Transplant Surgery

Reduce Allograft Risk with Intraoperative Blood Flow Measurements

- Identify Impaired Blood Flow before Closure
- Quantitively Assess Flow Quickly
- Document Restored Flow

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Intraoperative Measurements Inform during Transplantation Surgery

Lifesaving transplant surgeries challenge a transplant surgical team to perform at their highest level. During these high stake surgeries, intraoperative blood flow measurements provide quick, quantitative assessments of blood flow that may either confirm a clinical impression or alert the team to potential problems while they still can be more easily addressed.

Orthotopic liver transplantation, in particular, presents a unique opportunity for intraoperative flow measurements. Measurements are incorporated into the protocol for the multicenter Adult-to-Adult Living Donor Liver Transplantation (A2ALL) study. Since simple visualization of a pink-to-red reperfused liver doesn't ensure that both the hepatic artery and portal vein are each functioning, simultaneous hepatic/portal measurements provide an essential quality assurance.

In addition to checking the quality of anastomoses in liver, renal, pancreatic, lung and heart transplant surgeries, intraoperative measurements also identify potential kinking of conduits, particularly veins, and are useful in identifying donor-to-recipient mismatches. No other flow technology produces flow data as quickly, accurately and non-intrusively during transplant surgery as Transonic® intraoperative flow measurements.

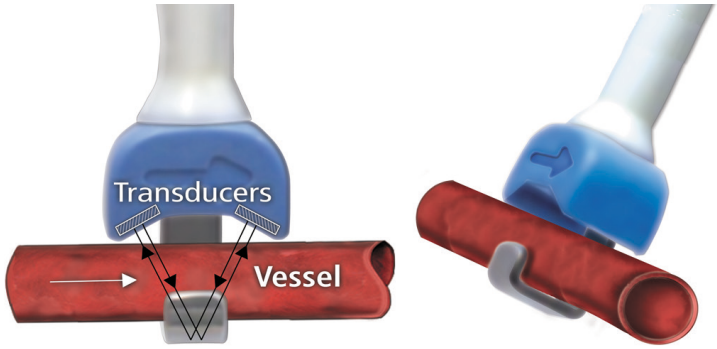
"The routine use of intraoperative flow measurements of the hepatic artery may be a useful adjunct in identifying the hepatic artery reconstruction, which is at risk of subsequent hepatic arterial thrombosis (HAT)."
Lin M et al, "Hepatic Artery Thrombosis and Intraoperative Hepatic Artery Flow Rates in Adult Orthotopic Liver Transplantation, ANZ J Surg 2002; 72: 798-800.

"Impaired hepatic arterial blood flow after reperfusion along with primary non-functioning organ (PNF) are significant predictors of increased graft injury and is associated with diminished long-term graft survival. ...Intraoperative transit time ultrasound flow measurements of the hepatic artery may allow identification of organ transplants at risk for poor outcomes. ...Hepatic arterial flow < 100 ml/min presents a significant risk on organ survival."
Pratschke S et al, "Arterial Blood Flow Predicts Graft Survival in Liver Transplant Patients," Liver Transplantation 2011; 17: 436-445.

"Intraoperative flow measurements offer the only practical method for measuring the components of portal venous and hepatic arterial flow."
Henderson JM et al, "Hemodynamics during Liver transplantation: the Interactions between Cardiac output and Portal Venous and Hepatic Arterial Flows," Hepatology 1992; 16(3) 715-71.

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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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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Flow-assisted Surgical Techniques and Notes* Adult Orthotopic Liver Transplantation[1-2]

Drawn from the clinical expertise of J Michael Henderson, MD, FACS, Emory University, Atlanta, GA

*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[2]

Abnormal hepatic hemodynamics and physiology in the transplanted liver pose continuing challenges for the surgeon. A practical method for measuring two of these hemodynamic parameters, portal venous and hepatic arterial flows, is by intraoperative flow measurements. Transit-time ultrasound technology is well suited to measure these flows. Flowprobes are easily applied and do not have to be applied tightly to vessels; they simply encompass the vessel.

Surgical Approach[2]

Measurement of portal venous and hepatic arterial flows can be easily performed at the completion of orthotopic liver transplantation using Transonic Flowprobes. Following completion of the vascular anastomoses, the new liver is reperfused, and hemostasis achieved. Prior to biliary reconstruction, the Flowprobes are placed on the reconstructed portal vein and hepatic artery.

The Probes are chosen to comfortably encompass - but not constrict - the vessels, and are placed such that extraneous tissue is excluded. The field is then immersed in saline which serves as a good acoustic contact with the vessels. Readings stabilize rapidly, usually within 1-2 minutes, and in stable patients fluctuate less than ± 10% when left in situ for 10-15 minutes. If there is wider fluctuation, this usually indicates improper positioning of the Flowprobes with poor alignment or extraneous tissue, and can normally be corrected by repositioning. Arterial flow readings are meaningful over a brief snapshot period. Venous flow exhibits a far slower rhythm, dictated by events such as gastric motility. A one-to-five minute observation period is often adequate.

Discussion[2]

Combined portal venous and hepatic artery flow are usually 15 - 25% of cardiac output. Of clinical importance is hepatic artery patency and flow, as survival of the graft depends on this. Flowprobes provide a volumetric measure of hepatic artery flow, and when this is low can be used to determine if there is a fixed anatomic limitation to flow or a physiologic limitation. For example, in a patient with a cardiac output of 10 L/min, portal flow of 2000 mL/min and hepatic artery flow of 75 mL/min, reduction of portal flow to 1000 mL/min resulted in a hepatic artery flow increase to 125 mL/min. Thus, the low basal hepatic flow resulted from a high physiologic resistance rather than a fixed, potentially surgically correctable low inflow. This kind of data can be captured on the Flowmeter for a permanent record.

The information obtained with these transit-time ultrasound Flowprobes is often at variance with "clinical impression." A transplant with obstructed hepatic artery may show a strong pressure pulse on the artery, and a healthy organ color due to its venous perfusion. Accurate information on volumetric flow at the time of operation can either be reassuring, or may indicate an unexpected problem which can be fixed at this time. In a procedure such as liver transplant, where the stakes are high, this technology can be a useful adjunct in operative decision.

Subsequent studies have identified the following intraoperative flow indices related to poor outcomes:

- Graft hyperfusion. Recipient portal venous flow in the recipient should be lowered when graft to recipient body weight ratio (GRBWR) < 0.8 is accompanied by portal inflow of > 250 mL/min/100g graft weight.[3]
- Hepatic arterial flow < 100 mL/min presents a significant risk on organ survival.[4]
- Hepatic artery flows of less than 200 mL/min following orthotopic liver transplantation increase the risk of subsequent hepatic artery thrombosis six times.[5]

References:

1. Henderson JM *et al,* "Hemodynamics During Liver Transplantation: The Interactions Between Cardiac Output and Portal Venous and Hepatic Arterial Flows," Hepatology 1992; 16(3): 715-718.
2. Henderson JM *et al,* Volumetric and Functional Liver Blood Flow Are Both Increased in the Human Transplanted Liver," J Hepatology 1993; 17: 204-207.
3. Troisi R, de Hemptinne B, "Clinical Relevance of Adapting Portal Vein Flow in Living Donor Liver Transplantation in Adult Patients, Liver Transplantation 2004; 9(9): S36-S41. (Transonic Reference # 6884AH)
4. Lin M *et al,* "Hepatic Artery Thrombosis and Intraoperative Hepatic Artery Flow Rates in Adult Orthotopic Liver Transplantation, ANZ J Surg 2002; 72: 798-800. (Transonic Reference # 7415AH)
5. Pratschke S *et al,* "Arterial Blood Flow Predicts Graft Survival in Liver Transplant Patients,"Liver Transplantation 2011; 17: 436-445.
6. Emond JC *et al,* "Hepatic Hemodynamics and Portal Flow Modulation: The A2ALL Experience," Transplantation. 2017 Oct;101(10):2375-2384. TRIAL REGISTRATION: ClinicalTrials.gov NCT01619475

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Flow-assisted Surgical Techniques and Notes*
Adult Orthotopic Liver TX Protocol[3]

Flow Measurement Steps

Living Donor

Measure right hepatic arterial and portal venous flow before hilar dissection.

↓

Document measurements to serve as guide for expected flows in the recipient.

Recipient

Recipient Hepatic Flow

Measure hepatic blood flow
- following reperfusion
- before biliary anastomosis
- before wound closure

↓

Compare with pre-transplant hepatic arterial flow

↓ < 50 mL/min

Examine anastomosis for arterial thrombosis

↓ > 100 mL/min

Remeasure hepatic flow

Flow has increased →

Recipient Portal Flow

Measure portal blood flow
- following reperfusion
- after portal pressure measurement
- before biliary anastomosis

↓

Compare with pre-transplant portal venous flow

Flow increased up to 3 times pre-transplant portal flow →

Flow increased > 3 times pre-transplant portal flow or >250 mL/min/110 gram graft weight ↓

Reduced graft inflow by shunting portal flow away from liver[1]

↓

Remeasure portal flow

→

Document flows and save waveforms for the operative record for post-op diagnostic consideration

3 Troisi R, de Hemptinne B, "Clinical Relevance of Adapting Portal Vein Flow in Living Donor Liver Transplantation in Adult Patients," Liver Transplantation 2004;9(9)Suppl 1 pp S36-S41. (6884AH)

Flow-assisted Surgical Techniques and Notes* Renal Transplantation Protocol

Drawn from the clinical expertise of A Lundell, MD, PhD, NH Persson, MD, PhD, Malmö General Hospital, Malmö, Sweden

*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[1,2]

Life saving renal transplant surgery challenges a transplant surgical team to perform at its highest level. The surgeon may elect, during these high stake surgeries, to use intraoperative blood flow measurements for a quick, quantitative assessments of blood flow that may either confirm his or her clinical impression about the quality of the anastomosis or alert the team to potential problems while they still can be more easily addressed.

Renal Arterial Flow Measurement[1]

Donor: Living Donor Kidney Retrieval

The first measurement is made on the renal artery before the kidney is removed from the donor.

Recipient: Living Donor or Cadaveric Kidneys

In primary transplantations, we use the hypogastric artery for the arterial anastomosis. In re-transplantations or in cases where the internal iliac is atherosclerotic the external iliac artery is used. In selected cases, we use a flow measurement to decide which artery to use. For the venous anastomosis, the external iliac is used. No venous flow measurements are made.

After completion of the arterial and venous anastomoses, and immediately after restoration of blood flow to the kidney, but before completion of the ureteroneocystostomy, the flow in the renal artery is measured. We use a 4 or 6 mm Flowprobe which is placed, preferably, distal to the anastomosis. The space between the Probe and the vessel is filled with sterile saline. Care is taken to avoid kinking the artery and to place the Probe perpendicular to the longitudinal axis of the vessel. Before the flow is recorded, we allow the flow signal to stabilize for 15-20 seconds. At the end of the operation, after the ureteroneocystostomy is completed and before the wound is closed, we make a second measurement.

MEAN RENAL ARTERIAL FLOWS[1]		
TRANSPLANTED KIDNEY (N = 34)[1]		
	Flow: Cadaver Kidney (mL/mm)	Flow: Living Donor Kidney (mL/mm)
Donor		381 ± 150 SD
Post flow restoration	283 ± 148 SD	338 ± 155 SD
At end of operation	422 ± 204 SD	505 ± 177 SD

FLOWPROBE RECOMMENDATIONS[3]		
VESSEL	Probe Size (mm)	Handle Probe Series
Renal artery	4, 6	-FMV
Renal vein	10	-FMV
External iliac artery	6, 8	-FMV
Hypogastric a	4, 6	-FMV

FMV Vascular Handle Flowprobes for spot flow checks during renal transplant surgery

References:
1. Lundell A *et al,* "Impaired Renal Artery Blood Flow at Transplantation Is Correlated to Delayed Onset of Graft Function" Transplant International 1996; 9(1): 57-61. (Transonic Reference # 685AH)
2. Bretan PN Jr *et al,* "Assessment of Preservation Induced Reperfusion Injury Via Intraoperative Renal Transplant Blood Flow and Endothelin Concentration Studies," J Urology 1997;158(3): 714-18. (Transonic Reference # 1093AH).
3. FlowprobeSelectionGuide(CV-66-tn) Rev I 2018USltr

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Flow-assisted Surgical Techniques and Notes*
Renal Transplantation Protocol cont.[1]

Donor

Cadaver Kidney

No measurements

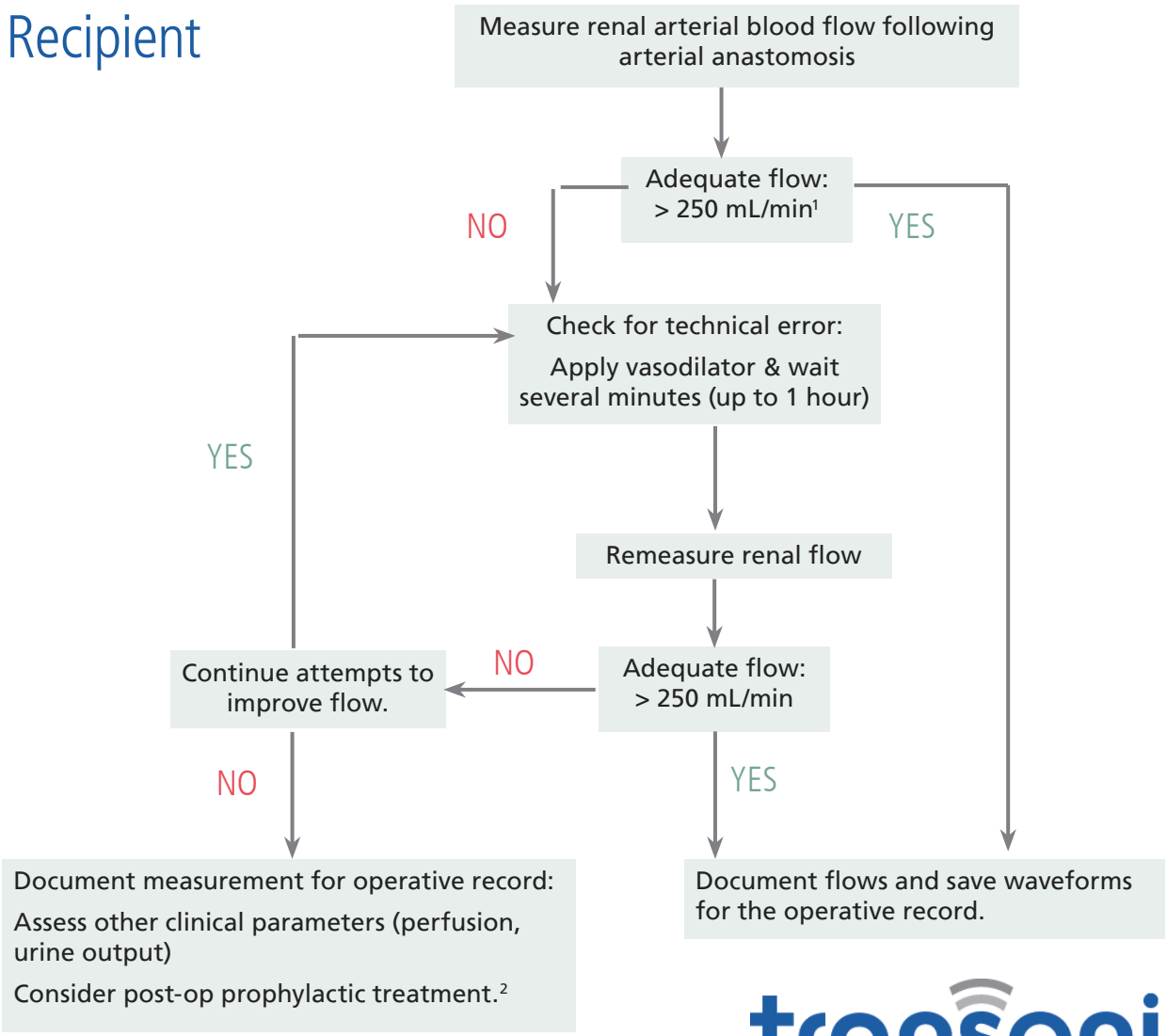
Living Donor Kidney

Measure renal arterial flow before removing the kidney

↓

Document measurements to serve as guide for expected renal flow in the recipient.

Recipient



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Flow-Assisted Surgical Technique (F•A•S•T) during Auto Islet Cell Transplantation after Pancreatectomy

F•A•S•T Medical Notes are intended to assist in surgical decision-making and are not diagnostic tools. Surgical interpretation is required.

Flow Measurement during Islet Infusion

Excising a diseased pancreas removes not only pancreatic cells that produce digestive enzymes but also Islet of Langerhans cells that produce insulin to control blood sugar. Without insulin a patient becomes diabetic and requires lifelong use of insulin to control blood sugars.

Auto islet cell transplantation takes these Islet of Langerhans cells from the pancreas and transplants them to the liver to reduce the diabetic risk. To do this, the removed pancreas is processed to isolate the insulin-producing Islets of Langerhans cells. The isolated cells are suspended in a solution and are then slowly infused through the splenic vein back into the patient's liver where it is anticipated that they will implant, grow and produce insulin to metabolize sugar.

Typically, 800 - 1500 cc of solution is infused into the portal vein distal to the splenic vein (Fig. 2) over an extended period of time. The team may elect to infuse a small amount over 5 minutes and allow the patient to recover before resuming the infusion. Blood pressure and flow are monitored continuously and for ten minutes after the infusion is completed (Fig. 1).

Flow Measurement during Islet Infusion

Surgeons measure portal venous flow during islet cell infusion to detect any sudden decrease in flow that may foreshadow a problem with the infusion. A 10 mm to 14 mm Perivascular Flowprobe is placed on the portal vein and flow is measured continuously. The Flowprobe is chosen to comfortably encompass - but not constrict - the portal vein. If needed, saline can be used to provide acoustic contact between the vein and Flowprobe. Readings stabilize within 1-2 minutes. Wide fluctuation of measurements may indicate improper positioning of the Flowprobe with poor alignment or fat within the ultrasonic sensing window. Repositioning can normally correct this problem.

Discussion

Portal venous flow measurements provide a continuous volumetric measure of flow that informs the surgeon about the safety, fluidity and success of auto islet cell transplantation.

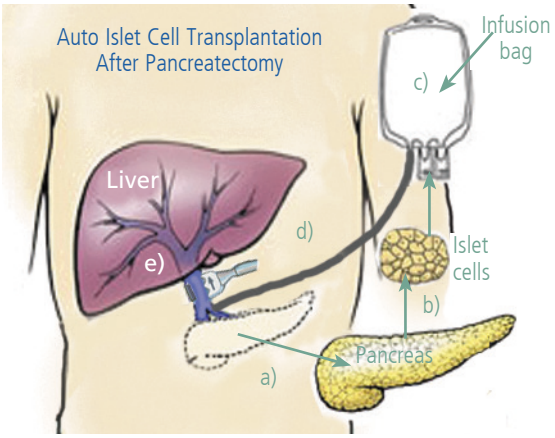

Fig. 1: Steps: Auto Islet Cell Transplantation
a) Removal of pancreas (pancreatectomy)
b) Isolation of Islet cells from removed pancreas
c) Islet cells placed in Infusion bag with solution
d) Islet cells infused into splenic vein
e) Islet cells implant in liver

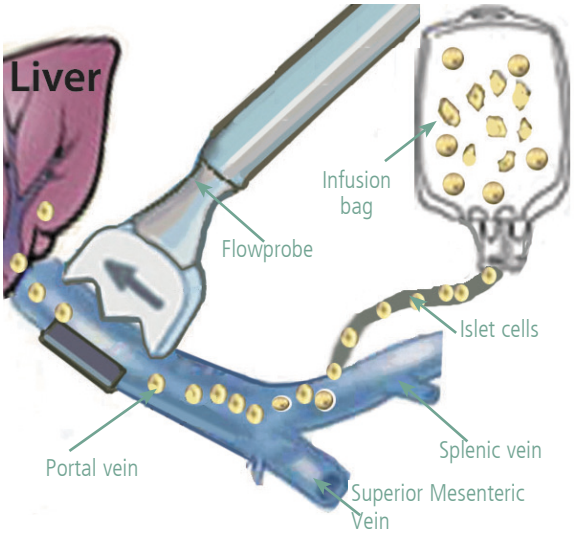

Fig. 2: Enlarged view of islet cell infusion into the splenic/portal venous system.

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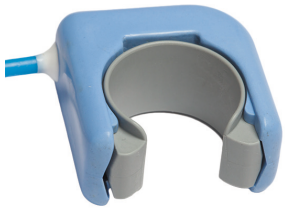
Flow-Assisted Surgical Technique (F•A•S•T) during Auto Islet Cell Transplantation after Pancreatectomy cont.

Flowprobe Needs:



COnfidence Flowprobe®

COnfidence Flowprobes® provide highly accurate measurements in vessels with fluctuating flows such as the portal vein. The Probes may be left in place for extended measurements and then easily removed via a ring attached to the pliable liner that cushions and protects the vessel.

8 mm to 14 mm FMV Vascular Handle Flowprobes are recommended for spot-check portal venous flow measurements during islet cell infusion.

F•A•S•T during Auto Inlet Transplantation surgery is based on the following:

Sutherland DE *et al,* "Total pancreatectomy and islet autotransplantation for chronic pancreatitis," J Am Coll Surg. 2012; 214(4): 409-24.

Bramis K *et al,* "Systematic review of total pancreatectomy and islet autotransplantation for chronic pancreatitis." Br J Surg. 2012; 99(6): 761-6.

http://www.hopkinsmedicine.org/transplant/programs/auto_islet/description.html#total_pancreatectomy

Henderson JM *et al,* "Hemodynamics During Liver Transplantation: The Interactions Between Cardiac Output and Portal Venous and Hepatic Arterial Flows," Hepatology 1992; 16(3): 715-718.

Henderson JM *et al,* Volumetric and Functional Liver Blood Flow Are Both Increased in the Human Transplanted Liver," J Hepatology 1993; 17: 204-207.

Troisi R, de Hemptinne B, "Clinical Relevance of Adapting Portal Vein Flow in Living Donor Liver Transplantation in Adult Patients, Liver Transplantation 2004; 9(9): S36-S41.

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Flow-assisted Surgical Techniques and Notes* Distal Spleno-renal (Warren) Shunt Construction

Drawn from the clinical expertise of J Michael Henderson, MD, FACS, Emory University, Atlanta, GA

*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[3]

Following hepatic (liver) surgery, a distal spleno-renal shunt (DSRS) provides selective variceal decompression to control bleeding gastroesophageal varices, while maintaining portal hypertension and prograde portal flow to the liver (Fig. 2).

Thrombosis of distal spleno-renal shunts occur in less than 10% of patients, but usually occurs early (in the first week) and requires reoperation. Intraoperative measurement of shunt flow shows great potential to reduce the risk of this complication.

Surgical Approach[1]

On completion of the distal spleno-renal shunt anastomosis, 2-3 cm of the splenic vein is free below the pancreas before it is anastomosed to the left renal vein. A Transonic® Flowprobe can be placed on this segment of the splenic vein for volumetric flow measurement (Fig. 2). A properly sized Flowprobe is chosen to fit comfortably around the vein without compressing it. It should lie in line with the vessel, and no tissue should be interposed. Ultrasonic contact is assured by immersing the field in saline. Flow measurements stabilize within one minute, and fluctuate less than ± 10%.

Discussion[1]

What should the flow be in a distal spleno-renal shunt? This is a high flow shunt, with volumetric flows determined largely by spleen size. There appears to be approximately 1 mL/min flow per cubic centimeter spleen volumes - i.e. a 750 cc spleen will give a shunt volumetric flow of approximately 750 mL/min.

After first removing the clamps, flow tends to be higher than it will be after 5-10 minutes when the initial hyperemia has resolved. If flow is significantly less than this approximation, a technical error should be considered.

- Is the splenic vein kinked?
- Is there a problem with the anastomosis?

Now is the time to identify and correct a technical problem: transit-time ultrasound Flowprobes offer a method for identifying low flow in this shunt.

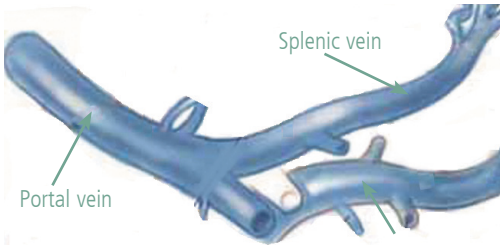

Fig. 1: Schematic of splenic vein in relation to renal vein.

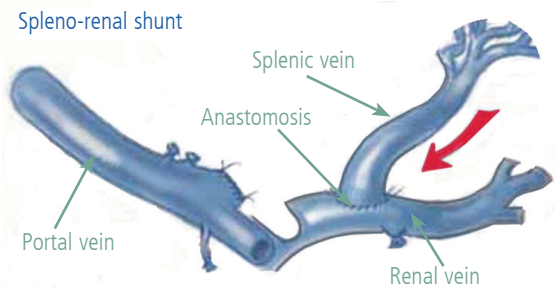

Fig. 2: Schematic of anastomosis of the splenic vein to the renal vein to create a distal Spleno-renal shunt.

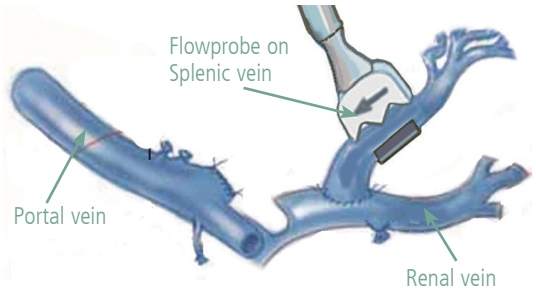

Fig.3: Flowprobe measuring flow in the splenic vein following anastomosis of the splenic vein to the renal vein.

http://www.vesalius.com/cfoli frms.asp illustrations modified by Transonic

References
1. Medical Note #3, 1990, written by J. Michael Henderson, MD, FACS
2. http://www.vesalius.com/cfoli frms.asp;
3. http://www.clevelandclinic.org/health/health-info/docs/1900/1930

Signature Annotated Transplant References

1. Emond JC *et al,* "Hepatic Hemodynamics and Portal Flow Modulation: The A2ALL Experience," Transplantation. 2017;101(10):2375-84. (Transonic Ref # TX112316AH). *A principal aim of the A2ALL-2 study was to measure liver flows during LDLT and to describe the use of flow modulation guided by Transonic flow measurements in order to determine the effects of portal modulation on hepatic hemodynamics and clinical outcomes.*

2. Spitzer AL, Dick AA, Bakthavatsalam R, Halldorson JB, Salvalaggio PR, Reyes JD, Perkins JD, "Intraoperative portal vein blood flow predicts allograft and patient survival following liver transplantation," HPB (Oxford). 2010 Apr;12(3):166-73. (Transonic Reference # TX11358AH) *"Intraoperative portal vein blood flow predicts allograft and patient survival following liver transplantation." "Recognition of appropriate inflow and conduit is among the surgeon's foremost responsibilities and offers an opportunity to effect a change in outcome."*

3. Wang HK, Chen CY, Lin NC, Liu CS, Loong CC, Lin YH, Lai YC, Chiou HJ, "Comparison of Two Devices for Intraoperative Portal Venous Flow Measurement in Living-Donor Liver Transplantation: Transit Time Ultrasound and Conventional Doppler Ultrasound," Transplant Proc. 2018; 50(4): 1157-1159. (Transonic Reference # TX11357AH) *Intraoperative TTU and CDU showed moderate agreement in portal flow measurement. However, a relatively wide range of variation exists between TTU and CDU, indicating that data obtained from the two devices may not be interchangeable.*

4. Wu TJ *et al*, "Impact of portal venous hemodynamics on indices of liver function and graft regeneration after right lobe living donor liver transplantation," Liver Transpl. 2011 Sep;17(9):1035-45. (Transonic Reference # 11197AH) *Comprehensive Taiwanese study of the hemodynamics in 64 patients with cirrhosis who underwent living donor liver transplantation.*

5. Abbasoglu O *et al,* "Does Intraoperative Hepatic Artery Flow Predict Arterial Complications after Liver Transplantation?" Transplantation 1998: 66(5) 598-601. *Early comprehensive landmark liver transplant study 367 patients. Conclusion: Hepatic artery flow measurement should be obtained at the time of OLT and may help predict early (but not late) post transplant stenosis or thrombosis. Patients with HA flows < 400 ml/min may carry a higher risk of complications.*

6. Pratschke S *et al,* "Arterial Blood Flow Predicts Graft Survival in Liver Transplant Patients," Impaired hepatic arterial blood flow after reperfusion along with primary non-functioning organ (PNF) are significant predictors of increased graft injury and is associated with diminished long-term graft survival," Liver Transplantation 2011; 17: 436-445. *Conclusion: Intraoperative transit time ultrasound flow measurements of the hepatic artery may allow identification of organ transplants at risk for poor outcomes.*

7. Troisi R *et al,* "Clinical Relevance of Adapting Portal Vein Flow in Living Donor Liver Transplantation in Adult Patients," Liver Transplantation 2004; 9(9): S36-41. *Flow measurements are important in determining liver donor/recipient graft mismatch in order to decide whether measures are needed to moderate a mismatch.*

8. Marcos A *et al,* "The Interrelationship between Portal and Arterial Blood Blood Flow after Adult to Adult Living Donor Liver Transplantation, Transplantation 2000: 70(12) 1697-1703. *"The hemodynamic pattern after right lobe transplantation is predictable and intraoperative measurements and ultrasonography are useful for monitoring. The size of the graft influences the magnitude of hemodynamic changes."*

9 Henderson JM *et al,* "Hemodynamcis during Liver Transplantation: The Interactions between Cardiac Output and Portal Venous and Hepatic Arterial Flows," Hepatology 1992; 16(3): 715-8. *Increased flow in the newly transplanted liver is predominantly portal, is associated with high CO and reduced hepatic flow.*

10 Lundell A *et al,* "Impaired Renal Artery Blood Flow at Transplantation Is Correlated to Delayed Onset of Graft Function" Transplant International 1996; 9(1): 57-61. (685AH) *Landmark study compared the transit-time flow measurements to other methodologies and measured flow and resistance before construction of the ureter anastomosis and after. Correlation established between low renal blood flow (<250 mL/min) and delayed onset, based on lack of a decrease in serum creatinine at 24 hours.*

11 Goodyear SJ *et al,* "The feasibility and applications of non-invasive cardiac output monitoring, thromboelastography and transit-time flow measurement in living-related renal transplantation surgery: results of a prospective pilot observational study" Transplant Res. 2014; 29(3): 16. "*Reduced renal arterial blood flow, was able to accurately predict an anastomotic complication in one subject. The reading was consistent with the intraoperative appearance of the allograft and facilitated the decision to immediately revise the anastomosis, perform thrombectomy and ultimately salvage the transplanted kidney."*

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Vascular Flowprobes for TX Surgery

Transonic® Flowprobes work with HT300-Series Flowmeters to measure volume flow in blood vessels and grafts from 0.5 to 36.0 mm. The measurement of flow in vessels during transplant procedures can guide surgical decisions. The ability to correct otherwise undetectable flow restrictions provides the surgeon with an opportunity to improve the outcome for the patient.

Fig. 1: 4 and 6 mm Vascular Flowprobes recommended for measuring hepatic arterial flow. Picture shows Flowprobe handle with size of Probe in mm, the Probe's flexible neck for optimal positioning of the Probe around the vessel, the Probe body that houses the ultrasonic transducers, and the Probe reflector. Vessel is positioned within the Probe sensing window that is defined by the Probe body and its stationary reflector.

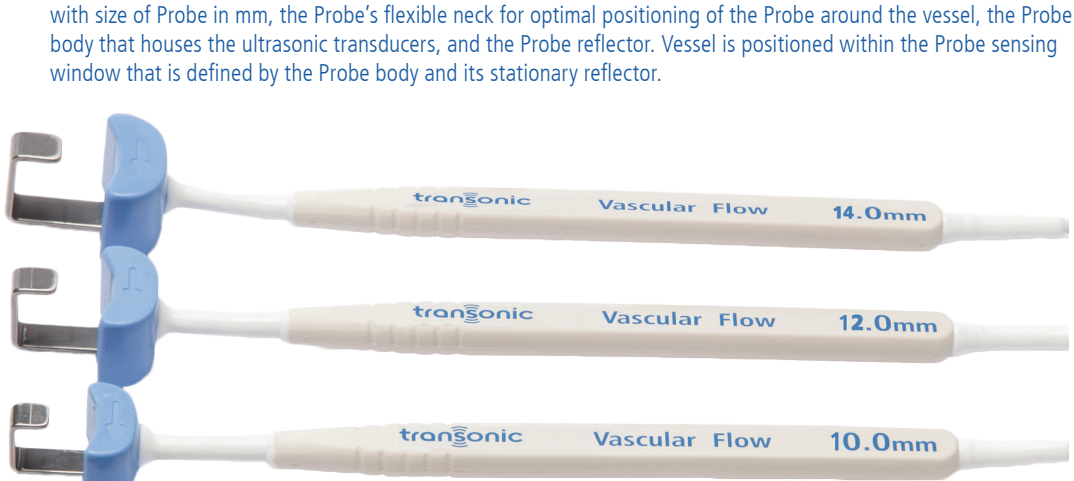

Fig. 2: 8 mm, 10 mm, 12 mm and 14 mm Vascular Flowprobes recommended for measuring portal venous flow.

FLOWPROBES: TRANSPLANT SURGERY		
LIVER	Probe Size (mm)	Probe Series
hepatic artery	4, 6	FMV
portal vein	10, 12, 14	FMV, -AU
KIDNEY		
ascending aorta	4, 6	FMV, -FSB
pulmonary artery	10	FMV, -FSB
PANCREAS		
common iliac artery	8	FMV, -FSB

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COnfidence Flowprobes for TX Surgery

Four-transducer COnfidence Flowprobes® provide highly accurate measurements in vessels with turbulent flows such as the ascending aorta or portal vein. Available in 17 sizes from 4 mm to 36 mm, the Flowprobe's slim, ergonomic profile is designed for measurements in great vessels in adults, pediatrics, and even neonates where a small Probe footprint is desirable. COnfidence Flowprobes® may be left in place for extended measurements and then easily removed via a ring attached to the pliable liner that cushions and protects the vessel.

Fig 1: COnfidence Flowprobes® (-AU-Series), designed with four transducers, provide highly accurate measurements in vessels with highly turbulent flows such as the portal vein. The Flowprobe's slim, ergonomic profile creates a minimal footprint that fits in tight anatomical sites. The soft, pliable liner cushions and protects the vessel. Available in 17 sizes from 4 mm to 36 mm.

Fig. 2: A COnfidence Flowprobe showing the Flowprobe shell and the pliable liner that cushions and protects the vessel during extended measurements.

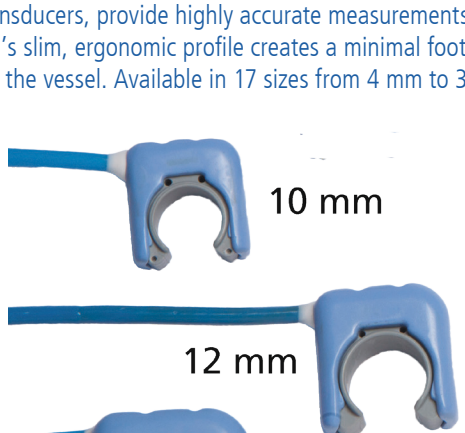

Fig. 3: 10 mm, 12 mm and 14 mm COnfidence Flowprobes recommended for extended measurements of portal venous flow.

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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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