

Intraoperative Normovolaemic Haemodilution in Total Knee Arthroplasty – A Prospective Randomised Trial

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ABSTRACT

Aim : To determine the efficacy of acute normovolaemic haemodilution (ANH) in blood conservation in patients with total knee arthroplasties.

Method : A prospective trial of 65 patients scheduled for unilateral total knee arthroplasty (TKR) was performed. Patients with haemoglobin of 11g% or more and without active cardiac disease were randomised preoperatively. Up to 10% of blood volume was harvested at induction by ANH and reinfused post-operatively.

Results : 23 patients were randomised to ANH (Group 1), 21 to the non-ANH control group (Group 2), 21 did not meet the ANH criteria (Group 3). Preoperative haemoglobin (Hb) was comparable in groups 1 and 2 (13g%, $p=0.760$), while in group 3 the average Hb was 11.3g% ($p=0.000$). We found the drop in Hb on the first operative day was comparable in all groups ($p=0.550, 0.162$). However, only 1 patient (4%) in group 1 received homologous blood transfusion for low Hb compared to 3 (14%, $p=0.252$) in group 2. In group 3, 7 patients (33%, $p=0.147$) were transfused.

Conclusion : In our elderly population where predonation is usually not suitable due to strict criteria and where blood loss is not well tolerated, ANH is an appealing technique. There appears to be a lower transfusion rate with ANH. It may also be useful to identify patients with increased risk of transfusion preoperatively as in group 3 which makes up about a third of routine TKR's in our population and study the efficacy of other methods like Hb build up with haematonic supplement or erythropoietin therapy to decrease the rate of homologous transfusion.

INTRODUCTION

Haemorrhage is a complication of total knee arthroplasty. An average of 400 total knee arthroplasties are performed in our department per year, of which about a third require one to two units of blood transfusion for significant blood loss. These patients are generally elderly, with more medical conditions and are less tolerable to blood loss. Concern about

the safety of our blood products and transfusion techniques, especially the infective and immunological risks as well as the decreasing blood availability due to decreasing number of blood donors has led to the development of several strategies to reduce homologous transfusions.

Currently, there are several established techniques of blood conservation including preoperative autologous donation, peri-operative acute normovolaemic haemodilution (ANH), intra-operative cell salvage, post-operative re-transfusion of blood collected in the drains as well as preoperative pharmacological haemoglobin buildup to avoid transfusion^{1,2,3}.

The aim of our study was to determine the efficacy of acute normovolaemic haemodilution (ANH) in blood conservation in our patients undergoing primary unilateral total knee arthroplasties.

MATERIALS AND METHODS

Sixty-five (65) consecutive patients scheduled electively for primary unilateral total knee arthroplasty from 1 December 1997 to 31 March 1998 by the department were assessed by the anaesthetist performing the operating list that day for suitability for the study. Inclusion criteria were haemoglobin of 11g% or more and absence of active cardiac disease with New York Heart Association status of Class I and II. Patients who consented to the procedure were then randomised into 2 groups where group 1 consisted of the ANH group and group 2 the non-ANH control group.

In the ANH group, up to 10% of blood volume was harvested at induction with simultaneous infusion of colloids (500 ml of gelafluidin) to maintain normovolaemia (ANH). Total knee arthroplasty was performed under tourniquet control and the blood harvested in group 1 was reinfused postoperatively before the patient had left the operating theatre.

Measurements of haemoglobin concentration preoperatively and on the first post-operative day were performed. Records of the age, sex, total blood loss, operative duration, tourniquet duration and number of post-operative homologous transfusions were made.

Total blood loss was defined as the combination of blood loss from the operative field as measured from the suction apparatus at the end of surgery and the measured blood collected in the drain on the first postoperative day. Post-operative blood loss to the first operative day was taken into consideration as all drains with initial drainage that exceeded 400ml in the 1st hour post-operatively were clamped and released in the ward the next morning. Duration

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of surgery was defined as the time from the first skin incision to the completion of skin closure at the end of surgery, while tourniquet was the total time between inflation and deflation of the tourniquet where the first inflation is just before skin incision and final deflation after the knee is bandaged at the end of surgery. The tourniquet may be deflated once during haemostasis to identify major bleeding vessels and inflated again for the closure of the knee. Haemoglobin fall was calculated from the difference between the pre-operative haemoglobin and the haemoglobin measured on the first post-operative day.

Mann-Whitney test was used to compare the continuous data and Chi-square test was used to compare patients who received postoperative blood transfusions and the risk of transfusion in the groups.

RESULTS

There were 61 female and 4 male patients, with a mean age of 64 (50 to 81) years. Ninety-two percent (92) underwent total knee arthroplasty for degenerative osteoarthritis and five for rheumatoid arthritis.

Group 1 comprised 23 patients, group 2 included 21 patients, group 3 included 21 patients (who did not meet the criteria for the randomisation). The mean age, total blood loss, duration of surgery and tourniquet time were comparable in the three groups (Table 1).

Table 1. Mean age, tourniquet time, duration of surgery and total blood loss

Group	Age (yrs)	Tourniquet time (min)	Duration of surgery (min)	Blood loss (m)
1	64 ± 8	79 ± 24	85 ± 23	515 ± 230
2	65 ± 8	82 ± 20	84 ± 23	622 ± 410
3	65 ± 6	87 ± 32	93 ± 38	508 ± 380
p	0.399	0.821	0.967	0.308

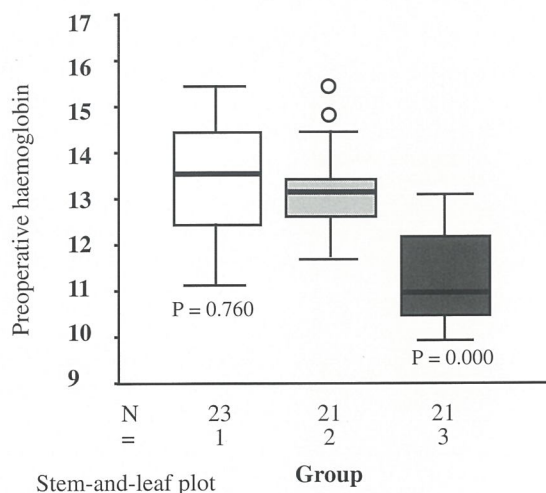
Mean ± 1 SD

Table 2. Haemoglobin fall on the first postoperative day

Group	Hb (g%)	P-value
1	3.0 ± 1	P=0.841
2	2.8 ± 1	
3	2.4 ± 1	P=0.162

Mean ± 1 SD

Pre-operative haemoglobin was comparable in groups 1 and 2 (p=0.760) but lower in group 3 (p=0.000). (Figure 1) Haemoglobin fall was comparable in all the groups. (Table 2) Homologous blood transfusion was given for patients with post-operative haemoglobin of less than 9 g% in all the groups. A total of 11 patients subsequently received homologous blood transfusion. Only one patient (4%) in

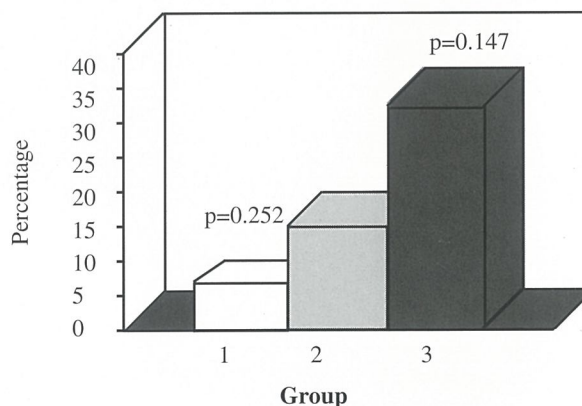


Legend

- Mean
- 25th - 75th percentile
- 5th, 95th percentile

	Group 1 (ANH)
	Group 2 (Control)
	Group 3 (not fit)

Fig. 1 - Preoperative haemoglobin



Legend

	Group 1 (ANH)
	Group 2 (Control)
	Group 3 (not fit)

Fig. 2 - Percentage of patients who received postoperative homologous transfusions

group 1 received transfusion of one unit of homologous blood while three (14%) in group 2 received one unit of homologous blood ($p=0.252$). In group 3, seven (33%) had homologous transfusion, six with one unit and one with two units, all for haemoglobin of less than 9 g% except for one who had significant heart disease. When compared to the control group 2, the number of transfusions were reduced to a third in group 1 while the transfusion rate was doubled in group 3 although the differences were not statistically significant (Figure 2). The odds ratio for the risk of transfusion was 1.4 in group 1 and 2.1 in group 3 when compared against the control group.

DISCUSSION

With recent cases of HIV transmission with homologous transfusion, there is a renewed awareness of the risks of homologous blood transfusions. Of the several methods for blood conservation to avoid homologous transfusion available today, not all are useful for patients undergoing total knee arthroplasty.

Predonation at the blood bank days to weeks before surgery is often not feasible due to the strict criteria, where patients are not to be above 65 years of age and without underlying diseases like hypertension, ischaemic heart disease, diabetes mellitus or pulmonary diseases. Many of our patients fall in this group^{2,4}. Predonation also does not eliminate the possible risks of transfusion errors. The use of intraoperative cell salvage where the washing process will yield about 25% of blood is only useful if at least a litre of blood is lost intraoperatively⁵. The equipment cost of \$400 for each unit, makes it less cost effective than the other methods. In the postoperative wound drainage autotransfusion system, the risk of sepsis, transfusion reactions and coagulopathies are present. Though proven to be safe by Marks et al, it was not found to be effective in blood conservation and reduction of homologous transfusion

in management of primary total knee arthroplasty⁶. Pharmacological agents like haematinics do improve the haemoglobin but the duration required is long. Recombinant erythropoietin has also been shown to be useful⁷, but it remains costly. Hence the relatively inexpensive use of ANH³, which is a logistically straightforward method, with theoretically less transfusion risks and errors⁸⁻¹², is an appealing technique to study for reducing homologous transfusions in our patients undergoing total knee arthroplasty.

This study of only elective unilateral and primary total knee arthroplasty showed that 32% of our patients were not suitable for ANH and therefore predonation techniques were also not feasible. We also found that the average blood loss postoperatively is about 3g% in our control. There appears to be a lower transfusion rate in our study group with ANH though this was not statistically significant. This could be due to the small sample size.

This study also identifies a group (group 3) which makes up a significant proportion of all our total knee arthroplasty patients, who are both unsuitable for predonation and ANH techniques and at a greater risk of homologous transfusion. This is probably because most of them had a haemoglobin below 9g% after haemorrhage of about 2.4g% of blood from surgery from their starting haemoglobin of less than 11g%. In this group, techniques such as preoperative haematinics and erythropoietin therapy in combination with ANH could be studied to effectively reduce the requirements for homologous transfusions.

CONCLUSION

Haemorrhage is significant at 3g% in our patients who underwent TKR but ANH is not recommended as a routine as the rate of transfusion is low (17%). However, it seems to show a lower transfusion rate, not significant probably due to the small sample size.

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