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BLOOD TRANSFUSION SAFETY : A REVIEW

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ABSTRACT

Blood transfusion is an essential component of health care which saves millions of lives each year. Blood transfusion generally considered a safe procedure that need three major components for safe blood transfusion that is safe donor, safe blood and safe transfusion. Other necessary components include positive patient identification, good documentation and excellent communication. Blood transfusion is a remarkably safe procedure, but like many other clinical procedures, it is associated with clinical risks. These include transfusion-transmitted infections (TTIs) and unexpected clinical complications. To minimise the risk of TTIs and all other complications, donor blood screening tests, proper medical history and monitoring the vital signs before and after transfusion is necessary for blood transfusion safety. In conclusion blood transfusion therapy is require for management of diverse hematological and other diseases, prevention of Transfusion Transmitted Infections (TTIs) remains a key element of blood transfusion safety by performing donor blood screening test prior to blood transfusion, considering safe dosage and rate of transfusion and new technologies (Barcode technology) for safe blood transfusion.

KEYWORDS: Safe blood transfusion, Transfusion-transmitted infections (TTIs), Donor blood screening tests, Barcode technology

INTRODUCTION

Blood transfusion is a unique technology that blends science with altruism. Though its collection, processing and use are technical, its availability depends entirely on the

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extraordinary generosity of the blood donor who donates this most precious of gifts – the gift of life. Safe transfusion not only requires the application of science and technology to blood processing and testing, but also social mobilization to promote voluntary blood donation by sufficient numbers of people who are healthy and are at low risk of infections that can be transmitted to the recipients of their blood.[1] Blood transfusion therapy is require for management of diverse hematological and other diseases. Prevention of Transfusion Transmitted Infections (TTIs) remains a key element of blood transfusion safety

Fig. 1: **Blood Transfusion**
Source: World Health Organization

To minimise the risk of TTIs, several screening tests was performed for safe blood transfusion. Rapid diagnostic testing is currently available for the screening of various pathogens including HIV, HBV, HCV, syphilis and malaria infections and newer technologies are being developed continuously. Key principles that underpins every stage of blood transfusion process are:[2, 3]

Accurate patient identification is one of the critical step in this procedure. Transfusion of blood to the wrong patient is an important avoidable serious hazard of transfusion. It can result from errors made anywhere in the transfusion process, including blood sample collection, laboratory testing and handling of samples, blood retrieval from blood transfusion refrigerators and during the bedside check just prior to transfusion.[4]

This review discuss the essentials of blood transfusion safety, Blood screening tests for safe blood transfusion, dosage and rate of transfusion, technologies to improve blood transfusion safety and some non-infectious & infectious hazards of blood transfusion.

ELEMENTS OF BLOOD TRANSFUSION SAFETY:

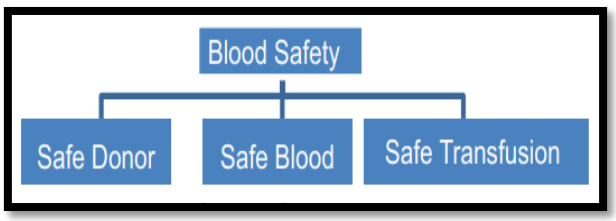

Fig.2**: Elements of Blood Transfusion**

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Source: Editor-Dr. Shivaram. Transfusion Medicine for Clinicians, Prism Publications, 2011

Safe donor - Safe blood comes from an 'altruistic' voluntary donor who donates blood without any expectations. A 'repeat voluntary donor' is one who donates blood at least once a year and is considered safer than occasional voluntary donors, as the blood bank is aware of his previous screening test results also.[5]

Safe blood- Blood banks have traditionally employed enzyme linked immunosorbent assay (ELISA) techniques for donor screening tests. Tests with greater sensitivity or those which take lesser time duration like chemiluminescence, enzyme-linked fluorescence assay (ELFA) are increasingly being used by blood banks. Now various expensive technologies like nucleic acid testing (NAT) have added to blood safety.[6, 7]

Safe transfusion- safe blood transfusion is achieved by accurate patient identification, good documentation and excellent communication.

ESSENTIALS FOR SAFE BLOOD TRANSFUSION

- Avoid unnecessary and inappropriate transfusions.
- Preventable 'wrong blood into patient' incidents are nearly always caused by human error and may cause fatal reactions due to ABO incompatibility.
- Most mis-transfusion incidents are caused by identification errors at the time of pre-transfusion blood sampling, sample handling in the laboratory, collecting the wrong component from the blood bank or transfusion to the patient.
- The identity check between patient and blood component is the crucial final opportunity to avoid potentially fatal mis-transfusion.
- At every stage of the blood administration process the key elements are positive patient identification, excellent communication and good documentation. These can be enhanced by the use of electronic transfusion management systems and barcode technology.
- Hospitals should develop local transfusion policies based on national guidelines and ensure all staff involved in the clinical transfusion process are appropriately trained and competency assessed.
- Where possible, patients should give 'valid consent' for transfusion based on appropriate information and discussion, but signed consent is not a legal requirement.
- Non-essential 'out of hours' requests for transfusion and overnight administration of blood should be avoided wherever possible because of an increased risk of errors[8].

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Table 1.4 Guidelines for Blood Transfusion in Hemodynamically Stable Patients (Not Actively Bleeding)[5]

Hemoglobin level	Transfusion
<6 g/dL	Transfusion recommended
6–7 g/dL	Transfusion almost always indicated
7–8 g/dL	Transfusion may be indicated in patients undergoing orthopedic surgery, cardiac surgery, or any major surgery as well as patients with stable cardiovascular problem
8–10 g/dL	Transfusion generally not indicated, but should be considered in symptomatic anemia, ongoing bleeding, ongoing ischemia, and severe thrombocytopenia
10 g/dL	Transfusion generally not indicated except in exceptional circumstances

Fig.3**: Guidelines for blood transfusion in Haemodynamically stable patients**
SOURCE**:**https://www.google.com/9905729829%2Fphotos%2Fguideline-for-blood-transfusion

KEY PRINCIPLES IN EVERY STAGE OF BLOOD TRANSFUSION[9]

- Positive patient identification
- Good documentation
- Excellent communication.

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Positive patient identification	Positive patient identification at all stages of the transfusion process is essential. Minimum patient identifiers are: • Last name, first name, date of birth, unique identification number. • Whenever possible ask patients to state their full name and date of birth. For patients who are unable to identify themselves (paediatric, unconscious, confused or language barrier) seek verification of identity from a parent or carer at the bedside. This must exactly match the information on the identity band (or equivalent). • All paperwork relating to the patient must include, and be identical in every detail, to the minimum patient identifiers on the identity band.
Patient information and consent for transfusion	Where possible, patients (and for children, those with parental responsibility) should have the risks, benefits and alternatives to transfusion explained to them in a timely and understandable manner. Standardised patient information, such as national patient information leaflets, should be used wherever possible.
Pre-transfusion documentation	Minimum dataset in patient's clinical record: • Reason for transfusion (clinical and laboratory data). • Summary of information provided to patient (benefits, risks, alternatives) and patient consent.
Prescription (authorisation)	The transfusion 'prescription' must contain the minimum patient identifiers and specify: • Components to be transfused • Date of transfusion • Volume/number of units to be transfused and the rate or duration of transfusion • Special requirements (e.g. irradiated, CMV negative).
Requests for transfusion	Must include: • Minimum patient identifiers and gender • Diagnosis, any significant co-morbidities and reason for transfusion • Component required, volume/number of units and special requirements • Time and location of transfusion • Name and contact number of requester.

Blood samples for pre-transfusion testing	All patients being sampled must be positively identified. • Collection of the blood sample from the patient into the sample tubes and sample labelling must be a continuous, uninterrupted event involving one patient and one trained and competency assessed healthcare worker. • Sample tubes must not be pre-labelled. • The request form should be signed by the person collecting the sample.
Collection and delivery of blood component to clinical area	• Before collection, ensure the patient (and staff) is ready to start transfusion and there is good venous access. • Only trained and competent staff should collect blood from transfusion laboratory or satellite refrigerator. • Authorised documentation with minimum patient identifiers must be checked against label on blood component. • Minimum patient identifiers, date and time of collection and staff member ID must be recorded. • Deliver to clinical area without delay.
Administration to patient	• The final check must be conducted next to the patient by a trained and competent healthcare professional who also administers the component. • All patients being transfused must be positively identified. • Minimum patient identifiers on the patient's identity band must exactly match those on blood component label. • All components must be given through a blood administration set (170–200 µm integral mesh filter). • Transfusion should be completed within 4 hours of leaving controlled temperature storage.
Monitoring the patient	Patients should be under regular visual observation and, for every unit transfused, minimum monitoring should include: • Pre-transfusion pulse (P), blood pressure (BP), temperature (T) and respiratory rate (RR). • P, BP and T 15 minutes after start of transfusion – if significant change, check RR as well. • If there are any symptoms or signs of a possible reaction – monitor and record P, BP, T and RR and take appropriate action. • Post-transfusion P, BP and T – not more than 60 minutes after transfusion completed. • Inpatients observed over next 24 hours and outpatients advised to report late symptoms (24-hour access to clinical advice).
Completion of transfusion episode	• If further units are prescribed, repeat the administration/identity check with each unit. • If no further units are prescribed, remove the blood administration set and ensure all transfusion documentation is completed.

Fig.4: **The British Committee for Standards in Haematology (BCSH) Guideline on the Administration of Blood Components (2009)** Source : https://b-s-h.org.uk

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DONOR BLOOD SCREENING FOR SAFE BLOOD TRANSFUSION:

Screening for blood-transmissible pathogens is a critical aspect of blood transfusion safety. Where effective screening tests minimise the risk of transmission of transfusion-transmitted infections (TTIs) has been reported to progressively and significantly decreases.[10]

Rapid diagnostic testing is currently available for the screening of various pathogens including HIV, HBV, HCV, syphilis and malaria infections and newer technologies are being developed continuously.

Some available quality rapid diagnostic test kits for transfusion-transmissible infections.

(The selection of examples is based mainly on high sensitivity and/or specificity).

Name	Manufacturer	Pathogen	Sensitivity (%)	Specificity (%)
Determine HIV1/2	Abbott Laboratories	HIV	100	99.6
HIV 1/2 STAT-PAK	Chembio Diagnostic Systems	HIV	99.7	99.3
HIV 1/2 STAT-PAK Dipstick	Chembio Diagnostic Systems	HIV	99.0	100
Uni-Gold HIV-1/HIV-2	Trinity Biotech	HIV	100	100
Immunocomb II HIV 1&2 BiSpot	Orgenics	HIV	100	99.7
Retrocheck HIV 1&2/Core HIV 1&2	Qualpro Diagnostics/Core Diagnostics	HIV	100	99.1
DoubleCheckGold HIV 1&2	Orgenics	HIV	100	99.3
OraQuick HIV-1/2	OraSure Technologies	HIV	100	99.2
Multispot HIV 1/2	Bio-Rad Laboratories	HIV	100	99.93
Determine Syphilis TP	Abbott Laboratories	Syphilis	100	98.6
HCV Tri Dot	J. Mitra & Co.	HCV	100	91.5
HCV SpoT	Genelabs Diagnostics	HCV	100	93.7
SeroCard HCV	Trinity Biotech	HCV	98.5	100
Determine HBsAg	Abbott Laboratories	HBV	100	100
Dainascreen	Abbott Laboratories	HBV	100	100
SD BioLine HBsAg (One Step HBsAg Test)	Standard Diagnostics	HBsAg	97.95	100
Assure HBsAg Rapid Test	MP Biomedicals Asia Pacific	HBsAg	97.95	100
Quick Chaser HBsAg	Mizuho Medy	HBsAg	97.95	100

Fig5**: Rapid diagnosting testing**

Source: Clin Microbiol Infect 2013; 19: 416–421

TRANSFUSION SAFETY: MORE THAN JUST BLOOD SAFETY

Safe blood transfusion therapy depends upon an interrelated series of processes shown in Fig. 1. Blood transfusion safety can be distinguished from blood safety. Blood safety concerns the safety of the component. Blood safety is largely the responsibility of blood collectors and has been a primary focus of both regulators and standard-setting agencies in the blood industry.[11]

Blood transfusion safety, in contrast, focuses on the overall process that results in delivery of transfusion therapies to patients. Blood transfusion safety includes blood safety but also includes additional critical steps that relate to the medical use of components and the outcome of the patient. These latter steps occur largely within the hospital.[12]

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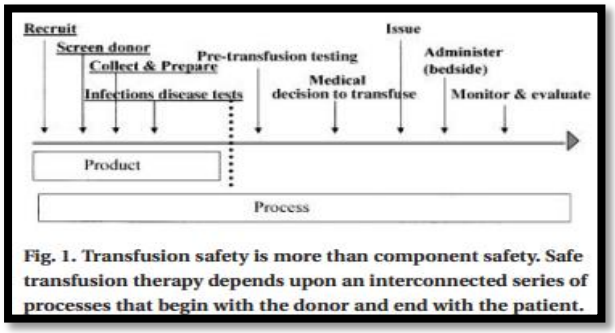

Fig. 1. Transfusion safety is more than component safety. Safe transfusion therapy depends upon an interconnected series of processes that begin with the donor and end with the patient.

Fig.6**: Transfusion safety is more than component safety**

Source: https://doi.org/10.1046/j.1537-2995.2003.00523.

DOSAGE AND RATE OF ADMINISTRATION FOR SAFE BLOOD TRANSFUSION[13]

Blood component	Notes on administration
Red cells in additive solution	Transfusions must be completed within 4 hours of removal from controlled temperature storage.
	Many patients can be safely transfused over 90–120 minutes per unit.
	A dose of 4 mL/kg raises Hb concentration by approximately 10 g/L. Note: The common belief that one red cell pack = 10 g/L increment only applies to patients around 70 kg weight – the risk of transfusion-associated circulatory overload (TACO) is reduced by careful pre-transfusion clinical assessment and use of single-unit transfusions, or prescription in millilitres, for elderly or small, frail adults where appropriate.
	During major haemorrhage, very rapid transfusion (each unit over 5–10 minutes) may be required.
Platelets	One adult therapeutic dose (ATD) (pool of four units derived from whole blood donations or single-donor apheresis unit) typically raises the platelet count by 20–40×10^9/L.
	Usually transfused over 30–60 minutes per ATD.
	Platelets should not be transfused through a giving-set already used for other blood components.
	Start transfusion as soon as possible after component arrives in the clinical area.
Fresh frozen plasma (FFP)	Dose typically 12–15 mL/kg, determined by clinical indication, pre-transfusion and post-transfusion coagulation tests and clinical response.
	Infusion rate typically 10–20 mL/kg/hour, although more rapid transfusion may be appropriate when treating coagulopathy in major haemorrhage.
	Because of the high volumes required to produce a haemostatic benefit, patients receiving FFP must have careful haemodynamic monitoring to prevent TACO.
	FFP should not be used to reverse warfarin (prothrombin complex is a specific and effective antidote).
Cryoprecipitate	Typical adult dose is two five-donor pools (ten single-donor units).
	Will raise fibrinogen concentration by approximately 1 g/L in average adult.
	Typically administered at 10–20 mL/kg/hour (30–60 min per five-unit pool).

Fig.7: **Dosage and rate of blood transfusion**.

Source: Transfusion Handbook / 4: Safe transfusion -right blood, right patient, right time and right place.

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NEW TECHNOLOGIES TO IMPROVE BLOOD TRANSFUSION SAFETY:

New technology has led the way toward improved blood component safety. That modern technology has not been applied to basic processes of patient identification, sample collection, and the bedside administration of blood is a serious and striking failing that can be corrected. A variety of new technologies exist that can be used to improve blood transfusion safety (Table 1)[14]

TABLE 1. Technologies to improve transfusion safety

- Machine-readable patient identification bracelets
- Hand-held bar code scanners (with or without interface to HIS/LIS*)
- Radio-frequency "smart tags" and readers
- "Smart" fluid pumps for blood and medication delivery
- "Smart" refrigerators for blood dispensing
- Nanotechnology
- CBUR and physician feedback

* HIS/LIS = Hospital Information System/Laboratory Information System.

Fig.8: **Technologies to improve blood transfusion safety**

Source**:** Emily Cooley Lecture 2002: transfusion safety in the hospital

In new **Barcode technology**, a hand-held computer reads a non-linear portable data format (PDF) barcode on the patient wristband containing patient's full details (surname, first name, gender, date of birth, and hospital number).[14]

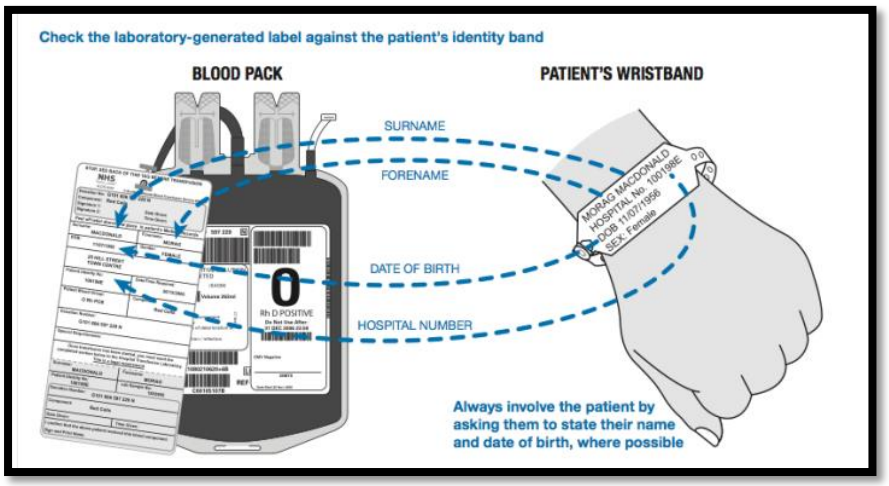

Fig.9**: Barcode technology**

Source: Transfusion Handbook / 4: Safe transfusion - right blood, right patient, right time and right place

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INFECTIOUS AND NON-INFECTIOUS HAZARDS OF BLOOD TRANSFUSION:

Transfusion-related complications can be categorized as acute or delayed, which can be divided further into the categories of non-infectious and infectious.

Transfusion-related infections are less common because of advances in the blood screening process, the risk of contracting an infection from transfusion has decreased.[15, 16]

Table 5. Noninfectious Serious Hazards of Transfusion

Acute
Acute hemolytic reaction
Allergic reaction
Anaphylactic reaction
Coagulation problems in massive transfusion
Febrile nonhemolytic reaction
Metabolic derangements
Mistransfusion (transfusion of the incorrect product to the incorrect recipient)
Septic or bacterial contamination
Transfusion-associated circulatory overload
Transfusion-related acute lung injury
Urticarial reaction
Delayed
Delayed hemolytic reaction
Iron overload
Microchimerism
Overtransfusion or undertransfusion
Post-transfusion purpura
Transfusion-associated graft-versus-host disease
Transfusion-related immunomodulation

Adapted with permission from Hendrickson JE, Hillyer CD. Noninfectious serious hazards of transfusion. Anesth Analg. *2009;108(3):760.*

Table 6. Infectious Complications of Blood Transfusions

Complication	*Estimated risk*
Hepatitis B virus	1 in 350,000
Hepatitis C virus	1 in 1.8 million
Human T-lymphotropic virus 1 or 2	1 in 2 million
Human immunodeficiency virus	1 in 2.3 million
Creutzfeldt-Jakob disease	Rare*
Human herpesvirus 8	Rare*
Malaria and babesiosis	Rare*
Pandemic influenza	Rare*
West Nile virus	Rare*

Fig.10: **Transfusion related complications**

Source**:** Hendrickson JE, Hillyer CD. Non-infectious serious hazards of transfusion. Anesth Analg. 2009;108(3):760.

CONCLUSION: Blood transfusion safety including some key elements like safe donor, safe blood and transfusion safety. Prior to blood transfusion some rapid screening tests are performed to limit the transmitted transfusion infections like AIDS, Hepatitis, syphilis etc. To know the management strategies after immediate and delayed hazards after blood transfusion, proper knowledge of non-infectious and infectious hazards after transfusion is necessary.

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