Intraoperative Autologous Blood Transfusion

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Autologous transfusion refers to those transfusions in which the blood donor and the transfusion recipient are the same. Allogenic transfusions refer to blood transfused to someone other than the donor.[1]

Autologous blood is most commonly collected and banked in the weeks prior to an elective surgical procedure. Shed blood also may be salvaged for reinfusion during a surgical procedure in which the patient has significant blood loss. Although once used almost exclusively for open heart and vascular procedures, it is now commonly used for orthopedic procedures, liver transplants, trauma cases and complex spinal surgeries.[1]

The advantages of autologous blood transfusion are many and include reduction of the risk of virus transmission, avoidance of allogenic transfusion reactions, and supplementation of the sometimes-sparse supply of allogenic blood.[7]

In intraoperative autologous blood transfusions, shed blood is collected from the patient during surgery and reinfused intravenously during surgery or immediately following surgery.

Autotransfusion can be accomplished either with a device that collects whole blood and washes it to separate its components or with a device that simply collects whole blood and filters it before reinfusion.[4]

The advantage of the former process is that blood is separated into its components (red blood cells, platelets, and plasma), and the patient can be given only the component needed. It also, theoretically, removes toxic byproducts, but may also remove clotting factors in the process.[4]

The washing devices also may require operation by specially trained personnel. While hemofiltration systems are limited in function, they are easy to use and costeffective.

HISTORY

The need for the salvage of blood during surgery was first recognized in the early 1800s when James Blundell, MD, suggested its use to treat postpartum hemorrhage. However, the first use of salvaged blood was clinically described in 1886 when John Duncan, MD, retransfused shed blood from the operative field of a trauma patient undergoing amputation. He removed the blood from the amputated limb and returned it to the patient by femoral injection. This method was fairly successful. These early experiences with salvage blood, while successful, did not gain serious attention.[3]

The history of autologous blood transfusion changed dramatically in 1915 with the development of the first sodium citrate blood anticoagulant and the ability to maintain blood outside the body. This discovery not only renewed interest in salvaged blood, but also sparked an interest in predeposit autologous blood transfusions.

The first predeposit transfusion was described in 1921 by F C Grant, MD, in a patient undergoing surgery to remove a cerebellar tumor and became standard medical practice in the 1920s and early 1930s. The era of organized blood banks in the late 1930s and during the outbreak of World War II helped to change transfusion practice when allogenic products became readily available.[8]

However, salvage procedures continued to be explored throughout this period. In 1931, Brown and Debenheim used salvage blood in civilian, hemothorax cases. In 1943, a milestone in blood salvage was reached when Arnold Griswold developed the first salvage autotransfusion device. Griswold collected blood into a bottle by suction, strained it through cheesecloth and reinfused it into the patient by gravity.[8]

After World War II, blood testing, typing and crossmatching techniques were improved, making blood banks the answer to increased demand for blood. However, in the 1960s, interest in autotransfusion revived once again.

With all the advances in the field of surgery, companies developed new autotransfusion devices. Problems still arose, however, with air embolisms, coagulopathy and hemolysis. The devices used during the Korean and Vietnam Wars collected and provided gross filtration of blood before it was reinfused.[6]

With the introduction of cardiopulmonary bypass in 1952, autotransfusion became an area of serious study. Klebanoff applied principles from cardiopulmonary bypass technology to develop a salvage device. His system—the Bentley Autotransfusion System®—aspirated, collected, filtered and reinfused autologous whole blood shed from the operative field. The problems with the Bentley system included the requirement of systemic anticoagulation of the patient, introduction of air embolism, and renal failure resulting from unfiltered particulate in the reinfused blood.[5]

As the Bentley system lost favor, Wilson and Associates proposed the use of a discontinuous flow centrifuge process for autotransfusion that would wash the red cells with normal saline solution.[11] In 1976, this system was introduced by Haemonetics Corporation and is known commonly as Cell Saver®. More recently, in 1995, Fresenius HemoCare introduced a continuous autotransfusion system.

THREE TYPES OF SYSTEMS

There are three types of autotransfusion systems: unwashed filtered blood, washed discontinuous flow centrifugal and washed continuous flow centrifugal. The unwashed systems are popu-

Autotransfusion in 1936

Like many of the technologies we take for granted today, autotransfusion hasn't been around very long.

TIME magazine published an article on Monday, February 24, 1936, about a young boy whose life was saved by two quick-thinking surgeons, who happened to be father and son.

The boy—"the skinny, scrappy son of a Pittsburgh butcher"—was stabbed in the chest by another boy. The surgeons used cheesecloth to soak up blood that was pooling in the boy's chest.

The entire article is available online at: ***http://www.time.com/time/magazine/article/0,9171,755869,00.html*** lar, because of their perceived low cost and simplicity. However, unwashed systems can cause increased potential for clinical complications.

The washed system requires a properly trained and clinically skilled operator. It returns only red blood cells suspended in saline and is rarely associated with any clinical complications. The autotransfusion process described in this article represents the washed discontinuous centrifugal system. This type of autotransfusion can practically eliminate the need for exposure to homologous blood in elective surgery and can greatly reduce the risk of exposure for emergency surgical patients.

FIGURE 1: Cell Saver® in use during author's chest surgery.

CELL SALVAGERS

Intraoperative cell salvage includes collecting, concentrating and washing the blood in the operating room. Salvage begins when shed blood is obtained from the operating site and immediately mixed with an anticoagulant (usually 30,000 units of heparin per liter of 0.9% normal saline or citrated dextrose) near the suction tip.

The anticoagulated blood is stored in a collection reservoir, where a 120-micron filter removes tissue, clots, orthopedic cement and other macro debris.[2] A simple push of a button activates the process.

A volume of 400–700 ml of blood is pumped into a spinning centrifuge. The centrifugal force in the bowl captures the red blood cells, concentrates and separates them from the plasma and other waste products.

Plasma overflows from the bowl into the waste bag, taking with it white cells, platelets, free hemoglobin, irrigation fluids, activated clotting factors and cell debris.

A light sensor detects when the centrifuge bowl is full of red cells (225 ml concentrated to a hematocrit above 50%), thereby activating the wash cycle. Sterile normal saline is pumped through the red blood cells within the centrifuge bowl, washing the packed red cells.

It takes 1–1.5 L to wash away the unwanted elements, such as soluble activated clotting factors, proteolytic enzymes, potassium, heparin, red cell debris and free hemoglobin. Orthopedic procedures have more debris to remove and therefore require more fluid for washing (usually 1.5–2 L).[2]

At the completion of the wash cycle, packed red cells suspended in saline (≥50% Hct) are pumped from the centrifuge bowl into a reinfusion bag. The washed cells are reinfused into the patient using a 40-micron filter in the usual manner.

These processed red cells contain no clotting factors and no anticoagulants. The entire procedure takes less than 10 minutes. Approximately 50% of the shed red blood cells are saved.[2]

INDICATIONS FOR AUTOTRANSFUSION

Autotransfusion is commonly used intraoperatively and postoperatively and is intended for use in situations characterized by loss of one or more units of blood. It may be particularly advantageous for use in cases involving rare blood groups, risk of infectious disease transmission, restricted homologous blood supply or other medical situations for which use of homologous blood is contraindicated.

Common autotransfusion cases include the following:

Orthopedic/ Neurosurgery

- Total knee replacement
- Total shoulder replacement
- ORIF of pelvic fractures
- Total hip replacement
- Femoral fracture repair
- IM rodding
- Insertion of spinal instrumentation
- Laminectomy
- Spinal fusion
- Discectomy

Trauma

- Subdural hematoma
- Chest injuries
- Liver fractures
- Aneurysms
- Amputations
- Blunt trauma (thoracic or abdominal)
- Gun shot wounds/ Stab wounds
- Kidney fractures
- Major vessel lacerations

Other

- Removal of ectopic pregnancy
- Abdominal aortic aneurysmectomy
- Thoracotomy (for non-malignant tumor)
- Craniotomy
- Liver resection (for non-malignant tumor)
- Treatment for cerebral aneurysms
- Hysterectomy (for non-malignant tumor)

ADVANTAGES OF INTRAOPERATIVE RED CELL SALVAGE

Blood salvage does not require the preoperative storage of the patient's own blood—Predeposit donation requires that the patient make periodic trips to the blood donation facility and submit to repeated "needle sticks." This type of donation is not available in emergency situations, and all of the same changes occur in allogenic blood during the storage process, including loss of red cell function. Hemolysis and acidosis also may occur in stored autologous blood.[8]

Rapid availability of the patient's own blood—Since the blood is being collected as it is shed, its return is almost immediate. It is possible to actually return the blood that is lost during surgery before stored blood can be retrieved.

Reduced net intraoperative blood loss—Retransfusion of blood loss during surgery reduces the need for allogenic transfusion and decreases the overall blood loss.

Decreased need for blood from the blood bank—This may be particularly important in emergency and trauma situations and in patients with rare blood types.

No compatibility testing required—Since the procedure is performed in the operating room, and only one patient with one blood type is involved, there is no need to type and crossmatch this blood.

Better quality of red blood cells than in stored blood—The higher levels of 2, 3 diphosphoglycerate (DPG) and normal survival of red blood cells in salvaged blood have been established. While red cell damage with release of hemoglobin into the plasma occurs in the salvage process just as it does in stored blood, the concentration and washing process prevent potential harm to the patient.[8]

Acceptable to religious groups—Some religious groups refuse to receive donated blood, because it is contrary to their beliefs. When blood salvage can be performed using direct reintransfusion—therefore establishing a "continuous circuit"—it may be more acceptable to some groups.

Usually costeffective—Many studies have been done on costeffectiveness of blood salvage procedures. Many considerations should be made, including the cost of allogenic blood and the cost of specialized equipment and trained operators necessary to perform these procedures, as well as the complication rate associated with allogenic blood transfusions. Most experts agree that costeffectiveness is accomplished if three units of red cells can be recovered and returned to the patient.[10]

THE DISADVANTAGE OF AUTOTRANSFUSION

The main disadvantage of autotransfusion is the depletion of plasma and platelets. The washed autotransfusion system removes plasma and platelets to eliminate activated clotting factors and activated platelets, which could cause coagulopathy if they were reinfused into the patient.

This disadvantage is only evident when very large blood losses occur. The autotranfusionist monitors blood loss and will recommend the transfusion of fresh frozen plasma and platelets when the blood loss and return of autotransfused blood increases. Typically, the patient will require fresh frozen plasma and platelets as the estimated blood loss reaches the total blood volume of the patient.

CONTRAINDICATIONS[8]

The use of blood recovered from the operative field is contraindicated in the presence of bacterial contamination or malignancy. The use of autotransfusion in the presence of such contamination may result in the dissemination of pathologic microorganisms and/or malignant cells.

Contamination of the surgical site from infection, generalized sepsis or bowel contents—Any abdominal procedure poses the risk of enteric contamination of shed blood. The surgical team must be diligent in observing for signs of bowel contamination of the blood. If there is a question of possible contamination, the blood may be held until the surgeon determines whether or not bowel contents are in the surgical field. If the blood is contaminated, the entire contents should be discarded.

Malignancy—There is the possibility of the reinfusion of cancer cells from the surgical site. There are two possible exceptions to this contraindication:

- The surgeon feels complete removal of an encapsulated tumor is possible. Blood may be aspirated from the surgical site, processed and reinfused with the surgeon's consent.
- If an inadequate supply of blood exists, the washed cells may be used to support the patient's vital signs, with the surgeon's consent.

Cesarean sections—Autotransfusion is contraindicated in these procedures, because of the possibility of an amniotic fluid embolism. The amniotic fluid may not be washed away during the wash phase of the autotransfusion process.

SPECIAL CONSIDERATIONS DURING COLLECTION[6]

Antibiotics that are plasma-bound can be removed during the autotransfusion wash cycle. However, topical antibiotics, which are typically not plasma-bound, may not be washed out during autotransfusion and may actually become concentrated to the point of being nephrotoxic.

When collagen-type products are used, autotransfusion should be interrupted, and a waste or wall suction source must be used. Autotransfusion can be resumed once these products are flushed from the surgical site.

If products like Gelfoam® are used, autotransfusion can be continued. However, direct suctioning of these products should be avoided.

Find Out More…

Historical perspectives

- Autotransfusion in 1925, *Canadian Medical Association Journal*—Available at: ***http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1707973&blobtype=pdf***
- Blood strained, 1932, *TIME* magazine—Available at: ***http://www.time.com/time/magazine/article/0,9171,929851,00.html***
- Military use of autologous blood before and during World War I and World War II—Available at: ***http://history.amedd.army.mil/booksdocs/wwii/blood/chapter1.htm***

Autologous blood

- Autologous blood donation—Available at: ***http://www.nataonline.com/Topics.php3?NumTopic=38***
- Blood conservation in orthopaedic surgery, European Society of Anaesthesiologists—Available at: ***http://www.euroanesthesia.org/education/rc_nice/6rc2.html***
- Transfusion alert use of autologous blood, National Heart Lung and Blood Institute—Available at: ***http://www.nhlbi.nih.gov/health/prof/blood/transfusion/logo.htm#expert***

Blood alternatives

- Alternatives to regular blood transfusions, US Food and Drug Administration—Available at: ***http://www.fda.gov/bbs/topics/CONSUMER/CON284b.html***
- Artificial blood experiment in 2006, ABC News—Available at: ***http://abcnews.go.com/WNT/Story?id=2166058&page=1***
- How do scientists make artificial blood? How effective is it compared with the real thing?, *Scientific American*—Available at: ***http://www.sciam.com/askexpert_question.cfm?articleID=0007ACC0-ACD3-1C71-9EB7809EC588F2D7***

Cement is often used or encountered during primary or revision total joint replacement surgery. The cement—when in a liquid or soft state—should not be introduced into the autotransfusion system.

When cement is applied, a waste or wall suction must be used. Once the cement hardens, autotransfusion may be resumed.

In some institutions, to maximize the effectiveness of autotransfusion and provide the best conservation and return of red cells, the soaking of sponges is employed. During the surgical procedure, the blood soaked sponges are collected and placed in a sterile basin by the surgical team.

Sterile heparinized saline is added to the basin to prevent clotting and facilitate the release of red cells.

The remaining solution can be suctioned into the autotransfusion reservoir, so that the red cells can be recovered. It has been estimated that 90% of the lost red cells can be returned when autotransfusion is performed in conjunction with soaking sponges.

CONCLUSION

Today, we see the use of red cell salvage both perioperatively and postoperatively, as well as in a variety of surgical procedures. Clinical applications for red blood salvage outside the operating room include the emergency center, the post-anesthesia care unit (PACU) and other intensive care units.

A more recent application of postoperative collection has been in the area of wound drainage during orthopedic surgery. Studies have shown that in some types of orthopedic surgery, the patient experiences the greatest blood loss in the immediate postoperative period in the PACU and that collection and reinfusion of this drainage can reduce a patient's need to receive allogenic blood during this period.[9] The American Association of Blood Banks (AABB) has specific guidelines on the period of time that postoperative wound drainage can be collected for subsequent transfusion.

ACKNOWLEDGEMENT

I would like to acknowledge Darren Delcher, Certified Autotranfusionist at Shore Memorial Hospital, for his help in researching this article.

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