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Utility of compatible non identical blood components in transfusion services

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Abstract
Background: *By means of component therapy, it is wise to provide the component which is required and keep the remaining components for other patients. Here compatible ABO non identical components (CC) are the need of the day to combat the shortage/ excess of particular blood components and on occasions it may be necessary to provide CC instead of identical blood component (IC).*
Aims and Objective: *The aim is to study the usefulness of Compatible components in transfusion medicine.*
Material and methods: *It is a approximately 7 years retro-prospective study from 1st January 2012 to 1st December 2018 conducted at Blood Bank in a tertiary care center in Gwalior. All data of components prepared, issued and its adverse effect of transfusion to the patients had been collected, tabulated and analyzed statistically.*
Result: *A total number of 122672 blood units were collected during the study period; Out of 122672 collected blood units, 253238 units blood components were prepared. Mean conversion rate of components against the units collected is 2.06. Units found to be transfusion transmitted infections (TTIs) positive were 4337 (3.53%). Incidence of total adverse event in the study was 1.497 %; where adverse event by identical components was 1.60% and by compatible components was 0.73 %.*
Conclusion: *Here we conclude that by the virtue of component therapy, we are able to avert the crisis of excess and shortage of blood components in our set up.*
Keywords: *Compatible components (CC), Identical components (IC), Transfusion.*

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I. Introduction

The earliest known blood transfusion was attempted in a 17th century. After few experimental attempts, journey of safe blood transfusion started with discovery of ABO blood grouping by Landsteiner in the beginning of 20th century [1]. Since then, there has been slow but steady rise in advances and discoveries. After 1950, the subject gained momentum with one of the single most influential technical development by Carl Walter and W.P. Murphy Jr. with introduction of plastic bag for blood collection [2]. By the discovery of plastic bags, easy preparation of multiple blood components from a single unit of whole blood was made possible [3].

In the present scenario blood banks are replaced by fully fledged medical departments of Transfusion Medicine because these are not only the places of supplying blood, but also to treat patients with different available blood components. Blood Components has therapeutic value; RBC for treating hypoxia, platelets for thrombocytopenia, plasma for coagulopathies, Cryo-ppt for hemophilia, etc [4].

Blood component therapy; it is a practice to transfuse the component which the patient requires and the rest of the components are kept available for other patients. It is also helpful in meeting the gap between demand and supply, especially in underdeveloped and developing countries like India [5, 6]. In the majority of cases it is preferable to provide ABO blood group identical components for transfusions; however, on occasions it may be necessary to provide ABO-compatible non identical components instead [7]. ABO-compatible non identical components can also be issued in situations where unavailability/ excess of particular components are there in stock. The compatibility chart for RBCs, Plasma, platelets and cryo-ppt, is shown in Figure no.1, similarly reported in reference no. [8]

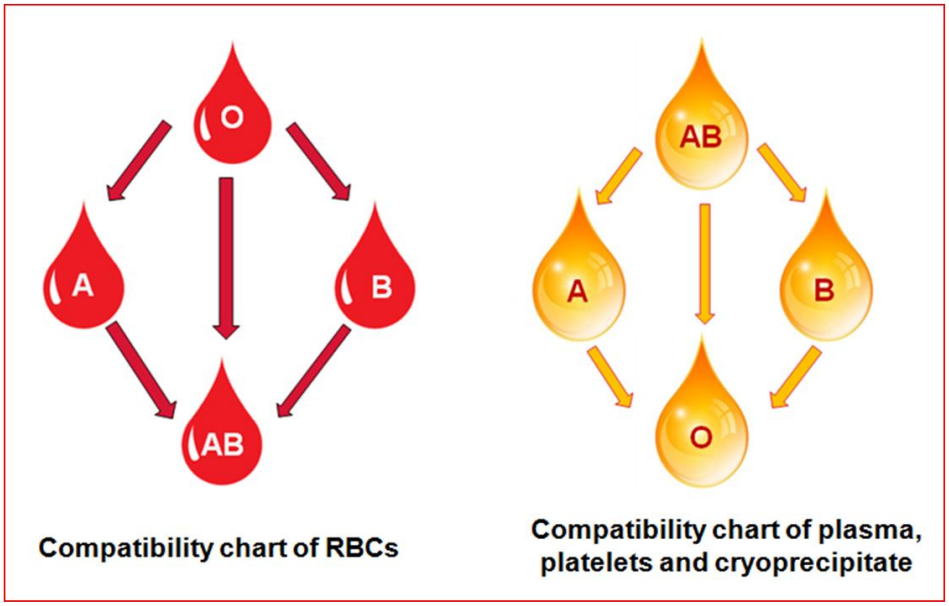

Figure no.1 Compatibility chart for RBCs, Plasma, platelets and Cryo-ppt.

Circumstances where the compatible blood components can be beneficial to the patients are:

1. Hemolytic disease of New Born (HDN). In these cases of ABO, RhD and Non ABO & RhD HDN, O cells with RhD status of mother and AB plasma i.e. Whole Blood Reconstituted ABO inert (WBR-I) can be provided for exchange transfusion in baby irrespective of mother's and baby's ABO Status (Provided O cells are cross matched with mothers serum) [9,10].
2. In the circumstances where ABO Identical Component (IC) is not available, Compatible Component (CC) to the patient is beneficial and life saving [11].
3. In the situations where excess of components are available, it can be issued according to the compatibility chart no 1 [8].
4. In the situations where blood group of the patients is not known or not confirmed, O RhD Negative cells and AB group Plasma/ platelets/cryo-ppt is the choice of components for transfusion [11].

There is a prevailing theoretical concept for the utility and safety of ABO compatible non identical blood components and their use is advocated and practiced worldwide. A handful of studies have explored the scope of these non identical compatible components individually [12, 13]. However, blood components in Toto have not been extensively studied with respect to feasibility in the situations where identical transfusion is not possible and compatible blood products have to be resorted to.

To the best of our knowledge, this is one of a kind study aiming to evaluate the efficacy of ABO compatible non identical blood components transfusions in routine and emergencies and its pro and cons over identical components.

II. Materials and methods

It is a approximately 7 years retro-prospective study from 1st January 2012 to 1st December 2018 conducted at Blood Bank, Department of Pathology, Gajra Raja Medical College, Gwalior M.P., India. During the studied period, we had done hundred percent blood components separation along with 1st log universal Leukoreduction of the collected units [14]. Blood components were prepared by conventional method of centrifugation and separation and Single Donor Platelet (SDP) by Aphaeresis using the device made – Haemonetics. The preparation of components is summarized in Figure no. 2.

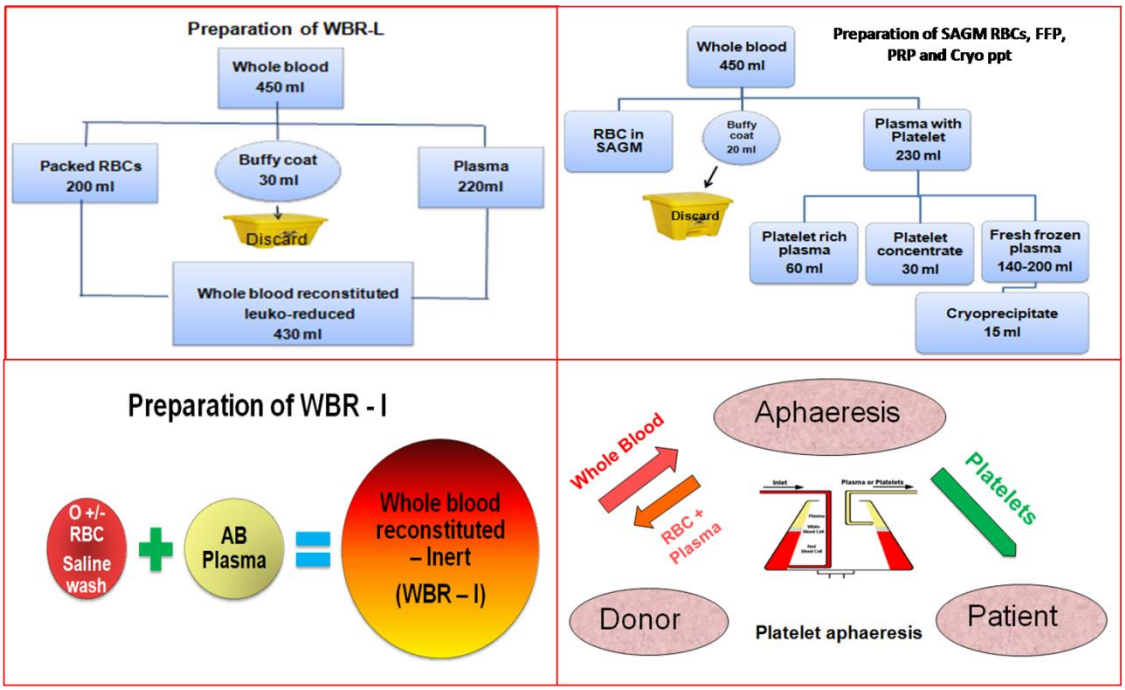

Figure 2 . Flow charts of preparation of blood components .

The Equipments used for the preparation and storage of components are; Cryofuge 6000i (Thermofisher), laminar flow, Optipress II (Bexter), Sterilized tube connecting device (Termopenpol), tube sealer (Termopenpol), Platelet incubator and agitator (Termopenpol), Storage device of 4^oC,-40^oC and -80^o C temperature etc.

Components routinely prepared and issued in our setup are:

1. Whole Blood Reconstituted; ABO inert **(WBR-I)** i.e. O Cells suspended in AB Plasma.
2. Whole Blood Reconstituted Leukoreduced (**WBR-L**); -Removal of Buffy coat from whole blood.
3. Packed Red blood cells in additive solution (**SAGM RBCs**) -

(SAGM: Saline Adenine Glucose Manitol);

4. Saline wash RBCs (**S-RBCs**) - RBCs are washed with saline thrice and suspended in saline.
5. Fresh Frozen Plasma (**FFP)** - Plasma is separated from whole blood within 6 hours of collection and stored at -40^0C or below.
6. Cryoprecipitate (**CRYO-PPT**) - Plasma kept on -80^0C for one hour, thawed up to 4^0 C, light Spin (1800 rpm) for 5 minutes and removes the supernatant and sediment left with 20 ml plasma, and stored at -40^0C or below.
7. Platelet Rich Plasma **(PRP**) - First light Spin (1800 rpm) whole blood, separate out the supernatant plasma, then heavy spin (3200 rpm) and supernatant separated out, 60 ml plasma left with the platelets sediment. Stored at 22^0C in platelets incubator and agitator.
8. Platelet Concentrate (**PC**) - Platelets are dissolved in 30 ml plasma.
9. Pooled Platelets (PP) -3 to 5 units of PC pooled and issued to patients.
10. Single donor platelets (**SDP)** – Platelet aphaeresis.
11. Umbilical cord blood (**UCB**).

Prepared blood components are stored at proper temperatures and issued to the patients as per Standard Operating Procedure (**SOP**).

All data of components prepared, issued and its adverse effect of transfusion to the patients had been collected and tabulated. Data is summarized and compared statistically by frequency distribution and percentage proportion. Chi square (X2) test was applied to know the significant *(p value)* ratio of difference statistically by using software **EpiCalc 2000,** a statistical calculator.

III. Result

A total number of 122672 blood units were collected during the study period; Out of 122672 collected blood units, 253238 units blood components were prepared. Mean Conversion rate of components against the units collected is 2.06. Yearly components prepared and conversion rate was shown in Table no 1.

Table no. 1: Yearly collection of blood units, components prepared and conversion rate

Year	Total Unit Collected	Total Unit generated Through 100% component	Component Conversion Rate/ unit
2018	23010	48781	2.12
2017	20500	37709	1.88
2016	18297	39161	2.14
2015	16630	34941	2.10
2014	15761	33313	2.11
2013	14473	30010	2.07
2012	14001	29323	2.10
Total	**122672**	**253238**	**2.06**

Out of 122672 collected blood units, 118335 (96.47%) blood units were found fit for transfusion (TTI non reactive) and 4337 (3.53%) units which were positive for transfusion transmitted infections (TTIs), were not fit for transfusion and discarded as per Drug and Cosmetic rules , Government of India (Table no 2, Figure no 3).

Table No. 2: Yearly distribution of TTI status of blood units.

Year	Total Units Collected	TTI non reactive	TTI Positive	*P Value*
2018	23010	22335(97.1%)	675 (2.9%)	*(P=0.000001)*
2017	20500	19783(96.5%)	717(3.5%)	*(P=0.000001)*
2016	18297	17582(96.1%)	715(3.9%)	*(P=0.000001)*
2015	16630	16018(96.3%)	612(3.7%)	*(P=0.000001)*
2014	15761	15250(96.8%)	511(3.2%)	*(P=0.000001)*
2013	14473	13941(96.3%)	532(3.7%)	*(P=0.000001)*
2012	14,001	13426(95.9%)	575(4.1 %)	*(P=0.000001)*
Total	**122672**	**118335(96.5%)**	**4337(3.5%)**	***(P=0.000001)***

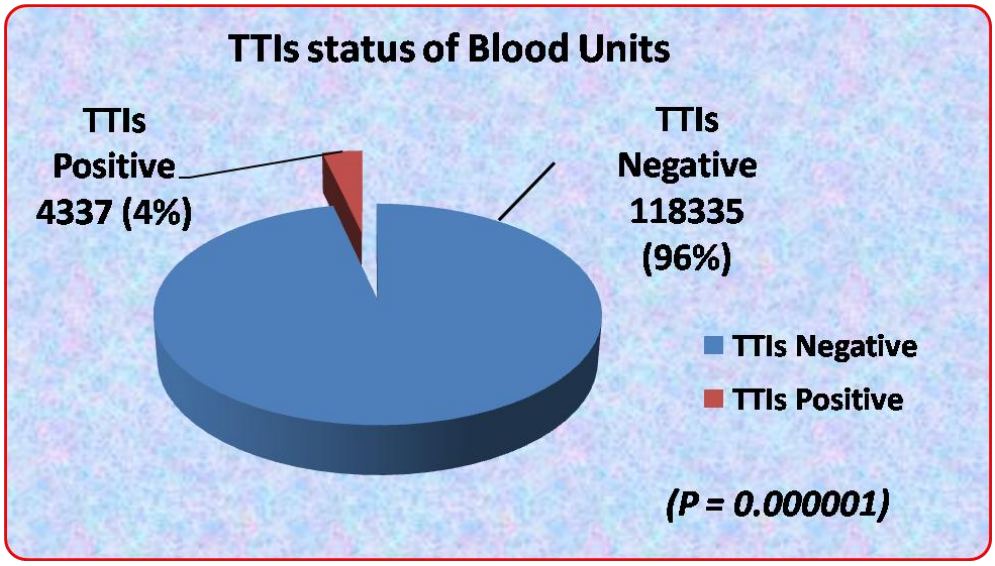

Figure no. 3 Total number of units deemed fit for transfusion and units rejected because of TTI positivity.

Distribution of total number of components prepared is depicted in Table no. 3

Table No. 3: Total components and their distribution

Components	**Number (%)**	
Components issued to patients	159036 (62.8%)	
Plasma issued along with WBR-LR	50095 (19.8%)	
Plasma sent for blood products	20020 (7.9%)	
Components TTIs Positive	8936 (3.5%)	***P = 0.000001***
Components discarded due to expiry	15151 (6%)	
Total components prepared	**253238**	

A total number of 159036 components were transfused to the patients. Details of different components transfused during study period and its yearly distribution is summarized in Table no 4 and Figure No 4.

Table No. 4 Yearly distribution of issued components

Year	Total Component	RBC	WBR-I	Platelets (PC+PRP PP)	FFP	CRYO PPT	WBR-LR	SDP	UCB	*P Value*
2018	30457	12420	62	3280	3914	140	10040	495	106	***0.000002***
2017	24225	10251	31	2749	3713	139	7059	138	145	***0.000002***
2016	24717	10422	51	2718	3607	94	7461	241	123	***0.000002***
2015	22376	9890	48	1901	3684	161	6442	231	19	***0.000002***
2014	20422	8051	56	1803	2734	124	7531	123	0	***0.000002***
2013	18863	8020	60	1867	2375	148	6148	245	0	***0.000002***
2012	17976	8400	85	1590	2294	91	5414	102	0	***0.000002***
Total	159036	67454	393	15908	22321	897	50095	1575	393	***0.000002***

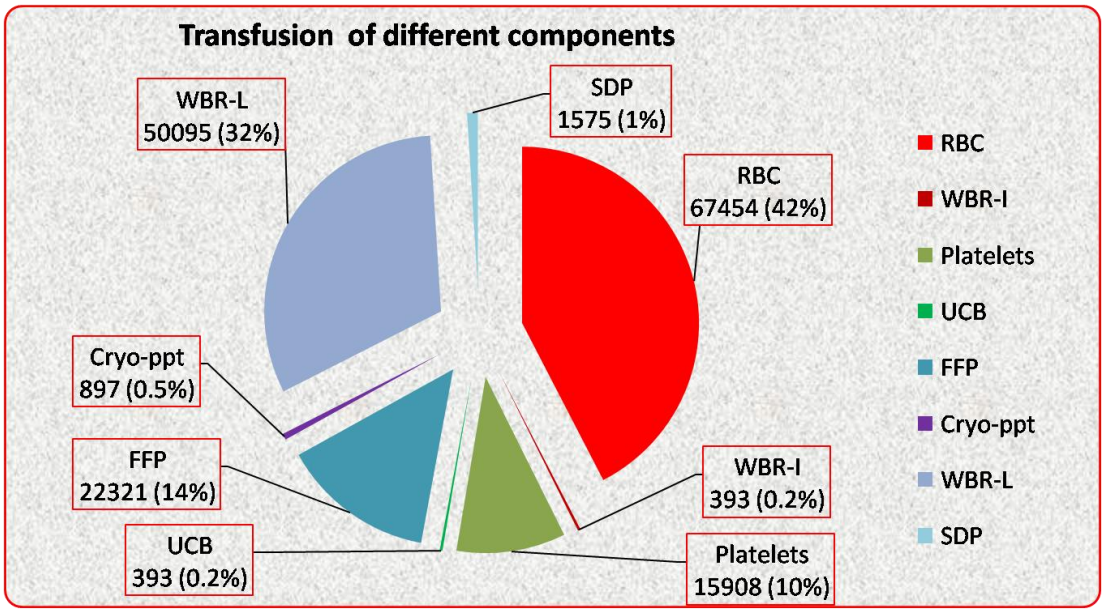

Figure No. 4 Distribution of the components issued in the study.

Transfusion of ABO and RhD Identical versus Compatible blood components in the study are summarized in Table no 5.

Table No 5. Identical vs. Compatible issued blood components

Component	Total	Identical Component	Compatible Component	*P value*
RBC	67454	53964 (80%)	13490 (20%)	*0.000001*
WBR -I	393	0 (0)	393 (100%)	*0.000001*
PLATELETS	15908	13045 (82%)	2863 (18%)	*0.000001*
FFP	22321	20982 (94%)	1339 (06%)	*0.000001*
CRY-PPT	897	449 (50.05%)	448 (49.95%)	*0.759028*
WBR-LR	49274	49274 (100%)	0 (0)	*0.000001*
SDP	1575	1323 (84%)	252(16%)	*0.000001*
UCB	1214	1214 (100%)	0 (0)	*0.000001*
Total	159036	140251(88%)	18785 (12%)	*0.000001*

Evaluation of compatible versus identical component was done on the basis of adverse transfusion reactions encountered with these components. Known adverse reactions to transfusion of blood and its components are Acute Hemolytic transfusion reaction (AHTR), Delayed hemolytic transfusion reaction (DHTR), Febrile non hemolytic transfusion reaction (FNHTR), Allergic reaction (AR), Anaphylactic reaction (AnR), Transfusion related acute lung injury (TRALI), Transfusion related sepsis (TRS), Non immune hemolysis (NIH), Transfusion associated circulatory overload (TRACO), Air embolism (AE), Alloimmunization, Graft versus host disease (GVHD), Post transfusion purpura (PTP) and Iron overload.

However, we have encountered AHTR, DHTR, FNHTR, AR and TRACO during our study. Adverse events of transfusion occurred during the study period by different components are summarized in Table no 6.

Table No. 6. Adverse events of transfusion by different components

Components	Type	Total Units	AHTR	DHTR	FNHTR	AR	TACO	Total Reactions	*P Value*
RBC	IC	53964	10	80	52	50	10	202	*0.000001*
	CC	13490	5	26	11	0	0	42	*0.000001*
WBR -I	IC	0	0	0	0	0	0	0	*0.000001*
	CC	393	0	0	0	0	0	0	*0.000001*
PLATELETS	IC	13045	0	0	232	10	0	242	*0.000001*
	CC	2863	0	0	48	0	0	48	*0.000001*
FFP	IC	20982	0	0	0	450	20	470	*0.000001*
	CC	1339	0	0	0	41	4	45	*0.000001*
CRY PPT	IC	449	0	0	0	0	0	0	*0.000001*
	CC	448	0	0	0	0	0	0	*0.000001*
WBR-LR	IC	49274	9	55	450	800	8	1322	*0.000001*
	CC	0	0	0	0	0	0	0	*0.000001*
SDP	IC	1323	0	0	2	7	0	9	*0.000001*
	CC	252	0	0	0	2	0	2	*0.000001*
CORD BLOOD	IC	1214	0	0	0	0	0	0	*0.000001*
	CC	0	0	0	0	0	0	0	*0.000001*
Total	159036		24	161	795	1360	42	2382	*0.000001*

Abbreviations; IC- Identical component, CC- Compatible component, AHTR -Acute Hemolytic transfusion reaction, DHTR - Delayed hemolytic transfusion reaction, FNHTR - Febrile non hemolytic transfusion reaction, AR -Allergic reaction, TRACO - Transfusion associated circulatory overload.

Incidence of total adverse event in the study was 1.497 %; where adverse event by identical components was 1.60% and by compatible components was 0.73 %.

IV. Discussion

Among all the 35 major human blood group systems [15] and 346 antigens expressed on blood cell membrane surfaces by November 2014 [16], the most important of these are ABO and RhD. Transfusion with ABO incompatible blood can lead to severe and potentially fatal transfusion reactions [17]. ABO is the ONLY system that the reciprocal antibodies (IGM) are consistently and predictably present in the sera of people who have had no exposure to human red cells [18]. RhD antigen is important because of it is highly immunogenic and can lead to red cell haemolysis in certain settings [17].

When we talk about identical components (IC) or compatible component (CC), it is related to ABO and RhD groups only. These components were issued after saline/ ICT (Indirect coomb's test) cross matching by Tube/ Gel technology to rule out other blood group irregular antibodies [17, 18].

Journey of our Blood Bank in the city of Gwalior started from 1950, achieving full functionality in 1959 at J. A. Group of Hospitals, Gwalior attached to G R Medical College, Gwalior. In 1994, the component unit was setup in blood bank. Till 2011 we achieved the target of 100% component preparation and 1st log universal leuko-reduction (ULR) of the collected blood units. Platelet aphaeresis was also started by then. We have comprehensively studied the component preparation in this study since 2012.

We are doing 1st log ULR by removal of Buffy coat layer during the preparation of blood components. The residual leukocytes in the units range from 500- 800/cu mm i.e. removal of approximately 90% of leukocytes from the units supplied. This dose is well below the critical antigenic load i.e. $0.5X10^8$ to prevent the febrile non hemolytic transfusion reactions (FNHTRs) [19]. In one of our earlier studies we have reported a significant reduction in rate of FNHTRs from 0.84% in the study group to 4.26% in control group. Significant reduction of FNHTRs in study group over control group was reported in WB/ WBR, Packed RBCs, SAGM RBCs and platelet concentrates while it was non-significant in case of saline washed RBCs and WBR because of the fact that saline washed procedure in both the components already reduced the WBC in study group [14].

Theoretically, one unit of whole blood yields four types of components i.e. RBCs, platelets, FFP and cryoprecipitate. However, we have achieved an average conversion rate of 2.06 from whole blood units to blood components as the blood collection from the donors is round the clock and processing and separation of components is done from the blood units collected during the day time and from odd hours units WBR-L is prepared. Thus a steady conversion rate is maintained without compromising the quality and viability of blood components.

We recorded a 3.5% TTIs positivity in total units collected in this study. Out of the total components prepared (253238), 3.5% were TTIs positive. In one of our 10 year study, overall prevalence of TTIs was 3.26%. It showed an increasing trend from 2.25% in first five years to 4.09% in later five years [20].

In other Indian studies by Chandekar et al, and Rawat et al the overall reported prevalence of TTIs was 2.10% and. 2.25% respectively [21, 22]. The higher prevalence in our study can be attributed to strict Sero-vigilance monitoring.

A total of 62.8% of prepared components were issued to patients, constituting; RBCs for replacement in hypoxia, major surgery and trauma, platelets for thrombocytopenia in dengue viral fever, trauma, malignancy, stroke and aplastic anemia, FFP issued in liver diseases, coagulopathies, burn, DIC, pre eclampsia and HELPP syndrome and Cryoprecipitate for hemophilia, eclampsia and DIC. Approximately 20% of the plasma prepared as component was added to separated packed RBCs which were left after Leukoreduction to make WBR - L.

As per directions by Central government, nearly 8 % of the plasma separated is sent for fractionization into freeze dried albumin and gamma globulin to INTAS pharmaceuticals limited, Ahmadabad, India.

Nearly 6 % of the components were discarded due to storage beyond expiry date, out of which platelets constitute majority (~ 90%) because of shortest shelf life (5 days).

Apart from conventional blood components, the components exclusively issued by our transfusion services are WBR-I, WBR- LR and UCB. The rationale behind WBR-I which is one of a kind practice in transfusion services as far as our knowledge goes, is that when O RhD +/- RBCs are washed with saline and reconstituted with AB plasma i.e. ABO Inert, thereby drastically reducing the chances of hemolytic transfusion reactions and allo- sensitization in recipient due to antibodies in donor plasma. This makes WBR- I immunologically much safer and better than whole blood for purpose of exchange transfusion in hemolytic disease of new born (HDN). In our earlier studies we have already reported the success of WBR-I in exchange transfusion in HDN with average fall in indirect serum bilirubin 54.6%, an average increase of Hb by 3.7 gm/dl, survival of transfused RBCs 100%, removal of sensitized RBCs and circulating mother's antibodies by 85% - 90% (double volume exchange transfusion)[9,10]. Another extremely promising utility of WBR - I is in emergency situations where the blood group is not known or cannot be determined in time. In our earlier studies we have found that Umbilical cord blood is safe and genuine alternative of adult blood. It is effective in degenerative and autoimmune diseases. [23, 24]

Adverse transfusion reactions of identical and compatible components were compared and compatible RBCs were found to be safer. None of the cases transfused with compatible RBCs showed any allergic reaction as compared to identical RBCs (50 cases with allergic reaction). Compatible RBCs (O +/-) are washed with saline issued within 6 hours of preparation. Plasma is completely removed, hence, eliminating any allergic reaction. Overall incidence of transfusion reaction with compatible components (0.73%) was also found to be lower in comparison to identical component (1.6%), which was highly significant statistically ($p = 0.0000$), thus justifying their use in benefit of the recipient along with benefit for the transfusion services.

V. Conclusion

Here we conclude that by the virtue of component therapy, we are able to avert the crisis of excess and shortage of blood components in our set up. Incidence of transfusion reaction with compatible components is less as compared to identical components. In certain circumstances, compatible components have proven to be a better option than the identical components.

COMPETING INTERESTS

Authors have declared that there is no competing interest

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References

[1]. Learoyd P. A short history of blood transfusion. Leeds, UK: National Blood Service; 2006
[2]. Valentinuzzi ME - 2011. The development of Transfusion. https://ieeexplore.ieee.org/iel5/5454060/5783420/05783443.pdf http://www.aabb.org/tm/Pages/highlights.aspx
[3]. Blajchman MA, Shepherd FA, Perrault RA.Clinical use of blood, blood components and blood products. Can Med Assoc J. 1979 Jul 7;121(1):33-42.
[4]. Agarwal, S. P. (2012). National Voluntary Blood Donation Day- Message of The Secretary-General. From http://www.indianredcross.org/sgmessage- 27-sep-2013.htm

[5]. Aggarwal S. and Sharma V. (2012). Attitudes and problems related to voluntary blood donation in India: A short communication. Ann Trop Med Public Health, 5(50).
[6]. Component compatibility | Australian Red Cross Blood Service April 14, 20102010 https://transfusion.com.au/blood_basics/compatibility
[7]. https://www.utmb.edu/bloodbank/blood-bank-transfusion-services/component-therapy/blood-component-abo-compatibility-chart.
[8]. Sharma DC, Rai S, Mehra A, Kaur MM, Sao S, Gaur A, Sapra R ." Study of 25 cases of exchange transfusion by reconstituted blood in hemolytic disease of newborn", Asian Journal of Transfusion sciences, Volume 1, issue 2, July 2007, pp 56-58. www.ncbi.nlm.nih.gov/pubmed/21938234
[9]. Sharma DC, Rai S, Iyengar S, Jain B, Sao S, Gaur A, Sapra R. Efficacy of Whole Blood Reconstituted (WBR) in Exchange Transfusion (ET) in Hemolytic disease of New Born (HDN) – A study of 110 Cases. Open Journal of Blood Diseases, 2013; 3(1): 15-20. DOI: 10.4236/ojbd.2013.31004,
[10]. ABO Compatibility and Acceptable Substitutions | Canadian Blood….. https://blood.ca/en/hospital-services/inventory.../compatibility-and-substitutions
[11]. Valsami S, Dimitroulis D, Gialeraki A, Chimonidou M, Politou M. Current trends in platelet transfusions practice: The role of ABO-RhD and human leukocyte antigen incompatibility. *Asian J Transfus Sci*. 2015; 9(2):117-23.
[12]. Inaba K, Branco BC, Rhee P, Holcomb JB, Blackbourne LH, Shulman I, Nelson J,Demetriades D. Impact of ABO-identical vs ABO-compatible nonidentical plasma transfusion in trauma patients. Arch Surg. 2010 Sep; 145(9):899-906. doi:10.1001/archsurg.2010.175. PubMed PMID: 20855762.
[13]. Dharmesh Chandra Sharma, Sunita Rai, Shruti Gupta and Bharat Jain. Universal Leukoreduction Decreases the Incidence of Febrile Nonhemolytic Transfusion Reactions to Cellular Blood Components: A 5 Year Study. International Blood Research & Reviews, ISSN: 2321–7219,Vol.: 2, Issue.: 6 (Nov.-December)
[14]. ISBT (2014). "Table of Blood Group Systems v4.0 (November)" (PDF). International Society of Blood Transfusion. Retrieved 19 February 2016.
[15]. Lane, W.J.; Westhoff, C.M.; Uy, J.M.; Aguad, M.; Smeland-Wagman, R.; Kaufman, R.M.; Rehm, H.L.; Green, R.C.; Silberstein, L.E. (2015). "Comprehensive Red Blood Cell and Platelet Antigen Prediction from Whole Genome Sequencing: Proof of Principle". Transfusion. **56** (3): 743–54.
[16]. Blood Transfusion : Blood Groups and Compatibilities
[17]. https://www.rch.org.au/bloodtrans/about_blood_products/Blood_Groups_and_Compa..
[18]. ABO grouping and Rh typing- National Blood Transfusion Council…. nbtc.naco.gov.in/assets/resources/training/5.pdf
[19]. Leucoreduction-The future of blood components -Medical Buyer Available:http://www.medicalbuyer.co.in/index.php?option=com_content&task=view&I d=3102&Itemid=49
[20]. Chandra Sharma, D. , Rai, S. , Bharat, S. , Iyenger, S. , Gupta, S. and Jain, B. (2014) A 10 Years Comparative Study to Assess Trends in Seroprevalence of Transfusion Transmitted Infections among Blood Donors at Gwalior, India. *Open Journal of Blood Diseases*, 4, 24-32.
[21]. Chandekar SA, Amonkar GP, Desai HM, Valvi N, Puranik GV. Seroprevalence of transfusion transmitted infections in healthy blood donors: A 5-year Tertiary Care Hospital experience. J Lab Physicians. 2017 Oct-Dec;9(4):283-287.
[22]. Rawat A, Diwaker P, Gogoi P, Singh B. Seroprevalence & changing trends oftransfusion-transmitted infections amongst blood donors in a Regional Blood Transfusion Centre in north India. Indian J Med Res. 2017 Nov;146(5):642-645.
[23]. Dharmesh Chandra Sharma, Nidhi Agrawal, Jyoti Bindal, Poonam Woike, A. S. Tomar, Anita Arya. A Study of 120 Umbilical Cord Whole Blood Transfusions in 77 Patients with Different Clinical Conditions. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) Volume 16, Issue 4 Ver. IV (April. 2017), PP 05-12 DOI: 10.9790/0853-1604040512.
[24]. Khatoon M, Bindal J, Sharma DC, Gupta P, Tomar AS, Saify K and Gupta R. Utility of Placental Umbilical Cord Blood in Autoimmune and Degenerative Disorders International Blood Research & Reviews 2018 8(4): 1-9, 2018.

Dr. Prakriti Gupta. "Utility of compatible non identical blood components in transfusion services". " IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 17, no. 12, 2018, pp 33-40.