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Blood management in total knee arthroplasty: an exploratory study regarding the use of drain and tranexamic acid in two types of instrumentation

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ABSTRACT

Background: This study investigates how presence or absence of drain or tranexamic acid (TXA) in 2 different types of instrumentation with invasion/sparing femoral canal affects hemoglobin drop after total knee arthroplasty (TKA).
Methods: This was a retrospective observational study that included 736 individuals divided in five groups, regarding conventional instrumentation (CI) or patient specific instrumentation (PSI), presence or absence of drain and TXA. Mean percentage of hemoglobin drop after the first postoperative day was compared for each group.
Results: Patients submitted to CI using drain and no TXA revealed the highest value (21,3%±9,1; p<0,001). Groups who received TXA and drain was not used, presented the lowest blood loss. Moreover, with the introduction of TXA PSI lost its advantage over CI.
Conclusions: TKA using CI, without drain and with TXA administration showed better results, reducing mean percentage of hemoglobin drop after surgery.

Keywords: Drain, Hemoglobin, PSI, TKA, TXA

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most performed orthopaedic surgeries. Up to 1580 ml of blood can be lost during surgery, predisposing to anemia and the need for blood transfusion, followed by its associated risks of allergic or hemolytic reactions, transmission of viral diseases, infection, etc.[1] Therefore, during time certain methods were successfully applied to this surgery, to lower hemorrhage such as, the use of tourniquets, drain clamping, PSI and use of antifibrinolytic agents.[2]

The use of intra-articular suction drains is widely applied by surgeons although its benefit in managing blood loss is questionable.[3] The use of temporary drain clamping in TKA has proven to be successful in preventing hemarthrosis, providing hemostasis during the first hours by creating a tamponade.[3,4] On the other hand, non-clamping drainage seems to have good results in decreasing haematoma formation, minimizing pain and oedema.[5] Nevertheless, drainage represents risk for retrograde infection and may increase bleeding following removal of the tamponade.[4,6.]

TXA is proven to be an effective adjuvant in TKA, reducing blood loss.[7] TXA acts by preventing dissolution of fibrin clots and reversibly binding to plasminogen.[8] To date, oral, intra-articular or intravenous (IV) administration can be used although the desirable method is not well defined.[9]

Less aggressive techniques that spare invasion of the femoral medullary canal, such as PSI, is expected to minimize blood loss. Patients' anatomy is assessed using imaging methods including, computer tomography (CT) or magnetic resonance imaging (MRI) to design personalized cutting blocks for distal femur and tibia.[10]

This study intended to retrospectively analyze the influence of different factors such as drain and TXA in two different types of instrumentation CI and PSI-affect the hemoglobin drop after TKA surgery.

METHODS

Study design

This retrospective observational study (level of evidence III) included 736 individuals submitted to TKA in hospital particular do Algarve (Faro, Portugal) over years 2011 to 2021. This study was approved by the medical ethical committee of the hospital; patients and medical personnel provided informed written consent for their data to be used in this study. The PSI system used was the Visionaire® (Smith and Nephew, Memphis, USA).

Patients data was collected including demographic information, hemoglobin value one week before surgery and first twenty-four hours after surgery using a hemogram test. Mean percentage (%) of hemoglobin drop after the first postoperative day was calculated for each group and then compared.

Patients were organized in five different groups in accordance with the specific technical methods applied in the knee arthroplasty during the time of the study: group A includes patients operated with CI using drain but no TXA; group B involves patients submitted to CI without drain and also no TXA; in group C patients who were operated by PSI without using drain and also no TXA; group D includes patients submitted to surgery using CI without drain and TXA was introduced; group E contains patients who received PSI without drain and TXA was used.

Different groups and the arrangement of each subsample are represented in Table 1.

Table 1: Different groups and the arrangement of each subsample.

Variables	Group A, n=27, (3.7%)	Group B, n=132, (17.9%)	Group C, n=155, (21.1%)	Group D, n=125, (16.9%)	Group E, n=297, (40.4%)
Instrumentation	CI	CI	PSI	CI	PSI
Drain usage	Yes	No	No	No	No
TXA usage	No	No	No	Yes	Yes

Inclusion and exclusion criteria

The sample size consisted of all the patients who had symptomatic arthrosis resistant to conservative treatment and underwent TKA at hospital particular do Algarve, between 2011 and 2021. All patients were assigned by default to the PSI group. However, whenever technical (inability to perform MRI or poor fitting of the cutting blocks) or logistical (delays in the manufacture obtaining cutting blocks) constraints occurred, the individual was automatically assigned to the CI group. For the exclusion criteria, we considered patients on anticoagulants or contra-indication to TXA use.

Surgical technique

All surgeries were performed by the same surgical team in presence of a senior graduate surgeon. Tourniquet was used at a pressure of 300 mmHg, inflated before skin incision and release after dressing the suture. A standard parapatellar incision was always used, with preservation of the posterior cruciate ligament. However, in cases that this was not possible, an ultra-congruent implant was used. PSI implants were sent to the hospital after patients had an MRI. Administration of TXA refers to a bolus of 1g IV administered over 15 minutes before tourniquet release. The capsule was closed with continuous suture. The knee was positioned in flexion for 20 minutes after surgery. In cases where a drain was used, its removal was scheduled when there was less than 50 ml of fluid in 8 hrs. Considering venous thromboembolism prophylaxis, enoxaparin 40 mg was prescribed for the first thirty postoperative days. Mobilization and rehabilitation of the knee was started soon after surgery.

Data analysis

Descriptive analysis was applied to all study variables using mean and standard deviation, median and interquartile range, and frequency analysis. In a bivariate context, the chi-square test was applied to both categorical variables and the T-student test to compare the means of two populations. In addition, a parametric ANOVA test was applied to compare various population averages and after its result, the Tukey test for multiple comparisons was performed ($p<0.05$ was used as cut-off for statistically significant values).

RESULTS

Regarding the type of instrumentation, the sample (n=736) was divided into 280 procedures (38.0%) for the CI group and 456 procedures (62%) for the PSI group. The study involved 502 women (68.2%) and 234 men (31.8%), aged 70.2±7.8 years with an average body mass index (BMI) value of 29.5±4.7. Drain was used in 27 (3.7%) patients and TXA was administered to 422 patients (57.3%). The groups were compared with each other regarding the variables age, sex and BMI, and no differences were found in any of the analyzes (age p=0.272; sex p=0.526 and BMI p=0.309).

In preoperative, the mean hemoglobin value was lower in group A (CI; yes drain; No TXA) compared to the other groups (p=0.029).

At 24 hours postoperatively, group A again presented the lowest hemoglobin value compared to the other groups and the highest mean value was observed in group E (PSI; no drain; yes TXA), (p<0.001).

Comparing mean percentage drop in hemoglobin, we also found differences between the groups (p<0.001). The highest value was observed in group A (21.3%±9.1) and the lowest in group D (CI; No drain; yes TXA; 14.6%±5.8). Table 2 shows mean preoperative and 24 hours postoperative hemoglobin value, as well mean percentage drop between these two moments in all study groups.

Table 3 presents the results of the Tukey test for the percentage drop in hemoglobin in the groups that reveal significant differences. The results were: between groups A and E (p=0,041); between groups B and C (p=0,015); between group B and E (p<0,001) and between group D and E (p<0,001).

Table 2: Mean preoperative and 24 hours postoperative hemoglobin value and hemoglobin percentage drop in all study groups.

Variables	Group A	Group B	Group C	Group D	Group E	P value
PO	13.3±1.5 [9.5-16.5]	13.9±1.4 [9.0-16.9]	13.8±1.6 [9.9-17.3]	14.0±1.4 [10.5-17.7]	13.9±1.5 [8.9-17.9]	0.029
24H	10.7±1.7 [7.3-13.3]	10.9±1.6 [7.1-15.3]	11.4±1.5 [8.5-15.9]	11.4±1.4 [7.7-15.1]	11.7±1.3 [7.1-15.4]	<0.001
% Drop	21.3±9.1 [7.6-40.8]	19.3±7.8 [1.4-44.7]	18.3±6.4 [2.2-40.5]	14.6±5.8 [-1.6-28.6]	15.8±6.5 [-2.6-46.1]	<0.001

PO-preoperative hemoglobin value (g/dL); 24H-hemoglobin value 24 hours after surgery; % Drop-mean percentage of hemoglobin drop 24 hours after surgery.

Table 3: Differences in hemoglobin percentage drop after application of the Tukey test.

Groups	Difference	CI*95%	P value
Group A-group E	4.0507	0.096-8.006	0.041
Group B-group C	2.6936	0.327-5.060	0.015
Group B-group E	4.1309	2.020-6.242	<0.001
Group D-group E	3.2863	1.112-5.460	<0.001

*CI-confidence interval

DISCUSSION

The purpose of this study was to investigate the effect of drainage and TXA in 2 different types of instrumentation. No differences in age, sex or BMI were found between the two types of instrumentation, the two options for drain or TXA. Therefore, we can claim that the results in the difference in hemoglobin drop are solely due to different techniques used, therefore when TXA is introduced, CI shows the lowest percentage of hemoglobin drop.

Evidence supporting insertion of drains after a TKA procedure is scarce. Nevertheless, it still is a common practice among surgeons.[3,6] Clamping drains after surgery remains an option to reduce bleeding after TKA although, optimal time for clamping is still debatable.[4,11,12] In our study, group A in which a drain was used, showed the highest difference in hemoglobin drop. This represents no advantage when compared to others where a drain was not used. Not using a drain, provides a tamponade effect causing less bleeding in the first hours after surgery.[3,11] Although, in this study we removed the drains when less than 50 ml were drained in an 8 hour period therefore, clamping was not applied. Two meta-analyses studies, showed higher rates of homologous blood transfusion in the closed suction drainage group although the mean percentage of hemoglobin drop after surgery was not investigated.[13-16] Supporting our results, Madan et al and Watanabe et al showed a greater drop in the mean postoperative hemoglobin value when a drain was placed after surgery.[17,18] Drain related complications (such as infection or thehematoma, swelling of the knee or deep venous thrombosis) were beyond the scope of our study.[16,19]

TXA is widely used by surgeons and is proven to be both effective and safe in reducing blood loss in TKA.[7,20] TXA is a synthetic lysine amino acid derivative that inhibits activation of plasminogen to plasmin which in turn suppresses binding to fibrinogen and fibrin clots and therefore its dissolution. As a consequence, it decreases blood loss after surgery.[8,20,21] Concerns about its systemic use and thromboembolic events are addressed in several studies. Moreover, no correlation was found between its use in high-risk patients, suggesting a lack of evidence in this particular group.[20,22,23] To date, the optimal route and dosage of TXA has not yet been established. Regardless of the route used, benefits in reducing bleeding and transfusion rates are widely accepted.[24-26] The results of our study support the use of TXA as shown in groups D and E with the lowest hemoglobin loss.

PSI is expected to have lower blood loss when compared to CI since the femoral medullary canal is not reamed during surgery.[27,28] By adapting the cutting blocks to the patient's anatomy, less complexity and surgical damage are anticipated, as Gong et al demonstrated less blood loss using PSI, also Tibesku et al analyzed 25 studies in a meta-analysis revealing a 53% reduction in blood transfusions with this technique.[27,29] Nonetheless, no significant difference in intraoperative blood loss and hemoglobin difference was found in other studies comparing both techniques.[30-36] Only two studies that compare the different techniques with regard to the management of blood loss mention the use of TXA.[31,37] Pietsch et al subtracted the preoperative hemoglobin value from the postoperative and found no differences comparing the two techniques, although resulted in a smaller volume of blood drained in the PSI technique, additionally there is no mention of the use of TXA.[38]

Comparing group B and C (Table 2 and 3), in which drainage and TXA were not used, PSI had a lower percentage of hemoglobin drop than CI. When TXA was introduced, CI showed the lowest percentage of hemoglobin drop when compared to PSI, i.e. comparing group D with E (Table 3), there is evidence that the difference in surgical technique is responsible for a smaller drop in hemoglobin after surgery. Moreover, a strengthened effect of TXA by plasminogen activator inhibitor-1 (PAI-1) present in the bone marrow when reaming the femoral canal in CI results in less blood being lost after surgery which might explain the differences.[39]

The authors assume the following limitations in the study: despite this study being about blood management, an analysis on transfusion rate was not included due to absence of defined criteria for its performance, during the first years of the collection of data; group drain output was also not considered, since the drains were not all removed at the same time and intraoperative losses, such as remaining blood in the pads, were not accounted for; the difference in surgical time between the two surgical techniques was not taken into account, which could have contributed to illustrating the impact of surgery on blood loss.

CONCLUSION

TKA using CI, without drain and with TXA administration proved to be better in reducing hemoglobin drop after surgery. The paradoxical effect of TXA when used at PSI requires further investigation.

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