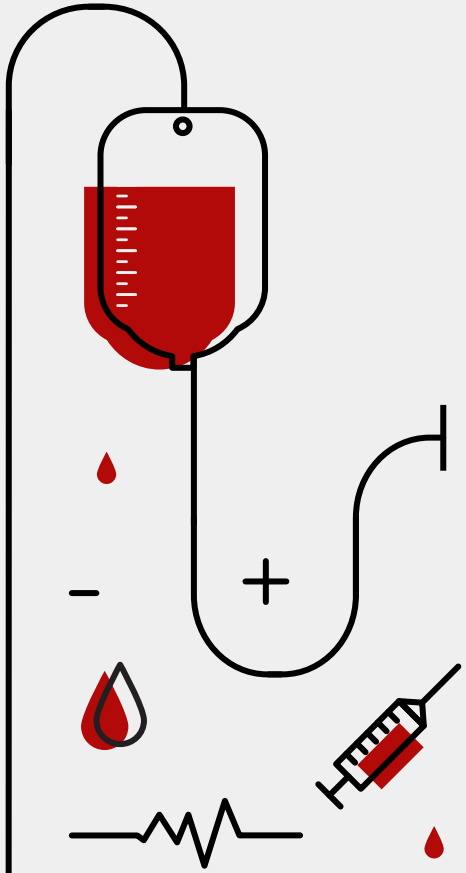

Μετάγγιση Παραγώγων Αίματος στον Τραυματία

Κλινικό Φροντιστήριο Hands-On Course: «ΑΝΑΖΩΟΓΟΝΗΣΗ ΣΕ ΤΡΑΥΜΑΤΙΑ»
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Επιμελήτρια Α', ΓΝΑ «Ο Ευαγγελισμός»

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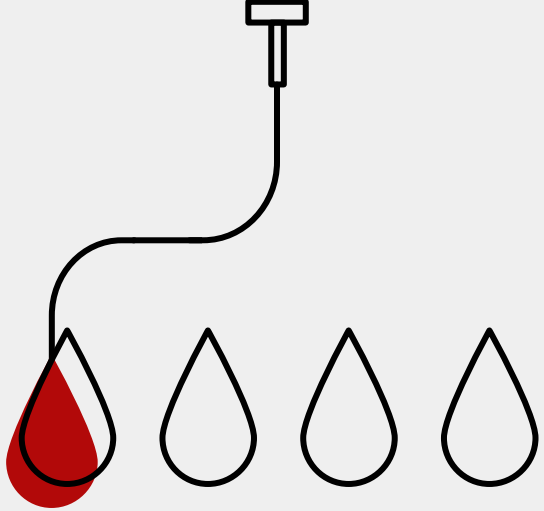
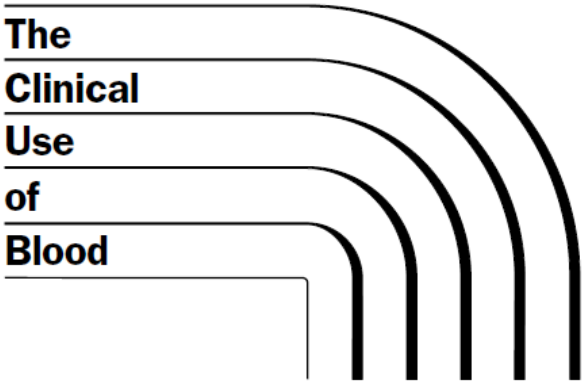


Παράγωγα Αίματος



Handbook

World Health Organization.
Blood Transfusion Safety
Team. (2001)

World Health Organization
Blood Transfusion Safety
GENEVA

Whole blood

WHOLE BLOOD (CPD-Adenine-1)

A 450 ml whole blood donation contains:

Description	Up to 510 ml total volume (volume may vary in accordance with local policies) ■ 450 ml donor blood ■ 63 ml anticoagulant-preservative solution ■ Haemoglobin approximately 12 g/ml ■ Haematocrit 35%–45% ■ No functional platelets ■ No labile coagulation factors (V and VIII)
Unit of issue	1 donation, also referred to as a 'unit' or 'pack'
Infection risk	Not sterilized, so capable of transmitting any agent present in cells or plasma which has not been detected by routine screening for transfusion-transmissible infections, including HIV-1 and HIV-2, hepatitis B and C, other hepatitis viruses, syphilis, malaria and Chagas disease
Storage	■ Between +2°C and +6°C in approved blood bank refrigerator, fitted with a temperature chart and alarm ■ During storage at +2°C and +6°C, changes in composition occur resulting from red cell metabolism ■ Transfusion should be started within 30 minutes of removal from refrigerator
Indications	■ Red cell replacement in acute blood loss with hypovolaemia ■ Exchange transfusion ■ Patients needing red cell transfusions where red cell concentrates or suspensions are not available
Contraindications	Risk of volume overload in patients with: ■ Chronic anaemia ■ Incipient cardiac failure
Administration	■ Must be ABO and RhD compatible with the recipient ■ Never add medication to a unit of blood ■ Complete transfusion within 4 hours of commencement

Blood components

RED CELL CONCENTRATE ('Packed red cells', 'plasma-reduced blood'

Description	■ 150–200 ml red cells from which most of the plasma has been removed ■ Haemoglobin approximately 20 g/100 ml (not less than 45 g per unit) ■ Haematocrit 55%–75%
Unit of issue	1 donation
Infection risk	Same as whole blood
Storage	Same as whole blood
Indications	■ Replacement of red cells in anaemic patients ■ Use with crystalloid replacement fluids or colloid solution in acute blood loss
Administration	■ Same as whole blood ■ To improve transfusion flow, normal saline (50–100 ml) may be added using a Y-pattern infusion set

RED CELL SUSPENSION

Description	■ 150–200 ml red cells with minimal residual plasma to which ±100 ml normal saline, adenine, glucose, mannitol solution (SAG-M) or an equivalent red cell nutrient solution has been added ■ Haemoglobin approximately 15 g/100 ml (not less than 45 g per unit) ■ Haematocrit 50%–70%
Unit of issue	1 donation
Infection risk	Same as whole blood
Storage	Same as whole blood
Indications	Same as red cell concentrate
Contraindications	Not advised for exchange transfusion of neonates. The additive solution may be replaced with plasma, 45% albumin or an isotonic crystalloid solution, such as normal saline
Administration	■ Same as whole blood ■ Better flow rates are achieved than with red cell concentrate or whole blood

LEUCOCYTE-DEPLETED RED CELLS

Description	■ A red cell suspension or concentrate containing <5 x 10^6 white cells per pack, prepared by filtration through a leucocyte-depleting filter ■ Haemoglobin concentration and haematocrit depend on whether the product is whole blood, red cell concentrate or red cell suspension ■ Leucocyte depletion significantly reduces the risk of transmission of cytomegalovirus (CMV)
Unit of issue	1 donation
Infection risk	Same as whole blood for all other transfusion-transmissible infections
Storage	Depends on production method: consult blood bank
Indications	■ Minimizes white cell immunization in patients receiving repeated transfusions but, to achieve this, all blood components given to the patient must be leucocyte-depleted ■ Reduces risk of CMV transmission in special situations (see pp. 100 and 147) ■ Patients who have experienced two or more previous febrile reactions to red cell transfusion
Contraindications	Will not prevent graft-vs-host disease: for this purpose, blood components should be irradiated where facilities are available (radiation dose: 25–30 Gy)
Administration	■ Same as whole blood ■ A leucocyte filter may also be used at the time of transfusion if leucocyte-depleted red cells or whole blood are not available
Alternative	■ Buffy coat-removed whole blood or red cell suspension is usually effective in avoiding febrile non-haemolytic transfusion reactions ■ The blood bank should express the buffy coat in a sterile environment immediately before transporting the blood to the bedside ■ Start the transfusion within 30 minutes of delivery and use a leucocyte filter, where possible ■ Complete transfusion within 4 hours of commencement

PLATELET CONCENTRATES (prepared from whole blood donations)

Description	Single donor unit in a volume of 50–60 ml of plasma should contain: ■ At least 55 x 10^9 platelets ■ <1.2 x 10^9 red cells ■ <0.12 x 10^9 leucocytes
Unit of issue	May be supplied as either: ■ Single donor unit: platelets prepared from one donation ■ Pooled unit: platelets prepared from 4 to 6 donor units 'pooled' into one pack to contain an adult dose of at least 240 x 10^9 platelets
Infection risk	■ Same as whole blood, but a normal adult dose involves between 4 and 6 donor exposures ■ Bacterial contamination affects about 1% of pooled units
Storage	■ Up to 72 hours at 20°C to 24°C (with agitation) unless collected in specialized platelet packs validated for longer storage periods; do not store at 2°C to 6°C ■ Longer storage increases the risk of bacterial proliferation and septicaemia in the recipient
Indications	■ Treatment of bleeding due to: — Thrombocytopenia — Platelet function defects ■ Prevention of bleeding due to thrombocytopenia, such as in bone marrow failure
Contraindications	■ Not generally indicated for prophylaxis of bleeding in surgical patients, unless known to have significant pre-operative platelet deficiency ■ Not indicated in: — Idiopathic autoimmune thrombocytopenic purpura (ITP) — Thrombotic thrombocytopenic purpura (TTP) — Untreated disseminated intravascular coagulation (DIC) — Thrombocytopenia associated with septicaemia, until treatment has commenced or in cases of hypersplenism

Dosage	■ 1 unit of platelet concentrate/10 kg body weight: in a 60 or 70 kg adult, 4–6 single donor units containing at least 240 x 10^9 platelets should raise the platelet count by 20–40 x 10^9/L ■ Increment will be less if there is: — Splenomegaly — Disseminated intravascular coagulation — Septicaemia
Administration	■ After pooling, platelet concentrates should be infused as soon as possible, generally within 4 hours, because of the risk of bacterial proliferation ■ Must not be refrigerated before infusion as this reduces platelet function ■ 4–6 units of platelet concentrates (which may be supplied pooled) should be infused through a fresh standard blood administration set ■ Special platelet infusion sets are not required ■ Should be infused over a period of about 30 minutes ■ Do not give platelet concentrates prepared from RhD positive donors to an RhD negative female with child-bearing potential ■ Give platelet concentrates that are ABO compatible, whenever possible
Complications	Febrile non-haemolytic and allergic urticarial reactions are not uncommon, especially in patients receiving multiple transfusions (for management, see pp. 62–63)

PLATELET CONCENTRATES (collected by plateletpheresis)

Description	■ Volume 150–300 ml ■ Platelet content 150–500 x 10^9, equivalent to 3–10 single donations ■ Platelet content, volume of plasma and leucocyte contamination depend on the collection procedure
Unit of issue	1 pack containing platelet concentrates collected by a cell separator device from a single donor
Infection risk	Same as whole blood
Storage	Up to 72 hours at 20°C to 24°C (with agitation) unless collected in specialized platelet packs validated for longer storage periods; do not store at 2°C to 6°C
Indications	■ Generally equivalent to the same dose of platelet concentrates prepared from whole blood ■ If a specially typed, compatible donor is required for the patient, several doses may be obtained from the selected donor
Dosage	1 pack of platelet concentrate collected from a single donor by apheresis is usually equivalent to 1 therapeutic dose
Administration	Same as recovered donor platelets, but ABO compatibility is more important: high titre anti-A or anti-B in the donor plasma used to suspend the platelets may cause haemolysis of the recipient's red cells

FRESH FROZEN PLASMA

Description
- Pack containing the plasma separated from one whole blood donation within 6 hours of collection and then rapidly frozen to –25°C or colder
- Contains normal plasma levels of stable clotting factors, albumin and immunoglobulin
- Factor VIII level at least 70% of normal fresh plasma level

Unit of issue
- Usual volume of pack is 200–300 ml
- Smaller volume packs may be available for children

Infection risk
- If untreated, same as whole blood
- Very low risk if treated with methylene blue/ultraviolet light inactivation (see virus 'inactivated' plasma)

Storage
- At –25°C or colder for up to 1 year
- Before use, should be thawed in the blood bank in water which is between 30°C to 37°C. Higher temperatures will destroy clotting factors and proteins
- Once thawed, should be stored in a refrigerator at +2°C to +6°C

Indications
- Replacement of multiple coagulation factor deficiencies: e.g.
  - — Liver disease
  - — Warfarin (anticoagulant) overdose
  - — Depletion of coagulation factors in patients receiving large volume transfusions
- Disseminated intravascular coagulation (DIC)
- Thrombotic thrombocytopenic purpura (TTP)

Precautions
- Acute allergic reactions are not uncommon, especially with rapid infusions
- Severe life-threatening anaphylactic reactions occasionally occur
- Hypovolaemia alone is *not* an indication for use

Dosage
Initial dose of 15 ml/kg

Administration
- Must normally be ABO compatible to avoid risk of haemolysis in recipient
- No compatibility testing required
- Infuse using a standard blood administration set as soon as possible after thawing
- Labile coagulation factors rapidly degrade; use within 6 hours of thawing

LIQUID PLASMA

Description
- Plasma separated from a whole blood unit and stored at +4°C
- No labile coagulation factors (Factors V and VIII)

FREEZE-DRIED POOLED PLASMA

Description
- Plasma from many donors pooled before freeze-drying

Infection risk
- No virus inactivation step so the risk of transmitting infection is therefore multiplied many times
- **This is an obsolete product that should not be used**

CRYOPRECIPITATE-DEPLETED PLASMA

Description
Plasma from which approximately half the fibrinogen and Factor VIII has been removed as cryoprecipitate, but which contains all the other plasma constituents

VIRUS 'INACTIVATED' PLASMA

Description
- Plasma treated with methylene blue/ultraviolet light inactivation to reduce the risk of HIV, hepatitis B and hepatitis C
- The cost of this product is considerably higher than conventional fresh frozen plasma

Infection risk
The 'inactivation' of other viruses, such as hepatitis A and human parvovirus B19 is less effective

CRYOPRECIPITATE

Description	■ Prepared from fresh frozen plasma by collecting the precipitate formed during controlled thawing at +4°C and resuspending it in 10–20 ml plasma ■ Contains about half of the Factor VIII and fibrinogen in the donated whole blood: e.g. Factor VIII: 80–100 iu/pack; fibrinogen: 150–300 mg/pack
Unit of issue	Usually supplied as a single donor pack or a pack of 6 or more single donor units that have been pooled
Infection risk	As for plasma, but a normal adult dose involves at least 6 donor exposures
Storage	■ At –25°C or colder for up to 1 year
Indications	■ As an alternative to Factor VIII concentrate in the treatment of inherited deficiencies of: — von Willebrand Factor (von Willebrand's disease) — Factor VIII (haemophilia A) — Factor XIII ■ As a source of fibrinogen in acquired coagulopathies: e.g. disseminated intravascular coagulation (DIC)
Administration	■ If possible, use ABO-compatible product ■ No compatibility testing required ■ After thawing, infuse as soon as possible through a standard blood administration set ■ Must be infused within 6 hours of thawing

Plasma derivatives

HUMAN ALBUMIN SOLUTIONS

Description	Prepared by fractionation of large pools of donated plasma
Preparations	■ Albumin 5%: contains 50 mg/ml of albumin ■ Albumin 20%: contains 200 mg/ml of albumin ■ Albumin 25%: contains 250 mg/ml of albumin ■ Stable plasma protein solution (SPPS) and plasma protein fraction (PPF): similar albumin content to albumin 5%
Infection risk	No risk of transmission of viral infections if correctly manufactured
Indications	■ Replacement fluid in therapeutic plasma exchange: use albumin 5% ■ Treatment of diuretic-resistant oedema in hypoproteinaemic patients: e.g. nephrotic syndrome or ascites. Use albumin 20% with a diuretic ■ Although 5% human albumin is currently licensed for a wide range of indications (e.g. volume replacement, burns and hypoalbuminaemia), there is *no* evidence that it is superior to saline solution or other crystalloid replacement fluids for acute plasma volume replacement
Precautions	Administration of 20% albumin may cause acute expansion of intravascular volume with risk of pulmonary oedema
Contraindications	Do not use for IV nutrition: it is an expensive and inefficient source of essential amino acids
Administration	■ No compatibility testing required ■ No filter needed

COAGULATION FACTORS

Factor VIII concentrate

Description	■ Partially purified Factor VIII prepared from large pools of donor plasma ■ Factor VIII ranges from 0.5–20 iu/mg of protein. Preparations with a higher activity are available ■ Products that are licensed in certain countries (e.g. USA and European Union) are all heated and/or chemically treated to reduce the risk of transmission of viruses
Unit of issue	Vials of freeze-dried protein labelled with content, usually about 250 iu of Factor VIII
Infection risk	Current virus 'inactivated' products do not appear to transmit HIV, HTLV, hepatitis C and other viruses that have lipid envelopes: the inactivation of non-enveloped viruses such as hepatitis A and parvovirus is less effective
Storage	+2°C to +6°C up to stated expiry date, unless otherwise indicated in manufacturer's instructions
Indications	■ Treatment of haemophilia A ■ Treatment of von Willebrand's disease: use only preparations that contain von Willebrand Factor
Dosage	See p. 113
Administration	■ Reconstitute according to manufacturer's instructions ■ Once the powder is dissolved, draw up the solution using a filter needle and infuse through a standard infusion set within 2 hours
Alternatives	■ Cryoprecipitate, fresh frozen plasma ■ Factor VIII prepared *in vitro* using recombinant DNA methods is commercially available. It is clinically equivalent to Factor VIII derived from plasma and does not have the risk of transmitting pathogens derived from plasma donors

PLASMA DERIVATIVES CONTAINING FACTOR IX

Prothrombin complex concentrate (PCC)
Factor IX concentrate

		PCC	Factor IX
Description	Contains:		
	■ Factors II, IX and X	✓	✓
	■ Factor IX only		✓
	■ Some preparations also contain Factor VII	✓	
Unit of issue	Vials of freeze-dried protein labelled with content, usually about 350–600 iu of Factor IX		
Infection risk	As Factor VIII		
Storage	As Factor VIII		
Indications	■ Treatment of haemophilia B (Christmas disease)	✓	✓
	■ Immediate correction of prolonged prothrombin time	✓	
Contraindications	PCC is not advised in patients with liver disease or thrombotic tendency		
Dosage	See p. 114		
Administration	As Factor VIII		
Alternatives	Plasma		

Factor IX produced *in vitro* by recombinant DNA methods will soon be available for the treatment of haemophilia B

COAGULATION FACTOR PRODUCTS FOR PATIENTS WITH FACTOR VIII INHIBITORS

Description	A heat-treated plasma fraction containing partly-activated coagulation factors
Infection risk	Probably the same as other heat-treated factor concentrates
Indications	Only for use in patients with inhibitors to Factor VIII
Administration	Should be used only with specialist advice

IMMUNOGLOBULINS

Immunoglobulin for intramuscular use

Description	Concentrated solution of the IgG antibody component of plasma
Preparations	Standard or normal immunoglobulin: prepared from large pools of donations and contains antibodies against infectious agents to which the donor population has been exposed
Infection risk	Transmission of virus infections has *not* been reported with intramuscular immunoglobulin
Indications	■ Hyperimmune or specific immunoglobulin: from patients with high levels of specific antibodies to infectious agents: e.g. hepatitis B, rabies, tetanus ■ Prevention of specific infections ■ Treatment of immune deficiency states
Administration	Do not give intravenously as severe reactions occur

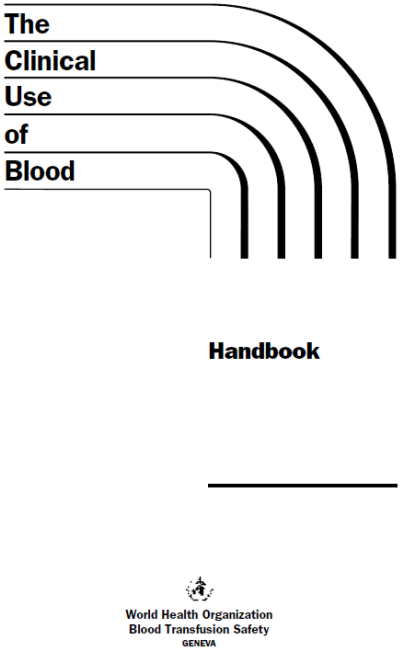
Anti-RhD immunoglobulin (Anti-D RhIG)

Description	Prepared from plasma containing high levels of anti-RhD antibody from previously immunized persons
Indications	Prevention of haemolytic disease of the newborn in RhD-negative mothers (see pp. 132–134)

Immunoglobulin for intravenous use

Description	As for intramuscular preparation, but with subsequent processing to render product safe for IV administration
Indications	■ Idiopathic autoimmune thrombocytopenic purpura and some other immune disorders ■ Treatment of immune deficiency states ■ Hypogammaglobulinaemia ■ HIV-related disease

Ορισμός - Συστάσεις - Στόχοι



World Health Organization. Blood Transfusion Safety Team. (2001)

Massive or large volume blood transfusions

'Massive transfusion' is the replacement of blood loss equivalent to or greater than the patient's total blood volume in less than 24 hours:

- 70 ml/kg in adults
- 80–90 ml/kg in children or infants.

Morbidity and mortality tend to be high among such patients, not because of the large volumes infused, but because of the initial trauma and the tissue and organ damage secondary to haemorrhage and hypovolaemia.

It is often the underlying cause and consequences of major haemorrhage that result in complications, rather than the transfusion itself.

However, administering large volumes of blood and intravenous fluids may itself give rise to the following complications.

Transfusion Handbook

7.3: Transfusion management of major haemorrhage

http://www.transfusionguidelines.org/transfusion-handbook/7-effective-transfusion-in-surgery-and-critical-care/7-3-transfusion-management-of-major-haemorrhage

7.3: Transfusion management of major haemorrhage

Major haemorrhage is variously defined as:

- Loss of more than one blood volume within 24 hours (around 70 mL/kg, >5 litres in a 70 kg adult)
- 50% of total blood volume lost in less than 3 hours
- Bleeding in excess of 150 mL/minute.

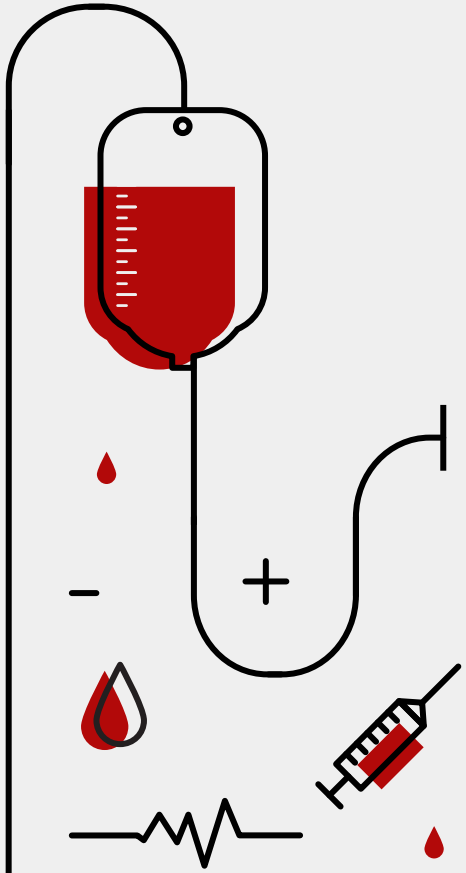
A pragmatic clinically based definition is bleeding which leads to a systolic blood pressure of less than 90 mm Hg or a heart rate of more than 110 beats per minute.

Table 3 American College of Surgeons Advanced Trauma Life Support (ATLS) classification of blood loss based on initial patient presentation. Signs and symptoms of haemorrhage by class. Table reprinted with permission from the American College of Surgeons [111]

Parameter	Class I	Class II (mild)	Class III (moderate)	Class IV (severe)
Approximate blood loss	< 15%	15–30%	31–40%	> 40%
Heart rate	↔	↔ / ↑	↑	↑ / ↑↑
Blood pressure	↔	↔	↔ / ↓	↓
Pulse pressure	↔	↓	↓	↓
Respiratory rate	↔	↔	↔ / ↑	↑
Urine output	↔	↔	↓	↓↓
Glasgow Coma Scale score	↔	↔	↓	↓
Base deficit*	0 to − 2 mEq/L	− 2 to −6 mEq/L	− 6 to −10 mEq/L	− 10 mEq/L or less
Need for blood products	Monitor	Possible	Yes	Massive transfusion protocol

*Base excess is the quantity of base (HCO_3^-, in mEq/L) that is above or below the normal range in the body. A negative number is called a base deficit and indicates metabolic acidosis

Original data from Mutschler et al. [117]



Haemoglobin

Recommendation 8 We recommend that a low initial Hb be considered an indicator for severe bleeding associated with coagulopathy. (Grade 1B)

We recommend the use of repeated Hb measurements as a laboratory marker for bleeding, as an initial Hb value in the normal range may mask bleeding. (Grade 1B)

Coagulation monitoring

Recommendation 10 We recommend that routine practice include the early and repeated monitoring of haemostasis, using either a combined traditional laboratory determination [prothrombin time (PT), platelet counts and Clauss fibrinogen level] and/or point-of-care (POC) PT/international normalised ratio (INR) and/or a viscoelastic method (VEM). (Grade 1C)

We recommend laboratory screening of patients treated or suspected of being treated with anticoagulant agents. (Grade 1C)

Platelet function monitoring

Recommendation 11 We suggest the use of POC platelet function devices as an adjunct to standard laboratory and/or POC coagulation monitoring in patients with suspected platelet dysfunction. (Grade 2C)

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https://doi.org/10.1186/s13054-019-2347-3

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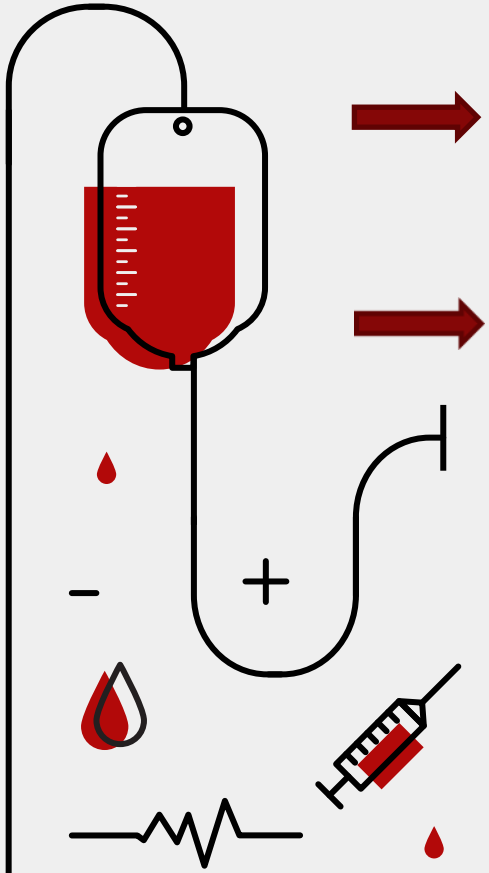
The European guideline on management of major bleeding and coagulopathy following trauma: fifth edition



Restricted volume replacement

Recommendation 13 We recommend use of a restricted volume replacement strategy to achieve target blood pressure until bleeding can be controlled. (Grade 1B).

Erythrocytes

Recommendation 16 We recommend a target Hb of 70 to 90 g/L. (Grade 1C)

Coagulation support

Recommendation 23 We recommend that monitoring and measures to support coagulation be initiated immediately upon hospital admission. (Grade 1B)

Initial coagulation resuscitation

Recommendation 24 In the initial management of patients with expected massive haemorrhage, we recommend one of the two following strategies:

- FFP or pathogen-inactivated FFP in a FFP:RBC ratio of at least 1:2 as needed. (Grade 1C)
- Fibrinogen concentrate and RBC. (Grade 1C)

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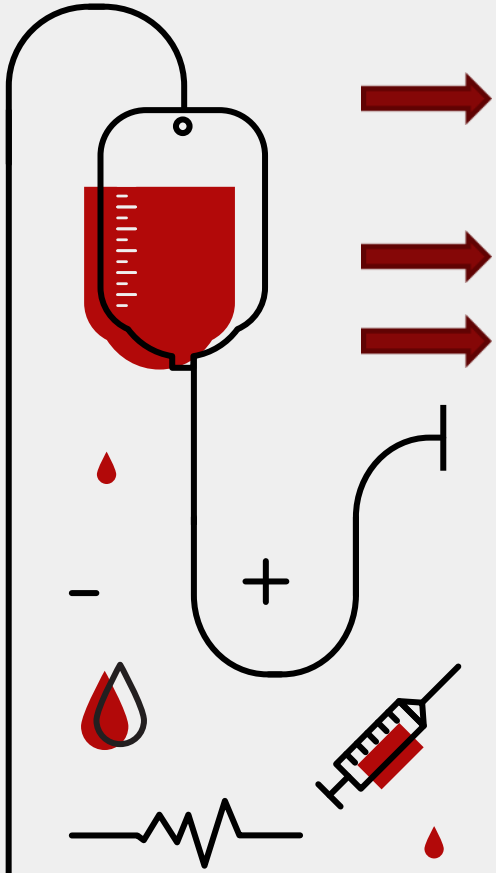


Fresh frozen plasma-based management

Recommendation 26 If a FFP-based coagulation resuscitation strategy is used, we recommend that further use of FFP be guided by standard laboratory coagulation screening parameters (PT and/or APTT > 1.5 times normal and/or viscoelastic evidence of a coagulation factor deficiency). (Grade 1C)

We recommend that FFP transfusion be avoided in patients without major bleeding. (Grade 1B)

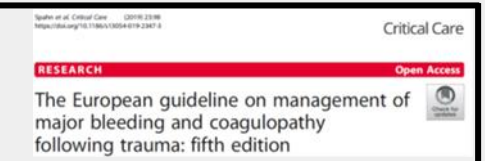
We recommend that the use of FFP be avoided for the treatment of hypofibrinogenaemia. (Grade 1C)

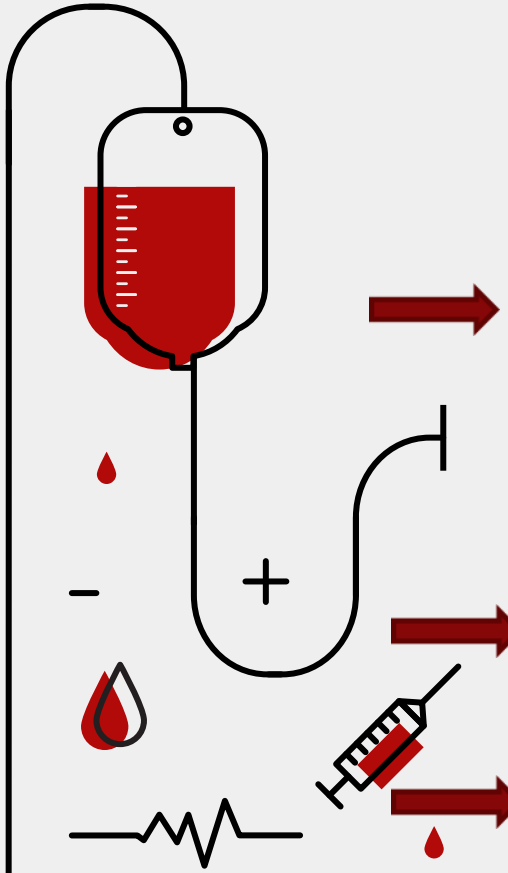
Coagulation factor concentrate-based management

Recommendation 27 If a CFC-based strategy is used, we recommend treatment with factor concentrates based on standard laboratory coagulation parameters and/or viscoelastic evidence of a functional coagulation factor deficiency. (Grade 1C)

Provided that fibrinogen levels are normal, we suggest that PCC is administered to the bleeding patient based on evidence of delayed coagulation initiation using VEM. (Grade 2C)

We suggest that monitoring of FXIII be included in coagulation support algorithms and that FXIII be supplemented in bleeding patients with a functional FXIII deficiency. (Grade 2C)





Fibrinogen supplementation

Recommendation 28 We recommend treatment with fibrinogen concentrate or cryoprecipitate if major bleeding is accompanied by hypofibrinogenaemia (viscoelastic signs of a functional fibrinogen deficit or a plasma Clauss fibrinogen level ≤ 1.5 g/L). (Grade 1C)

We suggest an initial fibrinogen supplementation of 3–4 g. This is equivalent to 15–20 single-donor units of cryoprecipitate or 3–4 g fibrinogen concentrate. Repeat doses should be guided by VEM and laboratory assessment of fibrinogen levels. (Grade 2C)

Platelets

Recommendation 29 We recommend that platelets be administered to maintain a platelet count above 50×10^9/L. (Grade 1C)

We suggest maintenance of a platelet count above 100×10^9/L in patients with ongoing bleeding and/or TBI. (Grade 2C)

If administered, we suggest an initial dose of four to eight single platelet units or one aphaeresis pack. (Grade 2C)

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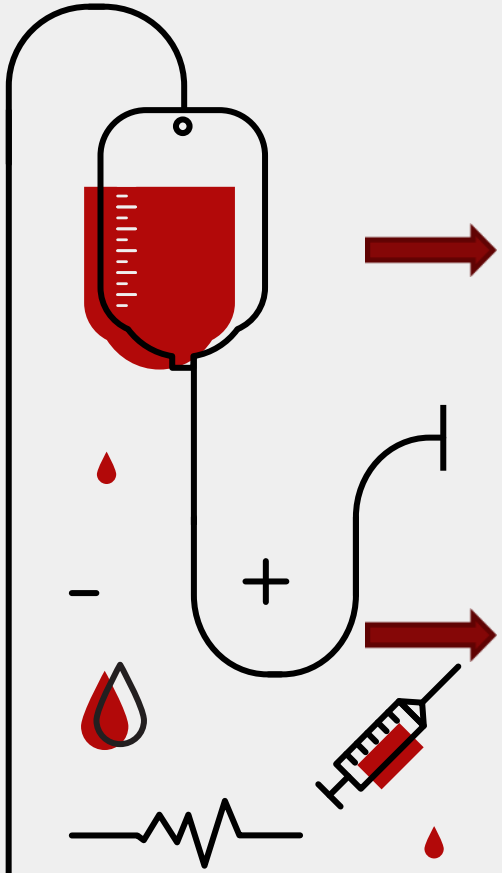

Recombinant activated coagulation factor VII

Recommendation 31 We do not recommend the use of recombinant activated coagulation factor VII (rFVIIa) as first-line treatment. (Grade 1B)

We suggest that the off-label use of rFVIIa be considered only if major bleeding and traumatic coagulopathy persist despite all other attempts to control bleeding and best-practice use of conventional haemostatic measures. (Grade 2C)

VII. Reversal of antithrombotic agents

Antithrombotic agent reversal

Recommendation 32 We recommend reversal of the effect of antithrombotic agents in patients with ongoing bleeding. (Grade 1C)

1. VKAs
2. Direct oral anticoagulants—FXa inhibitor
3. Direct oral anticoagulants—Thrombin inhibitor
4. Antiplatelet agents

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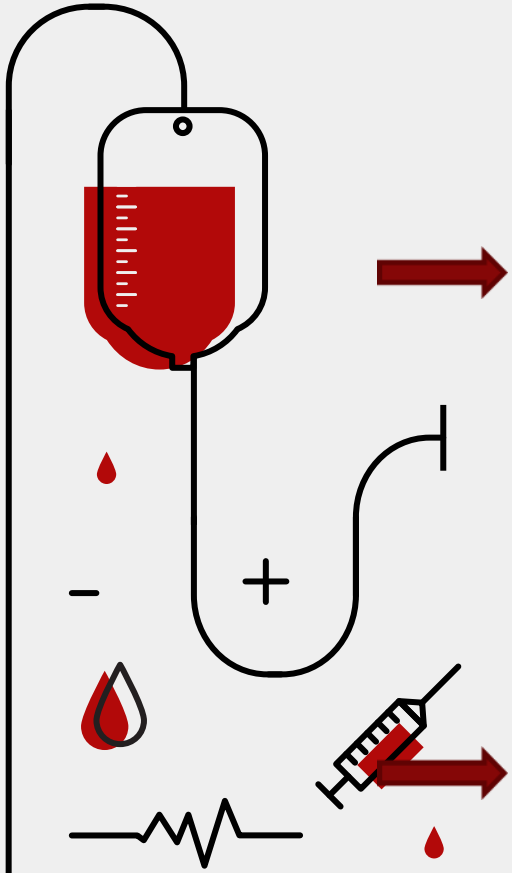

Reversal of vitamin K-dependent oral anticoagulants

Recommendation 33 In the bleeding trauma patient, we recommend the emergency reversal of vitamin K-dependent oral anticoagulants with the early use of both PCC and 5 mg i.v. phytomenadione (vitamin K_1). (Grade 1A)

Direct oral anticoagulants—factor Xa inhibitors

Recommendation 34 We suggest the measurement of plasma levels of oral direct anti-factor Xa agents such as apixaban, edoxaban or rivaroxaban in patients treated or suspected of being treated with one of these agents. (Grade 2C)

We suggest that measurement of anti-Xa activity be calibrated for the specific agent. If measurement is not possible or available, we suggest that advice from an expert haematologist be sought. (Grade 2C)

If bleeding is life-threatening, we suggest administration of TXA 15 mg/kg (or 1 g) intravenously and that the use of PCC (25–50 U/kg) be considered until specific antidotes are available. (Grade 2C)

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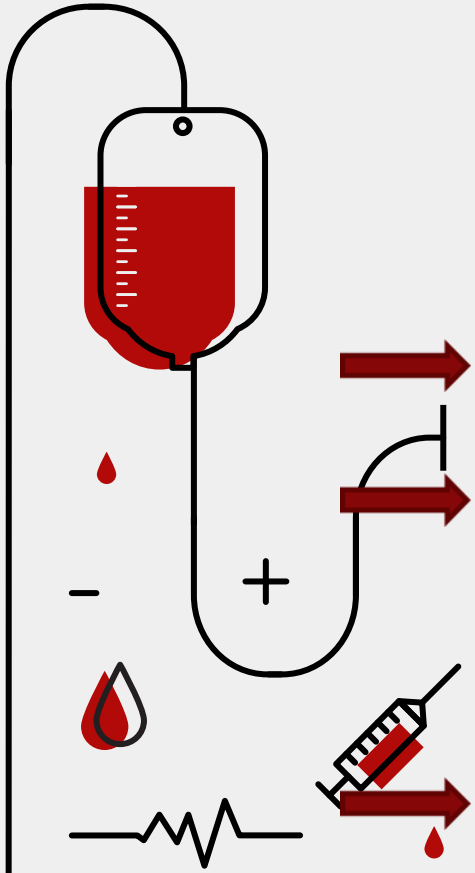


Direct oral anticoagulants—direct thrombin inhibitors

Recommendation 35 We suggest the measurement of dabigatran plasma levels using diluted thrombin time in patients treated or suspected of being treated with dabigatran. (Grade 2C)

If measurement is not possible or available, we suggest measurement of the standard thrombin time to allow a qualitative estimation of the presence of dabigatran. (Grade 2C)

If bleeding is life-threatening in those receiving dabigatran, we recommend treatment with idarucizumab

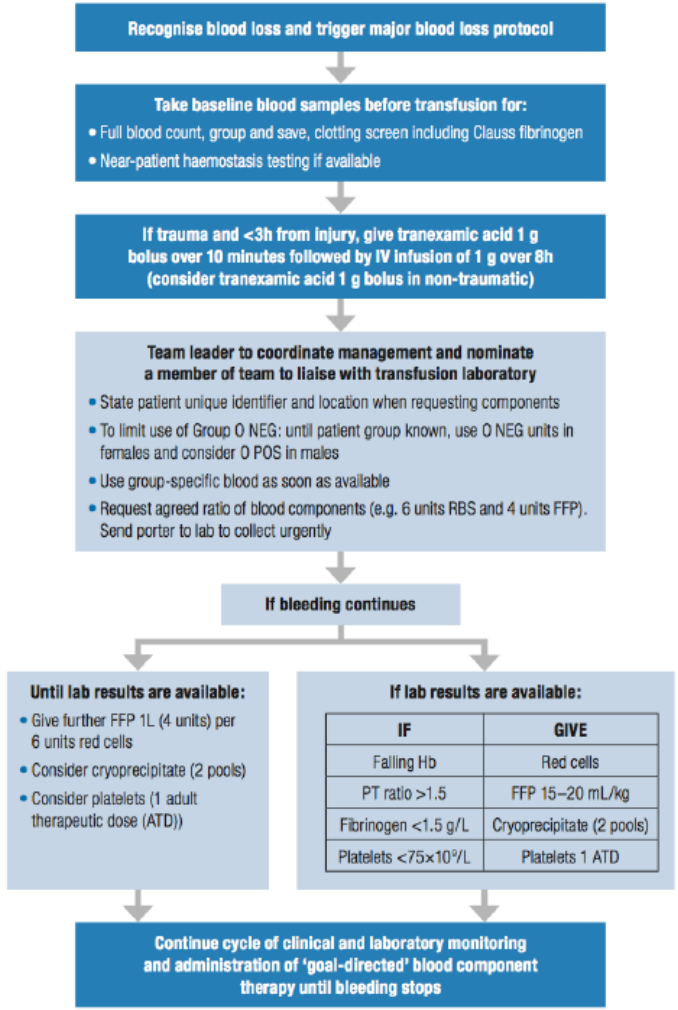
Antiplatelet agents

Recommendation 36 We suggest treatment with platelet concentrates if platelet dysfunction is documented in a patient with continued bleeding who has been treated with APA. (Grade 2C)

We suggest administration of platelets in patients with ICH who have been treated with APA and will undergo surgery. (Grade 2B)

We suggest that the administration of platelets in patients with ICH who have been treated with APA and will not undergo surgical intervention be avoided. (Grade 2B)

We suggest that the administration of desmopressin (0.3 μg/kg) be considered in patients treated with platelet-inhibiting drugs or von Willebrand disease. (Grade 2C)

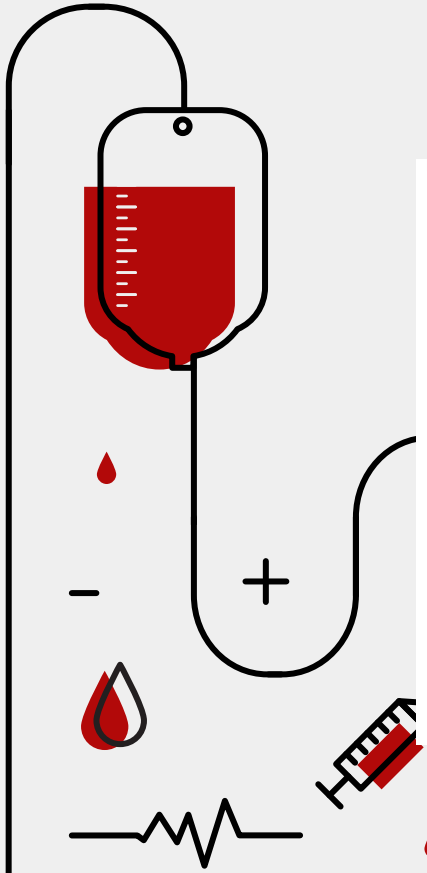


7.3.1: Red cell transfusion in major haemorrhage

Red cell transfusion is usually necessary if 30–40% blood volume is lost, and rapid loss of >40% is immediately life threatening. Peripheral blood haematocrit and Hb concentration may be misleading early after major acute blood loss and the initial diagnosis of major haemorrhage requiring transfusion should be based on clinical criteria and observations (see Figure 7.2).

For immediate transfusion, group O red cells should be issued after samples are taken for blood grouping and crossmatching. Females less than 50 years of age should receive RhD negative red cells to avoid sensitisation. The use of Kell negative red cells is also desirable in this group. Group O red cells must continue to be issued if patient or sample identification is incomplete or until the ABO group is confirmed on a second sample according to local policy (see Chapter 2).

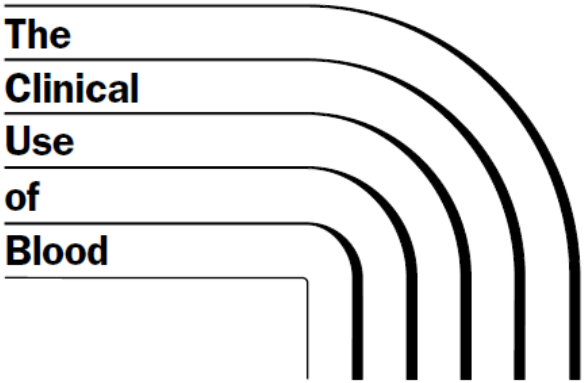
ABO-group-specific red cells can usually be issued within 10 minutes of a sample arriving in the laboratory. Fully crossmatched blood is available in 30 to 40 minutes after a sample is received in the laboratory. Once the volume of blood transfused in any 24 hour period is equivalent to the patient's own blood volume (8–10 units for adults and 80–100 mL/kg in children), ABO and D compatible blood can be issued without the need for a serological crossmatch.



Targets of resuscitation in massive blood loss

- Mean arterial pressure (MAP) around 60 mmHg, systolic arterial pressure 80-100 mmHg (in hypertensive patients one may need to target higher MAP)
- Hb 7-9 g/dl
- INR <1.5; activated PTT <42 s
- Fibrinogen >1.5-2 g/L
- Platelets >50 × 10^9/L
- pH 7.35-7.45
- Core temperature >35.0°C
- Base deficit <3.0/lactates <2 mEq/L.

Ασφάλεια Μαζικής Μετάγγισης



Handbook

World Health Organization.
Blood Transfusion Safety
Team. (2001)

World Health Organization
Blood Transfusion Safety
GENEVA

Red cell compatibility testing

It is essential that all blood is tested before transfusion in order to:

- Ensure that transfused red cells are compatible with antibodies in the recipient's plasma
- Avoid stimulating the production of new red cell antibodies in the recipient, particularly anti-RhD.

All pre-transfusion test procedures should provide the following information about both the units of blood and the patient:

- ABO group
- RhD type
- Presence of red cell antibodies that could cause haemolysis in the recipient.

ABO blood group antigens and antibodies

The ABO blood groups are the most important in clinical transfusion practice. There are four main red cell types: O, A, B and AB.

All healthy normal adults of group A, group B and group O have antibodies in their plasma against the red cell types (antigens) that they have not inherited:

- Group A individuals have antibody to group B
- Group B individuals have antibody to group A
- Group O individuals have antibody to group A *and* group B
- Group AB individuals do not have antibody to group A *or* B.

These antibodies are usually of IgM and IgG class and are normally able to haemolyse (destroy) transfused red cells.

Pre-transfusion testing (compatibility testing)

A direct test of compatibility (crossmatch) is usually performed before blood is infused. This detects a reaction between:

- **Patient's** serum
- **Donor** red cells.

The laboratory performs:

- Patient's ABO and RhD type
- Direct compatibility test or crossmatch.

These procedures normally take about 1 hour to complete. Shortened procedures are possible, but may fail to detect some incompatibilities.

Compatibility problems

1 If the patient's sample has a clinically significant red cell antibody, the laboratory may need more time and may require a further blood sample in order to select compatible blood.

Non-urgent transfusions and surgery that is likely to require transfusion should be delayed until suitable blood is found.

2 If transfusion is needed urgently, the blood bank and the doctor responsible for the patient must balance the risk of delaying for full compatibility testing against the risk of transfusing blood that may not be completely compatible.

Group, antibody screen and hold procedure

1 The patient's ABO and RhD type are determined.

2 The patient's serum is tested for clinically significant red cell antibodies.

3 The patient's serum sample is frozen and stored in the laboratory at –20°C, usually for seven days.

4 If blood is required within this period, the sample is thawed and used to perform an urgent compatibility test.

5 The blood bank should ensure that blood can be provided quickly if it is needed.

Using this method:

- Blood can be issued in 15–30 minutes
- It is unnecessary to hold crossmatched units of blood as an 'insurance' for a patient who is unlikely to need them
- Will reduce the workload and minimize the wastage of blood.

TIME LIMITS FOR INFUSION

	Start infusion	Complete infusion
Whole blood or red cells	Within 30 minutes of removing pack from refrigerator	Within 4 hours (or less in high ambient temperature)
Platelet concentrates	Immediately	Within 20 minutes
Fresh frozen plasma and cryoprecipitate	As soon as possible	Within 20 minutes

Disposable equipment for blood administration

Cannulas for infusing blood products:

- Must be sterile and must **never** be reused
- Use flexible plastic cannulas, if possible, as they are safer and preserve the veins
- A doubling of the diameter of the cannula increases the flow rate of most fluids by a factor of 16.

Whole blood, red cells, plasma and cryoprecipitate

- Use a new, sterile blood administration set containing an integral 170–200 micron filter
- Change the set at least 12-hourly during blood component infusion
- In a very warm climate, change the set more frequently and usually after every four units of blood, if given within a 12-hour period

Warming blood

There is no evidence that warming blood is beneficial to the patient when infusion is slow.

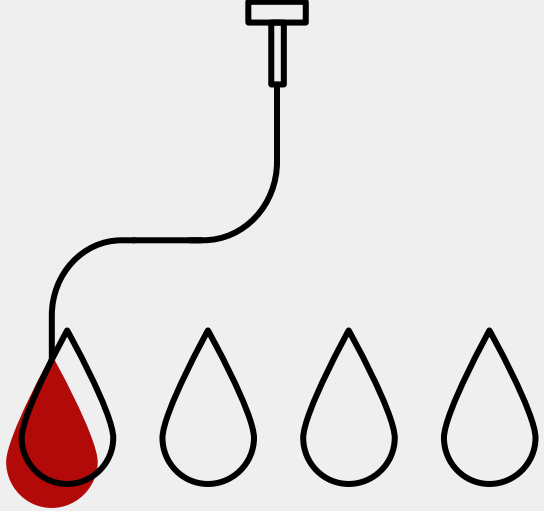
At infusion rates greater than 100 ml/minute, cold blood may be a contributing factor in cardiac arrest. However, keeping the patient warm is probably more important than warming the infused blood.

Warmed blood is most commonly required in:

- Large volume rapid transfusions:
  - Adults: greater than 50 ml/kg/hour
  - Children: greater than 15 ml/kg/hour
- Exchange transfusion in infants
- Patients with clinically significant cold agglutinins.

Blood should only be warmed in a blood warmer. Blood warmers should have a visible thermometer and an audible warning alarm and should be properly maintained. Older types of blood warmer may slow the infusion rate of fluids.

Blood should never be warmed in a bowl of hot water as this could lead to haemolysis of the red cells which could be life-threatening.



Ολικό Αίμα

Low Titer Group O Whole Blood

General Information

Approved Names:

- Low Titer Group O Whole Blood
- Whole Blood
- Heparin Whole Blood
- Whole Blood, antihemophilic factor removed

Commonly Used names:

- Low titer Group O whole blood
- Whole blood
- Leukocytes reduced whole blood
- Leukocytes reduced low titer whole blood
- Leukocytes reduced low titer TRALI mitigated whole blood

Description of Whole Blood Compared to Component Therapy

Currently, in the military care setting, the Armed Services Blood Program (ASBP) sends approximately 200 units of LTOWB weekly to support combat operations [5]. WB is collected in citrate–phosphate dextrose (CPD) storage solution and stored between 1 °C and 6 °C. WB can last up to 21 days in CPD and up to 35 days in citrate–phosphate dextrose-adenine (CPDA) solution. Most centers in the USA limit the use of WB to 14–21 days, and the product does not need to be agitated or frozen. Due to the risk of transfusion related acute lung injury (TRALI), the majority of institutions utilize group O Rhesus (Rh) positive male donors for all males, and females over the age of 50. Group O Rh negative WB is typically reserved for females of child-bearing age. LTOWB is group O WB with low levels of anti-A and anti-B immunoglobulins M (IgM), defined as a titer of less than 1:256. Some centers have a higher threshold for titers; these levels can reach as low as 1:50. These immunoglobulins occur as both IgG and IgM, with IgM being the greatest concern to cause immediate transfusion reaction [3].

Table 1 Whole blood composition compared to component therapy

Component therapy (675 mL)	Whole blood (500 mL)
1 unit of pRBC = 335 mL with hematocrit of 55%	Hematocrit of 38–50%
1 unit of PLTs = 50 mL with 88 K platelets	Platelet count of 150–400 K
1 unit of FFP = 275 mL with 80% coagulation activity	Plasma coagulation factors = 100%
1 unit of cryoprecipitate = 15 mL with 150 mg of fibrinogen	Fibrinogen = 1000 mg
Thus, 1 unit of pRBC + 1 unit of PLTs + 1 unit of FFP + 1 unit of cryoprecipitate = 675 mL with hematocrit of 29%, platelet count of 88 K and coagulation activity of 65% compared with WB	

pRBC packed red blood cells, *PLTs* platelets, *FFP* fresh frozen plasma, *WB* whole blood.

Current Anesthesiology Reports
https://doi.org/10.1007/s40140-021-00514-w

ANESTHESIA FOR TRAUMA (TE GRISSOM, SECTION EDITOR)

Check for updates

The Use of Whole Blood Transfusion in Trauma

Limitations

Despite many of the benefits of the use of LTOWB in trauma, there are some limitations that complicate its use. To begin, initiating a WB program in a blood bank can be very expensive as this cost is added onto the already established CT branch of the hospital's blood bank. For example, at Barnes Jewish Hospital, in association with Washington University School of Medicine in St. Louis, there is an average of 150 MTP activations for Level 1 trauma patients annually. The institution of a WB program for this number of MTP activations added an estimated additional $170,000 USD in costs of blood products annually. This cost addition is on-par with most US centers who have also added WB to their blood bank inventory. Due to uncertain benefits and high cost, many blood banks or hospital administrators may challenge the introduction of LTOWB. This underscores the importance of performing additional high quality Randomized Control Trials (RCTs) to prove the benefit of WB use in major trauma.

Another major challenge for the implementation of a WB program in a major trauma center is the logistical constraints of shipping, handling and cold chain management [14]. The military has overcome many of the challenges of maintaining blood products within tight parameters, especially in austere environments, such as developing progressively smaller and lighter blood storage containers to help medics carry blood products in their aid bags to ensure blood transfusions are available without delay. The military experience is proof that civilian blood bank programs may also surmount the logistical constraints of a WB branch in their blood bank.

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ANESTHESIA FOR TRAUMA (TE GRISSOM, SECTION EDITOR)

The Use of Whole Blood Transfusion in Trauma

In "normal" times, supply/demand issues have always been a point of hardship for blood banks. Since the beginning of the COVID-19 pandemic, blood donations have declined nationally. This has led to significant disruptions in supply of all blood components, including LTOWB. As we learn to navigate this new situation, we hope that the number of blood donations continues to increase and help replenish the LTOWB supply. The other issue with supply is finding the right candidates for LTOWB donations. At the moment, Group O Rh + males are the ideal donors to mitigate the risk of TRALI. This significantly reduces the pool of donors. Another significant limitation is the practice of excluding donors who have had aspirin within 48 h of donation [15]. However, there is currently evidence in the literature [16, 17•] demonstrating that group A plasma can be safely given to patients with unknown blood type without any major risk of complications or increase in mortality. One may hope that this evidence may be extrapolated for the use of other WB blood types in trauma.

The final limitation is the issue of waste. Many US programs only validate LTOWB for 14 days of storage, meaning that there is a significant risk of blood wastage if there is an inability to match supply/demand, or if LTOWB cannot be easily reallocated to other uses, such as in emergency general surgery cases. Some centers are able to take WB on day 15 and centrifuge the unit, salvaging the pRBC's, to be used again by the blood bank, but unfortunately, not all hospitals adopt this measure. There are health systems, however, that have succeeded in implementing LTOWB with minimal waste. One such example is the San Antonio, Texas area, where the use of LTOWB by ground and helicopter EMS, outlying hospitals, and level 1 trauma centers was implemented with less than 1% blood waste [18].

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SYSTEMATIC REVIEW META-ANALYSIS

Trauma

Whole blood transfusion versus component therapy in trauma resuscitation: a systematic review and meta-analysis

The Bottom Line

The use of whole blood instead of balanced component therapy during massive transfusion following trauma has been increasing. This meta-analysis of current studies demonstrates no difference in outcomes when whole blood is used, but it is limited by the small number of existing studies and significant heterogeneity of those studies.

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