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RESEARCH ARTICLE

Focused Educational Programs Make a Significant Difference in Applications of Blood Management

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ABSTRACT

Objectives: Bleeding and transfusion in cardiac surgery are serious complications that negatively impact patient outcomes, increasing morbidity, mortality, and costs. This study aimed to determine the changes in blood product usage and patient outcomes in our clinic following the introduction of patient blood management (PBM), component therapy training, and viscoelastic testing.

Methods: Between January 2021 and June 2024, demographic, intraoperative, and postoperative data of patients undergoing open-heart surgery with intraoperative blood loss of at least 1000 mL and requiring red blood cell (RBC) transfusion were retrospectively reviewed. In our clinic, the use of rotational thromboelastometry (ROTEM) was initiated in January 2023, alongside simultaneous training in PBM and component therapy. Patients operated on before (Group B) and after (Group A) this date were divided into two groups, and patient outcomes were compared.

Results: A total of 267 patients were included in the study. There was a significant increase in the use of fibrinogen, prothrombin complex concentrate (PCC), and autologous blood transfusion in Group A (p=0.017, p=0.006, and p=0.033, respectively). Postoperative complications and mortality rates were similar between the two periods.

Conclusion: PBM algorithms recommend targeted and individualized treatments. The use of fibrinogen concentrate, PCC, and tranexamic acid has increased with the implementation of ROTEM-guided blood transfusion algorithms and training in recurrent PBM and component therapy.

Keywords: Blood and blood product transfusion, cardiac surgery, component therapy, patient blood management, tranexamic acid

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Introduction

Bleeding and transfusion in cardiac surgery are serious complications that negatively impact patient outcomes, increasing morbidity, mortality, and costs. Cardiac surgery poses a high risk for bleeding and transfusion due to multiple factors, including the complexity of surgical procedures, patient characteristics with a high comorbidity burden, a wide range of medications, and the unique dynamics of cardiopulmonary bypass (CPB).[1]

Patient blood management (PBM) is an evidence-based, multidisciplinary approach to caring for patients who may require blood transfusion. PBM includes all aspects of the transfusion decision-making process, beginning with the preoperative patient evaluation and continuing through clinical management.[2] The basic goals of PBM are examined under three pillars; according to this model, the plan should make every effort to optimize the patient's blood volume, minimize blood loss, and optimize the patient's physiological tolerance of anemia.

During cardiac surgery, PBM begins with determining the risk of bleeding and thrombosis in the preoperative period, treating anemia, and optimizing antithrombotic therapies. Then, intraoperative blood conservation strategies such as meticulous surgical technique, optimal management of anticoagulation, and appropriate use

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of hemostatic agents serve to preserve the patient's blood. In addition, optimal treatment of coagulopathy and bleeding with the proper use of blood products will certainly reduce the risk of complications.[3] Therefore, the process that begins with a detailed preoperative evaluation of the patient for PBM in clinics can provide access to excellent care in these patient populations.

The basic steps for implementing PBM include developing nationwide and hospital-wide guidelines, establishing a commission to control the correct use of blood products, providing periodic training in all disciplines, monitoring compliance with the guidelines, and collecting data to evaluate the success rate. In this context, in addition to the guidelines prepared on PBM in Türkiye, our hospital's guidelines and in-clinic training have gained momentum in recent years.[4–6]

In 2014, the PBM program was partially implemented in the cardiac anesthesia clinic of our hospital, but due to some deficiencies, full implementation could not be achieved. Thereafter, the hospital moved to a new facility with a larger capacity, and a new program needed to be established. A before-after study was conducted to evaluate the point reached after the necessary steps were completed.

This study aimed to determine the changes in blood product use and patient outcomes with the implementation of PBM, component therapy education, and viscoelastic testing in our clinic.

Methods

This was a pre- and post-implementation cohort study with prospectively collected data and was conducted following the principles of the Declaration of Helsinki. The study was approved by the ethics committee (TABED number: 2-24-633, date: 13.11.2024) for clinical research at the university hospital.

Among ASA II-V adult patients who underwent cardiac surgery with cardiopulmonary bypass (CPB) between January 2021 and June 2024, those with at least 1000 mL intraoperative blood loss and requiring erythrocyte suspension transfusion were included in the study. Informed consent was obtained from each patient and their relatives via phone call.

The demographic, intraoperative, and postoperative data of these patients were retrieved from the archives, patient files, intensive care and ward follow-up forms, and electronic record documents.

The primary outcome measures were determined as blood product transfusion requirements. In our tertiary hospital department of cardiovascular anesthesia, the ROTEM-guided PBM strategy has recently become the standard practice in bleeding patients, and in this pre- and post-implementation setup, a comparison was made with the patient group previously managed using classical laboratory data.

ROTEM-guided transfusion management was introduced in our clinic in January 2023, and since then, concurrent PBM and component therapy training has been intensively provided to everyone involved in the anesthesia management of patients (specialists, residents, and technicians).

Patients were divided into two groups:

- Group Before: Patients who had surgery before this date.
- Group After: Patients who had surgery after this date.

Training was conducted by an anesthesiologist experienced in viscoelastic testing. ROTEM results were evaluated on a case-by-case basis in bleeding patients, and treatment was directed accordingly.

Additionally, monthly coagulation management panels were held for anesthesiologists, aiming to familiarize and educate them on perioperative bleeding management based on a specific guideline rather than following conventional methods.

For the preoperative period, the following data were recorded:

- Demographics: Age, gender, and body mass index (BMI).
- Risk scores: EuroSCORE II and ASA score.
- Existing comorbidities.

For the intraoperative period, the following parameters were documented:

- Type of surgery.
- Emergency/elective status.
- Cross-clamp and cardiopulmonary bypass times.
- Inotropic or vasopressor requirement.
- Blood product and component therapy usage.

Finally, the preoperative, postoperative 0-hour, and 24-hour laboratory data as well as postoperative complications were recorded.

Statistical Analysis

IBM SPSS Statistics 21.0 (IBM Corp., Released 2012) was used for statistical analyses and calculations. $p<0.05$ was considered significant.

Mean±standard deviation and median (minimum-maximum) values were used to represent continuous variables in the study, and their conformity to normal distribution was evaluated graphically and by the Shapiro-Wilk test.

For the comparison of continuous variables, the Independent Samples t-test was used for normally distributed parameters,

Table 1. Preoperative demographic and intraoperative data

	Group before (n=156)			Group after (n=111)			p
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			62.11±12.4			61.50±10.2	0.664
Gender (male)	93	59.6		72	64.9		0.384
BMI (kg/m²)			25.26±7.5			26.15±8.0	0.360
LVEF (%)			51.34±11.0			52.01±9.3	0.653
Euroscore 2			7.68±2.3			5.17±3.1	0.054
ASA							
II	45	28.8		19	17.1		0.081
III	95	60.9		77	69.4		
IV	16	10.3		15	13.5		
CAD	58	37.2		44	39.6		0.683
CHF	11	7.1		5	4.5		0.388
Diabetes mellitus	68	43.6		37	33.3		0.091
Hypertension	107	68.6		76	68.5		0.983
COPD	20	12.8		2	1.8		0.464
CKD	12	7.7		2	1.8		0.033
Stroke/TIA	4	2.6		3	2.7		0.944
Type of surgery							
CABG	62	39.7		46	41.4		0.908
Valve surgery	23	14.7		17	15.3		
Aortic surgery	19	12.2		16	14.4		
Combined procedures	47	30.1		30	27.0		
LVAD/heart transplantation	5	3.2		2	1.8		
Operative data							
Emergency surgery	41	26.3		27	24.3		0.717
Cross-clamp duration (min)			107.97±46.2			112.01±45.3	0.491
CPB duration (min)			160.48±64.8			163.92±64.9	0.676
UF	25	16.0		18	16.2		0.967
Dopamine	112	71.8		81	73.0		0.832
Dobutamine	65	41.7		58	52.3		0.087
Noradrenaline	64	41.0		58	52.3		0.070
Adrenaline	21	13.5		12	10.8		0.517

Independent Samples t-Test and Chi-square test results are given. SD: Standard deviation; BMI: Body mass index; LVEF: Left ventricular ejection fraction; ASA; American society of anesthesiologists; CAD; Coronary artery disease, CHF: Congestive heart failure; COPD: Chronic obstructive pulmonary disease; CKC: Chronic kidney disease; TIA: Transient ischemic attack; CABG: Coronary artery bypass graft; LVAD: Left ventricular assist device; CPB: Cardiopulmonary bypass; UF: Ultrafiltration.

and the Mann-Whitney U test was used for non-normally distributed parameters. In the comparison of categorical variables, cross-tabulations were created, and number (n), percentage, and chi-square (χ^2) test statistics were given.

Results

Between January 2021 and June 2024, a total of 267 patients who experienced at least 1000 mL of intraoperative blood loss and required erythrocyte suspension (ES) transfusion were identified and included in the study.

When comparing the preoperative demographic data (age, gender, body mass index, comorbidities, etc.) and intraoperative variables (type of surgery, inotropes, vasopressors, CPB durations, etc.), no statistically significant difference was found (Table 1).

Among the laboratory data, postoperative 0^{th}-hour PT, aPTT, platelet count, and 24^{th}-hour aPTT values were significantly lower in Group After; all other laboratory data were similar between the groups (Table 2).

When blood and blood product utilization were analyzed, pRBC, FFP, and PC transfusions were similar in both periods (Table 3). Although there was no statistical significance, the percentage of patients receiving three or more units of FFP was lower in Group After.

However, there was a significant increase in the use of fibrinogen, PCC, and autologous blood transfusion in

Table 2. Preoperative, postoperative 0 and 24th hour laboratory data

	Group before (n=156) Mean±SD	Group after (n=111) Mean±SD	p
Preoperative period			
Hemoglobin (g/L)	12.01±1.8	12.16±1.9	0.544
Platelet count (10^9/L)	249.11±88.3	240.3±86.9	0.423
Blood urea (mg/dL)	47.49±25.2	44.74±21.7	0.340
Serum creatinine (mg/dL)	1.11±0.7	1.10±0.9	0.980
eGFR (ml/min/1.73 m^2)	73.90±25.7	78.89±23.8	0.107
Aspartate aminotransferase (U/L)	47.84±4.4	36.50±8.0	0.349
Alanine aminotransferase (U/L)	33.93±7.3	33.00±3.4	0.891
Prothrombin Time (s)	13.65±3.4	13.44±4.5	0.679
Activated partial thromboplastin time (s)	26.53±5.3	26.78±10.3	0.800
International normalized ratio	1.20±0.3	1.19±0.4	0.916
Fibrinogen (g/L)	3.10±1.4	2.93±1.3	0.324
Postoperative period 0			
Hemoglobin (g/L)	9.34±1.2	9.19±1.1	0.312
Platelet count (10^9/L)	162.21±71.5	144.14±64.5	**0.032**
Blood urea (mg/dL)	54.59±25.5	49.96±19.6	0.095
Serum creatinine (mg/dL)	1.27±0.7	1.25±0.8	0.773
eGFR (ml/min/1.73 m^2)	65.32±26.4	68.48±26.0	0.336
Aspartate aminotransferase (U/L)	195.53±28.3	187.34±32.5	0.831
Alanine aminotransferase (U/L)	83.16±14.6	115.61±32.4	0.271
Prothrombin time (s)	16.96±5.8	15.69±4.0	**0.037**
Activated partial thromboplastin time (s)	35.76±1.8	31.33±1.3	**0.028**
International normalized ratio	1.53±0.7	1.41±0.3	0.113
Fibrinogen (g/L)	2.54±0.9	2.83±1.2	0.035
Postoperative 24th hour			
Hemoglobin (g/L)	9.08±1.0	9.05±0.7	0.778
Platelet count (10^9/L)	144.50±66.5	135.88±60.6	0.273
Blood urea (mg/dL)	71.90±30.2	66.12±22.6	0.090
Serum creatinine (mg/dL)	1.53±0.9	1.44±0.9	0.452
eGFR (ml/min/1.73 m^2)	57.68±30.8	62.63±30.8	0.200
Aspartate aminotransferase (U/L)	595.75±195.4	451.73±119.2	0.456
Alanine aminotransferase (U/L)	252.85±72.4	257.35±76.6	0.961
Prothrombin time (s)	17.04±7.1	16.12±4.9	0.216
Activated partial thromboplastin time (s)	36.48±19.4	31.97±11.4	**0.030**
International normalized ratio	1.56±0.9	1.45±0.5	0.251
Fibrinogen (g/L)	4.16±1.4	4.15±1.5	0.962

Independent Samples t-Test results are given. eGFR: Estimated glomerular filtration rate.

Group After (p=0.017, p=0.006, and p=0.033, respectively). Postoperative complications and mortality were similar in both periods.

Discussion

Patient Blood Management (PBM) represents a multidisciplinary and evidence-based approach developed to improve patient outcomes and prevent unnecessary blood transfusions.[7] The practices in our clinic serve as an important example of the integration of PBM into clinical practice, both theoretically and practically.

In this article, we examined the effectiveness of approaches aimed at overcoming both equipment and training deficiencies in current PBM practices. In our clinic, preoperative anemia treatment management and hematological drug use are meticulously addressed. Retrograde autologous priming (ROP) and ultrafiltration are used to limit hemodilution, while cell saver is utilized

Table 3. Intraoperative blood product use and postoperative complications

	Group before (n=156)		Group after (n=111)		p
	n	%	n	%	
pRBC transfusion					
≤3 units	105	67.3	84	75.7	0.138
>3 units	51	32.7	27	24.3	
FFP transfusion					
0 unit	47	30.1	29	26.1	0.319
1-3 units	98	62.8	78	70.3	
>3 units	11	7.1	4	3.6	
PC transfusion					
1 unit	23	14.7	11	9.9	0.485
2 units	2	1.3	2	1.8	
Cryoprecipitate	19	12.2	14	12.6	0.916
Fibrinogen concentrate	17	10.9	24	21.6	**0.017**
Prothrombin complex concentrate	14	9.0	23	20.7	**0.006**
Autologous blood transfusion	22	14.1	27	24.3	**0.033**
Tranexamic acid use	103	66	82	73.9	0.171
Cardiac failure	21	13.5	22	19.8	0.164
Acute kidney injury	35	22.4	17	15.3	0.182
Cerebrovascular event	15	9.6	8	7.2	0.489
Sepsis	6	3.8	7	6.3	0.650
Reoperation for bleeding	47	30.1	28	25.5	0.404
Mortality 30-day	37	23.7	20	18.5	0.313

Chi-square test results are given. pRBC: Packed red blood cells; FFP: Fresh frozen plasma; PC: platelet concentrate.

in patients with critical bleeding. Although tranexamic acid is routinely administered by most physicians, its use is occasionally restricted due to the preferences of certain cardiac surgeons.

It has been observed that the blood transfusion algorithms developed under ROTEM guidance, along with intensive training, have led to an increase in the use of fibrinogen concentrate, prothrombin complex concentrate (PCC), and autologous blood transfusion. This result suggests that component therapy for the proper management of hemostasis has improved.

With the widespread implementation of PBM, it has been scientifically proven that blood transfusions and related complications have decreased.[3] However, some challenges remain in the full implementation of these approaches.[8–10]

Firstly, the lack of education and awareness is a notable challenge. The successful implementation of PBM algorithms depends on the knowledge and skills of multidisciplinary teams. However, healthcare personnel may not always possess sufficient awareness or expertise on this subject. Continuous practical and theoretical education programs play a critical role in addressing these deficiencies. Conducting training on a case-by-case basis during intraoperative bleeding management allows clinicians to focus more effectively. Moreover, the periodic repetition of training is crucial; otherwise, as with many mandatory training programs, practical implementation may remain insufficient.

Secondly, technological and financial limitations pose another obstacle. The costs of advanced technologies such as cell savers, ROTEM, and ultrafiltration may not be affordable for every healthcare institution, limiting PBM applications in resource-constrained centers. ROTEM provides a dynamic and rapid assessment of hemostasis, guiding treatment by identifying specific deficiencies, especially in cases of coagulopathy frequently encountered in cardiac surgery. This capability may reduce unnecessary transfusions and complications by enabling targeted therapy.[11–13]

However, some studies and clinical observations suggest that ROTEM use may increase blood product consumption, particularly fibrinogen or PCC administration.[14,15] In a study on trauma patients, the initiation of ROTEM-guided transfusion was associated with increased fibrinogen use, yet no significant difference was observed in mortality rates or the transfusion of red blood cells, fresh frozen plasma, platelets, or cryoprecipitates.[14]

Similarly, in our study, ROTEM use led to a higher rate of detection of isolated fibrinogen deficiency during bleeding, thereby increasing the administration of targeted fibrinogen concentrate. ROTEM effectively detects specific hemostatic disorders, such as fibrinogen deficiency, platelet dysfunction, or hypocoagulation, allowing for more targeted but potentially increased blood product use.

Additionally, there is speculation in the literature that ROTEM promotes fibrinogen usage, while TEG (Thromboelastography) is more likely to encourage plasma use in viscoelastic testing.[16] ROTEM-based algorithms have been shown to predict a higher frequency of fibrinogen concentrate, PCC, and tranexamic acid use, as well as fresh frozen plasma or platelet transfusions.[16] This pattern suggests that ROTEM-guided strategies may increase blood component utilization compared to traditional methods.

The use of ROTEM in cardiac surgery may lead to higher blood product consumption. However, when applied to the right patient population with appropriate protocols, this increase may enhance patient outcomes by ensuring targeted therapy. It is essential to perceive ROTEM not merely as a tool to increase transfusions but as a method to optimize patient needs and prevent excessive transfusion.

Another issue that needs to be discussed is that, just like in our study, there are also articles indicating that the use of ROTEM has no significant effect on patient outcomes.[17] However, our results are relatively recent, making it difficult to draw premature conclusions on this issue. It would be appropriate to re-evaluate the results in the future once ROTEM-guided PBM implementation has been widely adopted by multidisciplinary operating room clinicians.

Although there was no statistical significance in this before-after study, which included a small number of patients, the observed decrease in the need for reoperation, reduction in FFP usage, and even the decline in mortality rates appear promising.

Conclusion

Patient Blood Management (PBM) is a paradigm aimed at improving patient safety and clinical outcomes by utilizing individualized and targeted treatment approaches. Our clinical experience demonstrates that this approach can be successfully implemented. However, increasing investments in education, technological access, and standardization will facilitate the wider adoption of PBM applications.

PBM is a strong reflection of the human-centered approach of modern medicine, and any advancements in this field will enhance the overall efficiency of healthcare systems.

Disclosures

Ethics Committee Approval: The study was approved by The Ankara Bilkent City Hospital Ethics Committee (no: 2-24-633, date: 13/11/2024).

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