Transfusion Therapy in Critically Ill Children

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CRITICALLY ILL CHILDREN IN PEDIATRIC INTENSIVE CARE UNITS ARE COMMONLY INDICATED FOR BLOOD TRANSFUSION DUE TO MANY REASONS. CHILDREN ARE QUITE DIFFERENT FROM ADULTS DURING GROWTH AND DEVELOPMENT, AND THAT SHOULD BE TAKEN INTO CONSIDERATION. IT IS VERY DIFFICULT TO ESTABLISH A UNIVERSAL TRANSFUSION GUIDELINE FOR CRITICALLY ILL CHILDREN, ESPECIALLY PRETERM NEONATES. TREATING UNDERLYING DISEASE AND TARGETED REPLACEMENT THERAPY ARE THE MOST EFFECTIVE APPROACHES. RED BLOOD CELLS ARE THE FIRST CHOICE FOR REPLACEMENT THERAPY IN DECOMPENSATED ANEMIC PATIENTS. THE CRITICAL HEMOGLOBIN CONCENTRATION MAY BE HIGHER IN CRITICALLY ILL CHILDREN FOR MANY REASONS. WHOLE BLOOD IS USED ONLY IN THE FOLLOWING CONDITIONS OR DISEASES: (1) EXCHANGE TRANSFUSION; (2) AFTER CARDIOPULMONARY BYPASS; (3) EXTRACORPOREAL MEMBRANE OXYGENATION; (4) MASSIVE TRANSFUSION, ESPECIALLY IN MULTIPLE COMPONENT DEFICIENCY. THE CHARACTERISTICS OF HEMORRHAGIC DISEASES ARE SO VARIED THAT THEIR TREATMENT SHOULD DEPEND ON THE SPECIFIC NEEDS ASSOCIATED WITH THE UNDERLYING DISEASE. IN GENERAL, PLATELET TRANSFUSION IS NOT NECESSARY WHEN A PATIENT HAS PLATELET COUNT GREATER THAN 10,000/μL AND IS WITHOUT ACTIVE BLEEDING, PLATELET FUNCTIONAL DEFICIENCY OR OTHER RISK FACTORS SUCH AS SEPSIS. PATIENTS WITH RISK FACTORS OR AGE LESS THAN 4 MONTHS SHOULD BE GIVEN SPECIAL CONSIDERATION, AND THE CRITICAL THROMBOCYTE LEVEL WILL BE RAISED. PLATELET TRANSFUSION IS NOT RECOMMENDED IN PATIENTS WITH IMMUNE-MEDIATED THROMBOCYTOPENIA OR THROMBOCYTOPENIA DUE TO ACCELERATION OF PLATELET DESTRUCTION WITHOUT ACTIVE BLEEDING OR LIFE-THREATENING HEMORRHAGE. THERE ARE MANY KINDS OF PLASMA-DERIVED PRODUCTS, AND RECOMBINANT FACTORS ARE COMMONLY USED FOR HEMORRHAGIC PATIENTS DUE TO COAGULATION FACTOR DEFICIENCY DEPENDING ON THE CHARACTERISTICS OF THE DISEASES. THE MOST EFFECTIVE WAY TO CORRECT DISSEMINATED INTRAVASCULAR COAGULATION (DIC) IS TO TREAT THE UNDERLYING DISEASE. ANTICOAGULANT THERAPY IS VERY IMPORTANT; HEPARIN IS THE MOST COMMON AGENT USED FOR DIC BUT THE RESULTS ARE USUALLY NOT SATISFACTORY. ANTITHROMBIN III, PROTEIN C, OR RECOMBINANT THROMBO MODULIN HAS BEEN USED SUCCESSFULLY TO TREAT THIS CONDITION. FOR REDUCING THE RISK OF ORGANISM TRANSMISSION AND ADVERSE REACTIONS RESULTING FROM BLOOD TRANSFUSION, THE FOLLOWING MEASURES HAVE BEEN SUGGESTED: (1) REPLACEMENT THERAPY USING PRODUCTS OTHER THAN BLOOD (E.G., ERYTHROPOIETIN, IRON PREPARATION, GRANULOCYTE COLONY-STIMULATING FACTOR); (2) SPECIAL COMPONENT REPLACEMENT THERAPY FOR SPECIFIC DISEASES; (3) AUTOTRANSFUSION; (4) SUBDIVIDING WHOLE PACKED BLOOD PRODUCTS INTO SMALLER VOLUMES TO REDUCE DONOR EXPOSURE; (5) ADVANCES IN VIRUS-INACTIVATING PROCEDURES. TO AVOID TRANSMISSION, VAPOR-HEATED OR PASTEURIZED PRODUCTS AND GENETIC RECOMBINANT PRODUCTS ARE RECOMMENDED. CYTOMEGALOVIRUS (CMV)-SERONEGATIVE BLOOD, LEUKOREDUCTED AND/OR IRRADIATED BLOOD ARE RECOMMENDED FOR PREVENTION OF CMV INFECTION, GRAFT-VERSUS-HOST-DISEASE AND ALLOIMMUNIZATION IN NEONATE AND IMMUNOCOMPROMISED PATIENT TRANSFUSION. THERE IS NO REASON TO PRESCRIBE A PLASMA PRODUCT FOR NUTRITIONAL SUPPLEMENTATION BECAUSE OF THE RISK OF COMPLICATIONS. THE PRINCIPLE: COMPLICATIONS OF TRANSFUSION MUST BE AVOIDED, THE RATE OF BLOOD EXPOSURE SHOULD BE REDUCED AND THE SAFETY OF THE TRANSFUSED AGENTS OR COMPONENTS SHOULD BE MAINTAINED MUST ALWAYS BE KEPT IN MIND.

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1. Introduction

Critically ill children in the pediatric intensive care unit (PICU) may be commonly indicated for blood product transfusion for the following purposes: (1) maintenance of the hemoglobin (Hb) level and oxygen-carrying capacity; (2) restoration of blood volume and cardiovascular function; (3) for normal hemostatic function. Children are quite different from adults during growth and development, and that should be taken into different consideration.1–5

Common diseases or conditions that may be indication for transfusion therapy are shown in Table 1.5

<table>
<thead>
<tr>
<th>Common diseases with hematology/oncology problems needing transfusion in the PICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancer: various, especially under chemotherapy or irradiation, e.g., leukemia, lymphoma etc.</td>
</tr>
<tr>
<td>Diseases due to thrombocyte dysfunction or deficiency, e.g., idiopathic thrombocytopenic purpura with active bleeding, or for procedure, aplastic anemia, thrombasthenia, malignancies, etc.</td>
</tr>
<tr>
<td>Anemic diseases due to various underlying disorders</td>
</tr>
<tr>
<td>Congenital or acquired coagulopathies, e.g., hemophilia, liver failure, disseminated intravascular coagulation, etc.</td>
</tr>
<tr>
<td>Systemic infectious diseases with disseminated intravascular coagulation or hematological problems</td>
</tr>
<tr>
<td>Collagen diseases manifesting with thrombocytopenia and/or vasculitis, e.g., systemic lupus erythematosus, juvenile rheumatoid arthritis/rheumatoid arthritis, etc.</td>
</tr>
<tr>
<td>Cardiovascular diseases under antithrombotic and/or anticoagulation therapy</td>
</tr>
<tr>
<td>Vasculitis due to various underlying diseases with hematological complications, e.g., in Henoch-Schonlein purpura, systemic lupus erythematosus, etc.</td>
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</table>

2. Treatment for anemia or volume deficit patients

2.1. General consideration in the transfusion of red blood cell products

Anemia, defined as Hb concentration below the age-matched normal range, occurred in 36.7% of critically ill children in a multidisciplinary PICU.2

The anemia resulted in 15% of critically ill children receiving a transfusion during their PICU stay. The most important consequence related to anemia is the reduction in oxygen delivery. Anemia can decrease oxygen-carrying capacity significantly. The process adaptive to acute anemia include: (1) increased extraction of available oxygen; (2) increased heart rate, stroke volume, and cardiac output; (3) a redistribution of blood flow from non-vital organs toward the heart and brain, at the expense of the splanchnic vascular bed; (4) a shift to the right of the oxyhemoglobin-dissociation curve; and (5) enhanced erythropoietin (EPO) production and release.2

A number of diseases and hosts may impair these adaptive mechanisms, especially in critical ill children. Red blood cells (RBC) are the first choice for replacement therapy in decompensated anemic patients. The cardiovascular physiology and its response to anemia and the disease process are different in children compared with adults. RBC transfusion should be given more stringently in children than adults because of the lower Hb level. In children without cardiopulmonary disease before surgery, maintaining Hb level higher than 8 g/dL may not be necessary because of their higher compensation ability.13

Factors other than Hb concentration that should be considered in deciding whether to transfuse RBCs...
include: (1) the patient’s symptoms, signs, and functional capacities; (2) the presence or absence of cardiorespiratory and central nervous diseases; (3) the cause and anticipated course of the disease; (4) alternative treatments such as recombinant EPO.\textsuperscript{13} There is a great debate about what the lowest Hb level and critical oxygen delivery are under which oxygen consumption is in jeopardy. Optimal and safe lower limits of transfusion threshold have not been established for critically ill children and newborns/infants. There is no consensus on the Hb concentration that should prompt a physician to prescribe RBC transfusion to critically ill patients. Unanimous guidelines for blood transfusion in critically ill children and premature infants are also not available. Suggested transfusion thresholds from major textbooks range from 4.0 to 16.0 g/dL for different underlying conditions in critical ill children.\textsuperscript{2,3,5,7,13} Despite the limited clinical evidence, there are many guidelines that address transfusion practice in critically ill children. They are based largely upon expert opinion, common practice, and evidence extrapolated from the adult literature, rather than high-quality clinical trials conducted in children. The general guidelines for pediatric RBC transfusion are shown in Table 3.\textsuperscript{1,2,5,13} The ultimate criterion establishing the need for transfusion is evidence of impaired tissue oxygenation. The critical Hb concentration may be higher in critically ill children for many reasons, which include: (1) basic metabolic requirement is

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Products & Contents & Volume & Application \\
\hline
Packed RBC\textsuperscript{†} & RBC 100 mL  \\
 & Plasma 40 mL  \\
 & Stable factors 40 U  \\
 & 150 mL  \\
 & Anemia without volume deficit  \\
\hline
Leukoreduced RBC & RBC 90 mL  \\
 & WBC < 5 x 10\textsuperscript{6}  \\
 & 120 mL  \\
 & Anemic patients allergic to leukocyte or plasma protein; long-term transfused patients  \\
\hline
Washed RBC & RBC 90 mL  \\
 & WBC < 5 x 10\textsuperscript{8}  \\
 & (leukocytes, no function)  \\
 & 130 mL  \\
 & Anemic patients allergic to leukocyte or plasma protein  \\
\hline
Frozen RBC & RBC 90 mL  \\
 & 130 mL  \\
 & Anemic patients allergic to leukocyte or plasma protein; rare blood type  \\
\hline
Whole blood\textsuperscript{†} & RBC 100 mL  \\
 & Plasma 150 mL  \\
 & Stable factors 120 U  \\
 & 285 mL  \\
 & Patients with RBC and volume deficit  \\
\hline
Fresh blood\textsuperscript{†} (storage < 3 d) & RBC 100 mL  \\
 & Plasma 150 mL  \\
 & Stable factors 120 U  \\
 & 285 mL  \\
 & Newborn/infant/very sick patients with RBC and volume deficit; BET  \\
\hline
Stored frozen plasma, cryopreserved beyond 8 hr after collection & Plasma 120 mL  \\
 & Stable factors 90 U  \\
 & Factors V, VIII and platelets deficit  \\
 & 120 mL  \\
 & Volume expander or stable factors (II, VII, IX, X) replacement  \\
\hline
Fresh frozen plasma, cryopreserved within 4 hr after collection & Plasma 120 mL  \\
 & All factors 90 U  \\
 & Without platelets  \\
 & 135 mL  \\
 & Factor replacement  \\
\hline
Cryoprecipitates & Fibrinogen 125 mg  \\
 & Factors VIII & XIII > 45 U  \\
 & Frinolecetin & vWF 20–30U  \\
 & 20 mL  \\
 & Factors VIII, XIII and vWF replacement therapy  \\
\hline
Platelet concentrates & Platelets about 2–3 x 10\textsuperscript{10}  \\
 & 35 mL  \\
 & Platelet deficiency or dysfunction  \\
\hline
Granulocyte concentrates & Granulocytes 1 x 10\textsuperscript{9}  \\
 & 25 mL  \\
 & Septic patients with neutropenia unresponsive to antibiotic treatment  \\
\hline
\end{tabular}
\caption{Classification of RBC products\textsuperscript{*} and their uses}
\end{table}

\textsuperscript{*}Products from 250mL whole blood (1 U in Taiwan); \textsuperscript{†}leukocytes/platelets present but of no use for transfusion.
higher; (2) stress experienced by critically ill children and their diseases frequently increase oxygen consumption; (3) critical threshold is shifted to the right in critically ill children. In general, blood transfusion within the first week of life is recommended when hematocrit is below 40% in infants with respiratory distress and below 30% in infants without respiratory distress. A suggested volume of transfused blood of 10–15 mL/kg in 82.6% of PICU responders has been postulated by the European Study Group. For avoidance of overloading, unnecessary component exposure and their complications, whole blood is used only in the following conditions or diseases: (1) exchange transfusion; (2) after cardiopulmonary bypass; (3) extracorporeal membrane oxygenation; (4) massive transfusion, especially in multiple component deficiency.

### 2.2. Special consideration in neonatology and special conditions

Special consideration should always be given to neonates, stem cell transplantation candidates and immunocompromised patients as transfusion may cause very serious complications. For example, graft-versus-host disease (GVHD) and transfusion-transmitted infectious diseases such as cytomegalovirus (CMV) infection are very common in these patients. The condition of a neonate is vastly different from that of adults and older children. The characteristics of the neonate hematological system in transfusion therapy are listed in Table 4.

The EPO response to decreased oxygen availability diminishes in preterm infants compared to anemic patients. The more immature the infant, the lower his EPO level and the response to anemia occurs. EPO therapy for these patients has been suggested. The increased incidence of retrolental fibroplasias and necrotizing enterocolitis in transfusion for neonates should be kept in mind in every transfusion procedure. Replacement of a large amount of blood by transfusion will lead to a right shift in the oxygen dissociation curve. This enhances oxygen delivery to the tissue and increases the risk of retrolental fibroplasias. Necrotizing enterocolitis is usually found after RBC transfusion in critically ill infants due to splanchnic vascular bed ischemia. The more blood is transfused, the more complications occur. Efforts to avoid blood transfusion and to reduce the exposure to blood in critically ill children by subdividing a whole pack of RBCs into halves or smaller volumes may be an effective measure to reduce donor exposure.

Blood loss due to diagnostic sampling has been described as the most common cause of anemia in hospitalized infants and intensifies “non-physiological” anemia in the premature infant in whom 10 mL of blood may represent more than 10% of the total blood volume. In a 2-day period, 10–15% of the infant’s blood volume may be removed. Obladen et al mentioned the study results of Nexø et al (1981) that 1–13 samples were collected from each infant per day, and the average blood loss within 4 weeks was 7–51 mL/kg and 25% of the collected blood volume exceeded the amount necessary for the laboratory. Twice as much blood was collected from critically ill patients than from “healthy” preterm infants. Madsen et al postulated that the mean blood loss and transfusion volume were 13.6 mL/kg and 6.3 mL/kg, respectively, in extremely low gestational age and in critically ill infants during the first week. Everyone involved in ordering or collecting blood from preterm infants should be aware of the fact that sampling is a painful and risky procedure in neonatal practice. Blood testing should be restricted to the minimum required for proper clinical management of the preterm infant. Leukoreduced and/or irradiated blood products are preferred for

### Table 3 Guideline for RBC transfusion in pediatric field

<table>
<thead>
<tr>
<th>Children and adolescents</th>
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<tbody>
<tr>
<td>Acute blood loss &gt; 25% of circulating blood volume</td>
<td></td>
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<tr>
<td>Hb &lt; 8 g/dL in perioperative period</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 8 g/dL and symptomatic chronic disease</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 8 g/dL and severe cardiopulmonary disease</td>
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</table>

<table>
<thead>
<tr>
<th>Infants within first 4 months of life</th>
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</thead>
<tbody>
<tr>
<td>Hb &lt; 8 g/dL and symptomatic anemia</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 10 g/dL and major surgery</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 10 g/dL and moderate pulmonary disease</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 13 g/dL and severe pulmonary disease</td>
<td></td>
</tr>
<tr>
<td>Hb &lt; 13 g/dL and severe cardiac disease</td>
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### Table 4 Characteristics of hematological system in neonate

<table>
<thead>
<tr>
<th>Characteristics of hematological system in neonate</th>
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</tr>
</thead>
<tbody>
<tr>
<td>It is adapted to low intrauterine oxygen tension</td>
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<tr>
<td>Deficiency in hemostatic components and their function</td>
<td></td>
</tr>
<tr>
<td>Antibodies identified in the newborn infant’s serum</td>
<td></td>
</tr>
<tr>
<td>Immunocompromised state</td>
<td></td>
</tr>
<tr>
<td>Serial blood sampling is usually a risk leading to anemia</td>
<td></td>
</tr>
<tr>
<td>More susceptible to citrate intoxication and heparin-induced hemorrhage</td>
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</tr>
<tr>
<td>Efforts to reduce the number and volume of blood transfusions and donor exposure should always be kept in mind</td>
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neonates/infants, especially preterms, transplantation candidates and immunocompromised patients for avoiding GVHD and viral infection.\textsuperscript{2,5,19,20}

The choice of blood products for exchange transfusion (BET), red cell transfusion in neonates or infants less than 4 months of age and stem cell transplantation are very important issues. Blood for exchange transfusion should be as fresh as possible. When choosing blood products in BET for Rh-incompatible hemolytic disease of the newborn, Rh-negative blood should be insisted on, and both the ABO blood type of the mother and compatibility with the mother’s serum should be taken into consideration (Table 5).\textsuperscript{8,19} The donor blood used in Rh-incompatibility obtained before delivery should be Rh-negative and O type with low anti-A and anti-B titer and compatible with the mother’s serum in indirect cross-matching test. After delivery, blood should be obtained from Rh-negative donor whose cells are compatible with both the infant’s and the mother’s serum; when possible, type O donor cells are usually used, but cells of the infant’s ABO type may be used when the mother has the same type. A complete cross match should be performed before the second or subsequent transfusion.\textsuperscript{19} In ABO incompatibility, O type RBCs and AB type plasma suspension was preferred and most commonly used.\textsuperscript{8} Though the incidence of hemolytic disease of the newborn caused by anti-D is much less in our country than in the West, the same conditions resulting from anti-E, anti-c, or anti-Mi\textsuperscript{a} are also important issues.\textsuperscript{8,9} Transfusion for stem cell transplantation candidates is also a very special and important issue, and the choices of blood are listed in Table 6.

\section*{3. Hemostatic transfusion therapy}

The diseases commonly leading to hemorrhagic condition are: (1) diseases causing thrombocytopenia; (2) diseases due to thrombocyte dysfunction; (3) disorders due to coagulation factor deficiency; (4) disseminated intravascular coagulation (DIC); (5) vasculitis; (6) trauma. The characteristics of these diseases are so varied that their therapy should depend on the specific needs associated with the underlying diseases. The blood products indicated for certain diseases are shown in Table 2. The principle treatment modalities are discussed separately below.
3.1. Thrombocyte transfusion

Thrombocytopenia is the most common hematological abnormality in critically ill patients with various underlying diseases (e.g., malignancies, idiopathic thrombocytopenic purpura, aplastic anemia, DIC) and in patients in the neonatal ICU (NICU). Roughly one quarter of all NICU patients and half of all sick preterm neonates and most hematology/oncology patients and septic patients develop thrombocytopenia. In neonates, early-onset thrombocytopenia (<72 hours) is most commonly associated with fetomaternal conditions complicated by placental insufficiency and/or hypoxia. The resulting neonatal thrombocytopenia is usually mild to moderate, may resolve spontaneously, and requires no specific therapy. Deviation from this pattern of thrombocytopenia suggests the presence of more significant precipitating conditions. The most important of these are immune thrombocytopenia, and every NICU should develop investigation and treatment protocols to manage these cases promptly and avoid unnecessary risk of hemorrhage. In contrast, late-onset thrombocytopenia (>72 hours) is almost always associated with sepsis or necrotizing enterocolitis, and the associated thrombocytopenia is severe, prolonged and often requires treatment with platelet transfusion.

The products of platelet concentrates include random donor platelet concentrates, single-donor platelet concentrates, human leukocyte antigen-matched single-donor platelet concentrates, and leukoreduced or post-irradiated platelets; all are processed by different procedures and have their different characteristics and indications. In general, there is no need for platelet transfusion when a patient’s platelet count is higher than 10,000/mm³ and there is no active bleeding, platelet functional deficiency or other risk factors such as sepsis. There are many conditions under which the transfusion threshold of platelet transfusion should be raised. Generally, the factors of platelet count, function, clinical condition and age should be taken into consideration in the treatment guidelines for platelet transfusion (Tables 7 and 8). The more critically ill the patient, the more platelets transfused. The critical threshold in patients younger than 4 months old will be higher than that in older children (Table 7). There are many conditions that need platelet transfusion even if the platelet count is normal (Table 8), but platelet transfusion in patients with qualitative deficiency will be justified only if significant bleeding has occurred or before an invasive procedure. To avoid alloimmunization,
thrombocyte transfusion should not be performed in patients with immune-mediated thrombocytopenia or thrombocytopenia due to acceleration of platelet destruction unless one of the following conditions are present: (1) active bleeding state or life-threatening hemorrhage; (2) plan to perform an invasive procedure.5

3.2. Hemostatic therapy due to coagulation factor deficiency or DIC

There are many clinical states resulting from congenital or acquired disorders that can cause critical bleeding events due to impairment of coagulation activity or thromboembolic events due to hemostatic unbalance. The most common disorders encountered are sepsis, malignancies, congenital or acquired coagulopathies, huge-amount stored blood transfusion and BET.13 Plasma-derived products such as fresh frozen plasma (FFP; which contains almost 80% of the original level of all coagulation factors), cryoprecipitates (rich in fibrinogen and factors VIII and XIII), factor concentrates, and recombinant factors are commonly used for the hemorrhagic diseases due to coagulation deficiency, depending on the characteristics of the diseases. FFP is only transfused to replace the deficiency of plasma hemostatic proteins when purified or recombinant factor concentrates are not available. In selected situations, FFP may be appropriate to use in the replacement therapy of patients with antithrombin III, protein C, or protein S deficiency.1,13 To avoid viral transmission, vapor-heated or pasteurized products and genetic recombinant products are recommended.1 CMV-seronegative bloods, leukoreduced and/or irradiated blood are recommended for the prevention of CMV infection, GVHD and alloimmunization in transfusion in neonates and immunocompromised patients (Table 9).1,20 If the clinical manifestations resulting from alloimmunization frequently occur, washed blood products with the allergens removed should be prescribed. There is no reason to prescribe a plasma product to a patient and adolescents with neutrophil count <0.5×10^9/L or qualitative defect whose bacterial and/or fungal infection is unresponsive to appropriate antimicrobial therapy; (B) infants within the first week of life with neutrophils <3×10^9/L or thereafter with neutrophils <1×10^9/L who suffer from fulminant bacterial infection; (C) infected patients with sustained bone marrow failure unresponsive to appropriate antimicrobial therapy.13,28,29 Because of the risk of GVHD, CMV infection and inducing alloimmunization, granulocyte transfusion is recommended only when infection is clearly unresponsive to appropriate antimicrobial therapy including antimicrobial drugs, intravenous immunoglobulin and recombinant G-CSF.13,28,29

5. Complications of blood transfusion and their prevention

The major complications of transfusion are transmitted infectious diseases (e.g., viral, bacterial, spirochetes and parasitic), febrile and allergic transfusion reaction and GVHD. Hepatitis B, hepatitis C, HIV, parvovirus B19 and CMV are the most common diseases transmitted by plasma or blood products, especially the plasma-derived factor concentrates.1,2,5,30–33 These complications occur very commonly in immunocompromised patients after transfusion therapy and cause high morbidity and mortality.1,30–33 To avoid viral transmission, vapor-heated or pasteurized products and genetic recombinant products are recommended.1 CMV-seronegative bloods, leukoreduced and/or irradiated blood are recommended for the prevention of CMV infection, GVHD and alloimmunization in transfusion in neonates and immunocompromised patients (Table 9).1,20 If the clinical manifestations resulting from alloimmunization frequently occur, washed blood products with the allergens removed should be prescribed. There is no reason to prescribe a plasma product to a patient

4. Granulocyte transfusion

Although granulocyte transfusion has been used sparingly, the ability to collect markedly higher amounts of neutrophils from the donor mobilized by G-CSF has led to renewed interest, particularly for marrow or peripheral progenitor cell transplantation. Granulocyte transfusion should be reconsidered in neutropenic patients who continue to deteriorate during progressive bacterial and fungal infections in spite of optimal antibiotics and recombinant G-CSF usage. Under the following conditions, granulocyte transfusion may be indicated: (A) children

<table>
<thead>
<tr>
<th>Table 9</th>
<th>Patients requiring irradiated blood components</th>
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</thead>
<tbody>
<tr>
<td>Intrauterine transfusion</td>
<td>Premature infants weighing &lt;1200g at birth</td>
</tr>
<tr>
<td>Patients with known or suspected cellular immune deficiencies</td>
<td>Patients undergoing marrow or peripheral blood progenitor cell transplant</td>
</tr>
<tr>
<td>Patients immunosuppressed by chemotherapy or irradiation treatment</td>
<td>Recipients of components from blood relative</td>
</tr>
<tr>
<td>Recipients of human leukocyte antigen-matched or platelet cross match-compatible components</td>
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</table>
for nutritional supplementation because of the risk of complications.

6. Conclusion

Transfusion is an important but dangerous procedure in therapeutic practice. The characteristics of the disease and which components will be restored should be clearly recognized by the physician before transfusion. It is very difficult to establish a universal guideline for transfusion for critically ill children, especially preterm neonates. The decisions made in transfusion practice usually depend on the patient's clinical condition and the physician's skillful judgment. The issues to be considered in children are quite different from those in adults. Treating un-

References