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# Study of Cross Match to Transfusion Ratio in Patients Undergoing Elective Orthopedic Surgery

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## ABSTRACT

**Background:** Blood transfusions are a common part of elective orthopedic surgeries, yet there is often significant wastage in the utilization of cross-matched blood. Optimizing blood usage through efficient blood ordering practices is essential for reducing costs and resource waste. However, the effectiveness of such practices needs further investigation in different hospital settings. **Objective:** To determine the frequency of blood transfusion, transfusion probability, and cross match to transfusion ratio in patients undergoing elective orthopedic surgery. **Study Design:** Descriptive cross-sectional study. **Duration and Place of Study:** This study was conducted from April 2024 to October 2024 at the Department of Anesthesia, Doctors Hospital and Medical Centre, Lahore. **Methodology:** A total of 92 patients aged 25–70 years, undergoing elective orthopedic surgeries, were enrolled. Patient demographics and clinical data, including comorbidities, surgical type, and blood ordering details, were recorded. The C/T ratio and TP were calculated to assess blood usage efficiency. **Results:** The mean age of the patients was 45.2 ± 14.1 years, and 64.1% had blood reserved for transfusion. The mean C/T ratio was 2.13 ± 2.38. The transfusion rate was 21.7%, with a higher transfusion probability observed in patients with diabetes (46.2%) and those undergoing lower limb surgeries (66.7%). **Conclusion:** The study highlights significant blood wastage in elective orthopedic practices and a disproportionate transfusion rate. Implementing a Maximum Surgical Blood Ordering Schedule can optimize resource utilization. Our findings align with previous studies, reinforcing the need for strict adherence to evidence-based practices to minimize waste and enhance the efficient use of blood in orthopedic surgeries.

## INTRODUCTION

Blood transfusion is an integral component of orthopedic surgical patient care, including total joint arthroplasty, spinal surgery, and fracture fixation.[1] These surgical interventions have significant blood loss following extensive tissue resection, bone resection, and prolonged operating time.[2] In elective surgical procedures, such as elective orthopedic surgery, patients may have underlying diseases such as cardiovascular disease or anemia, and therefore, their tolerance to intraoperative blood loss is diminished.[3] Therefore, adequate oxygen-carrying capacity by timely transfusion is required to prevent complications such as delayed healing, organ dysfunction, or hypovolemic shock.[4] Conversely, transfusion is also dangerous if transfused unnecessarily, and therefore, transfusion must be balanced against potential drawbacks.[5]

In clinical contexts, transfusion of blood in orthopedic surgery is normally regulated by clinical status and hemoglobin thresholds of the patient. Whereas autologous donations prior to surgery are transfused to certain patients, others receive allogeneic components of blood in case of excessive postoperative or intraoperative blood loss.[6] The decision to transfuse is made on such parameters as vital signs, signs and symptoms of inadequate tissue oxygenation, ongoing bleeding, and baseline hemoglobin. Such technologies as antifibrinolytics (i.e., tranexamic acid) and cell salvage systems have recently found their implementation in preventing excessive loss of blood and in reducing the rate of transfusion of allogeneic components.[7] Despite such innovations, transfusion practices exhibit variability between institutions, and evidence-based guidelines have to be established to optimize effects while minimizing excessive interventions. Cross-matching is mandatory preoperative procedure for elective orthopedic surgery, especially in patients who have a high transfusion probability.[8] Cross-matching is testing between donor and recipient serum for their compatibility to check for no immune adverse effects on transfusion. In elective surgery, cross-matching is performed to prepare in advance for available, compatible blood units in case of unexpected bleeding. Still, only few patients who undergo orthopedic surgery might have to receive transfusion, and hence, in such cases, cross-matched blood is discarded. An excessive prediction for transfusion might waste resources, increase cost, and cause inefficient inventory use in the blood bank.[9] Thus, prediction of transfusion is required to optimize effectively this preparatory procedure.

The cross-match to transfusion (C:T) ratio is a good metric to evaluate cost-effectiveness in elective orthopedic surgical blood ordering practices.[10] An optimal lower rate of C:T reflects greater congruence between expected and actual transfusion requirements, wastage reduction, and resource conservation.[11] Studies have shown that most elective surgical interventions in orthopedics, such as primary hip or knee replacement, have low transfusion frequencies in the postoperative and preoperative phases, and hence, have high C:T values if protocol is optimized.[12] Reducing transfusion triggers, prediction models to identify patients who might have increased transfusion demands, and implementation of institutional protocol for individual surgical interventions may optimize the rate of C:T.[13]

In one investigation, the overall cross-match to transfusion ratio was found to be 4.87, with a transfusion index of 0.55 and a transfusion probability of 25%.[14] Another study reported that 406 patients had blood requested for their procedures, resulting in a total of 898 units being cross-matched. In this case, the cross-match to transfusion ratio was 7.6, the transfusion probability was 15.3%, and the transfusion index was 0.29.[15] A separate study revealed that of the 186 blood units that were cross-matched, only 72 units (38.7%) were actually transfused, leaving 61.3% of the cross-matched blood unused.[16]

This research is essential to assess blood transfusion activity in anesthesia settings, particularly transfusion frequency and probability of transfusion. Through the quantification of how frequently blood is indeed required following cross-matching, we can measure blood use efficiency and possibly reduce waste and optimize resource utilization. In addition, review of the cross-match to transfusion ratio will assist in standardizing preoperative blood ordering policies, preparing blood in a systematic manner, eliminating unnecessary cross-matching, and optimizing blood bank resources.

## METHODOLOGY

This descriptive cross-sectional study was conducted from April 2024 to October 2024 at the Operation Theatres and the Department of Anesthesia, Doctors Hospital and Medical Centre, Lahore. A total of 92 patients undergoing elective orthopedic surgeries were included, with the sample size determined using the WHO calculator for single proportions, based on a 95% confidence level, a 10% margin of error, and an expected blood transfusion frequency of 38.7%.[16]

The inclusion criteria comprised patients aged 25 to 70 years, with an American Society of Anesthesiologists (ASA) status of I or II, undergoing elective orthopedic surgery. Exclusion criteria included patients with hemoglobin levels below 10 mg/dl, those with bleeding disorders (e.g., hemophilia, ITP), individuals undergoing hand or foot surgeries requiring a tourniquet, and patients unwilling to participate in the study.

Patient demographics, including name, age, gender, height, weight, BMI, presence of diabetes mellitus, and whether blood was cross-matched, were recorded on a specially designed form. BMI was calculated using the formula: BMI = weight (kg) / height (m²), with BMI > 25 classified as obese and ≤ 25 as non-obese. Diabetes mellitus was defined as patients diagnosed with diabetes for more than 2 years and having controlled blood glucose levels (FBS <110 mg/dl). Blood arrangement referred to one or two units of blood being cross-matched, including blood typing and screening. Blood transfusion was defined as the loss of more than 1000 ml of blood during the operation, assessed using suction bottles, pre-weighed sponges, and postoperative hemoglobin levels below 10 g/dl. Blood transfusion was measured within 24 hours of the surgery. After data collection, each patient underwent surgery performed by a consultant orthopedic surgeon, and postoperative data, including any blood transfusion required within 24 hours, were also documented. The cross-match to transfusion ratio (C/T) was calculated as the number of units cross-matched divided by the number of units transfused, with a ratio of 2.5 or below considered indicative of efficient blood use. The transfusion probability (TP) was calculated as the number of transfused patients divided by the number of patients cross-matched, multiplied by 100, with a value of 30% or above indicating significant blood use.

Data analysis was performed using SPSS version 25.0. The Shapiro-Wilk test was used to assess the normality of the data. Descriptive statistics, including mean, standard deviation, and interquartile range (IQR), were calculated for continuous variables. Frequency and percentage distributions were used for categorical variables. Post-stratification was done, and the chi-square test was used for comparison. A p-value of ≤0.05 was considered statistically significant.

## RESULTS

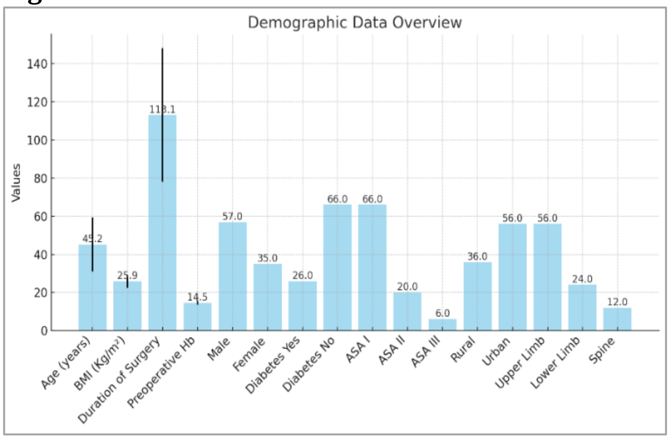
As shown in Table-I, the mean age of the patients was 45.2 ± 14.1 years, with a mean Body Mass Index (BMI) of 25.9 ± 3.32 kg/m². The average duration of surgery was 113.1 ± 35.09 minutes, and the preoperative hemoglobin level averaged 14.5 ± 1.14 g/dL. The gender distribution revealed 62% male and 38% female participants. Regarding comorbidities, 28.3% of patients had diabetes, while 71.7% did not. The majority of patients had an ASA grade of I (71.7%), followed by grade II (21.7%) and grade III (6.5%). Regarding residence, 60.9% of patients were from urban areas, while 39.1% were from rural areas. The type of surgeries performed included upper limb (60.9%), lower limb (26.1%), and spine surgeries (13%).

**Table I**

*Patient Demographics (n=92)*

| Demographics | | Mean ± SD |
|---|---|---|
| Age (years) | | 45.184±14.11 |
| BMI (Kg/m$^2$) | | 25.915±3.32 |
| Duration of Surgery | | 113.141±35.09 |
| Preoperative Hb | | 14.531±1.14 |
| Gender | Male n (%) | 57 (62%) |
| | Female n (%) | 35 (38%) |
| Diabetes | Yes n (%) | 26 (28.3%) |
| | No n (%) | 66 (71.7%) |
| ASA grade | I n (%) | 66 (71.7%) |
| | II n (%) | 20 (21.7%) |
| | III n (%) | 6 (6.5%) |
| Residence | Rural n (%) | 36 (39.1%) |
| | Urban n (%) | 56 (60.9%) |
| Type of Surgery | Upper Limb n (%) | 56 (60.9%) |
| | Lower Limb n (%) | 24 (26.1%) |
| | Spine n (%) | 12 (13%) |

**Figure 1**




As seen in Table-II, 64.1% of patients had blood reserved for transfusion, and 21.7% received blood transfusions. The mean Cross Match to Transfusion Ratio (CMTR) was 2.13 ± 2.38.

**Table II**

*Prevalence of blood reserved, blood transfusion and cross match to transfusion ratio*

| Cross match to Transfusion ratio | Frequency | % age |
|---|---|---|
| Blood Reserved | 59 | 64.1% |
| Blood Transfusion | 20 | 21.7% |
| Cross match to Transfusion ratio (Mean±SD) | 2.134±2.38 | |

Table-III displays the association of blood transfusion with various demographic factors. For age, 24.6% of patients aged ≤50 years received a blood transfusion, compared to 17.1% of those >50 years (p=0.402). Gender showed no significant difference, with 17.5% of males and 28.6% of females receiving a transfusion (p=0.213). BMI did not significantly affect transfusion rates (p=0.436), and similarly, duration of surgery (p=0.580) was not a significant factor. However, diabetes was strongly associated with blood transfusion (p<0.001), with 46.2% of diabetic patients receiving transfusions, compared to only 12.1% of non-diabetic patients. The ASA grade also had a significant relationship with transfusion: 12.1% of ASA grade I, 40% of grade II, and 66.7% of grade III patients received blood transfusions (p=0.001). Residence and type of surgery also influenced transfusion rates, with patients undergoing upper limb surgery having a very low transfusion rate (3.6%), compared to 66.7% for those undergoing lower limb surgery (p<0.001).

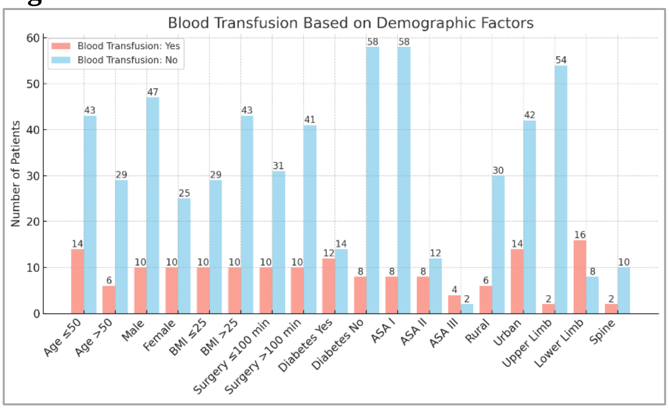
**Table III**

*Association of blood transfusion with Demographic Factors*

| Demographic Factors | | Blood Transfusion | | p-value |
|---|---|---|---|---|
| | | Yes n(%) | No n(%) | |
| Age (years) | ≤50 | 14 (24.6%) | 43 (75.4%) | 0.402 |
| | >50 | 6 (17.1%) | 29 (82.9%) | |
| Gender | Male | 10 (17.5%) | 47 (82.5%) | 0.213 |
| | Female | 10 (28.6%) | 25 (71.4%) | |
| BMI (Kg/m$^2$) | ≤25 | 10 (25.6%) | 29 (74.4%) | 0.436 |
| | >25 | 10 (18.9%) | 43 (81.1%) | |
| Duration of Surgery (minutes) | ≤100 | 10 (24.4%) | 31 (75.6%) | 0.580 |
| | >100 | 10 (19.6%) | 41 (80.4%) | |
| Diabetes | Yes | 12 (46.2%) | 14 (53.8%) | <0.001 |
| | No | 8 (12.1%) | 58 (87.9%) | |
| ASA grade | I | 8 (12.1%) | 58 (87.9%) | 0.001* |
| | II | 8 (40%) | 12 (60%) | |
| | III | 4 (66.7%) | 2 (33.3%) | |
| Residence | Rural | 6 (16.7%) | 30 (83.3%) | 0.344 |
| | Urban | 14 (25%) | 42 (75%) | |
| Type of Surgery | Upper Limb | 2 (3.6%) | 54 (96.4%) | <0.001* |
| | Lower Limb | 16 (66.7%) | 8 (33.3%) | |
| | Spine | 2 (16.7%) | 10 (83.3%) | |

**Fisher Exact Test**

**Figure 2**




## DISCUSSION

This study's data provide evidence for considerable heterogeneity in transfusion needs by such factors as diabetes status, ASA grade, and type of operation. The increased transfusion rate in diabetic patients (46.2 versus 12.1%) is to be expected in light of possible impaired healing and increased perioperative complications in such individuals, for whom transfusion might prove necessary. The strong association between transfusion and ASA grade is likely secondary to increased surgical complexity and risk in patients of higher ASA grades, who undergo closer monitoring and treatment under anesthesia. The extreme significant variability in transfusion rate by type of operation (upper limb versus lower limb) is in keeping with variability in surgical complexity and anticipated volume of blood loss in such surgical procedures.

In the study by Kour et al. [17] aimed to evaluate the economy of blood ordering and use of blood components in elective surgical interventions. From their data, 64.1% reserved blood proved to have remained unused, and their C/T ratio was 1.92. The implication is that most of the blood was unnecessarily cross-matched, and thus wastage and wastage of resources occurred. In our study, we saw the same pattern and excessive cross-matching is practiced in most of our institutions. The C/T ratio in our study was 2.13 ± 2.38, in accordance with data by Kour et al. and showing there is still opportunity for optimizing blood ordering to better use resources.

Chawla et al. [18] have documented a similar case of excessive ordering of blood, where 97.56% of patients registered a C/T greater than 2.5, and attributed by authors to excessive cross-matching. The authors' work advocated for implementation of a Maximum Surgical Blood Ordering Schedule (MSBOS) to reduce such excessive ordering. We have found similar evidence, where in our case, 64.1% of patients had reserved blood, and our transfusion indices for total blood also revealed poor utilization of blood, where multiple units remained untransfused. We agree with Chawla et al. on implementation of MSBOS to rationalize use of blood and reduce cost and wastage. While Chawla et al. have documented excessive ordering of blood, our case examined wasteful transfusion practices where blood remained reserved, and may indicate institutional practices such as types of surgical procedure or patient management may have differed.

In El-Sayed et al. [19] researchers also discovered inefficiency in blood ordering, wherein the C/T ratio was 3.5 and merely 38.7% of cross-matched bloods were transfused. The finding is aligned with our research, wherein a high volume of blood was cross-matched but not used. El-Sayed et al. attributed the implementation of MSBOS and Type and Screen policies, and our research is aligned. The inefficiency observed can be due to lack of compliance with evidence-based transfusion practices and application of clinical judgment in blood ordering. Similarly, our research is supportive of the utilization of structured and evidence-based practices, particularly in reducing over-ordering and unwarranted cross-matching.

Misganaw et al. [20] found 64.1% of the blood units to have remained unused after cross-match, and their C/T ratio was 2.9. The authors found better use of blood in emergencies compared to elective surgical procedures. We also observed such patterns in our study, but only in regard to the use of blood in types of surgical procedures. The elective surgical procedures, and in our case, interventions in lower limbs, found larger transfusion rates compared to upper limb interventions, and this is consistent with what is found in Misganaw's study. The difference between elective and emergencies may lie in the type of procedure, where emergencies tend to have greater complications or greater blood loss and therefore greater transfusion.

Hall et al. [21] have also addressed the issue of over-ordering of blood and have designed an MSBOS for elective surgical interventions. Their data yielded a C/T ratio of 2.1, indicating prevalent over-ordering of blood, and urged revised guidelines on the strength of systematic audits of blood use. Similar to their finding, our finding is in favor of implementation of MSBOS and also underscores the point that though blood is stocked in large volumes, in practice, their use is insufficient. In accordance with Hall et al.'s recommendation, evidence-based guidelines, derived through systematic audits, have the ability to limit wastage and optimize resource utilization.

Finally, Zewdie et al. [15] found 64.1% of cross-matched blood to have remained unused, and their C/T ratio was 7.6, showing wastage in the application of blood. The result is in accordance with our wastage observed in our study, where such wastage pattern in blood occurred. Furthermore, Zewdie et al. cited wastage in application of blood, and in our situation, in obstetric surgery, where wastage in our study occurred. Both studies point to the need for better stewardship in ordering, and in our situation, in elective surgery where expected loss is normally lesser than in initial estimates.

In summary, our data is in accordance with the pattern in various studies, where inefficiency in using blood in elective surgical interventions is a general phenomenon. Despite large stocks of blood having been requisitioned, most of them remain unutilized, and wastage and cost inflation is incurred. Introduction of an evidence-based structured Maximum Surgical Blood Ordering Schedule (MSBOS) and strict adherence to evidence-based practices are two chief recommendations by our study and by studies by Chawla et al. [18] and Hall et al. [21] to optimize blood utilization and limit wastage. Rationalization of practices in ordering blood is possible, and therefore, by optimizing resource use, hospital resource planning is enhanced, and transfusion services and health expenditure is minimized.

However, there are several limitations to our current study. First, our current study is single-center and in a tertiary hospital, and our data may thus not completely represent all health settings, including low resource settings. Finally, while our current study is made up of various types of surgery, our individual type sample may have been small and may thus have inadequate data to make general statements on individual procedure types. Further multicenter studies using larger datasets are required to validate our data and to check if implementation of MSBOS is effective in various settings.

## CONCLUSION

Our study revealed elective orthopedic practices to have significant wastage in their use of blood and a disproportionate transfusion rate, and evidence for instituting a systematic approach to ordering, such as having a Maximum Surgical Blood Ordering Schedule, to limit wastage and optimize resource utilization. The evidence is in accordance with studies conducted before, and our data corroborate their point, that strict adherence to evidence-based practices is crucial to optimize the use of blood and reduce wasteful expenditure.

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