

Technique

A Technique For Separation of Perfluorocarbons From Blood Used in Cardiopulmonary Bypass Laboratory Procedures

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ABSTRACT

Eliminating from physiologic circulation a significant amount of unnecessary perfluorocarbons (PFC) is advantageous since little is known about long-term effects of PFC in the circulatory system. The basic circuitry, cell-washer, mechanical manipulations, and overall concept revealed that a significant amount of PFC can be retrieved and estimated in volume and compared to initial volumes. A method of separating a certain PFC blood substitute from blood following laboratory cardiopulmonary bypass is described.

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INTRODUCTION

With the high interest in blood conservation, concern with human immuno-deficiency virus (HIV) transmission, along with known transient and permanent problems associated with cardiopulmonary bypass (CPB), some researchers are turning to blood substitutes such as perfluorocarbons as future possibilities for priming and additive solutions. However, little is known about adverse results from large volumes of PFC in human physiology. In four laboratory procedures, three liters of a perfluorocarbon developed by a University of Texas researcher^a were used during CPB. Since PFC is heavier than red blood cells (1), it was hypothesized that post-CPB significant amounts of the PFC could be removed by centrifugation. The purpose of this paper is to describe the technique developed to remove PFC after CPB.

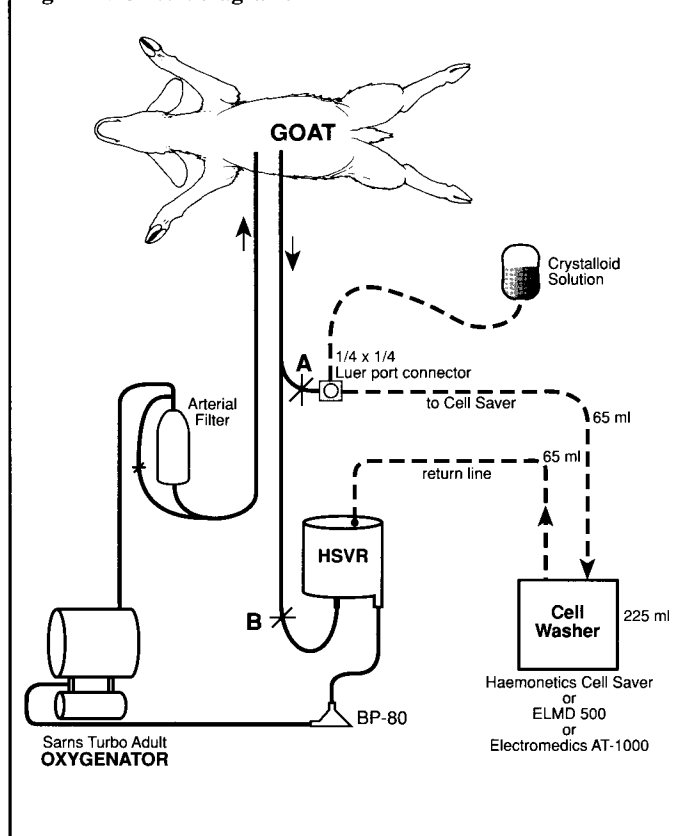
MATERIALS AND METHODS

Four goats averaging about 60-65 kg were placed on CPB after being anesthetized and paralyzed using guidelines according to "Guide for the Care and Use of Laboratory Animals (NIH Publication No. 86 23, revised, 1985). These animals were part of an ongoing pulsatile pump study. After 5 hours of CPB using 3 liters of PFC, the technique for removal of PFC from blood was begun.

The extracorporeal circuit consisted of a Sarns Turbo oxygenator^b with a Shiley Hardshell Venous Reservoir (HSVR)^c and a Bio Medicus BP-80 Bio-Pump^d. The interconnecting circuit lines adapted with the added lines (Figure 1, dotted lines) were primed with the line clamped at point A. The circuit was primed with 2 liters of Perfluorodecalin, a PFC being used by our investigators in an on-going laboratory procedure investigating the use of a new pulsatile pump. Venous drainage was through the right atrial appendage using a Sarns Dual Stage Cannula^b, while arterial access was gained by placement of an 8.0 mm cannula^b in the ascending aorta from CPB circuit. In the first case a Haemonetics[®] cell-saver was used to remove the PFC. In the second case, an Electromedics AT1000 was used^f, while an Electromedics ELMD500^f was used in the third and fourth procedures. CPB was initiated and continued for five hours with the addition of one liter of PFC.

In preparation for the removal of circulating PFC, the level sensor in the cell washer was removed and bypassed and thereby "fooled" into sensing an unfilled Latham Bowl, thus allowing the process to continue without stopping and going into wash-empty

Figure 1: Circuit diagram.



modes. The waste bag connection was changed to become the return line. This modification is not recommended by any manufacturer of any of the cell-washing devices nor is it an FDA approved method for any blood processing device which is used clinically. In Figure 1, the line from point A including cell washer bowl and return line (previously the waste line) were primed up to the HSVR entry point, using approximately 355ml of Normosol-R^g. Once CPB was terminated with the venous line clamped at "B", the cell-washer was turned on at 300ml/min after releasing the clamp at "A" and the process of removing PFC was initiated. As blood volume from the animal was rerouted through the perfluorocarbon removal system (PFRS) and into the HSVR, the perfusionist continued to infuse blood volume from the HSVR through the arterial cannula at a rate equal to the processing rate in order to maintain a relatively stable blood volume. The PFC removal was continued for an average of 30-45 minutes. Once the level of PFC collected in the bowl stabilized, the process was stopped and infusion from the HSVR was used as necessary for volume and pressure.

RESULTS:

Since one liter of perfluorodecalin is approximately 10% vol/vol, the total amount of PFC administered per animal was 300 ml.

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 c Sarns BioMedical, Inc., Irvine, CA
 d Medtronic, Biomedicus, Cardiopulmonary Products, Anaheim, CA
 e Haemonetics Corporation, Braintree, MD
 f Electromedics, Englewood, CO
 g Abbott Laboratories, North Chicago, IL

Figure 2: Latham Bowl after PFC Removal Process**Figure 3: Close-up of Latham Bowl with PFC on bottom layer**

Therefore, the volume of a Latham bowl (225ml) could contain a significant amount of the PFC given in this experiment. In addition, the PFC solution is 20%wt/vol, indicating that the heavier PFC would remain at the bottom of the bowl while the whole blood (lighter) would be eliminated from the Latham bowl and into the HSVR, thereby continuing the process until PFC removal appeared maximized. One-fourth to three-fourths of a 225 ml Latham bowl of the white PFC was removed in our four attempts, which would appear to significantly reduce the amount of circulating PFC. Figure 2 shows the Latham bowl after the PFC removal process. It was also found that the PFC, once in the Latham bowl, was very sticky and was not readily removed from the bowl. However, this did not pose an immediate problem, since in this experiment, the whole blood was transfused to the

animal continuously while the collection of PFC appeared to reach maximum within one 225 ml bowl. The amount of PFC removed from the Latham bowl by scraping was retained by another investigator to analyze for composition and comparison to original PFC contents in solution. Results are pending.

DISCUSSION:

The information presented is not intended to quantify nor to detail points and issues about PFC. The key point is to describe a method of separating PFC from blood which is demonstrated in the photographs (Figures 2 and 3). The described technique using the mentioned cell-washers is not an FDA approved method, nor is it recommended or suggested by any cell-washer manufacturer or blood-processing device manufacturer. Technique refinement in the measurement of retrieved PFC can lead to better, more accurate results. This methodology, it is believed, warrants further investigation, refinement of devices, and research of certain compositions of blood substitutes.

The use of large volumes of crystalloids in this experiment resulted in excessive hemodilution which required the administration of large amounts of PFC to maintain the oxygen-carrying capacity. The technique described was developed in an attempt to remove the PFC post-CPB. Using the fact that PFC is heavier than red blood cells, the hypothesis was made that it could be partially recovered by centrifugation. The process involved use of existing supplies and equipment that are common to most perfusionists while making minor modifications to blood salvaging equipment.

REFERENCES

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