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The Influence of Tourniquet Use and Timing of its Release on Blood Loss in Total Knee Arthroplasty

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Abstract: In surgical practice, hemostasis is used to minimize postoperative bleeding in total knee arthroplasty. We performed a prospective randomized study to determine the influence of tourniquet use and the timing of its release on amount of bleeding. Eighty four patients (96 knees) were scheduled for total knee arthroplasty and randomly divided into three groups. Posterior cruciate retaining bicompartamental total knee prostheses were used in all. In group I, no tourniquet was used. In group II, a tourniquet was used and was deflated for hemostasis once all components had been inserted. In group III, the tourniquet was deflated after wound closure and application of a compressive dressing. Mean blood drainage, mean volume of blood transfusion, hemoglobin (Hb) and hematocrit (Hct) values and operative time were compared between the three groups. Mean blood drainage was 810 mL (300-1300) in groups I 720 mL (240-1200) in group II and 705 mL (250-1150) in group III ($p = 0.062$). The Hb and Hct values, tourniquet time (for groups II and III) and volume of blood transfusion were similar. The operative time was significantly longer for first group ($p = 0.012$). Using tourniquet and its intraoperative release with hemostasis, does not reduce blood loss in total knee arthroplasty, but using tourniquet reduces operation time significantly.

Key words: Blood loss, total knee arthroplasty, tourniquet release, tourniquet use

INTRODUCTION

Intraoperative and postoperative bleeding, in series of Total Knee Arthroplasty (TKA), ranges from 340 to 1500 mL and various techniques of hemostasis are used to minimize this bleeding (Barwell *et al.*, 1997; Lotke *et al.*, 1991). In order to reduce blood loss to allow better visualization and to ease cementing of the implants, TKA is most often performed with a pneumatic tourniquet. However, the timing of tourniquet deflation is subject to debate. Coagulation of the genicular arteries in order to reduce blood loss was recommended by Page *et al.* (1984). Barwell *et al.* (1997) advocated early tourniquet release so as to avoid the potential complications of tourniquet use. On the contrary, some other reports record that hemostasis has no effect on blood loss in TKA (Lotke *et al.*, 1991; Burkart *et al.*, 1994; Jorn *et al.*, 1999; Widman and Isacson, 1999). Other recent reports are also inhomogeneous: Bell *et al.* (2010) suggested that timing of tourniquet release can all influence transfusion rates and/or blood loss in patients undergoing primary total joint arthroplasty. Sun *et al.* (2009) concluded that short duration of tourniquet application may help to decrease the incidence of complications after TKA. Li *et al.* (2008)

showed that the knee arthroplasty operation with the use of a tourniquet has only small benefits on the total blood loss, but hinder in patients' early postoperative rehabilitation exercises. Reikerås and Clementsen (2009) concluded that the use of tourniquet in total knee arthroplasty causes local thrombogenic and fibrinolytic activity, but without influences in the systemic circulation. Li *et al.* (2009) showed that knee arthroplasty operations with a tourniquet might promote postoperative hidden blood loss and hinder patients' in early postoperative rehabilitation exercises. Thorey *et al.* (2008) recommend a tourniquet release after wound closure to reduce the duration of TKA procedure. The aim of this study was to investigate the effect of tourniquet use and intraoperative release of it on blood loss in TKA.

MATERIALS AND METHODS

Eighty four patients (96 knees) who underwent bicompartamental posterior cruciate retaining knee replacement for osteoarthritis were studied prospectively. This study was performed during a one-year period (January 2009 to 2010). The inclusion criteria were a diagnosis of severe primary osteoarthritis, the insertion of

bicompartmental prosthesis and absence of any known coagulation disorder. Sealed opaque envelopes were used for randomization at the start of operation. In group I (31 knees) no tourniquet was used and hemostasis was ensured from the beginning. In groups II (36 knees), a tourniquet was used and was deflated for hemostasis once all components had been inserted. In group III (29 knees) the tourniquet was deflated after wound closure and application of a compressive dressing. Spinal-epidural anesthesia was used for all the operations, which were performed by the same experienced operating team. A standard operative procedure was followed. In groups II and III, a pneumatic tourniquet was inflated to 220-275 mmHg depending on systolic pressure of the patient and a straight midline skin incision and standard medial parapatellar arthrotomy were used. The posterior cruciate ligament was preserved in all patients. Lateral retinacular release was performed in 9 cases of group I, 6 patients of group II and 6 patients of group III. Intramedullary guides for femoral and extramedullary guides for tibial resection were used. The hole in the distal femur made for the femoral guide was plugged with an autogenous bone block. Electrocautery was used for hemostasis. In group I, no tourniquet was used. In group II the tourniquet was deflated after insertion of the prosthetic components and after wound packing for 2 min, bleeding points were coagulated. In group III the tourniquet was not deflated before wound closure and dressing and no intraoperative hemostasis was practiced. A Jones compression bandage was applied in all patients in all groups. For all patients suction drainage was routinely used and removed after 24 h. Low molecular weight Heparin (Enoxaprine) was administered to all patients and no monitoring for INR was performed. Antibiotic prophylaxis was started just before tourniquet inflation in groups II and III and just before incision in group I with 1 g Cefazolin and then continued three times daily for 48 h. The same rehabilitation program was followed in all patients, including isometric quadriceps exercise during first postoperative day, active movement being encouraged as soon as pain allowed and immediate full weight bearing the day after operation. We did not

use a Continuous Passive Motion (CPM) machine in any patient. Two different posterior cruciate-retaining total knee prostheses were used: Scorpio (Stryker, USA) and Nexgen (Zimmer, USA). Recording of hemoglobin and hematocrit levels was done preoperatively and 24 h after surgery (day 1). Blood loss in the suction drain was recorded. Intraoperative blood loss in group I in sponges was recorded. The intra operative blood loss in group II and the blood loss in sponges in group II and III were not recorded. Guided by laboratory values and clinical assessment, the decision to transfuse was decided by the surgeon and anesthesiologist. The total of blood transfusion was recorded in blood units but converted into milliliters. Tourniquet and operation times were recorded in all patients. Statistical evaluation was made using SPSS for Windows V 13.0 (SPSS Inc., IL, USA). One-way ANOVA and Tukey's tests were used for comparisons of numeric data and χ^2 -test for comparisons of categorical data. The p-values of less than 0.05 were regarded as significant.

RESULTS

Eighty four patients (96 knees) were recruited in this study. Basic data of the studied patients are shown in Table 1. Accordingly, there was no significant difference in age, gender and side of involvement between the three groups. The main data and outcomes are shown in Table 2. Based on these results, the mean blood loss was the highest in group I and the lowest in group III; however, this difference was not statistically significant. All baseline and day-one Hb and Hct levels and the mean volume of blood transfused were comparable between the three groups. Operation time was significantly longer in

Table 1: Basic data of the studied population

Variables	Group			p-value
	I (n = 29)	II (n = 33)	III (n = 22)	
Knees	31	36	29	-
Age (years)	66 (51-74)	64 (54-73)	68 (54-72)	0.087
Gender (M/F)	7/22	9/24	6/16	0.953
Side (R/L)	15/14	15/18	12/10	0.783

Table 2: Results in Three groups of the studied population

Variables	Group I (n = 29)		Group II (n = 33)		Group III (n = 22)		p-value
	Mean±SD	Range	Mean±SD	Range	Mean±SD	Range	
Preoperative hemoglobin (g dL ⁻¹)	12.23±1.21	9.9-16.3	13.03±1.30	9.8-15.5	13.49±1.22	9.8-14.9	0.251
Preoperative hematocrit (%)	41.10±5.12	22-48	40.11±6.12	28-45	43.10±5.21	29-44	0.303
Day 1 hemoglobin (g dL ⁻¹)	10.98±1.31	8.6-12.9	11.02±0.93	8.5-12.8	11.12±1.04	8.6-11.9	0.132
Day 1 hematocrit (%)	40.21±6.16	20-46	41.56±5.67	22-47	41.67±4.32	24-43	0.454
Blood loss (mL)	810.00±244	300-1300	720.00±266	240-1200	705.00±295	250-1150	0.062
Blood transfusion (mL)	248.00±201	0-1350	241.00±173	0-1350	239.00±144	0-900	0.052
Operation time (min)	115.00±18	96-260	82.00±12	70-105	77.00±12	70-115	0.012
Tourniquet time (min)	-	-	63.00±13	55-80	78.00±13	65-100	-

group I compared to the other two groups. There was no significant difference between the group II and III in this regard.

DISCUSSION

Hemostasis is used in TKA to minimize postoperative bleeding, improve visualization and cementing quality. Most TKAs are performed using a tourniquet except in some particular situations, but there is no consensus on the time of tourniquet deflation and ensuring hemostasis. Pattison *et al.* (1973) reported a study of the causes for hemoglobin and hematocrit differences after TKA. They suggested hemolysis as a possible explanation for hemoglobin reduction. On the other hand, another study by Erskine *et al.* (1981) using chromium-labeled red blood cells demonstrated that all of the total blood loss was associated with perioperative bleeding from the wound. It is obvious that the use of tourniquet, the timing of tourniquet release and hemostasis may play a role in the volume of blood loss associated with TKA (Burkart *et al.*, 1994; Jorn *et al.*, 1999; Widman and Isacson, 1999; Harvey *et al.*, 1997; Abdel-Salam and Eyres, 1995). One study demonstrated that TKAs with or without using tourniquet did not result in any meaningful difference in blood loss (Abdel-Salam and Eyres, 1995). However patients operated on without a tourniquet had less postoperative pain and obtained earlier straight-leg raising and greater range of motion. Tourniquet was used in three different ways by Harvey *et al.* (1997) no tourniquet use at all, limited use only during cementing, use throughout the whole operation. They showed significantly higher blood loss without tourniquet use and also reported that deep vein thrombosis was not influenced by the use of a tourniquet. We used tourniquet in two of three groups and did not investigate any relation with deep vein thrombosis. Widman and Isacson (1999) studied the effect of tourniquet release timing on blood loss in 85 knees. In group I, they released the tourniquet for hemostasis before wound closure and in group II, the tourniquet remained inflated throughout the entire operation. They found no difference in blood loss and no effect of hemostasis on blood conservation in TKA. Cementless TKAs are generally associated with a higher blood loss (Burkart *et al.*, 1994; Jorn *et al.*, 1999; Vandebussche *et al.*, 2002). Various properties of cement including mechanical, chemical and thermal effects were considered to be responsible for this reduced blood loss. All of our replacement procedures were made with cemented total knee prostheses. Use of an early postoperative rehabilitation program was another factor that was considered to influence blood loss in TKA. The

relationship of blood loss in TKA with the timing of tourniquet deflation and the use of continued passive motion was investigated by Lotke *et al.* (1991). They found a significantly higher blood loss in the group in which the tourniquet was deflated intraoperatively and CPM then started in the recovery room. In the second group the tourniquet was deflated intraoperatively but CPM was started on day 3. Patients in the latter group lost less blood. CPM was considered to be an important factor in the increase of blood loss associated with TKA (Lotke *et al.*, 1991). Our rehabilitation program was the same for all patients but we did not use CPM at all. We standardized factors that may affect blood loss, such as type of rehabilitation cementing technique and thromboemboli prophylaxis. No patella replacement was done in order to standardize the bone cut surface and posterior cruciate retaining prostheses were used in all. The total blood loss in TKA was calculated as 1518 mL, with only 511 mL being collected in the suction drain by Lotke *et al.* (1991). Similar results were reported by Vandebussche *et al.* (2002). Thus, most of the blood loss in TKA occurred during the operation if the tourniquet was deflated intraoperatively. We did not use tourniquet in group I and we did not record intraoperative bleeding after tourniquet deflation in group II, but we did compare the blood loss collected in the suction drain. The major source of blood loss has been continuous bleeding from cut cancellous bone, as mentioned by Mylod *et al.* (1990) and unfortunately, there is no possibility of stopping this source of bleeding with electrocautery. Hernández-Castaños *et al.* (2008) included 46 TKAs in a prospective study, dividing them into two groups. Group A in which the ischemia was released prior to wound closure and group B releasing the tourniquet after suturing and bandaging. They concluded that releasing ischemia prior to wound closure does not demonstrate a statistical difference. This has been also confirmed by Christodoulou *et al.* (2004). Schuh *et al.* (2003) found no significant blood conservation by using tourniquet in TKA. We reached the same results either. Although major vascular damage in TKA is very rare, intraoperative tourniquet release would be a practical way to determine the major vascular damage. Lotke *et al.* (1991) found no vascular damage in more than 1,500 TKAs. We encountered no patients with a popliteal artery injury related to intraoperative damage. However, as most of the reported vascular complications during TKA are due to atherosclerotic vascular disease (Rand, 1987) intraoperative tourniquet release may not be indicated. We suggest that intraoperative tourniquet deflation and hemostasis, as well as use of a pneumatic tourniquet at all have no effect on blood conservation in TKA. We found

no significant differences regarding the amount of blood transfusion in the three groups. Bilateral simultaneous TKA may increase and otherwise affect the transfusion volume and none of our patients underwent this. We believe that eliminating tourniquet use in TKA has no effect on blood loss during operation. However, this would increase the operation time significantly. Moreover, keeping the tourniquet inflated throughout the entire operation is an effective and safe method for decreasing blood loss in TKA. The effect of eliminating tourniquet use on complications of TKA such as postoperative pain, deep vein thrombosis and wound complications can be subjects of another study.

REFERENCES

- Abdel-Salam, A. and K.S. Eyres, 1995. Effects of tourniquet during total knee arthroplasty: A prospective randomised study. *J. Bone. Joint. Surg. Br.*, 77: 250-253.
- Barwell, J., G. Anderson, A. Hassan and I. Rawlings, 1997. The effects of early tourniquet release during total knee arthroplasty: A prospective randomized double-blind study. *J. Bone. Joint. Surg. Br.*, 79: 265-268.
- Bell, T.H., D. Berta, F. Ralley, S.J. Macdonald and R.W. McCalden *et al.*, 2010. Factors affecting perioperative blood loss and transfusion rates in primary total joint arthroplasty: A prospective analysis of 1642 patients. *Can. J. Surg.*, 52: 295-301.
- Burkart, B.C., R.B. Bourne, C.H. Rorabeck, P.G. Kirk and L. Nott, 1994. The efficacy of tourniquet release in blood conservation after total knee arthroplasty. *Clin. Orthop. Relat. Res.*, 229: 147-152.
- Christodoulou, A.G., A.L. Ploumis, I.P. Terzidis, P. Chantzidis, S.R. Metsovitis and D.G. Nikiforos, 2004. The role of timing of tourniquet release and cementing on perioperative blood loss in total knee replacement. *Knee*, 11: 313-317.
- Erskine, J.G., C. Fraser, R. Simpson, K. Protheroe and I.D. Walker, 1981. Blood loss with knee joint replacement. *J. R. Coll. Surg. Edinb.*, 26: 295-297.
- Harvey, E.J., J. Leclerc, C.E. Brooks and D.L. Burke, 1997. Effect of tourniquet use on blood loss and incidence of deep vein thrombosis in total knee arthroplasty. *J. Arthroplasty*, 2: 291-296.
- Hernández-Castaños, D.M., V.V. Ponce and F. Gil, 2008. Release of ischaemia prior to wound closure in total knee arthroplasty: A better method?. *Int. Orthop.*, 32: 635-638.
- Jorn, L.P., A. Lindstrand and S. Toksvig-Larsen, 1999. Tourniquet release for hemostasis increases bleeding. A randomized study of 77 knee replacements. *Acta Orthop. Scand.*, 70: 265-267.
- Li, B., Q.R. Qian, H.S. Wu, H. Zhao, X.B. Lin, J. Zhu and W.F. Weng, 2008. The use of a pneumatic tourniquet in total knee arthroplasty: A prospective, randomized study. *Zhonghua. Wai. Ke. Za. Zhi.*, 46: 1054-1057.
- Li, B., Y. Wen, H. Wu, Q. Qian, X. Lin and H. Zhao, 2009. The effect of tourniquet use on hidden blood loss in total knee arthroplasty. *Int. Orthop.*, 33: 1263-1268.
- Lotke, P.A., V.J. Faralli, E.M. Orenstein and M.L. Ecker, 1991. Blood loss after total knee replacement: Effects of tourniquet release and continuous passive motion. *J. Bone. Joint. Surg. Am.*, 73: 1037-1040.
- Mylod Jr., A.G., M.P. France, D.E. Muser and J.R. Parsons, 1990. Perioperative blood loss associated with total knee arthroplasty: A comparison of procedures performed with and without cementing. *J. Bone. Joint. Surg. Am.*, 72: 1010-1012.
- Page, M.H., B.D. Shepherd and J.M. Harrison, 1984. Reduction of blood loss in knee arthroplasty. *Aust. N. Z. J. Surg.*, 54: 141-144.
- Pattison, E., K. Protheroe, R.M. Pringle, A.C. Kennedy and W.C. Dick, 1973. Reduction in hemoglobin after knee joint surgery. *Ann. Rheum. Dis.*, 32: 582-584.
- Rand, J.A., 1987. Vascular complications of total knee arthroplasty: Report of three cases. *J. Arthroplasty*, 2: 89-93.
- Reikerås, O. and T. Clementsen, 2009. Time course of thrombosis and fibrinolysis in total knee arthroplasty with tourniquet application: Local versus systemic activations. *J. Thromb. Thrombolysis*, 28: 425-428.
- Schuh, A., M. Hausel and S. Salminen, 2003. Effect of tourniquet use on blood loss in total knee arthroplasty. *Zentralbl. Chir.*, 128: 866-870.
- Sun, Z., Y. Sun, J. Cao, L. Wang and M. Tian *et al.*, 2009. Cause analysis and clinical management of postoperative wound complications after total knee arthroplasty. *Zhongguo. Xiu. Fu. Chong. Jian. Wai. Ke. Za. Zhi.*, 23: 644-647.
- Thorey, F., C. Stukenborg-Colsman, H. Windhagen and C.J. Wirth, 2008. The effect of tourniquet release timing on perioperative blood loss in simultaneous bilateral cemented total knee arthroplasty: A prospective randomized study. *Technol. Health Care*, 16: 85-92.
- Vandenbussche, E., Duranthon, L.D. Couturier, M. Pidhorz and L.B. Augereau, 2002. The effect of tourniquet use in total knee arthroplasty. *Int. Orthop.*, 26: 306-309.
- Widman, J. and J. Isacson, 1999. Surgical hemostasis after tourniquet release does not reduce blood loss in knee replacement: A prospective randomized study of 81 patients. *Acta. Orthop. Scand.*, 70: 268-270.