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Research Article

The effects of patient related factors on hidden and total blood loss in single-level open transforaminal lumbar interbody fusion surgery

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ABSTRACT

Objective: The aim of this retrospective study was to identify the amount of TBL and HBL and analyse the risk factors using multivariate linear regression analysis during single-level OTLIF surgery.

Methods: In this study 62 patients (32 male, 30 female, mean age 49.22 ± 13.26) who underwent single-level interbody fusion procedures by a single surgeon between 2015 and 2021 were included. Retrospectively, relevant statistics regarding body mass index (BMI), American Society of Anesthesiologist Score (ASA), preoperative mean arterial pressure (MAP), and age were gathered. Preoperative MR images were used to assess and measure radiological parameters such as skin-disc distance (SDA), canal area (CA), paravertebral muscle area (PVMA),lumbosacral maximum subcutaneous fat thickness (LSMSF), operation level subcutaneous fat thickness (OPSF) and spinous process length (SPL).Total blood loss (TBL) was calculated according to Nadler's formula. Hidden blood loss (HBL) was measured by deducting the measured (visible) blood loss from TBL. TBL, HBL and their relationship with preoperative parameters were assessed.

Results: HBL was determined to be significantly higher in older patients ($P = 0.012$). MAP was seen to have a statistically significant correlation with operating time ($P = 0.002$), operative bleeding ($P = 0.002$), TBL ($P = 0.006$), and HBL ($P = 0.001$), and an inverse correlation with postoperative drainage ($P = 0.007$). The ASA scores were observed to be statistically significantly correlated with TBL ($P = 0.001$), and HBL ($P = 0.001$). LSMSF showed a significant correlation with TBL ($P = 0.005$) and HBL ($P = 0.002$). OPSF was determined to be correlated with TBL ($P = 0.011$), HBL ($P = 0.009$) and length of stay in hospital ($P = 0.034$). SDD was correlated with TBL ($P = 0.043$), and SPL with HBL ($P = 0.013$). It was shown that age ($P = 0.012$), MAP ($P = 0.001$), ASA ($P = 0.001$), LSMFS ($P = 0.002$), OPSF ($P = 0.009$), SPL ($P = 0.013$) were risk factors for HBL. According to multivariate logistic regression analysis; two anatomical factors LSMSF and SPL were independent risk factors for HBL ($P < 0.05$).

Conclusion: This results of this study have revealed that most patient-related parameters have a significant effect on HBL and TBL.The study has also demonstrated that LSMSF and SPL are independent risk factors for HBL.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Interbody fusion surgery aims to provide a biomechanically stable intervertebral fixation in the treatment of symptomatic spinal instability, spinal stenosis, spondylolisthesis, and degenerative disc disease.[1,2] In 1982, Harms and Rolinger[3] developed the transforaminal lumbar interbody fusion (TLIF) technique as an alternative to posterior lumbar interbody fusion (PLIF) for preserving the neural structures.

Adequate exposure of the anatomical landmarks is vital to prevent complications associated with posterior lumbar surgery. Increased body mass index (BMI) may limit the surgical exposure, increase intra-abdominal pressure in the prone position, surgical difficulties, and peri- and postoperative complications for posterior lumbar surgery.[4]

Multiple studies have shown that obesity increases the risk of perioperative complications caused by factors such as prolonged operating time, blood loss, and wound infections and may lead to poorer long-term survival.[3,5-10]

As BMI is based on height and weight, it fails to account for the variability of fat tissue distribution and non-specifically quantifies weight as a measurement of both muscle and adipose mass despite their different physiological implications.[2] Several studies have elucidated the relationship between postoperative infections and the amount of subcutaneous adipose tissue at the site of spine surgery.

The total blood loss (TBL) can be calculated by formulas using pre and postoperative hematocrit (Hct) or hemoglobin (Hgb) levels.[11,12] If the calculated TBL is greater than the visible (intraoperative blood loss+postoperative drainage) blood loss, this gap is known as hidden blood loss (HBL) and in 2000, Sehat et al[13] first described the concept of HBL for patients undergoing total knee arthroplasty. Although HBL

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plays a key role in the perioperative rehabilitation of patients undergoing spine surgery, few studies have focused on the risk factors of HBL after posterior lumbar interbody fusion surgery.[11,12]

There is no previous study evaluating the relationship between the thickness of subcutaneous fat, the distance between skin and the disc, the amount of disc area resected during surgery, paravertebral muscle mass, canal area, and the amount of TBL or HBL in single-level open TLIF (OTLIF) surgery. The aim of this retrospective study was to identify the amount of TBL and HBL and analyze the risk factors using multivariate linear regression analysis during single-level OTLIF surgery.

Materials and Methods

Informed consent was obtained from each patient. After ethics committee approval (2/2021.K-01), 123 patients underwent L3-4, L4-5, and L5-S1 single-level OTLIF surgery in our spine center hospital between 2015 and 2021. Of these, 61 were excluded from the study due to insufficient data, pre- or postoperative infections, fractures, neoplastic conditions, revision surgery, same level previous microdiscectomy, intraoperative dural puncture, intraoperative hemostatic agent usage (hemostatic matrix or tranexamic acid (TXA)), blood test abnormality (platelet, prothrombin time, activated partial thromboplastin time, international normalized ratio (INR)), blood-related diseases such as coagulopathies or severe anemia, or the use of antiplatelet or anticoagulant drugs within 1 week preoperatively. Thus, the study included 62 patients who underwent single-level (L3-4, L4-5, or L5-S1) OTLIF surgery for spondylolysis, spondylolisthesis, spinal stenosis, or degenerative disc disease.

The data for the included patients were retrospectively retrieved from the medical records. Demographic characteristics such as sex, age, weight, height, BMI, preoperative (before the anesthesia induction) mean arterial pressure (MAP), surgical duration, bleeding, the American Society of Anesthesiologists (ASA) classification, postoperative blood drainage, duration of postoperative drains, and stay in hospital were recorded. Preoperative Hgb, Hc, platelet, PT, APTT, and INR values were also recorded. The Hgb and Hct levels were checked on the postoperative first and third days. No transfusion was done prior to the blood extraction on day 3.

Radiological evaluation

All images were obtained from the hospital picture archiving and communication system (PACS). Preoperative T2 sagittal magnetic resonance imaging (MRI) was used to evaluate the distance from the intervertebral disc to the skin surface (skin-disc distance (SDD)), thickness of the subcutaneous fat at the fusion level (OPSF), maximum fat thickness at the lumbosacral area (LSMSF), and spinous process length (SPL) at the fusion level. Preoperative T2 axial MRI was used to calculate the area of the unilateral paraspinal muscles (PVMA), disc area (DA), and spinal canal area (CA) at the fusion level (Figure 1).

Surgical technique

All surgeries were performed by 1 experienced spinal surgeon (CO). For infection prophylaxis, 1 g of cefazolin was administered intravenously 30 minutes before the induction of anesthesia. After the induction of general anesthesia (avoiding hypotensive anesthesia), patients were placed in the prone position on the operating table. The fusion level was confirmed by C-arm fluoroscopy before draping. After a midline posterior incision and adequate dissection with bony exposure, pedicle screws were placed according to the conventional surgical method under C-arm fluoroscopic control. After that, laminectomy, facetectomy and resection of the ligamentum flavum was done. Dura mater and the traversing nerve root were exposed and gently retracted and carefully protected. The annulus was cut, and the nucleus and endplate cartilage were resected. The titanium cage was placed with autologous bone grafting. As the adequate positioning of the pedicle screws and cage was fluoroscopically confirmed, 2 curved rods were implanted. Two negative-pressure drainage tubes were placed under the paravertebral musculature, and bleeding control was provided before the closure. No hemostatic agents were used in the patients (hemostatic matrix or TXA, etc.). Infection prophylaxis was continued until 24 hours after the surgery. Drainage tubes were removed when the patient's drainage volume was less than 50 mL in 24 hours.

Intraoperative blood loss was identified by weighing the sponges used during each procedure, measuring blood volumes in suction tubes, and subtracting the volume of lavage fluid used during the operation. Postoperative blood loss was calculated by measuring the amount of blood in drainage bottles before they were removed.

All patients wore compression stockings on both legs, no patient received chemoprophylaxis against deep venous thrombosis after surgery, and hypotensive anesthesia was not used in this study. No transfusion was done prior to the blood extraction on day 3.

Calculation of TBL, VBL, HBL

We also used the following method to calculate TBL and HBL, like many studies.[11,14-17] We calculated the HBL by deducting the measured (visible) blood loss from the calculated TBL. To calculate the TBL, we estimated preoperative blood volume (PBV) in milliliters. It was estimated according to the formula of Nadler.[18] The patient's gender, weight, and height were taken into account. The PBV formula used was as follows:

$$PBV = k1 \times \text{height (m)}^3 + k2 \times \text{weight (kg)} + k3$$

(for male: k1 = 0.3669, k2 = 0.03219, and k3 = 0.6041; for female: k1 = 0.3561, k2 = 0.03308, and k3 = 0.1833).

The TBL in the perioperative period was reflected by the reduction of Hct. It was calculated according to the method of Gross,[19] using preoperative Hct, postoperative Hct, and PBV. The TBL formula used was as follows:

$$TBL = PBV\ (Hct_{pre} - Hct_{post})/Hct_{ave}$$

HIGHLIGHTS

- The relationship between the thickness of subcutaneous fat, the distance between skin and the disc, the amount of disc area resected during surgery, paravertebral muscle mass, canal area, and the amount of blood loss in single level open TLIF (OTLIF) surgery is not described in the existing literature. The aim of this study was to identify the amount of total and hidden blood loss and analyze the risk factors using multivariate linear regression analysis.
- Lumbosacral maximum subcutaneous fat tissue thickness and spinous process length were independent risk factors for hidden blood loss. Preoperative mean arterial pressure was a risk factor for intraoperative bleeding, operation time, total and hidden blood loss. Paravertebral muscles area was inversely correlated with operation time, operative bleeding, and hospitalization duration.
- In conclusion, a large amount of blood loss can exacerbate postoperative anemia and may lead to higher risk of complications including wound disruption, infection, cognitive impairment, and other complications. The risk factors found in this study should be kept in mind and preoperative planning should include consideration of these risk factors.

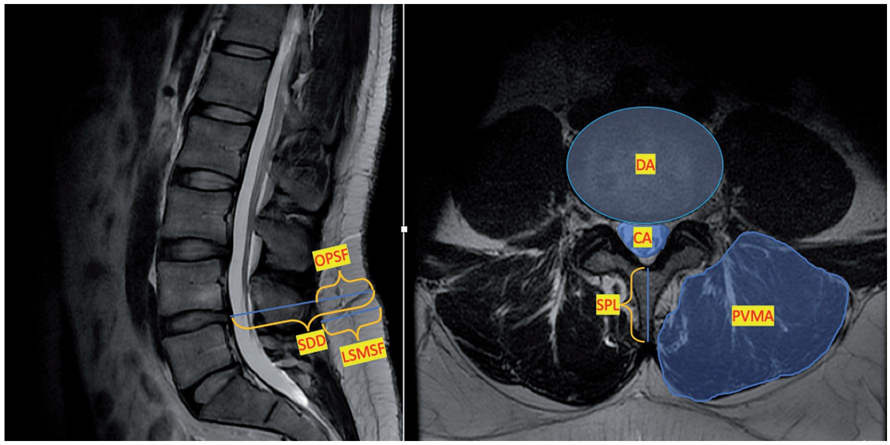

Figure 1. Preoperative T2 MRI sagittal and axial view. MRI, magnetic resonance imaging.

Hctpre is the preoperative Hct, Hctpost is the third day postoperative Hct, and Hctave is the average of Hctpre and the Hctpost.

Consequently, we calculated the HBL according to the formula of Sehat et al.[13]

HBL = TBL − visible blood loss (VBL).

(Visible blood loss is intraoperative blood loss + postoperative drainage)

Statistical analysis

Data analysis was performed using the International Business Machines Statistical Package for the Social Sciences software 21.0 software (IBM Corp., Armonk, NY). Descriptive data were expressed in mean and standard deviation (SD) or amount of frequency. Mann–Whitney *U* test was used to compare gender and etiopathogenesis with operative results and radiological measurements. Kruskal–Wallis test was used to evaluate effects of fusion levels. Pearson's correlation analysis, univariate and multivariate linear regression analysis was established to identify risk factors (such as age, BMI, MAP, ASA classification) for operative time, operative bleeding, TBL, VBL, HBL, drainage, durations of drainage, and stay in hospital. $P < .05$ was considered statistically significant.

Results

Sixty-two patients comprising 32 males and 30 females with a mean age of 49.22 ± 13.26 years (range: 25-82) and mean BMI of 20.3-34.7 kg/m² (26.3 ± 3.12) were evaluated. According to the etiopathogenesis, 16 patients had spondylolisthesis or spondylolysis and 46 patients had spinal stenosis or degenerative disc disease. All patients underwent 2 levels of posterior instrumentation and single-level interbody fusion procedures. The fusion levels were L3-4 in 4, L4-5 in 40, and L5-S1 in 18 patients. Other demographic characteristics are shown in Table 1.

There was no statistical significance according to gender in respect to operation time ($P = 0.49$), operative bleeding ($P = 0.95$), TBL ($P = 0.26$), VBL ($P = 0.19$), HBL ($P = 0.86$), the volume of postoperative drainage ($P = 0.08$), duration of drainage ($P = 0.98$), and duration of stay in hospital ($P = 0.68$). When anatomical measurement parameters were evaluated, DA and PVMA were significantly larger in males. Disc area was 2124.81 ± 198.21 vs. 1721.77 ± 3 20.92 (P = 0.003) and PVMA was 2101.93 ± 430.27 vs. 1932 ± 448.64 ($P = 0.022$) in men and women, respectively.

Operative duration was 210 ± 34.64 minutes for surgery to L 3-4, 165.5 ± 30.9 minutess for L4-5, and 160 ± 20.57 minutes for L5-S1 ($P = 0.043$). Operative bleeding was comparable for all patients ($P = 0.400$). Total blood loss, VBL, postoperative drainage, and duration of hospitalization was significantly higher in L4-5 patients ($P = 0.002$, $P = 0.015$, $P = 0.022$, $P = 0.021$, respectively).

In both types of etiopathogenesis, the results were similar for operation time, TBL, VBL, HBL, volume of postoperative drainage, duration of drainage, and length of stay in hospital ($P = 0.63$, $P = 0.47$, $P = 0.72$, $P = 0.48$, $P = 0.82$, $P = 0.27$, $P = 0.28$, respectively). The amount of operative bleeding was higher in the spondylolisthesis and spondylolysis group than in the spinal stenosis and degenerative

Table 1. Patient demographics

Parameters	Numbers
Total patients	62
Sex	
Male	32
Female	30
Age (years)	49.22 ± 13.26
BMI (kg/m²)	26.3 ± 3.12
MAP (mm/hg)	91.1 ± 11.9
PLT	251.45 ± 62.8
Pt (sec)	12.7 ± 1.7
Aptt (sec)	29.1 ± 2.7
INR	0.95 ± 0.06
Operation time (min)	166.77 ± 30.44
Operative bleeding (mL)	146.45 ± 86.1
TBL (mL)	1085.7 ± 314.28
VBL (mL)	581.45 ± 187.25
HBL (mL)	504.25 ± 350.6
Postoperative drainage (mL)	435 ± 142.68
Duration of drainage (days)	2.5 ± 0.7
Duration of hospitalization (days)	5.3 ± 1.13
LSMSF (mm)	29.9 ± 13.4
OPSF (mm)	25.3 ± 14.4
SDD (mm)	78.5 ± 13.9
SPL (mm)	27.45 ± 4.4
DA (mm²)	1929.9 ± 335.15
PVMA (mm²)	2015.35 ± 448.56
CA (mm²)	108.79 ± 54.89

BMI, body mass index; ASA, the American Society of Anesthesiologist Score; MAP, mean arterial pressure; VBL, visible blood loss; HBL, hidden blood loss; TBL, total blood loss; Hct, hematocrit; Hb, hemoglobin; PT, prothrombin time; APTT, activated partial thromboplastin time; PLT, platelet; LSMSF, lumbosacral maximum subcutaneous fat thickness; OPSF, operation level subcutaneous fat thickness; SDD, skin-disc distance; SPL, spinous process length; DA, disc area; PVMA, paravertebral muscles area; CA, operation level spinal canal area.

disc disease group (160 ± 90.7 vs. 107.5 ± 53.35, $P=0.026$). A positive correlation was determined between BMI and LSMSF ($P=0.047$) and OPSF ($P=0.014$).

Pearson's correlation analysis was performed to evaluate predicted preoperative risk factors (age, BMI, ASA, MAP, and anatomical variables) and operative bleeding, surgical time, TBL, VBL, HBL, postoperative drainage, duration of drainage, and duration of hospital stay. Hidden blood loss was determined to be significantly higher in older patients ($P=0.012$). Mean arterial pressure was seen to have a statistically significant correlation with operating time ($P=0.002$), operative bleeding ($P=0.002$), TBL ($P=0.006$), and HBL ($P=0.001$), and an inverse correlation with postoperative drainage ($P=0.007$). The ASA scores were observed to be statistically significantly correlated with TBL ($P=0.001$) and HBL ($P=0.001$).

Lumbosacral maximum subcutaneous fat thickness showed a significant correlation with TBL ($P=0.005$) and HBL ($P=0.002$). Operation level subcutaneous fat thickness was determined to be correlated with TBL ($P=0.011$), HBL ($P=0.009$), and the length of stay in hospital ($P=0.034$). Skin-disc distance was correlated with TBL ($P=0.043$) and SPL with HBL ($P=0.013$). An inverse correlation was determined between PVMA and operative time ($P = 0.031$), operative bleeding ($P=0.005$), and the length of stay in hospital ($P=0.004$) (Table 2).

The univariate logistics analysis showed that statistically significant risk factors were age ($P=0.012$), MAP ($P=0.001$), ASA ($P=0.001$), LSMFS ($P=0.002$), OPSF ($P=0.009$), SPL ($P=0.013$) for HBL. Body mass index had a significant effect on TBL ($P=0.043$). Mean arterial pressure was also a risk factor for operation time, operative bleeding, TBL, and HBL ($P=0.002$, $P=0.002$, $P=0.006$, $P=0.001$, respectively). The American Society of Anesthesiologists score was seen to be a risk factor for TBL and HBL ($P=0.02$ and $P=0.001$, respectively). According to the anatomical measurements, LSMSF, OPSF, and SDD affected TBL ($P=0.005$, $P=0.011$, and $P=0.043$, respectively). Operation level subcutaneous fat thickness was also a risk factor for a long stay in hospital ($P=0.034$). Paravertebral muscles area was significantly associated with a shorter operative time, less operative bleeding, and shorter length of stay in hospital ($P=0.031$, $P=0.005$, and $P=0.004$, respectively).

Multivariate Logistic Regression Analysis

Statistically significant variables selected from the univariate logistics analysis were imported into the multivariate logistic regression for HBL. The 2 anatomical factors namely LSMSF and SPL were independent risk factors for HBL (Table 3) ($P < 0.05$).

Discussion

Lumbar interbody fusion is a well-established surgical procedure used to treat several spinal disorders, including degenerative disease, trauma, infection, and neoplastic conditions.[20]

The TLIF technique was first described as a modification of posterior LIF by Harms and Rollinger in 1982.[3] This technique provides the opportunity for stable fusion of the vertebrae and less retraction of neural structures but is not valid for paravertebral muscles and fatty tissues. Excessive dissection and retraction of the musculature is one of the main disadvantages of this technique.[21]

High perioperative blood loss in OTLIF surgery deepens postoperative anemia and thereby increases the risks related to allogenic blood

Table 2. Results of Pearson correlation analysis

		Age	BMI	MAP	ASA	PLT	LSMSF	OPSF	SDD	SPL	D A	PVMA	C A
Operative time	Pearson's correlation	0.238	0.081	0.394 (**)	0.189	0.076	0.030	0.102	0.022	0.027	−0.028	−0.274 (*)	−0.169
	Sig. (2-tailed)	0.062	0.531	0.002	0.141	0.558	0.818	0.430	0.866	0.835	0.831	0.031	0.189
Operative bleeding	Pearson's correlation	0.013	0.241	0.378 (**)	0.141	0.047	−0.013	−0.036	0.052	−0.212	0.039	−0.356 (**)	−0.032
	Sig. (2-tailed)	0.917	0.059	0.002	0.274	0.715	0.920	0.779	0.686	0.098	0.762	0.005	0.803
TBL	Pearson's correlation	0.242	0.258 (*)	0.346 (**)	0.435 (**)	−0.005	0.351 (**)	0.319 (*)	0.258 (*)	0.206	0.110	−0.016	−0.248
	Sig. (2-tailed)	0.059	0.043	0.006	0.001	0.968	0.005	0.011	0.043	0.109	0.394	0.904	0.052
Visible blood loss	Pearson's correlation	−0.189	0.203	−0.187	−0.023	−0.188	−0.147	−0.076	0.071	−0.243	0.103	−0.181	−0.049
	Sig. (2-tailed)	0.141	0.114	0.145	0.859	0.144	0.254	0.555	0.582	0.057	0.427	0.160	0.707
HBL	Pearson's correlation	0.317 (*)	0.123	0.410 (**)	0.402 (**)	0.096	0.393 (**)	0.327 (**)	0.193	0.314 (*)	0.044	0.083	−0.196
	Sig. (2-tailed)	0.012	0.340	0.001	0.001	0.460	0.002	0.009	0.133	0.013	0.735	0.523	0.126
Drainage	Pearson's correlation	−0.156	0.120	−0.474 (**)	−0.115	−0.175	−0.185	−0.078	0.062	−0.191	0.111	−0.022	−0.044
	Sig. (2-tailed)	0.165	0.351	0.007	0.371	0.155	0.150	0.545	0.632	0.137	0.390	0.863	0.732
Duration of drainage	Pearson's correlation	−0.143	−0.040	−0.194	−0.132	−0.204	−0.100	−0.071	−0.008	−0.220	0.087	−0.240	0.048
	Sig. (2-tailed)	0.269	0.756	0.131	0.308	0.112	0.438	0.584	0.950	0.116	0.502	0.060	0.709
Hospitalization	Pearson's correlation	0.061	0.214	0.193	0.200	0.145	0.184	0.270 (*)	0.186	−0.190	0.083	−0.357 (**)	−0.205
	Sig. (2-tailed)	0.639	0.095	0.132	0.118	0.261	0.153	0.034	0.147	0.138	0.522	0.004	0.110

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).
BMI, body mass index; ASA, the American Society of Anesthesiologist Score; MAP, mean arterial pressure; LSMSF, lumbosacral maximum subcutaneous fat thickness; OPSF, operation level subcutaneous fat thickness; SDD, skin-disc distance; SPL, spinous process length; DA, disc area; PVMA, paravertebral muscles area; CA, operation level spinal canal area.

Table 3. Results of multivariate regression analysis

	Coefficients[a]				
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	SD	Beta	*t*	Sig.
1					
Age	0.720	3.352	0.027	0.215	0.831
MAP	6.419	3.947	0.218	1.626	0.110
ASA	134.000	80.443	0.236	1.666	0.101
LSMSF	21.415	8.777	0.819	2.440	0.018
OPSF	−17.168	8.639	0.688	1.987	0.052
SPL	21.559	10.173	0.271	2.119	0.039

MAP, mean arterial pressure; ASA, the American Society of Anesthesiologists classification; OPSF, thickness of the subcutaneous fat at the fusion level; LSMSF, lumbosacral maximum subcutaneous fat thickness; SPL, spinous process length.
Multivariate logistic regression analysis. $P < .05$.

transfusions. This may also cause a higher rate of infection, delayed healing, a higher risk of postoperative delirium, and negatively affect the rehabilitation period, increasing the psychological and economic burden on patients.[20,22]

Many studies have examined perioperative strategies to minimize allogenic blood transfusion and the possible side effects. Methods such as hypotensive anesthesia, autologous blood transfusion, and the use of erythropoietic agents and TXA are valid options for this purpose.[23]

Although clinical blood loss is accepted as the total intraoperative blood loss and the amount of postoperative drainage, the Hgb and Hct values of patients are usually seen to be decreased more than by this total. This gap known as HBL was first described by Sehat et al[11] in reference to a population undergoing total knee prothesis in 2000. Despite suggested theories regarding its cause, including hemolysis, extravasation of blood, blood in dead spaces, and free fatty acids membranous peroxidation injury, the definitive reason behind HBL is still unknown.[24]

Earlier studies have shown that HBL is 39.2%-52.5% of TBL in various spinal surgeries.[12,13,24-27] It was decided to conduct this study on single-level OTLIF procedures to analyze a more homogenous group and the results showed HBL to be 46.4% of TBL in single-level OTLIF surgery. This finding was consistent with the literature.

Recent studies have explored new strategies to decrease the perioperative blood loss related to HBL levels. Ren et al[28] showed that performing topical TXA decreases TBL and HBL in a series of 100 posterior lumbar fusion surgeries. In a cohort of 181 patients, Wang et al[29] reported that the use of IV TXA during thoracolumbar fracture surgery decreased HBL.

The results of the current study showed retrospectively that high preoperative MAP affected the TBL and HBL, and in both Pearson's correlation and univariate logistic analysis, MAP was a significant risk factor for surgical time and operative bleeding. This finding can be attributed to the prolonged time required when operative bleeding prevents visualization. Verma et al[30] similarly reported that patients with lower preoperative MAP had 33% less operative bleeding and shorter operative time.[30]

Zhou et al[22] and Wen et al[31] demonstrated that ASA classification was an independent risk factor for HBL in anterior cervical fusion surgery and minimally invasive TLIF surgery. The current single-level OTLIF series also found ASA to be a statistically significant risk factor for TBL and HBL.

Obesity is defined by the World Health Organization as BMI >30. This has been shown to be a risk factor for surgical infection in patients with posterior lumbar vertebrae surgeries.[28,32,33] However, as BMI is calculated from height and weight, it is not directly associated with the body fat distribution and muscle mass. Therefore, it could be considered to not be a completely appropriate criterion for surgical procedures.[4,28] It has been shown that soft tissue damage increases as the blood flow and oxygen saturation of the tissues around the incision decrease. Moreover, greater thickness of subcutaneous fatty tissue can increase postoperative drainage and the rate of infection consequent to increased fat necrosis and potential dead space.[10] Localized increased subcutaneous fat tissue was stated to be a better predictor of the risk of postoperative infection than BMI in a study by Lee et al[34] of posterior lumbar surgery and by Mehta et al[4] in a study of posterior cervical surgery.

Therefore, in the current study, the effects were evaluated of LSMSF, OPSF, and BMI on TBL and HBL. The results showed that LSMSF and OPSF were statistically significant risk factors for TBL and HBL, while BMI was only a risk factor for TBL.

Increased fatty thickness at the surgery site, a long spinous process, or wide paravertebral muscle tissue increase the working depth, strong retraction, and the difficulty of the surgical procedure. Therefore, it can be considered that anatomical differences have peri and postoperative effects. Interestingly, there was seen to be an inverse correlation of paravertebral muscle area with operative time, intraoperative bleeding, and length of hospital stay.

The aim of this study was to evaluate the correlation between anatomical features of patients and HBL based on these examples, and the data obtained demonstrated a significant correlation between HBL and TBL subcutaneous fat tissue.

Unlike previous studies, this study included preoperative MAP levels, canal area, paravertebral muscle area, and disc area at the operation level of patients undergoing OTLIF surgery.

Our study has several limitations. (1) It is a single-center retrospective study with a small number of cases. Therefore, the generalizability of the results needs to be confirmed with a great deal of patients in daily clinical working. (2) Perioperative soiling with blood (drape and dressing) was ignored. (3) We evaluated postoperative Hct at the third postoperative day, but as fluid shifts would not have been completed and perioperative IV fluid transfusion was ignored, these obviously could influence our conclusions. (4) The measured disc area or paravertebral muscle mass was calculated with axial MRI from the disc level only. During spine surgery, muscle and bone dissection included the upper and lower levels, along the fusion level. The amount of paravertebral muscle and bleeding was found to be inversely related, possibly due to this single section evaluation. (5) Our single-level OTILIF cases were performed by single surgeon with the same technique. (6) Finally, we were unable to investigate the influence of racial differences for HBL, because most patients included in our hospital were native residents. Due to these limitations, high-quality observational studies and basic experimental studies are still needed to investigate new risk factors for HBL.

In conclusion, HBL consists of approximately 1/3 to 1/2 of the calculated perioperative TBL. A large amount of HBL can exacerbate postoperative anemia and also may lead to higher risk of complications including wound disruption, infection, cognitive impairment, and other complications. Lumbosacral maximum subcutaneous fat thickness and SPL are independent risk factors for HBL. We recommend that risk factors should be kept in mind and has to be investigated preoperatively.

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Informed Consent: Informed consent was obtained from each patient.

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