

Early release of tourniquet in total knee arthroplasty: Is it worthwhile?

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Abstract

Objective: To compare the effects of duration and timing of tourniquet release on perioperative blood loss, transfusion requirement, duration of surgery, length of hospital stay and early complications in total knee arthroplasty with and without additional anti-fibrinolytic therapy.

Methods: The prospective quasi-experimental study was conducted at the Combined Military Hospital, Rawalpindi, from March to August 2014. The patients undergoing total knee arthroplasty were divided into two groups: in Group A tourniquet was released after closure of surgical wound and applying compressive dressing; and in Group-B tourniquet was deflated after cementation of implants following which closure was done. Each group was further divided into those who received tranexamic acid (A-T, B-T) and those who did not (A-C, B-C). Study variables were noted on a proforma and analysed.

Results: Of the 75 patients in the study, 27(36%) were male and 48(64%) were females. Calculated blood loss was 408mL and 422mL in group A-T and B-T respectively ($p=0.73$), and 615mL and 610mL in group A-C and B-C respectively ($p=0.95$). Tourniquet time was significantly shorter ($p<0.0005$) in group B whereas duration of surgery was significantly shorter ($p<0.0001$) in group A (68 ± 9 min vs 77 ± 11 min). Transfusion frequency was higher in group B. Complication rate in the two main groups was not significantly different ($p=0.314$). Mean length of hospital stay was not significantly different ($p>0.05$).

Conclusion: Earlier intra-operative release of tourniquet in patients undergoing total knee arthroplasty was associated with increased surgery time and higher frequency of blood transfusion without conferring any significant benefit.

Keywords: Total knee arthroplasty, Tourniquet time, Blood loss, Complications. (JPMA 65: S-77 (Suppl. 3); 2015)

Introduction

Total knee arthroplasty (TKA) is associated with significant blood loss. Reported blood loss for single TKA varies between 600 ml to 2 liters.^{1,2} In elderly patients undergoing simultaneous bilateral knee replacements, the loss sometimes leads to catastrophic results.

Allogenic blood transfusions are required in 50-60% of such cases to treat acute blood loss and to prevent potential cardiovascular risks.³ Allogenic blood transfusion itself has its complications, like immunologic reactions, infection transmission and immunosuppression.^{3,4}

A variety of blood-conserving techniques have been developed to reduce blood loss and avoid allogenic blood transfusions, such as preoperative blood donation, perioperative red cell salvage, hypotensive anaesthesia, use of tourniquet and antifibrinolytic agents like tranexamic acid (TXA), Aprotin, E-Aminocaproic acid (EACA) etc.

Use of tourniquet in TKA is a universally accepted

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phenomenon. It offers many advantages like minimal intraoperative blood loss, clear visualisation of operative field, shorter surgical time, improving the quality of cementation and ensuring long-term implant fixation.⁵ There are, however, disadvantages associated with tourniquet use reportedly including thigh pain, muscle damage, nerve palsy, thromboembolic complications, poor wound healing and patellar maltracking.⁶ Although the advantages of tourniquet use during TKA outweigh its disadvantages, but the most appropriate timing of the tourniquet release and its impact on total blood loss and functional outcome is still controversial.

The current study was planned to compare the amount of blood loss, transfusion requirement, duration of surgery, duration of tourniquet and early complications between early tourniquet release before closure and late release after closure, with and without the use of anti-fibrinolytic agent.

Patients and Methods

The quasi-experimental study was conducted in Orthopaedic Department of the Combined Military Hospital (CMH), Rawalpindi, between March and August 2014. All consecutive patients undergoing primary unilateral or bilateral TKA were considered for the study. In order to control for potential bias, patients with history of

thromboembolic disease, myocardial infarction (MI), bleeding disorder, previous surgery on the same knee, receiving anticoagulant drug treatment and age more than 85 years were excluded. After obtaining approval from the institutional ethical committee, informed consent was obtained from the patients included in the study.

The patients were divided into two groups based on two different surgeons' practice. Group A consisted of patients undergoing TKA in which tourniquet was applied from incision to arthrotomy closure (fulltime tourniquet). Group B comprised patients with release of tourniquet intra-operatively after cementing the implant and then homeostasis was secured before closure (part time tourniquet). A set of patients in each group randomly received TXA. Thus, each group had two subgroups; one which received TXA (subgroups A-T, B-T) and the one which did not receive TXA (subgroups A-C, B-C).

Preoperative data, including age at the time of the operation, gender, body mass index (BMI), preoperative haemoglobin (Hb) level, prothrombin time (PT), activated partial thromboplastin time (APTT) and platelet count, was collected. Anti-platelet medications were discontinued a week prior to the surgery. The patients were admitted a day prior to the surgery.

All patients were operated under spinal or combined spinal epidural anaesthesia by two experienced surgeons using pneumatic tourniquet. Similar cemented implants were used in both groups (DePuy PFC Sigma PS/CR, DePuy RPF or Zimmer Nex Gen LPS Flex with patellar component). Straight tourniquet was used with double cotton layer of padding between the skin and cuff. Tourniquet was inflated to a standard pressure of 250mmHg above systolic pressure, which was the first blood pressure reading after induction of the spinal anaesthesia. Operative technique was the same in both the groups. Duration of tourniquet and total duration of surgery was noted. The amount of blood loss during surgery was recorded from suction bottle output and blood-soaked sponges. In each knee, one intra-articular drain (14-gauge) was placed in the lateral gutter and was connected to a high-vacuum drain bottle. The drains were placed for 24 to 48 hours depending on the total outflow in the preceding 24 hours. The total volume of drained blood upto 48 hours postoperatively was recorded in the wards. Hb and haematocrit (Hct) were checked immediate postoperatively, 24 hours and 48 hours after surgery. Potential source of bias in assessing blood loss was carefully monitored by close supervision.

The need for blood transfusions was considered when Hb was below 8.5 gm/dl in healthy patients or between 8.5

and 10 gm/dl in patients with signs and symptoms of anaemia. During surgery, however, especially in patients undergoing bilateral TKA, blood transfusions were made on the recommendation of anaesthetist incharge, based on patient's clinical condition. Blood transfusions were recorded as the number of units of red cell concentrate (RCC) given in the perioperative period.

Cardiovascular, thromboembolic and other complications (e.g. wound complications) were noted during the hospital stay, at two weeks and six weeks follow-up. The presence of deep venous thrombosis (DVT) was evaluated by inspecting for thigh and calf swelling or oedema >3cm compared with the contralateral leg along with calf tenderness.³ If DVT was suspected, Doppler ultrasound of the leg was performed. Computed tomography (CT) pulmonary angiography [CTPA] was performed if there was suspicion of pulmonary embolism. No patient was lost to follow-up.

Statistical significance of differences in the length of tourniquet time, duration of surgery, perioperative blood loss per knee were determined using Student's t-test (Microsoft Office Excel 2007). P values for demographic and blood indices and transfusion events were analysed using the chi square test.

Results

Of the 75 patients in the study, 27(36%) were male and 48(64%) were females. There were in total 110 knee replacements.

There were 54(72%) patients in Group A; 34(63%) females and 20(37%) males. Group B comprised 21(28%) patients; 14(66.6%) females and 7(33.3%) males (Table-1).

In subgroup A-C there were 27(36%) patients and 34(31%) knees, with mean blood loss per knee being 615±274 ml. In subgroup B-C, there were 10(13%) patients and 17(15.5%) knees with mean blood loss per knee of 610±173ml (p>0.05).

Table-1: Patient Demographics and Duration of Tourniquet and Surgery.

	Group A	Group B
Number of patients	54	21
Females	34	14
Males	20	7
Average age ± S.D. (year)	62 ± 10	63 ± 10
Average BMI ± S.D.	30.2 ± 5	32.3 ± 6.9
Number of knees operated	75	35
Duration of tourniquet (min)	68±9	54 ± 11
Duration of surgery (min)	68±9	77 ± 11
Complications	2major. 1 minor	2major

Table-2: Data of Subgroups.

Non-Transamine	Subgroup A-C	Subgroup B-C
	Full time Tourniquet	Part time Tourniquet
Number of patients	27	10
Females	18	7
Males	9	3
Average age ± S.D. (year.)	62 ± 10	65±7
Average BMI ± S.D.	31 ± 5	33.6±9.2
Number of knees operated	34	17
Average blood loss per knee ± S.D. (ml.)	615 ± 274	610±173
T-test p-value blood loss Subgroups A-C and B-C	0.95	

Transamine	Subgroup A-T	Subgroup B-T
	Full time Tourniquet	Part time Tourniquet
Number of patients	27	11
Females	16	7
Males	11	4
Average age ± S.D. (year.)	62 ± 10	60±12
Average BMI ± S.D.	28.3 ± 7.5	31±4
Number of knees operated	41	18
Average blood loss per knee ± S.D. (ml.)	406 ± 191	422±110
T-test p-value blood loss Subgroup A-T and Subgroup B-T	0.73	

In subgroup A-T, there were 27(36%) patients and 41(37%) knees with mean blood loss per knee of 406±191ml. In subgroup B-T, there were 11(14.6%) patients and 18(16.4%) knees with mean blood loss per knee of 422±110ml ($p>0.05$) (Table-2, Figure-1).

Transfusion frequency was lower overall in Group A, in which 13(24%) patients were transfused blood compared to Group B in which 9(43%) required transfusion (Figure-

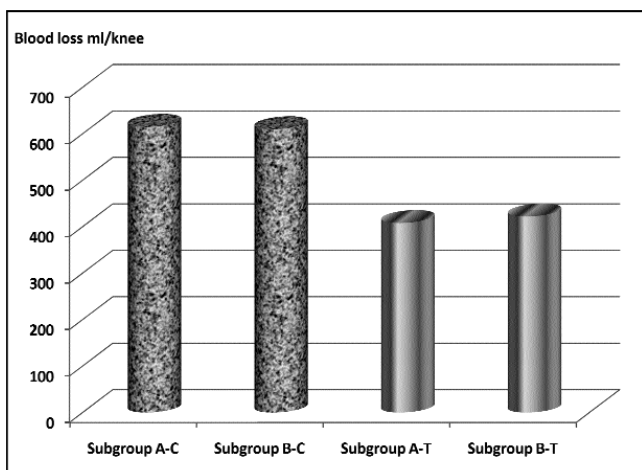


Figure-1: Comparison of blood loss per operated knee in patient subgroups.

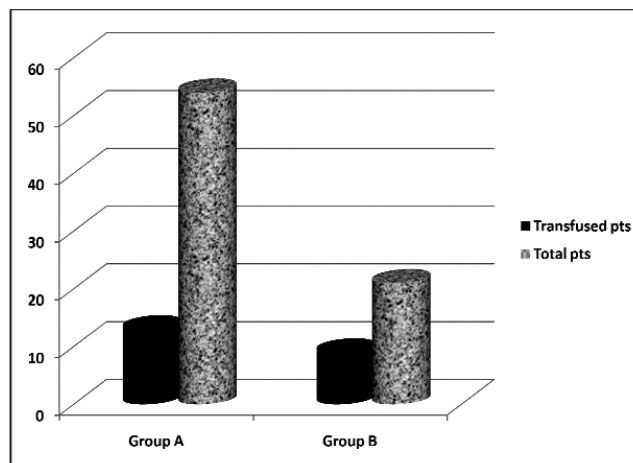


Figure-2: Numbers of patients requiring blood transfusions in Groups A and B.

2). Among the subgroups in patients who did not receive TXA, it was noted that 9(33%) patients in subgroup A-C received blood transfusions whereas 6(60%) patients in subgroup B-C required blood transfusions. In patients who received TXA, 4(15%) of subgroup A-T patients and 3(27%) of subgroup B-T patients required blood transfusions ($p>0.05$ each).

Duration of surgery was significantly shorter in Group A compared to Group B ($p=0.0005$); whereas tourniquet time was significantly shorter in Group B ($p=0.0001$).

Complication rate in the two main groups were comparable. There were 2(2.6%) major complications in each group. One (1.3%) case of pulmonary embolism was confirmed on CTPA in each of the two groups; both cases were treated medically and they recovered completely. In Group A, a 75-year-old male in American Society of Anaesthesiologists (ASA) grade3 developed ventricular fibrillations after surgery. He was initially treated in surgical intensive care unit (ICU) but expired on 4th post-operative day due to MI. In Group B, one (1.3%) patient had cardiac arrest in the recovery room 30min after surgery and recovered fully after resuscitation. There was one (1.3%) minor wound complication (superficial infection) in Group A which was treated with oral antibiotics.

Discussion

Tourniquet use is a common practice in TKA. Although tourniquet has fairly reduced the iatrogenic injuries to nerves and vessels during the surgery, but still its use is not benign. There are adverse effects related to tourniquet use. Tourniquet deflation is associated with precipitous decrease in blood pressure, increased heart rate and

hypothermia. Washout of accumulated metabolic wastes from the ischemic extremity increases potassium, carbon dioxide and lactate levels in arterial blood. These metabolic wastes may lead to increase in minute ventilation and, rarely, arrhythmias.⁶ Kato et al. described a phenomena called snowstorm-like echogenic particles on transesophageal echocardiography for several minutes after the deflation of tourniquet.⁷ We also observed signs of thromboembolism (hypotension, tachycardia and hypothermia) just after deflation of tourniquet in 3 of our patients. We believe that patients should be kept under close observation by the anaesthetist in the initial one hour after the deflation of tourniquet and the following 24 hours should be in an ICU setting.

Elderly patients and women are more susceptible to tourniquet-related complications. Similarly, patients classified as ASA2 or ASA3 have higher odds of tourniquet-related complications. The tolerance rate for tourniquet in women is far less than it is in men.⁸

In our series of 75 patients, four (three females, one male) developed major complications. All of them were elderly (61, 62, 65 and 75 years of age) with pre-existing comorbidities [in ASA grade 2/3]. They all underwent bilateral one-stage TKA. Two had pulmonary embolism, one had cardiac arrest in the recovery room and recovered fully after resuscitation; a 75 year male in ASA grade3 developed ventricular fibrillations after deflation of tourniquet and expired on the 4th post-operative day due to MI. We believe that elderly patients undergoing one-stage bilateral knee replacement are at high risk for tourniquet-related complications. This along with significant amount of blood loss (>2liters in bilateral one-stage TKA) puts these patients, with already low physiological reserves, under enormous stress. Special care should be taken when deciding a one-stage bilateral knee replacement procedure in elderly patients in ASA Grade 2 and above.

Biologically, application of the tourniquets for longer period of time (>2 hours) has shown to increase the depletion of creatinine phosphate and adenosine triphosphate (ATP) required for metabolic recovery of muscles. Elderly patients and patients with peripheral vascular damage are more susceptible to muscle damage, which warrants the use of tourniquets for a shorter period of time in these patients. Similarly, prolonged use of tourniquet has been shown to increase the fibrinolytic activity, increasing the degree of bleeding due to release of local mediators after the deflation of tourniquet. All the above-mentioned facts advocate early release of tourniquets in orthopaedic procedures, especially in the

elderly.[9] In our study, patients' tourniquet time was less than 105 min in all groups.

Minimum but effective tourniquet pressure is recommended for getting an avascular field during surgery as it causes least damage and complications. In literature, tourniquet pressure of 110-150 mmHg above systolic pressure for upper limbs, while 155-250mm Hg for lower limb is recommended. In our study group, we used a pressure of 200-250mm Hg above systolic pressure.⁹

Blood loss related to use of tourniquet has been studied in TKA procedures with conflicting results. Earlier studies (1984, 1991) had reported a decreased blood loss in groups where tourniquet was deflated early in the surgery.^{10,11} However, subsequent studies (1994,1999) showed no difference in the two groups.^{12,13} Lately a number of meta-analysis have documented significantly increased total blood loss, calculated blood loss as well as postoperative blood loss with early tourniquet release.^{14,15} Zhang et al. in a recent meta-analysis of 11 randomised controlled trials (RCTs) concluded that there were no significant differences in overt blood loss, Hb drop or blood transfusions.¹⁶ In our prospective study, although the blood loss and post-operative Hb levels were not significantly different in the two groups, blood transfusions were more frequent in Group B, although not reaching statistical significance. This may have been due to difference in anaesthesiologist's/surgeon's threshold for ordering transfusion. Kashif Abbas et al. reporting the first retrospective study from Pakistan concluded that early intra-operative tourniquet release did not reduce overall blood loss in TKA compared to the group in which tourniquet was released postoperatively, although hospital stay was relatively shorter.¹⁷

Concern regarding risk of complications in the two different tourniquet protocols has been addressed in many publications. A perception has emerged that late tourniquet release may be associated with greater risk of clinical thromboembolic phenomena and re-operation compared to early release of tourniquet.¹⁴⁻¹⁶ However, Zhang et al. concluded that there is not enough evidence to indicate that early release is superior to later release in cemented TKA.¹⁶ In our small series, the complication rate was insignificantly higher in the early-release group.

Another variable we introduced in our study was the use of TXA, an antifibrinolytic agent, on random subset of patients in both tourniquet groups. Apart from the expected reduction in blood loss in all patients who received the drug, our study clearly showed that influence of tourniquet timing was the same whether or not TXA had been administered. Surgery time, blood transfusion

requirements were reduced in subgroup A-T compared to B-T, while perioperative blood loss was similar in all patients receiving TXA (A-C, B-C) irrespective of tourniquet time.

To the best of our knowledge, the current study is the first prospective trial in Pakistan on the subject. We realise that a larger number of patients would have added to the strength of the study, but there were constraints of limited time. Besides, the study reflects two different individuals' hands-on surgical skill and thus cannot be completely free of intervention bias.

Conclusion

Tourniquet duration and timing did not influence perioperative blood loss in patients undergoing TKA. However, earlier tourniquet release intra-operatively was associated with increased surgery time and higher frequency of blood transfusion. The complication rate in the two groups was comparable. Therefore, we have not found early release of tourniquet before closure to be significantly worthwhile in TKA.

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