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Blood supply in emergency cases: A brief review

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ABSTRACT

Background: Blood transfusion services are a vital and integral part of modern healthcare. The decision to transfuse a patient should be considered on the basis of risks and benefits as well as alternative treatments available to avoid over transfusion or under transfusion and adverse effects that may occur.

Objective: This review aims to determine the role of blood supply in emergency cases. **Methods:** A total of 20 relevant kinds of literature were studied regarding type of blood supply. The data collection for eligible articles were conducted from 2008 to 2018. Different database and manual search methods were used to find the topic-related articles.

Results: Type of blood component transfused in critically ill patients included whole blood (WB), packed red cells (PRC), fresh frozen

plasma (FFP), thrombocyte concentration (TC), and cryoprecipitate. In the pre-transfusion setting, some relevant steps need to be carried out prior to the transfusion process as follows: blood type determination, antibody screen, serologic cross-match, and computer/electronic cross-match. However, the urgent need for transfusion may preclude the performance of usual testing protocol. If blood become an issued in an emergency situation and there is no time for cross-matching, group O Rh-negative packed red cells can be released and the clinician must sign a release authorizing and accepting responsibility for using incompletely tested products.

Conclusion: Group O packed red cells are selected for patients where transfusion cannot be postponed until their ABO and Rh type can be determined with minimal risk for complication.

Keywords: Blood component, emergency case, packed red cells

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INTRODUCTION

Critically ill patients, such as in trauma, surgical, obstetric cases with significant hemorrhage can lead to hemorrhagic shock. Acute hemorrhagic triggers a series of physiologic responses involving multiple organ systems, including cardiovascular, respiratory, renal, hematologic and neuroendocrine systems.¹ Fluid resuscitation and hemostasis achievement are the main priority in a patient with hemorrhagic shock. Based on this issue, the choice of the resuscitation fluid is equally important, there must be maintenance of adequate intravascular volume, oxygen-carrying capacity, clotting function and electrolyte balance and at the same time, minimization of extravascular edema and immune system activation. Although crystalloid administration in the form of normal saline or Ringer's lactate is the immediate means of resuscitation, careful titration of the quantity infused is required to avoid negative consequences of over-infusion. Only about 30% of infused crystalloid remains intravascular. Therefore, the volume required for infusion is about three times from the blood loss.^{1,2} The following sections will try to explore further the role of blood supply in emergency case.

Type of Blood Component Transfused in Critically Ill Patients

The blood transfusion should not only be based on triggering factors but also be coupled with

adequate knowledge of the clinical symptoms, rate, and extent of ongoing blood loss, cardiac function, and the need for operative intervention. The end goal of transfusion is to restore volume and oxygen-carrying capacity.³ The type of component to be transfused depends on assessment of the clinical status of the patient.^{1,3} Several types of blood component will be mentioned below:

1. Whole blood: Whole blood is the unmodified component, drawn from a donor, which consists of erythrocytes, leukocytes, platelets, and plasma proteins with the anticoagulant-preservative solution. The average standard whole blood volume is 450 ± 45 mL of blood collected in a bag containing 63 mL of anticoagulant or 500 ± 50 mL for the larger volume bag containing 70 mL of anticoagulant-preservative. If the collection is planned for less than 300 mL, the volume of anticoagulant-preservative solution should be reduced proportionately. Whole blood is stored in a monitored refrigerator at 1 - 6°C for 21 days if collected in Citrate Phosphate Dextrose (CPD) or for 35 days if collected in Citrate Phosphate Dextrose with Adenine (CPDA-1). The use of whole blood as a resuscitation fluid has become outdated. Whole blood is deficient in clotting factors and has high levels of potassium, ammonia and hydrogen ions. Although

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it provides volume expansion along with increased oxygen carrying capacity, there can be volume overload before the needed components are replenished.^{1,4}

2. **Packed red cells:** Packed red cells (PRC) contain hemoglobin, which transports oxygen through the bloodstream and to the tissues. PRC transfusions increase the mass of circulating red cells in situations where tissue oxygenation may be impaired by acute or chronic blood loss, such as in hemorrhage or anemia. Administration of packed red cells is the most important component of resuscitation, based on the central pathophysiology of hemorrhagic shock is a failure of oxygen delivery. Blood loss greater than 25% to 30% usually requires transfusion of packed red cells in addition to crystalloids.^{1,4}
3. **Fresh frozen plasma (FFP):** FFP contains all the coagulation factors, including the labile factors V and VIII. FFP is utilized for its clotting factor content in trauma resuscitation. In the presence of massive hemorrhage or coagulopathy, 1 unit of FFP is given for every 4 to 5 units of packed red cells administered.¹ Administration of FFP should be guided by serial measurement of prothrombin time (PT), activated partial thromboplastin time (APTT) and fibrinogen levels. A more proactive approach is beneficial in rapid bleeding to prevent the development of coagulopathy.^{4,5}
4. **Platelet concentrate (PC):** Platelets are collected either from whole blood donation or via the apheresis procedure. Platelet concentrates (PC) prepared from a unit of whole blood, contain at least 5.5×10^{10} platelets in 40–70 mL plasma per unit and under optimal conditions, should elevate the platelet count by about 5,000 / μL in a recipient weighing 75 kg. Platelets prepared from whole blood are also referred to as random donor platelets. Pooled platelets usually consist of four to six pooled random donor platelets.¹ Apheresis platelets contain at least 3.0×10^{11} platelet and can be considered an equivalent dose to pooled platelets. The product is also referred to as single-donor platelets. Platelets are stored at room temperature (20–24°C) for up to 5 days with constant gentle agitation. The decision to transfuse platelet concentrate should be based on the etiology of the thrombocytopenia, the presence or absence of active bleeding, and the need for surgical intervention.⁴ The trigger for platelet transfusion administration is also undecided. Generally, when the platelet count is below 10,000/ μL , platelets are

transfused prophylactically to prevent spontaneous hemorrhage. If the patient is bleeding or if invasive intervention is planned and the count is between 10,000/ μL and 50,000/ μL , then platelet transfusion should be given. In such patients, the count should be maintained above 50,000/ μL .^{6,7}

5. **Cryoprecipitate:** Cryoprecipitate, also referred to as cryoprecipitate AHF or cryo, is the cold insoluble precipitate that forms when a unit of FFP is thawed between 1 – 6°C. It contains, in a concentrated form, most of the coagulation factors that are found in FFP. These factors include von Willebrand's factor (vWF), fibrinogen, factor VIII, fibronectin, and factor XII. Once separated from FFP, cryo is refrozen within 1 hour of preparation and stored at –18°C or colder for up to 1 year from the date of phlebotomy. A typical adult dose is 10–15 units of cryoprecipitate (2–3 pools), which in a 70 kg adult will raise the fibrinogen level by 70–80 mg/dL. If FFP is used to supplement massive transfusion, cryoprecipitate may not be required unless fibrinogen level falls to below 100 mg/dl.^{1,4,8}

Pretransfusion Testing

Pretransfusion testing is a multistep process aimed at avoiding potentially fatal hemolytic transfusion reactions. The process begins on the clinical ward with identification of the intended recipient and collection of a properly labeled blood sample. When the sample and requisition are received in the transfusion laboratory, blood bank personnel review the recipient's transfusion history, perform necessary testing.⁹

Historical assessment

The patient's electronic blood bank record is reviewed for previous ABO and RhD type result and the presence of anti-erythrocyte antibodies. Previous ABO and RhD type results are important because discrepancies between previous and current result can signal wrong blood in a tube, misscollection, and prompt recollection of a patient sample.⁹ Historical antibodies are important because although their titers may have decreased to below the threshold of detectability in the current specimen, as a result of clinically significant hemolytic reaction if the recipient is transfused with erythrocytes bearing the corresponding antigen (an anamnestic immune response). Thus, the historical review is a first pass look at the patient's transfusion history and provides some information on the likelihood that the patient will present with clinically significant antibodies.⁹

Blood type determination

Determination of the recipient's ABO type is performed using both forward and reverse testing phases; these two phases of testing produce complementary information that serves to confirm each other result. Forward typing is performed by mixing the recipient's erythrocyte with commercially available anti-A and anti-B sera and observing for agglutination (clumping together of cells indicating antibody has bound to its target on the erythrocytes). The reverse type is performed using the recipient's serum and commercially available group A and B erythrocytes. Agglutination patterns of the forward and reverse types and the compatible erythrocytes for transfusion are depicted in Table 2.⁹

Typing of RhD antigen is performed similarly as the forward type, with commercially available anti-D sera reacting with RhD antigen expressed on recipient erythrocytes. Unlike the ABO blood group, antibodies directed against antigens in the Rh blood group do not occur naturally and are only made in response to a sensitizing exposure such as previous transfusion or pregnancy. Such antibodies are detected by the antibody screen.⁹

Antibody screening

The antibody screening is an antibody detection test in which the recipient's serum is added to a reference panel of commercially available erythrocytes with a known pattern of antigen expression include all clinically significant non-ABO antigens known to cause clinically significant hemolysis. The red cell antibodies, known as alloimmunization, occurs as a result of exposure to erythrocytes antigens during pregnancy or a previous transfusion. When antibody is detected, the blood bank must perform additional testing to identify the specificity of the antibody. The clinically significant antibody that can lead to the premature destruction of transfused erythrocytes makes antigen-negative erythrocytes units must be located.^{9,10}

Serological Crossmatch

Serological crossmatch involves physically mixing donor erythrocytes with recipient's plasma which can be performed in two ways, such as traditional or electronic/computer.¹¹ An immediate spin crossmatch was the traditional method of conforming ABO compatibility between potential donor unit and the recipient's plasma. A more extensive crossmatch involving antihuman globulin (Coombs reagent) used to ensure compatibility between antigen-negative erythrocytes and the serum of recipient with a current or historical non-ABO antibody. Incompatibility in either of these cross

matches indicated by the presence of erythrocyte agglutination or hemolysis. Serologic crossmatching adds approximately 10 minutes to pre-transfusion testing using the immediate spin method, and about 45 minutes to conduct an antihuman globulin crossmatch.⁹

Electronic crossmatch

Electronic crossmatch will recognize an incompatible unit selected for transfusion and will not permit that unit to be issued.¹¹ To be eligible for erythrocyte issuing using the electronic crossmatch, the recipient must determine their ABO and RhD group twice, a negative antibody screen, and no prior record of non-ABO anti-erythrocyte antibodies. Electronic crossmatch technology allows compatible units to be issued in less than 5 minutes because of physically mixing the recipient's plasma with the donor's erythrocytes is not required.¹¹ If any of the requirements mentioned above are not met, the electronic crossmatch cannot be used, and serologic crossmatching is necessarily important. The main advantage of electronic crossmatch is that erythrocytes can be issued in minutes. This can lead to a reduction in the cost associated with laboratory testing, in the number of units ordered but not transfused, and in improved blood inventory management crossmatch.⁹

Emergency Transfusion

During emergency transfusions, it is very important to decide early on how to use blood components where the benefits outweigh the inherent risks. In an emergency situation, clinicians administer blood components, usually packed red cells units, before the completion of standard compatibility testing, and in some cases, before infectious diseases testing. In emergent transfusions, smaller volumes are required more quickly.¹² In this setting, potentially electronic crossmatch may be performed if there is a valid type and antibody screen on file with no alloantibodies noted historically. More often, these units are uncrossmatched at the time of issue (to be crossmatched later when time allows it), and the risk of death/serious harm to the patient outweighs the risk of adverse reactions.^{9,12}

With the emergency release, the risk of alloimmunization has been reported to be 3% (with crossmatch this risk is 1%), the risk of incompatibility is 0.3% (0.001% with crossmatching), and the risk of hemolytic reaction is 0.02%. Transfusion of uncrossmatched blood has been reported having 10.9% positive screens with alloantibodies of which 6.5% were clinically significant. A study conducted by Mulay et al. found a minimal risk associated with

Table 1 Forward and reverse type agglutination patterns of recipient blood types in ABO antigen system⁹

Recipient Type	Forward		Reverse		Compatible donors
	anti-A	anti-B	A cells	B cells	
A	+	-	-	+	A, O
B	-	+	+	-	B, O
AB	+	+	-	-	AB, A, B, O
O	-	-	+	+	O

Table 2 The policy concerning the use of packed red cells in D-negative patients¹⁴**Indications for mandatory use of D-negative packed red cells**

1. D-negative patients with an anti-D antibody
2. D-negative females of childbearing age, newborns and children
3. In emergency: females of childbearing age, newborns, and children of unknown Rh group

Indications for recommended use of D-negative packed red cells

1. D-negative patients who may need multiple transfusions (Myelodysplastic syndrome/MDS, aplasia, thalassemia, etc.)

Indication for acceptable use of D-positive packed red cells

1. Massive transfusion (replacement of at least one blood volume within 24 hours, e.g., more than 8 units of packed red cells) in females of non-childbearing age or adult men (>35 years) with no detectable anti-D antibody.
2. Females of nonchildbearing age or adults men in the case of insufficient D-negative packed red cells in stock

Table 3 Massive Transfusion Protocol (MTP)²⁰

Steps	Transfusion Strategy
Initial	
Draw type and crossmatch	2 units group O packed red cells uncross-matched
Maintenance	
Prepare massive transfusion protocol pack by transfusion service	4 to 6 type-specific or crossmatched packed red cells 4 plasma 1 platelet pool or plateletpheresis
Monitor CBC, platelet count, PT/INR, APTT, fibrinogen	Add or subtract components based on lab values
Provide additional MTP packs	Continue transfusion until unneeded

the release of emergency uncrossmatched blood in the setting of an acutely bleeding patient.^{2,13}

The urgency clinical assessment of packed red cells transfusion will determine whether the patient receives unmatched emergency type O packed red cells, group-specific packed red cells or a fully cross-matched packed red cells unit.^{4,9}

In order of preference, red cell products will be issued as:

1. Crossmatch compatible (all pretransfusion testing completely satisfactorily),

2. Crossmatch incomplete (in the presence of an antibody, crossmatch compatible unit),
3. Group-specific unmatched (testing for ABO/Rh complete on a current specimen, antibody detection tests incomplete),
4. Emergency unmatched (ABO/Rh and antibody status of the patient undetermined from a current specimen: group O packed red cells issued).

In all cases, a pretransfusion sample of appropriately identified and labeled blood should be obtained from the patient and delivered to the blood bank for typing and initiation of compatibility testing. Recent transfusion history is highly desirable. Risks of potentially fatal ABO transfusion errors are high in the urgent clinical situation.⁴ Patient identification procedures in this setting must accompany particular care and attention. After the specimen in the blood bank, ABO and D phenotyping test need to be carried out so that blood can be issued. The recipient's records should also be consulted to provide a check on the ABO and D phenotype and to know any antibodies that might present in the recipient.⁴

Urgent need for transfusion may preclude performance of the usual testing protocol. Adequate pretransfusion samples should be collected before infusion of blood component so that compatibility testing, antibody screening and if necessary identification studies can be performed subsequently. If blood must be issued and there is no time for cross-matching in an emergency, group-specific blood can be issued. In extreme emergencies, when there is no time to obtain and test a sample, group O packed red cells or group AB plasma can be released. Type O, D-positive packed red cells can be transfused to males or elderly patients who have no prior history of transfusion with D-positive blood Group O (do not have anti-D antibodies), and women older than childbearing age. Type O, D-negative packed red cells should be reserved for females of child-bearing age, newborns and children, and others suspected or known to be alloimmunized D antigen. In the case of the D-negative female of childbearing age, it is preferable to use D-negative blood to the extent possible, but one must use D-positive blood if there is ongoing life-threatening bleeding and the D-negative inventory has been depleted. A study conducted by Gonzales-Porras et al. found that the use of D-positive packed red cells in selected D-negative patients did not induce adverse reactions and allows the saving of a significant number of D-negative packed red cells.^{4,14,15}

In addition, Balvers et al. recommended AB plasma as a universal donor plasma product initially when the blood group is unknown and

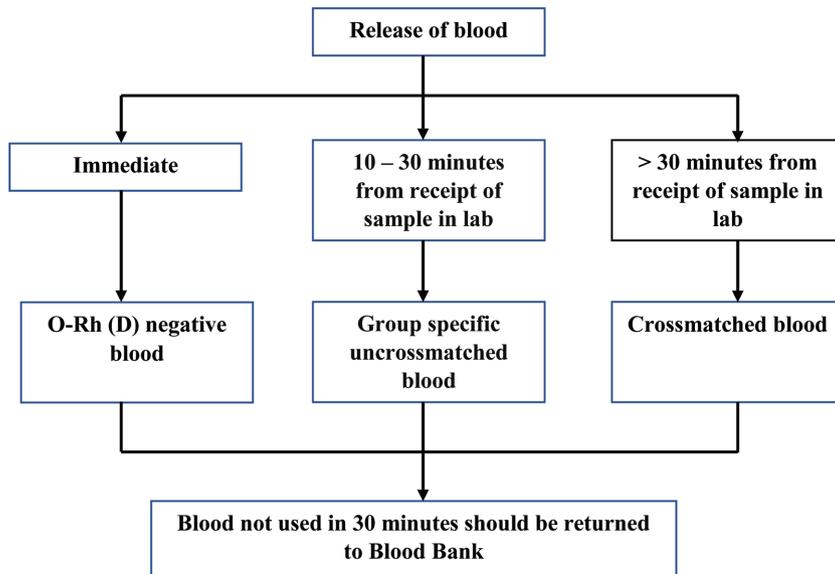


Figure 1 The blood release in an emergency situation⁴

switch to ABO-identical plasma once the blood group has determined. If AB plasma is not available, A plasma transfusion seems to be safe and preferably instead of using B or O plasma due to A plasma does not increase the incidence of transfusion-related complications and is more common than B plasma. Another study also proposes that group A plasma may be an alternative to AB plasma as the first option in the emergency release setting. O plasma is unsuitable due to carries both anti-A and anti-B. It is also a recommended policy to transfuse plasma derived from male donors only as transfusion of plasma from HLA antibody-positive female donors is associated with an increased risk for transfusion-related acute lung injury.^{16,17}

In such a situation, the clinician must sign a release authorizing and accepting responsibility for the use of incompletely tested products as a life-saving measure. All packed red cells issued before completion of pretransfusion testing will be dispensed as “unmatched.” The transfusion tag attached to the unit will indicate that the unit is unmatched (compatibility or infectious disease testing was not completed at the time of issue).⁴ Detailed records should be completed in the emergency release of blood products. These records must include the patient’s full name, unique identifiers, ABO and D phenotype, list of all issued units, name of the person who issued them, as well as the physician who requested the emergency release of blood.⁴

Figure 1 showed that the expected turn-around time for unmatched (O, Rh-D negative) is 10 minutes from the receipt of the request to the issue of the product. The expected turn around time for group-specific packed red cells is 30 minutes from the time of specimen receipt to issue of the

component. An emergency blood transfusion form must be completed and placed on the patient’s chart when unmatched units are transfused.¹⁸ During the acute emergency, the blood bank personnel should stay ahead by crossmatching additional packed red cells units, preparing platelet concentrates, and thawing cryoprecipitate and frozen plasma in anticipation of need by (and in consultation with) the team caring for the patient. If a positive reaction is noted, the patient’s physician must be advised of the problem.¹⁹

Further transfusion should be delayed, if possible until the problem is identified and safe units can be provided. If the patient dies as a result of the emergency, remaining compatibility testing may be waived or abbreviated at the discretion of the transfusion service physician. Testing should be complete enough to show that the death was unrelated to the transfusion of uncross-matched blood.⁴

In the setting of an emergency transfusion that is initiated with emergency supply type O packed red cells (PRC), a switch to ABO group-specific PRC should happen as soon as the patient’s blood type is determined and confirmed, regardless of the number of type O units the patients have received.^{1,4}

Massive Transfusion

A study conducted by Nunez et al. found that emergency transfusion of uncross-matched RBCs should be considered a potential trigger for activation of massive transfusion protocol. Massive transfusion has been variously defined as replacement of a patient’s entire blood volume in 24 hours, replacement of 50% of the patient’s blood volume in 3 hours, 10 or more packed red cells units per 70-kg adult per 24 hours, or administration of 4 or more packed red cells units in 4 hours with ongoing need for more blood. Analysis of the patient’s clinical status and laboratory tests is essential for guiding appropriate transfusion therapy. The massive transfusion pack can be adjusted for low hemoglobin or platelets or prolonged coagulation tests. Platelets are required if the platelet count is less than 50,000/ μ L, and plasma is needed if the PT ratio is greater than 1.5, or the INR is greater than 1.5, or the APTT exceeds 60 seconds. Fibrinogen levels should also be monitored because replacement by cryoprecipitate may be indicated when the fibrinogen level is less than 100 mg/dL.¹⁸⁻²⁰

Rapid administration of large volumes of RBCs combined with loss due to bleeding often results in dilutional thrombocytopenia coupled with consumptive coagulopathy. Most patients require a combination of packed red cells, platelet concentrate, cryoprecipitate, and plasma. Some facilities use a 1:1:1 fixed volume ratio of packed red cells to single donor platelet and plasma.²⁰

CONCLUSION

Group O packed red cells (PRC) are selected for whom transfusion cannot be postponed until their ABO and Rh type determined in the emergency case. Group O D-negative PRC units should be used if the patient is a female of childbearing potential. An RhD-negative male patient or an older female patient can be switched from D-negative to D-positive PRC if the group O D-negative units are available or massive transfusion is required. Delaying blood transfusion in emergency situations may be more dangerous than the small risk of transfusing incompatible blood prior to the antibody screen, and crossmatch are completed.

CONFLICT OF INTEREST

Author declares there is no conflict of interest regarding all aspect of the study.

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