



## Original Article

# Blood level changes in total knee arthroplasty with and without a tourniquet<sup>☆</sup>



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## ABSTRACT

**Objective:** To evaluate the difference between the total blood loss in patients undergoing primary total knee arthroplasty with and without the use of tourniquet.

**Methods:** A retrospective cohort study, with analysis of medical records of patients undergoing primary total knee arthroplasty in 2015, with and without the use of a tourniquet. Comparison was performed of hemoglobin (HB) and hematocrit (HT) variation in the complete blood count (CBC) during the pre- and post-operative period between the two groups. **Results:** There were 117 patients undergoing primary total knee arthroplasty included, minimum age of 33 and maximum of 86 years, with a mean of 67 years. 64.1% of the surgeries used a tourniquet and 35.9% did not. The mean preoperative HB in Group 1 was 13.08 and 12.97 in Group 2 ( $p=0.435$ ). The mean postoperative HB in Group 1 was 11.64 and 10.93 in Group 2 ( $p=0.016$ ). The variation of HB in Group 1 was 1.44 and 2.04 in Group 2 ( $p=0.025$ ). The mean preoperative HT in Group 1 was 38.96 and 39.01 in Group 2 ( $p=0.898$ ). The mean postoperative HT in Group 1 was 34.47 and 32.19 in Group 2 ( $p=0.005$ ). The variation of HT in Group 1 was 4.49 and 6.82 in Group 2 ( $p=0.001$ ). A total of 21 patients received transfusions RCC (red cell concentrates), as a result of HB below 8 g/dL or clinical symptoms, respectively, representing seven of Group 1 (9.3% of total intra-group) and 14 of Group 2 (33.3% of total intra-group), with  $p=0.001$ .

**Conclusion:** In patients undergoing primary total knee arthroplasty using a tourniquet, a lower variance in the hematimetric indices was observed and fewer blood transfusions were necessary.

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## Varição sanguínea nas artroplastias de joelho com e sem o uso de garrote

### R E S U M O

#### Palavras-chave:

Artroplastia do joelho  
Perda sanguínea cirúrgica  
Transfusão sanguínea  
Torniquetes

**Objetivo:** Avaliar a diferença entre a perda sanguínea total em pacientes submetidos à artroplastia total do joelho com e sem o uso de garrote.

**Métodos:** Estudo de coorte retrospectivo, com análise dos prontuários de pacientes submetidos a artroplastia primária total de joelho em 2015, com e sem o uso de garrote. Comparou-se a variação de hemoglobina (HB) e hematócrito (HT) no pré- e pós-operatório entre os dois grupos.

**Resultados:** Foram incluídos 117 pacientes submetidos a artroplastia total de joelho primária, idade mínima de 33 e máxima de 86 anos, com média de 67; em 64,1% das cirurgias, foi usado garrote e em 35,9%, não. No pré-operatório, a média da HB no Grupo 1 foi de 13,08; no Grupo 2, 12,97 ( $p=0,435$ ). No pós-operatório, a média da HB no Grupo 1 foi de 11,64; no Grupo 2, 10,93 ( $p=0,016$ ). A variação da HB no Grupo 1 foi de 1,44; no Grupo 2, de 2,04 ( $p=0,025$ ). No pré-operatório, a média do HT no Grupo 1 foi de 38,96; no Grupo 2, de 39,01 ( $p=0,898$ ). No pós-operatório, a média do HT no Grupo 1 foi de 34,47; no Grupo 2, de 32,19 ( $p=0,005$ ). A variação do HT no Grupo 1 foi de 4,49; no Grupo 2, de 6,82 ( $p=0,001$ ). Dos pacientes, 21 receberam transfusão de CH (concentração de hemácias), por HB abaixo de 8 ou sintomas clínicos, sete do Grupo 1 (9,3% do total intragrupo) e 14 do Grupo 2 (33,3% do total intragrupo) com  $p=0,001$ .

**Conclusão:** Nos pacientes submetidos a artroplastia total de joelho primária com o uso de garrote, ocorreu uma menor variância dos índices hematimétricos e um menor número de transfusões sanguíneas foi necessário.

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## Introduction

Total knee arthroplasty (TKA) is a procedure with excellent results in the treatment of degenerative diseases of the knee, but it is not free from complications<sup>1</sup>; it is associated with a great loss of blood, which can reach values equal to or greater than 1.5L, a situation in which blood transfusion becomes unavoidable.<sup>2</sup>

Complications depend on factors related to the patient, the environment and the surgical technique.<sup>3</sup> To reduce the number of blood transfusions in TKA, some care has been described to minimize perioperative and postoperative bleeding, such as occlusion of the femoral milling hole with bone graft, use of pneumatic tourniquet and suction drain, improvement of surgical technique, use of tranexamic acid, local infusion with norepinephrine and, more recently, the placement of gel with platelets in the operative wound.<sup>4</sup>

Orthopedic patients have a relatively high contribution to blood consumption. In the United Kingdom, for example, 10% of the units of red blood cell concentrate given in hospitals are consumed by orthopedic patients. Of these, 40% are used in patients undergoing TKA or total hip arthroplasty (THA).<sup>5</sup>

The use of homologous blood components is associated with an increase in mortality and morbidity. Risks associated with homologous transfusions include the transmission of infectious agents, and non-infectious risks (Table 1). Homologous transfusions are not risk-free and are associated with adverse events in 20% of cases and severe reactions in 0.5%.<sup>6</sup>

**Table 1 – Infectious and noninfectious risks associated to homologous blood transfusions.<sup>6</sup>**

Infectious risks	Noninfectious risks
Virus (e.g., human immunodeficiency virus)	Acute transfusional reaction
Bacteria (e.g., <i>Staphylococcus aureus</i> )	Late transfusional reactions
Parasites (e.g., malaria)	Febrile non-hemolytic reaction
Prions	Allergic reaction
	Acute transfusion-associated lung lesion
	Graft-versus-host disease
	Immunosuppression
	Posttransfusional Purpura
	Transfusion mistakes

In order to reduce the high rate of blood transfusions in TKA, it is essential to adopt strategies that lead to less blood loss. The use of a perioperative tourniquet allows the surgeon to have an exsanguinous field until the placement of the components of the prosthesis; it improves the technique of cementation. The moment of its withdrawal, however, is controversial in the literature; it can be done intraoperatively, soon after prosthesis cementing for direct hemostasis of the wound, or after the suture and placement of a compressive dressing.<sup>4</sup>

The aim of this study is to evaluate the difference between total blood loss in patients undergoing total knee arthroplasty with and without the use of a tourniquet.

## Material and methods

A retrospective analysis of the medical records of 117 patients undergoing unilateral total knee arthroplasty was carried out by the Department of Orthopedics and Traumatology of our institution from January 2015 to December 2015. All procedures were performed by a team of surgeons experienced in total knee arthroplasty.

Inclusion criteria was considered for patients with gonarthrosis and indication of total knee arthroplasty, with no hemoglobin and hematocrit changes, or blood dyscrasia in the preoperative exams. Patients on medication that could alter the blood coagulation system were instructed to suspend that medication before the surgical procedure, and all had normal coagulograms on the day of the procedure.

The surgical procedure was performed through a medial parapatellar approach, followed by eversion and lateral dislocation of the patella, resection of the menisci and anterior cruciate ligament, femoral and tibial cut according to standardized technique for knee arthroplasties. The femoral cuts were performed with an intramedullary guide and the tibial with an extramedullary guide. All the prostheses were cemented and the femoral orifice obliterated with bone graft. After the procedure, all the patients remained hospitalized in the ward, new hematimetric tests were performed, as well as antithromboembolism prophylaxis.

Patients were divided into two groups, Group 1 with the use of tourniquet, and Group 2 without tourniquet. The use or not of tourniquet was determined by the surgeon's preference. In order to analyze the statistical significance of general and specific information, patients were divided into those who used a tourniquet during surgery ( $n=75$ ) and those who did not ( $n=42$ ). The chi-square test for qualitative variables (gender, operated side, and use of RCC) and Student's *t*-test for quantitative variables (HB and HT before and after surgery and their variations) with a 95% confidence interval were applied to evaluate hematimetric variance. Data were analyzed using Bioestat 5.3 software.

## Results

All 117 patients were included in the study. Group 1 consisted of 75 (64.1%), and Group 2 of 42 (35.9%). In Group 1, the age ranged from 38 to 86 years (mean 67), and in Group 2 between 33 and 82 (mean 67). Regarding gender, Group 1 had 55 women and 20 men, and Group 2 had 30 women and 12 men. In Group 1, the R side was 46 and the L side was 29, in Group 2 the R side was 22 and the L side was 20. In the preoperative period the mean HB in Group 1 was 13.08, and in Group 2 was 12.97 ( $p=0.435$ ). In the postoperative period the mean HB in Group 1 was 11.64, and in Group 2 was 10.93 ( $p=0.016$ ). The HB variation in Group 1 was 1.44, and in Group 2 was 2.04 ( $p=0.025$ ). In the preoperative period the mean HT in Group 1 was 38.96, and in Group 2 was 39.01 ( $p=0.898$ ). In the postoperative period, the mean HT in Group 1 was 34.47, and in Group 2 was 32.19 ( $p=0.000$ ). The HT variation in Group 1 was 4.49, and in Group 2 was 6.82 ( $p=0.000$ ). Of the patients, 21 received RCC transfusion (red blood cells concentration), for HB below 8 or with clinical symptoms; seven from Group 1 (9.3% of intragroup

total), and 14 from Group 2 (33.3% of intragroup total) with  $p=0.001$ . The groups are detailed in [Tables 2 and 3](#).

## Discussion

The first total knee arthroplasty (TKA) was performed in 1974. Since then, it has been in permanent evolution; it changes and improves, despite being one of the two most successful orthopedic procedures in the history of the specialty, along with hip arthroplasty.<sup>7</sup>

According to Vane and Ganem,<sup>8</sup> in trauma and major surgeries, such as TKA, in which there is acute blood loss, oxygenation is the main indicator for fluid resuscitation. Thus, transfusions can be made with homologous blood, whose donor is foreign to the recipient, or with autologous blood, when the donor and recipient are the same person. In most cases, transfusion with homologous blood is the most used.<sup>8</sup>

The use of homologous blood components is associated with an increase in mortality and morbidity, and has high financial costs involved. Hopewell et al.<sup>9</sup> analyzed 32 studies related to the increase in morbidity and mortality following blood transfusions and concluded that patients receiving red blood cells concentrate had a higher incidence of complications and mortality than those who used other hemodynamic compensation methods.

Homologous transfusions are not risk-free and are associated with adverse events in about 20% of cases, and severe reactions in 0.5%. The risks associated with homologous transfusions include the transmission of infectious agents, and non-infectious risks ([Table 1](#)).<sup>6</sup> In order to reduce the high homologous blood consumption by part of patients undergoing these surgical procedures, it is essential to adopt strategies with less blood loss that can lead to blood transfusion.

Several hospitals have different transfusion protocols. Some studies recommend transfusion if hemoglobin concentration falls below 10 g/dL. The Consensus Development Conference in 1988 suggested that a hemoglobin level of less than 8 g/dL should be the trigger for blood transfusion.<sup>5</sup> However, adequate clinical judgment is imperative to decide whether a transfusion is needed instead of adhering to laboratory values alone.<sup>5,10</sup>

There are numerous studies analyzing blood loss in total knee arthroplasty, and comparing methods that lead to lower blood loss. Smith and Hing<sup>11</sup> conducted a meta-analysis in which 15 studies were included (1040 total knee replacement procedures in 991 patients) and evaluated the use of a tourniquet as a measure for lower blood loss. In their review they found that total knee replacement with a tourniquet was associated with a significant reduction in intraoperative blood loss compared to surgery that did not use tourniquet. There were no significant differences in total blood loss, postoperative blood loss measured from drainage systems, blood transfusion rates, time of surgery, and hospital stay length between the two groups. Significant heterogeneity was observed in all these results.

The use of a pneumatic tourniquet in TKA allows an exsanguinous field, which facilitates the dissection of soft parts and bone cuts, and improves the prosthesis cementation.<sup>12</sup> The moment of tourniquet removal as the best option for

**Table 2 – Patients in whom a tourniquet was used.**

Age	Gender	Side operated on	Used tourniquet	HB PRE	HB POS	HB variation	HT PRE	HT POS	HT variation
64	F	Right	Yes	3	10.6	2.4	39	31.4	7.60
74	F	Right	Yes	4.3	13.9	0.4	41.4	39.7	1.70
76	F	Right	Yes	11.1	12.8	-1.7	32.5	38.7	-6.20
79	F	Left	Yes	12.8	12	0.8	38.9	35.6	3.30
72	F	Left	Yes	13	11.8	1.2	36.8	33	3.80
68	F	Right	Yes	12.8	10.3	2.5	38	30.5	7.50
62	F	Left	Yes	12	10.5	1.5	35.7	30.7	5.00
71	F	Right	Yes	13.9	13.4	0.5	41	39.8	1.20
65	F	Right	Yes	13.3	10.6	2.7	38.7	32.2	6.50
47	M	Right	Yes	12.6	10.2	2.4	36.5	29.5	7.00
75	M	Left	Yes	14.8	14.7	0.1	42.5	42.2	0.30
72	F	Right	Yes	10.3	10.3	0	30.5	31.6	-1.10
68	F	Left	Yes	13.9	11.1	2.8	38.9	33.7	5.20
59	F	Right	Yes	13.6	12.5	1.1	42.7	36.5	6.20
60	F	Left	Yes	13.3	11.5	1.8	39.5	34.1	5.40
62	F	Right	Yes	14	10.9	3.1	41.9	33.1	8.80
69	M	Right	Yes	14.2	12.7	1.5	42.7	37.3	5.40
74	F	Left	Yes	12.3	11.9	0.4	36.9	35.7	1.20
66	M	Right	Yes	14.4	12.6	1.8	40.9	35.8	5.10
69	M	Left	Yes	15.2	14.5	0.7	44.8	41	3.80
60	M	Left	Yes	13.9	12.5	1.4	40	34.5	5.50
75	F	Right	Yes	11.9	11.5	0.4	34.6	33.5	1.10
64	F	Left	Yes	11.4	10.3	1.1	35.6	32.6	3.00
63	F	Left	Yes	14	13.4	0.6	40.4	38	2.40
71	M	Right	Yes	14.5	11.6	2.9	40.4	31.9	8.50
77	F	Right	Yes	13.9	12.6	1.3	40.3	36.8	3.50
52	F	Right	Yes	12.3	11.6	0.7	35.3	33.4	1.90
76	M	Right	Yes	12.9	12.1	0.8	41.1	39.3	1.80
59	F	Left	Yes	16.6	13.6	3	46.6	38.6	8.00
68	F	Right	Yes	13.1	12.5	0.6	38.2	32.1	6.10
71	F	Right	Yes	11.8	9.5 <sup>a</sup>	2.3	34.6	27	7.60
65	F	Left	Yes	12.2	12	0.2	35.9	33.8	2.10
72	F	Right	Yes	12.8	11.1	1.7	38	32.1	5.90
71	F	Left	Yes	13.7	12.5	1.2	41	37.2	3.80
74	F	Right	Yes	14	11.7	2.3	42	35.3	6.70
62	M	Left	Yes	15	12.4	2.6	44.4	37.1	7.30
69	F	Right	Yes	15.3	12.6	2.7	46.4	39	7.40
59	F	Left	Yes	11.4	10.4	1	33.7	32.3	1.40
70	F	Right	Yes	12.5	11	1.5	36.9	33.3	3.60
77	F	Right	Yes	13.5	11.1	2.4	40	33.3	6.70
59	F	Right	Yes	13	12	1	37.9	36.9	1.00
65	F	Right	Yes	13.5	10.5	3	41.3	33.2	8.10
66	F	Left	Yes	14.5	14.4	0.1	42.8	42.5	0.30
67	F	Left	Yes	13.9	11.4	2.5	42.1	35.6	6.50
53	F	Right	Yes	13.7	11	2.7	40.4	32.4	8.00
57	M	Right	Yes	11.5	10.2	1.3	34.8	30.4	4.40
71	F	Left	Yes	12	10.5	1.5	36.4	32.6	3.80
73	F	Right	Yes	12.1	11.5	0.6	36.4	30.2	6.20
66	F	Right	Yes	10.4	9.9	0.5	33.7	29.3	4.40
49	F	Left	Yes	10.5	8.9 <sup>a</sup>	1.6	35.5	30.8	4.70
69	M	Right	Yes	13.7	11.1	2.6	39.5	34	5.50
86	M	Right	Yes	12.7	12.1	0.6	38.7	37.9	0.80
65	M	Right	Yes	14.9	14.1	0.8	45.3	43.7	1.60
59	M	Right	Yes	13.3	12	1.3	38.7	35.9	2.80
63	M	Left	Yes	11.7	9.5 <sup>a</sup>	2.2	37.2	31	6.20
59	F	Right	Yes	10.6	9.5 <sup>a</sup>	1.1	32.5	30.2	2.30
66	F	Left	Yes	10.5	9.1 <sup>a</sup>	1.4	33.4	27.8	5.60
74	M	Right	Yes	12.5	11.4	1.1	37.3	34.1	3.20
64	M	Left	Yes	13	12.1	0.9	39.1	32.4	6.70
38	M	Right	Yes	15.5	14	1.5	46.7	42.3	4.40
78	M	Right	Yes	15.6	14.2	1.4	45.3	42.5	2.80
64	F	Left	Yes	14.3	13.9	0.4	41.7	38.3	3.40
80	F	Right	Yes	10.8	8.8 <sup>a</sup>	2	34.9	28.1	6.80
70	F	Right	Yes	12.7	11.4	1.3	37.3	33.6	3.70

– Table 2 (Continued)

Age	Gender	Side operated on	Used tourniquet	HB PRE	HB POS	HB variation	HT PRE	HT POS	HT variation
82	F	Right	Yes	12.1	11.2	0.9	37.2	34	3.20
70	F	Left	Yes	12.9	11	1.9	38.6	32.6	6.00
59	F	Right	Yes	13.1	9.6 <sup>a</sup>	3.5	38.5	28.1	10.40
75	F	Left	Yes	12.3	10.4	1.9	36.3	29.3	7.00
72	F	Left	Yes	13.3	12.5	0.8	38.4	32	6.40
60	M	Right	Yes	14.3	13.4	0.9	43	37.4	5.60
39	F	Right	Yes	13.3	12.2	1.1	37.8	35.4	2.40
67	F	Left	Yes	12.3	10.6	1.7	36.3	31.3	5.00
70	F	Right	Yes	13.3	9.8	3.5	39.8	29.6	10.20
72	F	Left	Yes	12.4	12.2	0.2	39.4	38.3	1.10
62	F	Right	Yes	13.4	11.9	1.5	42.7	38.7	4.00
<i>Average standard deviation</i>				13.08 ± 1.32	11.64 ± 1.41	1.44 ± 0.96	38.96 ± 3.51	34.47 ± 3.89	4.49 ± 2.80

<sup>a</sup> Received red blood cells concentrate.

Table 3 – Patients in whom a tourniquet was not used.

Age	Gender	Side operated on	Used tourniquet	HB PRE	HB POS	HB variation	HT PRE	HT POS	HT variation
75	M	Right	No	14.7	13.6	1.1	42.5	39.3	3.20
56	M	Right	No	14.8	11.4	3.4	42.3	33	9.30
64	F	Left	No	9.8	8.8 <sup>a</sup>	1	29.6	26.1	3.50
65	F	Right	No	11.8	10.5	1.3	36	32.1	3.90
69	F	Left	No	12.3	10.5	1.8	36.2	30.4	5.80
62	M	Right	No	13.5	12.4	1.1	40.2	36.5	3.70
71	F	Right	No	11.2	9.2 <sup>a</sup>	2	37	29.5	7.50
65	M	Right	No	16	11.6	4.4	46.5	33.8	12.70
33	F	Left	No	12.5	11.3	1.2	40	34.2	5.80
73	M	Left	No	14.8	13.7	1.1	49.9	38.1	11.80
82	F	Left	No	12.9	9.4 <sup>a</sup>	3.5	39.1	27.5	11.60
69	F	Right	No	10.5	9.2 <sup>a</sup>	1.3	30.8	27.2	3.60
76	F	Right	No	11	9.3 <sup>a</sup>	1.7	34.2	29.4	4.80
47	F	Right	No	15.8	13.4	2.4	44.5	38.5	6.00
47	F	Left	No	11.9	9.7 <sup>a</sup>	2.2	37.3	28.8	8.50
67	F	Right	No	13.9	9.5 <sup>a</sup>	4.4	39.9	27.3	12.60
66	F	Right	No	10.5	9.1 <sup>a</sup>	1.4	32.5	28.3	4.20
70	F	Left	No	13.9	10.5	3.4	40.5	30.1	10.40
76	M	Right	No	15	13.1	1.9	42.5	38.4	4.10
64	F	Right	No	12.6	9 <sup>a</sup>	3.6	36.3	26	10.30
62	F	Right	No	12.4	11.2	1.2	36.8	33.4	3.40
68	M	Left	No	13.4	13.4	0	37.9	31.1	6.80
74	F	Left	No	13.6	8.3 <sup>a</sup>	5.3	40.1	24.2	15.90
72	F	Right	No	12.7	11.7	1	36	33.5	2.50
56	F	Left	No	12.8	11.2	1.6	39.3	34.5	4.80
61	F	Right	No	12.9	10.3	2.6	39.7	31.3	8.40
76	M	Left	No	12.7	11.6	1.1	39.6	35.7	3.90
60	M	Right	No	14.7	11.2	3.5	43.8	32.7	11.10
66	F	Left	No	12.7	12.7	0	39.1	30	9.10
79	F	Left	No	11.7	8.7 <sup>a</sup>	3	36.6	28.1	8.50
77	M	Left	No	10.1	7.5 <sup>a</sup>	2.6	33.6	24.4	9.20
69	F	Left	No	13.2	12.3	0.9	41.7	38.3	3.40
69	F	Right	No	13.7	12	1.7	42	37.3	4.70
67	F	Left	No	12.5	9.8	2.7	39.7	30	9.70
71	F	Left	No	11.2	9.2 <sup>a</sup>	2	37	29.5	7.50
49	M	Right	No	14.2	12.3	1.9	41.8	36.2	5.60
68	F	Right	No	13.5	12.6	0.9	37.6	36.2	1.40
67	F	Left	No	11.1	9.5 <sup>a</sup>	1.6	34.6	29.8	4.80
65	F	Right	No	13.5	12.3	1.2	40	37	3.00
72	F	Left	No	13.8	11.8	2	40.3	34.2	6.10
79	M	Left	No	14.7	12.6	2.1	41.5	36.6	4.90
74	F	Right	No	14.3	11.5	2.8	41.9	33.5	8.40
<i>Average standard deviation</i>				12.97 ± 1.52	10.93 ± 1.63	2.04 ± 1.17	39.01 ± 3.95	32.19 ± 4.18	6.82 ± 3.37

<sup>a</sup> Received red blood cells concentrate.

preserving blood stock, however, is controversial. Vasconcelos<sup>4</sup> observed that the removal of the intraoperative or postoperative tourniquet showed no difference in blood loss when comparing hemoglobin and hematocrit variation in the pre and postoperative period.

## Conclusion

In patients undergoing total knee arthroplasty with the use of a tourniquet, there was a lower variance in the hematimetric rates, and a lower number of blood transfusions were necessary.

## Conflicts of interest

The authors declare no conflicts of interest.

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