A Technique of Hemoconcentration

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Abstract

Herein is presented a technique for concentration of shed blood, that returns most of the clotting elements to the patient.[1] This system allows for flow and pressure variations which can respond to different surgical needs.

Introduction

Inherent in modern day cardiac surgery is intentional hemodilution, introduced in many ways during the procedure, such as the prime to the pump and the administration of crystalloid cardioplegia.[2] The total of these events leads to hemodilution which has to be treated either by the administration of blood or by diuresis. Otherwise, some sort of concentration must occur in order to moderate volume expansion. Our present system, utilizing an ultrafiltration device that concentrates blood, is presented here.

Method

The extra-corporeal equipment consists of a 2500cc Travenol Cardiotomy Reservoir[a] (Figure 1) that is connected to wall suction in order to provide the necessary negative pressure. A Haemonetics[b] aspiration assembly is passed off from the surgical field. This aspiration assembly consists of a 1/4″ piece of tubing and an I.V. tubing that are molded together. The I.V. tubing is inserted into a 1000cc bag of normal saline (N.S.) to which 30,000 μ of beef lung heparin has been added thus supplying heparin to the 1/4″ suction line. The cardiotomy reservoir drains via a 1/4″ I.D. polyvinyl chloride (PVC) tubing that passes through a Sarns[c] coronary perfusion low speed pump head and into the Cordis Dow hollow fiber hemoconcentrator[d] (Model #300-100), through a 1/4 × 3/16 reducer. Once the blood passes through the hemoconcentrator, it flows through a piece of 1/4″ I.D. PVC tubing that either empties back into the cardiotomy reservoir or can be pumped directly into the oxygenator. This tubing has a screw clamp applied prior to the bifurcation. The hemoconcentrator is then connected to wall suction (Figure 1).

Preparation of the circuit prior to use is accomplished following the manufacturer's recommendations.[3] Initially, two liters of N.S. are added to the reservoir, a clamp is applied to the 1/4″ tubing leading into the reservoir from the hemoconcentrator, the pump is turned on, and 1000 cc of N.S. are pumped through this circuit into a waste receptacle and discarded. This step washes out the preservative, glycerin, that is within the hemoconcentrator. Next, a fiber leak test must be performed in order to determine the integrity of the membrane. The operator clamps the hemoconcentrator on the blood inflow side and drops the blood outflow line below the level of the concentrator by about 60–90 cm.[3] If a steady stream of

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[a] Artificial Organs Division, Travenol Laboratories Inc., Deerfield, IL 60015.

[b] Haemonetics Corporation, 400 Wood Road, Braintree, MA 02184.

[c] Sarns Inc., Ann Arbor, MI 48103.

[d] Bard Cardiopulmonary Division, 1425 South Village Way, Santa Ana, CA 92705.

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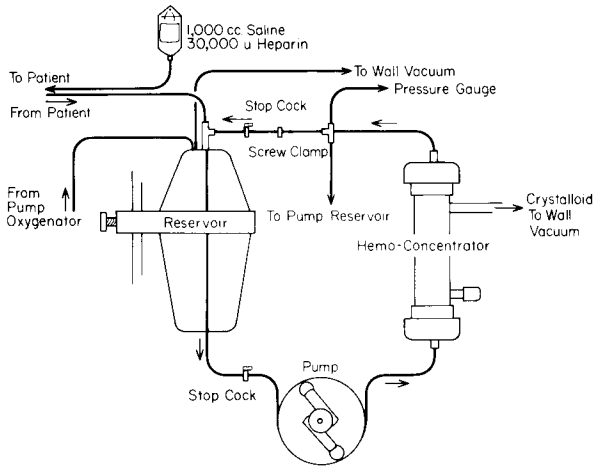

FIGURE 1. Schematic of hemoconcentrator circuit.

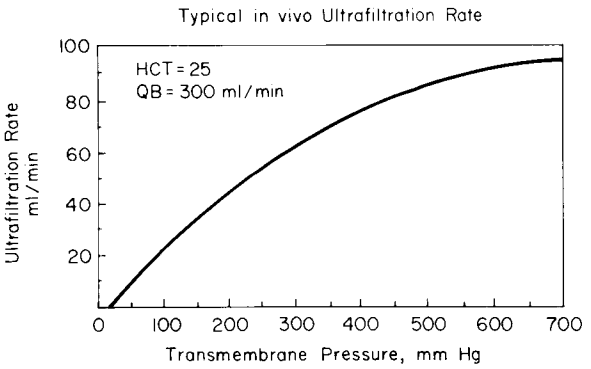

FIGURE 2. Typical in vivo ultrafiltration rate.

bubbles is observed coming from the exit port of the concentrator, this means that it is not functional and must be replaced.

After conducting the fiber leak test, the clamp is then removed from the inflow side of the concentrator and is now placed on the outflow side. At a flow rate of 50 cc/min, the remaining 1000 cc of N.S. is pumped through the concentrator. This maneuver forces the N.S. through the hollow fibers and causes it to exit the concentrator as an ultrafiltrate that is discarded. The clamp is now removed.

The hemoconcentrator is capable of ultrafiltering fluid at a maximum rate of about 100 cc/min. The ultrafiltration rate is dependent upon the transmembrane pressure. The greater the transmembrane pressure, the greater the rate of elimination. However, this pressure should not exceed 750 mmHg pressure.[3] Transmembrane pressure is defined as the absolute sum of the negative pressure on the outside of the fibers and the blood pressure within the fibers. There are a number of ways of producing this transmembrane pressure. Since the concentrator is connected to wall suction, the absolute value of the negative pressure is all trans-membrane pressure. We are able to get about 300 mmHg pressure in this manner. Figure 2 shows that the concentrator is capable of a much faster rate of ultrafiltration if more transmembrane pressure is applied.[3] Any positive pressure on the inside of the capillaries is transmembrane pressure; therefore, by tightening the screw clamp and partially occluding the outflow tract, this pressure can be increased significantly. Also, by increasing the flow of the pump to a maximum of 300 cc/min[3], the distal pressure can substantially increase the transmembrane pressure (Figure 2); therefore, maximal filtration due to maximal transmembrane pressure can be achieved under nearly all flow conditions.

Comment

This technique of hemoconcentration has been employed in our institution for single and multiple valve replacements wherein the use of large dose cardiopegia[2] and topical hypothermia are liberally employed. In each of the last five of these surgical procedures, an average of six liters of ultrafiltrate throughout has been eliminated throughout the hemoconcentrator, and an average of 500 cc of the patient's own blood has been returned to him with an hematocrit of about 55%. The advantage of this technique over a cell washing technique is that, in the cell washing device, only red cells suspended in N.S.[4], are returned to the patient. Whereas, with this ultrafiltration technique, only the crystalloid diluent is eliminated. The addition of the partial occluding screw clamp has rendered this technique much more efficient.

In our institution the patient cost per unit of blood is $102, the cell washing device is $137.50, and the ultrafiltration system is $200.

References

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