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Autologous canine red blood cell transfusion using cell salvage devices

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Abstract

Objective – To describe the use of automated blood salvage devices for autotransfusion in dogs.
Technique – Blood salvage devices can be used to collect blood from the intraoperative surgical field or postsurgical drainage sites. The salvage device washes cells in 0.9% saline, removing plasma proteins, other cellular components, and activators of coagulation and inflammation. Washed red blood cells may be safely returned to the patient, minimizing the need for allogeneic blood transfusions.
Significance – Blood salvage has been safely used in human medicine for decades and is feasible in veterinary medicine. Potential advantages include reduced reliance on banked blood for massive transfusions and minimization of morbidities associated with the use of allogeneic and stored blood products. Concerns about the safety of salvaged blood have been largely dispelled in human medicine but further investigation regarding the safety of such procedures in veterinary patients is warranted.
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Introduction

Transfusion of packed red blood cells (pRBCs) is an increasingly common therapy in small animal veterinary medicine, but one frequently hampered by a lack of availability of blood products. The maintenance of a large blood bank requires considerable monetary expenditure and expertise, and stored blood products may only be available to clinicians in limited quantities.[1] The availability of fresh blood products may also be limited, as blood donors should be prescreened to assure good health, ascertain their blood type, and to allow for appropriate infectious disease screening.[2]

The lack of availability of stored canine pRBCs for transfusion may be partially mitigated by the use of an autologous RBC salvage system or cell saver. Such systems can be used to collect blood from a surgical field or incisional drain. Once collected, viable RBCs may be concentrated and returned to the patient, minimizing the need for stored pRBC transfusion when large volumes of hemorrhage have occurred or are anticipated.[3] Cell salvage machines pump the collected blood from a reservoir into a centrifugation bowl where dense RBCs are separated from plasma proteins and lighter cellular elements. The RBCs are then washed and resuspended in 0.9% saline. This blood may then administered to the patient immediately or stored for administration within 6 h of collection.[4] Some newer salvage devices utilize a spiral centrifugation system rather than processing batches of blood in a bowl to allow continuous processing of blood and immediate return of salvaged cells to the patient.[5] Cell salvage systems are preferable to direct autotransfusion of blood from the surgical field as it removes other contaminants from the collected fluid and allows concentration of pRBCs, minimizing the transfusion volume.

Autotransfusion has traditionally been considered an option of last resort, yet it has potential benefits over traditional allogenic blood transfusion. Autologous blood transfusions ensure RBC antigenic compatibility, maximizing the longevity of transfused cells, minimizing the contribution of a transfusion to inflammation, and removing the costs and delays associated with

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cross-matching. Autologous transfusions eliminate the risk of transmission of systemic infectious disease and are thought to be associated with less immunosuppression than allogeneic transfusions.[6] Transfusion of stored blood products is associated with increases in acute phase proteins, increased duration of hospitalization and increased mortality rates,[6,7] whereas this is not the case for fresh autologous transfusions.[8] Experimental models indicate that transfusion of stored blood is also associated with at least short-term decreases in tissue perfusion and oxygenation.[6]

Despite the potential benefits of cell salvage devices, there are many areas of controversy and concern. Oncologic surgery was traditionally considered a contraindication to the use of salvage devices owing to concerns about the iatrogenic hematogenous spread of neoplastic cells. This is no longer considered to be the case, as the process of cell salvage and subsequent use of a leukoreduction filter is considered an effective method of tumor cell removal. In addition, many patients already have tumor cells in circulation, and the alternative (allogeneic transfusion) is associated with immunosuppression that may be detrimental to patients with cancer. Several human studies have failed to show an increase in adverse outcomes with the use of cell salvage techniques in oncologic surgical patients.[3,9,10] Similarly, salvage of bacterially contaminated blood (eg, during bowel surgery or following penetrating trauma) used to be considered a contraindication for salvage. Cell salvage with subsequent leukoreduction removes 99% of bacterial load, and many surgical patients receive intravenous antibiotics to treat anticipated perioperative bacteremia.[3,11] Additionally, it has been demonstrated that up to 30% of blood salvaged during clean procedures, such as cardiac surgery, have some bacterial contamination.[3] The true risk associated with contamination remains uncertain but existing literature does not support the idea that septicemia is a major complication of cell salvage.[3,11]

Whereas massive transfusion of banked blood may cause coagulopathies due to the administration of large amounts of citrate, blood salvage procedures effectively wash out anticoagulants, making this less of a concern. Nonetheless, coagulopathies may develop because of the removal of plasma proteins and platelets by the salvage procedure. Inadequate washing and retention of plasma proteins, fibrin degradation products, inflammatory cytokines, complement, free hemoglobin, and cellular fragments may lead to cell salvage syndrome, which can manifest in various ways, including disseminated intravascular coagulation, acute respiratory distress syndrome, acute kidney injury, or death.[12] This syndrome is mainly associated with poor technique and incorrect equipment usage. Because of this possibility, all personnel who use cell salvage equipment should be appropriately trained and the quality of the salvaged blood should be assessed, although no consensus exists as to how this should be done.[13] When correctly processed, salvaged RBCs are equal or superior to banked blood in terms of osmotic resistance, morphology, pH and levels of 2,3-diphosphoglycerate.[5]

Technique

The salvage device[a] used at the authors' institution can be used with 2 different disposable circuit arrangements. Most commonly the autotransfusion circuit (Figure 1) is used for the salvage of blood from intraoperative hemorrhage. This same configuration can also be used for salvage of postoperative hemorrhagic fluid. An alternate circuit and separation protocol (not shown) allows this device to be used for preoperative collection of blood from a patient and its separation into washed RBCs, plasma, and platelet rich plasma for later use.

As with any intraoperative equipment or transfusion system, strict aseptic technique is essential during the set-up and insertion of the disposable circuit[b] into the salvage device. The collection reservoir is attached to a vacuum with a pressure between –100 and –200 mm Hg that may be generated by the salvage device or from an operating room suction unit. Prior to use of the system for aspiration, the reservoir is primed with 100 mL of anticoagulant solution. At the authors' institution, unfractionated heparin[c] at a concentration of 30,000 IU per liter of 0.9% saline[d] is commonly used. Trisodium citrate[e] or Anticoagulant Citrate Dextrose Formula A[f] are the alternative anticoagulants that may be used. Following setup of this collection system, the surgeon may begin to use the anticoagulated double lumen suction tip for aspiration from the surgical field. Blood may additionally be harvested by rinsing used surgical sponges in warm isotonic crystalloid solutions and aspirating that fluid through the catheter.[13] As blood is aspirated from the field, it passes through a filter that removes tissue fragments and eliminates small bubbles. The flow of anticoagulant from the bag is adjusted so that 1 part anticoagulant mixes with 7 parts collected fluid within the reservoir. It is preferable to err toward overuse of anticoagulant as nearly all heparin will be eliminated by the washing process, because underuse may allow coagulation that can cause line occlusions and reduce salvage efficiency.[13]

Once a sufficient volume of blood has been collected to fill the centrifugation bowl (a minimum of 125 mL with the system used at the authors' institution) a salvage cycle may be initiated. This automated process consists of 3 phases: priming, washing, and emptying.

During the priming phase blood is pumped from the collection reservoir to the bowl. The curved shape of the

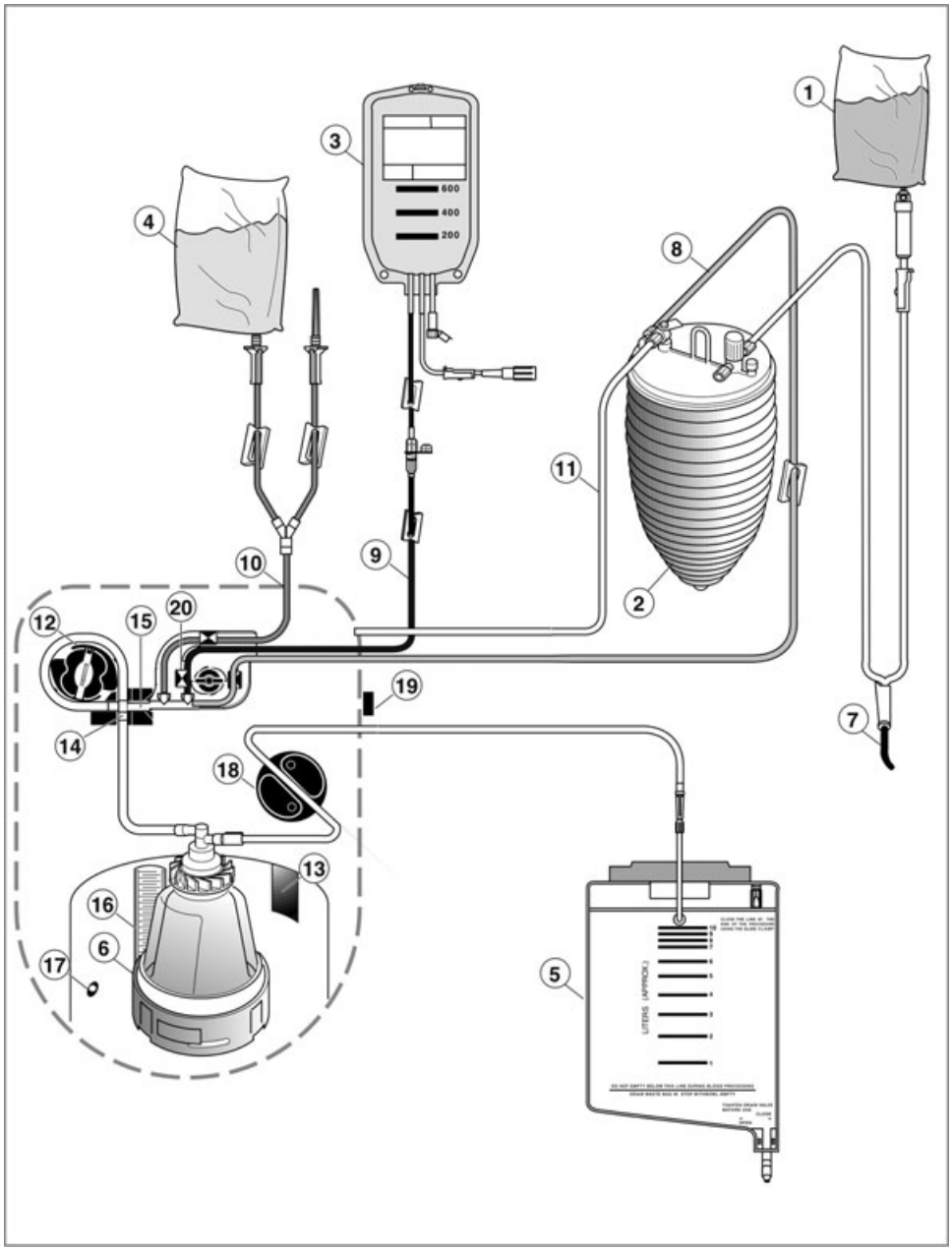

Figure 1: Schematic diagram of autotransfusion circuit for cell salvage. (1) Anticoagulant solution, (2) collection reservoir, (3) reinfusion bag, (4) washing solution, (5) waste bag, (6) centrifugation bowl, (7) suction tip, (8) priming line, (9) emptying line, (10) washing line, (11) vacuum line, (12) roller pump, (13) buffy coat sensor, (14) bubble sensor, (15) hematocrit sensor, (16) blood loss sensor, (17) bowl detector, (18) wash quality sensor, (19) waste bag level sensor, and (20) empty line occlusion sensor. See main text for a description of function. Reproduced with permission from Dideco Electa user's manual.[4]

spinning bowl causes the fluid to separate into 3 distinct layers: RBCs, buffy coat, and supernatant (Figure 2). Filling continues until a sensor detects that the buffy coat has reached the shoulder at the top of the bowl, meaning the bowl itself is filled with RBCs and the supernatant and buffy coat can be discarded into the waste collection bag.

Following completion of the priming step, the device automatically proceeds to the washing step. During this phase the priming line from the collection reservoir to the bowl is closed off and wash solution (0.9% saline) is pumped into the bowl. The saline dilutes the soluble factors associated with cell salvage syndrome to negligible concentrations,[4,13] and is removed

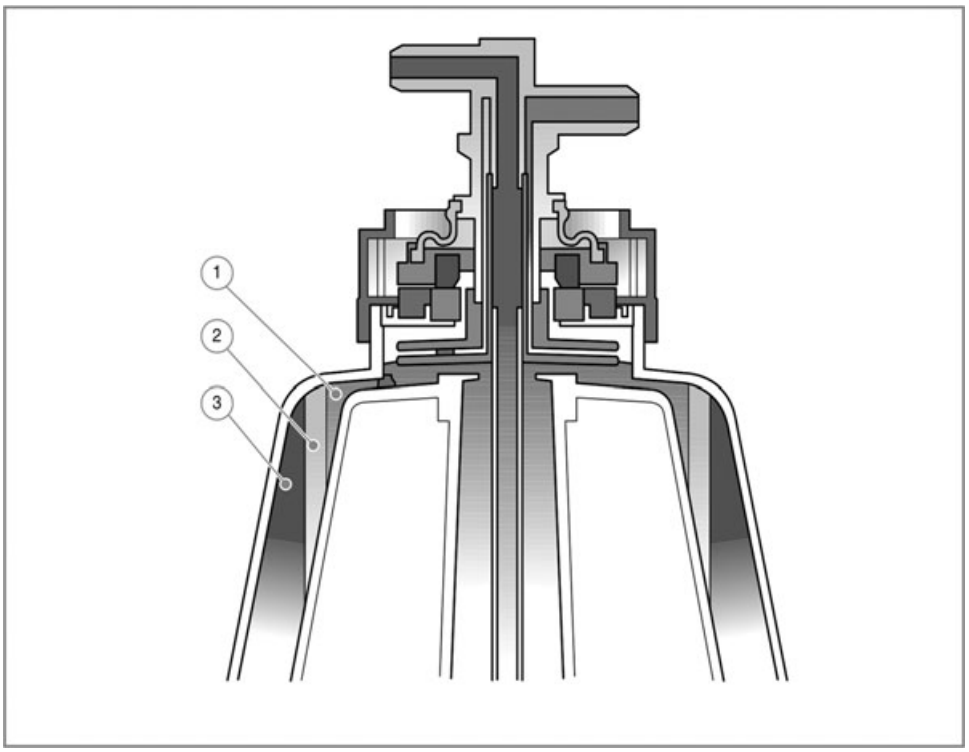

Figure 2: Cross-sectional diagram of the centrifugation bowl showing separation of collected fluid into (1) supernatant, (2) buffy coat, and (3) red blood cells. The bowl is filled during the priming phase until supernatant and buffy coat flow above the shoulder of the bowl into the waste collection system. Reproduced with permission from Dideco Electa user's manual.[4]

from the top of the bowl into the waste collection bag.

After completion of the washing phase, the emptying phase occurs, whereby blood is pumped from the bowl to the reinfusion bag while being mixed with wash solution to achieve a hematocrit of 60%. The priming, washing, and emptying cycle is completed in approximately 5 min. Following completion of the salvage procedure, the reinfusion bag may be disconnected and stored for up to 6 h, allowing clinicians time to assess the need for transfusion at later time points. If the blood is to be used immediately then the bag must still be disconnected from the system or passed through a separate transfer bag in order to prevent air from the system from reaching the patient and causing an air embolus.[13] An in-line leukoreduction filter[g] is used during the transfusion of salvaged blood to reduce the nucleated cell and bacterial load delivered to the patient.[3,9,11]

The technique described above applies to the device used at the authors' institution. Several other devices are available for purchase from other manufacturers.[h-k] The principles of operation of these other devices is similar but differences do exist, including alternative bowl volumes, centrifugation techniques, and aspiration equipment. These differences result in changes to the speed and efficiency of salvage and contaminant removal as well as alterations of the minimum volume of blood required to operate the machines. There are also different costs for purchasing, using, and maintaining the equipment and different degrees of complexity for equipment utilization. With the equipment detailed above and the pricing structure at the authors' institution, use of the cell salvage device is cheaper than the administration of two 250 mL units of canine pRBCs.

Discussion

At the authors' institution cell salvage for auto transfusion has been used successfully in several cases to augment blood bank supplies when massive transfusion has been required, principally for canine cardiotomy or hemoperitoneum surgeries.[14] Based on our experience the technique appears to be safe and effective, with many potential applications within small animal critical care.

Given the ability of the cell salvage devices to separate a patient's blood into cellular components and plasma, other potential therapeutic applications include its use in plasmapheresis for the treatment of autoimmune diseases. Plasmapheresis has been described in dogs for the

treatment of myasthenia gravis and immune-mediated hemolytic anemia by use of more traditional apheresis equipment.[15] The authors have used the cell salvage device described in this report to perform plasmapheresis, in addition to conventional treatment, in a small number of dogs with immune-mediated hemolytic anemia without obvious detrimental effect. Prospective human and experimental studies have found blood salvage to have minimal drawbacks, despite the many potential areas of concern.[3,5,9–13] Given that canine blood has many differences from human blood, that veterinary transfusion medicine involves significantly smaller volumes and that the nature of commonly encountered diseases differs between species, prospective veterinary trials are indicated to better elucidate the risks and benefits associated with blood salvage in canine patients. Nonetheless, based on initial experience, the use of blood salvage for autogenic transfusion of RBCs may prove to be greatly beneficial for veterinary applications.

Footnotes

[a] Dideco Electa Autotransfusion Cell Seperator, Sorin Group, Milan, Italy.
[b] Autotransfusion circuit for Dideco Electa, Sorin Group.
[c] Unfractionated heparin, 1000 IU/mL, Baxter Healthcare Corporation, Deerfield, IL.
[d] 0.9% NaCl, Vetivex l, Dechra Veterinary Products, Shropshire, UK.
[e] Anticoagulant Sodium Citrate 4%, Haemonetics Corporation, Braintree, MA.
[f] ACDA, Haemonetics Corporation.
[g] Purecell RC, Pall Medical, Portsmouth, UK.
[h] Autolog, Medtronic, Minneapolis, MN.
[i] Cell Saver 5, Haemonetics Corporation.
[j] Cobe Brat, Sorin.
[k] CATS, Fresenius Medical Care, Waltham, MA.

References

1. Feldman BF, Kristensen AT. Modern veterinary blood banking practices and their applications in companion animal practice. Vet Clin North Am Small Anim Pract 1995; 25:1231–1243.
2. Wardrop KJ, Reine N, Birkenheuer A, et al. Canine and feline blood donor screening for infectious disease. J Vet Intern Med 2005; 19:135–142.
3. Esper SA, Waters JH. Intra-operative cell salvage: a fresh look at the indications and contraindications. Blood Transfus 2011; 9:139–147.
4. Dideco Electa Instructions for Use. Mirandola, Italy: Dideco; 2001, pp. 9–45.
5. Allam J, Cox M, Yentis SM. Cell salvage in obstetrics. Int J Obstet Anesth 2008; 17:37–45.
6. Prittie JE. Controversies related to red blood cell transfusion in critically ill patients. J Vet Emerg Crit Care 2010; 20:167–176.
7. McMichael MA, Smith SA, Galligan A, et al. Effect of leukoreduction on transfusion-induced inflammation in dogs. J Vet Intern Med 2010; 24:1131–1137.
8. Muñoz1 M, Cobos A, Campos A, et al. Post-operative unwashed shed blood transfusion does not modify the cellular immune response to surgery for total knee replacement. Acta Anaesthesiologica Scandinavica 2006; 50:443–450.
9. Catling S, Williams S, Freites O, et al. Use of a leucocyte filter to remove tumour cells from intra-operative cell salvage blood. Anaesthesia 2008; 63:1332–1338.
10. Waters JH, Donnenberg AD. Blood salvage and cancer surgery: should we do it? Transfusion 2009; 49:2016–2018.
11. Waters JH, Tuohy MJ, Hobson DF, et al. Bacterial reduction by cell salvage washing and leukocyte depletion filtration. Anesthesiology 2003; 99:652–655.
12. Bull BS, Bull MH. The salvaged blood syndrome: a sequel to mechanochemical activation of platelets and leukocytes? Blood Cells 1990; 16:5–20.
13. Waters JH. Intraoperative blood conservation—every cell is sacred. Trauma Care 2005; 15:144–148.
14. Hirst C, Adamantos S. Autologous blood transfusion following red blood cell salvage for the management of blood loss in 3 dogs with hemoperitoneum. J Vet Emerg Crit Care 2012; 22:355–360.
15. Bartges JW. Therapeutic plasmapheresis. Semin Vet Med Surg (Small Anim) 1997; 12:170–177.