Don’t You Want To Know the Flow in Your Micro-vessels?

• Quantify restored flow in the smallest vessels
• Improve reattachment and flap outcomes
• Measure flow quickly and easily
Microsurgical Flowprobes take the guesswork out of knowing volume flow...

Transonic® Microsurgical Flowprobes work with HT350 and HT360-Series Flowmeters to measure volume flow in 0.37 - 4.0 mm blood vessels and grafts. The non-constrictive Flowprobes use gold standard transit time ultrasound technology to measure volume blood flow directly within these small blood vessels.

The new line of microvascular Flowprobes now offer the surgeon a quantitative tool with which they can objectively assess the quality of the reconstruction or replantation. Unseen blood flow obstructions can be detected intraoperatively and repaired before leaving the operating room.

No longer will a micro-vascular surgeon have to rely solely on clinical impressions to assess the quality of the surgery during the procedure. This on-the-spot volume flow technology produces flow information quickly, accurately, and non-intrusively. The ability to immediately correct otherwise undetectable flow restrictions provides the surgeon with a unique opportunity to improve their patients’ outcomes.

“...TTFV (Transit-time Flow Volume) provides novel physiologic flap data and identifies flow anastomoses and higher-flow venae comitantes. These data have clinical value in microsurgery and hold the potential to reduce microvascular complications and improve outcomes.”

JC Selber, MD, MPH et al

“Including flow in my surgical approach gives me a high degree of control over surgical outcomes. When I close the patient, I know the patient will recover without ischemic surprises. This translates into peace of mind for the patient and for me.”

F Charbel, MD, FACS

“Ackurate 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

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.
Flow-assisted Surgical Techniques & Notes*  
Reconstructive Microsurgery Protocol

*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.

Introduction
During reconstruction or replantation microsurgery, a surgeon may elect to use a Microsurgical Flowprobe as a quantitative intraoperative tool to detect unseen blood flow obstructions which could thus be repaired before leaving the operating room.

Measuring Blood Flow1,2
1. Identify Vessels to be measured
   Expose and identify arterial inflow and venous outflow vessels to be used in the reconstruction.
2. Select Flowprobe Size
   Measure the vessel diameter of the vessels to be measured with a gauge before opening the Flowprobe package. Select a Flowprobe size so that the vessel will fill between 75% - 100% of the Probe’s ultrasonic sensing window.
3. Prepare Vessel for Flowprobe
   Select a site wide enough to accommodate the Flowprobe’s acoustic reflector. Clear approximately 1 cm of the vessel of fascia or fat for an accurate measurement. Fat could interfere with acoustic transmission.
4. Add Couplant to Flowprobe
   Fill the window of the Flowprobe with ultrasonic gel or submerge the Flowprobe’s head in saline in the surgical field.
5. Apply Flowprobe
   Apply the Flowprobe at right angles to the vessel (Fig. 1) taking care not to “twist” or “lift” the vessel with the Flowprobe. Apply the Flowprobe so that the entire vessel lies within the ultrasonic sensing window of the Probe.
6. Check Signal Strength
   Check the Flowprobe’s ultrasonic signal strength on the Monitor display or Flowmeter front panel.
7. Measure Multi-stage Flow(s) as needed4
8. Document Flows for Case Record1,2
   When the waveform appears stable (10-15 seconds) record flow, take a snapshot of the measurement or print the waveform to document flow values. If the Flowmeter displays a negative flow, press the INVERT button to change the polarity before printing the waveform. Leave the probe on the vessel until the printing stops or a snapshot or recording has been captured (8 – 10 seconds).

Flow Measurement1,2,4
Select Correct Flowprobe Size
Measure Baseline Flows on arterial inflow and venous outflow vessels
Determine surgical strategy for flap reconstruction
Measure flows immediately after anastomosis and reperfusion
Record flow values of arterial inflows and venous outflows
Flow equal or more than baseline
Evaluate surgical strategy vis à vis flow values4
Measure flows 30 minutes after anastomosis and reperfusion
Compare to other flows and determine surgical strategy

References:
1 Measuring PeriFlowprobe(CV-180-mn)RevA2018USltr
2 AU-QRG-Optima-EN Rev E
Quantitative Patency Assessment

Steps for Successful Flow Measurement during Creation of a Microvascular Anastomosis

Measure baseline flow in the native vessel prior to any surgical manipulation:

1. Select the appropriate size Flowprobe. The vessel should fill 70-100% of the probe-sensing window (Figs. 1,2).

2. Clear approximately 1 cm of the vessel to be measured of extraneous tissue (i.e. fascia, fat) for an accurate measurement. This should provide adequate room for the probe head. Fat could interfere with acoustic transmission.

3. Fill the Flowprobe window with ultrasonic gel or submerge the Flowprobe head in saline in the surgical field.

4. Apply the Flowprobe at right angles to the vessel (Figs. 1-4). Take extra care not to “twist” or “lift” the vessel with the Flowprobe. This will restrict or occlude blood flow creating inaccuracies at such small flow values.

5. Check the Flowprobe’s ultrasonic signal strength on the Monitor display or Flowmeter front panel.

Once a repeatable, reproducible flow waveform is seen (Fig. 5), the Probe, Meter and Monitor combination has sensed volume flow through the vessel.

6. When the waveform appears stable (10-15 seconds), assess the mean flow value and either take a snapshot of the measurement, make a recording, or print the waveform with associated mean flow.

7. Leave the probe on the vessel until the printing stops or a snapshot or recording has been captured (8 – 10 seconds).

Measure flow after creation of a vascular anastomosis.

1. Re-measure volume flow following the above steps at a site distal to the anastomosis. Do not measure flow directly over the anastomosis. Suture material will interfere with acoustic coupling (Fig. 4).

2. If flow is less than expected, consider:
   - Technical error in anastomosis creation
   - Poor run-off (increased resistance in the vascular circuit)
   - Vasospasm, kinks or twists
   - Drop in MAP
   - Change in body temperature
Publication Brief

Transit-time Ultrasound Technology-assisted Lymphatic Supermicrosurgery

Chen WF, Zhao H, Dept. of Surgery, Univ. of Iowa Hospitals and Clinics, Iowa City, IA, wei-chen@uiowa.edu.

BACKGROUND
The efficacy and minimal invasiveness of lymphatic supermicrosurgery with construction of a lymphaticovenular anastomosis (LVA) make it increasingly used to treat lymphedema. However, the procedure depends on the use of healthy, functioning lymphatic vessels because its success relies on establishing a favorable lymph-to-vein pressure gradient. Here-to-fore, surgeons had relied on intraoperative visual inspection both to select the lymphatic vessels to be used and then, to assess anastomotic patency by observing for blood “wash-out” in the vein to which the lymph vessel is anastomosed.

OBJECTIVE
To examine and report whether transit-time ultrasound technology, with sensitivity reaching 0.01 mL/min, could be of value in measuring minuscule flows in microscopic lymphatic vessels.

METHOD
• Lymphatic supermicrosurgery was performed in two patients: one with Campisi stage IV upper and one with Campisi stage III lower extremity lymphedema;
• A Transonic 0.7 mm Microsurgical Flowprobe was used in conjunction with a Transonic AureFlo system to measure lymphatic flows before and after construction of the LVA;
• A total of 28 lymphatic vessels were assessed/measured and 15 LVAs were constructed;
• Mean flow values, based on three consecutive measurements, were recorded;
• Transit-time ultrasound flow measurements were compared with the surgeon’s visual assessments.

RESULTS
• Lymphatic flows ranged from 0 to 1.2 mL/min; LVA flows ranged from 0.22 to 1.4 mL/min;
• In all 28 lymphatic vessels, flow measurements consistently correlated with the surgeon’s observation;
• Healthy-looking lymphatics had flow values higher than those from unhealthy-looking vessels;
• All LVAs with positive “wash-out” had flow ≥0.47 mL/min.
• In 5 LVAs with no visual “wash-out”, there were reproducible flows, all < 0.47 mL/min;
• In 3 LVAs, lymphatic flows were higher after the anastomoses was constructed;
• Both patients experienced prompt relief of lymphedema symptoms during the first postoperative week and continued to do well at six months following the surgery.

CONCLUSION
• Based on the findings, the clinicians concluded that the transit-time ultrasound holds promise in: 1) guiding lymphatic vessel selection; 2) confirming anastomotic patency; 3) ascertaining if the absence of “wash-out” unequivocally indicates anastomotic occlusion.
• Further studies with higher sample sizes are needed to confirm the accuracy and reliability of the measurements and their correlation with varying qualities of the lymphatic vessels.

TAKE HOME
• Landmark, first-ever publication of direct flow measurements in lymphatic vessels in humans including a picture of a Flowprobe measuring human lymphatic flow and flow traces.

REFERENCE

www.transonic.com

Selber JC et al, University of Texas MD Anderson Cancer Center — 2013

OBJECTIVE
To determine if transit-time volume flow measurements would improve decision-making in microvascular free tissue transfer procedures.

STUDY
Transit-time volume flow was measured in 52 consecutive free flaps (five types) by five surgeons. Thirty-eight (73.1%) of the flaps were harvested to reconstruct head and neck defects, while the remaining 14 (26.9%) (all TRAMs) were harvested for breast reconstruction. Flow measurements were performed:
- In Situ, after flap elevation and isolation on its pedicle;
- Immediately following anastomosis and reperfusion;
- Thirty minutes following anastomosis and reperfusion.

Intraoperative decisions based on transit-time volume flow measurements were documented.

RESULTS
- Arterial inflow was, on average, 1.5 times greater than venous outflow, and arterial resistance was 3.59 times greater than venous resistance (arterial: 9.04 mL/min; venous: 7.24 mL/min)
- Free transverse rectus abdominis musculocutaneous (TRAM) flaps had the highest arterial and venous flows (14.2 mL/min; venous: 11.3 mL/min), and free radial forearm flaps (RFF) had the lowest (arterial: 6.33 mL/min; venous 5.29 mL/min).
- Compared to the baseline (In Situ) measurement, all flaps had higher flows immediately after transfer (Time 1) (p<0.0001), but no significant differences were seen 30 minutes later (Time 2) (p=0.68). Arterial resistance, however, increased during that interval (p=0.006).
- In more than a third of the cases (19 out of 52), operative decisions on when to revise an anastomosis, were modified on the basis of transit-time volume flow findings.

CONCLUSION
“Transit-time volume flow measurements provide novel physiologic flap data and identify flawed anastomoses and higher-flow venae comitantes. These data have clinical value in microsurgery and hold the potential to reduce microvascular complications and improve outcomes.”

TAKE HOME POINTS
- This publication from a microvascular surgeon key opinion leader provides proof that volume flow measurements can provide quantifiable measurements of one of the most critical pieces of microvascular reconstruction: inflow and outflow.
- The author notes that perhaps the most compelling finding of the study is that flow measurements could alter or augment surgical decision making as it had in 36% of the cases in the study. These quantitative measurements “fill a knowledge gap” in microsurgery.

REFERENCE:
Signature Annotated Microvascular References


4. Visscher K, Boyd K, Ross DC, Amann J, Temple C, "Refining perforator selection for DIEP breast reconstruction using transit time flow volume measurements," J Reconstr Microsurg. 2010; 26(5): 285-90. (Transonic Reference # CV-9953AHM) This study evaluated the correlation among computed tomographic angiography (CTA), intraoperative TFFV measurements, and hand-held Doppler signals in identifying perforators in ten consecutive free DIEP breast reconstructions. “Of the 54 perforators identified, TFFV showed arterial flow waveforms in 15 of 16 perforators identified by CTA and in 2 of the remaining 38 vessels. CTA and TFFV are highly correlated, and the use of TFFV may prevent poor perfusion seen in some DIEP flaps.”


6. Takanari K, Kamei Y, Toriyama K, Yagi S, Torii S, "Differences in blood flow volume and vascular resistance between free flaps: assessment in 58 cases," J Reconstr Microsurg. 2009 Jan; 25(1): 39-45. (Transonic Reference # 10313AH) “We investigated blood flow in the flap by transit-time ultrasound flowmeter in 58 free-flap transfers. Flow volume was compared between flap tissues as vascular resistance in the flap was calculated. Fasciocutaneous and osteocutaneous flaps had relatively low blood flow volume, myocutaneous flaps had more, and intraperitoneal flaps had still higher blood flow volume. These differences were statistically significant. Vascular resistance significantly decreased in the same order of comparison. Our findings will help in selecting the most suitable flaps for reconstructive surgery.”

7. Shaughness G, Blackburn C, Ballestin A, Akeлина Y, Asherman JA., Predicting Thrombosis Formation in 1-mm-Diameter Arterial Anastomoses with Transit-Time Ultrasound Technology. Plast Reconstr Surg. 2017 Jun;139(6):1400-1405. (Transonic Reference # 11200A) Transit-time ultrasound technology was used in this pilot study to investigate whether a minimal cutoff value for quantitative postoperative blood flow (in milliliters per minute) could be established that would reliably predict sustained vessel patency at 24 hours postoperatively.

8. Ballestin A, Casado JG, Abellán E, Vela FJ, Álvarez V2, Usón A, López E, Marinaro F, Blázquez R, Sánchez-Margallo FM, Ischemia-reperfusion injury in a rat microvascular skin free flap model: A histological, genetic, and blood flow study. PLoS One. 2018 Dec 27;13(12):e0209624. (Transonic Reference # 11532A) Transit-time ultrasound flowmeter and microvascular probes were used to verify blood flow patency intraoperatively after the end-to-end anastomoses performed in the animals of the I/R group and also to verify again blood flow one week after the procedure. Blood flow was also measured in the control group the day of surgery and at the end of the study.


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Microsurgical Flowprobes

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<table>
<thead>
<tr>
<th>PROBE SIZE (mm)</th>
<th>VESSEL OD (mm)</th>
<th>MAXIMUM FLOW (ml/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>0.4 - 0.7</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>0.7 - 1.2</td>
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<tr>
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<td>500</td>
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<tr>
<td>3</td>
<td>2.3 - 3.3</td>
<td>1000</td>
</tr>
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VESSEL SIZES FOR MICROVASCULAR FLOWPROBES
Microsurgical Flowmeters

Transonic’s new Optima Flowmeter takes transit-time ultrasound flow measurement resolution to the highest level. The Optima’s unprecedented resolution accompanies lower offsets, and doubles the accuracy for low flows. The Optima Flowmeter enables use of our new Microvascular Flowprobes for hand and other microvessel surgeries. Microprobes are available in 0.7 mm, 1 mm, 1.5 mm, 2 mm and 3 mm sizes. Their flexible neck permits optimal probe positioning and easy measurement.

- Provides unsurpassed accuracy and resolution
- Ensures vessel patency
- Immediate, quantitative flow measurements

HT353 single-channel Optima Flowmeter

HT364 dual-channel Optima Flowmeter permits simultaneous measurements with two Flowprobes.

The AureFlo® system continuously measures, displays, records and documents absolute volume flow and other derived parameters. Shown here with the new HT363 dual-channel Optima Flowmeter, it can be used with Transonic’s new Microsurgical Flowprobes.

Transonic Systems Inc. is a global manufacturer of innovative biomedical measurement equipment. Founded in 1983, Transonic sells “gold standard” transit-time ultrasound flowmeters and monitors for surgical, hemodialysis, pediatric critical care, perfusion, interventional radiology and research applications. In addition, Transonic provides pressure and pressure volume systems, laser Doppler flowmeters and telemetry systems.

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