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The Blood Shortage:

Is Autotransfusion an Answer?

MORE THAN EIGHT MILLION units of blood are administered to patients annually in the United States, and this volume will undoubtedly continue to increase as our surgical colleagues attempt increasingly complex procedures, ranging from radical cancer or trauma surgery to transplant and open-heart procedures. In fact, it has been suggested that if the growth of coronary-artery surgery were to continue at the present rate and the amount of blood used per case to remain the same, the nation's entire blood resource would be required for that one procedure by 1976.¹ Increased donor recruitment through such ingenious means as giving tax credits² or the new national blood system³ may alter the fact that 97 per cent of the eligible population are non-donors. Similarly, more efficient use of the available supply through selective component therapy,⁴ use of blood substitutes, and acceptance of lower hematocrits will also help to conserve a precious national resource.

Autologous blood transfusion is an additional technique that has been proven to reduce the requirement for homologous blood. There are three variations to this technique⁵:

- 1) preoperative collection and storage;
- 2) acute perioperative collection and simultaneous hemodilution;
- 3) intraoperative blood scavenging.

Preoperative Collection and Storage

Autologous blood banking has lagged behind homologous mainly because of an inability to store whole blood more than 21 days. However, preoperative collection and storage can be expanded to provide as many as four units of blood less than ten days old.⁶ Miles *et al.* now meet more than 90 per cent of their surgical blood needs with autologous blood. This group started conservatively in the mid-60's with single-unit phlebotomies ten days prior to operation and gradually expanded their work, until now they collect as much as three units at two-day intervals, the last being collected four days prior to operation.⁷

A variant of serial single-unit phlebotomies in which units are removed and reinfused at seven-day intervals in such a way that three units of blood less than ten days old are available at operation has been described

TABLE 1. "Piggyback" Technique of Preoperative Collection and Storage of Blood

	Day 1	Day 7	Day 14	Day 16	Day 23
Collect unit	A	B and C	D and E	F	Operation
Reinfuse unit		A	B and C		

(table 1). Using this "piggyback" technique, Ascari *et al.* were able to provide 80 per cent of the blood needed by 16 patients undergoing pulmonary surgery.⁸

The single greatest deterrent to widespread acceptance of this practice has been the fear that patients would come to the operating room with a contracted blood volume. However, numerous studies have demonstrated that the plasma volume is restored within 12 hours after single-unit phlebotomy. This is made possible by rapid mobilization of extracellular fluid and protein.^{6,8} A second deterrent has been the presumed inability of patients to replace erythrocytes adequately due to iron deficiency. Using intravenous iron dextran, stable hemoglobin levels have been maintained in healthy adult male subjects despite five single-unit phlebotomies per week for 22 weeks.¹⁹ The same technique has been used to avoid iron deficiency while removing as much as four units at 48-hour intervals from 178 patients during the ten days prior to operation. All these patients came to surgery with hematocrits greater than 30 per cent.⁶ Although there is no datum to substantiate the practice, a hematocrit of 30 per cent has been widely cited as a minimal acceptable preoperative level for surgical patients.^{6,10,11}

A circumstance in which preoperative collection and storage has proven invaluable is when suitable donors cannot be found. Depending on the magnitude of surgery planned, stored blood may have to be frozen. In one case, a patient whose blood was compatible with those of fewer than one dozen persons throughout the world donated six units of blood at eight-week intervals prior to left total hip arthroplasty. During the procedure four of these units were reinfused.¹² Disadvantages of frozen storage include expense, restriction to use in large centers where freezing methods are available, and the necessity for infusion of the blood within 24 hours after thawing.¹³ Advantages of this tech-

nique include the decreased risk of hepatitis, diminished quantity of ACD infused, and low incidence of pulmonary vascular reaction to donor leukocytes. Any blood collected that is not needed by the donor patient is then available for use in supplying the needs of other patients. In this way, preoperative collection and storage not only reduces demands on the blood bank—it also serves as a new source of homologous blood.

Perioperative Collection and Hemodilution

In this technique, blood is collected in CPD-preservative bags from an arterial line while either crystalloid or colloid solutions are infused simultaneously via the venous line. If crystalloid solutions are used, two to four times the volume of blood collected will be required to maintain intravascular volume. In a controlled study of 50 patients undergoing cardiac surgery, Hallowell *et al.* found that the removal of 1,252 ml prior to cardiopulmonary bypass decreased the requirement for homologous blood and blood components by 25 per cent.¹⁴ In a similar study of 300 patients, Ochsner *et al.* found the reduced requirement to average 50 per cent.¹⁵ Their technique differed slightly in that they removed the blood via the aortic cannula just prior to cardiopulmonary bypass. In this way, they were able to monitor arterial blood pressure during the collection period.

Intraoperative Blood Scavenging

This technique has been practiced in cardiac surgery for 20 years. While there have been early isolated reports of the use of autologous blood collected intraoperatively in varied circumstances, the application of equipment designed for cardiac surgery in other surgical procedures is a development of the past decade. In this issue, Stehling *et al.* review intraoperative autotransfusion and report

their experience. There has been no controlled study to demonstrate that use of this technique does reduce the requirements for homologous blood, as opposed to increasing bleeding by inadvertent systemic anticoagulation¹⁶ or initiation of disseminated intravascular coagulation. Yet the value of this technique in cases where the immediate need for large volumes of blood cannot be met by the blood bank is obvious. Thus, large trauma centers have been among the first to use this technique. In fact, the first clinical trials were carried out in battle casualties in Vietnam. A logical extension is to use this equipment for any surgical procedure in which major blood loss is anticipated. Where blood loss of less than one liter is anticipated, the use of this equipment is probably not warranted. Preoperative collection and storage, or use of blood substitutes, should suffice to maintain intravascular volume provided the patient was not anemic at the start of the procedure.

Summary

In addition to the obvious advantage of conservation of a vital national resource, the advantages of autotransfusion include: 1) decreased transmission of disease; 2) decreased incidence of isoimmunization; 3) ready availability of rare blood types; 4) elimination of technical errors in crossmatching. The three variations in the technique of autotransfusion are destined to become more widely used, and it is incumbent upon anesthesiologists to become familiar with the variations that are applicable to their patients.

NORIC ELLISON, M.D.

Department of Anesthesia

HAROLD A. WÜRZEL, M.D.

Department of Pathology

University of Pennsylvania

Philadelphia, Pennsylvania 19104

American Association of Blood Banks

Subcommittee for Liaison with the

American Society of Anesthesiologists

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