



## Protocol: Flow Measurement during Non-autogenous (Prosthetic) Vascular Access Graft Construction

Direct intraoperative flow measurement on newly inserted prosthetic ePTFE grafts is not possible due to air in the ePTFE graft walls (air blocks ultrasound transmission). Therefore, graft outflow is measured on the vein after construction of the arterial and venous anastomoses. (In cases where the vein has not been ligated, this flow measurement is made proximal to the anastomosis, with temporary occlusion applied to the distal portion of the vein.)<sup>2</sup>

### Measurement Steps:

#### 1. Identify Vessels to Be Measured

Identify the exposed segments of the venous outflow conduit for the graft. Determine the optimum site (wide enough to accommodate the probe's acoustic reflector) for applying the probe, and clean the vein at this site from fat and excess tissue.

#### 2. Select Flowprobe Sizes

Estimate the diameter of the artery and vein with a gauge. Select a probe size so that the vessel will fill between 65% - 100% of the lumen of the probe.

NOMINAL PROBE SIZE	ACCEPTABLE VESSEL RANGE
4 mm	3.2 - 5.3 mm
6 mm	4.5 - 7.5 mm

#### 3. Apply Flowprobe

Apply sterile Aquasonic Gel 100™ to the Flowprobe to provide ultrasound coupling between the probe body and probe reflector. Apply the Flowprobe to the vein, proximal to the anastomosis, bending the probe's flexible neck segment as necessary, so that the entire vessel lies within the lumen of the probe and aligns with the probe body. Listen to the pitch of **FlowSound™** as the Flowprobe is applied to the vessel. The higher the pitch, the greater the flow.

Check the Signal Quality Indicator (bucket display) on the flowmeter's front panel for ultrasound acoustic contact. An acoustic error message will be displayed if ultrasound contact falls below an acceptable minimum.

#### 4. Measure and Evaluate Venous Outflow

With the Flowprobe positioned as under Step 3 (above), measure venous average flow as displayed on the flowmeter. **An initial venous outflow < 400 ml/min is associated with a higher rate of initial graft failure.**<sup>1</sup> As the site recovers from surgery, flow will increase to levels preferred for hemodialysis (> 600 ml/min).

**Figs. 1-3: Non-Autogenous Prosthetic Grafts:** Loop (Figs. 1, 2) or straight (Fig. 3). PTFE grafts are constructed with inflow from the radial or brachial artery to the cephalic vein. End graft -to-side vessel anastomoses may be used to attach the prosthetic ePTFE graft to the artery and to the vein.

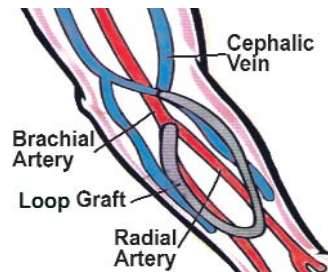
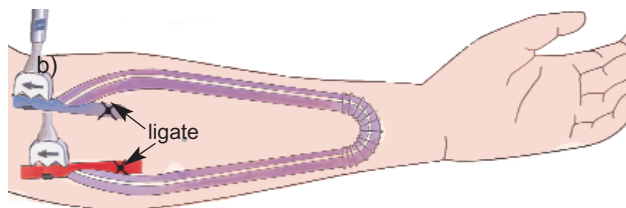


Fig. 1: Loop ePTFE Graft from brachial artery to cephalic vein.



a) Fig. 2: Loop ePTFE Graft anastomosed to the sides of an artery and vein.

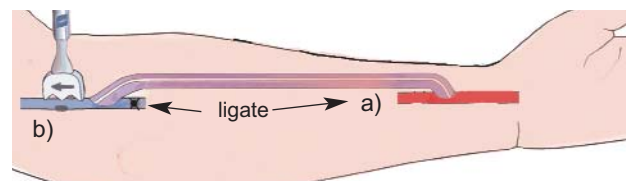


Fig. 3: Straight ePTFE Graft anastomosed to the sides of an artery and vein.

GRAFT TYPE	FAILURE WITHIN 90 DAYS (REQUIRING INTERVENTION)	
PTFE		
Flow <400 ml/min	65%	P=.01
Flow >400 ml/min	40%	

#### 5. Document Flows

After applying a Flowprobe to a vessel, wait 10-15 seconds for mean readings to stabilize. Then press the PRINT button on the flowmeter to document the phasic flow patterns for the case record. If flow is has a negative sign on the flowmeter display, press the INVERT button to change the polarity before printing the waveform.

#### 6. Measure Potential for Steal Syndrome (Optional)

With the flowprobe placed on the vein as before, measure flow with, and without, occlusion of the artery distal to the arterial anastomosis. The difference between the two readings equals flow in the distal branch of the artery. When the flow reading without distal occlusion is higher than the reading with occlusion, blood in the distal branch is flowing retrograde to augment fistula flow and vascular steal may develop. (Note: Alternately, distal arterial flow is measured directly by placing a flowprobe on a properly cleaned distal site of the artery.)

<sup>1</sup>Johnson et al, "Prognostic value of intraoperative blood flow measurements in vascular access surgery," Surgery 124:729-38, 1998<sup>1</sup>Johnson et al, "Prognostic value of intraoperative blood flow measurements in vascular access surgery," Surgery 1998:124:729-38.



Accurate flow measurements depend on careful attention to the following:

### Correct Vessel/ Probe Fit

The vessel must fill at least 65% of the Flowprobe lumen. Generally a 4 mm probe is used for flow measurement during graft construction. After placing the probe around the vessel hold the probe steady for 10-15 seconds to allow the signal to stabilize before taking a measurement. The vessel should be aligned parallel to the probe body and reflector (Fig. 2).

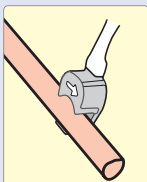


Fig. 4: Correct vessel/probe alignment.

### Use of Acoustic Couplant

Highest accuracy is achieved when the ultrasound signal is transmitted under uniform acoustic conditions. This occurs when the acoustic properties of the coupling media and tissue are stable and most closely match the acoustic properties of the liquid being measured. Aquasonic 100 Gel and physiological saline are used in the clinical setting as acoustic couplants with transit-time probes.

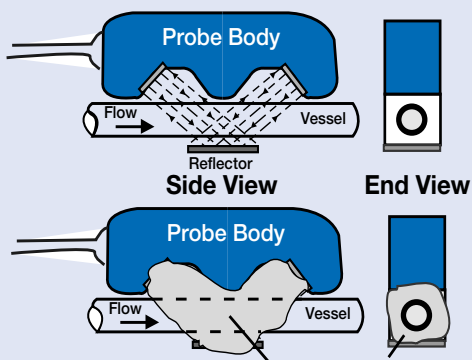


Fig. 5: Acoustic couplant fills air space between probe and vessel.

### Air

Air attenuates the probe's ultrasound signal and effectively blocks ultrasound transmission. Even small air bubbles can compromise measurement accuracy. Therefore, all spaces between the vessel and probe must be filled with a suitable coupling agent (Fig. 3).

### Fat

Fatty tissue has a low acoustic velocity and also blocks the ultrasonic beam. Fatty tissue should be carefully cleaned from the vessel where the probe is placed. A pad of fat on the vessel wall in the acoustic pathway of the ultrasonic beam can act like a lens, reflecting or defocusing the ultrasound and altering the transit time nonuniformly.

### Temperature

Acoustical velocity of ultrasound increases with temperature increases. Transonic perivascular Flowprobes are calibrated for measurements of blood at 37°C and will give the most accurate readings if used within a +/- 2 - 3 degree range. Gels may be warmed on a heating plate and the probe itself should be allowed to equilibrate to this temperature before use.