Cell salvage in obstetric anesthesia

S. LOUA GE (*) and M. VAN DE VELDE (**)
Various blood conservation techniques can reduce exposure to allogenic blood, thereby reducing risk and saving blood supply. Pre-operative autologous donation consists in collecting the patient’s own blood before an anticipated procedure and storing it in a blood bank until surgery. This technique reduces transfusion-transmitted diseases or infections and immunologically-mediated hemolytic, febrile and allergic reactions. It does not eliminate the risks of collection, storage, and identification errors found with allogenic blood and is not economically effective. The total amount of blood transfused is higher than with allogenic blood due to a lower hematocrit in patients donating blood preoperatively and a more liberal transfusion policy associated with autologous blood donation. In obstetric hemorrhage the amount of blood required is often far in excess of the blood that can be collected pre-operatively. The preoperative donation may cause anemia due to a reduced hemoglobin level. Pregnant women already have physiologically lower hemoglobin and increased intravascular water. In that case, erythropoietin and iron can be given to gain a reasonable amount of autologous blood. The usefulness of that technique is limited in case of severely hemorrhaging wounds. Preoperative autologous donation cannot be used in an emergency setting and is not acceptable for many Jehovah’s Witnesses. As there are very little experience and substantial organizational difficulties in performing preoperative autologous donation, it should be reserved for exceptional circumstances, such as parturients with a very high risk of bleeding or exceptional cross-matching difficulties due to rare blood type or unusual antibodies. Preoperative autologous donation is currently not recommended by the Centre for Maternal and Child Enquiries (CEMACH), the National Blood Service (NBS) or the National Institute for Health and Clinical Excellence (NICE) (1, 7).

Acute normovolemic hemodilution is the removal of blood from a patient immediately before operation and simultaneous replacement with an appropriate volume of acellular fluids to maintain normovolemia during surgery. The blood is stored in a blood bag and can be given back to the patient during surgery. It reduces the risk of both administrative error and infection but can deplete iron stores and cause anemia. The possible induction of anemia and cardiac failure limits its use in obstetrics. This technique cannot be used in an emergency. It may have a limited role in combination with other techniques. The NBS and NICE do not recommend acute normovolemic hemodilution in their latest guidelines (7).

Cell salvage is more effective and useful in obstetrics than the other techniques and overcomes their shortcomings. First, a provision of the patient’s own blood is made available, which means a low risk of disease transmission, clerical errors and immunological complications, as well as a decreased need of allogenic blood products. Costs are reduced and patient’s outcome is improved. This technique is usable in elective as well as emergent surgery (15), and is endorsed by several official bodies, including CEMACH, NBS, NICE, the Association of Anaesthetists of Great Britain and Ireland, and the Obstetric Anaesthesists’ Association (7).

Probably the most effective blood conservation technique is the decision of not transfusing a patient if hemoglobin is 8 g/dl or above (22). Current guidelines state that red cells are rarely required when the hemoglobin concentration is > 10 g/dl, and almost always needed when it is < 6 g/dl. At intermediate concentrations, the need...
for transfusion depends on the individual clinical situation (6).

**CELL SALVAGE**

**History**

In 1818 James Blundell reported in the Lancet the first documented use of autotransfusion for the treatment of postpartum hemorrhage. At that time, the method resulted in a 75% mortality rate, but it marked the beginning of autologous blood transfusion. A hundred years later, in 1914, Theis reported the first successful use of intraoperative autotransfusion in a patient with a ruptured ectopic pregnancy. His method was described as the simplest technique of cell salvage. Thereafter, the interest in autotransfusion decreased up until the 1960s, where it revived. The first prototype of a cell saving unit was built by Taswell and Wilson at the Mayo Clinic in 1968. At the same time, Dyer, Klebanoff and Watkins developed a cell salvage device with the help of the Bentley Laboratories. The problems with the Bentley system included the need for systemic anticoagulation of the patient, risk of air embolism, and renal failure resulting from filtered particles in the reinfused blood. As the Bentley system lost favor, Wilson and Latham proposed the use of a discontinuous flow centrifuge process for autotransfusion, which washed the red cells in a normal saline solution. In 1976, this system was made available by Haemonetics Corporation. Through five generations of Cell Savers, this technology improved and became so widely accepted that virtually all similar cell salvage instruments were referred to as ‘Cell Savers’. In the mid-1970s, a passive canister collection system was introduced. It was much less expensive, but unable to provide processed blood for reinfusion fast enough to be effective in massively bleeding patients. There also remained questions about the quality and safety of that unprocessed blood. More recently in 1995, Fresenius introduced a continuous autotransfusion system that washed and separated cells continuously, using a spiral-shaped separation chamber (35). Nowadays, several cell salvage systems are available. They differ in the ability to clear certain blood components, such as leukocytes and lipids. There are also differences in the production rate and mass of red cell recovery. However, these differences may not be clinically relevant (1). The first leukocyte filtration system was developed in 1928 by the pathologist Fleming, using a cotton wool plug. In 1961, Swank discovered a new microfilter-based leukocyte filtration technique. Thanks to his findings, the development of leukocyte depletion filters had started. The clinical use of the leucodepletion filter started during the late 1980s. In the mid-1990s, it was associated with cell salvage in oncological studies. The first clinical case of leucodepletion filter used with cell salvage in obstetric anesthesia was described in 1999 (13).

**Cell salvage technique**

Cell salvage is a unique form of autologous transfusion where blood loss is returned to the patient. In the direct form, there is no additional processing, whereas in indirect cell salvage, operative blood loss is recycled. The procedure starts with the surgeon aspirating blood from the operation site through a dual lumen anticoagulated suction tube. Passing an ultrafilter, the patient’s blood arrives in a collecting reservoir containing citrate solution or saline 0.9% with heparin. When there is sufficient blood for processing, it is pumped into a centrifuge bowl. The cells are separated by hemocentrification and differential centrifugation. When the centrifuge is activated, the less dense blood components and anticoagulant move toward the centre of the bowl, where they spill over into a waste bag. Afterwards, they are washed in 1 L of 0.9% saline and concentrated by centrifugation to a hematocrit of > 55%. Circulating fibrin, debris, plasma, leukocytes, microaggregates, complement, platelets, free hemoglobin, circulating coagulant factors, and most of the heparin are removed. The processed red cell suspension is pumped into an infusion bag to be given back to the patient (Fig. 4). The blood can be reinfused immediately or later. There is, however, a limit of 6 hours during which reinfusion can take place. Considerable volumes of blood are lost on swabs, sponges and in drains. This blood can also be collected but first has to be incorporated into an anticoagulant solution. Leucocyte depletion filters are used to remove white cells from donated blood by passive sieving through a microfiber web and active adhesion to a negatively charged surface. Using the cell saver in combination with a leucocyte depletion filter, leukocytes, platelets, tumour cells, fetal squames and phospholipid lamellar bodies can be removed. Processing a full reservoir of blood can provide 250 mL of packed red cells with a hematocrit of 55 to 80 percent within approximately three minutes, depending on the hematocrit of the patient. A massive bleeding patient can be provided with the
equivalent of 12 units of banked blood per hour (34).

Risks of cell salvage

Three groups of problems can be encountered with cell salvage: equipment malfunction, operator error, and blood-related sequelae, such as contamination or bad quality of blood. Equipment-related problems as well as operator error are greatly reduced by design refinements and increased experience of cell saver users that makes cell salvage a safe procedure.

Air embolism is reported with some cell salvage devices. To avoid this, modern cell salvage devices do not transfuse directly from the centrifuge and have an air detection system, which stops the system if air is introduced. An inappropriate clearing of anticoagulants can lead to an increase in anticoagulant plasma levels, prolonged activated partial thromboplastin time and activated clotting time, and to coagulopathy. However, modern centrifugal devices clear anticoagulant very effectively. The “salvaged blood syndrome” refers to the development of disseminated intravascular coagulation and increased capillary permeability in the lungs, causing an acute respiratory distress syndrome, or in the periphery, causing anasarca. It is responsible for multiple organ failure after the administration of washed autologous red cells. This syndrome appears to be mediated by platelet debris, responsible for disseminated intravascular coagulation, and polymorphonuclear leucocytes that, increase vascular permeability, leading to endothelial damage, coagulopathy and pulmonary dysfunction. Using CATS, polymorphonuclear leucocytes are not activated, and endothelial damage is reduced. Although cell salvage may cause a slight coagulopathy, especially after major blood turnover, there is no evidence that the ‘salvaged blood syndrome’ is really the result of autotransfusion. Shock, hypothermia and multiple transfusions may be responsible for causing this syndrome because of the reperfusion injury that follows an ischemic event. This rare syndrome can be prevented by avoiding the aspiration of very dilute blood and by using citrate, rather than heparin, as the anticoagulant (37). Bacterial contamination can lead to sepsis. It can be avoided by using prophylactic antibiotics and by not aspirating from obviously infected sites. Fat embolism, particularly seen after orthopaedic procedures, is preventable by extra washing and microaggregate filters. Microaggregates, consisting of white cells and platelet debris, can develop in salvaged blood. Microembolization can also be prevented by microaggregate filters. Patients receiving processed blood may develop a hyperchloremic metabolic acidosis and calcium, magnesium and proteins depletions. This is due to the presence of sodium and chloride alone in the washing solution. Alternative washing solutions are currently under investigation. If citrate is used to anticoagulate blood, hypocalcemia may occur (34).

Cell salvage in practice

a. Indications

The Guidelines for Autologous Transfusion published by the British Committee for Standards in Haematology (BCSH) state that cell salvage is indicated for surgeries with clean operative fields and anticipated blood loss greater than 20% of blood volume, or approximately one litre in an adult. For patients undergoing procedures where more than 10% are transfused allogeneically in the perioperative period, or where the mean transfusion rate is more than 1 unit, cell salvage is also indicated (5). Intraoperative cell salvage is widely applied in a variety of high blood need surgical procedures, including cardiac, vascular, orthopedic, urologic, trauma, gynecologic, and transplantation surgery. It is also used in neurosurgery and plastic surgery, when blood need is anticipated to be high. A Cochrane Review of cell salvage in adult elective surgery concludes that it is efficient at reducing the need for allogenic blood transfusion (22). Cell salvage is valuable for the patient with serologic problems, whom cross-match-compatible blood is unobtainable. It is also the method of choice for
blood conservation of patients with particular hematologic disorders, such as sickle cell anemia, spherocytosis, thalassemia, leukemia, and plasmacytoma, although some of them were considered as contraindications in the past (34).

b. Contraindications

An absolute contraindication for cell salvage is a setting where the possibility of a simultaneous collection of fibrin adhesives, hydrogen peroxide, betadine, chlorhexidine, alcohol, distilled water or non-parenteral antibiotics cannot be ruled out. The aspiration of topical clotting agents such as collagen and thrombin, and bone cement should also be avoided. Relative contraindications are patients with a known blood-borne infectious disease, which could endanger health care workers in case of device malfunction. By adding a leukodepletion filter, relative contraindications such as bacterial contamination, amniotic fluid contamination and contamination with tumour cells, can be overcome. For the prevention of bacterial contamination, systemic broad spectrum antibiotics can also be added (40). Blood irradiation can prevent duplication of tumor cells in salvaged blood. The underlying principle is the radiosensitivity of nucleated cells like cancer cells and the radioresistance of the non-nucleated erythrocytes. The amount of tumor cells in salvaged blood can be diminished, but cannot be completely eliminated (21).

c. Product Quality

The quality of salvaged red cells depends on the quality of the blood prior to washing, the type of surgery, the size and speed of the processing bowls, the volume of saline wash used, and the final concentration of red cells, all of which may vary between devices. Salvaged blood is at least equal and usually superior to banked blood. Homologous blood is cold, acidic, contains a lot of potassium, and few 2,3-diphosphoglycerate. Therefore, oxygen cannot be transported for a certain period. Blood recovered in a cell saver is fresh and close to room temperature, hence red blood cells are viable, have a near-normal osmotic membrane-stability, and come with a potentially normal life span. Their level of 2,3-diphosphoglycerate is close to normal, maintaining an oxygen carrying capacity that is not different from the one of patient’s circulating blood. After processing, salvaged blood can contain up to 80% of the lost red cells. Hematocrit after washing lies between 52 and 80%. Free hemoglobin, potassium and proteins are washed enough and 80-94% of leukocytes are removed. The washed product does not contain enough plasma coagulation factors or platelets to insure coagulation (26).

d. Cost-effectiveness

The cell salvage technique becomes cost-neutral at an expected blood loss of two units. The disposables for a cell saver run cost less than a single unit of red cells. There is also a reduction in the length of hospital stay and the amount of allogenic blood transfused. Savings are likely to increase with the rising cost of donated blood (16).

e. Standards

Hospitals with cell saving programs should establish written policies and procedures that are regularly reviewed by a physician in charge of the program. There must be written policy for the proper collection, labeling and storage of blood. Periodic quality control testing of recovered blood is recommended. Proper labeling should include, at a minimum, the name and identifying number of the patient, the component name, the statement ‘For Autologous Use Only’, and the expiration date and time. Blood collected by cell saving should never be transfused to any patient other than the one from whom it was collected (23).

OBSTETRIC HEMORRHAGE

Definition

The definition of obstetric hemorrhage varies widely in the literature. Blood loss of more than 500 ml during vaginal delivery and more than 1000 ml during cesarean section are considered abnormal. Additional resources should be mobilized if blood loss exceeds 1500 ml. Massive or major obstetric hemorrhage can be defined as blood loss of more than 1500-2500 ml, a decrease in hemoglobin of more than 4 mg/dL, acute transfusion requirement of more than four to five units, or treatment for coagulopathy (43).

Incidence

Obstetric hemorrhage poses a significant threat to maternal health. It remains the most important cause of maternal mortality, accounting for approximately 30% of all maternal deaths worldwide. Approximately 150,000 women die each year because of obstetric hemorrhage. About half of
these deaths occur in sub-Saharan Africa and about one third in south Asia. In Latin America and the Caribbean, hypertensive disorders play a more prominent role (33). Thrombosis and thromboembolism are the leading causes of direct maternal death in the developed world. This is followed by hemorrhage and hypertensive disease. Advances in medical and surgical management of hemorrhage and improved access to care have resulted in improved clinical outcomes, especially within the developed world. Over the past century the maternal mortality rate has decreased significantly. Although recent studies within the more developed regions have identified worrisome trends regarding obstetric hemorrhage.

Today, the incidence of maternal death from hemorrhage remains as high as it was 20 years ago. The report on CEMACH even shows that, in the UK, an increase in obstetric hemorrhage-related mortality rate is reported. This rise could be explained by a number of factors including increased maternal age, increased number of multiple gestations and a rise in caesarean section rate (24).

**Cause** (Table 1)

a. Antepartum hemorrhage

Obstetric hemorrhage consists in antepartum and postpartum hemorrhage. Antepartum hemorrhage occurs in 5-6% of the pregnant women. Most cases result from benign pathology or unknown origin. However, a significant proportion of pregnant women who experience antepartum hemorrhage have abnormalities in placation, such as abruptio placenta, placenta previa, or placenta accreta/increta/percreta. Uterine rupture, vasa previa, and amniotic fluid embolism are other causes of antepartum hemorrhage. A previous cesarean section or the presence of uterine scar increases the incidence of placenta previa, placenta accreta/increta/percreta, and uterine rupture.

b. Postpartum hemorrhage

Postpartum hemorrhage affects about 5% of deliveries. There are several known risk factors of postpartum hemorrhage, but each parturient has to be considered at risk. Postpartum hemorrhage occurs in response to an abnormality of one of four basic processes, referred to as the “4 T’s”. These problems may occur individually or in combination, and include abnormalities of tone, tissue, thrombin, or result from trauma. Retained placenta, uterine atony, and cervical/vaginal lacerations represent 95% of all causes of postpartum hemorrhage. Other less common causes are uterine inversion and coagulation disorders. Uterine atony is the most important etiology of postpartum hemorrhage with an incidence of 50% to 60%. Retained placenta is accounting for 20% to 30% of cases and cervical/vaginal lacerations for 10%. A careful differential diagnosis is necessary because above-mentioned causes of postpartum hemorrhage are often associated. All causes should be considered and investigated.

**Approach**

There are two approaches to control hemorrhage: the use of drugs and surgery. Oxytocin is the

### Table 1

<table>
<thead>
<tr>
<th>Triennium</th>
<th>Placental abruption</th>
<th>Placenta praevia</th>
<th>Postpartum haemorrhage</th>
<th>Total</th>
<th>Rate</th>
<th>95 per cent CI</th>
<th>Genital tract trauma*</th>
<th>Overall total</th>
</tr>
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<tbody>
<tr>
<td>Number</td>
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<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Rate</td>
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<td>Number</td>
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<td>4</td>
<td>0</td>
<td>6</td>
<td>10</td>
<td>0.44</td>
<td>0.24 - 0.81</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>1985-87</td>
<td>6</td>
<td>5</td>
<td>11</td>
<td>22</td>
<td>0.93</td>
<td>0.62 - 1.41</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>1991-93</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>15</td>
<td>0.65</td>
<td>0.39 - 1.07</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>1994-96</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>12</td>
<td>0.55</td>
<td>0.31 - 0.95</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>1997-99</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>0.33</td>
<td>0.16 - 0.68</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>2000-02</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>17</td>
<td>0.85</td>
<td>0.53 - 1.36</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>2003-05</td>
<td>2</td>
<td>3</td>
<td>9</td>
<td>14</td>
<td>0.66</td>
<td>0.39 - 1.11</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>

* Includes ruptured uterus. These deaths were discussed in a separate Chapter in previous Reports.

The safety of cell salvage in obstetrics has been questioned because of the presumed risk of amniotic fluid embolism and rhesus immunisation. Amniotic fluid embolism remains an entirely theoretical risk, as it has never been documented during cell salvage. It’s an obstetric emergency, presenting with cardiorespiratory collapse and coagulopathy, and a 50% mortality rate within the first hour of onset. The etiology of amniotic embolism remains uncertain. Amniotic fluid-derived tissue factor is thought to be an initiator of coagulation and may be responsible for the disseminated intravascular coagulopathy, which is seen with amniotic fluid embolism. Tissue factor may be only one of several components that lead to that syndrome. It appears that, although all recently delivered women must have amniotic fluid in their blood, the vast majority remains healthy. The term amniotic fluid embolism may therefore not be adequate. The syndrome should be regarded as a type of anaphylactic reaction causing the cardiorespiratory collapse. As the etiology of amniotic embolism is not completely understood, amniotic fluid and placental tissue should be removed as much as possible before reinfusing salvaged blood (20).

Fetal red cell contamination of saved blood remains a real risk. The cell saver cannot distinguish fetal from maternal red cells; hence any aspirated red cells will be retransfused. This will increase the dose of anti-D immunoglobulin required to prevent rhesus immunization of rhesus negative mothers. Kleihauer testing should be performed as soon as possible in rhesus negative mothers (7).

Experimental evidence

Before administering cell-salvaged blood in the obstetric setting, adequacy of the washing process should be assessed, with a focus on the components that are thought to be associated with amniotic fluid embolism. Amniotic fluid is an electrolyte solution that contains old fetal blood cells, trophoblasts, lanugo hair, and fetal squamous cells, such as vernix caseosa. As pregnancy advances and fetal lung maturation starts, lamellar bodies containing phosphatidylglycerol accumulate in the amniotic fluid. Alfa-fetoprotein is highly concentrated in fetal plasma and can be detected in maternal plasma after fetomaternal transfusion. Several laboratory-based studies examined blood, salvaged during obstetric procedures, on the presence of amniotic fluid components without reinfusing (Table 2-3).

Alfa-fetoprotein can be reduced to a concentration equivalent to maternal venous blood or can be completely removed. Phosphatidylglycerol nearly disappears after washing. Processed blood no longer contains lamellar bodies and trophoblasts. Lanugo hair and vernix caseosa are found in one of 15 samples (14). Amniotic fluid-derived tissue factor can be reduced or nearly eliminated. In 1999 a leukodepletion filter has been added for the first time, resulting in a complete removal of fetal squames and phospholipid lamellar bodies, and a significant reduction in bacterial contamination. Fetal blood is present in all samples, so alloimmunisation remains a real risk. Amorphous fetal debris cannot be eliminated adequately by washing and filtration.
Differences in results among these studies may result from differences in cell salvage devices, sizes of processing bowls, amounts of saline wash, degree of technical expertise in device operation and use of a depletion filter. Use of erythrocyte salvage devices using technologies other than a centrifugation-type bowl has not been studied (3, 4, 10, 14, 17, 18, 36, 39, 41, 44).

Clinical evidence

a. Randomized-controlled trial

Only one, small, prospective, non-blinded, randomized controlled trial on the elective use of cell salvage in obstetrics was published (31). Thirty-four patients receiving autologous, salvaged blood were compared with a control group of thirty-four patients, who only received allogeneic blood if transfusion was required. The results revealed a significant reduction in transfusion, higher postoperative hemoglobin levels, and shorter lengths of hospital stay in the study group. No serious complications were noted. The paper doesn’t provide enough details regarding randomization of patients into groups. No information is given concerning the postoperative hemoglobin threshold for allogenic transfusion. This carries the risk of invalidation of the findings due to selection bias.
<table>
<thead>
<tr>
<th>Publication</th>
<th>Amount of patients</th>
<th>Clinical Setting</th>
<th>Cell saving system</th>
<th>Separate suction</th>
<th>Median Volume of blood rein fused</th>
<th>Adverse events</th>
<th>Outcome</th>
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<tr>
<td>1983 Keeling</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>-</td>
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</tr>
<tr>
<td>1988 Grimes</td>
<td>2</td>
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<td></td>
<td></td>
<td>OR-BloodBanker</td>
<td>- 1900 mL</td>
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<td>1993 Jackson and Lonser</td>
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<td></td>
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<td>1996 Tawes and Duvall</td>
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<td>1998 Rainaldi</td>
<td>34</td>
<td>+</td>
<td></td>
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<td>1998 Rebarber</td>
<td>186</td>
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<td>Heparin toxicity (1 case)</td>
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<td></td>
<td>Medtronic Sequestra 1000</td>
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<td>+</td>
<td></td>
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<td>+</td>
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<td>2005 Boonstra</td>
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<td></td>
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<tr>
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<td>19</td>
<td>+</td>
<td></td>
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<td>+ 390 mL</td>
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**Table 4**

Case reports on cell salvage in obstetrics
CONCLUSION

Autotransfusion by cell salvage has a widespread role in major surgery and trauma and is a life-saving technique. The main advantage of cell salvage is the reduction of transfusion with banked blood. In addition, the cell saver can rapidly return red cells to the patient in cases of major bleeding, improving their outcome. When blood transfusion is unavoidable, conserving and using autologous blood wherever possible is increasingly favored. In the future, with a continued predicted shortage of donated blood, continued fears of potential infectious complications and rising costs of allogenic blood, we will need to find alternative means of returning oxygen carrying capacity to the circulation after major hemorrhage. Cell salvage may prove to be one of these means, but research must continue to support its efficacy and safety. Awareness of the technique of cell salvage should be increased and its use should be considered in cases of massive obstetric hemorrhage and as a part of the management plan for Jehovah’s Witnesses. The available literature on the use of intraoperative cell salvage in obstetrics demonstrates that there is limited evidence to support or refute the use of cell salvage in obstetric anesthesia. One randomized controlled trial, one triple-center historically cohort study and many clinical case reports have found no morbidity associated with the technique and a better outcome regarding hospital stay, postoperative hemoglobin level and a decreasing need for allogenic transfusion. Laboratory studies using various cell saver devices and filters have demonstrated removal of most amniotic fluid components. The risk of iatrogenic amniotic fluid embolus is probably remote and should be carefully weighted against the life-saving potential of this technique. Inevitable transfusion of fetal red cells may be a problem in rhesus incompatibility but can be treated with anti-D immunoglobulin. As the methodological quality of the trials is poor, the findings may be biased in favor of cell salvage. Large trials of high methodological quality that assess the relative effectiveness, safety, and cost-effectiveness of cell salvage in obstetrics, should be the focus of future research in this area. However, one should keep in mind that proving complete safety is not possible. A randomized-controlled trial with a power of 80% to rule out a fivefold increase in amniotic fluid embolism would require 265,000 patients (9).

Although the evidence is poor, my view is that the use of a cell saver associated with a leukodepletion filter, by trained staff, should be considered as safe, cost-effective and leading to a good outcome. In the mean time, the American Society of Anesthesiologists recommends in the Practice guidelines for Obstetric Anesthesia 2007: “Cell

b. Multicenter cohort study

In a triple centre historical cohort study, 139 patients in whom salvaged blood was autotransfused during cesarean section were compared to 87 control patients who underwent similar surgical procedures in the same centers without autotransfusion (32). All patients were considered as high risk patients. No differences were reported between the two groups in terms of length of hospital stay, postoperative infection rates, need for ventilatory support and occurrence of ARDS, DIC or AFE. Transfusion rates were not compared. There was one suspected case of heparin toxicity and one maternal death in the study group, due to an uncontrollable hemorrhage from a ruptured splenic artery aneurysm. As the study counts over years and over several hospitals, different models of the cell saver were used and cell salvage started at different times during surgery.

c. Case Reports

Documented clinical experience of cell salvage in a solely obstetric population is beyond these two papers limited to case reports. The cell saver has been safely used in over 400 published obstetric cases without causing any harm (Table 4). Cases of cell salvage in elective and emergency cesarean section are published, as well as of placenta previa, Jehovah’s witnesses and laparotomy for postpartum hemorrhage. Both early and more recent reports of blood salvage in obstetrics seem safe, although details are often incomplete. The few reported complications include operator error, heparin toxicity and coagulopathy (8,12,14,19,25,29-32,42). There’s one documented maternal death with the use of cell salvage in obstetric haemorrhage. A presumptive diagnosis of amniotic fluid embolism is described. A Jehovah’s witness with severe pre-eclampsia and HELLP syndrome died following cesarean section in which cell salvage was used. Her preoperative Hb was 7.1 g/dL, and platelet count $48 \times 10^9/L$. The saved blood had been transfused without the use of a leucocyte depletion filter. No other physiological or pathological details are given, so it is impossible to say whether the cell salvage contributed to her death or not (28).
salvage can be considered if severe hemorrhage occurs without available allogenic blood, or patient refusal of allogenic transfusion (2).

APPENDIX: Literature sources used in this manuscript

The evidence-based, peer reviewed information source UpToDate provided some basic information about the subject as well as the handbooks Clinical Anesthesiology by Morgan, Anesthesiology Review by Faust and Basics of Blood Management by Seeger. The search engine PubMed was used to brose the US National Library of Medicine. A combination of the keywords 'obstetric', 'cesarean', 'hemorrhage,' and 'cell salvage', ‘blood salvage’ or ‘autotransfusion’ let to several review articles, case studies, cohort, and controlled studies. After completing the electronic literature search, the article lists was reviewed. The reference lists of interesting articles were examined for additional citations. Relevant articles and websites were hand searched for further references. The Cochrane Database of Systematic Reviews was searched for reviews on the subject. Contact was taken with the Haemontec company for further information on the Cell Saver technique and with the Belgian Red Cross for blood bank statistics.

References


