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Patient Blood Management in Hip Replacements: An Observational Retrospective Cohort Study

Kalça Protezlerinde Hasta Kan Yönetimi: Gözlemsel, Retrospektif Bir Kohort Çalışması

Yonca Ozvardar Pekcan[1], Bahattin Tuncali[2], Suleyman Sukru Arac[3]

[1]Izmir Menemen State Hospital, Clinic of Anesthesiology and Reanimation, Izmir, Türkiye
[2]Baskent University School of Medicine, Department of Anesthesiology and Reanimation, Ankara, Türkiye
[3]Baskent University School of Medicine, Department of Orthopedics and Traumatology, Ankara, Türkiye

ABSTRACT

Objective: To retrospectively evaluate perioperative blood transfusion rates and effects after the implementing of patient blood management strategies in patients who underwent hip replacement surgery by the same experienced surgeon.

Methods: Patients were divided into two groups: before and after the implementation of patient blood management strategies. Patients who underwent hip surgery by the same surgeon were between the ages of 18-90, had an American Society of Anesthesiologists Physical Status Classification ≤3, platelet count >100 K μL^{-1}, had no history of hematological disease, did not use anticoagulants, or discontinued treatment before the recommended period were included in the study. In the intraoperative period, moderate hypotensive anesthesia, regional anesthesia, deep sedation methods, adjustment of intravenous fluid therapy according to the amount of bleeding and fluid deficit, warming of intravenous fluids, blood, and the patient during the operation, and monitoring of bleeding due to the operation were provided. When the amount of bleeding in the aspirator exceeded 1000 mL, when the mean blood pressure of the patient fell below 20% of the entrance mean blood pressure after the exclusion of causes other than bleeding, or when the amount of bleeding in the tampons or around the surgery site increased, a decision was made together with the surgeon and blood transfusion was applied.

Results: A total of 552 patients were included in the study. The red blood cell transfusion rate was significantly higher in the first 6-year period in patients with total hip replacement (p=0.017). Patients with higher transfusion rates were older and had lower body mass index (p<0.001).

Conclusion: In conclusion, this study showed that transfusion rates and related complications can be reduced using patient blood management strategies, in total hip arthroplasty. Additionally, patients with advanced age, female gender, low body mass index, and coronary artery disease received hyper red blood cells transfusions.

Keywords: Patient blood management, hip replacement, anesthesia

ÖZ

Amaç: Aynı deneyimli cerrah tarafından kalça protezi ameliyatı yapılan hastalarda hasta kan yönetimi stratejilerinin uygulanmasının ardından peroperatif kan transfüzyon oranlarını ve etkilerini restospektif olarak değerlendirmek.

Yöntem: Hastalar, hasta kan yönetimi stratejilerinin uygulanma tarihi öncesi ve sonrası olmak üzere iki gruba ayrıldı. Aynı cerrah tarafında kalça operasyonu uygulanan, yaşları 18-90 arasında olan, Amerikan Anestezistler Derneği Fiziksel Durum Sınıflaması ≤3, trombosit sayısı >100 K μL^{-1} olan, hematolojik hastalık öyküsü olmayan, antikoagülan kullanmayan veya önerilen süre öncesi tedaviyi bırakan hastalar çalışmaya dahil edildi. İntraoperatif dönemde orta derecede hipotansif anestezi, bölgesel anestezi ve derin sedasyon yöntemleri, intravenöz sıvı tedavisinin kanama miktarına ve sıvı açığına göre ayarlanması ve operasyon sırasında intravenöz sıvıların, kanın ve hastanın ısıtılması, operasyona bağlı kanamanın takibi sağlandı. Aspiratördeki kanama miktarı 1000 mL üzerine çıktığında, kanama harici sebepler ekarte edildikten sonra hastanın ortalama kan basıncı giriş değerinin %20 altına düştüğünde, tamponlardaki veya ameliyat yeri etrafındaki kanama miktarı arttığında cerrahla beraber karar verilerek kan transfüzyonu uygulandı.

Bulgular: Çalışmaya toplam 552 hasta dahil edildi. Total kalça protezi yapılan hastalarda hasta kan yönetimi stratejilerinin uygulanmasından önceki dönemde eritrosit transfüzyon oranı anlamlı olarak yüksekti (p=0,017). Transfüzyon oranı yüksek olan hastalar daha yaşlı ve vücut kütle indeksi daha düşüktü (p<0,001).

Sonuç: Sonuç olarak, bu çalışma total kalça artroplastisinde hasta kan yönetimi stratejileri kullanılarak transfüzyon oranlarının ve buna bağlı komplikasyonların azaltılabileceğini göstermiştir. Ek olarak ileri yaş, kadın cinsiyet, düşük vücut kitle indeksi ve koroner arter hastalığı hastalarına daha fazla eritrosit transfüzyonu uygulandığı saptandı.

Anahtar sözcükler: Hasta kan yönetimi, kalça protezi, anestezi

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***Corresponding author:** Yonca Ozvardar Pekcan • yncapek@gmail.com
Yonca Ozvardar Pekcan 0000-0002-0991-7435 / Bahattin Tuncali 0000-0002-7898-2943
Suleyman Sukru Arac 0000-0003-2331-7070

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INTRODUCTION

Hip replacement surgeries are among the operations whose frequency is increasing both in our country and globally. In these operations, procedures such as soft tissue dissection, preparation of the acetabulum, and cutting of the femur cause acute blood loss and continue in the postoperative period (1). It has been reported that the blood transfusion rate in hip operations in the United States is between 18-68% (2,3). There are also studies reporting that erythrocyte transfusion was applied to approximately 46% in the intraoperative or postoperative period (4).

Various complications may develop in patients during or after blood transfusion. These complications include local or systemic infections, venous thromboembolic events, allergic reactions, circulatory overload, transfusion-induced acute lung injury, increased morbidity, mortality, and hospital stay. In addition, a significant increase in cost can be observed (4). It is thought that the amount of bleeding varies according to the duration of the operation, the experience of the surgeon, and the type of surgery. Therefore, it is important for patient safety to reduce surgical bleeding and avoid transfusion as much as possible (5).

'Patient blood management' has been defined adoption of strategies to reduce the frequency of perioperative surgical bleeding and transfusion (6,7). This management includes perioperative patient blood management practices, correction of preoperative anemia, autologous blood donation, stopping of anticoagulants, acute normovolemic hemodilution, regional anesthesia, controlled hypotension, avoidance of hypothermia, appropriate fluid management, meticulous surgery, appropriate hemostasis, patient position, postoperative drain strategy, tranexamic acid use (8). Patient blood management measures have been actively used since 2017 in hip replacement surgeries.

This study aims to retrospectively evaluate the effects of patient blood management strategies, on blood transfusion rate in hip replacement surgery.

MATERIAL and METHODS

The present study was approved by Baskent University Institutional Review Board (Project no: KA22/430) and supported by Baskent University Research Fund. (ClinicalTrials.gov NCT05627544). Following ethics committee approval, the perioperative follow-up forms and patient records of 565 patients who underwent hip prosthesis operations (total hip prosthesis [THP] and revision hip prosthesis [RHP]) by the same experienced surgeon between January 2010 and August 2022 were retrospectively reviewed. Informed consent was obtained from all participants.

Patients aged 18–90 years, classified as classified as ASA Physical Status I-III, and with platelet counts ≥100 K μL^{-1} were included in the study. Exclusion criteria included patients outside the specified age range, ASA > 3, platelet counts < 100 K μL^{-1}, a history of hematological disorders, and failure to discontinue anticoagulants on the recommended date.

Demographic data of the patients, ASA scores, preoperative, perioperative, and postoperative transfusion amount, type of surgery and anesthesia, duration of surgery, fluid management, drainage volume, the intensive care unit admissions, and complications, were recorded. Patients were divided into 2 groups: before (Group 1) and after (Group 2) 2017, marking the implementation of blood management strategies.

Within these strategies, the transfusion risks were determined preoperatively and anemia was corrected. Intraoperatively, methods included moderate hypotensive anesthesia, regional anesthesia, and deep sedation methods, fluid therapy adjustments, warming of intravenous fluids, blood, and the patient, and meticulous monitoring of bleeding. When the amount of bleeding in the aspirator exceeded 1000 mL, when the mean blood pressure of the patient fell below 20% of the entrance mean blood pressure after the exclusion of causes other than bleeding, or when the amount of bleeding in the tampons or around the surgery site increased, a decision was made together with the surgeon and blood transfusion was applied. Postoperative care included continued warming, pain management with epidural or intravenous patient-controlled analgesia methods, drain monitoring and transfusion based on clinical and laboratory parameters. If the amount of bleeding was excessive and the patient's mean blood pressure was 20% below the entrance mean blood pressure, a blood transfusion decision was made together with the surgeon by monitoring the hemogram. If hemoglobin was < 8 g dL^{-1} in ASA I-II patients and < 9 g dL^{-1} in ASA III patients, transfusion was applied.

Statistical Analysis

Statistical analyses were analyzed using IBM SPSS Statistics 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) Program. Normal distribution control of numerical variables was examined by the Kolmogorov-Smirnov Test. The existence of a linear relationship between the frequency of transfusion and other numerical and ordinal variables was evaluated using the Spearman correlation analysis method. Transfusion frequency in two-group variables was compared between groups using the Mann-Whitney U Test. Comparisons were made with the Kruskal-Wallis Test in variables with three or more groups, and Dunn's Test (with Bonferroni correction) was used for pairwise group comparisons when the difference was significant. Categorical variables were expressed as counts and per-

centages and continuous variables were expressed as mean and SD.

All hypothesis tests were carried out bilaterally two-sided at the 0.05 significance level.

RESULTS

Of the 565 patients, eight were excluded due to missing data, anticoagulant use, or low platelet count. A total of 552 patients (400 women, and 152 men) were included. Demographic data are summarized in Table I.

The blood transfusion rate was significantly higher in patients, undergoing hip revision due to prosthesis deformation or infection (p<0.001). Detailed diagnoses and surgical operations are provided in Table II.

In Group 1, six patients (five undergoing THP and one undergoing RHP) received preoperative red blood cell transfusions, compared to three patients in Group 2 (two undergoing THP and one undergoing RHP).

Postoperative transfusion rates were significantly lower in Group 2, with 133 (65.8%) patients receiving transfusions compared to 250 (71.4%) in Group 1 (p=0.041). Most transfusions occurred on postoperative days 1 (68.8%) and 2. Transfusion rates were notably reduced in total hip replacement surgeries in Group 2 (p=0.017; Table III). However, there was no significant change in transfusion rates for revision hip prostheses.

Table I. Patients Characteristics

		Group 1 n=350	Group 2 n=202	p
Female gender n (%)		256 (73.1)	144 (71.3)	0.638$^{\gamma}$
Age (mean ± SD)		60.25 ± 15.91	61.35 ± 16.08	0.330$^{\alpha}$
BMI (mean ± SD)		27.08 ± 3.99	27.41 ± 4.49	0.365$^{\alpha}$
ASA n (%)	I	115 (33)	58 (%28.7)	0.594$^{\beta}$
	II	231 (66.2)	142 (70.3)	
	III	3 (0.9)	3 (1)	
CAD n (%)		17 (4.9)	14 (7)	0.301$^{\gamma}$
AU n (%)		61 (17.4)	41 (20.3)	0.403$^{\gamma}$
Op Typ	THR n (%)	303 (86.6)	175 (86.6)	0.951$^{\gamma}$
	RHR n (%)	46 (13.2)	27 (13.4)	
AN1 n (%)		301 (86)	179 (88.6)	0.279$^{\beta}$
AN2 n (%)		38 (10.9)	15 (7.4)	
AN3 n (%)		4 (1.1)	6 (3)	
AN4 n (%)		5 (1.4)	2 (1)	
AN5 n (%)		2 (0.6)	0	
Op T THR (min)		74.21 ± 25.38	74.51 ± 20.83	0.761$^{\alpha}$
Op T RHR (min)		138.4 ± 37.79	136.48 ± 41.60	
An T THR (min)		112.74 ± 27.19	118.11 ± 24.71	**0.003**$^{\alpha}$
An T RHR (min)		181.06 ± 42.37	185.93 ± 44.96	
HS THR (day)		6.14 ± 1.30	5.68 ± 1.25	**p<0.001**$^{\alpha}$
HS RHR (day)		7.68 ± 3.47	6.52 ± 3.67	**p=0.002**$^{\alpha}$

SD: Standart Deviation, **BMI:** Body mass index, **ASA:** American Society of Anesthesiologists' Physical Status Classification, **CAD:** Coronary artery disease, **AU:** Anticoagulant use, **Op Typ:** Operation type, **THR:** Total hip replacement, **RHR:** Revision hip replacement, **AN:** Anesthesia type, **AN1:** Combined spinal and epidural anesthesia, **AN2:** General anesthesia, **AN3:** Spinal anesthesia, **AN4:** Epidural and general anesthesia, **AN5:** Combined spinal and epidural and general anesthesia, **Op T:** Operation time, **min:** Minute, **An T:** Anesthesia time, **HS:** Hospital stay. Data were analyzed using: **α:** Mann-Whitney U Test, **β:** Fisher's Exact Test, **γ:** Chi-Square Test. p<0.05 was considered significant.

Table II. Diagnoses and Surgeries

	Group 1 n (%)	Group 2 n (%)	p-value
Hip osteoarthritis + total hip replacement	261 (%75.5)	174 (%86.13)	**p = 0.018**
Revision hip replacement	39 (%11.14)	9 (%4.45)	
Hip fracture + total hip replacement	37 (%10.5)	13 (%6.4)	
Hip fracture + Revision hip replacement	6 (%1.7)	2 (%0.99)	
Congenital hip dislocation + total hip replacement	6 (%1.7)	4 (%1.98)	
Infected hip replacement + Revision hip replacement	1 (%0.28)		

Data were analyzed using the Fisher's Exact Test and p<0.05 was considered significant.

Table III. Comparison of Perioperative Red Blood Cell Transfusions Between Periods in Total and Revision Hip Replacement

	Total Hip Replacement		p	Revision Hip Replacement		p
	Group 1 (n=303)	Group 2 (n=175)		Group 1 (n=47)	Group 2 (n=27)	
Preop Hb (gr dL^{-1}) (mean±SD)	12.83±1.51	13.05±1.61	0.191$^{\alpha}$	11.89±1.72	12.39±1.77	0.099$^{\alpha}$
Preop transfusion Yes n (%)	6 (%2)	1 (%0.6)	0.431$^{\beta}$	2 (%4.3)	2 (%7.4)	0.620$^{\beta}$
Number of preop transfusion						
Median/Mean Rank	0.0/241.0	0.0/236.9	0.153$^{\alpha}$	0.0/37.1	0.0/38.2	0.586$^{\alpha}$
Min-Max	0–2	0–1		0–2	0–2	
Perop transfusion Yes n (%)	40 (%13.2)	16 (%9.1)	0.184$^{\gamma}$	37 (%78.7)	24 (%88.9)	0.351$^{\beta}$
Number of perop transfusion						
Median/Mean Rank	0.0/242.9	0.0/233.7	0.215$^{\alpha}$	1.0/35.8	1.0/40.5	0.329$^{\alpha}$
Min-Max	0–2	0–1		0–3	0–3	
Postop transfusion Yes n (%)	204 (%67.3)	106 (%60.6)	0.136$^{\gamma}$	46 (%97.9)	27 (100.0%)	1.000$^{\beta}$
Number of postop transfusion						
Median/Mean Rank	1.0/248.9	1.0/233.7	**0.036**$^{\alpha}$	2.0/39.8	2.0/33.6	0.214$^{\alpha}$
Min-Max	0–6	0–4		0–4	1–5	
Number of total transfusion						
Median/Mean Rank	1.0/250.4	1.0/220.6	**0.017**$^{\alpha}$	4.0/38.0	3.0/36.6	0.784$^{\alpha}$
Min-Max	0–7	0–4		7–Jan	1–7	

SD: Standart Deviation, **Hb:** Hemoglobin. **α:** Mann-Whitney U Test, **β:** Fisher's Exact Test, **γ:** Chi-Square Test. p<0.05 was considered significant.

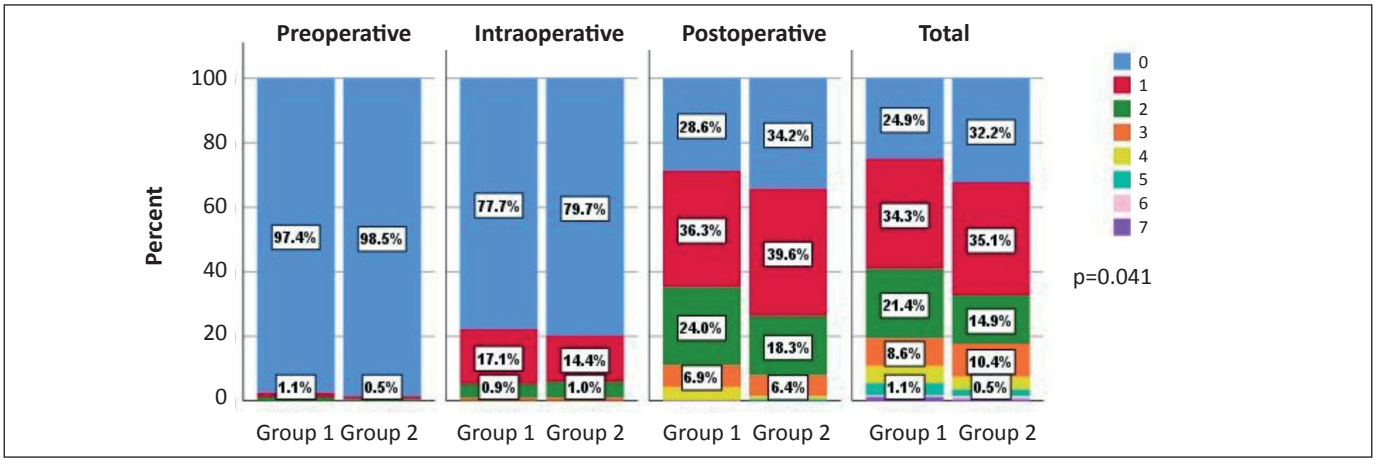

Figure 1. Stacked bar percent by the time of red blood cell transfusion by group (pre-, intra-, postoperative, and total).

Intraoperative data of patients with THP are summarized in Figure 2.

Higher transfusion rates were observed in older patients (r=0.173; p<0.001), women, and those with low body mass index (BMI) (r=- 0.129; p=0.002).

Prolonged surgery and anesthesia duration also correlated with increased transfusions (r=0.396 and r=0.357, respectively; p<0.001).

More drains correlated with increased transfusions (r=0.260; p<0.001).

The highest transfusion rates correlated with longer hospital stays (r=0.286; p<0.001), and lower postoperative urine volume (r=- 0.260; p<0.001).

The lowest transfusion rates were observed in combined spinal-epidural anesthesia (p=0.001) or epidural-general anesthesia (p=0.029).

Patients with coronary artery disease (CAD) (p=0.047), preoperative analgesic (p=0.001) and opioid use (p=0.009), non-smokers (p=0.016), had higher red cell transfusion rates.

Patients who received transfusion had higher intensive care unit admission rates (p=0.005) and experienced complications such as arrhythmias (p<0.001) and infections (p=0.033). No mortality was observed during hospitalization.

DISCUSSION

In this study, it was demonstrated that erythrocyte transfusion rates can be reduced by implementing patient blood management strategies in total hip replacement surgeries performed by the same experienced surgeon. In Group 2, the erythrocyte transfusion rate was significantly lower, even compared to previous studies (1,4,9). During the intraoperative period, 20.3% of patients required transfusions.

A study conducted in Korea on hip arthroplasty patients between 2007 and 2015 reported a blood transfusion rate of 81.1%, with an average of 4.3 units for total hip arthroplasty (THR) and 8.7 units for revision hip arthroplasty (RHR) (1). In this study, 132 (43%) patients who underwent THR did not require transfusion. Another study comparing blood loss between THR and revision hip prostheses revealed an average additional blood loss of 478.9 mL in revision patients (9-12). In this study, no significant reduction in blood transfusion

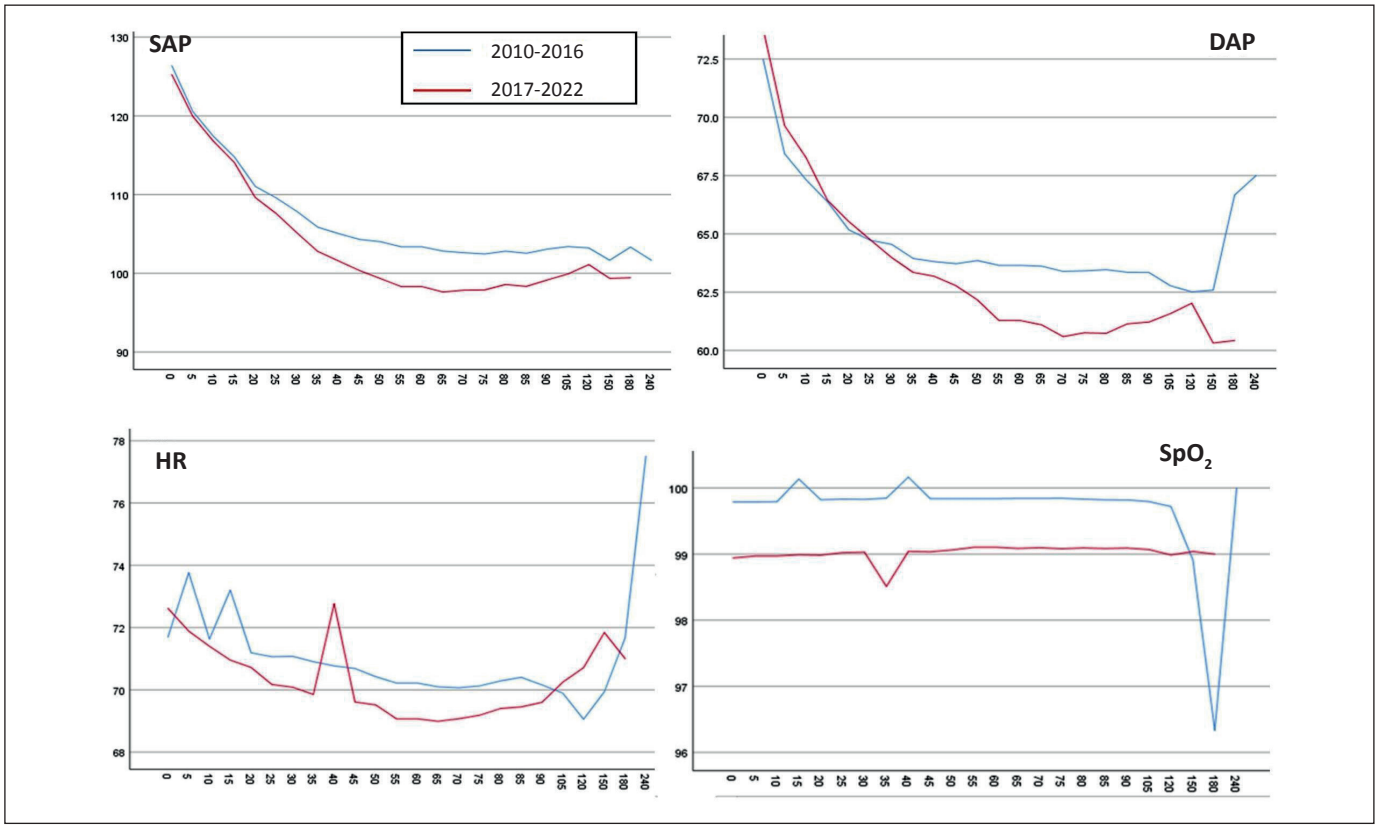

Figure 2. Mean values for systolic arterial pressure, diastolic arterial pressure, heart rate, and peripheric oxygen saturation. **SAP:** Systolic arterial pressure, **DAP:** Diastolic arterial pressure, **MAP:** Mean arterial pressure, **HR:** Heart rate, **SpO_2:** Peripheral oxygen saturation.

rates was observed in patients undergoing RHR, likely due to the small number of RHR surgeries and the longer duration of these procedures compared to THR surgeries (Table I).

Preparing patients for surgery, identifying causes of blood loss during and after the procedure, and developing preventive strategies are critical for all operations, particularly hip replacement surgeries. Patient blood management strategies, introduced at our hospital in 2017, have contributed to lower transfusion rates in THR. Similar findings in the literature confirm that such strategies effectively reduce transfusion rates in hip prostheses. For instance, Frish et al. observed that every 40-minute increase in operation time elevated the risk of transfusion in 1,573 patients undergoing hip and knee arthroplasty (13).

The impact of anesthesia type on transfusion rates remains inconsistent across studies. While some studies reported lower transfusion rates with regional anesthesia compared to general anesthesia, others found reduced intraoperative but increased postoperative bleeding with epidural anesthesia (14,15). In this study, combined spinal-epidural or epidural and general anesthesia were used, and transfusion rates were low. Moderate hypotension during THR (Figure 2) was thought to contribute to reduced blood transfusions, aligning with reports that epidural anesthesia decreases blood flow, sympathetic tone, and venous pressure (16). Additionally, the use of nitrous oxide during general anesthesia may inhibit erythropoiesis (17).

The higher transfusion rates observed in elderly and female patients align with findings in other studies (1,3). Higher iron reserves and preoperative hemoglobin levels in men likely increase their tolerance to intraoperative bleeding. Contrary to expectations, transfusion rates were higher in patients with low BMI. A previous study found transfusion rates increased from 16% to 37% in patients weighing less than 70 kg undergoing hip replacement, likely due to limited physiological reserves (18). Brawne et al. also reported that comorbidities, such as CAD, significantly increase transfusion rates (3). In this study, only CAD was associated with higher transfusion rates. No correlations were found between transfusion rates and conditions such as diabetes mellitus, congestive heart failure, chronic kidney failure, liver failure, arthritis, or hypertension. No mortality was observed during hospitalization.

Mortality rates post-surgery have been reported in the literature to increase at intervals such as 90, 120, or 365 days (19,20). However, meta-analyses found no significant link between transfusion and mortality (21). In this study, mortality and infection were monitored only during hospitalization. While no mortality occurred, a correlation-though not statistically significant—was observed between wound infection and transfusion rates. Transfusions may suppress the immune system, increasing the risk of infections and cancer recurrence (22,23). Techniques like leukoreduction and saline washing before transfusion have been proposed to mitigate these risks (24).

A decrease in intra- and postoperative urine output was noted in patients with high transfusion rates, potentially reflecting acute kidney injury caused by anemia-induced hypovolemia and fluid deficits. The harmful effects of transfusion, reduced oxygen delivery, and pre-existing kidney disorders likely contribute to this phenomenon (25).

This study has several limitations. First, it is a retrospective analysis with a small sample size. Additional limitations include insufficient data on pre- and post-transfusion hemoglobin levels, unrecorded intraoperative blood loss, lack of readmission data, and the inability to track mortality after discharge. A strength of this study is that all surgeries were performed by the same surgeon, minimizing variability related to skill and experience. Furthermore, pre-discharge hemoglobin levels and intraoperative hemodynamic data were analyzed.

CONCLUSION

In conclusion, this study demonstrates that patient blood management strategies can reduce transfusion rates and related complications in total hip arthroplasty. Advanced age, female gender, low BMI, and CAD were associated with higher transfusion rates.

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AUTHOR CONTRIBUTIONS

Conception or design of the work: YOP, BT
Data collection: YOP
Data analysis and interpretation: YOP, BT
Drafting the article: YOP
Critical revision of the article: YOP, BT, SSA
The author (YOP, BT, SSA) reviewed the results and approved the final version of the manuscript.

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