BLOOD LOSS IN TOTAL KNEE ARTHROPLASTY WITH AND WITHOUT TOURNIQUET RELEASE

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ABSTRACT

Objective: To evaluate blood loss in patients submitted to cemented total knee arthroplasty with and without perioperative tourniquet release for hemostasis. Methods: Seventy-two patients (eighty knees) were submitted to total knee arthroplasty, allocated into two groups: in Group 1, in which the pneumatic tourniquet was maintained until suture and dressing of the operated wound, and Group 2, in which the pneumatic tourniquet was released intraoperatively after cementing the prosthesis, with direct hemostasis, before the suture and dressing. The patients were evaluated for blood loss by the suction drain, and hemoglobin and hematocrit counts, at intervals of 2, 24 and 48 hours in the postoperative period tube. Results: There was no significant difference between the groups in terms of postoperative blood loss or decrease in hemoglobin and hematocrit parameters. Only one patient, from Group 2, required a blood transfusion in the postoperative period. Conclusion: Postoperative blood loss in TKA was similar with and without perioperative release of the pneumatic tourniquet for hemostasis.

Keywords: *Arthroplasty. Hemostasis. Knee. Blood loss, surgical.*

Citation: *Vasconcelos JW, Vasconcelos GA. Blood loss in total knee arthroplasty with and without tourniquet release. Acta Ortop Bras. [online]. 2011;19(1):32-6. Available from URL: http://www.scielo.br/aob.*

INTRODUCTION

Total knee arthroplasty (TKA) can be a cause of important blood loss and several studies demonstrate a high rate of transfusions.[1-4]

Homologous transfusions are related to a considerable number of complications, such as rise in the incidence of wound infections,[5] hydric overload, increase of hospital length of stay,[6] viral infections, immunosuppression, hemolytic reactions and inflammatory tissue lesions,[7,8] besides the inherent risks of contamination by HIV, hepatitis C, and other bloodborne diseases.

Pre-deposit self-transfusion (autologous) through the blood banking system has been defended in TKA in the attempt to avoid the complications of homologous transfusions.[9-11] Autologous transfusions, however, are expensive, not exempt from complications,[12] and cannot always be used in elderly patients.[13]

Aiming to decrease the number of blood transfusions in TKA, some precautions have been described for the minimization of peri- and postoperative bleeding, such as occlusion of the femoral milling orifice with bone graft,[14] use of a pneumatic tourniquet and of the suction drainage tube,[13] improvement of the surgical technique,[15] use of tranexamic acid,[16] local infusion with norepinephrine[17] and more recently the application of platelet gel on the surgical wound.[18]

The use of the pneumatic tourniquet in the perioperative period allows the surgeon a bloodless field until the placement of the components, also improving the cementation technique. The timing of its removal, however, is a motive for controversy in literature, and can occur in the perioperative period, soon after the prosthesis is cemented for direct hemostasis of the wound, or after the suture and the compressive dressing.

The first study comparing the two methods was carried out by Newman *et al*.,[19] with 80 patients submitted to cemented arthroplasty. The authors referred to less blood loss when the tourniquet was removed or after the suture and the pressure dressing. Page *et al*.,[20] however, in a non-randomized study, referred to better results in patients with perioperative release of the tourniquet for direct hemostasis. In spite of the reduction found all their patients were transfused.

Since then studies have been published with conflicting results. Jorn *et al*.[21] and Ishii and Matsuda[22] found significantly less blood loss in the group of patients where the tourniquet was removed after the closing of the surgical wound and the dressing, consistent with the report of Newman *et al*.[19]

Widman and Isacson,[23] Schuh *et al*.[24] and Hersekli *et al*.[25] did not find any difference in blood loss as concerns the pneumatic tourniquet removal time.

The aim of this study is to evaluate total blood loss in patients submitted to cemented total knee arthroplasty with and without pneumatic tourniquet release for hemostasis.

All the authors declare that there is no potential conflict of interest referring to this article.

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Article received on 8/30/08 and approved on 6/26/09

MATERIAL AND METHOD

Seventy-two patients (80 knees) submitted to TKA, and operated in the Hospital Universitário Presidente Dutra, of the Universidade Federal do Maranhão, in the period from June 2005 to December 2006, were the study subjects. The study was of the prospective type, approved by the Institutional Review Board. All the patients had routine preoperative tests, and the blood count was indispensable. The use of anticoagulants was discontinued in three patients ten days prior to surgery. All patients received full information about the study and were allowed to participated only by signing an informed consent.

The exclusion criteria were patients that exhibited some form of blood dyscrasia, those with previous surgery on the knee to be operated or when the surgical procedure had to be enlarged due to quadriceps tenotomy or tibial tuberosity osteotomy. As preoperative inclusion criterion the minimum hemoglobin accepted was 11 g/dL.

Seventy-one knees were operated for primary arthrosis, six for rheumatoid arthritis, one for gout sequelae, one for arthrosis secondary to advanced synovial chondromatosis and one for traumatic sequelae and semi-rigid knee.

The patients were divided into two groups, with the first 40 operated knees belonging to Group 1 and the subsequent 40 allocated in Group 2.

- Group 1 (35 patients, 40 knees) where the wound suture and the compressive dressing were performed, with successive crepe and orthopedic cotton wool bandages before the release of the pneumatic tourniquet.
- Group 2 (37 patients, 40 knees) where the pneumatic tourniquet was removed soon after the cementation of the prosthesis and open hemostasis before the suture and the compressive dressing.

The patients undergoing bilateral arthroplasty did not have just a single operation. They were discharged and were only submitted to the second procedure after the performance of further tests demonstrating normalization of the hematinometric parameters.

All the patients followed the routine established for TKA, with prophylactic antibiotic therapy according to the rules of the Commission for Control of Hospital Infection (CCIH). The antibiotic used was cefazolin 1g, 30 minutes before the incision, followed by 1g administered intravenously every 8 hours until the second postoperative day. The use of low molecular weight heparin started 18 hours after surgery and was maintained until patient discharge.

All the patients were operated by the same surgical team and the pre- and postoperative data were gathered by the investigator and team and noted down in an evaluation form.

The surgical procedure was performed through medial parapatellar approach, followed by eversion and lateral dislocation of the patella, resection of the meniscuses and anterior cruciate ligament, femoral and tibial cuts according to the standardized technique for knee arthroplasty. The femoral cuts were made with intramedullary guide and the tibial cuts with extramedullary guide. The posterior cruciate ligament was preserved in 64 knees. The patella was preserved in all the patients. The lateral patellar retinaculum was released in 18 knees from Group 1 and 20 from Group 2, with cauterization of the superolateral retinacular artery. All the prostheses were cemented and the femoral orifice occluded with bone graft.

In the patients from Group 2, compression of the surgical wound was performed soon after pneumatic tourniquet release, using pressure dresses and crepe bandages and raising the limb for 7 minutes. This was followed by the progressive and careful removal of the pressure dresses and the inspection of the soft tissues with subsequent cauterization of the bleeding vessels.

The surgical wound was sutured by planes, with knee in 60° flexion, and an intra-articular suction drain tube was inserted with outlet to the medial and proximal region of the leg. A dressing was applied with successive layers of pressure bandages and orthopedic cotton.

In the patients from Group 1, after the performance of the compressive dressing and release of the tourniquet, the presence of pulse was verified in the dorsal pedis and posterior tibial arteries, for evaluation of vascular perfusion.

All the patients remained in the post-anesthesia recovery room during the first two hours of the immediate postoperative period, with cardiac monitoring, pulse oximetry and monitoring of vital signs, performing the first measurement of blood loss and the hemogram. After two hours, depending on the clinical conditions, they were taken to the ward of the Orthopedics Service, where their vital signs were noted down every 6 hours, with blood drawing for the hemogram and measurement of blood loss at 24 and 48 hours.

In the postoperative period we adopted the transfusion criteria of the American College of Surgeons (Table 1), cited by Cangiani *et al*.,[26] as well as the postoperative hemoglobin measurement. We performed volemic replacement with crystalloids in a ratio of 3:1 for blood loss measured by the suction drain tube, and accepted minimum hemoglobin levels of 7.5 g/dL. However, the decision to perform the transfusion was always made by the surgeon in the peri- or postoperative period, based on the clinical state and hematologic profile of the patients.

On the first postoperative day patients were encouraged to perform exercises involving isometric contraction of the quadriceps and active, progressive flexion-extension of the knee, depending on the pain thresholds. Continuous passive motion apparatuses were not used on our patients.

Control was performed through blood loss measurement by the emptying of the suction drain tube and hemoglobin and hematocrit measurements 2, 24 and 48 hours after the operation. Bleeding of the surgical wound in Group 2, after removal of the pneumatic tourniquet, was considered negligible in this study. Complications up to 48 hours after surgery, both local and systemic, were recorded.

The size of the sample group was calculated to detect a difference of 200 ml in blood loss,assuming that the group with lower loss has an average of 750 ml, and that the standard deviation of the two groups is equal to 250 ml, with power of 80% at alpha level of 0.05 for a bilateral test. Twenty five patients would be necessary in each group for this purpose.

The data were analyzed using the SPSS for Windows 10.0® software (1999). The Student's t-test for independent samples (quantitative variables) was applied for evaluation of the hematinometric parameters (hemoglobin and hematocrit) and of blood loss. In all the tests the significance level of p to reject the null hypothesis was 5%.

Table 1. *Classification of acute hemorrhage – American College of Surgeons.*

Factors	I	II	III	IV
Blood loss (ml)	Up to 750	750 to 1,500	1,500 to 2,000	2,000 or more
Blood loss - %BV	Up to 15	15 to 30	30 to 40	40 or more
Pulse – bpm	Up to 100	100 to 120	120 to 140	140 or more
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal	Decreased	Decreased	Decreased
Capillary filling	Normal	Positive	Positive	Positive
Respiratory rate (mpm)	14 to 20	20 to 30	30 to 40	40 or more
Urine output (ml/h)	30 or more	20 to 30	5 to 10	Absent
Mental state	Anxious +	Anxious ++	Confused	Lethargic
Replacement (3:1)	Crystalloid	Crystalloid	Crystal+blood	Crystal+blood

BV = circulating blood volume. Reproduced from Cangiani et al. (2007).

RESULTS

Forty-nine patients (68%) were female and twenty-three (32%) male. The mean age at the time of surgery was 69.3 years, with minimum age 54 and maximum 79.

Blood loss was greater in the first two postoperative hours (45.33% of total bleeding in Group 1 and 42.85% in Group 2) and from two to 24 hours in both groups (40.37% of total bleeding in Group 1 and 43.42% in Group 2), with a decrease after 24 up to 48 hours. The mean blood loss was 747.25 mL in Group 1 (minimum of 156 and maximum of 1,219 ml) and 838.38 ml in Group 2 (minimum of 243 and maximum of 1,493 mL), with no significant statistical difference between the groups. (Table 2)

In the evaluation of the hemoglobin count the mean loss in Group 1 was 3.29 g/dL (minimum 0.9 and maximum 5.6 g/dL) while in Group 2 it was 3.69 g/dL (minimum 1.1 and maximum 8.0 g/dL) with a constant decrease in the counts at 2, 24 and 48 hours. (Table3) There was no significant difference between the two groups.

In the hematocrit evaluation the loss was 9,865 points in Group 1 (minimum of one and maximum of 20.3) and 10,433 in Group 2 (minimum 3 and maximum of 22.1), with no significant statistical difference, and a constant decrease at 2, 24 and 48 hours. (Table 4)

Only one patient (1.25%) from Group 2 was submitted to a blood transfusion on the second postoperative day as their hemoglobin was below 7.5 g/dL. No patient presented symptoms of acute anemia, such as dyspnea, lethargic state or tachycardia, in the peri- or postoperative periods.

None of the patients developed deep vein thrombosis or pulmonary embolism until the second postoperative day. One patient from Group 1 had intra-articular effusion after 24 hours and another from Group 1 had skin phlyctenae.

DISCUSSION

The use of pneumatic tourniquet in TKA allows a bloodless field, which facilitates the dissection of soft parts and the performance of bone cuts, also improving prosthesis cementing.[13,22] The timing of tourniquet removal as the best option in preservation of the blood stock levels, however, is controversial.

Table 2. *Evaluation of postoperative blood loss (ml) through the suction drain tube.*

	02 hours	02-24 hours	24-48 hours	Total
G1	338.7 ± 154.55	301.7 ± 159.2	106.85 ± 54.06	747.25 ± 242.83
G2	359.3 ± 157.47	364.0 ± 178.88	115.08 ± 72.15	838.38 ± 283.04
T	-0.59	-1.645	-0.577	-1.545
P	0.557	0.104	0.566	0.126

Table 3. *Evaluation of hemoglobin (g/dL) 02, 24 and 48 hours after surgery.*

	Preop.	02 hours	24 hours	48 hours	Total loss
G1	12.872 ± 1.248	11.62 ± 1.367	10.153 ± 1.268	9.588 ± 1.164	3.29 ± 1.28
G2	13.62 ± 1.587	11.738 ± 1.512	10.545 ± 1.437	9.933 ± 1.415	3.69 ± 1.46
t	-2.342	-0.365	-1.296	-1.191	-1.309
p	0.022	0.716	0.199	0.237	0.194

Table 4. *Evaluation of hematocrit (%) two, 24 and 48 hours after surgery.*

	Preop.	02 hours	24 hours	48 hours	Total loss
G1	38.62 ± 3.155	34.817 ± 3.803	30.613 ± 4.256	28.98 ± 4.168	9.865 ± 4.174
G2	41.075 ± 4.502	35.493 ± 5.062	32.215 ± 4.586	30.642 ± 4.531	10.433 ± 4.268
t	-2.825	-0.674	-1.62	-1.708	-0.601
p	0.006	0.502	0.109	0.092	0.549

Perioperative removal can, according to Jorn *et al*.,[21] lead to considerable loss due to the immediate bleeding that occurs in the wound, originating from the non-cauterized vessels or from the cut bone surfaces, thus giving preference to the release of the tourniquet after the suture and the pressure dressing. However Page *et al*.[20] affirmed that when the tourniquet is released at a later stage, there is the possibility of injury of larger vessels that could not be verified in the perioperative period, and the possibility of bleeding of the wound in spite of the pressure dressing.

In our study there was no significant difference in terms of postoperative bleeding when the pneumatic tourniquet was removed in the perioperative period or after the suture of the wound and pressure dressing, in conformity with the results of Widman and Isacson,[23] Schuh *et al*.[24] and Hersekli *et al*.[25] Based on the observations in our series, regardless of whether the tourniquet is removed in the perioperative period or not, the blood loss to be expected in the first two hours is practically equal to the loss between 2 and 24 hours, constituting approximately 80% of the total loss. The loss between 24 and 48 hours was approximately 20%, at which time the drainage tube was removed. Burkart *et al*.[27] reported the absence of blood drainage through the suction drain tube after 48 hours, recommending its removal to reduce the possibility of bacterial colonization. There was no significant difference in terms of the decrease of hemoglobin and of hematocrit in the two groups. We did not consider the bleeding that occurs on the drape soon after tourniquet release as a relevant aspect in the patients in which it was released in the perioperative period (Group 2), as its measurement is a controversial issue in literature. Christodoulou *et al*.[13] determined the perioperative loss by weighing the pressure dresses and by the quantity of

aspirated liquid. Burkart *et al*.[27] recommended the measurement of the aspirated liquid and did not weigh the pressure desses. Hersekli *et al*.[25] did not perform any measurement of perioperative loss, considering it negligible.

In our experience we observed that the firm compression of the surgical wound and the elevation of the operated limb for a minimum period of seven minutes, followed by careful hemostasis, leads to very small blood loss, which is hard to measure. We did not use an aspirator when releasing the pneumatic tourniquet for hemostasis in the patients from Group 2, as we consider there is an increase in the quantity of blood lost through aspiration. We gradually removed the pressure dresses and carefully executed the cauterization of the vessels as soon as they started to bleed.

It is important to emphasize that the surgeon should have good knowledge of the vascular anatomy of the knee and initiate, at the time of the procedure with the pneumatic tourniquet inflated, the cauterization of the most important vessels during the operation, to prevent them from bleeding upon the peri- or postoperative removal of the tourniquet.[15,28] Special emphasis should be placed on the cauterization of the inferolateral retinacular vessels, upon the resection of the lateral meniscus, and the superolateral retinacular vessels when it is necessary to release the lateral patellar retinaculum.[28]

It is also worth emphasizing the importance of palpation of the dorsal pedis and posterior tibial arteries pulse in the patients from Group 1, after release of the pneumatic tourniquet. Injury to large vessels in TKA is very rare,[25] yet can be diagnosed by palpation of the arterial pulse, especially upon later release of the tourniquet, when it is not possible to perform the direct inspection of the wound and of the bleeding vessels. Rand[29] reported three vascular complications in 9,022 operated patients, yet related to the profile of arteriosclerotic disease of the popliteal artery and not to trauma during surgery.

Some studies refer to more bleeding with the use of non-cemented prostheses than with cemented prostheses.[21,27] The use of orthopedic cement reduces blood loss in TKA due to the mechanical properties on the bone cuts as well as to the chemical and thermal properties of the cementation.[13,25] In our series all the prostheses used were cemented.

Another factor reported in literature that can influence blood loss in TKA is an early rehabilitation program, particularly due to the use of continuous passive motion apparatuses, related to the increase of postoperative bleeding.[25,28] In our cases we did not use continuous passive motion. Our rehabilitation program starts early, yet with active exercises, performed by the actual patients, and that progress up to their pain threshold. Early rehabilitation is important to avoid joint stiffness and to improve circulatory conditions, preventing thromboembolism.[28]

Only one patient from our series (1.25%) was submitted to blood transfusion, which is not in accordance with the majority of the articles investigated, which refer to a higher number of transfusions.

Rosencher *et al*.[30], in a multicentric study of 225 services in Europe with 3,996 patients submitted to knee and hip arthroplasty, referred to 69% of transfusions. Santana *et al*.[10] studied 107 patients submitted to TKA where 98 transfusions (91.6%) were performed. Gabriel *et al*.[31] evaluated 30 patients and presented mean loss of 550 ml in the postoperative period, with a 50% transfusion rate. These studies, however, did not present pre-established criteria for the performance of transfusions.

Spencer *et al*.[32] drew attention to the lack of defined criteria in peri- and postoperative transfusions of lower limb (hip and knee) arthroplasties, often performed on a routine basis without benefits for the patients. In studying 151 patients they found 84% of transfusions performed even on patients with hemoglobin above 10 g/dL, or during surgery, based only on the blood loss estimate. Tellisi *et al*.[4], in studying 85 TKA, referred, due to lack of a defined protocol, to transfusions in patients with hemoglobin above 10 g/dL.

Hadjianastassiou *et al*.[6] presented 169 operated patients where 34% had transfusions, 60% in the perioperative period. The authors draw attention to the lack of guidelines in these transfusions. They did not find any preoperative difference in the hemoglobin of the patients submitted and those not submitted to transfusions, and there was no adoption of a minimum level that would justify it. Moreover, only 10% of the transfused patients presented some degree of cardiovascular instability.

The establishment of a routine with defined protocols may significantly decrease the number of transfusions.15 Ballantyne *et al*.[15], with a protocol that established the adoption of preoperative hemoglobin under 11 g / dL to perform surgery and postoperative transfusion only when the hemoglobin was below 8.5 g / dL, reduced transfusions performed in TKA from 31 to 11.9%.

Pierson *et al*.[33] drew up a protocol for hip and knee arthroplasty, where the patient received erythropoietin in the preoperative period according to the postoperative criteria for the transfusion of blood elements. Of 500 operated patients distributed in two groups (433 that followed the established protocol and 67 without adopting the protocol), only 2.1% (nine patient) from the first group received the transfusion, against 16.4% from the other group.

Kourtzis *et al*.[34] also suggested a protocol with the use of erythropoietin, iron and folic acid in the perioperative period, maintenance of volemia, meticulous operating technique and acceptance of lower hematinometric levels for the transfusion. The authors refer to a reduction of 94% in the transfusions performed with the new protocol, in comparison to the patients operated before its deployment.

We attribute our low transfusion rate to the adoption of well-established criteria, with rationalization in the indication of these transfusions and the employment of a careful dissection technique and knowledge of vascular anatomy, followed by the cauterization of the most important vessels during surgery, as recommended by Burkart *et al*.[27]

Another precaution taken was in relation to patients with indication of bilateral TKA. The performance of one procedure at a time, on different occasions, and only after hematinometric normalization, contributed to a lower rate of transfusions, which would probably occur if the surgeries were performed concomitantly.

As established by the hospital's Orthopedics Service, TKA surgery is only indicated in patients with preoperative hemoglobin above 11 g/dL. Ballantyne *et al*.[5] referred to a signifi-

cant increase in the number of transfusions in patients submitted to TKA with hemoglobin below 11 g/dL in relation to those operated with a rate above 11 g/dL. In the postoperative period we adopted a restrictive transfusion strategy: acceptance of postoperative hemoglobin of up to 7.5 g/dL, providing the patient is without important clinical changes, volemic reposition with crystalloids in the ratio of 3:1 and delay in the use of low molecular weight heparin (18 hours after surgery).

The restrictive transfusion strategy, with lowering of the critical hemoglobin threshold, should be used with the aim of minimizing morbidity and mortality in patients with different clinical conditions, whereas hemoglobin of up to 7 g/dL can be accepted in patients without important symptomatology.[7,8]

Cangiani *et al*.[26] state that under basal conditions, only 4 g/dL are required to fulfill the needs ofthe human being. In surgical patients they recommend minimum hemoglobin of 7 g/dL, but reposition can be performed with higher levels if oxygenation is not adequate.

We did not find, in the literature investigated, any article where the hemoglobin accepted for transfusion needs in TKA was 7.5 g/dL or less. Most of the authors studied, as seen above, used higher rates above 8.5 g/dL as transfusion parameters. No complications occurred in our series, and we agree that 7.5 g/dL is a safe level, providing the patient is under the surveillance of other clinical parameters and does not present alterations resulting from anemia.

To continue with this study we will be proposing, in our service, a protocol of blood transfusion in TKA, with more precise monitoring of the clinical parameters up to the third postoperative day, for verification of the safety of these more restrictive hemoglobin levels. To this end we will rely on the collaboration of the Anesthesiology Service and of the Hematology Service of the hospital.

CONCLUSION

We do not find any difference in blood loss or in hemoglobin and hematocrit decrease, in cemented TKAs, between the peri- or postoperative removal of the pneumatic tourniquet. The removal of the tourniquet for hemostasis performance did not contribute to the reduction of postoperative bleeding or to the decrease of hemoglobin or of hematocrit.

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