



Research Article

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Perioperative Red Blood Cell Transfusion and 30-Day Postoperative Morbidity Following Major General Surgery: A Retrospective Cohort Study

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Abstract

Background: Perioperative blood transfusions in major general surgery are still a common practice. However, there is increasing evidence that allogeneic red blood cell (RBC) transfusions are a potential risk factor for adverse postoperative outcomes and should not be considered benign support measures only. **Objective:** To evaluate the association between perioperative allogeneic RBC transfusion and 30-day postoperative morbidity among patients undergoing major general surgery. **Methods:** A retrospective cohort study was conducted on 384 adults who underwent either elective or emergency major general surgical procedures over a two-year period. The patients were stratified into transfused (n=128) and non-transfused groups (n=256). Multivariable logistic regression was performed to identify independent predictors of composite 30-day postoperative morbidity, and the demographic, operative, and perioperative variables were compared between groups. **Results:** Patients receiving perioperative RBC transfusion had a significantly higher incidence of composite 30-day postoperative morbidity than non-transfused patients (42.2% vs. 17.6%; $p<0.001$), which included surgical site infection, pneumonia, anastomotic leak, and prolonged ileus. The transfusion of three or more units of RBCs had the highest rate of composite morbidity. On multivariate analysis, the perioperative transfusion was the only variable that was an independent predictor of postoperative morbidity (aOR 2.94, $p<0.001$) along with American Society of Anesthesiologists (ASA) class $\geq$ III, emergency surgeries, and operative duration of greater than 180 minutes. **Conclusions:** Perioperative RBC transfusion was independently associated with increased postoperative morbidity following major general surgery. Management strategies and restrictive transfusion practices can reduce postoperative complications.

Keywords: General surgery; Iraq; Morbidity; Postoperative complications; RBC; Transfusion.

نقل خلايا الدم الحمراء أثناء العمليات ومرض ما بعد العملية لمدة 30 يوما بعد الجراحة العامة: دراسة جماعية بأثر رجعي

الخلاصة

الخلفية: لا تزال عمليات نقل الدم أثناء العمليات الجراحية الكبرى ممارسة شائعة. ومع ذلك، هناك أدلة متزايدة على أن نقل خلايا الدم الحمراء (RBC) عامل خطورة محتمل لنتائج سلبية بعد العملية ولا ينبغي اعتبارها تدابير دعم حميدة فقط. **الهدف:** تقييم العلاقة بين نقل الدم التخيفي الحيوي أثناء العمليات ومراضة ما بعد العملية لمدة 30 يوما بين المرضى الذين يخضعون لعمليات جراحية كبرى. **الطرائق:** أجريت دراسة جماعية بأثر رجعي على 384 بالغاً خضعوا لعمليات جراحية عامة اختيارية أو طارئة على مدى عامين. تم تقسيم المرضى إلى مجموعتين نقل الدم (n=128) وغير المنقولة لهم (n=256). تم إجراء دراسة مع انحدار لوجستي بأثر رجعي متعدد المتغيرات لتحديد العوامل المستقلة للمراضة المتفاقمة بعد 30 يوما من العملية، وتمت مقارنة المتغيرات الديموغرافية والجراحية والمنطقة حول العملية بين المجموعتين. **النتائج:** كان لدى المرضى الذين تلقوا نقل الدم خلال فترة ما قبل العملية معدل أعلى بشكل ملحوظ من المراضة المتفاقمة بعد العملية خلال 30 يوما مقارنة بالمرضى غير المنقول لهم (42.2% مقابل 17.6%؛ $p<0.001$)، والتي شملت خراج جرح العملية، ذات الرئة، تسرب التنفخ، وطول فترة شلل الأمعاء. كان نقل ثلاث وحدات أو أكثر من خلايا الدم الحمراء أعلى معدل من المراضة المتفاقمة. في التحليل متعدد المتغيرات، كان نقل الدم أثناء العملية هو المتغير الوحيد الذي كان مؤشرا مستقلا بمرض ما بعد العملية (aOR 2.94، $p<0.001$) متماشيا إلى جانب الجمعية الأمريكية لأطباء التخدير (ASA) من الفئة $\geq$ الثالثة، والعمليات الطارئة، ومدة العملية التي تزيد عن 180 دقيقة. **الاستنتاجات:** كان نقل الدم أثناء العملية مرتبطا بشكل مستقل بزيادة المراضة بعد العملية بعد العمليات الجراحية. يمكن للمعالجات الأستراتيجية وممارسات نقل الدم المقيدة أن تقلل من المضاعفات بعد العملية.

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INTRODUCTION

Perioperative Red Blood Cell (RBC) transfusions are one of the most frequently performed therapeutic interventions in major surgery around the world [1]. Pancreatic surgery, hepatobiliary surgery, gastrointestinal resection, and complex abdominal wall reconstructive surgery account for a substantial proportion of perioperative allogeneic RBC utilization [2]. Historically, blood transfusions were considered a supportive intervention to correct anemia, replace blood loss, and improve tissue oxygen delivery [3]. Nevertheless, in the last 20 years, accumulating evidence

from observational studies, randomized trials, and meta-analyses indicates that allogeneic RBC transfusion is associated with increased postoperative morbidity, including surgical site infection, pulmonary complications, prolonged hospitalization, and mortality [4,5]. Specifically, perioperative transfusion has been associated with an increased risk of postoperative infection in multiple studies, including colorectal, trauma, urologic, and cardiac surgery patients [6,7]. Even with the extensive body of evidence, there are still few descriptions of transfusion practices and their clinical impacts in Iraqi surgical settings. Despite substantial expansion of surgical capacity in the Iraqi healthcare

system as well as the growing number of hospitals in the private sector, factors such as resource constraints, variability in blood component therapy availability, and heterogenous adherence to evidence-based transfusion practices have likely created transfusion practices different from those typically found in higher-income countries. Furthermore, differences in blood banking practices, donor screening, and blood component processing may limit the generalizability of evidence derived from multinational studies to Iraqi surgical populations. Consequently, the indications for transfusion and the associated risk factors also differ from those documented in these larger databases. Therefore, understanding the relationship between perioperative transfusion and postoperative morbidity within the local context is crucial to developing targeted blood management strategies for patients, optimizing the use of blood products, and ultimately improving surgical outcomes within the Iraqi private hospital system. In response to this knowledge gap, this study aimed to evaluate the association between perioperative RBC transfusion and 30-day postoperative morbidity among adults undergoing major general surgery at a private hospital in Baghdad, Iraq. We hypothesized that the independent use of perioperative RBC transfusions would increase the risk of composite 30-day postoperative morbidity. High-income healthcare systems may not provide evidence with as much external validity in environments with varied resources. Postoperative results and transfusion procedures may be affected by variations in perioperative blood management policies, transfusion thresholds, donor screening and selection, component processing and storage techniques, availability of leukoreduced products, and blood-bank infrastructure [8]. In Iraq, where there is a dearth of up-to-date information on perioperative transfusion methods and the results of these procedures, these contextual variables take on further significance. The findings of this study are expected to provide locally relevant evidence to support the implementation of standardized patient blood management programs and evidence-based transfusion practices in Iraqi surgical services, thereby reducing preventable transfusion-related morbidity while preserving the lifesaving benefits of clinically indicated blood transfusion.

METHODS

Study design and setting

A retrospective cohort study was conducted at the Department of General Surgery of a private tertiary care hospital located in Baghdad, Iraq, over a period of two years with data being collected from the hospital's electronic medical records, the operating room registry, anesthesia charts, and laboratory information system after approval from the hospital's institutional research and ethics committee had been obtained. The hospital

provides both elective and emergency services related to general surgery, which include surgeries of the gastrointestinal tract, surgeries of the gall bladder and liver, and surgeries of the anterior abdominal wall. The hospital also has an onsite blood bank that can provide typed blood (packed RBCs), fresh-frozen plasma, and platelet concentrates for our use.

Study population

The study included all patients aged ≥ 18 years who had elective or emergency major general surgery. Major general surgery includes any intra-abdominal or major soft tissue surgical procedure that requires either general or regional anesthesia and has a forecasted length of stay of at least 24 hours. Examples of surgeries considered major general surgery include but are not limited to gastrectomy, colorectal resection, cholecystectomy with common bile duct exploration, hepatic resection, pancreatic surgery, splenectomy, complex hernia repair with mesh, and exploratory laparotomy for acute abdominal emergency.

Exclusion criteria

Patients were not eligible for inclusion if they had undergone minor surgical procedures (e.g., uncomplicated laparoscopic cholecystectomy with no additional risk factors) or day-case surgical procedures, were missing perioperative records, had surgery for traumatic injuries with significant bleeds that activated a massive transfusion protocol (as these patients represent a separate physiological category for whom transfusion is life-saving but not elective), or had been transferred to other healthcare facilities within 30 days postoperatively, where reliable data regarding their outcomes could not be obtained. Patients with hematological malignancy and all patients with known hereditary coagulopathy also were excluded because their specific underlying disease processes may affect their overall transfusion therapy requirements.

Exposure definition

The main interest of our study was the use of perioperative blood transfusions, which we defined as the provision of at least one unit of allogeneic packed RBCs within the time frame of the beginning of anesthesia to 72 hours after the surgery was complete. In hemodynamically stable patients, red blood cell transfusion was often contemplated at the study institution when hemoglobin concentration fell below 7 g/dL. Higher criteria were implemented based on clinical judgement. The participants were allocated into two groups for primary comparison. The transfusion group that includes all patients received at least one packed RBC transfusion during the perioperative period. They were subdivided by the total number of RBC units administered to them (from one to two units or more than three units) to identify any possible response

relationships. We also documented the specific reason that the patient received an RBC transfusion (e.g., due to hemorrhage occurring during the surgery, due to symptomatic postoperative anemia, or prior to reaching an established institutional threshold). The non-transfusion group that includes patients who did not receive an RBC transfusion.

Outcome measurements

The composite outcome for 30-day morbidity postoperatively is defined as having one or more complications occurring within 30 days of surgery [9]. The following complications will be measured by CDC criteria: Surgical Site Infection (Type: superficial, deep, or organ confirmed at reoperation or radiologically); anastomotic leak confirmed at reoperation or by radiology; pneumonia; unplanned return to surgical theater; Acute Kidney Injury; Myocardial Infarction or new-onset arrhythmia; venous thromboembolism; prolonged postoperative ileus (5 days or longer) [10]. Secondary endpoints include the length of postoperative hospital stay, admission to an intensive care unit, and 30-day all-cause mortality/cause of death. Outcome data will be collected via structured chart abstractions of inpatient records, outpatient follow-up documentation, and telephone confirmation whenever applicable for patients who were discharged less than 30 days before the completion of the study.

Sample size calculation

Based on an estimated baseline postoperative morbidity rate (18%), calculated from the historical data (published) of non-transfused, general surgical patients [11], we assumed that the risk of morbidity would be at least double the baseline for those patients who received transfusions. From that, we derived a sample size of 320 patients (approximately 1:2 transfusions to no transfusions) to achieve 80% power at a two-sided alpha level of 0.05, using standard formulas for comparing two independent proportions. The total sample size for the study exceeded this value to be 384.

Data collection and variables

The data was collected utilizing a standardized data collection form, and in the datasheet each of the patients included will have the following variables recorded: age, sex, body mass index (BMI), ASA physical status classification, presence of diabetes mellitus, hypertension, chronic renal failure, chronic cardiac disease, preoperative hemoglobin concentration, type and urgency of surgery (i.e., elective or emergency), total duration of operating room time, total estimated blood loss intraoperatively, laparoscopy versus open technique, volume of perioperative transfusion, and whether or not they received a perioperative transfusion. According to World Health Organization (WHO) definitions, patients were categorized as having preoperative anemia if they

had a preoperative hemoglobin concentration that was less than 13 g/dL for men and 12 g/dL for women. Prior to data analysis, all data collected was anonymized by assigning a unique study identification number for each patient and was designed to be securely stored in the study investigators' password-protected electronic database that would limit access to the investigator(s) only.

Ethical consideration

Since the data collected was de-identified and retrospective, the requirements for individual patient consent were waived based on the guidelines for the standard practice for low-risk retrospective chart reviews.

Statistical analysis

IBM SPSS Statistics (version 28.0) was used to analyze the data. Continuous variables were evaluated for normality with the Shapiro–Wilk test and were presented as mean $\pm$ standard deviation or median and interquartile range as appropriate; categorical variables were presented as frequencies and percentages. Comparisons between transfused and non-transfused groups for continuous variables were performed by independent-samples t-tests or Mann–Whitney U-tests, while comparisons between transfused and non-transfused groups for categorical variables were performed by chi-square tests or Fisher's exact tests, depending on the data distribution and expected cell counts. To determine independent predictors of composite postoperative morbidity while controlling for possible confounding, we constructed a multivariate binary logistic regression model, with composite morbidity as the dependent variable and transfusion status, ASA class, surgical urgency, surgical duration, age, and anemia status as the independent covariates. Covariate balance before and after weighting was assessed using standardized mean differences (SMDs), with an SMD <0.1 considered indicative of adequate balance. Variables with a significance level $p < 0.2$ for the univariate analysis were eligible for inclusion in the multivariate model, and results are reported as adjusted odds ratios (aOR) with 95% CI. A two-tailed $p < 0.05$ was considered significant for all tests.

RESULTS

Throughout the duration of the study a total of three hundred eighty-four (384) cases of major general surgical procedures were included for evaluation and analysis. Of those patients who had surgery, one hundred twenty-eight received a blood transfusion during the perioperative period (transfused), whereas two hundred fifty-six received no blood transfusion during the perioperative period (non-transfused). The overall study cohort had a mean age of 52.6 ± 14.3 years, with a slight predominance of females (54.2%). Transfused patients

were significantly older than non-transfused patients, had a significantly higher proportion of ASA class III or IV, and had a significantly lower average preoperative

hemoglobin. Transfused patients had a significantly higher percentage of emergency operations compared to non-transfused patients (Table 1).

Table 1: Baseline demographic and clinical characteristics of the study cohort

Variable	Transfused (n=128)	Non-transfused (n=256)	p-value
Age (year)	57.1±13.8	50.3±14.1	<0.001
Female sex	66(51.6)	142(55.5)	0.462
BMI (kg/m ²)	26.8±4.5	26.1±4.1	0.121
ASA class III–IV	61(47.7)	58(22.7)	<0.001
Diabetes mellitus	39(30.5)	58(22.7)	0.098
Preoperative hemoglobin (g/dL)	10.4±1.9	12.8±1.6	<0.001
Preoperative anemia	87(68.0)	79(30.9)	<0.001
Emergency surgery	58(45.3)	62(24.2)	<0.001
Operative duration >180 min	71(55.5)	76(29.7)	<0.001
Open surgical approach	94(73.4)	139(54.3)	<0.001

Values are presented as frequency, percentage, and mean±SD.

Post-operative complications/symptoms were found at higher rates among patients who did receive blood transfusions versus those who did not receive blood transfusions (Table 2) across nearly all measured complications. In the 30 days following surgery, overall postoperative complications/symptoms (30-day

morbidity rate) were as follows: 42.2% for the transfusion group and 17.6% for the non-transfusion group ($p < 0.001$). Surgical site infection and prolonged ileus were found to be the two most common individual complications in the blood transfused patient population.

Table 2: Postoperative outcomes according to perioperative transfusion status

Outcome	Transfused (n=128)	Non-transfused (n=256)	p-value
Composite 30-day morbidity	54(42.2)	45(17.6)	<0.001
Surgical site infection	24(18.8)	15(5.9)	<0.001
Anastomotic leak	9(7.0)	4(1.6)	0.005
Pneumonia	11(8.6)	6(2.3)	0.006
Prolonged ileus	18(14.1)	12(4.7)	0.001
Acute kidney injury	7(5.5)	5(2.0)	0.061
Unplanned reoperation	10(7.8)	6(2.3)	0.013
ICU admission	28(21.9)	17(6.6)	<0.001
30-day mortality	9(7.0)	4(1.6)	0.006
Postoperative stay (day)	9(6–14)	5(3–7)	<0.001

Values are presented as frequency, percentage, median and IQR.

Transfused patients had a significantly longer median postoperative length of stay (9 days; IQR= 6 to 14) compared to the non-transfused patient population (5 days; IQR= 3 to 7), ($p < 0.001$), and patients who were transfused were more commonly admitted to the ICU (21.9% vs. 6.6%, $p < 0.001$). Thirty-day mortality was also found at higher rates among the transfused versus non-transfused population (transfused = 7.0% vs. non-transfused = 1.6%, $p = 0.006$). All covariates had SMDs

lowered to ≤ 0.12 after IPTW, and nine out of ten variables had SMDs reduced to ≤ 0.10 . Baseline balance also improved significantly. Emergency surgery, ASA classes III and IV, preoperative anemia, and hemoglobin levels were the most improved. Good covariate balance after weighing was seen in all cases except those with an operation length of more than 180 minutes, when a small residual imbalance was observed (SMD= 0.12) (Table 3).

Table 3: Covariate balance before and after inverse probability of treatment weighting (IPTW)

Variable	Before IPTW		SMD	After IPTW		SMD
	Transfused (n=128)	Non-transfused (n=256)		Transfused	Non-transfused	
Age (year)	57.1±13.8	50.3±14.1	0.49	56.6±11.7	55.1 ± 12.2	0.08
Female sex	66(51.6)	142(55.5)	0.08	68(53.1)	140(54.7)	0.07
BMI (kg/m ²)	26.8±4.5	26.1±4.1	0.16	27.1±4.3	26.9±4.32	0.05
ASA class III–IV	61(47.7)	58(22.7)	0.54	54(42.2)	91(35.5)	0.07
Diabetes mellitus	39(30.5)	58(22.7)	0.18	37(28.9)	59(27.7)	0.06
Preoperative Hb (g/dL)	10.4±1.9	12.8±1.6	1.38	11.9±1.6	12.3±1.4	0.09
Preoperative anemia	87(68)	79(30.9)	0.77	55(43)	91(35.5)	0.08
Emergency surgery	58(45.3)	62(24.2)	0.46	41(32.3)	68(26.6)	0.1
Operative duration >180	71(55.5)	76(29.7)	0.54	55(43)	81(31.6)	0.12
Open surgical approach	94(73.4)	139(54.3)	0.4	88(68.8)	149(58.2)	0.08

Values are presented as frequency, percentage, and mean±SD.

A relationship was found between the amount of blood transfusion and the amount of morbidity incurred, whereby patients who received ≥ 3 units of blood incurred composite morbidity at a frequency of 58.1% (25 of 43) compared to 1-2 units at 34.1% (29 of 85) ($p=0.011$). Furthermore, transfusion given in the perioperative period remained an independent predictor of composite postoperative morbidity when age, ASA

class, surgical urgency, duration of operation, and preoperative anemia were controlled for (Table 4). ASA class III-IV, undergoing an emergency operation, and the duration of the operation > 180 minutes were also found to be independent predictive factors of morbidity. The model demonstrated an acceptable level of discrimination (AUC= 0.79) and good calibration (Hosmer-Lemeshow $p=0.42$).

Table 4: Multivariate logistic regression for independent predictors of composite 30-day postoperative morbidity

Predictor	Adjusted OR	95% CI	p-value
Perioperative blood transfusions	2.94	1.71–5.06	<0.001
ASA class III–IV	2.41	1.42–4.09	0.001
Emergency surgery	2.18	1.26–3.77	0.005
Operative duration >180 min	1.96	1.14–3.37	0.015
Preoperative anemia	1.58	0.92–2.71	0.096
Age (per 10-year increase)	1.12	0.94–1.34	0.201

DISCUSSION

This retrospective cohort study was performed at a private hospital in Baghdad, Iraq, and presents evidence of a substantial statistical correlation between the risk of experiencing perioperative blood transfusions and the likelihood of adverse outcomes (composite morbidity) within 30 days of surgery among patients undergoing significant general surgical operations. Transfused patients had a combined morbidity rate that was over two times higher than that of non-transfused patients. This correlation remained significant even after controlling for confounding variables (such as ASA classification, urgency of surgery, duration of surgery, and the presence of anemia) through multivariate analysis. Perioperative transfusion was identified through regression analysis as the most significant independent predictor of poor outcomes. In addition, this evidence reinforces and adds to an already extensive international literature documenting transfusion-associated complications both in general and in colorectal surgery [7,12]. Furthermore, this study populates the above evidence base methodically for the first time within a private sector surgical population in Iraq. The association of composite morbidity among transfused patients (not adjusted for confounding) in this analysis has an estimated odds ratio (OR= 2.94) that is consistent with similar results previously reported by Patel *et al.*, who concluded that transfusion is associated with higher morbidity and mortality rates in those with higher hematocrit levels, even after controlling for pre-existing comorbidities [13]. Similarly, Ferraris *et al.* reported that low-risk patients have between an 8- and 10-fold excess risk of adverse outcomes when they receive a blood transfusion [14]. The dose-response relationship from the present study indicates that patients who received three or more units of blood subsequently exhibited significantly greater postoperative morbidity than patients who received only one or two units, thus providing further support for a possible causal (biological) relationship between volume of transfused blood and adverse outcomes, rather than an association based solely upon observation. There are

several biologic mechanisms that may explain the relationship between volume of transfused RBCs and increased morbidity. One such example is transfusion-related immunomodulation (TRIM). Transfusion associated with immunomodulation is a well-characterized immunologic alteration that has been described in the setting of renal transplantation, and many surgical procedures have documented TRIM occurred in the perioperative period following allogeneic blood exposure and transiently suppressed cell-mediated immune responses [15]. By inference, TRIM provides a biogenically plausible explanation for the increased rates of surgical site infection and pneumonia that occurred in transfused patients in the present study. The effect of the storage lesion on banked RBCs may also explain the above-referenced increase in anastomotic leaks. Both the reduction of 2,3-diphosphoglycerate and the reduced deformability of deformable RBCs due to depletion from cellular storage may impair microcirculatory oxygen delivery to the critical area of tissue where optimal healing and integrity of anastomoses will be dependent upon adequate perfusion of tissue (i.e., the level required for oxygen to reach target tissues) [16]. The high prevalence of preoperative anemia in transfused patients in this cohort (68%) highlights the importance of addressing preoperative anemia correction as a crucial component of patient blood management. Luo *et al.* showed that anemia is an independent risk factor for perioperative 30-day mortality, especially among emergency surgery, high-risk surgery, and surgery with intraoperative blood transfusion, indicating the importance of addressing preoperative anemia itself and the mechanism leading up to transfusion with proactive clinical intervention [17]. Structured preoperative anemia clinics that include early detection and treatment of iron deficiency and intravenous iron supplementation, when appropriate, have been demonstrated to decrease both the incidence of anemia present at the time of surgery and the need for allogenic transfusion in other healthcare systems [18,19]. Given the significant number of patients in this Iraqi cohort with untreated anemia, the establishment of

preoperative optimization pathways like those in other healthcare systems and in private surgical services in Baghdad has the potential to be a very low-cost and high-value intervention. Furthermore, the findings of this study indicated that transfusion rates and morbidity associated with open surgery and prolonged operations have both been shown to be increased, implying that a greater use of minimally invasive techniques, careful hemostatic technique, and the application of cell salvage and antifibrinolytic agents such as tranexamic acid could potentially lessen blood loss and transfusion-related morbidity. This research also found that even minimal blood loss during surgery could lead to transfusion of small amounts and that this practice could increase postoperative morbidity appreciably, given that blood conservation should therefore be the primary improvement area above and beyond simply changing transfusion algorithms [20]. There may be a significant opportunity for standardizing and rationalizing transfusion decision-making within and among the sample institutions included in this study and among all Iraqi private surgical hospitals as well, if transfusion triggers were solely restricted to those based on current evidence rather than being based solely on clinical judgment or historic institutional patterns.

Study Limitations

This study has certain limitations that warrant attention. This is a retrospective, single-center report of data and therefore does not provide definitive evidence for any specific causal relationship, nor does it represent a broad experience. The presence of unrecorded events, along with varying indications for transfusion that could apply to other Iraqi healthcare facilities—especially public ones serving different patient populations with distinct resources and transfusion practices—creates potential for further confounding factors. In addition, although adjustment for properly defined confounders was performed, other potential causes of confounding errors, such as variations in surgical technique and surgeon experience, as well as unrecorded events, create additional potential for confounding factors; while indications for transfusion have been improved through the study protocol, many confounding factors remain present and will always be a concern in observational studies. The study does not provide information regarding the length of time that blood components were stored, white blood cell reduction status, or the characteristics of blood donors, and these factors have been reported as potential confounders of transfusion associated with risks in some studies. While the number of subjects was adequate for assessing the primary combined outcome, a smaller number of subjects hampers our ability to be precise in estimating much less frequently encountered individual complications such as acute kidney injury and venous thromboembolism. Since this study represents a single private hospital study, our results may not apply directly to recipients receiving care

at publicly funded hospitals in Iraq who may exhibit significant differences in patient demographics, resource constraints, and availability of blood products; thus, additional studies conducted at various public and private hospitals throughout Iraq should be undertaken to improve our ability to generalize to similar populations.

Conclusion

There is a relationship between perioperative blood transfusions and adverse outcomes within the 30-day postoperative period in patients undergoing major general surgery in a private hospital in Baghdad, Iraq. There is a dose-dependent relationship between blood transfusions and the risk of complications, prolonged hospital stays, and increased mortality. Additional prospective studies are recommended for validation and extension of these findings across public and private hospitals in Iraq. Due to limited data concerning the effects of blood bank operations on the risk of RBC transfusion outcomes in this cohort, as well as the relative lack of published studies examining the effects of storage alterations on transfused patients, further research is needed to explore whether the duration of storage influences the observed risks.

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Conflict of interests

The authors declared no conflict of interest.

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Data sharing statement

The data that supports the findings of this study are available from the corresponding author upon a reasonable request.

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