of subgroups of patients at risk may have been missed. Aprotinin has also been used to reduce transfusion requirements during orthopaedic surgery.[20]

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2. Mojcik CF, Levy JH. Aprotinin and the systemic inflammatory response after cardiopulmonary bypass. *Ann Thorac Surg* 2001; **71:** 745–54.
3. Bidstrup BP, *et al.* Aprotinin cardiac centers in the United Kingdom. *Ann Thorac Surg* 1993; **55:** 971–6.
4. Laupacis A, Fergusson D. Drugs to minimize perioperative blood loss in cardiac surgery: meta-analyses using perioperative blood transfusion as the outcome. *Anesth Analg* 1997; **85:** 1258–67.
5. Henry DA, *et al.* Anti-fibrinolytic use for minimising perioperative allogeneic blood transfusion. Available in The Cochrane Database of Systematic Reviews; Issue 4. Chichester: John Wiley; 2007 (accessed 25/06/08).
6. Sedrakyan A, *et al.* Effect of aprotinin on clinical outcomes in coronary artery bypass graft surgery: a systematic review and meta-analysis of randomized clinical trials. *J Thorac Cardiovasc Surg* 2004; **128:** 442–8.
7. Mangano DT, *et al.* The risk associated with aprotinin in cardiac surgery. *N Engl J Med* 2006; **354:** 353–65.
8. Mangano DT, *et al.* Mortality associated with aprotinin during 5 years following coronary artery bypass graft surgery. *JAMA* 2007; **297:** 471–9.
9. Karkouti K, *et al.* A propensity score case-control comparison of aprotinin and tranexamic acid in high-transfusion-risk cardiac surgery. *Transfusion* 2006; **46:** 327–38.
10. FDA. Aprotinin injection (marketed as Trasylol) (issued 8th February, 2006). Available at: http://www.fda.gov/cder/drug/advisory/aprotinin.htm (accessed 26/11/07)
11. Brown JR, *et al.* Meta-analysis comparing the effectiveness and adverse outcomes of antifibrinolytic agents in cardiac surgery. *Circulation* 2007; **115:** 2801–13.
12. Schneeweiss S, *et al.* Aprotinin during coronary-artery bypass grafting and risk of death. *N Engl J Med* 2008; **358:** 771–83.
13. Shaw AD, *et al.* The effect of aprotinin on outcome after coronary-artery bypass grafting. *N Engl J Med* 2008; **358:** 784–93.
14. FDA. FDA requests marketing suspension of Trasylol (issued 5th November, 2007). Available at: http://www.fda.gov/bbs/topics/NEWS/2007/NEW01738.html (accessed 26/11/07)
15. EMEA. European Medicines Agency recommends suspension of marketing authorisation of aprotinin-containing medicines for systemic use (issued 21st November, 2007). Available at: http://www.emea.europa.eu/pdfs/human/press/pr/53467807en.pdf (accessed 26/11/07)
16. Porte RJ, *et al.* Aprotinin and transfusion requirements in orthotopic liver transplantation: a multicentre randomised double-blind study. *Lancet* 2000; **355:** 1303–9.
17. Rentoul TM, *et al.* The effect of aprotinin on transfusion requirements in pediatric orthotopic liver transplantation. *Pediatr Transplant* 2003; **7:** 142–8.
18. Lentschener C, *et al.* A review of aprotinin in orthotopic liver transplantation: can its harmful effects offset its beneficial effects? *Anesth Analg* 2005; **100:** 1248–55.
19. Molenaar IQ, *et al.* Efficacy and safety of antifibrinolytic drugs in liver transplantation: a systematic review and meta-analysis. *Am J Transplant* 2007; **7:** 185–94.
20. Kokoszka A, *et al.* Evidence-based review of the role of aprotinin in blood conservation during orthopaedic surgery. *J Bone Joint Surg Am* 2005; **87-A:** 1129–36.

Pancreatitis. Aprotinin has been tried in the management of pancreatitis (p.2361) because of the postulated role of proteolytic enzymes in this condition. However, results have been largely disappointing.

Preparations

BP 2008: Aprotinin Injection;
USP 31: Aprotinin Injection.

Proprietary Preparations (details are given in Part 3)
Arg.: Quagu-Test; Rivilina; ***Austral.:*** Trasylol†; ***Austria:*** Pantinol†; Trasylol†; ***Belg.:*** Trasylol†; ***Braz.:*** Trasylol†; ***Canad.:*** Trasylol†; ***Chile:*** Trasylol†; ***Cz.:*** Antilysin†; Gordox†; Trasylol†; ***Denm.:*** Trasylol†; ***Fin.:*** Trasylol†; ***Fr.:*** Trasylol†; ***Ger.:*** Trasylol†; ***Gr.:*** Trasylol†; ***Hong Kong:*** Trasylol†; ***Hung.:*** Gordox†; Trasylol†; ***Indon.:*** Trasylol; ***Israel:*** Protosol; ***Malaysia:*** Trasylol†; ***Mex.:*** Protinin†; Trasylol†; ***Neth.:*** Trasylol†; ***NZ:*** Trasylol†; ***Pol.:*** Traskolan†; Trasylol†; ***Rus.:*** Aprotex (Апротекс); Contrykal (Контрикал); Gordox (Гордокс); Trasylol (Трасилол)†; ***S.Afr.:*** Trasylol†; ***Singapore:*** Trasylol†; ***Spain:*** Trasylol†; ***Swed.:*** Trasylol†; ***Switz.:*** Trasylol†; ***Thai.:*** Trasylol†; ***Turk.:*** Trasylol†; ***UK:*** Trasylol†; ***USA:*** Trasylol†; ***Venez.:*** Trasylol†.

Multi-ingredient: ***Arg.:*** Beriplast P; Lacrimax; Maxus; Optilac; Tissucol; Tissucol Duo Quick†; ***Austral.:*** Tisseel Duo; ***Austria:*** Beriplast; TachoComb; Tissucol; Tissucol Duo Quick; ***Belg.:*** Tissucol Duo; ***Braz.:*** Beriplast P; Tissucol†; ***Canad.:*** Tisseel; ***Chile:*** Beriplast P; ***Cz.:*** TachoComb†; Tissucol; ***Denm.:*** Tisseel Duo Quick; ***Fin.:*** Tisseel Duo Quick; ***Fr.:*** Beriplast; Tissucol; ***Ger.:*** Beriplast; TachoComb†; Tissucol Duo S; Tissucol-Kit; ***Gr.:*** Beriplast P; ***Hong Kong:*** Beriplast P; TachoComb; Tisseel; ***Hung.:*** Beriplast P; TachoComb†; Tissucol-Kit; ***Indon.:*** Beriplast; ***Israel:*** Beriplast; Tisseel; ***Ital.:*** Beriplast; Tissucol; ***Mex.:*** Beriplast P; Tissucol†; ***Neth.:*** Beriplast P; Tissucol; Tissucol Duo; ***Pol.:*** Beriplast; ***Port.:*** Tissucol Duo; ***Rus.:*** TachoComb (ТахоКомб); ***Spain:*** Beriplast P Combi; Tissucol Duo; ***Swed.:*** Tisseel Duo Quick; ***Switz.:*** Beriplast P; Tissucol; Tissucol Duo S; ***Thai.:*** TachoComb†; ***Turk.:*** Beriplast P; Tisseel VH; ***UK:*** Tisseel.

Batroxobin *(rINN)*

Batroxobina; Batroxobine; Batroxobinum.

Батроксобин

CAS — 9039-61-6 (batroxobin); 9001-13-2 (haemocoagulase).
ATC — B02BX03.
ATC Vet — QB02BX03.

Profile

Batroxobin is an enzyme obtained from the venom of the viper *Bothrops atrox*. It has also been obtained from *Bothrops moojeni* and a similar preparation is derived from *Bothrops jararaca*.

Batroxobin is reported to act on fibrinogen to produce a fibrin monomer that can be converted by thrombin to a fibrin clot. It is used both as a haemostatic and, in larger doses, to induce a hypofibrinogen state in the management of thromboembolic disorders. When used as a haemostatic it is usually given with a factor-X activator; such a combined preparation is known as haemocoagulase (hemocoagulase). Batroxobin has been given parenterally or by local application.

Preparations

Proprietary Preparations (details are given in Part 3)
Austria: Defibrase; Reptilase; ***Fr.:*** Reptilase†; ***India:*** Reptilase; ***Ital.:*** Botropase†; ***Port.:*** Reptilase†.

Blood ⊗

Sangre.

Pharmacopoeias. Many pharmacopoeias have monographs, including *US*.

USP 31 (Whole Blood). It is blood that has been collected from suitable human donors under rigid aseptic precautions for transfusion or for further processing into one or more of its components for transfusion. It contains a citrate-based anticoagulant (Anticoagulant Citrate Dextrose Solution, Anticoagulant Citrate Phosphate Dextrose Solution, or Anticoagulant Citrate Phosphate Dextrose Adenine Solution).

Whole blood must be tested for syphilis, hepatitis B virus, human T-cell lymphotropic virus (HTLV) type I and type II, hepatitis C, and HIV. It should also be tested for blood group and rhesus factors, and for unexpected antibodies to red cell antigens.

One unit (dose) of whole blood contains a minimum of 50 g of haemoglobin. One unit of whole blood filtered for removal of leucocytes (Whole Blood, Leukocytes Reduced), contains less than 5×10^6 residual leucocytes.

Whole blood is stored in the original container or transferred to an equivalent one using a technique that does not compromise sterility. It should be stored at 1° to 6°, unless platelets are to be prepared, in which case the blood is stored for no longer than 8 hours after collection at room temperature.

Whole blood collected in Anticoagulant Citrate Dextrose Solution, Anticoagulant Citrate Phosphate Dextrose Solution, or in Anticoagulant Citrate Phosphate Dextrose-Dextrose Solution may be stored for up to 21 days at 1° to 6° after the blood has been drawn. Whole blood collected in Anticoagulant Citrate Phosphate Dextrose Adenine Solution may be stored for up to 35 days at 1° to 6°. If the hermetic seal of the container is broken during collection, preparation, or further processing, the expiry date is not later than 24 hours after the seal is broken (when blood is stored at 1° to 6°), but not to exceed the original expiry date of the unit.

It is a deep red, opaque liquid from which the corpuscles readily settle upon standing for 24 to 48 hours, leaving a clear, yellowish or pinkish supernatant layer of plasma.

The USP 31 gives the names ACD Whole Blood, CPD Whole Blood, CPDA-1 Whole Blood, and Heparin Whole Blood, which specify the anticoagulant used.

Adverse Effects

The rapid transfusion of large volumes of whole blood may overload the circulation and cause pulmonary oedema. Transfusion of very large volumes of citrated blood can lead to hypocalcaemia, although this is not usually a problem unless there is hepatic impairment or hypothermia. Hyperkalaemia may occur but on its own is rarely clinically significant. Hypothermia may result from rapid transfusion of large volumes of cooled blood and may, combined with hypocalcaemia, hyperkalaemia, and resultant acidosis, lead to cardiac toxicity. Disseminated intravascular coagulation may also occur in patients receiving large-volume transfusions. Repeated transfusions of blood, as in thalassaemia, may lead to iron overload.

The transfusion of incompatible blood causes haemolysis, possibly with renal failure. Pyrexia, rigors, and urticaria may be due to antibodies towards a number of blood components. Severe allergic reactions and anaphylaxis can occur. Delayed reactions may occur more than 24 hours after transfusion in patients in whom previous transfusion or pregnancy has induced sensitisation; these reactions are usually mild and manifest as fever, chills, fall in haemoglobin concentration, and haemoglobinuria.

Transmission of infections. The use of blood, blood components, or blood products has been associated with the transmission of viruses, most notably hepatitis B virus and HIV; other reports of transmission include CMV, hepatitis C and possibly other hepatitis viruses, HTLV-I and -II, and the agent causing Creutzfeldt-Jakob disease. Transmission of bacterial and parasitic diseases is also possible including syphilis, Chagas' disease, and malaria.

The main methods of minimising the risk of transmission of infection are by rigorous selection of blood donors and by microbiological screening tests. Contamination during collection and processing is minimised by using closed systems and by strict aseptic technique. Treatment of blood products with heat or chemicals can inactivate some organisms including some viruses, in particular HIV-1, but blood and blood components cannot be treated in either of these ways. Patients receiving multiple transfusions of pooled plasma products are at increased risk of contracting infections and can be offered immunological protection, for example hepatitis B vaccine.

◊ Reviews.

1. Contreras M, Mollison PL. Immunological complications of transfusion. In: Contreras M, ed. *ABC of transfusion*. 3rd ed. London: BMJ Books, 1998: 53–7.
2. Barbara JAJ, Contreras M. Infectious complications of blood transfusion: bacteria and parasites. In: Contreras M. ed. *ABC of transfusion*. 3rd ed. London: BMJ Books, 1998: 58–61.
3. Barbara JAJ, Contreras M. Infectious complications of blood transfusion: viruses. In: Contreras M. ed. *ABC of transfusion*. 3rd ed. London: BMJ Books, 1998: 62–6.
4. Regan F, Taylor C. Blood transfusion medicine. *BMJ* 2002; **325:** 143–7.
5. Goodnough LT. Risks of blood transfusion. *Crit Care Med* 2003; **31** (suppl): S678–S686.
6. Pomper GJ, *et al.* Risks of transfusion-transmitted infections: 2003. *Curr Opin Hematol* 2003; **10:** 412–18.
7. Hardy J-F, *et al.* Massive transfusion and coagulopathy: pathophysiology and implications for clinical management. *Can J Anesth* 2004; **51:** 293–310.
8. McClelland DBL, ed. *Handbook of transfusion medicine: United Kingdom Blood Services*. 4th ed. London: The Stationery Office, 2007.
   Also available at: http://www.transfusionguidelines.org.uk/docs/pdfs/htm_edition-4_all-pages.pdf (accessed 15/02/07)

Creutzfeldt-Jakob disease. While there is no proof that transmission of Creutzfeldt-Jakob disease by blood or blood products has occurred,[1] 3 cases have been reported of possible transmission of variant Creutzfeldt-Jakob disease (vCJD) by blood transfusion.[2-4] It is recognised that there is a need for further assessment of the potential risk of transmission of vCJD by such products.

A number of precautionary measures have been implemented in the UK to minimise transmission of vCJD by blood or tissues:[5]

- plasma is imported from outside the UK for fractionation to manufacture plasma derivatives
- leucocytes are removed from donated blood (leucodepletion) as it was thought that this would remove infectivity. However, *animal* studies have shown that this is not the case and that prion concentration in the blood is likely to be reduced by only about 40%[6]
- plasma is imported for clinical use in patients born after January 1996 (this date was chosen because it was considered that foods infected with bovine spongiform encephalopathy had been largely eliminated from the diet by this time[6])
- donations of blood, platelets, and live bone are not accepted from donors who themselves have received blood components since 1 January 1980, or from any donors who have received intravenous immunoglobulin prepared from UK plasma or who have undergone plasma exchange anywhere in the world

Concern at the risk of transmitting Creutzfeldt-Jakob disease by albumin prepared from placental blood has led to restriction on this source of albumin (see Transmission of Infections under Albumin, p.1052).

1. Wilson K, *et al.* Risk of acquiring Creutzfeldt-Jakob disease from blood transfusions: systematic review of case-control studies. *BMJ* 2000; **321:** 17–19.
2. Llewelyn CA, *et al.* Possible transmission of variant Creutzfeldt-Jakob disease by blood transfusion. *Lancet* 2004; **363:** 417–21.
3. Peden AH, *et al.* Preclinical vCJD after blood transfusion in a PRNP codon 129 heterozygous patient. *Lancet* 2004; **364:** 527–9.
4. Wroe SJ, *et al.* Clinical presentation and pre-mortem diagnosis of variant Creutzfeldt-Jakob disease associated with blood transfusion: a case report. *Lancet* 2006; **368:** 2061–7.
5. McClelland DBL, ed. *Handbook of transfusion medicine: United Kingdom Blood Services*. 4th ed. London: The Stationery Office, 2007.
   Also available at: http://www.transfusionguidelines.org.uk/docs/pdfs/htm_edition-4_all-pages.pdf (accessed 15/02/07)
6. Ludlam CA, Turner ML. Managing the risk of transmission of variant Creutzfeldt Jakob disease by blood products. *Br J Haematol* 2005; **132:** 13–24.

Effects on leucocytes. A study of 50 patients in an intensive care unit found that 45 of them developed leucocytosis after transfusion of packed red blood cells.[1] The leucocytosis, which was accounted for by neutrophils, occurred immediately after transfusion and persisted for 12 hours. A further study[2] of 96 critically ill patients found that leucocytosis commonly occurred in

those who were not septic and had received unfiltered packed red cells. Mean white cell counts were increased significantly 2 hours after infusion, remained elevated for about 12 hours, and returned to baseline by 24 hours. In 11 patients who required more than one transfusion, the use of filtered packed red cells was not associated with leucocytosis. Concentrations of interleukin-8 were found to be raised in unfiltered blood after 4 weeks of storage, and were higher in the transfused blood that caused leucocytosis. The authors suggested that cytokines produced by leucocytes in stored blood might be responsible for leucocytosis in recipients of unfiltered packed red cells.

1. Fenwick JC, *et al.* Blood transfusion as a cause of leucocytosis in critically ill patients. *Lancet* 1994; **344:** 855–6.
2. Izbicki G, *et al.* Transfusion-related leukocytosis in critically ill patients. *Crit Care Med* 2004; **32:** 439–42.

Effects on the lungs. A rare but life-threatening complication of transfusion of blood or other plasma-containing products is acute lung injury, often termed transfusion-related acute lung injury (TRALI). Symptoms develop during or within 6 hours of infusion and are those of acute respiratory distress syndrome[1-3] (p.1498). Treatment is the same as for acute respiratory distress of any cause but oxygen exchange usually begins to improve between 24 and 48 hours; if the patient survives there appear to be no long-term sequelae.[1] The presence of HLA-specific antileucocyte antibodies in plasma from multiparous female donors appears to play a role in starting the reaction;[1,3] such antibodies have also been identified in some implicated male donors.[2] Another mechanism, the neutrophil priming hypothesis, proposes that TRALI results from 2 independent events. The first event causes the recipient's neutrophils to be primed and is related to the recipient's condition; in the second event the infused blood product activates the primed neutrophils in the lung, which causes endothelial damage.[2,3]

1. Wallis JP. Transfusion-related acute lung injury (TRALI)—under-diagnosed and under-reported. *Br J Anaesth* 2003; **90:** 573–6.
2. Holness L, *et al.* Fatalities caused by TRALI. *Transfus Med Rev* 2004; **18:** 184–8.
3. Kleinman S, *et al.* Toward an understanding of transfusion-related acute lung injury: statement of a consensus panel. *Transfusion* 2004; **44:** 1774–89.

Graft-versus-host disease. Acute graft-versus-host disease (see Haematopoietic Stem Cell Transplantation, p.1811) has been reported in both immunocompromised and immunocompetent patients after blood transfusion.[1] Symptoms include fever, rash, abnormal liver function tests, diarrhoea, and pronounced leucopenia and pancytopenia. The reaction can be severe and fatal.

High-risk immunocompromised groups include bone marrow transplant recipients, patients with congenital immunodeficiencies, fetuses receiving intra-uterine transfusions, patients with Hodgkin's disease, and patients treated with purine analogue drugs such as fludarabine. Patients at less risk include those with acute leukaemia, non-Hodgkin's lymphoma, solid tumours treated with intensive chemotherapy or radiotherapy, premature infants and those undergoing exchange transfusion, and solid organ transplant recipients.

Immunocompetent patients who share an HLA haplotype with HLA-homozygous blood donors also appear to be at increased risk. Such cases have been reported particularly in Japan, where practices have included the use of transfusions from blood relatives. There is also a high incidence of shared haplotype in the population.

Infusion of products containing viable lymphocytes appears to be responsible. Treatment of graft-versus-host disease associated with transfusion is largely ineffective and patients considered to be at risk should be given products depleted of viable lymphocytes by irradiation. Blood products depleted of leucocytes by filtration still contain a small percentage of viable leucocytes, and this should not be used as the sole method to prevent graft-versus-host disease.

1. Schroeder ML. Transfusion-associated graft-versus-host disease. *Br J Haematol* 2002; **117:** 275–87.

Malignant neoplasms. It has been suggested that perioperative allogeneic blood transfusion is associated with an increase in the risk of recurrence, and decreased long-term survival, after resection of malignancy. This suggestion was based on retrospective observational studies, and was attributed to immunosuppressant effects of allogeneic blood. Randomised controlled trials have produced conflicting results, but a 1996 review[1] did not find a detrimental effect on the risk of cancer recurrence, and suggested that the findings of the observational studies probably resulted from the confounding effect of factors associated with the need for transfusion. A later meta-analysis[2] of 32 studies of perioperative transfusion in patients undergoing colorectal surgery concluded that the cancer recurrence rate was increased (odds ratio 1.68) in patients given transfusions. Risk factors associated with this increase were rectal disease, more advanced disease, and an increased number of transfused units. However, many of the included studies had small sample sizes, there was significant heterogeneity, and other possible surgery-related risk factors could not be evaluated, such that a causal association between the increased risk of cancer recurrence and transfusion could not be established. Other systematic reviews have come to different conclusions. A meta-analysis[3] of studies in patients undergoing resection of any type of solid tumour included only studies that used an active comparator (leucocyte-depleted or autologous blood). Only 8 studies met the inclusion criteria and the analysis provided no evidence of an increased risk of death or cancer recurrence in patients given allogeneic blood. The proposed detrimental immunosuppressive effect of perioperative allogeneic blood transfusion was studied in colorectal cancer patients given either allogeneic packed red cells (buffy coat removed) or leucocyte-depleted red cells.[4] Although the leucocyte count is reduced when the buffy coat is removed, more leucocytes are removed from leucocyte-depleted red cells, which should reduce any immunosuppressive effect. However, after 5 years there was no difference in survival or recurrence rates between the two groups. Survival was better for a third group of non-transfused patients, but this may be explained by a higher incidence of rectal cancer in the transfused groups, and the better clinical status of patients not requiring transfusion. A review[5] of individual studies and meta-analyses concluded that a causal relationship between allogeneic blood transfusion and solid cancer recurrence had not been proven. There was some evidence for transfusion-associated immunomodulation, but the mechanisms of effect and the specific constituents of allogeneic blood that mediate the effect remain unclear.

Epidemiological studies have reported an increase in the incidence of non-Hodgkin's lymphoma coinciding with the increase in the use of allogeneic blood transfusions since the 1950s. Proposed mechanisms have included transfusion-associated immunosuppression, transmission of oncogenic viruses, and blood donation by prelymphomatous donors.[6,7] Although some case-control studies have reported no association between blood transfusion and the development of non-Hodgkin's lymphoma,[8,9] others have reported a positive association, particularly for some subtypes of lymphoma.[10] Reviews[6,7] of these and other studies have found considerable disagreement between reports. This may result from biases in study design, confounding factors such as HIV infection, and lack of consensus on lymphoma classification.

1. Vamvakas EC. Transfusion-associated cancer recurrence and postoperative infection: meta-analysis of randomized, controlled clinical trials. *Transfusion* 1996; **36:** 175–86.
2. Amato AC, Pescatori M. Effect of perioperative blood transfusions on recurrence of colorectal cancer: meta-analysis stratified on risk factors. *Dis Colon Rectum* 1998; **41:** 570–85.
3. McAlister FA, *et al.* Perioperative allogeneic blood transfusion does not cause adverse sequelae in patients with cancer: a meta-analysis of unconfounded studies. *Br J Surg* 1998; **85:** 171–8.
4. van de Watering LMG, *et al.* Perioperative blood transfusions, with or without allogeneic leucocytes, relate to survival, not to cancer recurrence. *Br J Surg* 2001; **88:** 267–72.
5. Vamvakas EC, Blajchman MA. Deleterious clinical effects of transfusion-associated immunomodulation: fact or fiction? *Blood* 2001; **97:** 1180–95.
6. Vamvakas EC. Allogeneic blood transfusion as a risk factor for the subsequent development of non-Hodgkin's lymphoma. *Transfus Med Rev* 2000; **14:** 258–68.
7. Chow EJ, Holly EA. Blood transfusions and non-Hodgkin's lymphoma. *Epidemiol Rev* 2002; **24:** 269–79.
8. Maguire-Boston EK, *et al.* Blood transfusion and risk of non-Hodgkin's lymphoma. *Am J Epidemiol* 1999; **149:** 1113–18.
9. Chow EJ, Holly EA. Blood transfusions as a risk factor for non-Hodgkin's lymphoma in the San Francisco Bay Area: a population-based study. *Am J Epidemiol* 2002; **155:** 725–31.
10. Cerhan JR, *et al.* Blood transfusions and risk of non-Hodgkin's lymphoma subtypes and chronic lymphocytic leukemia. *Cancer Epidemiol Biomarkers Prev* 2001; **10:** 361–8.

Precautions

Whole blood should generally not be transfused unless the ABO and Rh groups of the patient's and the donor's blood have been verified and a compatibility check made between the patient's serum and the donor's red cells (see under Blood Groups, below).

The Rh group of the recipient should always be determined and ideally all patients should be transfused with blood of homologous Rh groups.

To reduce the possibility of cardiac arrest from cardiac hypothermia when large volumes are used or the blood is transfused rapidly, and to minimise postoperative shivering, stored blood should be carefully warmed to about 37° before transfusion.

Whole blood should not be given to patients with chronic anaemia who have a normal or elevated plasma volume.

Drugs should *not* be added to blood.

Transfusion of blood from donors who have recently been receiving drug treatment may be hazardous to the recipient.

◊ Guidelines[1-4] for accepting blood from donors who have been receiving drugs have been published.

1. Ferner RE, *et al.* Drugs in donated blood. *Lancet* 1989; **ii:** 93–4.
2. Stichtenoth DO, *et al.* Blood donors on medication: are deferral periods necessary? *Eur J Clin Pharmacol* 2001; **57:** 433–40.
3. UK Blood Transfusion Services. Whole blood and components donor selection guidelines: drug index (revised 23/04/08). Available at: http://www.transfusionguidelines.org.uk/index.asp?Publication=DI&Section=4 (accessed 29/08/08)
4. American Red Cross. Blood donation eligibility guidelines (revised 08/05/08). Available at: http://www.redcross.org/services/biomed/0,1082,0_557_,00.html#med (accessed 29/08/08)

Abuse. References to the infusion of whole blood or packed red blood cells to enhance athletic performance.[1,2]

1. Ekblom BT. Blood boosting and sport. *Baillieres Best Pract Res Clin Endocrinol Metab* 2000; **14:** 89–98.
2. Leigh-Smith S. Blood boosting. *Br J Sports Med* 2004; **38:** 99–101.

Blood groups. The chief blood group systems are the ABO system and the Rhesus system.

In simple terms red blood cells carry on their surface genetically determined antigens. A person with antigen A, B, A plus B, or neither is classified as group A, B, AB, or O respectively. Such persons will have, in their serum, antibodies to B, A, neither, or both respectively—anti-B (β), anti-A (α), or anti-B plus anti-A (α + β). Giving blood containing red cells from a person of group A to a person with anti-A results in agglutination or possibly haemolysis. For the determination of the ABO group the agglutinogens of the red cells and the agglutinins of the serum are determined by testing against known standards.

In the Rhesus system many persons carry an antigen (Rh-positive) which stimulates antibody formation in Rh-negative persons; subsequent exposure to Rh-positive blood causes haemolysis.

Many variants of these and other systems, are recognised.

Uses and Administration

Blood is a complex fluid with many functions including the maintenance of hydration of the tissues, maintenance of body temperature, and the transport within the body of gases, ions, nutrients, hormones, enzymes, antibodies, waste products of metabolism, and drugs.

The main components of blood are plasma, red blood cells (erythrocytes), white blood cells (leucocytes), and platelets (for further information on different blood cells and their formation, and average counts in adults, see Haematopoiesis, p.1042). Serum is the fluid which remains once blood or plasma has clotted; it is, in effect, plasma with fibrinogen removed.

Whole blood is used as a source of red cell concentrates, clotting factors, platelets, plasma and plasma fractions, and immunoglobulins, each of which has specific indications for use. Because of the risks involved in transfusing whole blood and the need for economy in its use, the appropriate blood component should be used whenever possible.

Whole blood may be used where replacement of plasma proteins as well as red blood cells is needed, for example after acute blood loss during surgery or severe haemorrhage. It may also be used to supplement the circulation during cardiac bypass surgery.

The amount of whole blood transfused and the rate at which it is given depend upon the patient's age and general condition, upon the state of their circulatory system, and upon the therapeutic indication for transfusion.

The expression 'unit of blood' generally represents a volume of about 510 mL, including anticoagulant. For blood preparations a unit generally refers to the quantity of a blood component obtained from 1 unit of whole blood. Specific units of activity are used for some blood components.

The haemoglobin concentration of the blood of the average adult is raised by about 1 g per 100 mL by the transfusion of 1 unit of whole blood.

◊ Reviews and guidelines for the use of blood and blood components.

1. Contreras M, ed. *ABC of transfusion.* 3rd ed. London: BMJ Books, 1998.
2. Goodnough LT, *et al.* Transfusion medicine: blood transfusion. *N Engl J Med* 1999; **340:** 438–47.
3. World Health Organization. *The clinical use of blood in medicine, obstetrics, paediatrics, surgery and anaesthesia, trauma and burns.* Geneva: World Health Organization, 2001. Also