Red Blood Cell Salvage During Obstetric Hemorrhage

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OBJECTIVE: To describe which obstetric patients lose enough blood during postpartum hemorrhage to receive a reinfusion of intraoperative blood salvage.

METHODS: Eight years of intraoperative blood salvage data from a regional tertiary care maternity hospital were analyzed. The volume of blood returned through intraoperative blood salvage was standardized to the volume of red blood cells in an allogeneic red blood cell unit from the blood bank.

RESULTS: There were 884 obstetric hemorrhage cases in which intraoperative blood salvage was utilized. Sufficient blood was collected by intraoperative blood salvage to permit reinfusion in 189 of 884 (21%) patients. For patients in whom intraoperative blood salvage blood was reinfused, the mean ± standard deviation number of reinfused shed blood units was 1.2 ± 1.1 units. Although intraoperative blood salvage was most commonly performed on patients who underwent routine cesarean delivery (748/884 patients), only 13% of these patients received an intraoperative blood salvage reinfusion; 73% of the patients undergoing cesarean hysterectomy, 69% of those who had bleeding after cesarean delivery, and 53% of the patients who bled after vaginal delivery received an intraoperative blood salvage reinfusion (P < 0.001).

CONCLUSION: Although intraoperative blood salvage was attempted on many patients, on only 21% of the women was a sufficient amount of intraoperative shed blood collected to proceed with reinfusion. Patients who experienced bleeding or who underwent a cesarean hysterectomy were the most likely to receive a reinfusion of intraoperative blood salvage–processed blood.

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LEVEL OF EVIDENCE: II

The incidence of postpartum hemorrhage and the rate of red blood cell (RBC) transfusion during childbirth have increased in the United States and around the world.1,2 In many operative settings, one strategy for managing hemorrhaging patients is reinfusing the blood that is shed from the surgical field using intraoperative blood salvage.3 The intraoperative blood salvage procedure collects the shed blood and washes and filters it before returning it to the patient.4,5 Intraoperative blood salvage has been shown to reduce the need for allogeneic transfusions in bleeding operative patients,6 and it avoids some of the adverse effects of allogeneic transfusion including RBC alloimmunization, certain transfusion reactions, and the transmission of several infectious agents. It might also be accepted by patients who refuse allogeneic transfusion. However, a minimum quantity of shed blood must be recovered to operate the intraoperative blood salvage machinery; otherwise, no shed blood can be returned. Intraoperative blood salvage has historically been considered to be contraindicated in managing obstetric patients as a result of the potential contamination of the recovered blood with amniotic fluid, activated clotting factors, and other embolic debris. However, recent evidence suggests that intraoperative blood salvage can be safely used in obstetric patients.7 Many national organizations are now recommending that it should indeed be used to manage obstetric hemorrhage.8–11 This study analyzed 8 years of intraoperative blood salvage use in obstetric hemorrhage patients at a regional tertiary care maternity hospital. The goal of this study was to describe which patients lost enough blood to
receive an intraoperative blood salvage reinfusion during their obstetric hemorrhage.

**MATERIALS AND METHODS**

This database review was approved by the Quality Improvement section of the University of Pittsburgh’s institutional review board (study #0001736). As part of a regional tertiary care maternity hospital’s perioperative autologous blood management program, a database was created that captured information on all patients who either had a standby intraoperative blood salvage case or who received a reinfusion of intraoperative blood salvage blood during an obstetric hemorrhage. Establishing and maintaining this database is required to receive accreditation from the AABB (formerly known as the American Association of Blood Banks) in perioperative blood collection and reinfusion. Data were entered into the database by the anesthesia technician performing the salvage procedure. Periodic validation of the data is performed by the hospital’s quality department, and the database is regularly scrutinized by AABB auditors. For this study, which included all of the patients in the database between January 1, 2006, and June 30, 2014, the demographics and the volumes of blood that were processed by intraoperative blood salvage were analyzed.

Briefly, intraoperative blood salvage management takes place in the following manner: an intraoperative blood salvage machine is routinely kept in a storage room in the labor suite’s operating room. The initial set of disposables that is required to collect shed blood is always installed on the machine so that at the discretion of the surgeon or anesthesiologist, the intraoperative blood salvage machine can be moved into a bleeding patient’s room, ready to collect shed blood within 1 minute. Collection of the shed blood proceeds throughout the case. If the minimum amount of shed blood for processing is not collected by the end of the case, typically between 500 and 700 mL, the collection system is simply discarded. This is known as a standby case. No blood is reinfused to the patient in a standby case. Only if the minimum amount of shed blood that is required for processing is collected are the additional disposables that are needed for the processing used (Table 1). Processing of the shed blood begins as soon as a sufficient volume of blood is collected. The processed blood is passed through a leukocyte depletion filter as it is being transferred from the primary reinfusion bag to a secondary reinfusion bag. This filter removes both white blood cells and particulate matter. The secondary reinfusion bag is separated from the system, labeled according to the AABB standards for the handling of shed blood, and handed to the anesthesia provider for reinfusion.

By separating the blood from the machine using a secondary bag, air embolism is prevented. All processed blood is returned to the patient. Using this stepwise approach to collecting and processing the shed blood, the cost of the disposables is minimized because only those that are necessary given the amount of recovered shed blood are used. Blood that is shed before amniotomy and after membrane rupture is directed into the salvage system. In so far as possible, amniotic fluid is disposed of using a separate suction apparatus, thereby preventing large-scale contamination of the collected shed blood. It is important to note that all laparotomy sponges are rinsed in normal saline to remove blood from them. This bloody saline is periodically suctioned into the intraoperative blood salvage reservoir, thereby increasing the amount of recovered shed blood.

To standardize the volume of RBCs that were returned to the patient using intraoperative blood salvage, the salvaged RBC volume was normalized to the volume of RBCs in an allogeneic RBC unit from the blood bank using a previously published method. In addition to a volume of approximately 200 mL of RBCs, an allogeneic RBC unit also contains approximately 110 mL of preservative solution and 50 mL of plasma. Thus, the hematocrit (volume of RBCs in the unit) of an allogeneic RBC unit typically ranges from 55 to 65%. The packed RBC unit equivalent (PRBCeq) is the volume of red blood cells returned to the patient using intraoperative blood salvage.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (U.S. Dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby*</td>
<td>$36.00</td>
</tr>
<tr>
<td>Collection reservoirs</td>
<td>$15.00</td>
</tr>
<tr>
<td>Suction tubing</td>
<td>$13.45</td>
</tr>
<tr>
<td>Citrate solution</td>
<td></td>
</tr>
<tr>
<td>Additional costs incurred on processing and reinfusing the shed blood†</td>
<td>$44.00</td>
</tr>
<tr>
<td>Standard bowl processing set</td>
<td>$1.50</td>
</tr>
<tr>
<td>Transfer bag</td>
<td>$16.00</td>
</tr>
<tr>
<td>Leukodepletion filters</td>
<td></td>
</tr>
<tr>
<td>Estimated cost of an allogeneic packed RBC unit, including costs for a type and screen and crossmatch</td>
<td>$310.00</td>
</tr>
</tbody>
</table>

RBC, red blood cell.

* Total cost of a standby case = $64.45.
† When sufficient blood is collected for processing and reinfusion, these additional three items are required.
salvage, expressed as a fraction of the RBC volume in an allogeneic RBC unit from the blood bank:

\[
PRBCeq = \frac{\text{Recovered Blood Volume, mL}}{200 \text{ mL}} (0.53),
\]

where the average hematocrit produced by the cell salvage machines over the past 5 years at this institution is 53%, and each unit of allogeneic RBCs from the blood bank contains approximately 200 mL of erythrocytes. For example, a PRBCeq value of 1 indicates that the quantity of RBCs returned to the patient using intraoperative blood salvage was equivalent to one allogeneic RBC unit from the blood bank (ie, 200 mL; in this example, 377 mL of salvaged blood and fluid would have been recovered to produce a reinfused intraoperative blood salvage RBC volume of 200 mL).

To better understand the clinical circumstances in which intraoperative blood salvage in obstetric hemorrhage had been used at this hospital, the patients who received intraoperative blood salvage (either standby only or with reinfusion depending on the quantity of recovered shed blood) were divided into four clinical categories of hemorrhage. The first group was composed of patients undergoing cesarean delivery who had risk factors that suggested the potential for requiring an allogeneic RBC transfusion. The common risk factors are abnormal placentation, prior cesarean deliveries, anemia, and bleeding disorders. The other three categories were: cesarean hysterectomy, postcesarean delivery with active hemorrhage, and postvaginal delivery with active hemorrhage. Postvaginal delivery includes blood collected vaginally plus that which might take place from a laparotomy.

Descriptive statistics are reported for all analyses. Analysis of variance was used for comparing the demographics among the four different categories of obstetric hemorrhage. Fisher’s exact test and \( x^2 \) tests were used to compare differences between categorical variables. \( P < .05 \) was considered statistically significant.

RESULTS

During the study period, 884 patients had intraoperative blood salvage used during their obstetric care. The mean±standard deviation age of these patients was 31±6 years with a mean±standard deviation height and weight of 167±117 cm and 89±23 kg, respectively. Only one patient was missing the data for her weight, whereas the rest of the cohort’s information was complete. Most of these patients, 695 of 884 (79%), only had standby intraoperative blood salvage because inadequate amounts of blood were collected during their surgery to allow for processing and reinfusing the shed blood. No shed blood at all is reinfused in a standby case. There were 189 of 884 (21%) patients who had a total of 235 PRBCeq reinfused. A mean±standard deviation of 1.2±1.1 PRBCeq units were reinfused to the 189 patients who received intraoperative blood salvage–processed blood. The distribution of the PRBCeq volumes of the reinfused intraoperative blood salvage–processed blood for the 189 patients who received a reinfusion is shown in Figure 1.

![Fig. 1. The distribution of packed red blood cell unit equivalents reinfused to the 189 obstetric patients who received intraoperative blood salvage–processed blood during hemorrhage.](image)

Table 2 demonstrates the number of PRBCeq units reinfused to the patients in the four categories of obstetric hemorrhage. There was no statistically significant difference in the average age and weight among the patients in the four categories of obstetric bleeding (Table 2). There was also no significant difference in the height of the patients among these four categories (data not shown). The patients who underwent a cesarean hysterectomy had the highest rates of receiving a reinfusion of intraoperative blood salvage–processed blood (73%) and also received the highest mean number of reinfused pRBCeq units. Patients undergoing cesarean delivery without bleeding were significantly less likely to have intraoperative blood salvage blood reinfused than the patients in the other three categories ($P < .001$) (Table 2).

**COMMENTS**

These data indicate that in certain obstetric bleeding situations, such as when patients are experiencing a brisk bleed, intraoperative blood salvage can be an effective method for returning shed blood. However, to make the best use of this resource, it should only be used in circumstances where active hemorrhage is actually occurring or where a high probability of hemorrhage is expected such as in cesarean hysterectomy procedures.

Because no blood is reinfused, each standby case effectively represents a waste of operating room personnel time and the cost of the disposables. Reimbursement for any form of intraoperative blood salvage collection and processing is performed by hospital employees. Although clinical circumstances, not cost, should direct patient care and thus some standby cases will always be inevitable, greater accuracy in predicting the patients who will experience major hemorrhage would be useful in reducing the number of standby cases; however, this prediction is notoriously difficult. This challenge was evident in the cesarean delivery group, which had the highest proportion of standby cases and consequently the lowest proportion of patients who received an intraoperative blood salvage reinfusion (Table 2).

Intraoperative blood salvage blood reinfusion offers certain advantages over allogeneic RBCs. Of particular importance in females of childbearing age is the prevention of alloimmunization to RBC antigens because some of these RBC antibodies can lead to hemolytic disease of the fetus and newborn. Certain transfusion reactions, such as allergic reactions, also are reduced with the use of intraoperative blood salvage blood along with the transmission of certain infectious diseases, such as acquired immune deficiency syndrome, hepatitis, and Chagas disease. Furthermore, intraoperative blood salvage reinfusion has been shown to reduce the need for allogeneic RBCs. Thus, when a reinfusion of shed blood is likely, intraoperative blood salvage has advantages over allogeneic RBC transfusion.

Shed blood reinfusion is a form of autologous transfusion. However, it should not be confused with preoperative autologous donations whereby the patient donates one or more units of their blood days or weeks before surgery in anticipation of requiring a transfusion.

<table>
<thead>
<tr>
<th>Nature of Hemorrhage</th>
<th>No. of Patients in Whom Intraoperative Blood Salvage Was Performed</th>
<th>No. of Standby Cases (%)</th>
<th>No. of Cases in Which Intraoperative Blood Salvage Blood Was Reinfused (%)</th>
<th>Total No. of Transfused PRBCeq Units</th>
<th>Mean No. of PRBCeq Units Reinfused/Patient/†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cesarean delivery</td>
<td>30.7 ± 6.4</td>
<td>88.6 ± 23.6</td>
<td>748</td>
<td>654 (87)</td>
<td>94 (13)$^\dagger$</td>
</tr>
<tr>
<td>Cesarean hysterectomy</td>
<td>32.3 ± 5.6</td>
<td>90.6 ± 21.8</td>
<td>103</td>
<td>28 (27)</td>
<td>75 (73)</td>
</tr>
<tr>
<td>Bleeding post–cesarean delivery</td>
<td>33.8 ± 6.3</td>
<td>83.5 ± 20.1</td>
<td>16</td>
<td>5 (31)</td>
<td>11 (69)</td>
</tr>
<tr>
<td>Vaginal delivery</td>
<td>31.1 ± 6.2</td>
<td>85.9 ± 18.1</td>
<td>17</td>
<td>8 (47)</td>
<td>9 (53)</td>
</tr>
</tbody>
</table>

PRBCeq, packed RBC unit equivalent.

Data are mean ± standard deviation, n, or n (%).

$^*$ There were no significant differences among the patients in these four groups ($P > .05$).

$^\dagger$ Patients undergoing cesarean delivery without bleeding were significantly less likely to have blood reinfused than the other patient groups ($P < .001$).

$^\dagger$ For the patients who received a reinfusion.

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in the perioperative period. Preoperative autologous donation can make the patient anemic before surgery, does not avoid many of the risks of allogeneic transfusion (such as bacterial contamination of the unit, a clerical error leading to transfusion of the wrong unit, or volume overload), and in many cases, the autologous units are not transfused and are discarded. Thus, many institutions now offer intraoperative blood salvage as an alternative to preoperative autologous donation, although as these data indicate, its efficacy depends on the amount of collected shed blood.

This study has some limitations. Although beyond the scope of this article, a detailed cost analysis should be performed to elucidate the point at which intraoperative blood salvage becomes cost-effective in postpartum hemorrhage. Albright and colleagues\(^1\) have demonstrated that intraoperative blood salvage is only cost-saving in cesarean delivery when there is a high probability of blood loss, such as when two to three intraoperative blood salvage units are reinfused. There are the costs of the disposables and the technologists’ time that are associated with a standby intraoperative blood salvage case, and even more disposables are required should a reinfusion of intraoperative blood salvage occur; these costs need to be balanced against that of allogeneic RBC units and their potential for adverse events.

REFERENCES