The Institution of Veno-veno-bypass by Peripheral Cannulation under Emergent Intraoperative Conditions

AARON L. ZUCKERBERG, M.D.,* CHARLES BEATTIE, M.D. PH. D.,† WILLIAM T. MERRITT, M.D.,‡ KEITH D. LILLEMoe, M.D.,§ ANDREW S. KLEIN, M.D.,§ G. MELVILLE WILLIAMS, M.D.¶

Experience from orthotopic liver transplantation has demonstrated the adverse hemodynamic consequences of suprahepatic inferior vena cava cross-clamping,1 as well as the utility of centrifugal pump-assisted veno-veno-bypass in avoiding these complications.2 Specifically, venous return, and as a result, cardiac output, is maintained while avoiding visceral engorgement, excessive bleeding, and the accumulation of acid metabolites. Veno-veno-bypass has also been used for patients undergoing dissection of the retrohepatic inferior vena cava for renal cell carcinoma.3–5 Cannulation for bypass in these instances was accomplished by thoracotomy to access the right atrium and by femoral vein cutdown. Current practice in our institution includes participation of the anesthesia team in the percutaneous placement of cannulae for bypass and in the management of pump flow during routine orthotopic liver transplantation. This experience was invaluable in the following case, wherein the emergent implementation of veno-veno-bypass by peripheral cannulation was lifesaving during an hepatic resection for metastatic tumor.

CASE REPORT

A 60-yr-old woman with a history of hypertension was scheduled to undergo a right hepatic lobectomy for a solitary ovarian metastasis. She had undergone a total abdominal hysterectomy and bilateral salpingo-oophorectomy for an ovarian granulosa cell tumor 13 yr previously.

The patient was brought to the operating room, and a radial arterial catheter, two peripheral (18-G), and a 14-G and an 8.5-Fr internal jugular intravenous cannula were inserted. Anesthesia was induced with fentanyl, midazolam, and thiamylal; the trachea was intubated; and anesthesia was maintained with fentanyl, enfurane, and pancuronium. The patient remained hemodynamically stable throughout the initial aspects of the procedure. Exploration revealed a large mass located posteriorly in the right hepatic lobe with no evidence of extrahepatic disease.

During dissection of the right hepatic vein, retraction of the large tumor mass distorted the anatomy, leading to inadvertent complete transection of the suprahepatic inferior vena cava. Inadequate control of the massive hemorrhage from the right hepatic vein led to profound hypotension. During the next 2.5 h, complete control of hemorrhage was obtained with occlusion of the proximal and distal vena cava and hepatic veins. During this period, the patient received 30 units of blood and required an epinephrine infusion of 0.5 µg · kg⁻¹ · min⁻¹ to maintain systolic blood pressures greater than 60 mmHg. As a result, her heart rate increased to >120 beats per min with resultant 5-mm ST-segment depressions in ECG leads II and V5. A persistent metabolic acidosis (base deficit of 11) developed, which was resistant to 850 mEq of sodium bicarbonate. Anuria developed at this time; dopamine was infused, and furosemide and mannitol were administered.

Exposure of the surgical field had become increasingly difficult due to visceral distention. The right hepatic lobectomy was completed; however, it was apparent that reconstruction of the vena cava would be necessary, but hemodynamic instability and massive venous congestion appeared to make this impossible. At this time a right antecubital vein was cannulated with an 8.5-Fr cannula using a modified Seldinger technique. An 8.5-Fr cannula also was placed in the left femoral vein by surgical cutdown. Using a Biomedicus centrifugal pump (Biomedicus, Eden Prairie, MN), veno-veno-bypass was initiated with the antecubital cannula accepting pump outflow and the femoral cannula supplying inflow. Flow rate was begun at 0.74 l/min and increased to 1.0–1.5 l/min; heparin was not administered. During the bypass period, hemodynamic stability was restored, with an 80% reduction in epinephrine requirements. The tachycardia resolved along with the ST-segment depression. Urine output resumed shortly after bypass was begun. Hemoglobin and intravascular volume were replenished; minimal transfusions were required throughout the remainder of the case. During the period of veno-veno-bypass, an inferior vena cava–right atrial shunt was constructed using an 18-mm ringed Gortex graft. At the completion of the vascular reconstruction, hemostasis was achieved, and the abdomen was closed using a Marlex mesh necessitated by residual intestinal distention.

The patient's condition continued to improve in the immediate postoperative period. There was no evidence of a myocardial infarction; renal function never appeared to be impaired; and the patient remained neurologically intact. She was returned to the operating room on postoperative day 7 for removal of the Marlex mesh and primary closure of the abdomen. Although the patient required prolonged tracheal intubation and respiratory support, she suffered no other postoperative complications and was discharged home on postoperative day 46.

DISCUSSION

The use of a veno-veno-bypass system during the anhepatic phase has virtually revolutionized orthotopic liver

Downloaded From: http://anesthesiology.pubs.asahq.org/pdfaccess.ashx?url=/data/journals/jasa/931327/ on 06/19/2017
transplantation. Prior to the reports of Shaw et al.\(^6\) and 
Griffith et al.\(^7\) in 1984, the anhepatic phase was marked 
by abdominal venous engorgement with massive blood 
loss and metabolic derangements. Without bypass, only 
a 60–90-min period of venous occlusion was tolerated by 
most patients.\(^8\)

Two reports suggested the routine use of vено-veno-
bypass in liver transplantation. Griffith et al. described a 
veno-veno-bypass system using a Biomedicus pump that 
did not require systemic administration of heparin.\(^7\) Shaw 
et al.\(^6\) then described the use of this system in a series of 
28 patients. Hemodynamic parameters were preserved 
during the anhepatic phase with a decrease in systemic 
oxygen extraction. Cardiac index decreased 22% 
compared to 50% in a nonbypass group. Furthermore, the 
bypass group required less blood intraoperatively and 
demonstrated better postoperative renal function and 
better survival.\(^6\) Although some controversy still 
surrounds the routine use of bypass during liver transplant-
ation,\(^8\) the hemodynamic, metabolic, and technical ad-

tantages makes this system attractive.

Aside from its use in orthotopic liver transplantation, 
veno-bypass has been used as an aid in other retrohepatic 
vena cava surgery. Attwood et al.,\(^9\) David et al.,\(^4\) and 
Janosko et al.\(^5\) separately reported the use of venoatrial 
bypass using a Biomedicus pump during resection of renal 
carcinoma invading the vena cava. In each of these cases, 
the patients received heparin prior to institution of 
veno-bypass. The suprahepatic vena cava was clamped, and 
bypass was begun. David et al.\(^4\) reported the use of pump 
flows of 1.3–2 l/min in order to maintain right atrial 
pressure of 5–8 mmHg. Janosko et al.\(^5\) used the pump as 
a means to recirculate extravasated blood and as a means 
to rewarmp the patient by interposition of an oxygenator 
circuit. In each of these reports, veno-bypass was extolled 
as a means of providing a superior operative field while 
maintaining adequate venous return. Veno-veno-bypass is 
not without its own complications, such as mechanical 
malfunction, thrombosis, and air embolism.\(^9\)

To expedite initiation of vено-veno-bypass in routine 
orthotopic liver transplants, we have developed techniques 
that include the percutaneous placement of 8.5-Fr can-
nulae for veno-bypass outflow to the proximal circulation, 
and occasionally for pump inflow via the femoral vein, by 
the anesthesia team before surgery. This team then assists 
in the subsequent management of bypass parameters. 
Based on this experience, in the above case the anesthe-
siologists placed the outflow cannula and managed vено-
veno-bypass in conjunction with the perfusion technologist 
during a period of massive hemorrhage. Because of the 
proximity of the femoral circulation to the surgical field, 
the femoral vein was cannulated by the surgical staff using 
a cutdown technique. Up to 1.5–4.1/min flow was attained 
using the two 8.5-Fr catheters; thus, heparin administra-
tion was not required.

The case we report is unique in a number of aspects. 
Veno-veno-bypass was instituted as an emergent interven-
tion when intraoperative events dictated that continued 
suprahepatic inferior vena cava obstruction was life-
threatening. A surgical approach to more central venous 
structures in an effort to establish more traditional vено-
veno-bypass access was severely limited by the massive 
going hemorrhage; thus, peripheral cannulation was the 
sole option. The anesthesiologists' assessment of the ade-
quacy of cardiac output and volume status in collabora-
tion with the surgeons' evaluation of the operative field 
contributed to the rational management of vено-veno-
bypass. After the institution of bypass renal function re-
turned, ongoing blood loss decreased; visceral distention 
was diminished; and hemodynamic stability was restored.

REFERENCES

5. Janosko EO, Powell CS, Spence PA, Hodges WE, Lust, RM: Surgical management of renal cell carcinoma with extensive intra 
caval involvement using a venous bypass system suitable for rapid conversion to total cardiopulmonary bypass. J Urol 145: 
555–557, 1991