Cell Salvage Is Beneficial for All Cardiac Surgical Patients: Arguments For and Against

Robert A. Baker, PhD;* Alan F. Merry, FANZCA†

From the *Cardiac and Thoracic Surgical Unit, Department of Surgery, Flinders Medical Centre and Flinders University, Adelaide, South Australia, Australia; and the †University of Auckland and Green Lane Department of Anesthesia, Auckland City Hospital, Auckland, New Zealand

Abstract: Extensive literature has been published evaluating the use of cell salvage in cardiac surgery. However, the most recently published blood management guidelines do not give unequivocal direction on the use of cell salvage in cardiac surgical procedures and neither do recent meta-analyses and randomized controlled trials. In part, this reflects variation in the details of how cell salvage is used, including the specific equipment chosen. Consensus on the optimal approach to cell salvage would be helpful. A well-designed, appropriately powered, multicenter study could then be carried out with one or more specified devices to evaluate the efficacy of this agreed approach to cell salvage in the cardiac surgical environment. Keywords: autotransfusion, cardiac surgery. JECT. 2012; 44:P38–P41

CONTEXT

Cardiac surgery is associated with high use of allogeneic blood products and, because of the known risks of these products, there is ongoing interest in reducing this use (1,2). Various ways of reducing the use of allogeneic blood have been tried, individually or within overall strategies for blood conservation. These include iron supplementation, pretreatment with erythropoietin, acute normovolemic hemodilution, retrograde autologous priming, pharmacological interventions (e.g., with tranexamic acid, aprotinin, and other agents), improved surgical hemostasis, strict adherence to transfusions protocols, and cell salvage.

The extent of risk associated with the transfusion of blood products today is clearly lower than in the past and is perhaps a matter for debate, but it is not zero. Furthermore, blood is a limited and expensive resource. There is therefore little dispute that it should be used as sparingly as reasonably possible. Debate arises over the relative risks and costs of techniques designed to reduce the need for transfusion. Many trials have been conducted and many (often contradictory) opinions expressed on various aspects of transfusion policy. The “2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists Blood Conservation Clinical Practice Guidelines” (3) provides a comprehensive synthesis of the relevant evidence in this area and on this basis offers authoritative recommendations for best clinical practice.

Cell salvage (the autotransfusion of shed blood), first proposed in 1818 and first mentioned in the literature in 1885, provides a fine example of an intuitively sensible idea for which clear evidence of benefit has proven surprisingly elusive and which has ended up as a focus of controversy, at least in the context of cardiac surgery (4). In this article, we begin with an overview of the technical aspects of cell salvage and then discuss some of the issues and evidence related to its use. We attempt to guide readers to a position from which they can come to reasonable conclusions about the place of this technique in their own practices.

Technical Aspects of Cell Salvage

The principles of contemporary cell salvage are fairly straightforward. Blood is taken from the operative field and returned to the patient. Variations in the detail of how this is done may influence the impact of this technique on patient outcomes. Of note, red blood cells may be washed and concentrated by centrifugation before being returned to the patient and the process may be continuous or discontinuous (a matter of considerable importance to some
Jehovah’s Witnesses). The precise technicalities of the washing process may also make a difference (e.g., whether it is automatic or manual and what wash rates and volumes are used).

Today, essentially all salvage practice uses techniques that wash the scavenged blood, usually with normal saline (9% sodium chloride), and return a solution of red blood cells suspended in normal saline with a hematocrit of 50–70%. The Fresenius Continuous AutoTransfusion System (CATS®) device (Fresenius HemoCare Inc., Bad Homburg Germany) is currently the only cell salvage apparatus that uses a continuous technique, thereby allowing scavenged blood to be collected, washed, concentrated, and returned in an uninterrupted process. Other devices use a system that requires a minimum amount of blood volume to be scavenged before processing can be initiated. Most devices now allow several alternative modes of processing, including modes designed to promote optimal hematocrits, modes that emphasize rapid processing, and modes that permit the immediate return of unprocessed blood in emergencies. Further modification can be achieved through manual (user-defined) control of fill and wash cycles and centrifuge speed.

The variation between devices and operators introduces complexity to the evaluation of the literature on the benefits and risks of cell salvage. In 2003, Serrick and coworkers investigated five devices using both continuous and discontinuous processing (namely the Cobe Baylor Rapid Autotransfusion Device (BRAT) 2®, COBE Cardiovascular Inc., Denver, CO; Medtronic Sequestra® 1000, Medtronic Inc., Minneapolis, MN; Haemonetics® Cell Saver 5, Haemonetics Corp., Braintree, MA; Medtronic Autolog®; and the Fresenius CATS®); they concluded that leukocytes were not adequately washed out by any of the autotransfusion devices (although the BRAT-2® performed best in this respect) and “that the variation in process between the different types of cell saving devices also results in drastic variations in the quality of concentrated RBC product” (4). Naumenko et al. conducted a study of the Haemonetics® Cell Saver 5 and showed that changing centrifuge speed and washing speed resulted in considerable variation in the product with respect to red blood cell harvest and contaminant removal (5). More recently, Yarham et al. reported an investigation of the Xtra® Cell Saver (Sorin Group, Mirandola, Italy) and reported a higher end-product hematocrit with the manufacturer’s integrated protocol than with their teams’ standard protocol (6).

Another important variable in cell salvage is the timing of when cell salvage is used during and after the surgical procedure. This is not always clearly described in the literature, but recent meta-analyses suggest when timing of when cell salvage is used is important to the usefulness of the technique (7,8).

Assessment of Efficacy
Research has tended to focus on cell salvage as an intraoperative intervention and on outcomes assessed during the index admission; most studies have reported outcomes such as the number of patients receiving allogeneic or autologous blood or both and the amount of allogeneic or autologous blood transfused. Recent studies have considered a wider range of outcomes, including all allogeneic blood products used, the effect of cell salvage on the systemic inflammatory response and neuropsychological sequelae, reoperation rates, and postoperative morbidity and mortality (9–11).

Outcomes: Meta-Analyses and Randomized Controlled Trials
Two Cochrane reviews have dealt with cell salvage (7). The 2010 review identified 75 randomized controlled trials (31 involving cardiac surgery), using washed or unwashed cell salvage techniques, over the intraoperative and postoperative periods. The review encompassed trials using more than 40 different devices over a 29-year period dating back to 1979 in a population described by the authors as extremely heterogeneous. The authors concluded that in the cardiac surgical population, there was relative risk reduction (RRR) in exposure to allogeneic blood transfusion of 23% (95% confidence interval [CI] = 14–31%), and RRR was superior with washed (.66; 95% CI = .55–.80) than unwashed cell salvage (.85; 95% CI = .76–.95). In the 2006 review, factors influencing the efficacy of cell salvage were considered, including the timing of the cell salvage and the volume of blood transfused.

Since completion of the 2010 Cochrane review, at least five randomized controlled trials evaluating cell salvage and one meta-analysis have been reported. Of these, two studies were specifically designed to evaluate exposure to allogeneic blood transfusion (one also evaluated cost-effectiveness), two evaluated neurocognitive outcome associated with using cell salvage during the bypass period (one also dealt with exposure to allogeneic blood transfusion), and the final study evaluated the effect of cell salvage on the inflammatory response. The contribution of these studies to our understanding of the efficacy of cell salvage is not straightforward.

Two Canadian studies (10,11) compared the use of cell salvage during the bypass period with cardiotomy suction. Rubens et al. suggested that the use of cell salvage (discontinuous BRAT 2® resulted in increased allogeneic transfusion of both red cell and other products (11). However, the interpretation of this study was confounded in relation to secondary bleeding and transfusion outcomes by the use of cell salvage in both groups for the period after protamine administration until 4 hours postoperatively. Djajiani et al. aimed to evaluate continuous flow cell salvage (CATS®) vs. cardiotomy suction for the period.
of bypass only by assessing neurocognitive outcome with secondary bleeding and transfusion-related outcomes (10). They reported no advantage for salvage with respect to transfusion of red blood cells or an increase in fresh-frozen plasma use. These two studies failed to clarify the role of cell salvage on either neurocognitive outcomes or transfusion. Both studies did show an increase in non-red blood cell product use in the cell saver group. A third study by Klein compared the CATS device used throughout the procedure and for 6 hours into the intensive care unit stay with cardiomyotomy suction and residual blood retransfusion; this failed to show a difference in allogeneic blood use, but the authors reported a benefit after excluding those patients who were returned to the operating room for bleeding (.71: .52–.97) (13).

These three studies, all modestly powered, were included in Wang’s 2009 meta-analysis, which reported an advantage for cell salvage over use of the cardiomyotomy suction with a reduction of risk of exposure to allogeneic blood products (.63; 95% CI = .43–.94) (8). Wang et al. identified the timing of cell salvage use as important, dividing studies in the meta-analysis into those in which cell salvage collection was directly compared with the period of cardiomyotomy suction use and those in which cell salvage was used throughout the procedure with or without cardiomyotomy suction and with or without salvage of residual blood volume. Wang reported an advantage with cell salvage with the latter group only (1.35 [.95–1.93)] compared with .49 [.34–.71]). The remaining two studies (Reyes et al. [14] and Damgaard et al. [9]) were too small to be interpreted confidently.

Interpretation

Ferraris et al. (3) provide a good summary of the situation. They make the point that most studies are small and deal predominantly with coronary surgery. However, they concluded that “Routine use of red cell saving is helpful for blood conservation in cardiac operations using CPB, except in patients with infection or malignancy (Level of evidence A)” and that “Consensus suggests that some form of pump salvage and reinfusion of residual pump blood at the end of CPB is reasonable as part of a blood management program to minimize blood transfusion” (Level of Evidence C). They also conclude that “Centrifugation instead of direct infusion of residual pump blood is reasonable for minimizing post-CPB allogeneic RBC transfusion” (Level of Evidence A). There is no clarity over the detail of cell salvage or over choice of device.

Assessment of contemporary practice of cell salvage would suggest clinical practice mirrors these recommendations. The only published survey looking specifically at cell salvage in cardiac surgery was conducted in the United Kingdom in large cardiac surgical units (defined as having greater than 600 cases annually) and showed that 71% of units practiced cell salvage routinely with 91% of these units using cell salvage throughout the operation (15). Forty-seven percent of the units reported processing some or all of the pericardial suction blood and 85% processed the residual pump blood. Recent data collected from the International Consortium for Evidence Based Perfusion Pilot Registry, which collects data from 11 institutions in the United States (greater than 2800 procedures), indicate that all of units use cell salvage for some cases (unpublished data). This varies by procedure with salvage being used in over 95% of all cases in six of 11 units, whereas two centers use salvage in less than 30% of cases. Data from the Perfusion Downunder Collaboration data set (n = 7634, 2007–2011) suggest a much lower level of adoption of cell salvage by participating centers with only two sites reporting use of cell salvage in more than 70% of cases; overall cell salvage was used in 17.3% of cases with blood being processed and reinfused in 79% of these cases (unpublished data).

We are therefore left with some questions because the evidentiary base is unclear and clinical practice reflects this:

1. Should cell salvage be used for all cases? If not, who should it be used for?
2. When during a case should cell salvage be used?
   a. Should cell salvage be used to process cardiomyotomy suction blood?
   b. Should cell salvage be used to process residual pump blood?
3. Should cell salvage be used after the patient leaves theatre?

It would be helpful to develop consensus on the optimal approach to cell salvage. A well-designed, appropriately powered, multicenter study could then be carried out with one or more specified devices to evaluate the efficacy of this agreed approach to cell salvage in the cardiac surgical environment.

REFERENCES