Continuing Medical Education

Perioperative blood and blood component therapy

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This overview examines blood, blood components, their indications and contra-indications, from an anaesthetist's viewpoint. The dangers of any blood transfusion, including infection transmission and immune suppression, as well as the risks of massive and rapid transfusions, are discussed. Autologous predonation, intraoperative haemodilution and salvage are described to help prevent some of the risks of homologous blood transfusion. Preoperatively an acceptable individualised haemoglobin concentration should be calculated for each patient and a history for potential bleeding problems taken. In most patients perioperative anaemia does not adversely influence patient morbidity and mortality. However, if blood is required, 4 ml · kg⁻¹ body weight of packed red blood cells will raise the patient's haemoglobin concentration by 1 g · dl⁻¹. The bleeding time as a test of platelet function does not predict perioperative blood loss. However, it remains a useful test in patients with a known bleeding problem or in operations where even small amounts of bleeding increase the surgical difficulty and patient morbidity. If bleeding is due to thrombocytopenia it is usually slow enough to allow time to check platelet number and function before ordering and transfusing them. Fresh plasma is a much overused product which should mainly be used for coagulation factor replacement, in adequate volumes (4–8 packs in dilutional coagulopathy). The well-informed anaesthetist should be better able to use blood products which, while they may be life saving, are neither innocuous nor inexpensive.¹

Key words

BLOOD: plasma, platelets;
TRANSFUSION: stored blood.

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Cette étude considère avec l'oeil de l'anesthésiste l'usage du sang et de ses dérivés, leurs indications et contre-indications. Les dangers de la transfusion, incluant la transmission infectieuse et l'immuno-suppression aussi bien que les risques inhérents aux transfusions administrées massivement et avec précipitation. Les techniques de prélèvement préopératoire de sang autologue, de l'hémodilution peropératoire et de la récupération du sang doivent être considérées comme des apports précieux pour la prévention des risques de la transfusion homologue. A la période préopératoire un taux d'hémoglobine acceptable devrait être calculé pour chaque individu qui sera aussi questionné sur une diathèse hémorragique possible. Pour la plupart des patients, l'anémie préopératoire n'influence en rien la morbidité et la mortalité. Cependant, si le besoin de transfusion se fait sentir, il faut se rappeler que 4 ml · kg⁻¹ de culot globulaire augmente la concentration d'hémoglobine de 1 g · dl⁻¹. Comme test de la fonction plaquettaire, le temps de saignement n'a pas de valeur prévisionnelle sur la perte sanguine périopératoire. Cependant, ce test demeure utile chez les malades à risque ou pour des interventions où une hémorragie même mineure augmente la difficulté technique chirurgicale et la morbidité. Si le saignement est causé par une thrombocytopénie, il évolue assez lentement pour permettre de réaliser un décompte plaquettaire avant d'en prescrire la transfusion. On fait un usage abusif du plasma frais qui devrait être réservé spécifiquement pour le remplacement des facteurs de coagulation (4–8 sacs pour traiter la coagulopathie par dilution, par exemple). L'anesthésiste compétent devrait faire meilleur usage de dérivés sanguins qui, parfois salvateurs, sont loin d'être anodins et bon marché.¹

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Attention has recently focussed on methods of decreasing transfusions by: accepting lower initial and postoperative haemoglobin concentrations,²⁻⁵ rationalisation of component therapy⁶⁻⁹ and autologous blood transfusions.^{10,11} Anaesthetists are probably responsible for the transfusion of up to 50% of all red cell products. Yet, recent surveys reported that over 50% of anaesthetists in teaching hospitals practice were lacking in basic knowledge as to the indications and problems involved in blood and blood component therapy.^{12,13}

With all transfusions the important principle is that the microcirculation must be maintained by an adequate intravascular volume. Whether this is by transfusion of up to three times the volume of crystalloid compared with colloid or blood appears to be unimportant.¹⁴ As routine blood coagulation tests are of limited use in surgery where large volumes of blood have been transfused,¹⁵ the thromboelastogram may prove to be extremely useful. This device gives a graphical representation of the strength of *in vitro* clot formation. Using it, the requirement for clotting factors, platelets or anti-fibrinolytics can be assessed and reassessed after drugs or replacement of the specific component without excessive "blind therapy."¹⁶

Blood transfusion

Collection, storage and transfusion

One unit of whole blood contains approximately 450 ml blood and 63 ml preservative, with an haematocrit ranging from 36–40%. Packed cells, prepared by removing 200–250 ml plasma, have an haematocrit of 70–80% if stored with citrate-phosphate-dextrose (CPD) or citrate-phosphate-dextrose-adenine (CPD-A). Whole blood with CPD has a shelf life at 1–6° C of 21 days and 35 days if mixed with CPD-A. Most blood banks now store packed cells with a solution containing mannitol, adenine and glucose to increase storage time to 42 days. This solution gives an haematocrit of about 55% with greatly improved flow characteristics. At the end of the shelf life of stored blood there should be at least 70% survival of the RBC's, 24 hr after transfusion. Whole blood stored for over 24 hr has few viable platelets or granulocytes. Of the labile clotting factors only 25% Factor VIII remain after 24 hr and about 50% Factor V after 14 days. The remaining coagulation factors remain relatively constant during storage.¹⁷

If blood is not used, it must not be allowed to warm above 10° C or it cannot be reissued by the blood bank because of the risk of bacterial contamination. A zipped cooler bag or polystyrene insulated box with added "cold" blocks have been in use for many years in the author's hospital to transport the blood from the blood bank to the operating theatre. The organisms which may survive refrigeration in the blood bank (i.e., psychotrophic bacteria) are unable to begin their logarithmic growth phase for several hours even after returning to room temperature.¹⁸ Thus, provided the blood has not been removed from the cooler bag, except for label verification, the blood bank will accept the blood back up to four hours after issue. Individual blood bank policies vary widely.

Filters

The use of an in-line microfilter (20–40 µm pore size) instead of the standard 170 µ blood filter is only recommended (1) for the cardiopulmonary bypass pump, because infusion of microaggregate debris, when the lungs are excluded from the circuit, can result in postoperative mortality and morbidity¹⁹ and (2) if thrombocytopenia is present, because the micro-aggregates in the transfused blood may further decrease the platelet count.²⁰ For massive transfusion microfilters are not recommended and may critically impede the rate of transfusion.

Blood warming

There is no evidence that patients receiving 1–3 units of blood over several hours receive any additional benefit

TABLE I

<i>Problem</i>	<i>Comments</i>
<i>Infection transmission viruses</i>	
– Hepatitis Non A Non B	Responsible for majority of transfusion-related hepatitis. Recent anti-HCV assay shows good predictability but at present relatively poor sensitivity. ²²
– Hepatitis B	7–17% of transfusion-related hepatitis. Screening tests may not detect low but infectious levels of viraemia. ²³
– HIV	The “window period” when the HIV antibody test remains negative in infectious blood continues to be a problem.
– HTLV I & II	These retroviruses are rare but may be important in endemic areas or in drug addicts who share needles. HTLV I has been linked with adult T cell leukaemia/lymphoma and tropical spastic paraparesis. HTLV II has been linked with hairy cell leukaemia. ²⁴
– Cytomegalovirus, Epstein barr virus	Both have been transmitted via blood transfusions.
<i>Bacteria</i>	
– Syphilis	Treponema Pallidum is not viable after 72 hr at 40° C. The test may be used as a marker for “high-risk” category donors.
<i>Protozoa</i>	
– Malaria, toxoplasmosis, babesiosis	
<i>Immunological suppression</i> ^{25–27}	
– Renal transplant survival	Statistically improved survival but better results with the newer immuno-suppressive drugs.
– Malignancy	About 30 retrospective studies: one third show worse survival, one third show a similar non-significant trend: one third show no difference. Prospective studies awaited.
– Postoperative infections	May be increased.
Alloimmunisation	Reactions vary from mild fever, chills and urticaria to fatal haemolysis if ABO incompatible blood has been transfused.
Transfusion-related acute lung injury	Non-cardiogenic acute pulmonary oedema within 2–4 hrs of transfusion, possibly due to leukoagglutinin reactions. ²⁸ Patients often have a history of obstructive airways disease, multiple transfusions or multiple pregnancies. May need mechanical ventilation. Lungs usually clear within 48 hr.
Anaphylaxis	Probably due to antibodies against plasma proteins, white cells or platelets.

from warming the blood. The two types of blood warmer available are (a) those in which the blood passes through tubing which goes through or round a heated waterbath at 37° C or (b) the blood bag is warmed between heated plates which limit the temperature rise to less than 40° C thus preventing haemolysis. Blood should be warmed for: (1) adult patients receiving rapid transfusions ($> 100 \text{ ml} \cdot \text{min}^{-1}$); (2) exchange transfusions in infants; (3) children receiving blood in volumes in excess of $15 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{hr}^{-1}$; (4) patients with cold agglutinins active *in vitro* at 37° C; or (5) infusion through central venous lines.²¹

Medication into blood units

Medication should never be added to blood units as: (1) it may cause haemolysis if the drug has a high pH; (2) a drug reaction would be impossible to differentiate from a transfusion reaction; (3) any blood reaction necessitating stopping the transfusion would mean the full dose of drug not being administered.

Blood products: dangers (Table I)

*Treatment of acute adverse transfusion reactions*²¹

IMMEDIATE STEPS FOR ALL REACTIONS

- 1 Stop transfusion and check blood bag, blood bank forms and patient identification for clerical errors.
- 2 Keep *iv* open with 0.9% NaCl. If the reaction is mild, with pruritis or urticaria, administer antihistamines if necessary and resume transfusion, at a slower rate than previously. If there is no improvement, stop the transfusion. Severe reactions due to acute haemolysis or anaphylaxis may require a combination of adrenaline, corticosteroids or forced diuresis.

IF TRANSFUSION IS TERMINATED

- 1 Notify attending physician and blood bank.
- 2 Collect blood in anti-coagulated and clotted tubes and collect 10–50 ml of urine.
- 3 Send the blood samples, urine, the administration set and all unused blood back to the blood bank.

TABLE II

Problem	Comments
Hyperkalaemia	High K^+ levels in old blood may be important if infusion rate $> 1.5\text{--}2\text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$. ECG changes occur. Peaked T waves, wide PR and QRS intervals with ultimately loss of P wave, and ST elevation may be seen with ventricular fibrillation or cardiac standstill in diastole. If ECG signs of hyperkalaemia occur the transfusion should be stopped and intravenous calcium given. After redistribution and warming, K^+ rapidly re-enters red cells and the patient's potassium levels may become sub-normal.
Hypocalcaemia	Caused by the citrate chelating circulating ionised calcium. The effect is transient, lasting about 10 min with rapid transfusions (more than $1.5\text{--}2\text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$). ECG may show prolonged QT intervals, widened QRS complexes and flat T waves, associated with a decrease in blood pressure. Treatment is <i>iv</i> calcium chloride ($2.5\text{ mg} \cdot \text{kg}^{-1}$) or calcium gluconate ($7.5\text{ mg} \cdot \text{kg}^{-1}$). In neonates, because of low calcium stores and the fact that a large fraction of their blood volume can be replaced very rapidly, hypocalcaemia is a real risk.
Acid base derangements	The initial metabolic acidosis becomes an alkalosis later as citrate is metabolised to bicarbonate. Sodium bicarbonate should not be given routinely.
Hypothermia	Blood should be warmed prior to transfusion.
Oxygen dissociation	With CPDA stored blood the oxygen carrying capacity of the transfused blood, normalises within a few hours.
Microembolism	Microfilters are no more effective than standard $170\text{ }\mu$ blood filters in preventing clinically important microemboli. This is possibly due to the endogenous formation of microemboli in shock.
Dilutional thrombocytopenia	Unusual if less than two blood volume replacements are given and if normal platelet count and function are present pre-transfusion. One whole blood volume replacement lowers the platelet levels only 30–40% due to mobilisation from the spleen and bone marrow. However, abnormal generalised microcapillary bleeding from all cut surfaces after a massive transfusion is more likely to be due to thrombocytopenia than a lack of clotting factors.
Dilutional coagulaopathy	Unusual if whole blood is transfused. Even with 1.5 blood volume replacements, enough labile Factors V and VIII are still present to initiate clotting. With packed cells, frozen plasma may be required after one blood volume replacement.
Hyperglycaemia	May be a problem due to dextrose of the storage medium especially in children.

4 Untoward reaction reports should be completed by both the doctor and nurse responsible for the patient.

5 If haemolysis is suspected, baseline urea, creatinine, electrolytes and coagulation screen should be obtained.

Massive or rapid transfusion

When blood is transfused rapidly or large amounts (more than one blood volume) are transfused in less than 24 hr, adverse effects may occur (Table II).

Indications for blood transfusion with preoperative anaemia (Figure 1)

Based on clinical criteria, an *acceptable haemoglobin* concentration for each patient should be set. This is the lowest concentration that the anaesthetist will allow the patient to reach before transfusion and should be estimated according to:

CAUSE AND CHRONICITY

Diseases of the liver and thyroid may cause anaemia and have a profound effect on the anaesthesia if not recognised preoperatively. In chronic anaemia the blood volume is normal and the decreased viscosity, concomitant vasodilatation, capillary recruitment, increased oxygen extrac-

tion ratio, and increased 2:3 DPG (diphosphoglycerate) all improve organ oxygenation. Thus the patient has a more stable haemodynamic status than the individual with acute anaemia.

In acute blood loss the initial haemoglobin concentration may be a poor indicator of the degree of blood loss due to haemoconcentration. The author's policy is to give clear fluid replacement unless the initial haemoglobin concentration is less than $9\text{ g} \cdot \text{dl}^{-1}$. At this concentration, blood is given urgently because of the risk of dilutional hypoxia if large volumes of clear fluids are transfused.

SYMPTOMS AND CONCOMITANT DISEASE

Symptoms of anaemia such as dyspnoea on effort, excessive tiredness, weakness and tachycardia at rest occur at different haemoglobin concentrations depending on concomitant medical disease. Where appropriate, symptomatic anaemia should be corrected prior to surgery.

SMOKERS

Cigarette smokers have haemoglobin which is "compromised" by carbon monoxide "poisoning." They are also mildly haemoconcentrated, giving a falsely high haemoglobin concentration and require careful fluid pre-loading

FIGURE 1 Indications for blood transfusion with preoperative anaemia.

prior to induction of anaesthesia. Smoking should be stopped for at least 24–48 hr before operation.

PROPOSED OPERATION AND SURGEON

The extent of the operation, the expected blood loss and the surgical skill of the operator must all be taken into account when considering the patient's minimal acceptable haemoglobin concentration.

CYTOTOXIC ANTIBODY RISK

Patients in chronic renal failure are accepted for surgery with a low haemoglobin ($5\text{--}8\text{ g} \cdot \text{dl}^{-1}$) as blood transfusion may create cytotoxic antibodies. Such antibodies may cause future difficulty in finding a compatible donor.

Treatment of anaemia

Treatment of clinically important anaemia before surgery depends on the urgency of the operation.

ELECTIVE SURGERY

Patients for elective surgery with a chronic anaemia of $\leq 8\text{ g} \cdot \text{dl}^{-1}$, without evidence of blood loss should be investigated for a nutritional reason for their anaemia. Nutritional therapy, and not transfusion, with postponement of their operation is the more appropriate treatment. Iron deficiency, the most common cause of nutritional anaemia, should be treated by building up to $4\text{--}5\text{ mg} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$ of elemental iron, three times a day. A delay of seven to ten days occurs before an increase in haemoglobin concentration of the order of $1\text{--}2\text{ g} \cdot \text{wk}^{-1}$ is seen.²⁹

SURGERY WHICH CAN BE TEMPORARILY DELAYED

Preoperative transfusion should be by packed red blood cells given slowly (four hours per unit), one to two days before operation to allow time for normalisation of fluid shifts, especially in the frail or elderly. Furosemide $20\text{--}40\text{ mg iv}$ may be ordered if there is a risk of cardiopulmonary embarrassment.

URGENT SURGERY

If the anaemia is chronic, i.e., blood volume is normal, transfusion should be commenced slowly, before surgery. If the patient shows signs of shock, as a result of haemorrhage, i.e., heart rate $> 100\text{ bpm}$, BP $< 100\text{ mmHg}$ systolic, skin periphery cold, mucous membranes pale, oliguria and a haemoglobin of $\leq 9\text{ g} \cdot \text{dl}^{-1}$, rapid replacement with blood should be commenced. Isovolaemia should be maintained aggressively with clear fluids and blood to maintain an haematocrit of 30%. Central venous or pulmonary artery pressure monitoring may be required.

How much blood to transfuse?

To increase the haemoglobin concentration by $1\text{ g} \cdot \text{dl}^{-1}$ requires $4\text{ ml} \cdot \text{kg}^{-1}$ packed red blood cells: or $6\text{ ml} \cdot \text{kg}^{-1}$ body weight of whole blood. The rate of blood transfusion depends on the clinical condition of the patient but should not take more than four hours.

Optimum blood ordering for the operation

Every hospital should have a regularly revised maximum blood ordering schedule (MBOS) which is easily available

to all members of the surgical team. This consists of a recommended list of the maximum number of units of blood which should be cross-matched for most surgical procedures.^{30,31} Blood should be ordered as group and screen (type and screen) when doubt occurs whether blood will be required. The test takes about one hour and is less expensive than a full cross-match. It consists of ABO and Rhesus typing, and a screen for unexpected antibodies in the recipient's blood. Blood administration following a negative antibody screen is 99.94% with regard to an incompatibility reaction. Most blood banks prefer to complete a full cross-match (one hour), if time allows, before releasing blood for transfusion, although, statistically, this only increases the serological safety of the blood to 99.95% safe.³²

Blood transfusion during operation

Isovolaemia should be maintained throughout any operation. The extent of the blood loss should be estimated by: visual assessment of blood on drapes and swabs; volume in the suction bottles; weighing swabs; and by serial haemoglobin or haematocrit estimation. These latter two techniques are the most accurate, although all methods have drawbacks. The author starts to transfuse patients once they have reached the previously assessed minimal acceptable haemoglobin concentration. Postoperative anaemia (Hb 9 g · dl⁻¹) has not been shown to increase morbidity or mortality.³³

Platelets

Normal values

Adult 300,000 · mm⁻³. Full-term and pre-term newborn 250,000 · mm⁻³.

Collection, storage and transfusion

Random donor units are prepared from individual units of whole blood, each bag containing not less than 5500 · mm⁻³ platelets with 50–70 ml of residual plasma volume. They are stored at 20–24° C with continuous agitation for up to five days, depending on the type of storage bag used. Repeated transfusions with random donor platelets may cause alloimmunisation to HLA antigens. Single donor units are collected from a single individual donor and are usually reserved for patients with platelet antibodies or where the risk of HLA antibody formation is to be avoided. They contain the equivalent of 6–8 random donor units. Platelets should be transfused through a special half size 170 µ filter set with minimal tubing (to prevent adherence to the plastic walls). ABO compatibility, while desirable, is not essential. However, rhesus negative women of childbearing age should only

receive Rh-negative platelets because of the small amounts of red blood cells still present in the packs.

Dosage

One random unit of platelets will raise the platelet count in an adult by 5,000–8,000 · mm⁻³. In children 0.1 to 0.2 units · kg⁻¹ will increase the platelet count by 30–50,000 · mm⁻³. The expected increase will be less if the patient has sepsis, splenomegaly, platelet auto- or allo-antibodies, or is receiving chemotherapy. If chills, fever or allergic reactions occur, treatment with non-steroidal anti-inflammatory agents or aspirin should be avoided because of their adverse effect on platelet function.

Indications for platelet transfusion (Figure 2)

CAUSE OF PREOPERATIVE THROMBOCYTOPAENIA

Patients with auto-immune thrombocytopenia, splenomegaly or haemolytic uraemic syndrome do not respond to platelet transfusions. Patients with disorders of primary haemostasis, for example hereditary functional platelet disorders, or Von Willebrand's disease, should have a bleeding time performed prior to surgery. This allows the response to a test dose of desmopressin acetate, which increases plasma Factor VIIIc and Von Willebrand Factor, to be determined and definitive therapy to be planned.³⁴

LEVEL OF THROMBOCYTOPAENIA

The minimal recommended platelet level before surgery is 50–75,000 · mm⁻³.

CONCOMITANT DISEASE

Patients with advanced hepatic or renal insufficiency may have associated disorders of platelet function. Platelet transfusion may be required preoperatively to correct the bleeding time, although no pertinent studies have been done.

PLATELET FUNCTION

The commonest cause of platelet dysfunction is drug-induced. Aspirin affects platelet function for their effective life (e.g., 7–10 days). The non-steroidal anti-inflammatory drugs (NSAID's), however, only inhibit platelet cyclo-oxygenase temporarily and platelet function returns to normal after their elimination from the body. Different NSAID's also have different anti-cyclo-oxygenase activity and thus affect platelet function differently. Analgesics not affecting platelet function include codeine, opiates, propoxyphene and acetaminophen. Preoperative bleeding times have not proved useful in predicting perioperative bleeding, but they should be measured in patients with known platelet disorders where pre-treatment with desmopressin or frozen plasma is contemplated or before

FIGURE 2 Indications for platelet transfusion.

those operations where even small bleeding may cause surgical problems and patient morbidity.³⁵

TYPE OF OPERATION

In neurosurgery, eye operations or middle ear surgery a platelet count and a careful drug history including all over-the-counter medications which may contain aspirin should be taken. If indicated, a bleeding time should be measured.³⁵

Frozen plasma

Collection, storage and transfusion

Frozen plasma (FP) is prepared from whole blood by separating and freezing the plasma (200–250 ml) within six hours of donation. It may be stored for up to one year at -18°C or lower. Under these conditions the loss of labile Factors V and VIII is $<30\%$.⁶ The FP should be thawed between $30\text{--}37^{\circ}\text{C}$ with constant agitation. After thawing it may be refrigerated but should be used within 24 hr to obtain adequate coagulation levels of Factors V and VIII:C which start to diminish after a few hours.³⁶ Some authorities, e.g., the FDA limit storage, after thawing, to six hours. Only ABO compatible plasma should be transfused through a standard $170\text{ }\mu\text{m}$ blood filter.

Indications (Figure 3)

DOSAGE

The main cause of non-surgically remediable haemorrhage in patients receiving massive blood transfusion (>1.5 blood volumes rapidly) is dilutional thrombocytopenia.³⁷ However, if depletion of coagulation factors is considered to be clinically important, 800–2,000 ml (four to eight

packs of FP) in a 70 kg adult for each blood volume lost should be given over 90–120 min. Slower rates of infusion or smaller volumes of FP are probably ineffective.³⁸

Cryoprecipitate

Patients who have had a massive and rapid transfusion of blood, especially where intravascular coagulopathy has been initiated due to a prolonged period of shock before resuscitation, may require additional Factor VIII and fibrinogen given as cryoprecipitate. Cryoprecipitate from one donor usually contains 100 anti-haemophilic units (AHU) and 250 mg of fibrinogen, it is thawed at 37°C and administered through a standard blood filter. The author transfuses ten packs (1000 AHU) rapidly where cryoprecipitate is indicated.

Autologous transfusion: decreasing the risk of blood transfusion

Pre-donation autologous transfusion

A healthy patient with an haematocrit $>34\%$ can donate a unit of his or her own blood, every four to seven days. This allows the preoperative acquisition of up to four units of blood. The last donation is made three days before operation. More units of “fresh blood” can be obtained by transfusing a previously donated unit of “old” blood and simultaneously removing two units “fresh” blood. Thus it is possible to have at least four units of less than ten-days-old autologous blood available. If necessary, the blood can be washed and frozen for use at a later date. The use of recombinant erythropoietin allows more blood to be donated and may be indicated in patients with a low initial haematocrit. However, there is the potential risk of a drug reaction or thrombosis with its use and further studies on its safety are recommended.³⁹

FIGURE 3 Indications for frozen plasma (FP).^{3,16}

TABLE III

Advantages	Comments
Infectious disease transmission	No risk except during blood collection and storage.
Incompatibility reactions	No risk.
Host vs graft reaction	No risk.
Isoimmunisation	No risk.
Patient's red blood cells & circulation	Improved rheology, increased 2.3 DPG. Bone marrow pre-primed to increase production of RBC's.
Immune system	Leucocyte production increased, phlebotomy may be immunostimulating. ²⁵
Patient's psyche	May enhance patient's self-esteem and confidence.
Contra-indications relative & absolute	Comments
Inconvenience & expense	To doctor, patient and blood bank. Poor venous access, severe vasovagal response to phlebotomy. Patient unable to give consent, e.g., paediatrics.
Concomitant disease	Pre-existing anaemia, infection, severe heart or lung disease. Hypertension (except if controlled on minimal medication), epilepsy, insulin dependent diabetes, cerebrovascular disease.
Patient has Hepatitis B, Non A Non B, or HIV positive	Fear by blood bank of accidental cross-over contamination or transfusion.
Urgent surgery	No time to pre-donate.

Advantages and contra-indications for autologous transfusion (Table III)

Intraoperative salvage transfusion

Transfusion of the patient's own shed blood by intra-operative salvage is possible where bleeding into the pleural or peritoneal cavity has occurred with no bowel soiling, or where there is no risk of the blood being contaminated by tumour cells or bacteria. There are simple scavengers which anti-coagulate the suctioned blood and pass it through a standard 170 µ filter, before it is available for retransfusion, and other, more complex machines, which recycle, wash and filter the salvaged blood. These latter "cell savers" often require a dedicated technician.

Despite the trauma imposed by suction, cell washing and reinfusion, red blood cell survival appears to be only mildly reduced.

Preoperative haemodilution⁴

After induction of anaesthesia and prior to operation equal volumes of colloid (1 ml · ml⁻¹ of blood removed) or crystalloids (3 ml · ml⁻¹ of blood removed) are infused simultaneously as blood is removed. The end point should be an haematocrit of 27–33% depending on the patient's cardiovascular and respiratory reserves. This blood (one to three units) is kept in the operating room and is ideally re-infused after most of the operative blood loss has ceased. Reinfusion is started with the last unit of blood removed

(which contains the least red blood cells). The first blood bag, rich in platelets, red cells and coagulation factors, is given last. This technique takes time (about seven to ten minutes per unit bled) and often requires central venous monitoring because of the large fluid shifts involved.

Preoperative assessment of the patient with a bleeding history

History

A complete history should be taken together with specific questions such as: do you or any of your family bleed a lot from small cuts or bruise easily? Have you ever had teeth extracted or suffered from nose bleeds, if so, for how long did you bleed for and did you bleed again the next day? What medicines, including over-the-counter preparations, do you use for pain or headaches and when did you last take aspirin?

Specific examination

Look for bruising, petechiae and signs of liver failure. A useful bedside test for platelet dysfunction or capillary fragility is to place a blood pressure cuff over the upper arm and inflate it to about 40 mmHg. Sharp flicks with the finger over the volar aspect of the forearm may elicit petechiae, if platelet dysfunction is present or if capillary fragility exists.

Haematological tests

Negative history and examination: full blood and platelet count are all that is required.

Positive history or examination. In addition to a full blood and platelet count:

- 1 Haematologists opinion if: there is a history of a genetic bleeding disorder; or there is a systemic disease with manifestations of, or predisposition to, liver failure, disseminated intravascular coagulopathy (DIC) or fibrinolysis.
- 2 Coagulation screen: this usually consists of – “extrinsic” function – prothrombin time should not be more than the control; “intrinsic” function – activated partial thromboplastin time should not be more than 50 seconds; fibrinogen – normal level $2-4 \text{ g} \cdot \text{L}^{-1}$ (by Clauss method); D dimer for fibrin degradation products, normal less than $200 \text{ pg} \cdot \text{ml}^{-1}$.
- 3 If platelet dysfunction is suspected order a bleeding time. It should be less than ten minutes.

Conclusion

The anaesthetist must have a “game plan” of when and what he wants to transfuse. When faced with a patient who is bleeding excessively the decisions should be logical and not influenced by surgical prejudices.

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Multiple choice questions

Questions 1–4 (One correct answer)

Questions 5–8 (One or more possible correct answers)

- B Blood transfusions improve long-term renal transplant survival rate.
 - C TRALI (transfusion related acute lung injury) will respond rapidly to diuretics.
 - D With recent advances in testing blood products have no risk of HIV transmission.
- 6 A A metabolic alkalosis is common following a blood transfusion.
- B Hypocalcaemia is a problem with all blood transfusions and boluses of *iv* calcium should be given routinely.
 - C Clinically significant hyperkalaemia due to a blood transfusion should be treated by *iv* calcium.
 - D Hypoglycaemia may be a problem with blood transfusions in paediatrics.
- 7 A Frozen plasma (FP) contains all the clotting factors including Factors VIII and V.
- B FP can be used to reverse prolonged succinylcholine paralysis.
 - C When FP is transfused it should be ABO compatible.
 - D Two paths of FP's should be given after a transfusion of three to four packed red cells.
- 8 A Micro-aggregate filters should be used when large blood transfusions are given?
- B One dose of non-steroidal anti-inflammatories affect platelet function for the lifespan of the platelet (7–10 days).
 - C A bleeding time of nine minutes is abnormal.
 - D One whole blood volume replacement by banked blood lowers the platelet count by 30–40%.

ANSWERS

2	B	4	C	6	A,C	8	D
1	A	3	B	5	A,B	7	A,B,C