Evaluation of Short-term Effects of Tourniquet Release Time on Postoperative Hemoglobin Levels in Patients Undergoing Total Knee Arthroplasty

Abstract

Background: Although the tourniquet is frequently used in total knee arthroplasty (TKA), there is no definitive agreement on the tourniquet's release time. The purpose of this study was to determine the effect of the tourniquet release time on postoperative hemoglobin levels in TKA patients.

Methods: For one year, patients undergoing TKA were randomly assigned to one of two groups: early release tourniquets (tourniquets opened immediately after cementation) and late release tourniquets (tourniquets opened after wound dressing). Hemoglobin levels were determined and compared before and one week following surgery. Additionally, the duration of surgery, the need for blood transfusions, and early wound complications were compared between the two groups.

Results: The mean duration of surgery in the early release group was 82±11.2 minutes, while in the late release group, this was 73±14 minutes (P<0.001). Hemoglobin levels decreased by 1.8±0.82 and 1.1±0.71, respectively, in the first group, and by 1.4±0.94 and 0.6±0.82, in the second group. In this study, the tourniquet group required more blood transfusions due to their early release (four cases in the first group and two in the second group). Nonetheless, the difference was not statistically significant.

Conclusion: In patients undergoing TKA, releasing the tourniquet after wound dressing can reduce surgery time and hemoglobin levels.

Keywords: Tourniquets, Knee Replacement Arthroplasty, Hemoglobins , Knee, Hemorrhage

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Introduction

Tourniquets are frequently used in total knee arthroplasty (TKA) to improve operative vision, minimize intraoperative bleeding, facilitate the cementing process, and significantly reduce the surgical time (80-90%) in TKAs [1, 2]. Nonetheless, this procedure has been associated with various complications, including neuromuscular injuries, increased postoperative pain, delayed wound healing, rhabdomyolysis and necrosis of the thigh's subcutaneous fat tissue, increased risk of thromboembolism, and decreased joint range of motion [3-6].

There is no clear consensus concerning the appropriate time to use tourniquets. However, the timing of tourniquet release can significantly impact clinical outcomes, particularly postoperative blood loss [7]. There are two types of tourniquet release in TKAs, each with its own set of supporters and critics: tourniquet release during cemented TKA and before wound closure for hemostasis (early tourniquet release), and tourniquet release following wound closure and the application of compression dressing (late tourniquet release). Reduced tourniquet time and its release after cementing and before wound closure can result in decreased postoperative blood loss, pain relief, faster recovery of knee function, and a decreased occurrence of wound complications and infection, particularly in reoperation due to potential severe vascular injury during surgery [7, 8].

Nevertheless, some studies have shown that tourniquet release after wound closure can significantly reduce blood loss and shorten the duration of TKA [9, 10]. The purpose of this study was to determine the effect of early and late tourniquet release on postoperative hemoglobin levels in TKA patients. The aim was to determine whether using a tourniquet and its delayed release effectively reduced blood loss, resulting in milder levels of hemoglobin decrease following TKA. Additionally, this technique did not increase the risk of developing early wound complications.

Methods

This study was a retrospective comparative study of patients who underwent TKA between 2018 and 2019. The inclusion criteria were 50-85 years of age and candidacy for TKA. On the other hand, patients with a body mass index (BMI) greater than 45kg/m2, patients with coagulation disorders, a history of bleeding disorders, a history of deep vein thrombosis (DVT), thromboembolic complications, preoperative anemia requiring blood transfusion (hemoglobin less than 10mg/1), a history of TKA in the same knee, bilateral TKA, and patients with severe knee deviation were excluded (varus higher than 15 degrees, flexion contracture higher than 20 degrees).

Patients were randomly assigned to one of two groups (alternate selection). The first group consisted of patients who underwent TKA with early tourniquet release, which involved cementing, tourniquet release, and bloodletting, followed by wound closure. The second group (late tourniquet release) had the tourniquet released after surgery and immediately after wound closure and compression dressing. The sample size was estimated to be 64 per group based on research conducted by Soleimanpoor et al. [11] at a 95% confidence level plus 90% test level and considering the clinical difference of 1mg/l of postoperative hemoglobin.

1-α = %95 $Z_{1-\alpha/2}$ = $Z_{\%95}$ = 1.96

1-β = %90 $Z_{1-\beta}$ = $Z_{\%90}$ = 1.28

Mean ± SD= 11.43±1.77

d= Expected significance (expected clinical difference) = 1mg/l

$$n=\frac{2\,(Z_{1-\alpha/2}+Z_{1-\beta})^2\,(s_1^2)}{d^2}=\frac{2\,(1.96+1.28)^2\,(1.75^2)}{1^2}$$

=64

Initially, participants were informed of the study's objectives, and tourniquets were applied to both groups following patient preparation and spinal/epidural anesthesia administration. Furthermore, a medial parapatellar approach was used to perform knee arthroplasty. All patients received an intravenous injection of 1g of tranexamic acid following tourniquet release. The two groups were homogenous in terms of postoperative antibiotics and rehabilitation protocols. Additionally, low-molecular-weight heparin (LMWH) was used to prevent thromboembolic diseases (TED) under the brand name Enoxaparin sodium 4000U.I (40mg). LMWH was initiated 24 hours after surgery and continued every day for the next two weeks. Afterward, 80mg of ASA was administered every 12 hours for four weeks.

Immediately after surgery, postoperative rehabilitation started, which included walking, ankle pump exercise, active isometric extension,and a 0 to 30-degree passive flexion. The same surgical team performed all surgical procedures in both groups, and the same type and brand of knee prosthesis were used (Sigma-P.S TKA Depuy Synthes, Warsaw, IN).

In addition, both groups were fitted with a lower limb air tourniquet system (micro-base digital tourniquet, Ryan Sanat, Iran). Both groups also used a lower extremity pneumatic tourniquet system(micro-base digital tourniquet device, Raeen Co., Iran). The length of each group's surgery was recorded, and hemoglobin (Hb) levels were measured before, 24 hours after, and one week after the procedure.

Moreover, based on clinical and laboratory indicators, the surgeon determined the number of cases requiring blood transfusion during or after surgery. Blood transfusions were administered to patients with hemoglobin levels below 8g/dl or symptoms of anemia such as dizziness, nausea, asthenia, mucosal paleness, and a hemoglobin level

between 8 and 9g/dl [12]. Early wound complications were also assessed by the surgeon and the level of infection and wound healing. The surgeon also assessed early wound complications or a delay of more than two weeks in wound healing plus any other postoperative complications.

The data were analyzed in SPSS version 24 using an independent t-test (to compare the two groups in terms of surgery duration, preoperative hemoglobin levels, and their changes 24 hours and one week after surgery), the Shapiro-Wilk test (to determine the distribution of hemoglobin levels), and Fisher's exact test (to compare the need for blood transfusion). Notably, a P-value of less than 0.05 was deemed statistically significant.

Results

The study enrolled a total of 128 patients (92 women and 36 men), with a mean age of 66.5±7.4 years (minimum and maximum ages of 56 and 82 years, respectively). Patients were randomly assigned to one of two 64-member groups for TKA with early tourniquet release or TKA with late tourniquet release. The mean duration of tourniquet use was reported to be 59±7 minutes in the first and 68±14 minutes in the second group. According to Table 1, there were no significant differences in the demographic characteristics of the participants before and after surgery between groups (Table 1).

Table 1. Preoperative characteristics in both groups of patients

Group	Early tourniquet release	Late tourniquet release	P-value
Gender (male/female)	19.45	21.43	n.s
Age (year)	68.3±4.6	67.4±4.6	n.s
BMI (kg/m^2)	31.8±2.8	33.1±4.1	n.s
Preoperative hemoglobin level (g/1)	12.2±1.5	12.4±1.3	n.s

The difference in hemoglobin levels between the two groups is shown in Table 2. According to the results, the late tourniquet release group experienced significantly less blood loss than the early release group (P<0.001). Additionally, hemoglobin levels decreased by 1.8±0.82 in the early release group and 1.1±0.71 in the late release group, up to 24 hours after surgery, deemed statistically significant (P<0.001). Furthermore, there was a significant difference in hemoglobin decrease levels between the groups up to one week after surgery (1.4±0.94 and 0.6±0.82, respectively, in the early and late tourniquet release groups). Six patients required blood transfusions in total. In Table 3, the number of cases requiring a blood transfusion is compared between the two groups.

Table 2. The rate of blood loss in patients of the two groups of patients

	Early tourniquet release	Late tourniquet release	P-value*
Preoperative Hb level (g/1)	12.2±1.5	12.4±1.3	0.424
Level of Hb decrease 24 hours after surgery (g/dL)	10.4±1.1	11.3±2.1	0.005
Level of Hb decrease 24 hours after the surgery (g/dL)	1.8±0.82	1.1±0.71	<0.001
Level of Hb decrease one week after the surgery (g/dL)	10.8±1.5	11.8±1.6	<0.001
Level of Hb decrease one week after the surgery (g/dL)	4.1±0.94	0.6±0.82	<0.001

*Independent T-test

Table 3. Comparison of both groups in the number of cases requiring a blood transfusion

	Patients in need of blood transfusion N (%)
Early tourniquet release group	4 (6.25%)
Late tourniquet release group	2 (3.12%)
P-value*	0.340

* Fisher's Exact Test

The surgery was reported to take 82±11.2 minutes (70-105) and 73±14 minutes (55-85) in the early and late tourniquet release groups, respectively, demonstrating a significant difference in this regard (P<0.001). Concerning wound discharge and pain, the two groups were almost identical. Only one patient in the late tourniquet release group was transferred to the operating room for DAIR (debridement and replacement of polyethylene), eight days after surgery, due to the persistence of serous secretions. After six weeks of antibiotic therapy under clinical and laboratory supervision, the infection was eliminated.

Discussion

While tourniquets reduce intraoperative bleeding in general, the effect of various tourniquet release strategies on postoperative blood loss is not entirely clear [10, 13]. The most significant finding in this study was that patients who received tourniquet release following wound closure and compression dressing had a shorter TKA and experienced less postoperative hemoglobin loss. However, in terms of early complications, the two groups were nearly identical. Zhang et al. discovered that early tourniquet release increased intraoperative blood loss [4].

In another study, Kvederas et al. discovered that the group that received a tourniquet after closing an open wound experienced the least blood loss [8]. Tai et al. found that study bias and a lack of agreement regarding the effect of tourniquets on blood loss could be attributed to the use of differing blood loss measurement techniques. The majority of studies have calculated intraoperative blood loss using the amount of blood collected in suction canisters [10]. According to Sehat et al., blood loss during TKA was both visible and hidden, suggesting that hidden blood loss accounted for 50% of total blood loss, attributed to homeostasis [14].

Tourniquet release immediately following cementing results in blood leakage at the surgical site, lengthening the procedure. According to the current study's findings, the late tourniquet release group's surgery duration was significantly shorter than the other group. In another study, Zan et al. discovered a significant correlation between the tourniquet release time and the duration of surgery [15]. According to a meta-analysis conducted by Zhang et al., late tourniquet release may reduce surgery duration. On the other hand, early tourniquet removal reduced the risk of complications [16].

According to Thorey et al., while no significant difference in postoperative blood loss or increased complications was observed between the groups six months after surgery, the duration of surgery was significantly shorter in the late tourniquet release group. As a result, these scholars recommended that a tourniquet be applied following wound closure to avoid the possibility of prolonged anesthesia [13]. Each additional ten minutes of tourniquet time resulted in an increased risk of complication [17]. In another study, Tie et al. proposed that tourniquet release for homeostasis before wound closure compared to after wound closure in TKA procedures with cementing could reduce the risk of overall complications [18]. Therefore, if the patient is severely anemic, releasing the tourniquet following wound closure may be a better option to minimize blood loss. Otherwise, it is recommended to apply the tourniquet before closing the wound to minimize the risk of complications.

In the present study, the need for blood transfusions was statistically insignificantly greater during early tourniquet release. While blood loss was not significantly different between the two groups studied by Tie et al., the need for postoperative blood transfusion was significantly greater in the early tourniquet release group than in the late tourniquet release group [18].

One of the study's major limitations was its small sample size and brief follow-up period. Further double-blind, randomized controlled trials with larger sample sizes and a more precise scientific design are suggested.

Conclusion

According to the present study's findings, tourniquet release following wound closure

and compression dressing application resulted in a significant decrease of postoperative hemoglobin loss in patients undergoing TKA without increasing the risk of early wound complications. In addition, this method significantly reduced the duration of surgery.

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