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Technique Article

A Technique for Autologous Priming of the Veno-Venous Bypass Circuit during Liver Transplantation

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Abstract: Orthotopic liver transplantations (OLT) have been associated with significant blood loss and hemodilution, necessitating significant homologous blood component replacement. Increasing administration of homologous blood products has been found to be inversely related to patient and graft survival. Various methods to reduce the amount of blood products patients receive during OLT, such as antifibrinolytic therapy, thromboelastography-guided transfusion, phlebotomy, reduced central venous pressures intraoperatively, and the use of the veno-venous bypass (VVB) circuit, have been explored. The asanguineous priming volume of the VVB circuit increases the likelihood of the patient receiving homologous blood products due to hemodilution. It was reasoned that autologous priming of the VVB circuit in OLT surgery was a plausible adjunctive blood conservation technique given its application to the extracorporeal circuit during cardiac surgery. We describe our technique of modifying the VVB circuit for autologous priming. This technique adds minimal risk and a small amount of cost to the procedure, requires slightly more communication among members of the surgical team, and with proper sequencing, adds no additional length to the surgical procedure. It is recommended that this technique be considered for addition to the arsenal of blood conservation techniques when VVB is used during OLT. **Keywords:** liver transplant, veno-venous bypass, autologous priming, blood conservation. *JECT. 2011;43:89–92*

OVERVIEW

Over 6000 orthotopic liver transplantations (OLTs) are performed in the United States annually (1). Historically, OLTs have been associated with significant blood loss and hemodilution, necessitating significant homologous blood component replacement (2). Increasing administration of homologous blood products has been found to be inversely related to patient and graft survival (3). Various methods to reduce the amount of blood products patients receive during OLT, such as antifibrinolytic therapy, thromboelastography-guided transfusion, phlebotomy, reduced central venous pressures intraoperatively, and the use of the veno-venous bypass (VVB) circuit, have been studied and reviewed (1,2,4–6).

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The advantages and disadvantages of using VVB for OLT have been debated and documented (7). The VVB circuit does bring additional considerations to the operation; however, there are times during OLT when VVB is warranted. Indications may include the need for preserved cardiac output and increased hemodynamic stability, prevention of splanchnic and lower systemic venous hypertension if the inferior vena cava (IVC) and portal vein are being clamped, and the prevention of hypothermia (7,8). The VVB circuit is commonly primed with a balanced electrolyte asanguineous solution, which affords an air free fluid-to-fluid connection to the patient's venous vascular circulation and is mixed with the patient's blood on VVB. Because of this additional hemodilution, the likelihood of the patient receiving homologous blood products is increased, as compared to a patient undergoing OLT without VVB (2). However, if there was a way to minimize the priming solution of the VVB circuit, and thereby reduce the hemodilution, it is conceivable the likelihood of the patient receiving homologous blood products would be lessened. It was hypothesized the VVB circuit could be autologously primed immediately before commencement of VVB. The purpose of this paper is to

document our technique for autologous priming of the VVB circuit.

Description of the VVB Circuit

At our institution the priming volume of the VVB circuit is approximately 600 mL. The conduct of VVB is achieved by removing blood from the patient's femoral vein, using either a 15 French or 17 French arterial Biomedicus® femoral cannula (Medtronic Inc., Minneapolis, MN). Because of the shorter length, an arterial cannula is preferred to be used in the femoral vein. Once the femoral vein is cannulated, a fluid-to-fluid connection is made between the cannula and the VVB circuit. The VVB circuit consists of 3/8″ polyvinyl chloride tubing (Gish Biomedical Inc., Rancho Santa Margarita, CA) attached to the inlet of a centrifugal pump (Capiox® SP Pump, Terumo Cardiovascular Systems, Ann Arbor, MI). As blood is withdrawn from the patient, it pumps through a segment of 3/8″ tubing and into an extracorporeal heat exchanger, model number HE-1 (Gish Biomedical Inc., Rancho Santa Margarita, CA). Blood exiting the heat exchanger is returned to the patient through a 3/8″ segment of tubing that is wyed into two 1/4″ tubing segments with male leur connectors that are attached via a fluid-to-fluid connection to two large bore intravenous 7 French catheters (Johnson & Johnson-Cordis Corp., Miami Lakes, FL). These catheters have been placed into the patient's larger veins, such as the subclavian or internal jugular (Figure 1).

Modification of the Veno-Venous Circuit for Autologous Priming

To configure the VVB circuit for autologous priming, a large bore four-way stopcock with rotating male leur lock #2C6204 (Baxter Healthcare Inc., Deerfield, IL) is attached at the connection between the male leur connector of one of the 1/4″ reinfusion tubing segments of the VVB and the large bore intravenous catheter of the patient. Next, a 1/4″ (.64 cm) barbed connector, with male leur DLP® perfusion adapter #10007 (Medtronic Inc., Minneapolis, MN) is connected to the open female leur on the large bore four-way stopcock. Finally, the spike of 1000 mL transfer pack #4R2032 (Fenwal, Inc., Lake Zurich, IL) is inserted securely into the 1/4″ end of the perfusion adaptor (Figure 2). These constructed items are collectively referred to as the autologous priming kit.

Autologous Priming Procedure

Prior to commencing VVB, the large bore stopcock on the reinfusion line is configured such that blood flow is not flowing to the patient, but rather to the transfusion bag. Once ordered to initiate VVB, only the reinfusion line with the large bore stopcock is unclamped (Figure 3). The bypass pump is slowly started; as the patient's blood begins flowing through the circuit, the crystalloid prime from the VVB circuit is pumped into the transfer pack. This continues until anesthesia personnel visualize venous blood at the large bore stopcock. Once this occurs, the stopcock is turned to permit blood flow from the VVB circuit into the patient. Lastly, the other reinfusion line to the patient is unclamped and VVB is performed, according to protocol.

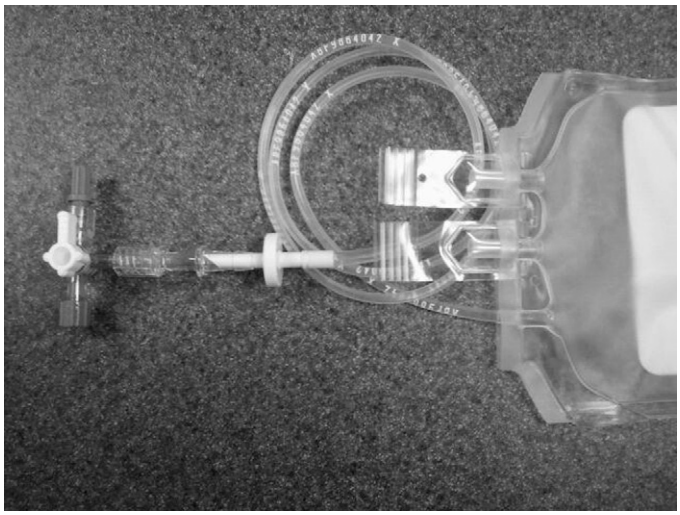

Figure 2. Photo of constructed autologous priming kit.

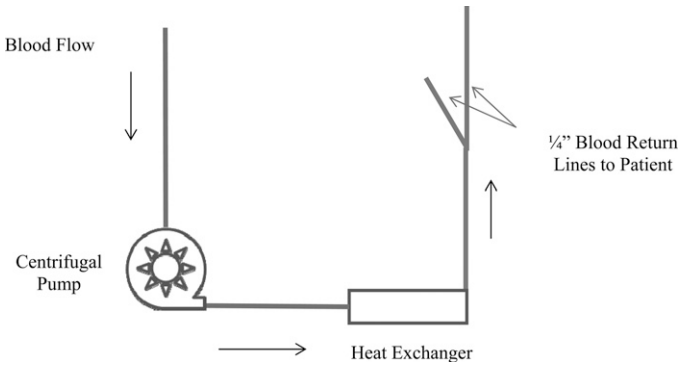

Figure 1. Schematic representation of VVB circuit.

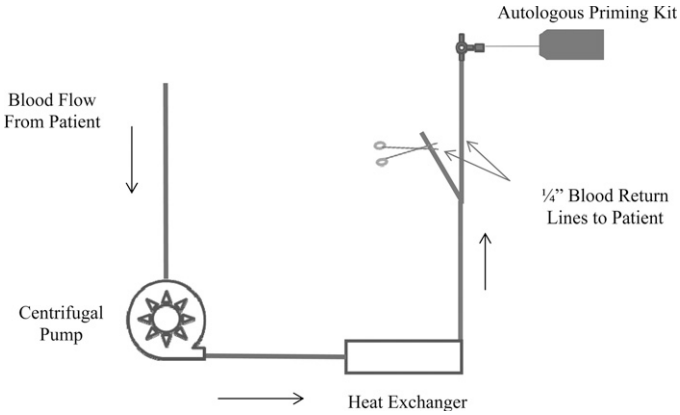

Figure 3. Schematic representation of VVB circuit with attached autologous priming kit

DISCUSSION

Concept of Autologous Priming of the VVB Circuit

Recognizing that many factors contribute to a patient requiring blood transfusions during OLT (6), practitioners must continually be vigilant in their pursuit of improving patient outcomes. This concept of autologous priming of the VVB circuit was born out of a broad based service line quality improvement initiative by the Solid Organ Transplant Quality Improvement Committee at our hospital. Specifically, the concept was generated during an exhaustive effort to examine the necessity of all asanguineous components administered during the intraoperative period and to search for any alternatives and techniques that could eliminate or reduce this volume. Understanding that OLT is not the only surgical procedure where large blood transfusions potentially occur (9), other high-risk clinical procedures that have been faced with a similar challenge were examined to determine if any of those specialties could provide additional techniques that could be adapted to the OLT procedure.

Rationale to Support Autologous Priming of the VVB Circuit

In the field of cardiac surgery, one such technique that has been shown to reduce hemodilution is autologous priming of the extracorporeal bypass circuit (10–13). At our facility, we also perform open-heart surgery and because our extracorporeal circuit's priming volume is approximately 1200 mL, we routinely autologous prime the circuit prior to commencing cardiopulmonary bypass. Since the priming volume of our VVB circuit is approximately half our extracorporeal circuit's priming volume, consideration was given to whether the approximate 600 mL of priming volume would have an impact on blood transfusion rates. However, when performing a dilution calculation for a 70-kg patient, it was determined an additional 600 mL would reduce the patient's hematocrit by approximately four percentage points. The question remains—is this reduction in hematocrit significant for a patient in so far as to produce a substantial change in the patient's hemodynamic stability that would warrant a blood transfusion? Perhaps the answer is no, for a patient whose hematocrit initially was 36% and now is 32% because of the additional 600 mL of crystalloid volume. However, it is very plausible that there are patients with multiple co-morbidities (e.g., initial and intraoperative low hematocrit values, reduced cardiac function) and circumstances where this dilutional impact could directly result in the patient becoming hemodynamically unstable and therefore necessitate a blood transfusion. Furthermore, for the same 70-kg patient described above, to restore the hematocrit to its value prior to the VVB circuit volume would require slightly more than one unit of packed-red blood cells. This single transfusion, according to Spiess et al., when viewed from a cost perspective, would result in a total financial cost to the facility in the range of $1600–$2400 (14). Therefore, given these considerations, autologous priming of the VVB circuit in OLT surgery satisfied the charge of the Solid Organ Transplant Quality Improvement Committee and was a plausible adjunctive technique that could be incorporated into our practice.

Utilization of Autologous Priming of the VVB Circuit

This technique is simple, adds minimal risk and a small additional cost to the procedure, requires slightly more communication among members of the surgical team and, with proper sequencing, adds no additional length to the surgical procedure. The use of this described technique minimizes the contribution the VVB circuit has on hemodilution and at our institution is attempted every time VVB is used. One of the quality improvement initiative's directives was to put in place policies and procedures that would fit the individual patient; arbitrarily administering asanguineous volume (via the VVB circuit prime) without the patient displaying a need for the volume flew in the face of our directive. However, even given these efforts, we have encountered circumstances, such as patient hypovolemia prior to VVB, which has precluded us from autologous priming the VVB circuit. Yet, it has been our experience to achieve greater than a 90% utilization rate in autologous priming of the VVB circuit.

To our knowledge, no literature has been published documenting the use of autologous priming of a VVB circuit during OLT. At our institution, no direct efficacy study has been performed to assess the impact of this technique prior to complete adoption, because as previously described, the value of reducing the amount of crystalloid volume a patient receives and improved outcomes are logical and previously supported by evidence (4). However, the authors are not precluding that a prospective randomized controlled study or retrospective analysis should not be performed to assess if blood transfusions have been reduced, or outcomes have improved or that a cost benefit has been realized because of this technique. Hence, an opportunity for future research exists and the latter option is being given serious consideration at the time of this paper's writing.

Future Directions

The various components described to adapt our VVB circuit to facilitate autologous priming is specific to our institution's custom tubing pack and is not intended to exclude additional variations that could still achieve the purpose. It is our group's plan that in future revisions of our custom tubing VVB pack, the circuit will be modified to minimize or eliminate the additional steps and additional components with the intent of the changes to reduce the additional small costs and more conveniently afford autologous priming of the VVB for the surgical team.

In conclusion, this technique minimizes the contribution the VVB circuit has to the overall hemodilution that a patient encounters during OLT. It is recommended that this technique be considered for addition to the arsenal of blood conservation techniques when VVB is used during OLT.

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