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Risk Factors for Blood Loss Following Total Knee Arthroplasty

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Background: Blood loss following total knee arthroplasty (TKA) is a challenging issue faced by orthopedic surgeons. Determination of risk factors for significant blood loss is a significant step toward blood management.

Objectives: The aim of this study was to determine factors predicting intraoperative blood loss, postoperative drainage, and need to blood transfusion in patients undergoing TKA.

Patients and Methods: In a prospective study, 96 consecutive patients who underwent primary cemented TKA were included. Intraoperative blood loss, postoperative blood drainage, and hemoglobin (Hb) drop were measured and analyzed in terms of age, sex, body mass index, and tourniquet closure time.

Results: The mean age of patients was 68.4 ± 5.6 years (range, 52-75). Mean intraoperative blood loss and postoperative drainage were 147.1 ± 97.4 mL and 494.4 ± 188.1 mL, respectively. Based on a regression model, males and obese patients had significantly higher intraoperative blood loss ($P < 0.05$). Additionally, male sex and older age were significantly associated with more severe drop in Hb on the first postoperative day; however, there was no predictor of need for transfusion in regression analysis.

Conclusions: Male sex and obesity were the risk factor for intraoperative blood loss while the elderly and male patients experienced more severe postoperative bleeding.

Keywords: Total Knee Arthroplasty; Blood Loss; Risk Factor

1. Background

Despite extensive improvement in surgical technique and instruments, perioperative blood loss remains an important concern in total knee arthroplasty (TKA) (1-7). With increasing number of TKA during the last decades, the importance of blood loss control has nearly doubled (2-4, 6, 8). This is especially concerning in patients with previous cardiovascular morbidities and those with hematologic disorders (9, 10).

To date, numerous preventing strategies have been introduced for management of perioperative blood loss in patients undergoing TKA, which include smaller surgical site incision (11), modification of draining tube placement (12, 13), application of tourniquet and cold compressive dressings (13-19), and administering coagulative therapies (20). Although these strategies have been efficient to some extent, blood loss due to TKA is still associated with postoperative consequences and requires transfusion in many cases (21, 22). Hence, identifying patients at higher risk or cases with less tolerability for major bleeding constitute the mainstay of managing TKA-related blood loss.

2. Objectives

This study aimed to determine risk factors for perioperative blood loss in patients undergoing TKA.

3. Patients and Methods

3.1. Study Design

This prospective study was conducted at Orthopedic Department of the Rasoul-e-Akram Hospital, Tehran, Iran, between February 2010 and October 2012. Institutional Review Board of our hospital approved the study protocol and patients gave an informed consent before enrolment in this study.

3.2. Patients

Consecutive patients, who aged ≥ 18 years and were planned for elective TKA, were included. Patients with previous knee surgery, history of deep vein thrombosis, diagnosed coagulopathy or other cardiovascular diseases, and perfusion disorders of the lower limbs were excluded.

3.3. Perioperative care

All the patients received iron supplement therapy from four weeks before through four weeks after surgery. Nonsteroidal anti-inflammatory drugs (NSAIDs) was discontinued seven days prior to TKA. Low molecular weight heparin was started 12 hours before the operation and continued up to ten days after discharge.

All the procedures were performed with similar anesthesia and surgical technique by the first author (M.M.). A cemented prosthesis was used for TKA (NexGen, Zimmer, Warsaw, Indiana). Pneumatic tourniquet was applied for bleeding control during the surgery. The tourniquet was released in 48 patients after prosthesis implant while it was released in the remainder 48 cases following suturing surgical site in layers and bandages. A suction draining tube was inserted inside the joint before the meticulous closure and remained for 48 hours. Patients received similar rehabilitation care following the surgery and were discharged on the preference of the attending orthopedic surgeon.

3.4. Risk Factors and Outcomes Measurement

Patients' primary characteristics, eg, age, sex, and body mass index (BMI), and perioperative events such as operation time, tourniquet closure time, blood loss, drained blood, hemoglobin (Hb) drop, and need to transfusion) were evaluated. The Outerbridge scoring system was used to evaluate the severity of osteoarthritis (23).

Intraoperative blood loss was defined as the amount of collected blood in the suction bottle plus the weight difference between wet and dried surgical site sponges. Moreover, Hb was measured before the surgery and at the first and third postoperative days. Any decrease in Hb was considered significant and was followed by serial measurement. Transfusion of packed cell was considered if Hb < 90 g/L.

3.5. Follow-up

Patients were visited at outpatient clinic two weeks after the surgery and then followed regularly every three months and if unremarkable once a six months.

3.6. Statistical Analysis

Statistical analysis was performed using SPSS 16 (SPSS Inc., Chicago, Il, USA). Independent-samples t test, Mann-Whitney U test, and Pearson's correlation were employed for continuous variables. Furthermore, the amount of blood loss was analyzed in a regression model in terms of age, considering a cutoff point of 65 years for elderly (24), sex, BMI, and duration of tourniquet closure. Data were presented as mean ± standard deviation and frequency (%). P values < 0.05 were considered statistically significant.

4. Results

Of 96 included patients, 42 patients were male (43.75%) and 54 (56.25%) were female. The mean age of patients was 68.4 ± 5.6 years (range, 52-75) and their mean BMI was 27.9 ± 2.2 kg/m^2 (range, 24.8-33.5). Patients' demographic and primary clinical characteristics are summarized in Table 1. Most patients were at grade III of Outerbridge classification prior to surgery.

The means of surgery and tourniquet closure time were 85 ± 11.4 and 80.3 ± 14.6 minutes, respectively. Furthermore, the mean of intraoperative blood loss was 147.1 ± 97.4 mL whereas the mean of the first 48-hour postoperative drainage was measured 494.4 ± 188.1 mL. On the other hands, the mean of Hb was 126 ± 8 g/L preoperatively and 99 ± 10 g/L and 102 ± 8 g/L at the first and third postoperative days. Hence, the mean of Hb decrease percentage was 27% ± 7% and 25% ± 6% at the first and the third postoperative days, respectively. Finally, 34 patients (35.41%) required blood transfusion. Other postoperative complications are summarized in Table 2.

Intraoperative blood loss, postoperative drainage volume, Hb drop at the first and third postoperative days, and need to transfusion were all compared between patients in terms of age (> or < 65 years old), sex (male and female), BMI (> or < 30 kg/m2), and time of tourniquet release (Table 3). Patients > 65 years old had more intraoperative blood loss and more severe Hb drop after the surgery (P < 0.05). On the other hands, males had more severe intraoperative blood loss and Hb drop at the first postoperative day (P < 0.05). Considering the BMI, obese patients had more intraoperative blood loss, less postoperative bleeding, and shorter hospitalization period (P < 0.05). Finally, late tourniquet release was associated with less intraoperative blood loss (P < 0.05).

Based on a linear regression model, males (P < 0.0001) and obese patients (P = 0.003) had significantly more intraoperative blood loss. Additionally, males (P = 0.016) and older patients had more severe drop in Hb at the first postoperative day (P = 0.001). In a logistic regression analysis, no variables had any effect on need for blood transfusion (Table 4).

Table 1. Demographics and Primary Characteristics of Study Population [a,b]

Feature	Values
Age, y	68.4 ± 5.6
Sex	
Male	42 (43.75)
Female	54 (56.25)
BMI, kg/m^2	27.9 ± 2.2
Preoperative Hb, g/L	126 ± 8
Outerbridge classification	
Grade 0	0
Grade I	0
Grade II	26 (27.1)
Grade III	43 (44.8)
Grade IV	27 (28.1)

[a] Abbreviations: BMI, body mass building; and Hb, hemoglobin.
[b] Data are presented as mean ± SD or No. (%).

Table 2. Intraoperative Events and Postoperative Complications [a,b]

Parameters	Features
Duration of surgery, min	85 ±11.4
Tourniquet closure time, min	80.3 ± 14.6
intraoperative blood loss, mL	147.1 ± 97.4
1st 48 h postoperative drainage, mL	494.4 ± 188.1
1st postoperative day Hb, g/L	99 ± 10
3rd postoperative day Hb, g/L	102 ± 108
1st postoperative day Hb drop, %	27 ± 7
3rd postoperative day Hb drop, %	25 ± 6
Transfusion	34 (35.4)

[a] Abbreviations: BMI, body mass building; Hb, hemoglobin.
[b] Data are presented as mean ± SD or No. (%).

Table 3. Comparison of Bleeding Events According to Age, Sex, BMI, and Time of Tourniquet Release [a,b]

	Age, y			Sex			BMI			Tourniquet Release		
	< 65	> 65	P value	Male	Female	P value	< 30	> 30	P value	Early	Late	P value
Intraoperative Blood Loss, mL	112.9 ± 69.4	161.2 ± 104	0.01	184.5 ± 93.7	118 ± 90.7	0.001	130.7 ± 93.4	188.9 ± 97.4	0.008	169.2 ± 104.9	125 ± 84.6	0.005
Postoperative drainage, mL	457.1 ± 203.5	509.7 ± 180.7	0.21	481.4 ± 189.5	504.4 ± 188.1	0.55	554.1 ± 185	471 ± 185.4	0.049	469.8 ± 179.6	519 ± 195	0.2
Hb drop at the 1st day, %	27 ± 7	29 ± 6	< 0.0001	30 ± 7	25 ± 8	0.002	27 ± 6	27 ± 7	0.57	26 ± 5	28 ± 7	0.28
Hb drop at the 3rd day,%	25 ± 6	23 ± 7	0.06	26 ± 7	24 ± 5	0.15	24± 5	24 ± 6	0.66	25 ± 5	24 ± 7	0.31
Transfusion, %	29	38	0.48	33	37	0.83	40	22	0.1	33	37.5	0.83
Hospital stay, d	6.2 ± 1.5	5.7 ±0.9	0.14	6 ± 1.1	5.8 ± 1.2	0.57	6.1 ± 1.1	5.4 ± 0.01	0.01	5.8 ± 1	6 ± 1.3	0.48

[a] Abbreviations: BMI, body mass building; Hb, hemoglobin.
[b] Data are presented as mean ± SD

Table 4. Multivariate Analysis of Study Outcomes

	Elderly	Obesity	Male	Tourniquet Release Time
Intraoperative blood loss	NS [a]	0.003	0.0001	NS
Postoperative blood loss	0.0001	NS	0.0001	NS
Hb drop At the 1st postoperative day	NS	NS	NS	NS
Hb drop At the 3rd postoperative day	NS	NS	NS	NS
Need to transfusion	NS	NS	NS	NS

[a] Abbreviations: Hb, hemoglobin; NS, not significant.

5. Discussion

Blood loss control in patients undergoing TKA is an important but still challenging issue faced by orthopedic surgeons. Introducing new and less invasive surgical procedures and modifying intraoperative hemostasis techniques have been successful to some extent in reducing intraoperative blood loss (11, 15, 21, 25, 26); nonetheless, identifying patients at higher risk for perioperative blood loss and/or hard-to-manage severe postoperative bleeding following TKA is another potentially efficient strategy. Our study revealed that males and obese pa-

tients had significantly higher intraoperative blood loss. On the other hand, males and elderly patients had more severe Hb drop at the first postoperative day. Nevertheless, no factor could predict the need for blood transfusion.

Ogbemudia et al. investigated preoperative predictors of the need for transfusion in patients undergoing hip and knee arthroplasty (27). They showed that low preoperative Hb, total hip arthroplasty, previous history of myocardial infarction, and previous blood transfusion were significant predictors of the need for allogeneic blood transfusion in the recent procedure; however, their retrospective design restricts implication of their study findings. In our study, medical conditions and previous history of patients were not analyzed. On the other hands, in the same line with our findings, other authors have documented that being male is a risk factor for losing more blood during TKA (2, 3, 6). In contrast, Mesa-Ramos et al. showed that age, sex, and BMI are not predictors of blood loss in TKA while patient's blood parameters were associated with need for transfusion (5).

Evidence shows that despite greater blood loss due to massive manipulated muscle or bone cuts during the surgery in males, female are more prone to receive blood transfusion as a result of lower preoperative Hb level (28). The same might be applied to obese and elder patients, as there is need to severe and tough manipulation when performing TKA. However, it should be noted that with introduction of minimally invasive procedures, traumatic damage to surrounding tissues of knee might be reduced considerably and hence, it might not be associated with significant blood loss or Hb drop. Moreover, underlying disease has been considered important in the amount of blood loss where rheumatoid arthritis is associated with hemolysis (26); however, our patients were all diagnosed with osteoarthritis, which little is known about its potential association with perioperative bleeding.

Timing of tourniquet closure did not affect perioperative bleeding or Hb drop in our study. It has been shown that most amount of blood is lost during the first operation hours when surgical incisions is made and prosthesis are implanted and using the tourniquet has been shown to be effective in the literature (29). This might explain why regardless of closing or releasing time, pressure effect of the tourniquet is kept in most of today surgeries.

Our study had a relatively small sample size and lacked consideration of comorbidities, inter-surgeon differences, and structural comparison of knee prosthesis. These should be taken into account when interpreting the findings of this study and implementing its results to the bedside. However, as the unique feature of this study, it distinguishes between intraoperative and postoperative blood loss. It should be noted though that most studies neglect the hidden blood that is spreading into the tissues and is not measurable by routine techniques and have to be estimated by proposed formula. This might justify the inconsistency between the amounts of perioperative blood loss and postoperative drop in Hb level. In conclusion, intraoperative blood loss is more severe in males and obese patients while Hb drop at the first postoperative day is highly probable in males and the elderly. However, we found no predictor of need for transfusion in TKA.

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Authors' Contributions

Mehdi Moghtadaei participated in study concept and design as well as acquisition of data. Mehdi Moghtadaei and Gholamreza Shahoseini contributed to acquisition, analysis, and interpretation of data, drafting of the manuscript, and critical revision of the manuscript for important intellectual content.

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