Medical Note

Intraoperative Blood Flow Measurement during Adult Orthotopic Liver Transplantation

Courtesy of J. Michael Henderson, M.D., F.A.C.S.

Introduction

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

Measurement of portal venous and hepatic arterial flows can be easily done 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

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 artery flow resulted from a high physiologic resistance rather than a fixed, potentially surgically correctable low inflow. This kind of data can be collected on the flowmeter's strip chart recorder 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.

transonic
THE MEASURE OF BETTER RESULTS.

Intraoperative Blood Flow Measurements

Flow-Assisted Liver Transplantation

LIVER HEMODYNAMICS		
TRANSPLANTED LIVER (N = 34)[1]		
Vessel	Flow: Mean ± SD (L/mm)	Range
Total Liver	2.091 ± .932	.570 - 4.540
Portal vein	1.808 ± .929	.300 - 4.500
Hepatic artery	0.268 ± 157	0.30 - 0.675

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:

- Poor outcome is associated with 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]

Equipment Needed

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

8-14 mm -AU 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.

References

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[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.

[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.

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FLOWPROBE RECOMMENDATIONS		
VESSEL	Probe Size (mm)	Probe Series
Hepatic artery	4 - 8	-FMV
Portal vein	8 - 14	-FMV, -AU
Common iliac a	8	-FMV, -FSB

4 mm and 6mm FMV Vascular Handle Flowprobes are recommended for hepatic arterial flow measurements.

8 to14 mm FMV Vascular Handle Flowprobes are recommended for portal venous flow measurements.

Adult Liver Donor Liver Transplantation

Hepatic Artery & Portal Vein

Protocol

Living Donor

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

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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

↓

Remeasure hepatic flow

↓ Flow has increased

↓ > 100 mL/min

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

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