}$].

Retrograde Flow: To measure retrograde flow, the probe is placed on the target vessel [position E] just proximal to the distal anastomosis and flow is measured with the graft open [Fro] and clamped [$F_{rc}$]. Observe the direction of blood flow carefully observed and negative and positive signs correctly employed to accurately measure flow. Net graft flow is calculated as $(F_{ao} - F_{ac}) + (F_{ro} - F_{rc})$. Resistance is measured as in Method A.

Note: Pulse is a manifestation of pressure, not flow, so an occluded graft may still have a distinct pulse.

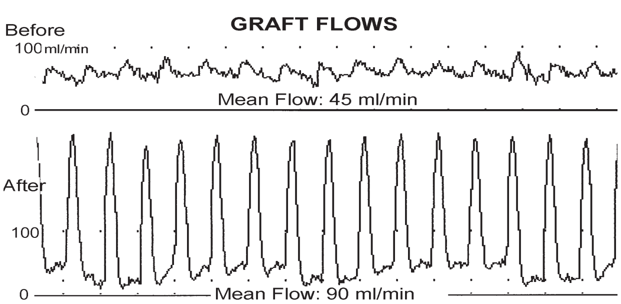


Fig. 4: These waveforms demonstrate a case in which a vein graft initially had a stenosis near its origin. The upper waveform shows flow (45 mL/min) before correcting the stenosis. The lower waveform shows flow (90 mL/min) along with a representative flow pattern after correcting the stenosis.

## Equipment Needs

| BYPASS | SIZE | PROBE SERIES |
|---|---|---|
| Profunda femoris | 8 | -FMV, -AU |
| Common femoral | 8, 10 | -FMV, -AU |
| Popliteal | 4, 6 | -FMV, -AU |
| Tibial | 3, 4 | -FMV, -AU |


2 mm - 10 mm Vascular Handle Flowprobe (-FMV-Series)

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