Section: Transfusion Medicine

Original Research Article

PREVALENCE OF RED CELL ALLOANTIBODIES IN MULTI-TRANSFUSED HAEMATOLOGY PATIENTS IN A TERTIARY CARE CENTER

Archana Kuruvanplackal Achankunju[1], Soonam John[2], Indu Pachampully Kumaran[1], Sasikala N[3], Sreenath S[4]

[1] Assistant Professor, Department of Transfusion Medicine, Government Medical College, Thrissur, India.
[2]Associate Professor, Department of Transfusion Medicine, Goverment Medical College, Paripally, Kollam, India.
[3]Professor, Department of Transfusion Medicine, Government Medical College, Kozhikode, India.
[4]Professor, Department of General Medicine & Hematology, Government Medical College, Thiruvananthapuram, India.

Received : 24/07/2023
Received in revised form : 30/08/2023
Accepted : 11/09/2023

Keywords:
Multiple Transfusion, Alloimmunization, Hematology, Transfusion Reaction.

Corresponding Author:
Dr. Archana Kuruvanplackal Achankunju,
Email: archanapriyanka21@gmail.com

DOI: 10.47009/jamp.2023.5.5.117

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5 (5); 603-608

Abstract

Alloimmunization is a common and potentially serious consequence of multiple blood transfusion. Since majority of haematology patients are dependent on lifelong transfusion support, the development of alloimmunization is a significant event which may delay the availability of compatible blood. The understanding of the common alloantibody specificities will help to adopt a policy of extended RBC phenotyping for providing antigen negative blood to such patients. With this backdrop, our study was intended to provide a baseline data of the prevalence of alloantibodies in multitransfused patients of our institution. This was a cross sectional study, conducted for a period of 18 months in the Department of Transfusion medicine and Hematology and Internal Medicine. The patients admitted with various Hematological disorders, who received more than five packed red cell transfusions were included in this study. The patients with autoimmune disorders were excluded from this study. The data collection was collected with the help of a proforma, filled by the principal investigator using case records and interview with patients. 2ml of EDTA and plain samples were collected. All the sample collected were tested for ABO and Rh Grouping, Direct Antiglobulin test, Indirect Antiglobulin test and Antibody screening. Red cell phenotyping was done to confirm antibody identification results. The prevalence of RBC alloimmunization was 2.66% in multitransfused patients. Antibodies identified were of various specificities, and majority were against the Rh system. The specificities were Anti C, ANTI c+Anti M, Anti D, Anti P, Anti Jka, Anti E+Anti Jka. The female participants contributed to the major share of alloimmunized individuals. A fair number of patients were on lifelong immunosuppressive therapy. Development of clinically significant irregular antibodies may cause crossmatch incompatibilities, transfusion reactions and can cause HDFN in females. Hence hospitals may introduce pretransfusion antibody screening of all transfusion dependent patients to reduce further alloimmunization and its complications.

INTRODUCTION

Blood transfusion Therapy is the cornerstone of medical management of patients, who were diagnosed to have various Hematological diseases. Lion's share of haematology patients admitted and treated at our institution had severe anemia which demanded lifelong packed red cell transfusion. Multiple exposure to packed red cell transfusion leads to the development of irregular antibodies that do not belong to ABO system had been rising. This results in difficulty in obtaining compatible blood, development of auto and alloantibodies, acute or delayed hemolytic transfusion reactions, hemolytic disease of the newborn and poor survival of the transfused red cells. The blood Centre play an important role to supply sufficient quantity and quality of safe blood to alloimmunized patient to reduce complications.

The antibody that is routinely encountered in pre-transfusion test can be either an autoantibody or an alloantibody.[1] The development of Red cell allo and auto immunisations remains a major problem in patients, who require frequent Transfusion Support.

If a person's immune system produce an antibody to an antigen that he or she lacks is called an Alloantibody.[2] Antibodies developed against self-antigen is called as Autoantibody,[3] Alloantibody reacts only with allogenic red cells, while autoantibody reacts with most of the reagent panel cells. AlloImmunization occurs mainly due to multiple transfusions, pregnancy, transplantation, needle sharing or injections of immunogenic material. In some instance alloimmunization can occur without a prior immunisation event.[4] A prior exposure to donor antigents can lead to anamnestic or secondary response where even very small amounts of donor antigenic RBC can elicit an alloimmune response resulting in increase in antibody production leading to red-cell destruction. The development of alloantibodies and/or autoantibodies against RBC antigens complicate RBC cross matching, shortens in vivo survival of transfused cells, can delays the provision of safe transfusions and can cause haemolytic disease of newborn.

The frequency of alloimmunization in patients and donors are variable according to their ethnicity and race.[5,6] Hematology patients are on lifelong transfusion dependent like MDS, Aplastic anemia, Thalassemia etc. Such patient's are at higher risk of developing alloimmunization.[7]

The severity of transfusion complications depends upon the clinical significance of a particular antibody. A clinically significant antibody is defined as "An antibody which is frequently associated with hemolytic disease of fetus and newborn, hemolytic transfusion reaction or notable decrease in red cell survival,[8,9] which is associated with serious immunological complications like crossmatch incompatibility, development of autoantibodies, and even transplant rejection. It is important to identify the presence of alloantibody, its specificity and clinical significance before transfusions. The degree of clinical significance varies among antibodies with same specificity in different patients. Most of the hematology patients are admitted with severe anemia and these patients require multiple transfusions who may develop alloantibodies. So, when these patients need transfusions, cross matching with antigen negative blood is essential to minimise complications. Some medication like IVIG and RHIG have reported the presence of irregular antibodies.

As the cases of incompatible Crossmatches raised and to reduce Transfusion complications Red cell Antibodyscreening of all Multiple transfused Hematology patients mandated at our institution. The mandatory antibody screening in multitarnsfused patients helped us to profile minor antibodies and ensured serological safety to the patient.

MATERIALS AND METHODS

Study Design

This study was conducted at State Model blood Center at Department of Transfusion Medicine Government Medical college, Thiruvanathapuram, In collaboration with Hematology division of General Medicine from 2016 April to October 2018.

Objective

Primary Objective: To study the prevalence of RBC alloantibodies in multitransfused haematology patients

Secondary Objective: To estimate number of blood units to be cross matched to find out compatible blood unit for each alloimmunized patient.

Study Setting and Sample Size: In this Hospital based cross-sectional study, a total of 300 samples were consecutively analyzed.

Study Subject

Inclusion Criteria

Patients admitted with haematological disorder who received more than 5 units of packed red cell transfusion.

Exclusion Criteria

Patients who diagnosed to have Auto immune haemolytic anemia.

Patients whose clinical history and regular follow-up were not possible were excluded from this study. Patients not willing to give consent also excluded from this study.

Data Collection Technique

The Clinical history was collected by reviewing patient records and through a performa which noted 1) Socio demographic variables,2) Clinical and transfusion records 3) Transfusion history before the first visit to our blood bank. Transfusion history include the number of units of blood transfused, date of transfusions, indication for each transfusion. 4)Age of first transfusion 5) Age of splenectomy6) H/o pregnancy and abortion 7) Drug history.

Data Collection Tool

After taking written informed consent according to proforma from the patients attending haematology unit, fulfilling the inclusion criteria will be enrolled as study subjects. 3-4ml of blood sample was required for this study, which was taken from the sample received at blood bank for cross matching. No additional sample is required.

A volume of 2 ml of blood was collected in plain and ethylenediaminetetraacetic acid tubes from multiply transfused patients. The plasma/serum was used for antibody screening and antibody identification test. The red cells were used for ABO typing, Rh typing, antigen phenotyping, and DCT. For antibody screening serum tested against a commercial 3 cell screening panel of O' cells (Biorad, Switzerland). Samples with positive antibody screen were subjected to antibody identification by using commercially available 11 cell panel according to FDA recommendation. Antigens which are tested are Rh system, MNS, P, Kell, Duffy, Lewis, Kidd and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Lutheran. The specificities of antibodies were determined by comparing the reaction pattern with the antibody identification chart (antigram) provided by the manufacturer along with the 3- and/or 11-cell panel reagents. Patients are considered to be alloimmunized if antibodies to 1 or more RBC antigens are identified in their plasma. Panel of cells which is used for antibody screening subjected to quality control check before the study. If a patient has antibodies that were already identified, the panel cells for such patients should be carefully selected.

RESULTS

The present study shows that of the total 300 samples 8 participants were developed irregular alloantibodies. This results an alloimmunization rate 2.66% (8/300). The frequency of alloimmunization is matching to similar studies conducted across our country. The Rh system tops the chart of alloimmunization. Anti C(n=2) being the most common irregular antibody identified, Anti kidd, anti Levis, anti M,anti P antibodies were also reported. Two patients had multiple antibodies in their account. Participants were categorised in 4 groups to study age pattern. Those 4 categories were 20,20-40,40-60 and above 60 years of age. Majority of patients (40%) were above 60 years of age. Mean age is 37years. Out of total 300 patients 183, (61%) were females and 117(39%) were males. Among them alloimmunized cases were 8. Greater part of alloimmunized participants comprise female gender (n=7) in comparison with male gender. A total of 300 participants of majority 61(20) had secondary anemia due to chronic disease. Followed by 50 (17) participants had transfusion due to Myeloid aplastic Syndrome and 41 participants diagnosed as Aplastic anemia. Among the study subjects 92 (31%) were O positive group followed by 85 (28%) B positive group, 26% were A positive group, 6% were AB positive, 3% participants were O negative and B negative, 2% were A negative .1% belonged to AB negative. The data regarding the blood group distribution seen in this study similar that of Indian population. Among the multi-transfused study subjects 63.3% received packed red cell transfusions in the range of 5-25, 29% patients PRC transfusions received 25-50 transfusions. 23 patients (7%) received more than 50-75; who were diagnosed to have Hematological disorder at an earlier age. The interval between >2weeks= 25 patients and 2-4 weeks in 40 patients and transfusions 235. Patients received transfusion in an interval more than 4 weeks. The second objective of this study was to estimate number of blood units to be cross matched to find out compatible blood. We used LISS Coombs cross match method. Number of units that need to be tested = Number of units required /percentage of donors negative for antigen.

For emergency cases we issued O' negative packed red cells (most compatible/ least incompatible) after giving necessary medications. When we considered the splenectomy status in study subjects out of 300, 10 had undergone splenectomy. Out of which only one patient with alloimmunization had undergone splenectomy and no significant association noticed. During the study period Out of 300 patients 30(10%) developed transfusion reactions.21 /30 had allergic type of reaction and 9 febrile non haemolytic reaction.

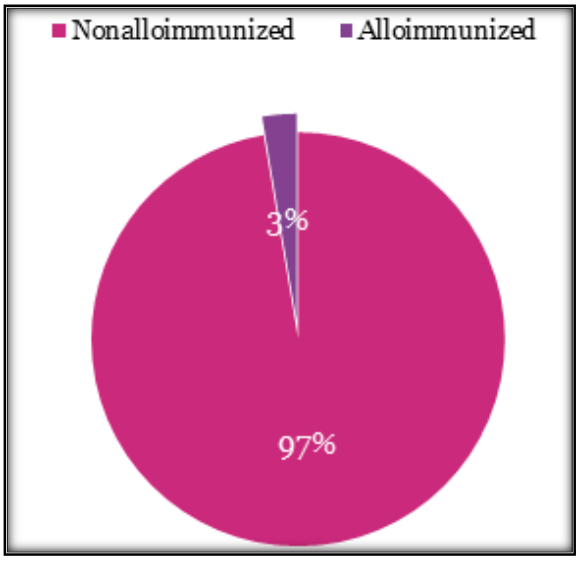

Figure 1: Prevalence of alloimmunization

Table 1: Clinical data of patients who developed alloantibody due to packed red cell transfusions

Sl no	Antibody specificity	Age	Gender	Diagnosis	Number of crossmatch for one compatible unit	Splenectomy	Immunosuppressant Therapy
1	Anti C	23	Female	Myelodysplastic sydrome	8	No	Yes
2	Anti C	48	Female	Fanconis Anemia	8	Yes	No
3	Anti c+ Anti M	35	Female	Thalassemia	21	No	Yes
4	Anti D	26	Female	Pure Red Cell Aplasia	15	No	Yes
5	Anti P	36	Male	Malignancy	1	No	No
6	Anti Jka	63	Female	Aplastic Anemia	5	No	Yes
7	Anti c	25	Female	Thalassemia	3	No	Yes
8	Anti E+ Anti Jka	40	Female	Multiple Myeloma	7	No	No

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 2: Data of Transfusion of Packed red cells

Number of PRC UNITS transfused	Interval between Transfusion's	Types of transfusion reaction
5-25(63.33%)	>2weeks= 25 patients	Allergic reaction 21(70%)
25-50(29%)	2-4 weeks =40 patients	Febrile non hemolytic reaction 9(30%)
50-75(7.67%)	More than 4 weeks =235 patients	

DISCUSSION

This Hospital based cross sectional study was conducted to analyse alloimmunization in multitransfused Hematology patients. Transfusion therapy is a double edged sword, on one hand, it is a major life saving modality, and while on the other hand, it can lead to complications like alloimmunization. A greater number of these patients rely on repeated packed red cell transfusion due to severe anemia. Frequent blood transfusion resulted in the development of red cell allo and autoantibodies. The presence of clinically significant alloantibodies made the transfusion therapy burdensome in terms of pre-transfusion testing and post transfusion survival of red cells. We tried to profile red cell alloantibodies of multiple transfused patients to decipher this crisis. Naturally occurring Antibody An ant Antibody B are the only red cell antibodies that are commonly found in serum or plasma. All other antibodies are named "unexpected red cell antibodies.[10]

The present study showed that out of the total 300 samples,8 participants (2.66%) developed irregular alloantibodies. The frequency of alloimmunization is identical to similar studies conducted across our in our study Rh system tops the chart of alloimmunization. Anti C(n=2) being the most common irregular antibody identified. Anti D, Anti Kidd, Anti M, Anti P antibodies were also reported. Two patients had multiple antibodies in their account. Available literature from the distinct part of the world among different population has reported prevalence of alloimmunization ranging from 2.6 -76%.[11,12] Indian investigators have reported the prevalence ranging from 0.49-11%. Research paper published by Conrath et al, on alloimmunization in sickle cell patients stated the prevalence as 2.6%, which is in agreement with the result of our study.[13]

Among the 8 alloimmunized patients 7 were females. Females had the higher in incidence of alloimmunization. In terms of gender the obtained result was comparable with available literature.[14] Reisner et al.[15] reported a significantly higher rate of alloimmunization in women and suggested that the risk of alloimmunization might be influenced by the gender of the recipient, and be due to pregnancy in women. To reduce alloimmunization in women, antenatal antibody screening in pregnancy must be done. However, the cost of the antibody screening may not affordable for patients who are from law financial backgrounds, by mandating proper ICT screening technique will timely identify the alloimmunization in antenatal women. Furthermore, RBC alloimmunization can have serious clinical consequences, it is widely accepted that transfusion should be avoided as much as possible in female patients of childbearing potential (due to the risk for hemolytic disease of the fetus and newborn) and for patients that may require extended transfusion support and/or stem cell transplantation.[16-18] In the current study, the mean age of alloimmunized patients (8) was 37years.Majority of study population (120/300)were above 60 years of age and they did not develop irregular antibodies. It is known that the process of aging can diminish the immune system response overall, thus aging may also reduce RBC alloimmunization rates.[19,20]

Transfusions given to our study subjects varied from 5 units to 75 units. Multiples number of transfusions increases the incidence of alloimmunization. Patients diagnosed as Fanconis anaemia, MDS, Aplastic anemia, Megaloblastic anaemia and Thalassemia are usually alloimmunized because they have been receiving transfusion very frequently. This correlated with the similar studies in Indian population.[21]

In our center a good number of patients were treated with immunosuppressants and 70% of patients received steroids as part of there treatment. Various investigators observed that the immunosuppressive regimens can substantially reduce the incidence of alloimmunization.[22,23] Hence the development of new alloantibodies necessitate an enhanced immunotherapy in such patients.

The second objective of our study was to find out number of blood units to be crossmatched to get most compatible blood. In cases were antibody was identified the number of units cross matched to obtain an antigen negative compatible blood was based on clinical scenario.[24] In routine cases the number of antigen negative units cross matched was based on the formula= Number of units required/percentage of donors negative for antigen. In antibody identified cases 10 – 25 units of corresponding groups were crossmatched for each transfusion. For emergency and in incompatible cases we issued O' negative packed red cell (most compatible / least incompatible). The blood transfused after giving necessary medications, patient was carefully monitored during and after transfusion .No transfusion reactions were observed for these patients during the study period.

While considering the fact that splenectomy can augment alloimmunization rate.[25] our study splenectomy hadno significant association with alloimmunization. A major complication of alloimmunization is the probability to develop transfusion reactions. In our study 30 patients had transfusion reactions. 21 (70%) of them had allergic reaction and rest encountered febrile non hemolytic reaction. A study conducted by Yazer MH, Triulzi DJ observed that patients experiencing febrile transfusion reactions were much more likely to

ISSN (O): 2687-5365; ISSN (P): 2753-6556

develop alloantibodies than similarly transfused patients who had no concomitant inflammatory stimulus.[26]

The clinical consequences of the antibodies are different and can be complex because blood group antibodies formed against most antigens tend to fade over time and may eventually become undetectable, a phenomenon known as antibody evanescence.[27] At present, there is no laboratory test available to stimulate evanesced antibodies in vitro.

Clinical Approaches to Limit Alloimmunization and it's consequences

The most reliable approach to limit minor RBC alloimmunization is to provide RBCs for transfusion with the minimum number of antigen mismatches.[28] To accomplish this, hospitals may phenotype or genotype recipients for various minor RBC antigens and then attempt to obtain RBCs from donors who are matching. This approach has been shown to be very promising for the prevention of alloimmunization in multiply transfused patient population.[29,30] Such a practice has been proposed to be cost-effective in some settings it is believed to be cost-prohibitive in others,[31] especially in patient populations that are unlikely to alloimmunization due to underlying severe immunosuppression.

One of the effective mechanisms to prevent alloimmunization is the exclusion of RBC transfusions that are not clinically necessary. The AABB has published clinical guidelines to achieve this goal. Implementation of such guidelines with reasonable enforcement (e.g., via prospective utilization audits) is an effective way to limit unnecessary transfusions, and thereby reduce resultant alloimmunization.[32]

The efficacy of leukoreduction at preventing alloimmunization is controversial. According Yazer MH et al, Rh-negative patients transfused with prestorage leukoreduced RBCs had a lower (13%) alloimmunization rate compared to patients transfused with non-leukoreduced RBCs (22%).[33] However the leukoreduction of RBCs does substantially reduce the likelihood of alloimmunization to HLA antigens. Regarding other clinical modifications available in most blood banks/transfusion services (e.g., irradiation, washing, or saline replacement), there is no proof at present to suggest that any of these methods has an effect on alloimmunization rates.[34,35]

CONCLUSION

The prevalence in of RBC alloimmunization was 2.66% in multiramified patients. Antibodies identified were of various specificities, majority belong to Rh system. The specificities are Anti C(2), ANTI c+Anti M (1),Anti DO), Anti P(1), Anti Jka(1), Anti E+AntiJka(1). Female participants added the major share of all immunized individuals. A fair number of patients were lifelong immunosuppressive therapy. Development of clinically significant irregular antibodies may cause crossmatch incompatibilities and transtusion reactions. Treatment of alloimmunization should be a joint effort by treating physician and Transfusion services. Their combined measures can be streamline the therapy. Hence, blood centers may introduce pretransfusion antibody screening of all transfusion dependent patients to reduce alloimmunization and its complications.

REFERENCES

1. Cutbush M, Mollison PL, Parkin DM. A new human blood group system. Nature 1950;165:188-189.
2. AABB Technical Manual, Identification of antibodies to red cell antigens
3. Elkon k &CasaliP. Nature and functions of autoantibodies. Nature clinical practice Rheumatology.20084(9);4(9):491-498.
4. Poole J, Daniels G: Blood group antibodies and their signiticance in transfusion medicine. Transfus Med Rev 2007; 21: 58-71.
5. Schonewille H, Van De Watering LMG, Loomans DSE, Brand A. Red cell alloantibodies after transfusion: factors influencing incidence and specificity. Transfusion. 2006;46:250-256
6. Vichinsky EP, Earles A, Johnson RA, Hoag MS, Williams A, Lubin B. Alloimmunization in sickle cell anemia and transfusion of racially unmatched blood. N Engl Med. 1990;322:1617-21. [PubMed:2342522]
7. Pahuja S, Pujani M, Gupta SK, Chandra J, Jain M. Alloimmunization and red cell autoimmunization in multitransfusedthalassemics of Indian origin. Hematology. 2010;15(3):174-17
8. Stiegler G, Sperr W, Lorber C, Fabrizii V, Höcker P, Panzer S. Red cell antibodies in frequently transfused patients with myelodysplastic syndrome. Ann Hematol, 2001;80:330-333
9. PhyllisS. Walker andJanis R. Hamilton. Identification of redcellantigens.AABB 18" Edition;392
10. Petz LD and Garratty G. Hemolytic disease of the fetus and newborne. In: Immune Hemolytic Anemias. 2nd edition. Philadelphia PA: Elseviers Inc. 2004. p. 517-540
11. OluhungbeA, HambletonI,StephensL,Serjeant B, Serjeant .G. Redcell antibodies in patients with homozygous sickle cell disease:a comparison of patients in Jamaica and united Kingdom. Br. Journal of Haematol.2001 Jun;113(3):661-5.
12. Ameen R, Al shemmari S, Al -Bashir A,Red blood cell alloimmunization among sickle cell Kuwaiti Arab patients who received red blood cell transfusion. Transfusion .2009. Aug 49(8): 1649-5413.
13. Conrath S, Vantilcke V, Parisot M, Maire F, Selles P, Elenga N. Increased Prevalence of Alloimmunization in Sickle Cell Disease? Should We Restore Blood Donation in French Guiana? Front Med (Lausanne). 2021;8:681549. doi: 10.3389/fmed.2021.681549.
14. Hoeltge GA, Domen RE, Rybicki LA, Schaffer PA: Multiple red cell transtusions and alloimmunization. Experience with 6996 antibodies detected in a total of 159,262 patients from 1985 to 1993. Arch Pathol Lab Med 1995; 119: 427-2773.
15. Reisner EG, Kostyu DD, Philips G, Walker C, Dawson DV. Alloantibody responses in multiply transfused sickle cell patients. Tissue Antigens .1987 Oct;30(4):161-6.
16. Booth GS, Gehrie EA, Savani BN: Minor RBC Ab and allo-SCT. Bone Marrow Transplant 2014; 49: 456 457
17. De La Rubia J, Arriaga F, Andreu R, Sanz G, Jimenez C, Vicente A, Carpio N, Marty ML, Sanz MA: Development of non-ABO RBC alloantibodies in patients undergoing allogeneic HPC transplantation. Is ABO incompatibility a predisposing factor? Transfusion 2001; 41: 106-110.
18. Ting A, Pun A, Dodds AJ, Atkinson K, Biggs JC: Red cell alloantibodies produced after bone marrow transplantation. Transfusion. 1987; 27: 145-147.
19. Sansoni P, Cossarizza A, Brianti V, Fagnoni F, Snelli G, Monti D, Marcato A, Passeri G, Ortolani C, Forti E, et al.:

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Lymphocyte subsets and natural killer cell activity in healthy old people and centenarians.Blood 1993; 82: 2767-2773
20. Gonzalez-Porras JR, Graciani IF, Perez-Simon JA, Martin-Sanchez J, Encinas C, Conde MP, Nieto MJ, Corral M: Prospective evaluation of a transfusion policy of D+ red blood cells into D- patients. Transfusion 2008; 48: 1318-1324.
21. Sarnaik S, Schornack J, Lusher JM: The incidence of development of irregular red cell antibodies in patients with sickle cell anemia. Transfusion 1986; 26: 249-252.
22. Ramsey G, Hahn LE, Cornell FW, Boczkowski DJ, Staschak S, Clark R, Hardesty RL, Griffith BP, StarzI TE: Low rate of Rhesus immunization from Rh-incompatible blood transfusions during liver and heart transplant surgery. Transplantation 1989; 47: 993-995.
23. Yuan S, Davis R, Lu Q, Goldfinger D, Ziman AF: Low risk of alloimmunization to the D antigen in D- orthotopic liver transplant recipients receiving D+ RBCs perioperatively. Transfusion 2008; 48: 2653-2655.
24. Jeanne E.Hendrickson, JohnD, Roback Christopher D Hillyer and James C. Zimring An intact spleen is required for alloimmunization to transfused redcells due tonintrasplenic activation of CD4+T Cells. Blood 2007 110:453
25. ThuretI, Pondarre C. Loundou A, Steschenko D, Girot R, Bachir D, et al. Complications and treatment of patients with beta thalassemia in France:results of the national registry.Hematologica.2010 May;95(5):724-9
26. YazerMH, TriulziDJ, ShazB, KrausT, ZimringIC. Doesafebrilereactionto platelets predispose recipients tonred blood cell alloimmunization?.Transfusion.2009;49(6): 1070-1075
27. Tormey CA, Stack G: The persistence and evanescence of blood group alloantibodies in men. Transfusion 2009; 49: 505-512
28. Castro O, Sandler SG, Houston-Yu P, Rana S: Predicting the effect of transfusing only phenotypematched RBCs to patients with sickle cell disease: theoretical and practical implications. Transfusion 2002; 42:684-690.
29. Ambruso DR, Githens JH, Alcorn R, Dixon DJ, Brown LJ, Vaughn WM, Hays T: Experience with donors matched for minor blood group antigens in patients with sickle cell anemia who are receiving chronic transfusion therapy. Transfusion 1987; 27: 94-98.
30. Spanos I, Karageorga M, Ladis V, Peristeri J, Hatziliami A, KattamisC: Red cell alloantibodies in patients with thalassemia. Vox Sang 1990;58: 50-55
31. Lau FY, Wong R, Chan NP, Chui CH, Ng E, Ng MH, Cheng G: Provision of phenotype-matched blood units: no need for pre-transfusion antibody screening. Haematologica 2001; 86: 742-748.
32. Carson JL, Grossman BJ, Kleinman S, Tinmouth AT, Marques MB, Fung MK, Holcomb JB, Illoh O, Kaplan LJ, Katz LM, Rao SV, Roback JD, Shander A, Tobian AA, Weinstein R, Swinton McLaughlin LG,Djulbegovic B: Red blood cell transfusion: a clinical practice guideline from the AABB. Ann Intern Med 2012; 157: 49-58.
33. Yazer MH, Triulzi DJ: Detection of anti-D in D- recipients transfused with D+ red blood cells. Transfusion 2007; 47: 2197-2201
34. Sanz C, Gita G, Franquet C, Martinez I, Pereira A: Red-blood-cell alloimmunization and female sex predict the presence of HLA antibodies in patients undergoing liver transplant. Vox Sang 2010; 99:261-266

ISSN (O): 2687-5365; ISSN (P): 2753-6556