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ORIGINAL ARTICLE

Impact of a Type and Screen Protocol on Surgical Blood Utilization Indices: A Retrospective Pre- and Post-Implementation Study at Vajira Hospital

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ABSTRACT

Objectives: To evaluated the impact of type and screen protocol for surgical blood management by comparing three blood utilization indices, the proportion of inadequate preoperative crossmatches, and the incidence of blood incompatibility before and after protocol implementation.

Materials and Methods: This retrospective pre- and post-protocol study analyzed anesthetic records and blood reservation data of adult inpatients in 11 departments who underwent elective surgeries at Vajira Hospital between November 2020 and April 2021 (pre-protocol group) and between August 2021 and January 2022 (post-protocol group). Three blood utilization indices, namely, crossmatch-to-transfusion (C/T) ratio, transfusion probability (%T), and transfusion index (Ti), were calculated for each department and overall, then compared to international benchmarks. Multilevel mean difference regression was utilized to investigate the protocol's impact on three indices, as well as on the percentage of inadequate preoperative crossmatch and transfusion mismatches.

Results: The study included 1533 patients in the pre-protocol group and 1404 patients in the post-protocol group. Multivariable analysis adjusted for patient demographics, preoperative laboratory results, and intraoperative blood loss demonstrated significant improvements in the C/T ratio (mean difference (MD) -0.65, $p < 0.01$), %T (MD 34.1%, $p < 0.01$), and Ti (MD 0.5, $p < 0.01$) following protocol implementation. However, C/T ratios across all departments still failed to meet international benchmark. The proportion of inadequate preoperative crossmatches did not differ significantly between the two periods (MD -0.73, $p = 0.15$) and no blood incompatibilities were recorded in either group.

Conclusion: The type and screen protocol were associated with improved blood utilization efficiency for elective surgeries at Vajira Hospital without difference in percentages of underordering. While these observational findings are promising, C/T ratios failed to reach international standard. Further refinement of the protocol or the development of an institute-specific maximum surgical blood-order schedule is recommended.

Keywords: blood utilization, crossmatch-to-transfusion ratio, type and screen

INTRODUCTION

Blood utilization is the appropriate and effective use of blood products to maintain a safe and adequate blood supply. This has long been a focus for many organizations involved in transfusion therapy.[1] However, several countries still faced inadequate supplies of red cell products.[2] Previous studies have shown that elective surgeries often involved over-ordering of blood components that were not ultimately transfused.[3-8] In the traditional crossmatch method, compatible units of red cell products are removed from general inventory, reserved for immediate use by matched recipients, and decreased availability for other patients for at least 48 hours. The type and screen (T&S) method has been proposed as a substitute compatibility test for procedures wherein transfusion was less likely.[9-11] This approach involved testing a recipient's blood for ABO and Rhesus types and irregular antibodies without involving donor units. Research revealed that T&S increased the availability of blood in stock, reduced the number of expired units, lowered costs associated with unnecessary complete crossmatches, and decreased blood bank staff workload.[12-15] Moreover, T&S for blood reservation maintained patient safety with concerning timely blood release and compatibility.[10,13,16] The T&S method was integrated into Maximum Surgical Blood Order Schedule (MSBOS), a clinical framework designed to optimize preoperative blood reservation. The MSBOS facilitates the decision of whether a T&S is appropriate for a specific procedure and establishes the maximum number of packed red blood cells (PRCs) to be ordered if crossmatching is warranted, based on the anticipated risk of major hemorrhage and documented transfusion requirements.[11,17]

During the Coronavirus Disease 2019 (COVID-19) pandemic, blood donations decreased worldwide.[18-20] In Thailand, this problem led to blood supply shortage.[21] To deal with this issue, Vajira Hospital implemented the T&S protocol for elective surgical blood management to ensure sufficient blood reserves. Prior to the implementation of the protocol, no explicit guidelines for preoperative blood ordering existed. The number of PRCs crossmatched for surgery was determined at the discretion of the attending surgeons or residents. Following protocol initiation, PRCs ordered by surgical teams as "crossmatch for operation" were prepared using T&S in a blood bank. On surgery day, during the sign-in process, anesthesiologists determined whether to request a crossmatch for each patient and the number of PRC units required, considering the type of surgery and patient profiles. Then, the blood bank delivered the typed and screened PRCs, as requested, to the operating rooms within 15 minutes, while performing a complete crossmatch in parallel. However, T&S did not cover all situations; a complete crossmatch was permitted from the outset for patients with rare blood types and antibodies against red blood cells, those scheduled for cardiac or transplant surgeries, those aged < 10 years, and those receiving blood components donated by relatives.

The T&S protocol has been used for elective surgical patients at Vajira Hospital since May 2021; thus, its result in improving blood utilization and its consequence on patient safety have not been formally evaluated. Therefore, the primary objective of this study was to evaluate the impact of the protocol by comparing three key blood utilization indices, namely, crossmatch-to-transfusion (C/T) ratio,[12] transfusion probability (%T),[22] and transfusion index (Ti),[11] during the 6-month periods before and after implementation. The authors hypothesized that all indices would demonstrate significant improvement after the protocol was implemented. Additionally, the study compared the proportion of inadequate preoperative crossmatches and blood incompatibility between the two periods.

MATERIALS AND METHODS

This retrospective pre- and post-protocol study received expedited review and approval from the Vajira Institutional Review Board's Ethics Committee on 28 April 2023 (COA 081/2566). Data from patients undergoing surgery in the operating theaters at Vajira Hospital were reviewed for the 6 months before (November 2020 to April 2021) and after (August 2021 to January 2022) T&S implementation. The initial 3 months of the transition period were excluded to ensure consistent practices among all personnel. The inclusion criteria involved patients aged > 15 years who were admitted for non-emergency surgeries in one of the following 11 departments: orthopedic surgery, general surgery, esophagogastric surgery, colorectal surgery, hepatobiliary surgery, urologic surgery, vascular surgery, neurosurgery, plastic surgery, thoracic surgery, and otolaryngology surgery. The exclusion criteria comprised patients with international normalized ratio > 1.5, activated partial thromboplastin time (aPTT) > 40 seconds, or thrombocytopenia (platelet count < 80,000 cells/mm^3); those on

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antiplatelet or anticoagulant therapy without appropriate cessation (except for vascular surgery); those undergoing procedures with preexisting blood management guidelines (e.g., cesarean section, organ transplantation, and cardiac surgery); those undergoing procedures for which preoperative blood management was not routinely required (e.g., eye surgery, ear surgery, rigid bronchoscopy, direct laryngoscopy, vocal cord surgery, hemorrhoidectomy, and fistulectomy); those simultaneously undergoing multiple unrelated surgical procedures; and those whose planned operations were changed intraoperatively.

Data were extracted from anesthesia records and the blood bank's electronic database. This included patient age, sex, weight, height, comorbidities such as end-stage renal disease (ESRD) and cirrhosis, American Society of Anesthesiologists Physical Status (ASA-PS) classification, preoperative laboratory results (e.g., hematocrit, platelet count, and coagulation profiles), department, operation performed, intraoperative blood loss, type and amount of preoperative and intraoperative PRC orders, the number of PRC units transfused intraoperatively, and intraoperative record of suspected blood incompatibility. Inadequate preoperative crossmatching was identified when the quantity of transfused PRCs exceeded the preoperatively crossmatched volume.

Data were analyzed using Stata version 14.4 (StataCorp LLC., College Station, T.X., USA) and Microsoft Excel version 16.0 (Microsoft Corp., Redmond, W.A., USA). To evaluate blood product utilization, three indices were calculated for each department and overall patients. The C/T ratio was determined by dividing the total number of units of blood crossmatched by the total number of units of blood transfused. A C/T ratio ≤ 2 indicated appropriate blood use.[12] The %T was calculated by dividing the number of patients transfused by the number of patients crossmatched and multiplying the result by 100. The %T should be at least 30% to ensure that proper proportion of patients who had been cross-matched were precisely transfused.[22] Finally, the Ti was obtained by dividing the number of units of blood transfused by the number of patients crossmatched. A Ti of at least 0.5 indicated that blood products were efficiently used.[11]

Because the three transfusion indices were calculated as aggregated metrics, the department served as the unit of analysis. Data normality was evaluated using the Shapiro-Wilk test. Patient demographics in each department were presented as means and standard deviations or medians and interquartile ranges (IQR), depending on the data distribution. For comparisons between the pre- and post-protocol periods at the department level, the dependent-samples t-test or the Wilcoxon signed-rank test was employed, as appropriate. To evaluate the impact of the T&S protocol while accounting for the hierarchical structure of the data, a multilevel mean difference regression model with a random intercept and fixed effects was utilized. This model analyzed changes in the C/T ratio, %T, Ti, and the percentage of inadequate preoperative crossmatches and blood incompatibility. Results were reported as mean differences with 95% confidence intervals. Statistical significance was defined as $p < 0.05$.

RESULTS

Overall, 2937 patients undergoing 258 different surgical procedures were analyzed. Of these, 1533 were in the pre-protocol group and 1404 in the post-protocol group. The distribution of patients across departments is summarized in Table 1. The department of orthopedic surgery had the largest patient volume, while the esophagogastric surgery department had the smallest. Table 2 presents patients' demographics, preoperative laboratory values, and intraoperative blood loss. Statistically significant differences between the two groups were observed in age, preoperative hematocrit, platelet count, and aPTT.

In the pre-protocol period, none of the blood utilization indices for overall patients met the benchmarks for appropriate use: C/T ratio, 5.87 (Figure 1); %T, 18.3% (Figure 2); and Ti, 0.38 (Figure 3). In examining each department, C/T ratios exceeded 2 and %T was < 30% in all 11 departments. Esophagogastric surgery had the highest C/T ratio (9.25), whereas Ear, Nose, and Throat surgeries exhibited the lowest %T (10.6%). Regarding Ti, only colorectal, hepatobiliary, and neurosurgery achieved the target value > 0.5, with neurosurgery reaching the highest Ti (0.62).

In the post-protocol period, the blood utilization indices for overall patients improved: C/T ratio, 3.79 (Figure 1); %T, 39.2% (Figure 2); and Ti, 0.73 (Figure 3). However, the C/T ratio remained above the target value in all departments. Except urology and plastic surgery, all departments achieved the appropriate %T and Ti values. Neurosurgery achieved the highest %T and Ti during the post-protocol period.

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Table 1 Distribution of Surgical Patients by Department between Pre- and Post-Type and Screen Protocol Implementation Periods

Departments	Pre-protocol n (%)	Post-protocol n (%)
General surgery	144 (9.4)	109 (7.8)
Esophagogastric surgery	19 (1.2)	7 (0.5)
Colorectal surgery	73 (4.8)	77 (5.5)
Hepatobiliary surgery	90 (5.9)	98 (7.0)
Vascular surgery	68 (4.4)	88 (6.3)
Neurosurgery	154 (10.0)	131 (9.3)
Otolaryngology surgery	114 (7.4)	126 (9.0)
Thoracic surgery	97 (6.3)	96 (6.8)
Plastic surgery	46 (3.0)	48 (3.4)
Urologic surgery	137 (8.9)	119 (8.5)
Orthopedics surgery	591 (38.6)	505 (36.0)
Overall patients	1533 (100.0)	1404 (100.0)

Abbreviation: n, number

Table 2 Comparison of Patients' Demographics, Preoperative Laboratory, and Intraoperative Blood Loss between Pre- and Post-Type and Screen Protocol Implementation

Variables	Pre-protocol (n = 11)	Post-protocol (n = 11)	P-value
Percentage of male	47.8 [40.4-63.0]	42.9 [37.5-59.7]	0.37
Age (years)	55.5 ± 4.9	57.8 ± 3.5	0.04*
Weight (kg)	65.3 [62.6-66.2]	63.4 [61.0-64.3]	0.29
Height (cm)	163 [161-164]	161 [161-162]	0.42
BMI (kg/m^2)	24.8 [23.5-25.1]	24.3 [23.5-25.0]	0.08
Percentage of ASA-PS classification			
I	10.0 ± 7.8	8.0 ± 5.5	0.11
II	52.8 [46.5-55.8]	49.4 [46.6-57.1]	0.72
III	36.0 [30.9-38.3]	36.7 [28.6-48.1]	0.42
IV	0.2 [0.0-1.8]	1.3 [0.9-2.3]	0.29
Percentage of comorbidity			
Cirrhosis	0.68 [0.00-1.39]	0.00 [0.00-0.79]	0.05
ESRD	0.73 [0.00-2.78]	1.39 [0.00-2.52]	0.07

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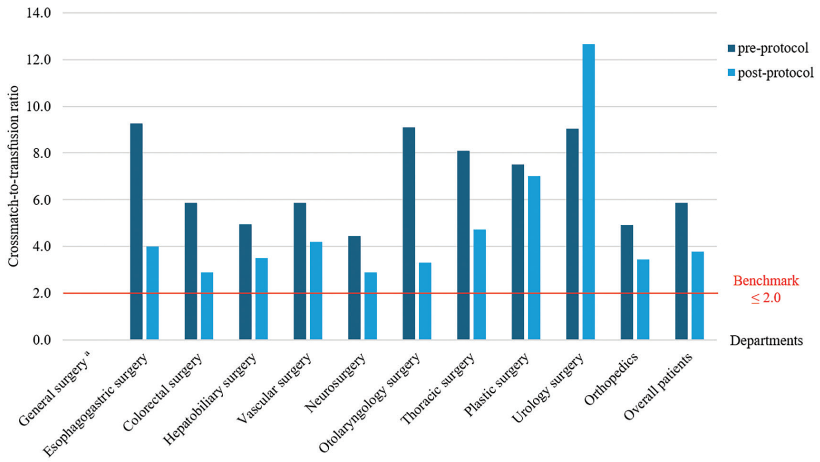
Table 2 Comparison of Patients' Demographics, Preoperative Laboratory, and Intraoperative Blood Loss between Pre- and Post-Type and Screen Protocol Implementation (cont.)

Variables	Pre-protocol (n = 11)	Post-protocol (n = 11)	P-value
Preoperative laboratory			
Hematocrit (%)	38.8 [37.7-39.3]	37.9 [36.8-38.7]	< 0.01**
Platelet (/μL)	286,000 ± 19,000	273,000 ± 17,000	0.03*
INR	1.03 [1.02-1.04]	1.03 [1.02-1.05]	0.21
aPTT (sec)	25.9 [25.7-26.4]	25.4 [25.0-25.4]	< 0.01**
Intraoperative blood loss (ml)	50 [20-100]	50 [20-150]	0.59

Abbreviations: μL, microliter; aPTT, activated partial thromboplastin time; ASA-PS, American Society of Anesthesiologists Physical Status; BMI, body mass index; cm, centimetre; ESRD, end stage renal disease; INR, international normalized ratio; kg, kilogram; m^2, square meter; ml, milliliter; n, number; sec, second

Data were presented in mean ± SD or median [IQR] according to the normality of data tested by Shapiro-Wilk test.
* p < 0.05
** p < 0.01



[a]Crossmatch-to-Transfusion Ratio was Unavailable in General Surgery Department because of Absence of Blood Transfusion.

Figure 1 Comparison of Crossmatch-to-Transfusion Ratio between Pre- and Post-Type and Screen Protocol Implementation

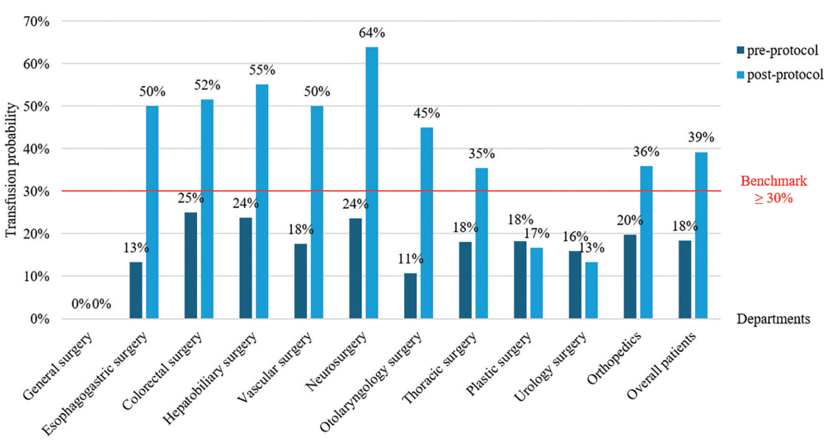


Figure 2 Comparison of Transfusion Probability between Pre- and Post-Type and Screen Protocol Implementation

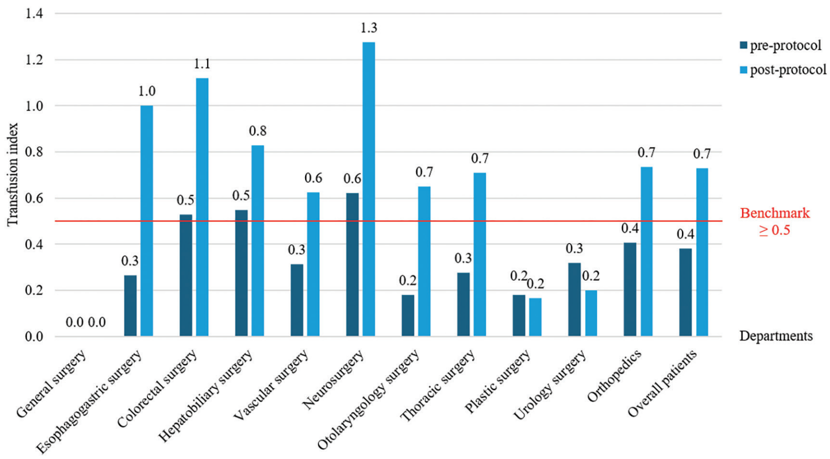


Figure 3 Comparison of Transfusion Index between Pre- and Post-Type and Screen Protocol Implementation

Interestingly, urologic surgery was the only department wherein all blood utilization indices failed to improve after T&S implementation.

In general surgery, which mainly involved breast and hernia operations, no patients received blood transfusions before or after T&S implementation, precluding calculation and comparison of the three indices. Figure 1 compares the blood utilization indices for each department and overall patients in the pre- and post-protocol groups.

Because no PRCs were transfused in the general surgery department during either period, the C/T ratio was mathematically undefined (denominator of zero); consequently, this department was excluded from the regression analysis for the C/T ratio endpoint. Univariable analysis demonstrated a significant decrease in the C/T ratio (mean difference (MD) -2.04, $p = 0.01$), an increase in %T (MD 21.0%, $p < 0.01$), and increase in Ti (MD 0.33, $p < 0.01$) following the protocol implementation. To account for imbalanced demographics and potential confounders, multivariate analysis was performed. Variables exhibiting high collinearity (correlation coefficient ≥ 0.7), including weight, height, ASA-PS, ESRD status, and international normalized ratio, were removed to prevent multicollinearity. After adjusting for sex, age, body mass index, cirrhosis, hematocrit, platelet count, aPTT, and median blood loss, the improvement in the C/T ratio (MD -0.65, $p < 0.01$), %T (MD 34.1%, $p < 0.01$), and Ti (MD 0.5, $p < 0.01$) remained statistically significant (Table 3).

Table 3 Multilevel Mean Difference Analysis of the Impact of Type and Screen Protocol on Blood Utilization Indices and Inadequate Crossmatching

Endpoints	Pre-protocol mean (SD)	Post-protocol Mean (SD)	Univariable analysis		Multivariable analysis[a]	
			MD (95% CI)	P-value	Adjusted MD (95% CI)	P-value
C/T ratio[b]	6.90 (1.90)	4.86 (3.00)	-2.04 (-3.59 to -0.49)	0.01	-0.65 (-0.93 to -0.36)	< 0.01
Transfusion probability	16.9 (7.1)	37.9 (20.0)	21.0 (11.9 to 30.1)	< 0.01	34.1 (17.2 to 51.0)	< 0.01
Transfusion index	0.33 (0.18)	0.66 (0.40)	0.33 (0.17 to 0.49)	< 0.01	0.50 (0.34 to 0.67)	< 0.01
Percentage of inadequate preoperative crossmatch	0.68 (1.13)	0.38 (0.80)	-0.31 (-0.91 to 0.30)	0.32	-0.73 (-1.73 to 0.27)	0.15

Abbreviations: CI, confidence interval; MD, mean difference; SD, standard deviation
[a] Multivariable analysis adjusted for sex, age, body mass index, cirrhosis, hematocrit, platelet, activated partial thromboplastin time, and median blood loss.
[b] General surgery was excluded from the analysis due to unavailability of C/T ratio from absence of blood transfusion. The remaining sample size was 10 for this endpoints.
* Statistical significance at $p < 0.05$
** Statistical significance at $p < 0.01$

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Regarding secondary outcomes, the percentage of inadequate preoperative crossmatches did not differ significantly between the two periods in either the univariable (MD -0.31, p = 0.32) or multivariable (MD -0.73, p = 0.15) analyses. Notably, no blood incompatibility events occurred intraoperatively during both study periods.

DISCUSSION

This study evaluated the impact of T&S protocol for managing surgical blood reservations at Vajira Hospital during the COVID-19 pandemic. By comparing three blood utilization indices (i.e., C/T ratio, %T, and Ti), we observed significant improvements across all metrics following protocol implementation. Although patient demographics and volumes differed between the two study periods, these imbalances likely reflect actions taken to address decreased blood supply during the COVID-19 pandemic, such as cancelling some major and elective surgeries.[18] Importantly, the improvements in blood utilization remained statistically significant even after adjusting for confounders, including patient demographics, preoperative laboratory values, and intraoperative blood loss, underscoring the efficiency of the T&S protocol.

The results of this study aligned with that in Mahattanobon and Sunpaweravong's study[4] investigating the efficiency of blood ordering guideline for elective surgery at their institution, replacing crossmatching with T&S for selected operations. They reported a decrease in C/T ratio (3.6 to 2.6), an increase in %T (36.8% to 52.3%), and an increase in Ti (0.8 to 1.1) after implementing the guidelines.[4] Alavi-Moghaddam et al. established the benefit of T&S in the emergency department, noting a decrease in C/T ratio from 1.41 to 1.13.[16] In another study, Aggarwal et al. found a notable C/T ratio decrease (1.94 to 1.01) after introducing T&S in their tertiary care hospital.[15]

In this study, although the overall C/T ratio improved after T&S implementation, decreasing from 5.87 to 3.79, it remained substantially higher than the target value of ≤ 2. Moreover, the C/T ratio of the urology department increased from 9.03 to 12.67 during the post-protocol period. These unfavorable outcomes were also reported in other studies which applied T&S into the MSBOS for elective surgeries.[4,23,24] Woodrum et al. revealed a C/T ratio of 3.17 after implementing a blood ordering schedule among many hospitals in their regional healthcare network and mentioned inadequate program communication and noncompliance as possible causes.[23] Jitmun and Chatmongkolchart identified similar problems in Thailand.[24] Although the MSBOS had been established in their institution since 2008, a recent study collecting data in 2020 and 2021 revealed an overall C/T ratio of 2.78, exceeding the international benchmark. They posited that blood ordering protocols may be ignored and blood utilization may remain inefficient without consistent follow-up and feedback.[24]

For Vajira Hospital, a potential reason for unfavorable C/T ratios after T&S implementation is that the protocol itself was not rigorous in controlling the number of PRCs reserved for each operation, causing over-ordering of PRCs by junior residents with limited experience for certain operations and inaccurate predictions of blood loss. Furthermore, the protocol had weaknesses allowing deviation from the prescribed requirements, that is, to switch from T&S back to complete crossmatching. First, the protocol specified that PRCs should be prepared using T&S only if they were ordered in the Hospital Management Information System (E-Phis) as "crossmatch for operation." Thus, if orders were placed as "ready to use," the PRCs would be completely crossmatched. Second, every unit of PRC reserved for patients whose relatives donated blood would be crossmatched. The campaign to encourage patient relatives to donate blood intensified after the COVID-19 pandemic, along with T&S initiation. Some PRCs originally ordered as T&S during the pre-protocol period may have been crossmatched during the post-protocol period for this reason, increasing the C/T ratio. Finally, any PRCs launched to operating rooms would be automatically crossmatched, regardless of the requestors, such as anesthesiologists, nurse anesthetists, surgical staffs, and trainees. This allowed less-experienced practitioners to request excessive PRCs to the operating room.

Moreover, the present study found improvements in overall %T and Ti, increasing from 18.3% to 39.2% and 0.38 to 0.62, respectively. These indices reached target values in all departments except urology and plastic surgery. The discrepancy among departments, especially in urology, wherein all blood utilization indices worsened during the post-protocol period compared to pre-protocol, requires further investigation for hidden causes. Apart from ensuring understanding of the protocol and compliance of the personnel within the department, the details of operation may provide an explanation on surprising outcomes in urology. Less-invasive procedures implemented to alleviate blood shortage during the COVID-19 pandemic may have decreased actual blood transfusions than the requested units, increasing the C/T ratio. Furthermore, other studies demonstrated higher C/T ratios in urologic procedures compared to other subspecialties, ranging from > 3.00 to 5.88.[17,24,25] Uniqueness of operations and organ involved, bleeding complications, and the increasing use of less-invasive surgical techniques in the urological field may contribute to the imbalance between the numbers of units ordered and transfused.

Another notable finding concerned the general surgery department, which involved breast surgeries and hernia repairs. Although no transfusions were required during the study periods, crossmatches were occasionally requested in some patients, with a smaller proportion after the T&S protocol implementation (50.0% vs. 20.2%). Other studies reported that blood reservations could be omitted[17,25] or that T&S was sufficient for these operations.[4]

Given the risks associated with T&S, this study found similar percentages of patients with inadequate crossmatch between pre- and post-protocol periods. This paralleled findings from another university hospital in Thailand, which reported nonsignificantly different proportion of patients transfused with more blood than preoperatively crossmatched (2.5% vs 2.3%) after introducing a blood ordering schedule.[4] In the current study, no intraoperative blood incompatibility was found, supporting the safety of T&S reported in the existing literature.[10,13,16]

Despite improvements in blood utilization at Vajira Hospital after T&S implementation, opportunities remain for further gains. During the post-protocol period, only 26.4% (264 units) of crossmatched PRCs were transfused intraoperatively. Considering that the C/T ratio was the only index below the international standard, the authors hypothesized that excessive preoperative crossmatching per patient was the primary driver of inefficient blood use. This necessitated the development of an institute-specific MSBOS to provide a structured guideline, defining the appropriateness of T&S and setting a ceiling for the number of PRC units for surgical blood reservation. Numerous studies demonstrated the benefits of MSBOS in blood utilization, patient safety, and cost savings.[7,25-28] Although various calculation strategies for establishing MSBOS have been proposed,[17,22,29,30] the researchers used a method by Frank et al.[17] to recommend MSBOS for Vajira Hospital.

A major strength of this study is the large patient cohort and the use of inferential statistics. While previous studies have often reported the effect of T&S method in a purely descriptive manner, comparing results to internation benchmark, this study employed multilevel mean difference regression. This approach allowed us to confirm the protocol's impact and explore the effect size on improving surgical blood utilization.

However, this study still had several limitations. First, the retrospective design limited comprehensive assessment of complications resulting from the protocol, such as delayed transfusions and subsequent morbidity. The reasons for switching from T&S to crossmatching were not recorded in the blood bank database, limiting the evaluation of protocol compliance and deviations that may have decreased the protocol's effect. Second, residual potential confounders, such as variations in surgeon expertise, disease severity, and the specific types of operations performed, may have influenced the results. The COVID-19 pandemic caused blood shortages that delayed some elective major surgeries, resulting in less PRCs reservation for operation and thus improvement of blood utilization indices during the post-protocol period. However, this study did not analyze outcomes at the individual procedure level, as the mathematical invalidity of the C/T ratio (where the denominator is zero) and the lack of matched operations in both time periods would have led to significant data exclusion. Consequently, the result would not demonstrate the impact of the T&S protocol on entire patient cohort. Third, the study only considered intraoperative transfusions in the calculations, not recognizing the potential influence of blood use during the postoperative period. Finally, a single-center design limited the external validity of these findings. Future research should prioritize prospective designs to get rid of potential confounders and explore the protocol's impact on procedure level. Moreover, impact of the suggested MSBOS should be evaluated.

CONCLUSION

T&S protocol implementation significantly improved all three indices of blood utilization for elective surgeries. However, in all departments, the C/T ratio remained failed to reach international benchmark. Revision of

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the protocol or developing an institute-specific MSBOS is recommended. No blood incompatibility was recorded, and proportion of inadequate preoperative crossmatch did not significantly differ following protocol implementation.

Conflict of Interest

The authors declare no conflicts of interest.

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Author Contributions

Conceptualization: S.H., P.P.

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Formal analysis: S.H., P.P.

Funding acquisition: P.P.

Investigation: S.H., S.T., P.S., A.C., S.K., M.P.

Methodology: S.H., P.P.

Project administration: P.P.

Resources: P.P.

Software: -

Supervision: P.P.

Validation: -

Visualization: P.P.

Writing – original draft preparation: S.H.

Writing – review & editing: P.P.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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