Universal Leukoreduction Decreases the Incidence of Febrile Nonhemolytic Transfusion Reactions to Cellular Blood Components: A 5 Year Study

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Authors’ contributions

This work was carried out in collaboration between all authors. Author DCS designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors SR and SG managed the literature searches; analyses of the study performed the spectroscopy analysis. Author BJ managed the experimental process and supervised the research work. All authors read and approved the final manuscript.

ABSTRACT

Background: Febrile nonhemolytic transfusion reactions (FNHTRs) are common complications associated with allogenic transfusion and it is caused by the leucocytes and cytokines released by leucocytes during storage of blood/blood components. These reactions are generally not life threatening, but they are expensive in their management, evaluation, and associated blood-product wastage. 1st log prestorage universal leukoreduction (ULR) i.e. removal of Buffy coat is a useful and effective procedure in developing countries to control FNHTRs significantly.

Aims and Objects: To know the efficacy of pre-storage 1st log universal leukoreduction in controlling febrile nonhemolytic transfusion reactions (FNHTRs).

Place and Duration of Study: Study was carried out at Blood Bank, Department of Pathology, G. R. Medical College, Gwalior from January 2009 to December 2013 (5years).

Materials and Methods: Study was divided into control group (Year: 2009) and study group (Years: 2010-13). 14,292 recipients in control group and 45,064 in study group

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were transfused with non-leukoreduced and prestorage 1st log leukoreduced blood/ blood components respectively. Usefulness of prestorage 1st log ULR over non-leukoreduced blood/ blood components was observed, compared and discussed.

**Result:** In the control group 610 (4.26%) out of 14,292 \((p=0.0003)\) and in study group 381(0.84%) out of 45,064 \((p=0.0003)\) recipients were reported to have FNHTRs. The comparative study showed significant reduction in FNHTRs from 4.26% to 0.84% \((-3.42\%)\) \((p=0.000001)\).

**Conclusion:** 1st log Universal Leukoreduction (ULR) is a better option over Selective Leukoreduction (SLR) to prevent FNHTRs and it also helps the transfusion services of under-resourced developing countries in many ways.

**Keywords:** Blood transfusion; universal leukoreduction; selective leukoreduction; febrile non-hemolytic transfusion reaction.

1. INTRODUCTION

Half a century ago, most of the blood transfused was whole blood. In last fifty years, there was a significant shift in strategy of the transfusion of allogenic blood after a concept that blood can be separated in its components; RBCs, WBCs, Platelets, Plasma and Cryoprecipitate [1]. Since blood component therapy came in existence with the thought to transfuse only those components which patients require and keep the rest for the others. At present blood and blood components are treated as drugs because of their use in treating diseases and like drugs, it has adverse effects also [2].

Among all the components, indications of transfusion of White Blood Cells (WBC or leukocytes) in transfusion services are limited or there is no valid indication of transfusion of WBCs except uncontrolled bacteremia, septicemia and eclampsia not responding to antibiotics. On the other hand it produces severe adverse effects to the recipient when transfused along with blood or blood product. These are febrile non-hemolytic transfusion reactions (FNHTRs), alloimmunization, immunomodulation, transmission of cytomegalovirus (CMV), other leukotropic viruses and so on [3-8]. Now a days, the removal of white blood cells (or leukocytes) from the blood or blood components supplied for transfusion is recommended. After the removal of leukocytes, the blood product is said to be ‘leukoreduced’.

Leukoreduction when performed on each and every supplied blood component is called Universal Leukoreduction (ULR). When it is done for a special group of patients, is called Selective leukoreduction (SLR) [9,10,11]. Several authors describe the usefulness of ULR over SLR [1,12]. Leukoreduction when performed at the time of preparation of components prior to storage is termed as prestorage leukoreduction and when it is performed before or concurrent with administration, is termed poststorage leukoreduction [13,14]. Prestorage leukoreduction is recommended over post storage because of its advantages [12,15-22].

FNHTR is one of the most common adverse effects of blood / blood components transfusion. It is caused by the interaction between transfused leucocytes and recipients cytotoxic antibodies as well as release of cytokines by WBC during the storage of blood components [23]. These reactions are generally not life threatening, but they are expensive in their management, evaluation, and associated blood-product wastage.
The usual level of leukoreduction to prevent the febrile non-hemolytic transfusion reaction (FNHTR) is $0.5 \times 10^8$, i.e., 1 log reduction, which can be achieved by removing Buffy coat. However, for preventing alloimmunization or transmission of viruses like CMV, the residual leukocyte level should not be more than $5 \times 10^6$, is called critical immunogenic leukocyte load [24] which can be achieved by filtration.

1st log prestorage universal leukoreduction (ULR) i.e. removal of Buffy coat is a useful, effective and non-expensive procedure in under resourced developing countries to control FNHTRs significantly [24].

2. MATERIALS AND METHODS

Present study was carried out at the Blood Bank, Department of Pathology, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India from 2009 to 2013 (5 years). Study was divided into two groups; control and study group. Control group constituted of 14,292 blood transfusions from 1st January 2009 to 31st December 2009 (one year) where non-leukoreduced whole blood (WB) / blood components were supplied to the recipients. In study group 45,064 transfusions were performed with leukoreduced Whole Blood Modified (WBM) /blood components during the period of 1st January 2010 to 31st December 2013 (4 years).

Blood and blood components supplied were whole blood (WB), Whole Blood Modified (WBM), Whole Blood Reconstituted (WBR), Packed Red Blood Cells (RBCs), Saline Wash Red Blood Cells (Saline RBCs), Saghm Blood Cells (Saghm RBCs), Platelet Concentrate (PC), Buffy Coat Platelets (BP) and Aphaeresis Platelets (AP). All blood/blood components were screened for transfusion transmitted infections i.e. Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), Syphilis and Malaria as per National AIDS Control Organization (NACO) guidelines in India [25]. All blood/blood components were issued after blood grouping (ABO & Rh) and cross matching by saline / Indirect Coomb’s Test (ICT by Gel Technology; Make Tulip) method.

All blood components were prepared by conventional method; centrifugation and separation in close system. Blood was collected in triple bags, quadruple SAGM (an additive solution; saline, adenine, glucose & manitol) bags, top and bottom SAGM bag and aphaeresis bags. For preparation of components, our blood bank is fully equipped with the instruments like; deep fridge centrifuges (Cryofuse 6000i: Make- Thermo Scientific), laminar flow (Make- Yarco), plasma extractors, Optipress II (Make- Baxter), dielectric tube sealer (Make- Ljungberg & Kogel AB), sterilized tube connecting device (Make- Terumo Penpol), deep freezers of -40°C and -80°C (Make- Haier & Terumo Penpol), cryo-water bath (Make- Yarco), electronic balance etc.

In the study group 1st log universal leukoreduction i.e. removal of buffy coat was done with the closed method. In the process of leukoreduction, 5 to 10% loss of RBCs was observed as reported [26]. Between 6 PM to 6 AM, blood was collected in triple bags and it was processed after 6 to 12 hours of collection, leukoreduced WBM was prepared by removal of buffy coat and keeping RBCs and plasma within the unit. Removal of buffy coat from rest of the components was done during its preparation. Saline washed RBCs were prepared by washing the RBCs with 0.9% normal saline (NS) thrice, using sterilized tube connecting device. Whole Blood Reconstituted (WBR) i.e. O +/- cells suspended in AB plasma was prepared for exchange transfusion in Hemolytic Disease of Newborn [27,28]. Platelet concentrate was prepared by conventional method while buffy coat platelets and aphaeresis
platelets were prepared by using automatic plasma extractor and aphaeresis device respectively.

FNHTRs are characterized by temperature increase of ≥1°C (2°F) above the base line (baseline ≤37°C or ≤98.4°F) during or shortly after transfusion and it can also be accompanied by chills/rigors, hypertension, tachycardia and dyspnea [29,30]. Blood/ blood components were issued along with transfusion reaction card and feedback was recorded in transfusion reaction register as a routine procedure. Whenever adverse reactions were reported, proper inventory and investigation procedures were done to confirm the type of reaction. Registry of FNHTRs was tabulated and its incidence was calculated and discussed. Allergic and other adverse effects of transfusion were not included in the study. Data has been compared statistically by frequency distribution and percentage proportion. Chi square \( (X^2) \) test was applied to know the significant \( (p \text{ value}) \) ratio of difference statistically.

3. RESULTS

In 5 year study, total 59,356 transfusions were given to the patients. In control group it was 14,292 and in study group it was 45064. In control group, 610 (4.26%) out of 14,292 \( (p=0.0003) \) transfusions were reported to have FNHTRs while in study group it was 381 (0.84%) out of 45064 \( (p=0.0003) \). Declining incidence of FNHTRs from control (4.26 %) to study group (0.84%) was 3.42% (\( \downarrow \) \( p=0.000001 \)) while for different components it was WB/ WBM; 5.50% (240/5333) to 0.88% (42/4770) (\( \downarrow \) \( 4.62\%) \( p=0.000001 \)), Packed RBCs; 4.19% (296/7054) to 0.86% (240/27897) (\( \downarrow \) \( 3.33\%) \( p=0.000003 \)), Sagm RBCs; 4.28% (6/140) to 0.82% (4/5970) (\( \downarrow \) \( 3.46\%) \( p=0.000018 \)), Saline Wash RBCs; 1.01% (1/99) to 0.63% (4/631) (\( \downarrow \) \( 0.38\%) \( p=0.0624 \)), WBR; 3.57% (2/56) to 0.51% (1/196) (\( \downarrow \) \( 3.06\%) \( p=0.0624 \)), Platelet concentrate; 4.03% (65/1610) to 0.84% (32/3777) (\( \downarrow \) \( 3.19\%) \( p=0.00001 \)). Incidence of FNHTRs in buffy coat platelets and aphaeresis platelels was 0.71% (11/1540) and 0.70% (2/283) respectively in study group while facilities for preparation of these components were not present in the year 2009 (control group period) (Table 1, Fig. 1).

![Comparative incidence of FNHTRs in control and study group](image)

**Fig. 1. Comparative incidence of FNHTRs in control and study group**

*Abbreviations: FNHTRs- Fibril Non Hemolytic Transfusion Reactions, WB- Whole Blood, WBM- Whole Blood Modified, RBCs- Red Blood Cells, Sagm- Saline Adenine Glucose Manitol; additive solution, WBR- Whole Blood Reconstituted*
Table 1. Incidence of FNHTRs in control and study group

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Blood components transfused</th>
<th>Control group (Year: 2009)</th>
<th>Study group (Year:2010-2013)</th>
<th>↓ Incidence of FNHTRs from control to study group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of transfusions</td>
<td>No. of FNHTRs</td>
<td>Incidence of FNHTRs</td>
<td>No. of transfusions</td>
</tr>
<tr>
<td>1.</td>
<td>WB / WBM</td>
<td>5333</td>
<td>240</td>
<td>5.50</td>
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<td>2.</td>
<td>Packed RBCs</td>
<td>7054</td>
<td>296</td>
<td>4.19</td>
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<tr>
<td>3.</td>
<td>Sagm RBCs</td>
<td>140</td>
<td>6</td>
<td>4.28</td>
</tr>
<tr>
<td>4.</td>
<td>Saline wash RBCs</td>
<td>99</td>
<td>1</td>
<td>4.28</td>
</tr>
<tr>
<td>5.</td>
<td>WBR</td>
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<td>2</td>
<td>3.57</td>
</tr>
<tr>
<td>6.</td>
<td>Platelet concentrate</td>
<td>1610</td>
<td>65</td>
<td>4.63</td>
</tr>
<tr>
<td>7.</td>
<td>Buffy coat platelets</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8.</td>
<td>Aphaeresis platelets</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1 to 8.</td>
<td>Total</td>
<td>14292</td>
<td>610</td>
<td>4.26</td>
</tr>
</tbody>
</table>

Abbreviations: FNHTRs- Febrile Non Hemolytic Transfusion Reactions, ↓ incidence – declining incidence, WB- whole blood (in Control group), WBM- whole blood modified (in study group), RBCs- Red Blood Cells, Sagm- Saline Adenine Glucose Manitol (additive solution), WBR- Whole Blood Reconstituted
4. DISCUSSION

Before the year 2010, transfusion services of our institute was supplying non-leukoreduced whole blood and its components to the recipients. Only in selected cases of multiple transfusions like hemato-oncology patients, thalassemia etc, saline washed RBCs were supplied and whenever patient's attendant could bear the expenses of the procedure, prestorage or poststorage leukoreduction filters were used to supply the leukoreduced RBCs i.e. selective leukoreduction (SLR). Since 2010, we have chosen the policy of universal leukoreduction and we are doing 1st log ULR by removal of buffy coat layer during the preparation of blood components. The residual leukocytes in the units were 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. .5X10^8 to prevent the FNHTRs [24]. By doing that, rate of FNHTRs came down significantly in the study group (0.84%) over control group (4.26%) with the reduction of 3.42% (↓) which was comparable with the study done by Perrotta PL et al. & King KE et al. [30,31]. Significant reduction of FNHTRs in study group over control group was reported in WB/ WBM, 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.

Our study also supports the finding of several recent studies [32,33]. Prestorage leukoreduction is currently the most widely accepted mode over post storage leukoreduction because it eliminates the scope of inflammatory cytokines (interleukin 1, interleukin 6 and tumor necrosis factor) release from leukocytes during storage, hence efficient in the prevention of FNHTRs [34,35,36]. It also minimize the risk of leukotropic transfusion transmitted virus as leukocytes disintegrate and release the intracellular organism after 72hours of storage in blood components [32,37] and HLA alloimmunization in multi-transfused patients as it removes the intact leucocytes [38,39].

When the unit of blood (approximately 450 ml) is collected; about 2 billion (2x10^9) WBCs are present. Even with blood component processing, 90% of these cells remain with the RBCs, primarily as granulocytes; 8% of the cells remain with the platelets as mononuclear cells; and 2% of cells remain in an aliquot of fresh frozen plasma. The intent of leukoreduction is to reduce the number of white blood cells in the aliquot but the 0.0005% of the cells left after leukoreduction leaves 5000 residual leucocytes. Filtering of white cells can lead to a 5-10% loss in the number of RBCs recovered per unit. These losses may be justified, however, because they are balanced in part by the improved quality of leucoreduced RBCs unit [26]. Similar loss of RBCs was also reported in our study using 1st log leukoreduction i.e. removal of Buffy coat.

Removal of Buffy coat significantly reduces the FNHTRs, however the limitation of this technique is that it can only reduces the chances but cannot prevent the alloimmunization, immunomodulation, transmission of cytomegalovirus (CMV) and other leukotropic viruses [1,12,24]. In under-resourced developing countries like India, main hurdle for ULR by leukofiltration is the expense of the procedure and it is only limited to SLR. Under these circumstances ULR by removal of Buffy coat is a clinically useful option because of 1) No processing expenses transfer to the patients. 2) Incidence of alloimmunization, immunomodulation, transmission of cytomegalovirus (CMV) and other leukotropic viruses is very low [12]. Author has rarely reported these reactions in his 33 years of clinical practice. 3) Reduction in over all transfusion reactions. 4) Prevents the wastage of precious human resources i.e. blood/ blood components. 5) Prevents the extra cost of management of
FNHTRs. 6) Reduces the panic of transfusion reaction among hospital staff and patients, hospital stay of patients and the extra load on overburdened hospital management.

5. CONCLUSION

We concluded that prestorage even 1st log universal leukoreduction of allogenic cellular components is better option over selective leukoreduction by filtration in under-resourced developing countries like India. It reduces the incidence of FNHTRs significantly and also helps in preventing the other adverse effects of WBCs when transfused along with the cellular components of blood. Hence we recommend that 1st log universal leukoreduction is a clinically useful procedure where universal leukoreduction by filtration or other expensive methods is not practically possible.

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CONSENT

The author(s) declare that written informed consent was obtained from the patients before being recruited for this research.

ETHICAL APPROVAL

All author(s) hereby declare that all procedure have been examined and approved by the appropriate ethics committee of Gajra Raja Medical College, Gwalior, India and research have therefore been performed in accordance with the ethical standards laid down in the 1964 declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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