CE **1.5 ANCC Contact Hours**

AUTOLOGOUS BLOOD TRANSFUSION FOR POSTPARTUM HEMORRHAGE

Julia A. Greenawalt, PhD, RNC-OB, CHSE, and Denise Zernell, MSN, BSN, RNC

Abstract

Postpartum hemorrhage (PPH) is a leading contributor to maternal morbidity and mortality in the United States and globally. Although the rate of PPH is generally decreasing nationally, severity of PPH appears to be increasing, potentially related to the various comorbidities associated with women of childbearing age. There is increasing evidence of risks associated with allogeneic blood transfusion, which has historically been the classic therapeutic approach for treatment to PPH. Pregnant women are particularly susceptible to the implications of sensitization to red cell antigens, a common sequela to allogenic blood transfusion. Autologous blood transfusion eliminates the potential of communicable disease transmission as well as the conceivable threat of a blood transfusion reaction. Recent technological advances allow cell salvage coupled with the use of a leukocyte filter to be used as an alternative approach for improving the outcome for women experiencing a PPH. Modest changes in standard operating procedure and continued training in use and application of cell salvaged blood may assist in minimizing negative outcomes from PPH. Salvaged blood has been demonstrated to be at least equal and often superior to banked blood. We discuss nursing implications for application of this technology for women with PPH. Continued research is warranted to evaluate the impact that application of cell salvage with filtration has on the patient experiencing a PPH.

Keywords: Autologous blood transfusion; Blood loss; Postpartum hemorrhage; Pregnancy.

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Background

Postpartum hemorrhage (PPH) is the leading cause of maternal morbidity, cardiac arrest, intensive care unit admissions, and death during childbirth in the United States (Bateman, Berman, Riley, & Leffert, 2010; Berg, Callaghan, Syverson, & Henderson, 2010; Bingham, Scheich, Byfield, Wilson, & Bateman, 2016; Kramer et al., 2013; Mhyre et al., 2014; Wanderer et al., 2013). Obstetric hemorrhage is a major cause of maternal mortality, with more than 140,000 deaths each year worldwide (Butwick & Goodnough, 2015). Nationally in 2013, the pregnancy-related mortality rate was reported to be 17.8 deaths per 100,000 live births with PPH accounting for approximately 11.4% of these deaths (Creanga et al., 2015). However, in light of recent attention on PPH hemorrhage, this number is most likely underrepresented. Researchers have noted similar trends in Canada, Australia, and Europe (Shields, Wiesner, Fulton, & Pelletreau, 2015). Postpartum hemorrhage is a major contributor to maternal morbidity, often resulting in hysterectomy (Silver & Barbour, 2015). Although the rate of PPH has continued to decline in recent years in the United States, there remains a concern that there has been a worldwide increase in severe PPH over the past few decades (Bateman et al., 2010; Bateman, Mhyre, Callaghan, & Kuklina, 2012; Bingham et al.; Callaghan, Kuklina, & Berg, 2010; Kramer et al.) with much of the severe maternal morbidity and mortality thought to be preventable (Berg et al., 2005; Bingham et al.; Della Torre et al., 2011; Geller et al., 2014; Lawton et al., 2014). This is most likely attributable to the concerted efforts that have been initiated in the United States with targeted approaches by concerned stakeholders at various levels; including state and federal agencies (Health People 2020), and professional organizations (National Partnership for Maternal Safety, the California Maternal Quality Care Collaborative, the Alliance for Innovation on Maternal Health). National success may be partially attributable to better data gathering techniques by surveillance systems such as the Pregnancy Mortality Surveillance System, of which only about half of the U.S. states currently contribute. As technology improves, more states may contribute such that mortality and morbidity of pregnancy-related issues within states may be enhanced (Creanga et al.).

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Definition of Postpartum Hemorrhage

Hemorrhage in the postpartum period is defined as either primary (within the first 24 hours of birth and most common) or secondary (from 24 hours to 6 weeks after birth). Traditionally, PPH was defined as a blood loss of 500 mL or greater from a vaginal birth or greater than 1,000 mL from a cesarean birth (London, Ladewig, Ball, Bindler, & Cowan, 2014). Severe PPH was defined as a blood loss of greater than 1,500 mL (Shields et al., 2015). Most recently, Hamm, Wang, Bastek, and Srinivas (2017) suggested that the American College of Obstetricians and Gynecologists adopt a change in the definition of PPH in the revitalize program recommending use of a universal threshold to estimate blood loss of 1,000 mL or greater for all births regardless of mode of birth (Hamm et al.).

Physiologic Aspects of Postpartum Hemorrhage

Estimation of blood loss is highly subjective, and even experienced clinicians can underestimate the blood loss by as much as 50% (Larsson, Saltvedt, Wiklund, Pahlen, & Andolf, 2006; Schorn, 2010). Hamm et al. (2017) found no matter mode of birth, the maternal blood supply is equipped to lose the same amount of blood before adverse outcomes are observed. Therefore, PPH is often identified through patient symptomatology: lightheadedness, weakness, palpitations, diaphoresis, restlessness, confusion, air hunger, and syncope (El Ayadi, Robinson, Geller, & Miller, 2013). Healthy women often do not exhibit signs and symptoms of hemodynamic instability until a blood loss of 1,000 mL or greater (Lu, Korst, Fridman, Muthengi, & Gregory, 2009). Postpartum hemorrhage may not be recognized immediately if the woman is compromised with comorbidities such as anemia, preeclampsia, or sources of intra-abdominal bleeding (Chandraharan & Arulkumaran, 2008). Recent evidence shows that with underestimation of blood loss, it is critical to use quantification of the loss in the antenatal, intrapartum, and postpartum periods (Al Kadri, Anazi, & Tamim, 2011; Gabel & Weeber, 2012; Patel et al., 2006).

Data trends from the last decade suggest that incidence of PPH is increasing, most likely related to the increase of the number of cesareans (Chandraharan & Arulkumaran, 2008). In a recent study, O'Brien and Uhl (2016) demonstrated a steady increase nationwide that was complicated by abnormal placentation. These atypical placental implantations include accreta, increta, and percreta. Incidence of accreta has increased 10-fold over the past 50 years, occurring in one of every 2,500 births to as high as one in 533 pregnancies and is the most common reason for cesarean hysterectomy in highly industrialized countries (O'Brien & Uhl). The most common risk factor related to abnormal placentation is cesarean birth.

In a healthy pregnant woman at term, blood volume and cardiac output increase such that 20% of cardiac output or 600 mL/minute of blood perfuses the gravid uterus, supporting the developing fetus. When the placenta separates from the uterine wall, the many vessels nourishing it are disrupted. The normal mechanism for hemostasis after birth is contraction of the uterine muscles to occlude the open sinuses. Uterine atony, or a

lack of contractility, can result in significant blood loss if undetected. Other causes of PPH include, but are not limited to, laceration of the genital tract, episiotomy, retained placenta, undiagnosed coagulopathies, vulvar or vaginal hematomas, uterine inversion, or uterine rupture (Creanga et al., 2015). Clinicians must be astute to the possible underlying causes of PPH and react early. A common mnemonic to help clinicians recall the causes of PPH is the four T's (Table 1), referring to tone, tissue, trauma, and thrombin (Anderson & Etches, 2007).

Uterine atony is the most common cause (50%–80%) of PPH. Contributing factors may include grand multiparity, gestational hypertension, a history of previous PPH, multiple gestation, fetal macrosomia, polyhydramnios, chorioamnionitis, placenta previa, Asian or Hispanic heritage, oxytocin induction or augmentation of labor, use of anesthesia, and a dysfunctional or prolonged labor (particularly a prolonged third stage) (Cunningham et al., 2014). Tissue may contribute to excessive postpartum bleeding directly related to retained placental fragments, retained blood clots, uterine fibroids, or invasive placental implantations. Passage of the fetus through the birth canal or an operative vaginal birth may contribute to PPH by causing trauma to the birth canal and surrounding perineal area. Lacerations of the perineum, vagina, cervix, or uterus can occur, particularly if birth is precipitous or instrumented with forceps or a vacuum. Other potential sources of hemorrhage are hematomas, which can be especially problematic for nurses as they are not always visible to the naked eye. Hematomas may be vaginal, vulvar, or retroperitoneal. Coagulopathies may be a result of hemophilia, von Willebrand disease, idiopathic thrombocytopenia or thrombotic thrombocytopenia purpura, disseminated intravascular coagulopathy, amniotic fluid emboli, severe preeclampsia or eclampsia, sepsis, fetal demise, HELLP syndrome or secondary to use of heparin, coumadin, or aspirin. Additional predisposing risk factors for obstetrical hemorrhage are active bleeding on admission, prolonged second stage of labor, prolonged oxytocin use, active bleeding, chorioamnionitis, and magnesium sulfate use (O'Brien & Uhl, 2016).

Autologous Blood Transfusion

The beginning of cell salvage can be traced back to James Blundell (1818) and William Highmore (1874). The first published use of cell salvage and transfusion for a woman with PPH was by Blundell (1818). Autologous transfusion has now become an emerging technique in the management of massive PPH (Wilson & Wrench, 2015). Current technology, when used effectively and appropriately now allows this blood salvaging mechanism to be applied to have a positive impact on the outcome of PPH.

Intuitively, *allogenic* or homologous blood (blood from an anonymous compatible donor) is the safest source of blood for transfusion; however, it may be scarce and expensive. *Autologous* blood (reinfusion of one's own blood) delivery to patients in obstetrics is not a new phenomenon. Patient blood management in obstetrics has historically used autologous blood as a solution for spinal headaches as a consequence of misplacement of epidural insertions (Stein, Cohen, Mohiuddin, Dombrovskiy, & Lowenwirt, 2014). Autologous infusions foster blood conservation strategies, including cell salvage, which aim to reduce consumption of allogeneic blood (Teare, Sullivan, & Ralph, 2015). Cell salvage offers a safe and relatively inexpensive alternative to allogeneic red cell transfusions (Esper & Waters, 2011). Salvaged blood is at least equal and usually superior to banked blood (Waters, Biscotti, Potter, & Phillipson, 2000). Cell salvage should be considered in those patients particularly at high risk for obstetric hemorrhage and transfusion (Goucher, Wong, Patel, & Toledo, 2015). *Homologous* blood is cold, acidic, and contains a great deal of potassium with few 2,3-diphosphoglycerate, limiting the oxygen carrying capacity of the allogeneic blood (Rebarber, Lonser, Jackson, Copel, & Sipes, 1998). Autologous blood recovered by cell salvage is fresh and close to room temperature, with viable red cells near normal osmotic membrane stability and a potentially normal lifespan. Administration of autologous blood yields few nonhemolytic febrile reactions in patients with less chance for sensitization to foreign red blood cell (RBC) antigens, thus protecting future pregnancies for women (Waters et al.).

There are limited data on cell salvage with vaginal births, as current practice has generally restricted its use for cesareans (Teare et al., 2015). Teare et al. note that blood loss during a vaginal birth can be salvaged. They found that blood composition was similar to that reinfused after a cesarean birth following washing of the salvaged blood from a vaginal birth in the cell saver (Teare et al.). Intraoperative blood salvage is a common practice in many surgical specialties, particularly in orthopedics. However, its safety and efficacy has been questioned in obstetrics secondary to theoretical concerns about contamination of blood with foreign substances such as amniotic fluid and fetal and meconium substances. Intraoperative blood salvage has historically been considered to be contraindicated in managing obstetric patients due to potential contamination of the recovered blood with amniotic fluid, activated clotting factors, and other embolic debris (Milne, Yazer, & Waters, 2015). Recent findings note that what was previously thought to be an amniotic fluid embolism was likely a rare anaphylactic response to a fetal antigen rather than predictable exposure to amniotic fluid (Catling, 2007; Gallos,

Table 1.
Mnemonic for the Specific Causes of Postpartum Hemorrhage: The Four T's

4 T's	Specific Cause	Relative Frequency
Tone	Atonic uterus	70%
Trauma	Lacerations, hematomas, inversion, rupture	20%
Tissue	Retained tissue, invasive placenta	10%
Thrombin	Coagulopathies	1%

Redai, & Smiley, 2009). Of the more than 400 published cases of the application of cell saver for obstetrical patients, none have identified incidence of iatrogenic amniotic fluid emboli (Pacheco, Saade, Gei, & Hankins, 2011).

In 2013, the Obstetric Anaesthetists' Association and the Association of Anaesthetists of Great Britain and Ireland acknowledged use of intraoperative cell salvage in the obstetric population. (Association of Anaesthetists of Great Britain & Ireland Obstetric Anaesthetists' Association, 2013).

This innovative technology encompasses standard cell salvaging with the incorporation of a leukocyte filter into the recovery process. Waters et al. (2000) found cell salvaging was executed effectively by cell washing with the use of a leukocyte reduction filter in 15 women who underwent cesarean birth. Leukocyte depletion filters are used to remove white cells from salvaged blood by the sifting through a microfiber web and active adhesion to a negatively charged surface. Use of the cell saver in combination with a leukocyte depletion filter allows leukocytes, platelets, tumor cells, fetal squames, and phospholipid lamellar bodies to be removed.

Modern cell-salvage devices do not transfuse directly from the centrifuge and have an air detection system to assist in avoidance of an air embolism. Amniotic fluid embolism to date is a completely theoretical risk in autologous transfusions. As of 2011, there was close to 400 reported cases where contaminated blood consisting of amniotic fluid had been washed and reinfused with no adverse effects noted in the mother (Esper & Waters, 2011). New technology allows the modern centrifugal device to clear anticoagulants effectively, which is a consideration as the washing solution is infused with heparin. A minimal amount of salvaged blood is necessary to operate the intraoperative blood salvage machinery (Milne et al., 2015).

Candidates

A candidate for autologous blood collection must meet specific criteria for administration of salvaged blood. Blood loss must meet specified criteria of greater than 1,000 mL regardless of mode of birth. Additional candidates ideal for autologous transfusion include women who are unwilling to accept allogeneic blood secondary to concerns regarding transmissions of infectious diseases or their religious beliefs. Some Jehovah's Witnesses accept salvaged blood as the process approximates a closed circuit. Women with antibodies that make cross matching difficult and women giving birth at centers with limited blood bank resources are also ideal for preparation for blood salvage in the event of a PPH.

Equipment

Equipment used for an autologous blood transfusion must be readily available and easily accessible to minimize delay in the salvaging process. Preparation of an obstetric autologous transfusion cart works well (Figure 1). Necessary equipment to have on hand is the obstetrical vacuum/suction setup, blood salvage machine with leukocyte depletion filter, sterile replacement drapes (abdominal or underbuttocks), sterile aspiration tubing, sterile basin, bottled normal saline solution (1,000 mL), blood collection setup reservoir, and a sterile replacement Yankauer head. Anticoagulation medications must also be readily available for use such as Anticoagulant Citrate Dextrose Solution or Solution A (ACD-A) and heparin 10,000 units.

Autologous blood transfusion has many benefits over allogeneic blood transfusions.

Procedure

Obstetrical hemorrhage can occur at any time and in any obstetrical patient (O'Brien & Uhl, 2016). The process is initiated when a woman is identified as a candidate for autologous cell salvage. The multidisciplinary team (obstetrician, obstetrical nurses, anesthesia providers, and the perfusionist) prepares for the autologous transfusion according to facility guidelines, policies, and procedures. A perfusionist is a specially certified healthcare provider who typically is noted to operate extracorporeal circulation or autotransfusion equipment. Although not all smaller hospitals have a perfusionist on staff, some do, particularly if the hospital physicians perform either cardiovascular surgeries or orthopedic surgeries on a regular basis. Smaller facilities often contract with outside groups to support their perfusion needs. A minimal amount of shed blood is necessary for processing, typically between 500 and 700 mL (Milne et al., 2015). Processing of the shed blood is not initiated until the appropriate amount is collected, although the collection begins at the delivery of the placenta. The labor and delivery nurse prepares for the transfusion by notification to the perfusionist and assembling of equipment in unison with the primary care provider taking steps to separate recoverable blood from contaminants. The surgeon aspirates blood from the operative or birth site through a dual-lumen anticoagulated suction tube. The

blood-soaked sponges are placed in the heparinized solution using sterile technique for washing and RBC recovery. Processing the blood begins as soon as a sufficient volume of blood is collected (Milne et al.). The processed blood is then run through an ultrafilter, and pumped into a centrifuge bowl. Cells are separated by hemoconcentration and differential centrifugation. Circulating fibrin, debris, plasma, leukocytes, microaggregates, complement, platelets, free hemoglobin, circulating anticoagulant factors, and most of the heparin are removed. The processed red cell suspension is pumped into an infusion bag and given back to the woman. Processing a full reservoir of blood can provide 250 mL of packed red cells with a hematocrit of 55% to 80% within approximately 3 minutes.

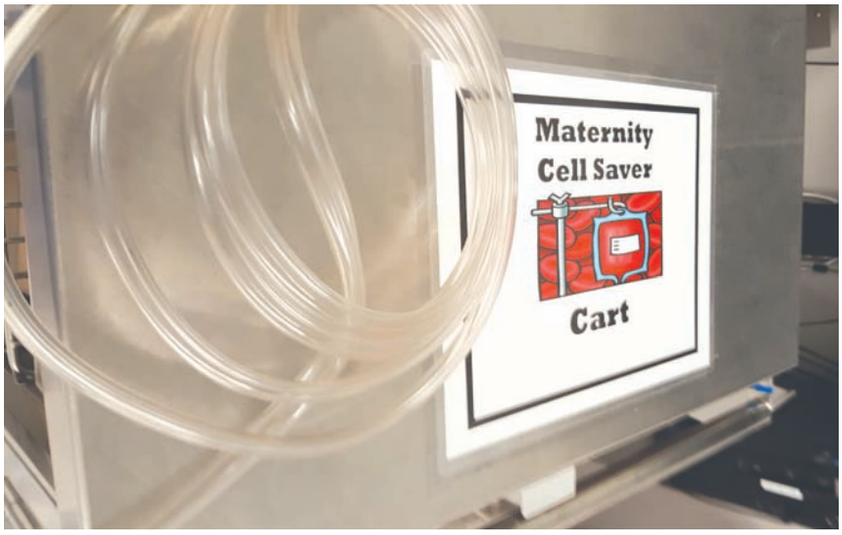
Relative Contraindications

Although the purpose of an autologous transfusion is to maintain the patients' oxygen carrying hematocrit during an acute blood loss event, not all patients are ideal candidates and relative contraindications do exist. If the woman has received clotting agents such as Avitene, Surgicel or Gelfoam relative contraindications exist as these substances may activate the patient's own clotting cascade if given intravascularly. Exposure of the blood to gastric fluids raises concern that proteolytic enzymes could also activate the clotting process. Betadine contamination may cause hemolysis of red cells and is also considered a relative contraindication. Topical antibiotic use contraindicates receiving autologous blood as this sets the patient up for potential serious reactions such as hypertensive crisis or shock. Although uncommon in obstetrics, methyl methacrylate, or fresh bone cement along with heat is known to produce hemolysis in patients and contraindicates the consideration of autologous blood administration to the patient. Other relative contraindications for consideration are blood that has been significantly contaminated by such substances as urine, bone chips, fat, bowel/fecal contents, or amniotic fluid. Soluble components such as amniotic fluid may contain proteolytic enzymes that could activate the clotting cascade. Squamous cells could cause pulmonary emboli. If the woman has any internal infection or malignancy, autologous transfusion is negated. The oxygen carrying capacity of RBCs may be compromised in a woman with hematological disorders such as sickle cell disease or thalassemia placing her at risk for autologous blood administration. If a woman has recently been exposed to papaverine, oxymetazoline, catecholamines, or carbon monoxide from electrocautery smoke, she should be considered a suboptimal candidate for an autologous blood transfusion.

Cost

Autologous blood transfusion is shown to be cost effective in patients with predictably high rates of hemorrhage or transfusion (Goucher et al., 2015). Cell salvage should not be a routine (Lu et al., 2009). According to a 2007 cost analysis of intraoperative cell salvage, a method entitled "standby use" should be considered to improve cost effectiveness (Waters, Meier, & Waters, 2007). Standby use refers to the implementation of a system that only accommodates the basic equipment for collection and holding as most often the patient does not yield enough blood to merit the use of the filtration processor (Waters et al.). Waters et al. conducted a cost analysis and determined the average cost of a unit of allogenic packed red cells was $200.00 as compared with $89.46 for salvaged blood. As noted by Milne et al. (2015), cell salvage was attempted on many patients throughout their study, with only 21% shedding a sufficient amount of blood for processing, and only 13% actually receiving the salvaged reinfusion. Costs do not reflect the various factors that apply to each individual institution using this salvaged blood intervention. With autologous transfusion being a low-volume, high-risk obstetric intervention, routine staff education is an essential consideration for patient safety. At our facility, education via simulation is conducted routinely with the expectation that the obstetrical team remains competent.

Figure 1. Obstetric Autologous Transfusion Cart



Clinical Implications

Cell salvage should be considered in those patients at high risk for obstetric hemorrhage and transfusion (Goucher et al., 2015). Effective use of cell salvage into routine obstetrical care requires a reorganization of standard care thought processes. When providing care to the mother during childbirth, it is advantageous to separate contaminated sponges from bloodied sponges necessitating early recognition of excessive bleeding, and implementing early actions to separate recoverable blood. Although many community facilities may not have the resources for this intensive process, it is suggested that a cell-salvage cart should be immediately accessible and integrated into

Salvaged blood is at least equal and usually superior to banked blood.

care of women giving birth who are anticipated to be at higher risk of PPH. Salvaging of only 1 unit of autologous blood can prevent the need to transfuse a patient with allogeneic blood and expose them to its related risks. To change the current mode of care at birth and immediate postpartum and to plan for possibility of reinfusion of autologous blood to the new mother, it is imperative that it become "second nature" to obstetrical staff and nurses. Regularly scheduled education and drills are recommended. Barriers can be identified and overcome as part of the planning and continuing education process. Incorporation of cell-salvage technology presents a unique opportunity to improve outcomes for women experiencing a PPH when used in a timely and effective manner.

Suggestions When Using Cell Salvage for Autologous Blood Transfusion for PPH:

- An interdisciplinary team (obstetrician, anesthesiologist, perfusionist, nurse, laboratory technician) is required.
- A shift in common practice is required. The team must anticipate the use of cell salvage in selected women and be ready to initiate as appropriate.
- Blood collection should begin at time of birth.
- Saturated blood-soaked sponges should be separated from contaminated sponges for future processing.
- Education and simulation in the process for the team should be regular and ongoing.
- Equipment, cart, and operational procedures need to be identified and articulated.
- All team members should be competent in their use and application. ✣

Julia A. Greenawalt is an Associate Professor, Indiana University of Pennsylvania, Indiana, PA. The author can be reached via e-mail at jgreen@iup.edu

Denise Zernell is a Nurse Educator, Penn Highlands, Dubois, PA.

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