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Clinical Study

Hidden blood loss following 2- to 3-level posterior lumbar fusion

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Abstract

BACKGROUND CONTEXT: Patients undergoing single-level posterior lumbar decompression and fusion (PLDF) usually do not need transfusions. However, patients undergoing two or three-level PLDF occasionally require transfusion postoperatively even when estimated blood loss (EBL) or blood loss from drains appears acceptable. Estimating the volume of HBL is critical in perioperative fluid management.

PURPOSE: To determine the volume of hidden blood loss (HBL) in two- or three-level PLDF.

STUDY DESIGN: Single-center, multisurgeon, secondary analysis from a prospective randomized clinical trial of cell saver use.

PATIENT SAMPLE: Patients enrolled in a prospective randomized trial of cell saver undergoing two- or three-level PLDF were included in this analysis.

METHODS: Total blood loss was calculated using four estimation formulas including Bourke's, Gross', Camarasa's, and Lopez-Picado's formulas. HBL was determined by subtracting the visible loss (EBL and blood loss from drains) from the calculated total blood loss.

RESULTS: A total of 89 patients (36 males, mean age 62 years) were included. Seventy-five patients underwent open two-level fusion while 14 had three-level fusions. Intervertebral fusion was performed in 20 patients. Mean surgical time was 261 minutes, and EBL was 685 mL. Mean blood loss from drains was 824 mL. Seventy patients received allogenic blood whereas 47 cell saver blood reinfused intraoperatively. HBL was calculated to be 678 mL, 963 mL, 1,267 mL, and 819 mL using each formula.

CONCLUSIONS: HBL following two or three-level PLDF was substantial and more than EBL. Postoperative management of blood loss should take HBL into account.

Keywords: Complication; Hidden blood loss; Posterior lumbar decompression and fusion; Postoperative management; Total blood loss; Transfusion

FDA device/drug status: Not applicable.

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Introduction

Posterior lumbar decompression and fusion (PLDF) is a common procedure for lumbar degenerative diseases. Patients undergoing single-level PLDF usually do not need transfusion. However, patients undergoing multilevel PLDF occasionally require transfusion despite what appears to be a limited intraoperative blood loss. This may be due to undetectable blood loss, called hidden blood loss (HBL). HBL was first described in 2000 by Sehat et al. who found that HBL accounted for 26% and 49% of the total blood loss (TBL) after total knee and hip replacement, respectively [1]. Subsequently, a number of studies about HBL following orthopedic procedures have been done [2−4]. There have been several reports on HBL in spine surgery including anterior cervical fusion [5], percutaneous kyphoplasty [6], thoracolumbar fracture [7], and single-level open or minimally invasive (MIS) transforaminal interbody fusion (TLIF) [8,9]. There are a few published studies about PLDF [10−13]. However, these studies included a heterogenous sample with multilevel procedures. The need for transfusions or cell saver use in two- or three-level PLDF remains unsettled and needs further study. The purpose of our study was to determine the volume of HBL in two- and three-level PLDF and identify the factors associated with greater HBL.

Methods

Subjects

Data from patients enrolled in the prospective randomized controlled trial to investigate the cost effectiveness of cell saver [14] were used. Patients were eligible if they were over 18 years of age, they underwent a two- or three-level PLDF between L1−S1 for a symptomatic lumbar degenerative disease, and they had both pre- and postoperative complete blood count results.

Transfusion

Intraoperative transfusion was at the anesthesiologists' discretion based on the intraoperative bleeding, patient's vital signs and preoperative hemoglobin level. Patients with hemoglobin of less than 8.0 g/dL or who were symptomatic received a transfusion postoperatively.

Visible blood loss

The visible blood loss was calculated by adding intraoperative estimated blood loss (EBL) to the volume of blood obtained from drains postoperatively. EBL was determined from the blood in suction bottles and the weight of the saturated gauzes.

Calculation of blood loss

There are a number of formulas to determine the TBL using pre- and postoperative hematocrit (Ht). None of these have become accepted as the gold standard. This means that the choice of formula may affect the results. Therefore, we chose to compare the four frequently used formulas to estimate the TBL [15−18] for the current study. In addition, all the formulas require an estimation of the total blood volume (TBV), and different methods are used to calculate the TBV in each formula. In brief, the formulas are as follows. We used the latest Ht value before discharge as the postoperative Ht for calculation.

(1) Bourke's formula [15]: TBL (mL)=TBV (mL)×(preop Ht−postop Ht)×(3−mean Ht)

(2) Gross' formula [16]: TBL (mL)=TBV (mL)×(preop Ht−postop Ht)/mean Ht

(3) Camarasa's formula [17]: TBL (mL)=TBV (mL)×(preop Ht−postop Ht+transfused red cell volume)/mean Ht

(4) Lopez-Picado's formula [18]: Same as the Camarasa's formula, but uses different method in estimating TBV.

After calculating TBL, HBL was determined as follows:

(1) Bourke's and Gross' formulas: HBL=TBL−visible blood loss+blood transfusion

Camarasa's and Lopez-Picado's formulas take transfusion into account; therefore, following formula was used.

(2) Camarasa's and Lopez-Picado's formulas: HBL=TBL−visible blood loss

Statistical analysis

Analysis of variance was used to assess the difference of HBL calculated with four formulas. The Spearman's rank correlation coefficient was used to discover the strength of a correlation between HBL and other variables. A p value of <.05 was considered statistically significant. All statistical analyses were performed using SPSS Statistics 25 (IBM Corp., Armonk, NY). A statistical significance was defined as p value <.05.

Results

Patient demographics were shown in Table 1. In total, 89 patients (36 males, mean age 62.6 years) were included. Seventy-five patients underwent two-level fusion, whereas 14 had a three-level fusion. TLIF was performed in 20 patients. Mean surgical time was 262 minutes.

The pre- and postoperative hematological and blood management data are shown in Table 2. As expected, the

Table 1
Demographic characteristics of patients

Variables	Mean (SD)
No. of patients	89
No. of males	36
Age (y)	62.6 (10.9)
BMI	32.6 (7.5)
No. of level fused	
2	75
3	14
No. of TLIF levels	
1	13
2	7
Surgical time (min)	261.5 (71.8)

BMI, body mass index, TLIF, transforaminal lumbar interbody fusion.

Table 2
Summary of hematological and blood management data

Variables	Mean (SD)
Preop hematocrit (%)	40.9 (3.5)
Preop hemoglobin (g/dL)	13.8 (1.3)
Postop hematocrit (%)	29.3 (3.9)
Postop hemoglobin (g/dL)	9.7 (1.4)
Allogenic blood transfusion	
No. of patients	41
Transfused volume (mL)	272.0 (357.2)
Cell saver blood reinfusion	
No. of patients	37
Reinfused volume (mL)	111.1 (164.2)
Visible blood loss (mL)	
EBL	685.0 (405.6)
Blood loss from drains	823.7 (484.5)

EBL, estimated blood loss.

mean postoperative hematocrit (29.3%) was lower compared to the preoperative hematocrit (40.9%); and the mean postoperative hemoglobin (9.7 g/dL) was lower than the preoperative hemoglobin (13.8 g/dL). Forty-one patients underwent allogenic transfusion with the mean volume of 272.0 mL. Thirty-one patients had intraoperative transfusion and seven among them had postoperative transfusion as well. Ten patients had only postoperative transfusion. Thirty-seven patients had cell saver blood reinfused with the mean volume of 111.1 mL. Mean visible blood loss amounted to 1,509 mL, with an EBL of 685 mL and blood loss from drains of 823.7 mL (Table 2). HBL was estimated 678, 963, 1,267, and 819 mL, respectively (Table 3). HBL calculated with Camarasa's formula was significantly higher than those calculated with other formulas.

Correlation coefficients of factors associated with HBL including demographics, EBL, blood loss from drains, height, weight, BMI, age, sex, operative time, and number of fusion levels are summarized in Table 4. All of the formulas for calculating HBL had strong correlations with the other formulas. Although some of the demographic and surgical variables had statistically significant correlations with HBL, none were strongly associated with HBL.

Table 3
Estimated hidden blood loss using four formulas

Formula used	HBL (mL)
Bourke	677.9 (829.1)
Gross	962.9 (890.1)
Camarasa	1,266.8 (1,119.1)
Lopez-Picado	818.6 (969.1)

Mean (SD).

Discussion

Since Sehat et al. report that HBL following total hip replacement was 49% of the total blood loss, surgeons became aware that HBL plays an important role in orthopedic procedures [1]. However, HBL is still not well known or used in the setting of spine surgery. As a result, even if the patients' EBL or postoperative drainage seems acceptable, patients may develop anemia postoperatively, causing hypoperfusion or dysfunction of coagulation [19].

There have been several reports on HBL following PLDF [8−11]. Using different formulas available, HBL was reported to be 246 to 536 mL in one-level, 389 to 686 mL in two-level, and 322 to 1,039 mL in three or more-level PLDF. We assessed HBL following two- or three-level PLDF, and mean HBL was 678 to 1,267 mL. Overall, our findings were consistent with the previous reports. HBL was more than the mean EBL of 685 mL in our study. It is also noteworthy that postoperative drainage was substantial and exceeded EBL. Considering a considerable amount of HBL and postoperative drainage, appropriately accounting for HBL is critical in the postoperative fluid management in multilevel PLDF.

Perioperative strategies to minimize allogenic transfusion should be considered. There are several strategies including hypotensive anesthesia, autologous blood

Table 4
Spearman rank correlation between hidden blood loss and patients' demographics

	HBL (Bourke)	HBL (Gross)	HBL (Camarasa)	HBL (Lopez)
HBL (Bourke)	1			
HBL (Gross)	**0.905**	**1**		
HBL (Camarasa)	**0.82**	**0.947**	1	
HBL (Lopez)	**0.83**	**0.875**	**0.939**	1
EBL	0.136	**0.263**	**0.351**	**0.243**
Surgical time	**0.262**	**0.271**	**0.337**	**0.253**
Drains	**−0.427**	**−0.27**	−0.159	**−0.299**
Height	0.15	0.158	0.162	0.158
Weight	**0.257**	**0.396**	**0.41**	0.187
BMI	0.14	**0.298**	**0.318**	0.064
Age	−0.116	−0.108	−0.057	−0.008
Female	**−0.241**	**−0.234**	−0.201	−0.201
Preoperative Ht	**0.403**	**0.253**	0.134	0.09
Fused level	0.058	0.133	0.199	0.138

HBL, hidden blood loss, EBL, estimated blood loss, BMI, body mass index.

Bold letters indicate p<.05.

transfusion, erythropoietic agents, and tranexamic acid (TXA) use. Recently, TXA has been reported to decrease HBL as well as visible blood loss. Ren et al. examined the efficacy of topical use of TXA during PLDF and showed that topical TXA significantly decreased HBL [12]. Wang et al. evaluated the efficacy of intravenous administration of TXA during the surgery for thoracolumbar fracture and concluded that TXA significantly reduced visible blood loss and HBL [7]. Subsequently, Mu et al. compared the efficacy of topical and intravenous TXA use during PLDF and showed that intravenous administration reduced HBL more effectively.

The source of HBL remains unclear. HBL can be explained by blood hemolysis, extravasation of blood into the tissues, residual blood in a dead space, or simply inaccurate determination of EBL [20]. We found that weight and BMI were weakly associated with HBL. Patients with higher BMIs may have more space for blood extravasation. The positive correlation between HBL and surgical time may support the extravasation hypothesis. Yang et al. compared HBL between MIS and open TLIF, in which MIS TLIF had significantly less HBL [8]. This finding may be due to the fact that there is presumably less dead space in MIS compared to open approaches contributing to less HBL. Poorly functioning drains may also lead to underestimation of actual blood loss. In this study, blood loss from drains had a negative correlation with HBL. Another possible source of HBL is inaccurate EBL or drain output measurement. Thus, strategies to improve measurement accuracy would be needed to decrease the amount of HBL. Interestingly, the four formulas used to calculate HBL had only slight differences, but showed that the HBL following two- or three-level PLDF was substantial. Thus, it is important to take HBL into account in perioperative fluid management.

In conclusion, HBL is substantial in patients undergoing two- to three-level PLDF ranging from 678 to 1,267 mL. In addition, blood loss through the postoperative drains was substantial as well and often exceeded EBL. As part of appropriate perioperative fluid management, physicians should be cognizant of HBL and pay attention to ongoing blood loss through postoperative drains.

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