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The timing of tourniquet release and its influence on blood loss after total knee arthroplasty

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Abstract We performed a prospective, randomized study on 76 patients (82 knees) scheduled for total knee arthroplasty to determine the effect of tourniquet release and hemostasis on the peri- and postoperative blood loss. Patients were randomly divided in two groups. Posterior cruciate retaining tricompartamental total knee prostheses were used in all. In group 1, the tourniquet was deflated intraoperatively after the prosthetic components were settled and hemostasis was done. In group 2, the tourniquet was released after the wound was closed and a compressive bandage was applied. Mean blood drainage was 880.85 ml (320–1,315) in group 1 and 745.36 ml (220–1,175) in group 2 ($p=0.03$). The mean number of blood transfusions given, hemoglobin and hematocrit values, operation time, and tourniquet time were similar in both groups. Intraoperative tourniquet release and hemostasis does not reduce total blood loss in total knee arthroplasty.

Résumé Nous avons exécuté une étude prospective et randomisée sur 76 malades (82 genoux) programmé pour arthroplastie du genou total pour déterminer l'effet de la levée de garrot- hémostase sur la perte de sang per—et postopératoire. Une prothèse tricompartementale du genou, avec conservation du croisé postérieur totale a été utilisée dans tous les cas. Les malades étaient randomisés et divisés en deux groupes. Dans le groupe 1 le garrot a été dégonflé en intraopératoire après que les composants prothétiques aient été posés et l'hémostase a, alors été faite. Dans le groupe 2 le garrot a été retiré après la fermeture et la mise en place d'un pansement compressif. La perte moyenne de sang par drainage était 880.85 ml (320–

1315) dans le groupe 1 et 745.36 ml (220–1175) dans le groupe 2 ($p=0.03$). Le nombre moyen de transfusions du sang effectuées, les valeurs de l'hémoglobine et de l'hématocrite, la durée opératoire et la durée du garrot étaient semblables dans les deux groupes. La levée du garrot pendant l'opération avec hémostase ne réduit pas la perte totale du sang dans l'arthroplastie du genou.

Introduction

In surgical practice, hemostasis is used to minimize postoperative bleeding, which, in series of total knee arthroplasties (TKA), ranged from 0.8 to 1.5 l [6]. It is generally accepted that total knee arthroplasty be performed with a pneumatic tourniquet in order to reduce blood loss and to allow better visualization and cementing technique. However, there is no consensus on the timing of tourniquet deflation and ensuring hemostasis. Page and Shepard recommended the coagulation of the genicular arteries in order to reduce blood loss [9]. Barwell and Anderson advocated early tourniquet release so as to avoid the potential complications of tourniquet use [1]. In contrast, some other reports record that hemostasis has no effect on blood loss in TKA [2, 5, 6, 8, 14]. The aim of our study was to investigate the effect of intraoperative tourniquet release and hemostasis on blood loss in TKA.

Patients and methods

Seventy-six patients (82 knees) who underwent total knee replacement for osteoarthritis were studied prospectively (Table 1). The inclusion criteria were a diagnosis of primary osteoarthritis, the insertion of a unilateral tricompartamental posterior cruciate-retaining total knee replacement, and patients without any coagulation disorder. Randomization was done at the start of the operation using sealed opaque envelopes. In group 1 (41 knees), the tourniquet was deflated for hemostasis once all the components had been inserted. In group 2 (41 knees), the tourniquet was deflated after the wound had been closed and a compression dressing applied.

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Table 1 Clinical features, mean (range)

Variable	Group 1	Group 2
Patients	36	40
Knees	41	41
Age	65(53–76)	68 (56–83)
Gender M/F	6/30	4/36
Side R/L	22/19	18/23

All the operations were performed by the same experienced operating team and under combined spinal-epidural anesthesia. A standard operative procedure was followed by all surgeons. A pneumatic tourniquet was inflated to 350–400 mmHg, and a straight midline skin incision and standard medial parapatellar arthrotomy were used. Any tight medial soft tissues were released, and the posterior cruciate ligament was preserved in all patients. No lateral retinacular releases were required. Intramedullary femoral and extramedullary tibial resection guides were used, and 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 1, the tourniquet was deflated after insertion of the prosthetic components, and then an abdominal pad was placed firmly on the wound for about 2 min. Any bleeding artery or vein was then coagulated by electrocautery. In group 2, the tourniquet was not deflated before the wound had been closed and dressed, and thus no intraoperative hemostasis was practiced. After “water-tight capsule and skin closure,” a Jones compression bandage was applied in all patients of both groups. In group 2, the tourniquet was only deflated after the compression bandage had been applied. Suction drainage was used routinely and was removed 24 h after wound closure. Warfarin (Coumadin) was exhibited for thromboemboli prophylaxis in all patients with monitoring of INR (International Normalized Ratio) values. Antibiotic prophylaxis was started 30 min before the operation with 1 g Sefazolin (Sefazol) and then continued three times daily for 2 days. The same rehabilitation protocol was followed in all patients. Isometric quadriceps exercises were initiated during the first day after operation, with active movement being encouraged as soon as pain allowed. Immediate full weight bearing was permitted, as cement was used in all patients. We did not use a continuous passive motion (CPM) machine in any patient.

Five different trade mark posterior cruciate-retaining total knee prostheses were used: Search (Aesculap, Tutlingen, Germany), Maxim (Biomet, Warsaw, IN, USA), PFC Sigma (Johnson & Johnson, New Brunswick, NJ, USA), Nexgen (Zimmer, Warsaw, IN, USA), and Genesis II (Smith & Nephew, Memphis, TN, USA). The hemoglobin and hematocrit levels were recorded preoperatively, immediately after surgery, and on the first and third postoperative days. The preoperative prothrombin time, partial

thromboplastin time, and platelet count were measured in all patients, and all these results were found to be normal. The blood loss in the suction drain was recorded in both groups by our nurses using graduated cylinders. The intraoperative blood loss in group 1 and the blood lost in sponges were not recorded. The need for transfusion was decided by the surgeon, guided by laboratory values and clinical assessment. The total of any blood transfused was recorded in units but converted into milliliters for statistical evaluation. Operation and tourniquet times were recorded in all patients.

Statistical evaluation was made by computer using SPSS for Windows V11.0 (SPSS Inc., Chicago, IL, USA). Equality of variance was evaluated with Levine’s test. The independent *t*-test and the Mann Whitney *U* test were used for statistical evaluation of variables. *P* values of less than 0.05 were regarded as significant.

Results

There was no difference in age and gender between the groups. The mean blood loss was 881 ml (320–1,315) in group 1 and 745 ml (220–1,175) in group 2 ($p=0.03$). The mean volume of blood transfused, all hemoglobin and hematocrit levels, and operation and tourniquet times were similar in both groups (Table 2). The number of patients who did not require transfusion was ten (24%) in group 1 and 16 (39%) in group 2. Thus, there were no significant differences in results between the two groups. There was one superficial infection in group 1, but no complications from the use of a tourniquet in either group. No patient required reoperation because of hematoma, infection, or other problems.

Discussion

TKAs are usually performed with a pneumatic tourniquet that allows for blood conservation, better visualization, and cementing technique. Nearly all surgeons use a tourniquet except in some special situations, but there was no consensus on the timing of tourniquet deflation and establishing hemostasis when this was practiced.

A study of the causes of hemoglobin and hematocrit differences after TKA has been reported by Pattison and Protheroe [10]. They suggested that not all the reduction

Table 2 Results

Variable		Group 1			Group 2		
		Hemostasis			No hemostasis		
		(n 41)			(n 41)		
	Mean	SD (±)	Range	Mean	SD (±)	Range	<i>P</i> value
Blood loss (ml)	881	292	320–1315	745	262	220–1175	0.03
Blood transfusion (ml)	484	355	0–1350	380	384	0–1600	0.224
Preoperative hemoglobin (g/dl)	13.22	1.46	9.8–16.7	12.76	1.20	9.5–14.6	0.125
Postoperative hemoglobin	11.31	1.36	8.6–14.8	10.72	1.16	8.5–13.3	0.137
Day 1 hemoglobin	10.85	1.21	8.5–13.2	10.25	0.79	8.6–12.0	0.226
Day 3 hemoglobin	11.03	1.05	9.2–13.5	10.51	0.90	7.6–12.4	0.119
Operation time	87	14	65–120	81	13	60–110	0.056
Tourniquet time	79	13	57–113	83	13	64–115	0.157

in hemoglobin levels could be explained by perioperative bleeding, and they suggested "hemolysis" as a possible alternative explanation. In contrast, another study using chromium-labeled red blood cells demonstrated that all of the total blood loss and hemoglobin reduction were associated with bleeding from the wound [3].

The use of a tourniquet, the timing of tourniquet release, and hemostasis may play a role in the volume of blood loss associated with TKA [2, 4, 5, 12, 14]. Salam and Eyres found that TKAs with or without the use of a tourniquet did not result in any difference in blood loss [12]. But patients operated on without a tourniquet had less postoperative pain and obtained earlier straight-leg raising and a greater range of knee flexion. Harvey and Leclerc used a tourniquet in three different ways: either no tourniquet at all, limited use only during cementing, use throughout the whole operation [4]. They showed that the blood loss was significantly higher when no tourniquet was used and also reported that deep-vein thrombosis was not influenced by the use of a tourniquet. We used a pneumatic tourniquet in all patients and did not investigate any relation with deep-vein thrombosis. Widman and Isacson studied the effect of tourniquet release timing on blood loss in 85 knees of 81 patients [14]. In one group, they released the tourniquet for hemostasis before wound closure, and in the other group the tourniquet remained inflated throughout the entire operation. They found no difference in blood loss, and thus concluded that hemostasis has no effect on blood conservation in TKA. Jorn and Lindstrand carried out cemented, hybrid and noncemented unicondylar and TKAs in 77 knees and assessed the effect of tourniquet release for hemostasis on blood loss and transfusion requirements [5]. They found that the total intraoperative and postoperative blood loss was 858 ml in an early tourniquet deflation group and that postoperative blood loss was 589 ml in the other group. Because of this significant difference, they did not advise tourniquet release for hemostasis. Although intraoperative blood loss was not calculated in our early tourniquet release group, we found that blood loss was significantly higher in this group ($p=0.03$). We demonstrated that there was no difference between our groups either in respect of the volume of blood transfused or in the numbers of patients who required blood replacement.

The use of either a cemented, or uncemented prosthesis may influence blood loss during knee replacement, with cementless procedures being generally related to a higher blood loss [2, 5, 7]. The mechanical, chemical and thermal properties of cement were considered to be responsible for this reduced blood loss. In our series, all replacements were made with cemented total knee prostheses.

Another factor that may influence blood loss in TKA is the use of an early postoperative rehabilitation program. Lotke and Faralli investigated the relationship of blood loss in total knee replacement with the timing of tourniquet deflation and the use of continued passive movement (CPM) [6]. They found a significantly higher blood loss in the group where the tourniquet was deflated in-

traoperatively and CPM then started immediately in the recovery room. In another group, the tourniquet was released intraoperatively but CPM was started on day 3. Patients in this group lost less blood. Therefore, CPM was considered to be an important factor in the increase of blood loss associated with TKA. We followed the same rehabilitation protocol in all our patients but did not use CPM.

The duration of the operation and the type of any thromboemboli prophylaxis may play a role in blood loss. Harvey and Leclerc reported that longer operations had a greater blood loss [4]. In the same study, patients who had received thromboemboli prophylaxis lost more blood than a placebo group, whatever type of prophylaxis was exhibited. We found no difference in operation time between our two groups and used the same thromboemboli prophylaxis protocol in all patients.

Factors that may affect blood loss, such as cementing, type of rehabilitation, operation time and thromboemboli prophylaxis, were standardized in our study. Posterior cruciate-retaining prostheses were used, and all patellae were replaced in order to standardize the bone cut surface. Lotke and Faralli calculated the total blood loss in TKA as 1,518 ml, with only 511 ml being collected in the suction drain [6]. Vandenbussche and Duranthon reported similar results [13]. Thus the majority of the blood loss in TKA occurred during the operation if the tourniquet was deflated intraoperatively. We did not record intraoperative bleeding after tourniquet deflation in group 1, but we did compare the blood loss collected in the suction drain. In spite of this, we found a significantly higher blood loss in the intraoperative tourniquet-deflated group. Mylod and France stated that the major source of blood loss was continuous bleeding from cut cancellous bone [7] and, unfortunately, there is no possibility of stopping this with electrocautery.

Intraoperative tourniquet release would be a practical way to determine the major vascular damage in TKA, although major vascular damage in TKA is very rare. Lotke and Faralli found no vascular damage in 1,500 TKAs [6]. Rand reported three vascular complications in 9,022 patients, and these complications were related to atherosclerotic vascular disease and not to intraoperative trauma [11]. We have encountered only one patient who had a popliteal artery thrombus related to atherosclerosis in 313 primary TKAs. However, as most of the reported vascular complications during TKA are due to atherosclerotic vascular disease, intraoperative tourniquet release may not be indicated. Palpation of the dorsal pedis or posterior tibial pulses in the operating room after deflation of the tourniquet could be another practical way to detect major vascular damage in TKA.

In conclusion, we suggest that intraoperative tourniquet deflation and hemostasis has no effect on blood conservation in TKA, and we demonstrated no differences resulting from blood transfusion in our two groups. None of our patients underwent bilateral simultaneous TKA, as this procedure may increase and otherwise affect the transfusion volume. This will be the subject of another

study. We believe that keeping the tourniquet inflated throughout the entire operation is a safe and effective method for conserving blood in TKA.

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