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Nondrainage Decreases Blood Transfusion Need and Infection Rate in Bilateral Total Knee Arthroplasty

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ABSTRACT

This retrospective study enrolled 526 patients undergoing bilateral total knee arthroplasties at our institution. In nondrainage group (Group 1) of 255 patients (510 knees), a disposable elastic sterile exsanguination tourniquet (HemaClear), wound closure in layers and Jones Bandage, without pre-tourniquet removal hemostasis or Hemovac drain were used. In drainage group (Group 2) of 227 patients (454 knees), pneumatic tourniquet, post-deflation hemostasis, a Hemovac drain and Jones bandage were used. The maximal drop in hemoglobin was significantly greater in Group 2 than Group 1 ($P < 0.001$). Also infection rate was significantly lower in Group 1 ($P = 0.017$). The use of sterile tourniquet removed after wound closure without Hemovac drain decreases blood transfusion need, infection rate, tourniquet related pain and postoperative complications.

TKA, as a major orthopaedic procedure, is usually accompanied by significant blood loss and postoperative allogenic blood transfusion (ABT), which is considered as tissue–cell transplantation. The average blood loss after bilateral standard TKA can be high; Lin reported 1222 ml of blood loss and similar values have been reported in literature [1–5]. ABT is associated with potential risks of increased infection rate [6], transmission of infectious diseases [7], down-modulation of the immune system [8] and matching errors which can lead to significant medical problems, and even death. The infection rate after TKA also varies, with most studies reporting infection as the most challenging complication after TKA, at an incidence of 1%–4% [9–11].

Use of drains and tourniquet deflation prior to full wound closure have previously been shown to increase blood loss during and following TKA. To decrease postoperative bleeding, platelet-rich plasma gel application, tranexamic acid injection, fibrin tissue adhesive use, minimally invasive surgery, drain clamping and tourniquet use have all been attempted [12–15]. In addition, prevention of the infection is a substantial part of management after TKA. Therefore, identifying and treating possible sources of infection before surgery, lowering theatre traffic, using laminar flow, preoperative antibiotics, meticulous exposure and treating preoperative anemia have been used [16–18]. Because of lack of established evidence, it has not been determined whether the above mentioned modalities are more beneficial than other conventional methods in controlling postoperative bleeding and infection.

The research question of this study was whether nondrainage with a disposable sterile elastic exsanguination tourniquet application will decrease blood transfusion need, infection rate and postoperative complications in TKA when compared to application of pneumatic tourniquet, post-deflation hemostasis, a Hemovac drain and Jones bandage. For this purpose, a retrospective controlled study was designed to evaluate the results in two groups of patients.

Materials and Methods

Between May 2005 and July 2007, 526 patients (total of 1052 knees) were enrolled in the study, all with grade III or IV osteoarthrosis. Institutional review board approval was obtained. Of these patients, comorbidities which can alter the rates of postoperative bleeding or infection rate such as inflammatory arthrosis (n = 31), preoperative anemia (n = 5) and preoperative history of deep vein thrombosis (DVT) (n = 2), malignancy (n = 1), or uncontrolled hypertension (n = 2), diabetes mellitus (n = 1), bleeding disorder (n = 1) or coronary artery disease (n = 1) were excluded. Other patients who had any of the above co-morbidities but were considered medically controlled or who had undergone previously an arthroscopic debridement or a high tibial osteotomy

The work was performed at Kecioren and Ataturk Education and Research Hospitals, Ankara, Turkey.

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were not excluded from the study. As such, 44 patients (8%; 88 knees) were excluded from the study, leaving a total of 964 knees of 482 patients for evaluation.

There were two intervention groups: non-drainage group (Group 1), using disposable sterile elastic exsanguination tourniquet that was released after closure (Fig. 1, HemaClear, OHK Medical) and drainage group (Group 2), using pneumatic tourniquet that was deflated prior to haemostasis and closure with Hemovac drain. Group 1 consisted of 255 patients (39 male, 216 female) with an average age of 64.4 years (range, 47–84 years). Group 2 comprised 227 patients (26 male, 201 female) with an average age of 63.9 years (range, 43–88 years) (Table 1). There were no demographic differences between the two groups (Table 2). There were no statistical differences between the groups in terms of co-morbidities such as hypertension, diabetes mellitus or coronary artery disease and both groups had the same levels of preoperative hemoglobin (13.1 ± 2.5 and 12.8 ± 1.8 g/dl; respectively, Tables 1, 2).

All operations were performed under spinal anaesthesia by 2 staff surgeons (KK and AO) who regularly perform at least 150 knee arthroplasty operations per annum using a midline approach. Implants were supplied by Corin Ltd, Cirencester, UK PCL retaining cemented prosthesis with Rotaglide mobile polyethylene inserts and were used for all patients. In the first group, potential bleeding sources were coagulated intraoperatively, wound closure was done in layers and a sterile Jones bandage was applied prior to the release (by cutting) of the sterile exsanguination tourniquet (Group 1, n = 255, 510 knees). In the second group, exsanguination of the leg was performed by Esmarch bandage, and a pneumatic tourniquet was inflated to a mean pressure that was 100 mm/Hg above the systolic blood pressure. At the end of the operation the tourniquet was deflated, careful haemostasis was performed, a Hemovac drain was inserted, the surgical wound was closed in layers and a Jones bandage was applied (Group 2, n = 227, 454 knees).

The two groups of patients were compared in terms of postoperative blood transfusion need as a primary outcome. In addition to comparison of the lowest levels of postoperative hemoglobin and infection rates, DVT, pulmonary emboli (PE) rates, postoperative tourniquet related pain defined as pain in the quadriceps muscle underneath the tourniquet cuff [19], duration of operation, haemarthrosis, and requirement for post operative analgesia (IM 100 mg Tramadol per ampule) were also determined. Blood transfusion need was evaluated for the entire duration of hospitalization. All of the patients included in the study received antibiotic prophylaxis of 1 g Cephazolin Sodium one hour before induction of anesthesia. During their stay in the hospital, patients were administered 1 g cephazolin sodium three times a day for the first day postoperatively.

Infection was followed up by observing local and systemic signs such as erythema, swelling, elevated ESR, CRP and white blood cell count. In case of any suspicion for deep infection, fluid and tissue cultures were taken and aspirate was sent for cell count and differential. For management of postoperative pain, iv tramadol was given through PCA on postoperative day 1 and diclofenac sodium was used on the following days. At the preoperative stage, all the patients were administered 40 mg Enoxaparin prophylaxis beginning at the postoperative 12th hour and the INR was measured preoperatively and 12 h postoperatively. The patients were administered 40 mg prophylaxis of enoxaparin once a day, for 3 weeks.

Preoperative standard haemoglobin level had to be 10 g/dl or higher to be operated on and thereby included in the study. Blood transfusion (Erythrocyte suspension) was given to patients with haemoglobin levels of 7.9 g/dl or less in the postoperative 3rd day follow-up in both groups. In addition, blood transfusion was given to symptomatic patients in the postoperative 3rd day follow-up with haemoglobin levels of 8–10 g/dl in the postoperative period if their heart rate was over 120 or systolic blood pressure was less than 90 mm Hg. Intraoperative blood loss was not usually used as an indicator of transfusion unless there was an excessive blood loss exceeding 10% of the patient's estimated total blood volume. Colloid solutions were infused for less significant blood loss (<10%).

All of the data for this study were obtained from the hospital's computerized medical records. For analysis of differences within and between groups, Excel and the statistical software package SPSS (v.15, Chicago, Illinois) were used. To analyze differences between the groups, a 2-way, repeated-measure analysis of variance was used. An unpaired 2-sided t-test was used to analyze differences between means and 2-sided z-test was used to analyze the significance of differences between proportions. All P values < 0.05 were considered significant.

Table 1
Demographics and Preoperative Haemoglobin Levels of the two Patient Groups.

Demographic/hb	Group 1 (n = 255)	Group 2 (n = 227)	P
Average age (years)	64.4 (47–84)	63.9 (43–88)	0.41
Male:female	39:216	26:201	0.32
Prhb	12.8 ± 1.8	13.1 ± 2.5	0.62

Hb = Haemoglobin; Prhb = Preoperative haemoglobin.

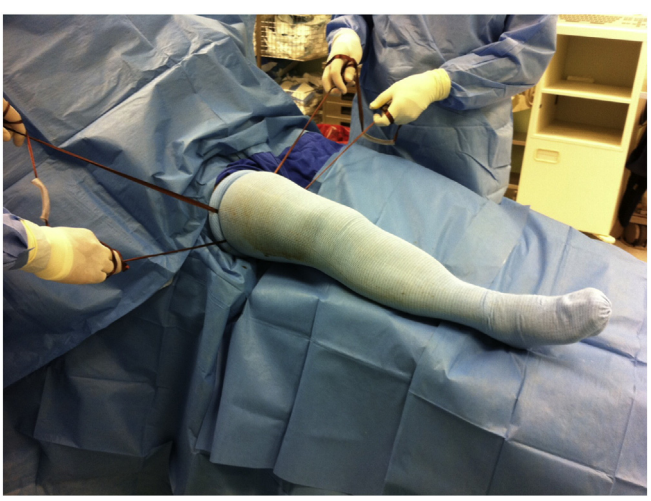

Fig. 1. Application of sterile elastic exsanguination tourniquet. The torus, consisting of a silicon ring wrapped by a stockinette is rolled up the disinfected and draped leg by pulling the straps (top) all the way to the upper thigh (middle). The pressure applied by the rolling ring along the way effectively exsanguinates the limb and arterial flow into the leg is blocked (bottom). The elastic ring is cut with a scalpel at the end of surgery (not shown) to resume blood flow.

Table 2
Comparison of Comorbidities Among Patient Groups.

	Group 2	Group 1	P
Overall comorbidity rate	132 (51.8%)	128 (56.4%)	0.309
Ht	88 (34.5%)	81 (29.2%)	0.192
DM	51 (20%)	48 (17.3%)	0.429
CAD	31 (12.2%)	28 (10.1%)	0.452
Ht + DM + CAD	6 (2.4%)	4 (1.4%)	0.531
Ht + DM	18 (7.1%)	13 (4.7%)	0.245
Ht + CAD	14 (5.5%)	11 (4%)	0.408
Weight (kg)	83 ± 6.5	79 ± 4.2	0.376
Height(m)	1.643 ± 1.7	1.661 ± 2.1	0.445
BMI (kg/m^2)	30.9 ± 3.87	30.1 ± 2.2	0.657
Surgical time (min)	156 ± 12.39	162 ± 11	0.721
Previous surgery	11 (4.8%)	14 (5.5%)	0.237

Ht = Hypertension; DM = Diabetes Mellitus; CAD = Coronary artery disease.

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Table 3
Comparison of Blood Transfusion Rates and Postoperative Haemoglobin Levels.

Blood units	Group 1	Group 2	*P*
0	61 (23.9%)	0 (0%)	s.
1	121 (47.5%)	1 (0.4%)	s.
2	63 (24.7%)	28 (12.3%)	s.
3	9 (3.5%)	113 (49.8%)	s.
4	1 (0.4%)	81 (35.7%)	s.
5	0 (0%)	4 (1.8%)	s.
Total units	278	740	
AV	1.09 ± 0.81	3.26 ± 0.71	<0.001
Pohb	7.2 ± 1.1 g/dl	6.5 ± 1.8 g/dl	<0.001

s = significant ($P < 0.05$); AV = average number of blood units per patient; Pohb = Postoperative haemoglobin.

Results

Blood transfusion rate was three fold higher in Group 2 (Table 3). A total of 740 U were transfused in Group 2 (3.26 ± 0.71 U/patient, mean ± SD) and only 278 U in Group 1 (1.09 ± 0.81 U/patient) ($P < 0.001$). There were no reported significant complications or side effects due to blood transfusion in either group aside from the higher cost of treatment. The mean lowest post-operative haemoglobin was 6.5 ± 1.8 g/dl in Group 2 and 7.2 ± 1.1 g/dl in Group 1 ($P < 0.001$).

The infection rates which were seen unilaterally among the two groups are shown in Table 4. Superficial wound infection was diagnosed in 11 patients in Group 2 (4.85%) and in 5 patients (1.96%) in Group 1 ($P = 0.078$). Deep prosthesis infection was found in 6 patients (2.64%) in Group 2 and in 2 patients (0.78%) in Group 1 ($P = 0.1$). Surgical treatment was needed for 6 of the 8 patients diagnosed with deep prosthesis infection (5 in Group 2 and 1 in Group 1). In 1 of the infected patients in Group 2, with two failed revision attempts, the revision type prosthesis was removed and arthrodesis was performed. Other cases were treated with two step revision surgery which included prosthesis removal, antibiotic impregnated spacer application, at least 6 weeks of medium specific IV antibiotic therapy and revision total knee arthroplasty. All of these patients were eventually healed. Note that the percentages reported above were calculated based on the number of patients and should be divided by 2 if the rates per operated knee are sought. The overall (superficial wound and deep prosthesis) infection rates were 7 (2.7%) in Group 1 and 17 (7.5%) in Group 2 ($P = 0.017$).

Additional complications and side-effects were noted for both groups and these are shown in Table 5. The rate of tourniquet related pain was more commonly seen in Group 2 (18 vs. 5 patients, $P = 0.002$). Deep vein thrombosis (DVT), which was diagnosed by sonography after clinical suspicion was observed in 12 patients (5.29%) in Group 2 and in 4 patients (1.57%) in Group 1 ($P = 0.023$). There was no haemarthrosis in Group 2 (Table 5, $P = 0.1$). Among the patients in Group 1, haemarthrosis developed in 3 knees (0.6%) and was treated by aspiration, cold-pack and application of compressive dressing. No further complications were observed during the follow-up of these patients.

Pulmonary embolism was diagnosed in 7 patients (3.1%) in Group 2 and in 2 in Group 1 (0.78%) ($P = 0.06$). All of them survived with supportive therapy. No other major complications were noted. Statistical analysis showed a minor yet significant difference between the two groups with respect to their analgesic need (Table 5). The mean duration of the operations (each knee) was 22.4 min (24.2%) longer for Group 2 (115.1 ± 14.4 min) than for Group 1 (92.7 ± 6.7) ($P < 0.001$). The length of stay in the hospital was essentially the same for both groups.

Table 4
Comparison of Infection Rates.

Infection Rate	Group 1 (n = 255)	Group 2 (n = 227)	*P*
Total	7 (2.7%)	17 (7.5%)	0.0168
Deep	2 (0.78%)	6 (2.6%)	0.111
Superficial	5 (1.96%)	11 (4.85%)	0.0776

Table 5
Postoperative Complications.

	Group 2	Group 1	*P*
Urinary tract infection	10 (4.4%)	11 (4.3%)	0.961
Deep venous thrombosis	12 (5.3%)	4 (1.6%)	0.023
Pulmonary embolism	7 (3.08%)	2 (0.78%)	0.063
Hemarthrosis	0 (0%)	3 (1.2%)	0.101
Tourniquet related pain	18 (7.9%)	5 (2%)	0.0022
Post op analgesics need[a]	3.1 ± 0.5	2.9 ± 0.4	<0.001

[a] Tramadol 100 mg/ampule.

Discussion

This study showed a dramatic reduction in blood transfusion needs, which can be explained by the non-linear nature of applying a rigid policy for blood transfusion that was applied. Quantitatively, a difference of 0.2 g/dl or 2 g/l means a total difference of 10 g of hemoglobin loss which is only about 125 ml of blood in a patient who has a blood volume of 5 l and hemoglobin level of 8 g/dl. Although it is quite inaccurate to try to infer the reduction of blood loss between Group 1 and Group 2 from their lowest post operative hemoglobin, we can attempt to estimate it as $(7.2-6.5)/6.5 \times 5000$ ml = ~ 540 ml. While this calculation is rough at best, it provides an order of magnitude estimation of the difference in blood loss between the methods.

The overall infection rate was determined to be lower in Group 1 ($P = 0.016$). The rates of deep prosthesis and superficial wound infections individually were non-significant when the two-sided statistical analysis was used (i.e. generic null hypothesis of difference, rather than of Group 2 infection rate being greater than in Group 1). This difference in infection rate can be attributed to: (a) no drain in Group 1; (b) sterile tourniquet in Group 1 versus non-sterile one in Group 2; (c) shorter procedure duration in Group 1; and (d) less blood transfusion in Group 1. It is not possible to discern which of these factors actually played a dominant role in the reduced infection rate. If, however, the trend for reduced deep infection is an indication, the drop from 2.6% (based on patient number) or 1.3% (based on knees number) to 0.8% (0.4%) could translate into a substantial improvement in outcome and a very significant financial saving (e.g. over $140,000 per 1000 TKAs in our institution).

In the present study an alternative set of procedures was evaluated with the primary aim of reducing blood loss and thereby minimizing the need for blood transfusion. Firstly, the Esmarch and pneumatic tourniquet were replaced with the sterile exsanguination tourniquet (HemaClear) in the first group due to its ease of use, drier surgical field and sterile application. The second change was in the sequence of activities towards the end of the operation. In particular, the incision was first sutured in layers, the Jones dressing was applied and only then was the exsanguination tourniquet removed by cutting it. No Hemovac drain was used in this set. By so doing, a substantial reduction in blood loss was anticipated during the period from (pneumatic) tourniquet deflation to application of the compressive dressing. The physiological reactive hyperemia that occurs at this time due to the extreme vasodilatation, promotes bleeding beyond the amount usually observed from a surgical incision. It was felt that perhaps much of the blood accumulation inside the closed surgical wound (which is subsequently drained by the Hemovac in the traditional approach) could be avoided by properly packing the knee with the Jones dressing prior to removal of the arterial occlusion. The results of this study confirm our hypothesis as outlined below.

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Other researchers have investigated blood loss in and around TKA. The methods commonly used to estimate intra-operational blood loss have been the measurement of volume and the haematocrit of the liquid accumulating in the suction container and weighing the sponges [20]. The extent of post-operative blood loss has usually been determined from measuring the volume of blood accumulating in the drainage container(s) in the first 24, 48 or 72 h postoperatively. The sum of the two volumes was used as a measure of the tangible total blood loss. Most of these studies also reported pre and post operative hemoglobin levels, calculated the "hidden loss" and specified the need for blood transfusion. We believe our study, which uses the need for blood transfusion as the primary endpoint for the investigation while applying a rigorous protocol for the determination of transfusion requirement, provides a simple, quantitative and objective way of comparing surgical strategies with blood loss as a primary objective.

Three patients in Group 1 (1.2%) developed haemarthrosis, while none was seen in Group 2. This is believed to be a direct result of not releasing the arterial blood flow blocking in Group 1 prior to the closure of the incision. The haemarthrosis that developed despite the Jones bandage could have been from arterial vessels. However, none of the 3 patients required open haemostasis in the OR. They were successfully managed with needle aspiration, cold packs and compressive dressing with no consequences.

A number of unexpected results were observed in this study; the statistically significant reduction in DVT rate and the trend for a lower rate of Pulmonary Emboli (PE) were not foreseen. In fact, we do not fully understand the mechanism of these findings. It could be speculated that the smaller area under compression by the narrow ring of the elastic exsanguination tourniquet as compared to the larger volume of tissue (and length of the underlying veins) that is under compression by the wide pneumatic tourniquet may have contributed. Competing theories may include the shorter operations in Group 1 and the improved exsanguination, not leaving clotted blood behind in the veins for the duration of the operation. We are not aware that transfusion of RBC suspension promotes DVT, but this could theoretically be yet another factor.

Significantly fewer patients reported pain in the thigh at the site of the placement of a sterile elastic exsanguination tourniquet than at the site of the pneumatic tourniquet. This finding, again, was not expected, but correlates with the results of several studies that have compared the way volunteers tolerated an elastic exsanguination tourniquet to a pneumatic tourniquet [21,22]. The need for post operative analgesia was 6.6% less in Group 1 than in Group 2, but this small difference was nevertheless statistically significant. While tourniquet pain may have been a factor in this finding, other elements such as no drain and limited use of diathermy intra-operatively may have played a role.

The concern about blood loss in TKA and its prevention has been the subject of many studies carried out in order to understand its extent and causes and to find strategies to minimize it [23–27]. In 1991 Lotke et al [32] documented a significant blood loss in unilateral TKA with the mean value being 1519 ml and called attention to the need for preoperative preparation of sufficient blood products for the patient. Bottner, Pavone et al [4,28] studied the need for blood transfusion in patients undergoing one-stage bilateral TKA. In a group of 461 patients described in 2003 [28] and in an expanded group of 501 patients described in 2004 the mean blood transfusion need was 2.8 U, which is not very different from the 3.26 ± 0.71 U reported for Group 2 in the current study (Table 3). Passad et al [29] studied the risk factors associated with greater blood loss and need for transfusion. They found that men lost significantly more blood than women ($P = 0.001$) which may be relevant to our own study where there were substantially more women than men. They also found a significant correlation between tourniquet time and operation duration. This observation may contribute, in part, to the reduced blood loss in our Group 1 patients.

Among the strategies for reduction in blood loss during TKA there have been multiple reports on the effects of the timing of tourniquet release, on the placement of drains and combinations thereof, and on the use of Tranexamic acid. Steffin and Green-Riviere [30] studied the effect of a blood-salvage drain on the haematocrit drop in 37 patients randomized into either an early or late tourniquet release groups. No differences were observed between the groups in maximal haematocrit drop, drainage amounts or total surgical time. The authors concluded that the use of a blood salvage drain should not influence the preference of timing of tourniquet release in TKA. A recent study by Li et al [31] also evaluated blood loss in 100 patients undergoing TKA randomized into two groups: with and without a drain. They found that blood loss was more than 300 ml higher in the with-drain group with a higher need for blood transfusion, with no detrimental consequences in the no-drain group. They concluded that placement of a drain does not present a significant advantage in TKA. The beneficial effect of Tranexamic acid was recently described [32] with blood loss reduction of nearly 500 ml, a lower drop in hemoglobin and a lesser need for transfusion. Other studies on this topic have shown similar results.

There are several significant limitations of this study that should be outlined. Although the same surgeons performed the operations on both groups and the temporal proximity was close, one may argue that the technical and clinical skills of the entire team may have improved from the first to the second year. Additionally, the interpretation of the study results are complicated by the fact that more than one parameter was changed between the groups. In fact, five parameters were varied from Group 1 to Group 2: (a) drain/no drain; (b) tourniquet type; (c) exsanguination method; (d) hemostasis technique; and (e) timing of tourniquet release. As such, the full impact of these changes will probably be transferable only if all five changes are implemented together.

The exclusive inclusion of one-stage bilateral knee arthroplasty population in the current study raises the question of if and to what extent the findings are transferable to unilateral TKA cases. The need and use of blood transfusion post TKA performed in the traditional way vary considerably from no transfusion at all to 2 U as a standard in nearly all patients. While it is plausible that the blood loss and need for transfusion will be reduced using our new method, it is necessary in our opinion to repeat the study in a unilateral TKA population. Other findings, such as reduced infection, reduced DVT and PE, reduced operative time and less tourniquet pain are probably still relevant to unilateral TKA cases as for these parameters, each knee that was operated on in the current study can be viewed as an independent observation.

In conclusion, the results of this study confirmed our hypothesis that better exsanguination and tourniquet removal only after suturing and packing with a Jones dressing without a drain will reduce blood loss and infection rate and the need for blood transfusion. The study was sufficiently powered to provide conclusive statistical significance. The additional observations indicate that this approach is safer and more effective than the traditional method. The occurrence of haemarthrosis in 3 of 510 knees that were operated on is a non-negligible complication that should be watched for and treated promptly by aspiration, cold pack and compressive Jones dressing. We do not consider it a reason for not using the non-drainage method described here in view of the range of its benefits.

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