



Predictors for blood transfusion following total knee arthroplasty : A prospective randomised study

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A prospective randomised study was conducted on 121 patients undergoing total knee arthroplasty, to identify factors predicting the need for postoperative transfusion. Patients were additionally distributed into two groups, one of which received local adrenaline into the surgical field before wound closure, while the other served as control. A statistically significant correlation was noted between preoperative haemoglobin level, haematocrit and erythrocyte count and the need for transfusion ; haemoglobin level emerged as the main predictor. No correlation was observed with patients' age, sex, body mass index, blood pressure or number of comorbidities. Local administration of adrenaline into the surgical field did not result in any reduction in blood loss, nor did it modify transfusion requirements.

Keywords : total knee arthroplasty ; transfusion ; adrenaline ; haemoglobin ; haematocrit.

deflation of the pneumatic tourniquet (4,12), continuous versus intermittent drainage (15), use of cold compression dressings (26) and cementing of the arthroplasty (3-5,16,19).

Attempts have been made to develop strategies aimed at reducing blood transfusion requirements in elective orthopaedic surgery (1). Such attempts depend on identifying the factors likely to predict the need for transfusion. A number of factors may predict the need for blood transfusion in hip and knee arthroplasty ; some of these are susceptible to modification (e.g. duration of surgery, intraoperative and postoperative bleeding, preoperative haemoglobin levels, intra- and perioperative blood pressure), while others are not (e.g. patient size, prior comorbidities).

In a study of patients undergoing total hip arthroplasty (THA), Grosflam *et al* (9) reported that

INTRODUCTION

Total knee arthroplasty (TKA) is associated with considerable loss of blood – up to 1500 ml, according to Lotke *et al* (18). Reduction in perioperative blood loss and allogeneic blood requirements should be a clinical priority (1,7).

The extent of perioperative bleeding depends on a number of factors such as surgical approach (25), use of drainage (6), type of anaesthesia (13), position of the knee during surgery (20), timing of the

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predictors of greater total blood loss included advanced age and male gender, general anaesthesia and higher American Society of Anesthesiologists (ASA) class ; they also established a classification aimed at predicting the number of units of blood required per patient. Keating *et al* (14) found that only preoperative haemoglobin levels and blood volume were predictors for the transfusion risk.

A number of studies have sought to minimise perioperative blood loss. Many of these have focussed on the use of local vasoconstrictors. Adrenaline/epinephrine is usually applied topically at concentrations between 1:50000 and 1:1000. It acts by stimulating α and β adrenergic receptors in the sympathetic nervous system, thus prompting vasoconstriction. It is commonly used in conjunction with local anaesthetics to achieve vasoconstriction and reduce bleeding (8,24).

Lombardi *et al* (17), in a study of knee-arthroplasty patients, found that intraoperative infiltration of periarticular soft-tissue with 0.25% bupivacaine, epinephrine and morphine following closure of the capsule provided better pain control in the immediate postoperative period, decreased blood loss, and decreased the need for rescue narcotics and reversal agents.

Padala *et al* (21) also reported that infiltration of adrenaline into the skin, subcutaneous tissues, and capsule before surgical incision made it possible to perform the arthroplasty without a pneumatic tourniquet or postoperative drains.

The present prospective study sought to identify the variables influencing blood loss in patients undergoing total knee arthroplasty, and to identify those that might be considered as predictors for transfusion ; at the same time, it sought to determine whether local administration of a vasoconstrictor into the surgical field would reduce intraoperative and/or postoperative blood loss.

PATIENTS AND METHODS

A prospective randomised study was conducted on 121 patients undergoing unilateral cemented total knee arthroplasty in the course of one year. The minimum sample size to ensure sufficient power to the study was estimated at 20 patients per subgroup.

Inclusion criteria

Patients :

- resident in the health district covered by the hospital,
- with primary three-compartmental arthrosis of the knee,
- undergoing surgery consecutively.

Exclusion criteria

Patients in which results could be affected for any reason, either through allergy to any of the drugs to be used in the study, or through any factor that might influence normal bleeding, e.g. :

- patients requiring intra-operative removal of previously implanted osteosynthesis devices,
- patients with coagulation disorders,
- patients receiving antiaggregant or anticoagulant treatment.

Additionally, those patients whose specific requirements, or intraoperative complications, required any modification of the surgical technique were also excluded from the study.

The surgical technique was standardised, and blood loss was quantified.

Surgical technique

Low molecular weight heparin was administered 12 hours before total knee arthroplasty and continued up to 40 days after discharge from the hospital ; antibiotic prophylaxis was also implemented.

Operations were performed in all cases by the same surgeons, under epidural anaesthesia and using a pneumatic tourniquet at a constant pressure of 300 mm Hg. An Esmarch bandage was not used.

Approach was through a midline longitudinal skin incision and medial parapatellar arthrotomy, performed – like the subsequent synovectomy – with an electric cautery. Two types of prosthesis were used : fixed tibial bearing (FB) and mobile tibial bearing (MB). Following implantation, the pneumatic tourniquet was removed and haemostasis was completed ; the surgical wound was then closed in layers, drains being left in the joint cavity and the subcutaneous bursa.

Evaluation of blood loss

Blood collected in drains was measured 48 hours after surgery, with partial measurements made on every

8-hour nursing shift. The following variables were noted for all patients : age, sex, body mass index (BMI), blood pressure, diabetic status, comorbidities, type of arthroplasty (mobile or fixed bearing), and drains.

To examine the effect of the vasoconstrictor on blood loss, patients were distributed into two groups. A control group (55 patients) underwent the surgical procedure as described above. The other 66 patients comprised the adrenaline group : following bone preparation and prior to implantation of the prosthesis, the joint cavity was washed with saline serum and dried, then bathed for one minute with 100 ml saline with 4 ml adrenaline (1/1000) (concentration 1/25.000 in the saline).

Blood loss was evaluated in both groups by measurement of red blood cell count (RBC), haemoglobin (Hb) and haematocrit (HCT) ; the difference between preoperative and postoperative values was noted in each case.

Statistical analysis

Data obtained were analysed using a statistical software package (SPSS 11.0 for Windows).

Descriptive univariate analysis of dependent and independent variables was carried out using the appropriate statistics : frequency distribution for qualitative variables and mean, standard deviation, maximum and minimum for quantitative variables. Student's t test was used to check for differences between preoperative and postoperative means. To test for correlation between blood loss and both patient sex and adrenaline administration, differences between means were calculated and subjected to Student's t test for independent samples.

To examine the relationship between blood loss and age, BMI, and the amount of blood collected in drains, scatter diagrams were plotted and Pearson's correlation coefficients were obtained for the variables concerned. Multiple linear regression was used to examine the relationship between blood loss and the variables analysed. The relationship between adrenaline administration and transfusion requirements was examined using a Chi-square contingency table analysis. Finally, multiple logistic regression analysis was performed. In all tests, differences were considered statistically significant at $p < 0.05$.

RESULTS

Descriptive analysis : Mean patient age was 71 years (SD = 5.32), with a range from 52 to 82 years. Mean BMI was 3.31 (SD = 3.49), with a

range from 2.25 to 4.9. High blood pressure was found in 55.4% of patients ; 16.5% were diabetic. A total of 13.2% of patients had no comorbidity, 33.9% had one comorbidity, 32.2% had two and the rest (20.6%) had three or more comorbidities. Female patients accounted for 83.5% of the total.

Intra-articular adrenaline was administered in 54.5% of patients (66/121). The mean amount of blood in drains was 771.4 cc, and 23.1% of patients (28/121) required transfusion.

A fixed bearing prosthesis was used in 71.9% of patients (87/121), and a mobile bearing prosthesis in the remaining 28.1% (34/121).

Analytical study

Differences in blood loss :

On the first day after operation, the mean values for RBC count (3.09×10^6 ml, versus 4.75×10^6 /ml preoperatively), Hb level (9.16 g/dl versus 14.06 g/dl preoperatively) and Hct (27.12% versus 42.02% postoperatively) were significantly ($p < 0.01$) lower than preoperative values.

Relationship between blood loss and age :

Significant differences in RBC count, Hb level and Hct loss were found in relation with age (table I). Age accounted for 21% of the variance in blood loss with respect to RBC count. For every one-year increase in patient age, there was an increase of 0.314 g/dl in blood loss (as measured by Hb level).

Table I. — Blood loss differences between pre- and post-operative values in relation with age. (RBC : red blood cell count ; Hb : haemoglobin level ; Hct : haematocrit)

	Age Coeff. (p)
Difference RBC count	0.21 (0.019)
Difference Hb level	0.31 (< 0.001)
Difference Hct	0.24 (0.007)

Table II. — Blood-loss differences between pre- and post-operative values in relation with body mass index (BMI)

	BMI Coeff. (p)
Difference RBC count	-0.14 (0.133)
Difference Hb level	-0.18 (0.053)
Difference Hct	-0.23 (0.011)

Relationship between blood loss and sex :

Significant differences were noted between male and female patients with respect to blood loss (Hb), with greater blood loss in men (5.46 g/dl) than in women (4.78 g/dl) ($p = 0.020$).

Relationship between blood loss and BMI

A statistically significant inverse relationship was noted between blood loss (evaluated from the Hct) and body mass index (table II).

Relationship between blood loss and blood pressure :

No significant difference was noted in blood loss in relation with blood pressure.

Relationship between blood loss and diabetic status :

No significant difference was noted in blood loss in relation with diabetic status.

Relationship between blood loss and comorbidity :

No significant difference was noted in blood loss in relation with patient comorbidity.

Differences in blood loss as a function of the prosthesis type :

Blood loss (Hb and Hct) was significantly greater in patients with a fixed bearing prosthesis (table III).

Relationship between blood loss and amount of drained blood :

A statistically significant positive correlation was noted between blood loss (RBC and Hb) and the amount of blood lost in the drains (table IV).

Differences in transfusions :

Of the 121 patients undergoing total knee arthroplasty, 28 (23.1%) received blood transfusions. Twenty-three patients received 2 units of predonated autologous blood, and the other 5 received one unit. Autologous transfusions were carried out in patients with haemoglobin levels below 8.5 g/dl, following the recommendations of the local Haemotherapy Commission.

A statistically significant correlation ($p < 0.001$) was noted between preoperative haemoglobin levels and the need for transfusion. However, there was no statistically significant correlation between the need for transfusion and age, sex, body mass index, blood pressure, diabetic status, number of comorbidities, type of arthroplasty, or blood collected in drains.

*Differences due to administration of adrenaline :
Differences in blood loss in relation with adrenaline administration :*

No significant differences were found in blood loss (analysing independently the three parameters

Table III. — Differences in blood loss as a function of the type of prosthesis. FB : fixed bearing prosthesis ; MB : mobile bearing prosthesis

	Blood loss /Type of prosthesis		t Student	p
	FB Prosthesis	MB Prosthesis		
Blood loss RBC ($\times 10^6$ /ml)	1.69	1.56	1.610	0.110
Blood loss Hb (g/dl)	5.03	4.56	1.988	0.049
Blood loss Ht (%)	15.60	13.11	2.494	0.014

Table IV. — Differences in blood loss in relation with blood collected in drains

	Drains Coeff. (p)
Difference RBC ($\times 10^6$ ml)	0.20 (0.028)
Difference Hb (g/dl)	0.27 (0.003)
Difference HCT (%)	0.14 (0.116)

-RBC, Hb and Hct-) in relation with local adrenaline administration (table V).

Differences in amount of blood collected in drains as a function of adrenaline administration :

No significant differences were noted in the amount of blood collected in drains in relation with adrenaline administration ($p = 0.501$).

Differences in transfusion requirements as a function of adrenaline administration :

Analysis of contingency tables for adrenaline administration and transfusion requirements revealed no significant differences in transfusion requirements in relation with adrenaline administration ($p = 0.582$).

Transfusion risk :

Multiple logistic regression analysis disclosed that only preoperative red blood cells count behaved as an independent predictor of transfusion risk. A decrease in preoperative haemoglobin levels of 1 g/dl increased the likelihood of transfusion by 2.6 ($p < 0.001$) ; similarly, a drop in the preoperative erythrocyte count of one million increased the probability of transfusion by 24.4 ($p < 0.001$). Finally, a 1 unit reduction in haematocrit values entailed a 1.2-fold increase in the transfusion risk

($p < 0.008$). A probability table for transfusion risk using these results enabled identification of those patients who, by virtue of their preoperative haemoglobin levels, were at greatest risk of requiring transfusion. This approach may help to determine alternatives to predonation of autologous blood (table VI).

DISCUSSION

The mean volume of blood collected in drains 48 hours after surgery was 771 ml, less than reported by Hersekli *et al* (12) (881 ml) in a group of patients in which the pneumatic tourniquet was deflated prior to wound closure ; the figure is also lower than noted by Kiely *et al* (15) (806-969 ml), although higher than reported by Senthil *et al* (23) (627 ml). It should be borne in mind, however, that this measure does not accurately reflect actual blood loss ; Lotke *et al* (18) estimated total blood loss at 1518 ml, while only 511 ml had been collected in drains.

Blood loss was significantly greater in men, and also increased directly with age. A one-year increase in patient age corresponded to an increase in blood loss, as measured by a drop in Hb level of 0.314 g/dl. Significantly more blood was lost by patients given the fixed tibial bearing ; this is felt to be attributable not to the design of the prosthesis, but to patient selection criteria, as mobile bearings were considered more suitable for younger patients with better functional potential, and these patients bleed less.

The remaining variables analysed – blood pressure, diabetes, number of comorbidities – had no significant influence on blood loss.

Only 23.1% of patients – all of whom had postoperative haemoglobin levels below 8.5 g/dl – received postoperative blood transfusion.

Table V. — Differences in blood loss in relation with local adrenaline administration

Blood loss / adrenaline	Blood loss With adrenaline	Without adrenaline	t	p
RBC loss ($\times 10^6$ /ml)	1.67	1.64	0.417	0.677
Hb loss (g/dl)	5.04	4.73	1.412	0.161
HCT loss (%)	14.70	15.14	-0.474	0.636

Table VI. — Transfusion risk table based on preoperative haemoglobin levels

Hb (g/dl)	Probability (%)
11.0 – 11.9	75.0
12.0 – 12.9	56.3
13.0 – 13.9	22.2
14.0 – 14.9	14.3
15.0 – 15.9	5.9
16.0 – 16.9	0.0

According to the Guidelines for the Clinical Use of Red Cell Transfusions published by the British Committee for Standards in Haematology (Blood Transfusion Task Force) (10) indications for transfusion are clear when haemoglobin levels are either above 10 g/dl (no transfusion required) or below 7 g/dl (transfusion definitely required), with however a grey area between 7 and 10 g/dl Hb, an interval that Hebert *et al* (11) reduces to 7-9 g/dl Hb.

Padala *et al* (21), reporting on the effect of adrenaline infiltration into the skin, subcutaneous tissues and capsule before arthroplasty performed without a pneumatic tourniquet or postoperative drains, noted that 23.6% of patients in the control group required transfusion (a figure very similar to that recorded here), as opposed to 3.3% in the adrenaline group. In our study however, no correlation was found between adrenaline use and either blood loss or need for transfusion.

Although haemoglobin level was the most sensitive predictor, total erythrocyte count and haematocrit values also appeared to be transfusion predictors in the present study. Pattison *et al* (22) attribute this difference in significance between the changes in haemoglobin level and haematocrit values following TKA to possible haemolysis.

The other variables studied displayed no significant correlation with the transfusion risk. Boralessa *et al* (2) also found that blood pressure had no influence on either transfusion requirements or perioperative blood loss. Taking into account the limitations of the present study, the following conclusions may be drawn: The best predictor for transfusion risk was the preoperative haemoglobin level, although haematocrit value and erythrocyte count also displayed some predictive value.

A correlation, although of little predictive value, was also noted between blood loss and age, male gender, amount of blood collected in drains and type of prosthesis, although the latter may well be attributable to age as an underlying factor.

The transfusion risk table drawn up on the basis of these findings would enable identification of patients likely to require transfusion and would allow adoption of prior corrective measures in order to avoid transfusion.

Intraoperative bathing of the surgical field with adrenaline, under the conditions of the present study, proved ineffective for reducing blood loss during total knee arthroplasty.

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