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Research Article

Red Cell Usage for Red Cell Exchange in Propanil Poisoning: A Descriptive Study

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Abstract

Background: Propanil poisoning is a significant herbicide poisoning in Sri Lanka and has a high morbidity following ingestion and could lead even to death. In the management of propanil poisoning, Red Cell Exchange (RCE), has been identified as an effective treatment modality when other treatment modalities are inadequate. There is a lack of high-quality data regarding RCE in propanil poisoning. This study was carried out to study the red cell usage in RCE in propanil poisoning.

Methodology: Retrospective data were collected on red cell usage for RCE within the 24-month period at a District general Hospital, Sri Lanka. Data were entered to a spreadsheet and descriptive analyses were performed.

Results: During the study period, a total of 22 RCE procedures were captured in 16 patients. Out of the 16 patients 14 (87.5%) were male and 2 (12.5%) were females. 16 (72.73%) procedures performed with automated cell separator and 6 (27.27%) procedures were completed in manual method. A total of 164 red cell units were needed for all patients giving a mean of 10.25 units per patient. The commonest blood group was O Rh D Positive (n=90, 54.88%), followed by A Rh D Positive (n=53, 32.32%). There were no RCE associated adverse events reported.

Conclusion: This study assesses the usage of red cell units and provides the impact of propanil poisoning on blood banks. It emphasizes the need for objective clinical thresholds to guide RCE initiation for severe methemoglobinemia. Further audits are recommended on blood product usage in apheresis procedures.

Keywords: Propanil poisoning, red cells, red cell usage, red cell exchange, apheresis

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Introduction

Propanil (3,4–dichlorophenyl propionanilide), which is an acetanilide, is a commonly used herbicide in Sri Lanka [1]. In propanil poisoning, the active metabolite of propanil is 3,4–dichloroaniline (DCA). Fe2+ ions are converted to Fe3+ ions in red blood cells, resulting in the formation of methaemoglobin [2]. Methaemoglobinaemia, which is defined as an elevation of blood methaemoglobin level by more than 1%, results in tissue hypoxia because methaemoglobin has a low oxygen-carrying capacity. Direct oxidative damage to red blood cells is another cause of low oxygen-carrying capacity [3]. Tissue hypoxia will lead to multi-organ failure, and in severe cases, this could be

fatal. Other toxic effects are lipoperoxidation, myelotoxicity, and immune dysfunction.

In the management of propanil poisoning, Supportive care such as intravenous (IV) fluids, strict bed rest, and oxygen therapy is beneficial [2]. Gastric lavage is useful for removal of the poison within 2 hours of ingestion. The drug of choice to treat propanil poisoning is methylene blue, which reduces blood methaemoglobin levels by converting methaemoglobin into haemoglobin. The usual dose is 1 - 2 mg/kg body weight (1% methylene blue 0.1 ml/kg) over 5 minutes, and this can be repeated in one hour. Ideally, methemoglobin levels must be monitored continuously.

If the clinical condition does not improve with the treatment of methylene blue, Red Cell Exchange (RCE) is an accepted treatment modality [2,4-6]. RCE is a type of apheresis in which red cells with methemoglobin are replaced with healthy donor red cells, thus improving oxygen-carrying capacity. RCE is an apheresis procedure that is performed using automated cell separators; however, when machines are not available, it can be carried out manually [7]. Blood volume is calculated according to the patient's gender, body weight, and height, and the patient's red cell volume is replaced with healthy red cells according to haematocrit. Therefore, patients need varying amounts of packed red cells for the procedure.

Blood products are a scarce resource as they cannot be manufactured artificially or replaced by pharmaceutical products. The blood stocks depend on many factors, including availability of donors, consumables, and blood bank staff [8]. Shortage of blood products is a challenge for every transfusion service in the world, and it poses a severe threat to healthcare systems, directly compromising patient outcomes. Furthermore, during mass-casualty incidents, transfusion services must transition from standard inventory management to emergency release of blood products [9]. Usually, Group O Rh D negative packed red blood cells and AB plasma have higher demand in such situations. As far as the financial impact of blood banking is concerned, the economic burden of blood products extends far beyond initial donor collection, heavily impacting healthcare infrastructure through hidden operational expenses. Considering all facts, studies are required to assess blood product utilisation. This study was conducted to assess red cell usage for RCE in propanil poisoning.

Methodology

This descriptive study was conducted at a blood bank of a District General Hospital in Sri Lanka for a period of 2 years from January 2024 to December 2025. The study population included patients who have undergone RCE for propanil poisoning. The researcher collected data by checking the patient records from the hospital. Information on patients' gender, age, blood group, number of RCE cycles performed, method of RCE, number of red cell units used and complications of the procedure was recorded. Data were entered in spreadsheet software and analysed.

RCE procedures have been performed automatically or manually. In both methods, patients' red cell volume was replaced with donor red cells. Red cell packs were tested for compatibility at the blood bank. Procedures were carried out at the medical intensive care unit (ICU) or at the high dependency units (HDU).

Results

The study population included 16 patients who underwent RCE for propanil poisoning. Out of them, 14 (87.5%) were male, and 2 (12.5%) were female. The mean age of the patients was 38.37 years (SD = 17.58). Regarding blood group, O Rh D Positive was the most common (n=8, 50%), followed by A Rh D Positive (n=4, 25%). 3 (18.75%) patients were B Rh D positive, and 1 (6.25%) was O Rh D Negative. The study population had a mean weight of 60.43 kg (SD = 11.43kg). The mean of the pre-procedure haemoglobin level was 11.64 g/dl (SD = 2.68 g/dl).

Depending on the clinical improvement, patients were offered one or two RCE cycles (two cycles, n = 6; and one cycle, n=10). Therefore, there was a total of 22 RCE procedures for 16 patients during this period. Out of the 22 RCE procedures, 16 (72.73%) were done using an automated cell separator, and 6 (27.27%) procedures were performed manually. None of the RCE procedures caused complications in patients.

During the study period, a total of 164 red cell units were utilised for all 22 RCE procedures. Out of those 164, 119 red cell units were exchanged during the first RCE cycle, and 45 red cell units were used for the second RCE cycle in 6 patients. Therefore, the average blood usage per RCE cycle was 7.45 units, and 10.25 units were needed per patient on average. The mean red cell exchange volume per cycle is 2074.63ml. The blood groups of the utilised red cell packs are summarised in Table 1.

Table 1: Blood groups of the red cell units utilised in RCE

Blood group	Number of red cell units (%)
A Rh D Positive	53 (32.32)
B Rh D Positive	21 (12.8)
O Rh D Positive	90 (54.88)
Total	164 (100)

Discussion

The results of the study have shown that a significant number of red cell units have been utilised for RCE in propanil poisoning. On average, 10.25 red cell units were needed for a patient who underwent RCE. As far as the blood groups of red cell units are concerned, the most common blood group used was O Rh D Positive, which is compatible with the Sri Lankan donor population as well [10]. Six (37.5%) patients needed a second RCE cycle for clinical improvement, increasing the demand for red cell units for RCE. Depending on patient blood volume, apheresis protocols, and clinical practices, each procedure requires a substantial volume of blood, typically ranging from 3 to 15 red blood cell units [11]. Usually, in an adult apheresis procedure, 1 to 1.5 volumes are exchanged. When RCE is performed using automated cell separators, average red cell usage is 8 - 10 units per procedure [12]. However, when automated apheresis equipment is unavailable, a manual RCE procedure is performed, and it needs 6 - 8 red cell units per cycle [13]. Hence, the observed average use of 10.25 red cell units per patient in the current study is comparable to the available data. Considering this amount of blood usage for RCE in propanil poisoning, indications for RCE procedure should be clearly defined in the management protocols.

Propanil is a very potent and widely used herbicide, and it has been categorised as a moderately hazardous poison by the WHO [14]. It is a commonly used herbicide and has shown an 8.2% case fatality rate in Sri Lanka [1]. In propanil poisoning, red blood cells produce and accumulate methaemoglobinemia because propanil is converted to 3,4-dichlorophenylhydroxylamine, which is subsequently co-oxidised with oxyhemoglobin to the ferric state and decreases oxygen-carrying capacity [15]. Therefore, cyanosis and acidosis occur, and finally organ failure could happen. IV methylene blue is considered the treatment of choice in methaemoglobinaemia [4].

RCE is also an effective treatment modality in methemoglobinemia when IV methylene blue fails to achieve full recovery [2,4-6,16]. In RCE, affected red cells are replaced with healthy donor red cells, thus improving tissue oxygenation. Therefore, clinical improvement of the patient is observed immediately. The procedure can be performed using an automated cell separator or manually. For both methods, healthy donor red cell units are needed, and those units are tested for compatibility with the patient. That includes ABO blood group matching, screening for unexpected antibodies, and crossmatch compatibility [17]. Adverse events of RCE include transfusion reactions, including haemolytic transfusion reaction due to incompatible blood transfusion, allergic reactions, hypocalcaemia due to citrate toxicity, hyperkalaemia, hypothermia and transmission of infectious agents [18]. In addition, procedure-related complications such as machine failures could happen. Vascular access-related complications like infections, bleeding, and thrombosis are also possible in apheresis procedures. None of the patients in the study population developed any adverse event related to the RCE procedure. The occurrence of adverse events was 19.7% in a study that analysed 760 RCE procedures in sickle cell disease [19]. However, the current study included only 22 RCE procedures, and this could be the reason for not showing any adverse events. Treatment with exchange transfusion requires extensive monitoring and is ideally done in the ICU set-up. There can be a requirement for additional methylene blue doses even after exchange transfusion [3].

There are studies conducted to audit red cell usage in hospitals; however, audits on red cell usage in apheresis procedures are lacking. A quality audit conducted on red blood cell transfusion in southern Finland revealed that consumption of red cells has decreased with time [20]. The researchers have highlighted the importance of restrictive transfusion policy. Evidence-based practice on patient blood management (PBM) programmes can increase awareness of rational RBC use. The strategy is beneficial as transfusion of blood products carries risk and has a considerable cost for the health care service. Another study conducted in the United States has shown that out of 6518, 2063 red cell units were transfused as single units [21]. So, utilising more than 10 units per patient is a considerable amount.

So the risk of Rh D alloimmunization is inevitable. Nevertheless, RCE procedure in the critically ill period is considered a life-saving measure. Therefore, despite the risk of Rh D alloimmunization, RCE with O Rh D-positive red cells is justifiable when O Rh D-negative

red cell units are unavailable. The risk of developing anti-D when transfusing RhD-positive blood to an RhD-negative patient is low, and it is beneficial when balanced against its potential benefits [22]. This approach is particularly indicated for high-volume transfusion requirements, such as RCE.

Notably, one patient in the study group, whose blood group was O RhD negative, received O RhD-positive red cells. While transfusing RhD-positive blood to RhD-negative recipients carries an inherent risk of anti-D alloimmunization, current literature demonstrates that the absolute incidence of seroconversion remains low [22]. In resource-constrained settings or emergencies, this risk must be carefully balanced against the immediate therapeutic benefits of volume restoration and improving oxygen-carrying capacity. Because the threat of acute hemorrhagic shock poses an imminent risk to life, the strategic utilisation of RhD-positive units is considered highly beneficial and clinically sound when balanced against the lower, delayed risk of subsequent antibody formation. Furthermore, studies have revealed that the risk of Rh D-alloimmunization does not increase with the number of red cell units transfused [23].

Conclusion

RCE appears to be beneficial in the management of severe propanil poisoning by rapidly replacing affected red cells with functional donor red cells and thereby improving oxygen-carrying capacity. However, this therapeutic benefit comes at the cost of substantial red-cell utilisation, as RCE requires transfusion of a large number of packed red-cell units per patient, which has implications for blood component availability and transfusion-resource utilisation, particularly in settings with limited blood supplies. This study highlights the importance of standardised, early intervention in severe propanil poisoning, pivoting away from RCE as only a last-resort rescue therapy. Furthermore, clear, objective thresholds for initiating red cell exchange to manage severe methemoglobinemia must be established. Transfusion services must implement contingency plans that ensure the rapid provision of blood units required for urgent RCE. Further audits are recommended to improve patient outcomes.

Ethics approval:

Ethical clearance for the study was obtained from the Ethical Review Committee of the Teaching Hospital, Polonnaruwa

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