Autologous blood transfusion

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Key points

Allogenic blood is an increasingly scarce and expensive resource.

The transmission of vCJD via allogenic blood transfusion has been reported.

Autologous blood transfusion conserves resources and reduces the risk of viral/prion transmission.

Cell salvage is the most effective and versatile means of autologous blood transfusion.

NHS Trusts are encouraged to develop cell salvage programmes.

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Autologous blood transfusion is the collection of blood from a single patient and retransfusion back to the same patient when required. This is in contrast to allogenic blood transfusion where blood from unrelated/anonymous donors is transfused to the recipient. The primary driving forces for the use of autologous blood transfusion are to reduce the risk of transmission of infection and to protect an increasingly scarce resource.

Initial concerns about allogenic transfusions arose from the transmission of viral infection including the hepatitis viruses, human immunodeficiency virus (HIV) and human T-cell lymphotropic viruses (HTLV). Rigorous and reliable screening tests have reduced the risk of infection from transfusion, but have added to the cost of each unit. More recently, concerns have focussed on blood-borne transmission of variant Creutzfeldt–Jakob disease (vCJD). In 2004, case reports emerged of presumed transmission of vCJD via allogenic blood transfusion.[1] Unlike hepatitis and HIV, there is no effective screening test and the disease has a variable and often prolonged asymptomatic incubation period. In 1999, leukodepletion was introduced to further reduce the risk of vCJD transmission via blood transfusion.

As a result, allogenic donor blood is becoming an increasingly costly and scarce resource. As demand for blood is outstripping donation, there is a real social and economic pressure to increase the proportion of blood transfused by autologous transfusion.[2]

Autologous transfusion techniques

There are three methods of autologous transfusion.

(i) Cell salvage: blood is collected from suction, surgical drains, or both and retransfused back to the patient after filtration or washing.
(ii) Preoperative autologous donation (PAD): blood is collected in advance of an elective procedure, stored in the blood bank and transfused back to the patient when required.
(iii) Acute normovolaemic haemodilution (ANH): blood is collected immediately prior to surgery and blood volume restored by crystalloid or colloid. The blood is then retransfused towards the end of surgery once haemostasis is achieved.

Cell salvage is the most important and commonly used technique. It is widely practiced in cardiothoracic, vascular, orthopaedic, neuro- and transplantation surgery. It is estimated that the use of cell salvage in all routine surgical procedures with an expected blood loss of >1 litre would save 160 000 units in the UK per annum.[3]

The use of autologous blood transfusion is not without risk, complications and cost and therefore should only be considered in situations where there is a high incidence of blood loss/transfusion (anticipated blood loss of >20%). Strict protocols and guidelines must be in place to ensure patient safety.

The advantages and disadvantages of the techniques are shown in Table 1.

Cell salvage

This technique can be performed intraoperatively (ICS), postoperatively (PoCS), or by both ways. The process involves collection of shed blood from the surgical field. The salvaged blood is then either filtered or washed and processed prior to retransfusion back to the patient in the immediate postoperative period (Fig. 1). The blood generated is labelled and kept with the patient at all times and is not refrigerated.

Several devices are available for cell collection, which broadly fit into three categories:

(i) Blood may be collected from surgical suction into reservoir canisters. It is then processed in batches (1000 ml salvaged blood) producing units of packed red blood cells for reinfusion. The cycle can be repeated once further quantities of blood are salvaged.

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Table 1 Advantages and disadvantages of autologous blood transfusion

Advantages	Disadvantages
• Reduced risk of transmission of infection • Reduced risk of transfusion reaction • Allows safer transfusion in patients with rare blood groups and multiple auto-antibodies • Eliminates immunosuppression • May be acceptable to some Jehovah's Witness patients • Reduces the demand on allogenic blood supplies	• Cost pressures—may require capital expenditure, increased use of disposables and staff training • Complex logistics for collection, storage and transfusion of the correct unit to the appropriate patient may increase the potential for clerical error • Unused blood is wasted and cannot be returned to the donor pool • Increased risk of bacterial contamination

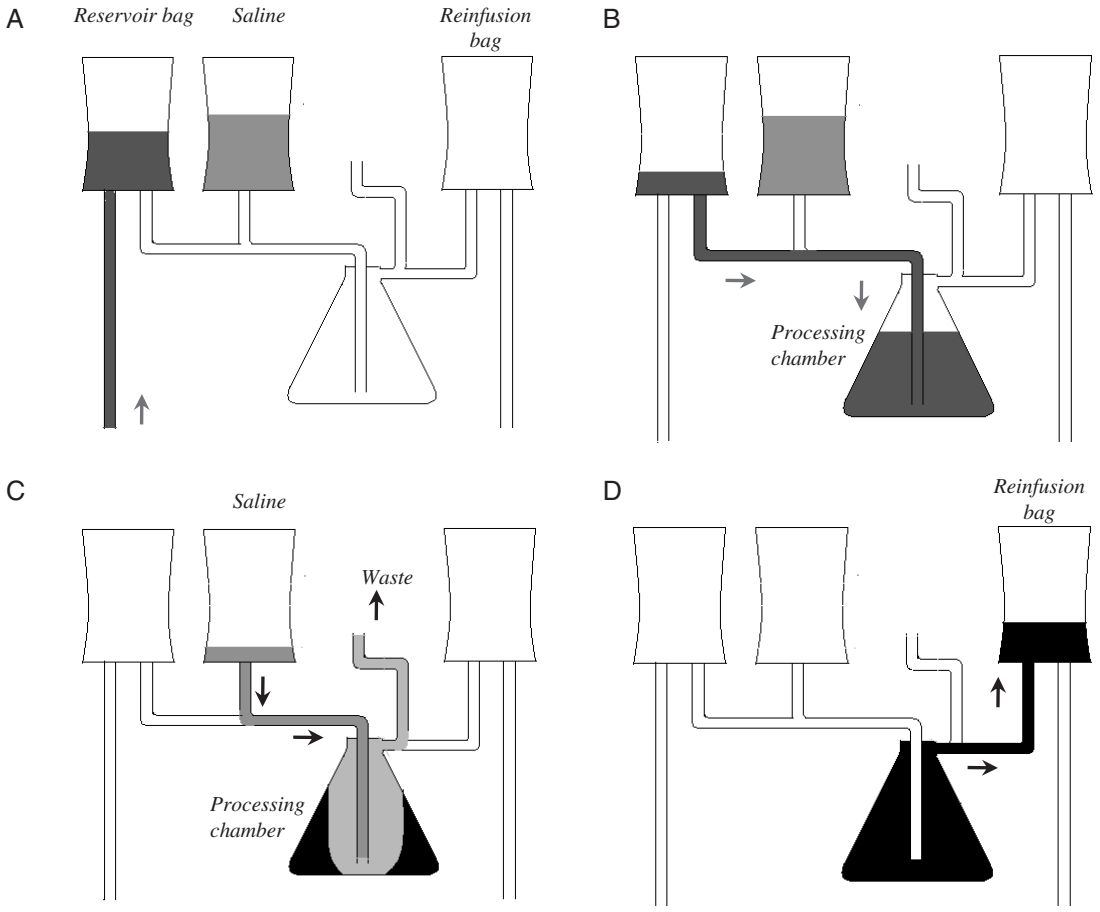

Fig. 1 (A) Suctioned blood is heparinized, filtered and collected into a reservoir bag. (B) Blood passes into the processing chamber (spinning bowl or disc device). (C) Red cells are separated from debris and other blood components using centrifugal fractionation. The waste component is removed. The red cells are washed in saline and centrifuged again. (D) The cells are transferred to a reinfusion bag ready to be given back to the patient.

(ii) A semi-continuous system may be used where blood is simultaneously scavenged, anticoagulated and washed ready for reinfusion. Smaller volumes of blood can be processed with this system.
(iii) Simple single use reservoir bags, which are attached to surgical drains to collect blood lost after the operation.

After red cell collection the blood must be processed before reinfusion. These techniques can be divided into separation and filtering. In cell separation (washing), RBCs are separated by centrifugation. This occurs in a rotating separation chamber where the salvaged blood is washed with 1000–1500 ml saline and then spun to produce packed RBCs of a preset haematocrit. This concentrate is transferred to infusion bags and waste products drained from the system. After each cycle, the process can be repeated by adding more blood from the reservoir canister. In the semi-continuous device, a double spiral separation chamber is used. Blood is pumped into the inner loop where

low density material is expelled. The RBCs move by centrifugal force towards a continuously spinning outer spiral, which is washed with saline. As all steps occur simultaneously, small amounts of blood can be processed.

The filtering devices are much simpler and only suitable for oozing blood rather than brisk haemorrhage. For this reason, the technique is largely confined to PoCS. Blood is collected from wound drains and passes through a filter into a citrated collection/retransfusion bag. The vacuum pressure should be between 0 and −40 mm Hg. No other processing or washing occurs. The procedure can be carried out for up to 12 h after operation or until a maximum of 1500 ml is transfused.

Combined intra- and postoperative cell salvage is increasingly used for joint replacement surgery. Collection and washing of blood starts intraoperatively and continues postoperatively as the patient and machine are transferred to the recovery ward where collection from postoperative drains continues.

Advantages

Red blood cells which would have been lost are scavenged and reinfused. The technique provides a supply of red blood cells in proportion to the losses and theoretically an unlimited amount of blood may be collected, processed and returned to the patient. It is therefore the technique of choice when large blood losses are expected and becomes increasingly cost-effective with large volume losses. It has an excellent long-standing safety record.[3]

PoCS utilizes simple and inexpensive collection and retransfusion devices. This provides a cost-effective means of reducing the requirement of allogenic blood transfusion. Cell salvage is accepted by some Jehovah's Witnesses.

Disadvantages

ICS requires complex specialized equipment resulting in high initial capital expenditure and ongoing costs of disposables. A high level of training is required for the operator. The process is complex and can result in serious complications (see below). The blood salvaged may contain cell debris, free haemoglobin and micro-aggregates.

Precautions and contraindications

The technique is contraindicated in patients with sepsis and in contaminated surgery, for example bowel surgery. The use of cell salvage in malignant disease and obstetrics remains controversial (see later).[4]

Complications

When large volumes of salvaged blood are retransfused, significant changes in haematological parameters may occur including the following:

- Electrolyte disturbances such as increased concentration of sodium and chloride and reduced magnesium, calcium and albumin.
- Dilutional coagulopathy as washed blood does not contain platelets or clotting factors. This may require blood-component therapy.
- DIC (salvaged blood syndrome).[5]

Incorrect use of washing and filtration devices may result in red cell destruction. There is potential for air embolism. Pyrexia and shivering is often reported following retransfusion of unwashed salvaged blood, occurring with an incidence ranging from 1.5 to 12%. The exact cause is unknown but may be because of activated cytokines in the salvaged blood.[6]

Controversies

The evidence-base proving that cell salvage saves allogenic blood transfusion and is cost-effective is limited. A recent Cochrane review of 49 randomized controlled trials over a 24-yr period showed that the use of cell salvage reduced the rate of exposure to allogenic blood transfusion by 40%.[7] It did not adversely affect mortality or complications such as bleeding, infection, myocardial infarction, thrombosis and stroke. The review concluded that better quality research specifically designed to assess the cost-effectiveness of cell salvage across a range of surgical procedures is required.

In surgery for malignancy there is concern because of potential systemic dissemination of tumour cells from salvaged blood. Malignant cells may be removed by filtration and further reductions achieved by irradiation. This remains an area of much research.[4] The use of cell salvage during caesarean section remains controversial because of concerns regarding amniotic fluid embolism and rhesus sensitisation resulting from reinfusion of foetal cells in salvaged blood. There are a small number of studies indicating that it can be used without these complications, but larger safety studies are required.[8]

Preoperative autologous donation

PAD is not widely used in the UK, but is common in parts of Europe and the US. The patient is required to present to a National Blood Service (NBS) out-patient department for repeated blood donation of ~450 ml blood every few days prior to elective surgery. This process commences up to 5 weeks prior to surgery (defined by the limit of conventional blood storage techniques) allowing the collection of up to 4 units of blood. Oral or i.v. (faster increase in Hb—but more expensive) iron supplementation may be required to maintain erythropoiesis. The last donation should take place at least 48–72 h before surgery to allow for equilibration of blood volume. The blood is collected into citrated phosphate dextrose blood bags and stored in the blood bank in the conventional manner. It should be clearly labelled to identify it from allogenic units. At the time of surgery, the predonated blood is drawn from the blood bank as required in the conventional manner. There must be clear communication and documentation that PAD blood is available.

Advantages

The technique provides up to 4 units of blood, which will cover many elective operations and eliminate the need for bank blood. The risks of viral transmission and immunologically mediated haemolytic, febrile or allergic reaction are virtually eliminated provided the patient only receives autologous blood. Immune-modulation seen after allogenic transfusion does not occur. This may decrease the risk of postoperative infection and recurrence of cancer.[9]

Disadvantages

The system requires a great deal of logistical planning well ahead of surgery. This may be a particular problem where surgery is rescheduled at short notice. Predonated blood must be clearly labelled in the blood bank and the risk of clerical or human error remains. Up to 50% of predonated blood is unused; this wastage together with costs of administering PAD programmes results in higher cost per unit of blood in comparison with allogenic blood.[9]

Not all PAD patients are able to tolerate the preoperative donation process. Iron therapy may be insufficient to support increased erythropoiesis. Erythropoietin may be used to improve haemoglobin concentrations but this adds to the expense and is not without side effects; for this reason, it is not routinely recommended by the NBS.[10]

Precautions and contraindications

The patient must be able to tolerate repeated phlebotomy and the resultant haematological and cardiovascular challenges this entails. Patients are excluded if they have pre-existing anaemia, cyanotic heart disease, ischaemic heart disease, aortic stenosis or uncontrolled hypertension.

Complications

All the usual complications of blood donation/storage may occur, including bacterial contamination at collection and haemolysis because of improper collection, handling, storage or transfusion technique. In a recent SHOT report, several instances were reported where allogenic blood was transfused, despite availability of PAD blood, because of lack of communication.[6]

Controversies

In practice, it is difficult to maintain erythropoiesis and Hb concentrations during weekly autologous blood donation. So much so, it is suggested that the patient who embarks on a PAD programme with a Hb of 13 g dl^{-1} ends up undergoing surgery with a Hb of ~10 g dl^{-1} and 3 units of autologous blood in the blood bank.[10] The lower preoperative Hb at the start of surgery increases the need for perioperative transfusion, which may offset some of the benefits.

For these reasons PAD is only recommended in the following specific circumstances in the UK[3]:

- Patients with extremely rare blood groups or multiple red cell antibodies where cross-matching is very difficult (in this situation the PAD blood may be frozen to allow greater flexibility in timing of surgery).
- Patients donating bone marrow.
- Patients who are so reluctant to receive allogenic transfusion that they would refuse surgery otherwise (within reason).

Acute normovolaemic haemodilution

ANH is performed in the anaesthetic room shortly after induction of anaesthesia. A large-bore cannula is inserted to allow the collection of 15–20 ml kg^{-1} of blood prior to surgery. Blood volume is restored with crystalloid or colloid. The collected blood is carefully labelled and kept with the patient in the operating room at all times; there is no need for refrigeration. The blood is transfused back to the patient at the end of surgery once haemostasis is achieved. The technique has similar exclusion criteria as for PAD.

To achieve maximum efficacy in terms of Hb spared, aggressive haemodilution is required to haematocrits of approximately 20%. The amount of Hb spared can be calculated using the following equation:

$$(Hb_I - Hb_{ANH}) \times V_{BL},$$

where Hb_I = Initial [Hb] (g dl^{-1}), Hb_{ANH} = [Hb] following ANH and V_{BL} = volume of blood lost during surgery (dl^{-1}).

For example, reducing the Hb from 12 to 10 g dl^{-1} will only spare 20 g Hb per 1000 ml blood loss (16%) whereas a reduction from 12 to 8 g dl^{-1} would spare 40 g per 1000 ml (33%).

Advantages

This inexpensive technique is performed immediately prior to surgery eliminating the need for the complicated preoperative donation regimes and storage requirements. It produces whole blood containing platelets and clotting factors. The haemodilution results in a lowered haematocrit so that during surgery relatively dilute blood is lost because of surgical bleeding. Blood is maintained at the point of care reducing the risk of blood mismatch because of administrative errors.

Disadvantages and complications

There is an acute and significant reduction in haematocrit leading to haemodynamic instability and a possibility of myocardial ischaemia in susceptible patients. Additional training is required for anaesthetic personnel. Complications arise because of the physiological effects of the acute haemodilution.

Controversies

Despite the sound theoretical basis of the technique, there is little published data to indicate how effective the technique is

in terms of reducing the requirement for allogenic blood.[3] Concerns remain about the overall safety, particularly in patients with asymptomatic ischaemic heart disease.[9]

Conclusion

Autologous blood transfusion, when used appropriately, can provide a safe alternative to allogenic blood transfusion. However, there will always be a need for allogenic blood (even patients who have autologous blood may need further transfusion with allogenic units). There is an important need to balance use of resources in ensuring safe blood transfusion for all those who need it. Cell salvage is emerging as the preferred technique for autologous transfusion and an increasing amount of evidence is accumulating with respect to the efficacy and safety of the technique. However PAD and ANH could be useful in rare blood groups and some elective high blood loss procedures.

Despite evidence of efficacy and safety, more research is required to demonstrate cost-effectiveness. However as allogenic blood becomes a scarcer resource the cost issue may become less important. Most emphasis should be on reducing blood transfusion generally (e.g. reducing unnecessary transfusion, presurgical optimization of Hb, better surgical techniques). It is likely that autologous transfusion may be increasingly used as part of a comprehensive blood transfusion strategy.

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Please see multiple choice questions 16–19.