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Exchange Autotransfusion Using the Cell Saver during Liver Transplantation

To the Editor:—The use of blood salvage techniques to reduce demand for banked red blood cells and minimize the risk of transfusion-transmitted diseases is well accepted during most surgical procedures. However, the role of the cell saver is controversial in patients undergoing liver transplantation.[1] Potential risks of heparinization or contamination of salvaged blood from the abdomen has only recently been evaluated.[2]

Patients presenting for liver transplantation may be in severe hepatic and renal failure, resulting in extremely high serum levels of ammonia, lactate, potassium, and other products of catabolism, despite preoperative dialysis. Intraoperative plasma ultrafiltration (and partial dialysis) can be continued utilizing a continuous arteriovenous hemofiltration device.[3] Rapidly infused banked red blood cells may cause lethal elevations in serum potassium. This can be ameliorated either with preoperative laboratory cell washing,[4] which is time-consuming and expensive, or with intraoperative processing with the cell-saver.[5]

Despite all of these measures, high serum levels of ammonia, lactate, and potassium can still occur. These problems are compounded at the time of hepatic graft reperfusion, when a considerable acid and potassium load may be flushed into the systemic circulation. This may result in severe hemodynamic compromise, potentially causing cardiac arrest or loss of the newly grafted organ. To reduce this risk, serum levels of these catabolites could effectively be lowered during the anhepatic phase of the transplantation by exchange transfusion.

We were able to effectively "exchange autotransfuse" a 62-yr-old male in fulminant hepatic and renal failure using the cell saver (Haemonetics Cell Saver System III), during the anhepatic phase of a liver transplantation. The patient had been hemodialyzed preoperatively, and a continuous arteriovenous hemofiltration device had been inserted *via* the femoral vessels; however, ammonia and lactate serum levels remained elevated. The patient's blood was withdrawn in sterile fashion *via* regulated suction applied directly to an 8 Fr. jugular venous catheter, and drained into the cardiotomy reservoir of the cell saver. This was then washed with normal saline and reinfused, along with a like quantity of washed banked red blood cells, to a total of 5000 cc. Additional plasma components and calcium were replaced as indicated by laboratory values and the thromboelastograph. Table 1 shows the effectiveness of the cell saver in removing ammonia, lactate, and potassium. We also tested banked red blood cells, and the levels obtained from similar processing in the cell saver; these are also shown in table 1. These results generally agree with those of others.[5]

Graft reperfusion was well tolerated, and the case concluded uneventfully, with good evidence of a functioning hepatic graft.

We believe that this provides a new and potentially valuable application of autotransfusion technology, and one which merits more intensive investigation.

TABLE 1. Electrolyte Changes with Cell-saver Processing

Serum Values (Normals)	—Patient's Blood— *In Vivo* Pre-CSP	*In Vitro* Post-CSP	*In Vivo* Post-CSP	Banked PRBCs Pre-CSP	Post-CSP
Ammonia (15–40 μm/l)	85	40	43	693	92
Lactate (0.5–2.2 mm/l)	16.4	5.1	5.9	24.8	10.6
Potassium (3.5–5.0 meq/l)	4.2	1.1	3.6	>30	1.3

CSP = cell saver processing; PRBC = packed red blood cells.

MARC R. BROWN, M.D.
Fellow in Anesthesiology
Baylor University Medical Center and
The University of Texas
Southwestern Medical Center
Dallas, Texas

MICHAEL A. E. RAMSAY, M.D.
Director of Transplant Anesthesia
Baylor University Medical Center

THOMAS H. SWYGERT, M.D.
Attending Anesthesiologist
Baylor University Medical Center
3600 Gaston Avenue
Dallas, Texas 75246

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Air Entrainment Through a Multiport Injection System

To the Editor:—The FDA recommends that anesthesiologists avoid recapping of needles after their use to prevent needle stick injuries.* For anesthesiologists, who administer multiple drugs for complex cases, this poses a considerable difficulty. Consequently several devices have recently been introduced that allow the injection of multiple drugs *via* a manifold system of one-way valves interposed in the intravenous tubing. We have recently discovered that such a system may allow significant air entrainment.

Report of a case: A 64-yr-old male was scheduled for coronary artery bypass grafting. Prior to induction of anesthesia, a 14-gauge catheter was inserted in a vein in the left forearm, a 20-gauge catheter was inserted into the left radial artery, and a pulmonary artery catheter was inserted *via* the right internal jugular vein. A Multiport Anesthesia Injection Set with Check Valves (item 9113, Quest Medical Inc., Carrollton, Texas) was interposed in the side port of the sheath introducer. Anesthesia was induced with fentanyl (100 μg/kg) and maintained with fentanyl/oxygen. All drugs were administered *via* the Multiport Anesthesia Injection Set. Just prior to initiation of cardiopulmonary bypass, the anesthetist administered additional fentanyl and muscle relaxants and removed the syringes from their individual check valves. Upon initiation of bypass, the perfusionist immediately noted that large amounts of air were returning *via* the venous cannulae. The anesthetist noted that air bubbles were moving down the side port of the sheath introducer into the internal jugular vein. Since it appeared that the air bubbles were originating from the check valve areas of the Multiport Anesthesia Injection Set, the anesthetist capped each port with a solid plastic Luer-Lock cap. This immediately stopped the air from being entrained. The Multiport Anesthesia Injection Set was removed and the case continued uneventfully.

In order to rule out the possibility that the valves in this case were "stuck" in the open position, we measured the negative pressure necessary to open the one-way valves in this system and in two other check valve systems currently available in our department. A simple water manometer was attached to each system in turn. The pressure required to open the one-way valves to allow air entrainment and to overcome the valve to cause a leak was measured. Tested were the device described above, which consists of a hard plastic manifold with three side ports, the Quest™ model 9107 trifurcated extension set which has two side ports with check valves, and the Cutter Chexet™ anesthesia set which has one check valve on the main intravenous tubing and a spring-loaded check valve on a single side port. Each set is sold with plastic caps attached to the side ports.

Results for the two models manufactured by Quest were similar: when used directly from the package, a negative pressure of 28–35 cm H_2O resulted in entrainment of air. With the caps then tightened as much as possible, a negative pressure greater than 100 cm H_2O was required to overcome the valve and entrain air. With the caps removed, however, as is the case whenever drug injections are made, *negative pressures of as little as 2–4 cm H_2O were sufficient to overcome the valve.* Altering the orientation of the valves made little difference. Also noted was that, of eight sets of valves tested, two leaked with back pressures of only 15–20 cm H_2O (*i.e.*, considerably less than that achieved by injections at an adjacent valve). The remaining valves remained closed to pressures over 100 cm H_2O. We also demonstrated that there was an apparent Venturi effect that resulted in entrainment of air through the one-way valves when fluid was infused into the iv port of the set.

The spring loaded check valve in the side port of the Cutter Chexet™ withstood negative pressures greater than 60 cm H_2O, and did not leak with back pressures of greater than 100 cm H_2O. The check valve without a spring entrained air at 3–5 cm H_2O.

These studies demonstrate that currently available multiport injection systems entail significant risk of air entrainment unless they are continuously capped or clamped. Most worrisome was that the Venturi effect of rapidly infusing fluid past the side ports was sufficient to entrain air. The Cutter spring-loaded valve successfully resisted entrainment when properly connected, but since only one side of the Y contains a spring-loaded valve, it entails the same risk as the Quest sets if the intravenous and side port connections are reversed.

Anesthesiologists must carefully examine multiport injection systems in use in their hospitals, and take measures to prevent air entrainment. Manufacturers are urged to provide spring-loaded check valve systems on each arm of multiport systems, or to clearly delineate which ports allow air entrainment.

DEAN GILBERT, M.D.
Resident in Anesthesiology

THEODORE J. SANFORD, JR., M.D.
Associate Clinical Professor of Anesthesiology
Chief of Service—VA Medical Center

BRIAN L. PARTRIDGE, M.D., D.PHIL.
Assistant Professor of Anesthesiology
Department of Anesthesiology

University of California San Diego and Veterans Administration Medical Center
San Diego, California 92161

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