Commentary

Is there still a role for cell salvage?

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Allogeneic blood transfusion was pioneered in 1818 by James Blundell. Because no knowledge existed of how to anticoagulate the blood, transfusion took place by direct vein to vein transfusion. This required the donor to be immediately available. In 1874, William Highmore M.D. observed the death of a young woman who bled to death from postpartum hemorrhage. Highmore commented that there was no capable individual to provide an allogeneic transfusion but that the blood in her bed may have been used to save her. This observation was transformed into the alternative transfusion practice of autotransfusion or using the patient's own blood for circulatory support. For a period of 50 years, autotransfusion or a vein-to-vein allogeneic transfusion were the options for the bleeding patient.

After the discovery of anticoagulation, which allowed for blood to be stored, the first blood bank was established in 1937[1]. This has morphed into the modern blood bank system, which is remarkably successful, with 17.9 million blood transfusions being given every year in the US, making transfusion the most performed procedure in a hospitalized patient. The blood banking system has made treating anemia and hemorrhagic shock remarkably easy. A physician simply writes an order for a unit of blood and the system makes it happen. This simplicity has led to the overuse of this precious resource, with Jadwin *et al.* reporting that 44% of transfusions were unnecessary[2].

While the blood banking system provides large amounts of blood, it is fragile from several perspectives. First, the system is a fragile infrastructure of 66 not-for-profit blood banks with no financial reimbursement for the product that they provide. The cost is passed on to the hospital which needs the product. Again, the hospital receives no compensation for this product. Thus, the financial standing of these blood centers is tenuous at best. The average cost of a unit of allogeneic red blood cells in 2013 was $225[3]. Leukoreduction and pathogen inactivation strategies have increased the cost of this product.

There are also continuing problems with delivering the blood that American hospitals demand. From 2019-2021, there was a 60.7% decrease in blood donations from individuals 16-18 years old and a 31.9% decrease from 19-24 years old. As a result, the number of people donating blood has dropped by 40% over the last two decades with blood shortages expected only to worsen. The American Red Cross reported that inventories of donor-banked blood have decreased by 25% in July 2024. On many days, the blood supply is adequate to provide less than one day's demand. In the developing world, the stress is even more acute. The Economic Times reports that "12,000 persons die per day in India due to non-availability of blood".

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In the early 1970s the process of unwashed autotransfusion was automated with the Bentley autotransfusion system. Shortly thereafter, Jack Latham developed a method of washing the salvaged blood. He founded Haemonetics Inc. (Boston, MA, USA), which produced the first "cell saver". The popularity of "cell salvage" surged in the early 1980s due to concerns about viral transmission from allogeneic blood transfusions. Autotransfusion was an opportunity to avoid allogeneic transfusion and the risks of viral disease.

Recent migration toward minimally invasive surgery and a significant reduction in the risk of transmitting viral disease via an allogeneic transfusion has changed the popularity of autotransfusion. So, this raises the question of "*is there still a role for autotransfusion?*"

A simple solution to the scarcity of allogeneic blood and its cost is by decreasing the demand via the pillars of Patient Blood Management (PBM) and autotransfusion[4]. In addition to bridging the gap between the allogeneic supply and demand, the adverse complications associated with allogeneic blood are mitigated using autotransfusion. There is no risk of viral transmission, the immunomodulatory effects of allogeneic blood are avoided and the risk of ABO mismatch and alloimmunization are avoided.

While minimally invasive surgery has changed blood loss for many surgical procedures, there are still growth opportunities for autotransfusion. The most obvious of these opportunities is autotransfusion use in obstetrics. Babies will never be delivered in a minimally invasive fashion. Autotransfusion has been avoided in obstetrics because of fears of amniotic fluid embolism. This fear arose from FDA labeling rather than adverse outcomes associated with autotransfusion. As discussed earlier, autotransfusion was first pioneered in obstetrical hemorrhage back in 1874. The fear of amniotic fluid embolism appears to have been debunked. It is now recommended by several prominent obstetrical institutions such as the American College of Obstetrics & Gynecology (ACOG), the United Kingdom's National Institute for Health and Care Excellence (NICE). Peripartum hemorrhage is increasing in the developed world, so the opportunity for autotransfusion is growing. In addition, the immunologic consequences of allogeneic transfusion in young women are unclear. Alloimmunization can interfere with future pregnancies, and chimerism from donor blood has been hypothesized to be one mechanism responsible for a higher rate of autoimmune disease in women.

Trauma patients have historically avoided autotransfusion because of fears related to bacterial contamination; however, the data do not substantiate these fears. Blood collected during traumatic hemorrhage comes from the patient's wound, so the patient is already exposed to these pathogens. This is the reason operative antibiotics are administered. In addition, autotransfusion has been demonstrated to reduce bacterial concentrations significantly below the original salvaged blood concentration.

In addition to these areas, the rate of surgical procedures is increasing worldwide. In resource-poor settings, the availability of allogeneic blood is poor because of the complex infrastructure required to maintain and operate it.

As such, it is essential to look at what can be done to maximize the utility of autotransfusion techniques. In this way, allogeneic blood use is reduced, and the demand on the blood banking industry is lessened. Ways of improving blood return during autotransfusion are highlighted in **Table I**. In summary, the lowest possible suction pressure will minimize sheer forces on the red cell while it is collected. Suction can be regulated when large blood loss is occurring, but it should be downregulated

Table I - *Actions to maximize red blood cell capture*

Actions	Effects
Regulated suction	Minimizing suction pressure to as low as possible will minimize mechanical forces applied to the RBC and reduce hemolysis.
Rinsing of sponges	A laparotomy sponge that is fully soaked will contain up to 100 mL of RBCs. Rinsing of these sponges will capture up to 94% of the RBCs. This can be facilitated by sponge recovery devices (Procell Surgical US Inc., Canton, MA, USA).
Restriction to wall suction	Frequently, autotransfusion will be used in conjunction with wall suction cannisters. When blood loss is vast, surgeons don't differentiate between suction lines so recoverable blood can be loss to wall suction.
Adequate anticoagulation	Manufacturer recommendations are typically to have anticoagulant regulated to one drop per second however if blood loss is profuse, then this level of anticoagulation may be inadequate and lead to clotting in the collection reservoir.
Periodic flushing of cardiotomy reservoir	Over large blood loss cases, clot and tissue can plug up the macroaggregate filter in the collection reservoir. RBCs can be freed from this clot by instilling normal saline into the filter and manually agitating the collection reservoir.

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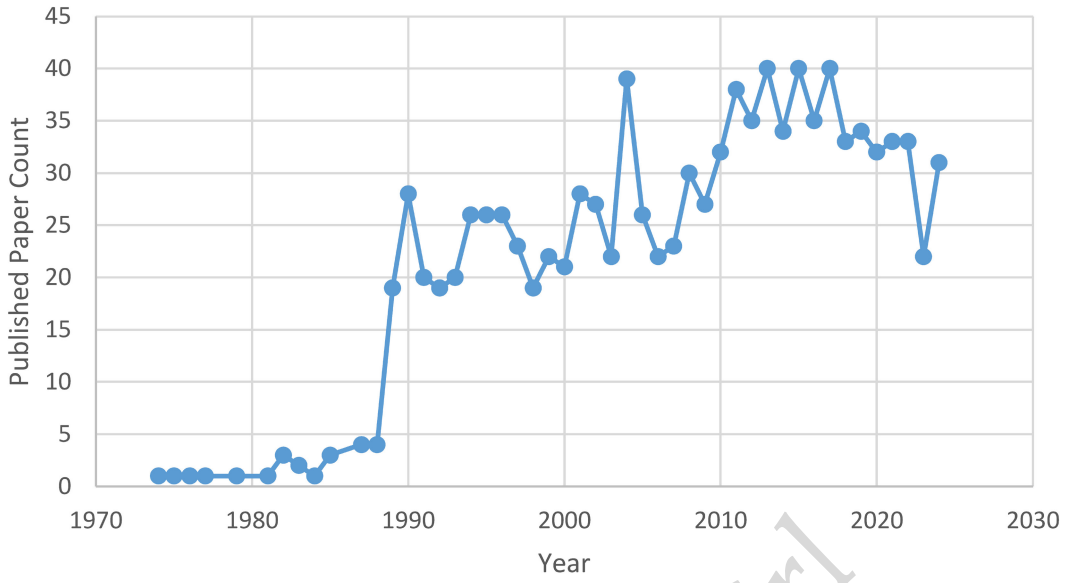

Figure 1 - A count of the number of publications with cell salvage
Autotranfusion from 1974-2023.

when scant blood is being skimmed from the surgical surface. Sponges and swabs used to remove blood from the surgical field can be rich sources of red blood cells. A laparotomy sponge can harbor 100 mL of blood with 94% of it retrievable through rinsing. Alternatively, a sponge blood recovery unit (Procell Surgical US Inc., Canton, MA, USA) is available to squeeze the blood out. Anticoagulant should be used in 10 mL of anticoagulant to 100 mL of shed blood, so anticoagulant rates should be regulated dependent on the speed of blood loss; otherwise, blood can be lost into clotted blood. By performing these extra steps, autotransfusion can result in 60% or more of shed blood being captured and returned to the patient.

While the use of minimally invasive techniques has changed how autotransfusion is being used, it still has a role in preserving the blood supply, minimizing the immunologic effects of allogeneic blood, eliminating the infectious risks associated with allogeneic blood, and providing an opportunity to provide blood to a patient in a resource-poor setting. There appears to be continued academic interest in autotransfusion, as indicated in **Figure 1**, which is a count of academic publications on the use of autotransfusion over the last 50 years. Resoundingly, autotransfusion still has a role!

CONFLICTS OF INTEREST

JHW has previously served on the Advisory Committee for Haemonetics Inc., and is a consultant for ProCell Surgical Inc. and LivaNova Inc. (Mirandola, Italy).

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