Enhanced recovery protocol and hidden blood loss in patients undergoing total knee arthroplasty

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Abstract

Background: Perioperative blood loss and postoperative pain following total knee arthroplasty prevent early mobilisation of patients. The Enhanced Recovery Protocol (ERP) followed for patients in our institute aims at reducing post operative pain, blood loss and length of stay. **Materials and Methods:** 50 consecutive patients that underwent ERP following total knee arthroplasty with another group of 70 patients that underwent the same surgery without ERP were compared in terms of hidden blood loss and length of hospital stay. Hidden blood loss was calculated according to previously described method. **Results:** Reduction in blood loss was found in both males (305 ml) and females (150 ml) following ERP. Length of stay reduced by 1.5 days in both genders. Regression analysis showed a significant correlation between body weight and blood loss in females. **Conclusion:** Enhanced recovery protocol could be a useful tool to reduce patient morbidity and reduce length of inpatient stay.

Key words: *Enhanced recovery programme, hidden blood loss, total knee arthroplasty*
MeSH terms: *Arthroplasty, replacement, knee, blood loss, surgical*

Introduction

Perioperative blood loss and post operative pain following total knee arthroplasty are the major hindrances preventing early mobilisation of patients. Post operative anaemia following total knee arthroplasty and pain affect rehabilitation and physiotherapy leading to longer inpatient stay which can be expensive for the hospital. Pain is moderate in 30 percent of patients and severe in 60 percent of patients.[1,2] The Enhanced Recovery Protocol (ERP), followed for knee arthroplasty patients, aims at reducing post operative pain without using intravenous morphine or nerve blockade along with minimising perioperative blood loss. Pain is controlled with large volume periarticular infiltration of local anaesthetic combined with adrenaline along with multimodal oral analgesia. The adrenaline has potent vasoconstrictive properties that may have an impact on perioperative blood loss. Very few studies looking into blood loss during surgery take into account the 'hidden blood' lost into the surrounding tissues leading to incorrect estimates. This study compares total blood loss and subsequent length of stay in consecutive patients that underwent the ERP following total knee arthroplasty with another group of patients without the ERP.

Materials and Methods

Seventy consecutive patients from 2009 composed the control group. Control group was defined as the set of patients undergoing total knee arthroplasty prior to the commencement of ERP. There were thirty males [average age, seventy two years; (range 55-88 years)] and forty females [average age, sixty nine years; (range 46-84 years)] in control group. Fifty consecutive patients composed the case group. Case group was defined as the set of patients

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after the commencement of the ERP. There were eight males [average age, seventy one years; (range 60-81 years)] and forty two females [average age, seventy one years; (range 42-90 years)] [Tables 1 and 2]. All the patients had posterior stabilised knee prosthesis (Maxim®, Biomet, Inc. Warsaw, IN, USA) inserted by single surgeon (NMG). All patients had local anaesthetic infiltrated according to the regime[4] described in Table 3. Tourniquet was released before closure, and haemostasis obtained. No drains were used. The length of stay of individual patients, body weight and pre and post operative haematocrit were recorded using digital records and patient files (H_O = pre operative haematocrit and H_F = post operative haematocrit). To correct for any disparity in body weight, blood loss in *every* individual was further divided by their body weight to calculate the blood loss per unit kilogram. This was referred to as the unit blood loss. For the calculation of length of stay, the day of surgery was defined as post operative day 0 (POD 0) and POD 1 as the first day after surgery. As a hospital policy, post operative haematocrit was taken at twenty hours following surgery. Estimated blood volume (EBV) was calculated by multiplying the body weight with seventy millilitres per kilogram of body weight. The hidden blood loss (V_L) was calculated according to equation 1 based on the formula described by Ward *et al*.[3]

Pearson's correlation coefficient was calculated to assess relationship between hidden blood loss and variables including age, gender and body weight. Correlation coefficient was also calculated to assess relationship between the length of stay of the patients and age, gender and body weight. Mann – Whitney U test was performed to compare data and assess statistical significance. Scatter plot was created and univariate linear regression analysis was performed to predict hidden blood loss based on the body weight of an individual. IBM SPSS (version 17), Chicago, USA) and Microsoft Excel 2007 were used to calculate data and *P* value of less than 0.05 was considered significant.

RESULTS

A reduction in blood loss was found in both males (305 mL) and females (150 mL) [Table 3] following the initiation of ERP [Figure 1]. The demographics of patients have been described in Table 2. Males [average body weight 90.8 kg (range 60.8 – 114 kg)] were found to be significantly heavier than females [average body weight 80.5 kg (range 44 – 116.5 kg)] ($P < 0.01$).

A significant relationship was found between total blood loss and gender of the patients ($P = 0.03$) with males showing a tendency to lose more blood than females [Tables 3, 4 and Figure 2]. However, this correlation lost significance when calculated between the variables: Blood loss per unit body weight (ml/kg) and gender. Prior to the initiation of ERP, males lost more blood per unit body weight (14.5 ml/kg) compared to females (13.8 ml/kg). After ERP was commenced, blood loss per unit body weight was less in males (10.4 ml/kg) than females (11.9 ml/kg) [Table 4]. In females, the reduction in blood loss per unit body weight was significant ($P = 0.02$) post ERP initiation. In males, blood loss per unit body weight was reduced post ERP initiation but did not reach significance ($P = 0.059$).
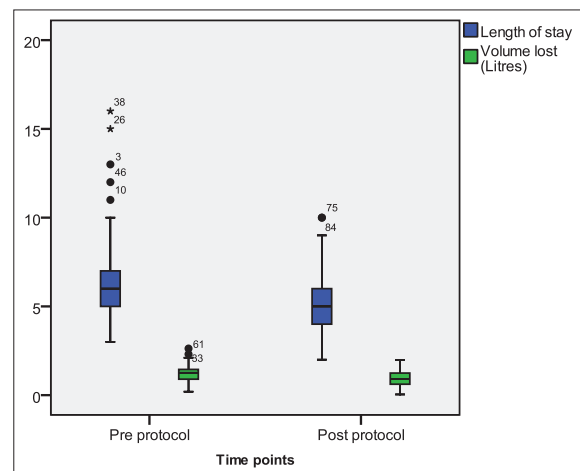
Table 1: Patient demographics

TKR Patients	Males	Females	P
Weight (mean; minimum-maximum)	90.8 (60.8-114.0)	80.5 (44.0-116.5)	<0.01
Age (mean; minimum-maximum)	71.9 (55.4-88.1)	70.2 (42-90)	

Table 2: Total blood loss in patients before and after the introduction of enhanced recovery protocol

TKR Patients	2009	2012	P
Males (mean; minimum-maximum)	1294 (451.4-2626.4)	989.3 (456.7-1489.5)	0.115
Females (mean; minimum-maximum)	1118.6 (181.4-1846.3)	965.4 (103.7-1977.2)	0.041
P	0.184	0.303	

Table 3: Infiltration technique with ropivacaine 0.2% or bupivacaine 0.125%

150 mL local anesthetic + 1 mg adrenaline	Timing	Procedure
First 50 mL	After preparation of femoral and tibial surfaces	From the front into the posterior capsule at 3 mm depth from right to left
Second 50 mL	After prosthesis insertion and before tourniquet release	Deep tissues around the medial and lateral collateral ligaments
Third 50 mL	Before skin closure	In the subcutaneous tissue, injections to the skin edges

Figure 1: The reduction in length of stay (days) and blood loss (l)

In females, correlation between total blood loss and body weight was significant ($r = 0.48$; $P < 0.01$). In males, no significant correlation was found between body weight and loss of blood ($P = 0.191$). Given the results of linear regression analysis, formulae that represented the relationship between blood loss and body weight in males and females were created. In the female group: Hidden blood loss = ($15 \times$ body weight) – 17S. Therefore, in a female patient with a body weight of 60 kilograms (kg), the estimated blood loss would be approximately 725 millilitres (ml). Male patients had a flatter slope with estimated hidden blood loss = ($7.7 \times$ body weight) + 529. This shows that for a unit increase in body weight, a female patient loses more blood than a corresponding male patient with the same body weight [Figure 3]. No significant correlation was found between blood loss and age of the patient ($P = 0.55$) or blood loss and length of in-patient stay ($P = 0.1$).

Length of stay was reduced for both males and females following ERP [Figure 1]. The reduction in length of stay was significant in females ($P = 0.003$) and not in males ($P = 0.18$) [Table 5]. Length of stay was less in males compared to females both pre ($P = 0.05$) and post ($P = 0.26$) ERP initiation. No significant correlation was found between length of stay and body weight.

DISCUSSION

Optimising the level of haemoglobin during and after surgery has been shown to increase the vitality in patients, decrease the number of medical complications and improve quality of life during the post operative period.[4-6] Conlon *et al.* have showed a positive correlation between haemoglobin levels and change in quality of life scores [SF-36 and Functional Assessment of Cancer Therapy (FACT) Anaemia subscale]

from pre operative stage to 2 months post operatively.[6] Peri-operative blood loss has been calculated in the past using various techniques that include weighing of surgical gauzes, measuring post operative drains and fluid levels of suction reservoirs and measuring pre and post operative haemoglobin levels. These methods do not take into account the haemodilution achieved by administration of intra venous fluids. These methods also do not measure postoperative blood loss due to bleeding into periarticular tissues leading to spurious results. Studies using labelled red blood cells have shown unexplained peri operative blood loss attributable to loss into tissue compartments.[7] In order to avoid this error, the method used in the current study to assess total blood loss takes into account the haemodilution factor as well as the dispersion of blood into neighbouring tissues.

It was seen in our study that volume of blood loss was significantly related to body weight and gender of the patient. Total blood loss in males was more than females both pre

Table 4: Blood loss per unit body (mL/kg) weight before and after the introduction of enhanced recovery protocol

TKR Patients	2009	2012	*P*
Males (mean; minimum-maximum)	14.54 (7.4-30.10)	10.36 (4.8-15.7)	0.059
Females (mean; minimum-maximum)	13.81 (1.89-22.79)	11.90 (1.3-22.95)	0.02
P	0.97	0.34	

Table 5: Length of inpatient stay (days) before and after the introduction of enhanced recovery protocol

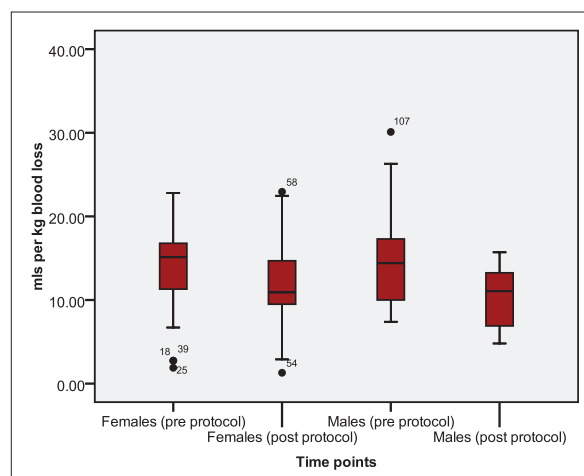| TKR Patients	2009	2012	*P*
Males (mean; minimum-maximum)	5.97 (3-16)	4.5 (4-6)	0.18
Females (mean; minimum-maximum)	6.82 (4-15)	5.39 (2-9)	0.003
P	0.05	0.26	

Figure 2: Reduction in blood loss per kg body weight in both males and females
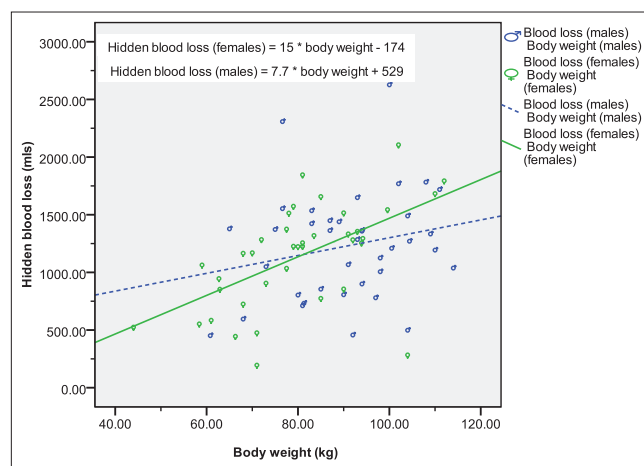

Figure 3: Scattered plot showing regression analysis of blood loss (ml) against body weight (kg)

and post ERP. However, the blood loss per unit body weight was not significantly different between males and females [Table 5]. The difference in total blood loss between males and females could be due to the fact that males were in general heavier (average body weight = 90.8 kg) than female patients (average body weight = 80.5 kg). We feel that knowledge of total blood loss and blood loss per unit body weight is important for the surgical and anaesthetic team as it gives an idea of what to expect from a certain group of patients. Having an idea of blood loss per unit body weight could be useful in assessing the outcomes of any regimes or surgical techniques designed to reduce peri operative blood loss.

The effect of tranexamic acid in reduction of peri operative blood loss has been described extensively in the past. Various studies have shown significant reduction in blood loss.[8-13] Our results were similar to those described in literature. Along with the use of tranexamic acid, local infiltration of anaesthetic and adrenaline also could be attributable to a reduction in intra operative blood loss before and after the release of tourniquet.

There is conflicting evidence with regards to the use of steroids and cyclooxygenase 2 (COX 2) inhibitors reducing the length of hospital stay.[14-18] In our case, the combined use of one dose of steroid along with COX 2 inhibitor, pregabalin and an antiemetic has been effective in reducing the length of stay by a day and half on an average in both males and females. The benefits from early rehabilitation has been noted in knee and hip arthroplasty patients resulting in shorter length of stay and quicker achievement of short term functional goals.[19] A reduced length of stay has also been found in patients with hip fractures that were treated with accelerated rehabilitation regime.[20] Along with reduced length of stay, the authors also reported a cost saving of up to 38% per patient. The reduction in length of stay is comparable to previously described results.[16,21,22] With the ever increasing demand for joint replacement surgery, enhanced recovery protocol could be a useful tool to reduce patient morbidity and reduce length of inpatient stay.

Conflicts of interest
There are no conflicts of interest.

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