

Total and hidden blood loss between open posterior lumbar interbody fusion and transforaminal lumbar interbody fusion by Wiltse approach

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Abstract

The purpose of this study was to calculate and compare the volume of hidden blood loss (HBL) and perioperative blood loss between open posterior lumbar interbody fusion (PLIF) and transforaminal lumbar interbody fusion (TLIF) by Wiltse approach.

We retrospectively analyzed 143 patients between March 2017 and December 2017, they were randomly divided into PLIF group and TLIF group. The following information were collected on admission: patient's age, gender, height, weight, body mass index (BMI), surgery levels, surgical time, duration time, disorder type, intraoperative bleeding, wound drainage, visual analog scale (VAS) scores, neurological complications, transfusion rate. Preoperative and postoperative hematocrit (Hct) were recorded in order to calculate total blood loss (TBL) according to Gross's formula. To calculate each patient's HBL, chi-square test and Student's *t* test were used to analyze data.

Patients in PLIF had a mean TBL of 1144 ± 356 mL, and the mean HBL was 486 ± 203 mL, $43.9 \pm 16.2\%$ of the TBL. While patients in TLIF, the mean TBL was 952 ± 303 mL, and the mean HBL was 421 ± 178 mL, $44.7 \pm 17.0\%$ of the TBL. Hence, there was significant difference in TBL and HBL between 2 groups, respectively ($P = .000$, $P = .044$). However, there was no difference in the ratio of the HBL between 2 groups ($P = .797$).

The volume of HBL is lower in open TLIF by Wiltse approach than that in PLIF, which may be a large proportion of TBL in posterior lumbar fusion surgery. Comprehensive understanding of HBL can contribute to keep patient safety and better to rehabilitation in perioperative.

Abbreviations: BMI = body mass index, Hb = hemoglobin, HBL = hidden blood loss, Hct = hematocrit, LDH = lumbar disc herniation, LS = lumbar spondylolisthesis, LSS = lumbar spinal stenosis, MI-TLIF = minimally invasive transforaminal lumbar interbody fusion, PBV = patient's blood volume, PLIF = posterior lumbar interbody fusion, TBL = total blood loss, TLIF = transforaminal lumbar interbody fusion, VAS = visual analog scale.

Keywords: hidden blood loss, posterior lumbar interbody fusion, total blood loss, transforaminal lumbar interbody fusion

1. Introduction

Cloward first described posterior lumbar interbody fusion (PLIF) in the 1950s, using autologous bonegraft to increase fusion rates,^[1,2] pedicle screw systems were introduced later.^[3] The transforaminal lumbar interbody fusion (TLIF) technique was initially described by Harms et al in 1982,^[4] as an alternative to

PLIF that allows to reduce potentially harmful traction of the neural structures. The 2 procedures have been reported with treatment of lumbar degenerative disease and spinal instability over the past years with good results. Wiltse et al first described a bilateral transsacrospinalis approach that resulted in less tissue destruction and blood loss compared to the conventional midline

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incision approach in 1968.^[5] Wiltse et al revised his approach by substituting 1 midline incision for the pair of lateral cutaneous incisions in 1988.^[6] There are numerous studies that have reported the advantage of Wiltse approach treatment degenerative lumbar diseases.^[7–11]

Usually, the amount of blood loss during posterior spinal surgery is merely the sum of intraoperative blood loss and postoperative drainage volume, but it ignores the extravasation of blood into interstitial tissue and hemolysis. Therefore, patients are found to have a lower hemoglobin (Hb) than anticipated postoperative hemoglobin, which is thought to be hidden blood loss (HBL). The concept of HBL was first put forward by Sehat in 2000.^[12] Sehat et al^[13] showed that HBL accounted for 26% and 49% of total blood loss in total knee and total hip arthroplasty. Smorgick et al^[14] found that the HBL in posterior spine fusion surgery was 39% of total blood loss. The concept of HBL has gradually received more attention by surgeons in recent years.^[15–19] Even, some scholars have compared the HBL of minimally invasive TLIF (MIS-TLIF) and open TLIF.^[20] To the best of our knowledge, there are no studies focusing on comparing the HBL of open PLIF and TLIF by Wiltse approach. In this study, we retrospectively reviewed to evaluate absolute amount of HBL and its ratio upon total blood loss (TBL) during open PLIF and TLIF by Wiltse approach.

2. Patients and methods

2.1. Patients

We retrospectively analyzed 143 patients between March 2017 and December 2017, they were divided into PLIF group (69) and TLIF group (74). This study protocol was reviewed and approved by the Ethics Committee of the Affiliated Hospital of Southwest Medical University. The Ethics Committee particularly approved that informed consent was not required because of the characteristic of retrospectively study and data were analyzed anonymously. All surgeries were performed by the same experienced surgeon in our department. Inclusion criteria: lumbar spinal stenosis and lumbar disc herniation with instability indicated for lumbar fusion surgery, lumbar spondylolisthesis, all of those were primary surgeries. Exclusion criteria: lumbar tumor, tuberculosis, fracture, cerebrospinal fluid leakage during surgeries, coagulation dysfunction, patients with medications of anti-platelet aggregants, anemia before surgeries and received bank blood, revision posterior spinal fusion surgery. The recorded data included age, gender, height, weight, body mass index (BMI), surgery levels, surgery time, duration of symptom, disorder type, drainage volume, visual analog scale (VAS) scores, complication, transfusion rate, pre-operative and postoperative hematocrit (Hct), and Hb. The pedicle screws were placed through the conventional posterior approach in the decompression lateral. Drainage-tube was routinely used with each patient.

2.2. Surgical procedures

All operative procedures were performed by a senior surgeon with a 10-year experience. The patients were placed in prone position with the abdomen and administered with general anesthesia. A posterior midline incision was made at the skin, and bilateral incision of lumbodorsal fascia with 2cm paraspinous process. Using the Wiltse paraspinous muscle-splitting approach through the longissimus and multifidus, the post-column

structure including the lamina (partial lamina dissection for TLIF) and the facet joint were exposed. After pedicle screw instrumentation, unilateral or bilateral laminotomy and partial facetectomy were performed according to the patient's symptoms (the TLIF technique decompression range is only facetectomy). The thecal sac and nerve roots are carefully taken to protect with a retractor. After exposure of the posterior annulus, complete discectomy and cartilaginous endplate were performed using disc shavers, rongeurs, and curved curettes. After adequately decompression with the neural elements had been performed, adequate autologous bone graft originated from the excision lamina or facet was placed in the anterior intervertebral space. Then, an interbody cage filled with autologous bone with appropriate size was then obliquely placed into the intervertebral space. A standard closure with fascia and skin was performed. Wound drainage was placed routinely for 24 to 48 hours after operation.

2.3. Blood loss management

Nineteen patients accepted transfusion, a majority of surgeries were performed without autologous blood transfusion system. Allogenic blood was transfused during perioperative period complying with transfusion standard. All the patients completed operation under general anesthesia. Blood count containing Hct was measured before and 2 to 3 days after operation, at this time, the hemodynamics were stable, hence, fluid shifts would not been changed.^[13] Intraoperative bleeding was recorded by anesthetist and contained the blood in the suction bottles (after subtracting the flush fluid used in operation) and in the weighed sponges used in operation.

2.4. Calculation of HBL

HBL was calculated according to the previous literature,^[13] following the formula:

Hidden blood loss = total blood loss – measured blood loss.

The gender, height, and weight were used to calculate patient's blood volume (PBV) by the method introduced by Nadler et al^[21]:

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

where $k1=0.3669$, $k2=0.03219$, and $k3=0.6041$ for men, and $k1=0.3561$, $k2=0.03308$, and $k3=0.1833$ for women.

The decreasing of Hct can reflect total blood loss in the perioperative period, therefore, the total blood loss was calculated according to the Gross formula^[22]:

$$\text{Total blood loss} = PBV(\text{Hctpre} - \text{Hctpost})/\text{Hctave},$$

where Hctpre is the Hct before operative, Hctpost is the Hct on 2 to 3 days postoperative, and Hctave is the average of the Hctpre and Hctpost.

If the patient accepted allogenic transfusion, the total blood loss is equivalent to the loss calculated from the change in Hct add the transfusion volume. The formula then changes to

Hidden blood loss = calculated total blood loss + blood transfusion – measured blood loss

2.5. Additional measurements

Hb concentration was used to define anemia, according to the criterion established World Health Organization [$<120\text{g/L}$ for female and $<130\text{g/L}$ for male].^[23] The hematocrit below 25%

and hemoglobin concentration lower than 80 g/L was transfusion triggers. If the patients older than 60 years, a hemoglobin concentration lower than 100 g/L was the transfusion trigger.^[24]

2.6. Statistical analysis

SPSS 21.0 software was used to perform the statistical analysis. Data are presented as mean ± SD deviation. Student's *t* test was used to compare quantitative variables (age, height, weight, BMI, surgery time, duration time, drainage volume, VAS scores). The chi-square test was used to compare qualitative variables (gender, surgery levels, disorder type, complication, transfusion rate). The level of statistical significance was set at *P* < .05.

3. Results

A total of 143 patients met the inclusion criteria were reviewed retrospectively. All demographic and baseline characteristics for preoperative in 2 groups are summarized in Table 1. No significant differences were observed between 2 groups regarding patient's age (*P* = .429), gender (*P* = .733), BMI (*P* = .053), duration time (*P* = .361), disorder type (*P* = .393).

When referring to clinical outcomes (Table 2), surgery time of TLIF was shorter than that of PLIF (150 versus 168 min, *P* = .038), wound drainage of TLIF was fewer than that of PLIF (167 versus 214 mL, *P* = .042). Comparing each of other parameters, it revealed no statistical significance (preoperative VAS: 4.5 ± 1.6 versus 4.0 ± 1.2, *P* = .053, postoperative VAS: 1.5 ± 1.1 versus 1.2 ± 1.0, *P* = .113, surgery levels *P* = .298, neurological complications: 5 versus 2, *P* = .263, transfusion: 18 versus 8, *P* = .511).

The perioperative blood changed was shown in Table 2 and Figure 1, In PLIF group, patients had a mean TBL of 1144 mL. Their calculated hidden loss was 486 mL, 43.9% of the total loss. While in TLIF group, the mean TBL was 952 mL, and the mean HBL was 421 mL, 44.7% of the total loss. The amount of intraoperative bleeding was 445 mL and 364 mL, respectively. Significant differences were observed for TBL (*P* = .000), HBL (*P* = .044), and intraoperative bleeding (*P* = .029) between 2 groups. Meanwhile, as regard the ratio of HBL upon TBL, there was no significant difference (*P* = .797). Hb and Hct loss were clinically significant (*P* = .028, *P* = .027).

Table 1
Comparison of preoperative baseline data between 2 groups.

Parameters	PLIF group	TLIF group	<i>P</i> value
Number of patients	69	74	
Age (yr)	53.3 ± 12.1	51.8 ± 10.6	.429
Gender (M/F)	40/29	46/28	.733
BMI (kg/m ²)	23.1 ± 2.7	24.1 ± 3.6	.053
Duration time	15.9 ± 8.7	18.0 ± 17.1	.361
Disorder type			.393
LDH	21	27	
LSS	26	20	
LS	22	27	
Preoperative VAS score	4.5 ± 1.6	4.0 ± 1.2	.053
Surgery levels			.298
1	37	48	
2	29	22	
3	3	4	

Data are mean ± SD. **P* < .05. BMI = body mass index, LDH = lumbar disc herniation, LS = lumbar spondylolisthesis, LSS = lumbar spinal stenosis.

Table 2
Comparison of intraoperative and postoperative data between 2 groups.

Parameters	PLIF group	TLIF group	<i>P</i> value
Hemoglobin loss (g/L)	29.5 ± 17.8	24.0 ± 11.6	.028*
Hematocrit level loss (%)	0.10 ± 0.03	0.09 ± 0.03	.027*
Intraoperative bleeding (mL)	445 ± 251	364 ± 181	.029*
Wound drainage (mL)	214 ± 150	167 ± 124	.042*
Calculated blood loss (mL)	659 ± 313	531 ± 244	.007*
Total blood loss (mL)	1144 ± 356	952 ± 303	.000*
Hidden blood loss (mL)	486 ± 203	421 ± 178	.044*
Percentage of hidden loss in total (%)	44.0 ± 16.2	44.7 ± 17.0	.797
Postoperative VAS score	1.5 ± 1.1	1.2 ± 1.0	.113
Surgery time	168 ± 51	150 ± 50	.038*
Complication	5/64	2/72	.263
Transfusion rate	11/58	8/66	.511

Data are mean ± SD.
**P* < .05.

4. Discussion

Remarkably intraoperative blood loss is a universal trouble that can be encountered in lumbar posterior fusion surgery. In daily clinical experience, the blood loss measured after posterior lumbar fusion surgery includes merely the intraoperative blood loss and postoperative drainage volume. Although, an obviously satisfactory blood management on blood loss, patients still had encountered anemia, some other factors for blood loss may be neglected. However, it ignores the extravasation of blood into interstitial tissue and hemolysis, which are known as hidden blood loss and had been first described by Sehat in 2000.^[12] Hidden blood loss can result in exacerbate postoperative hemoglobin drop and anemia, which also contributed to medical complications. The concept of hidden blood loss has gradually received more attention by surgeons in recent years.^[15-19]

Lumbar posterior fusion surgery is usually associated with a significant blood loss perioperative. Smorgick et al^[14] reported mean 1439 mL total blood loss in single level and multi-level PLIF with the traditional approach. Their calculated hidden blood loss was 600 mL, 42% of the total blood loss. In our study, patients underwent PLIF had a mean TBL of 1144 mL. Their calculated HBL was 486 mL, 43.9% of the TBL. While in the TLIF group, they had a mean TBL of 952 mL. Their calculated hidden blood loss was 421 mL, 44.7% of the TBL. Hence, the mean TBL and HBL in PLIF group were significantly higher than that in TLIF (*P* = .000, *P* = .044). Meanwhile, compared with the ratio of HBL upon TBL, there was no difference between both groups (*P* = .797). The amount of TBL and HBL was lower than that reported by Smorgick et al,^[14] which maybe contributed by the difference between Wiltse approach and conventional midline approach. Wiltse approach is better exposed surgical site and less paraspinal muscle distracted than the conventional approach. In addition, blood loss with the Wiltse approach is primarily originated from bone surface bleeding after osteotomy and bleeding associated with break of the spinal venous plexus. Those factors were resulted in very little bleeding. There were some biases of TBL with previous literatures, which may be contributed to the number of surgical level. Zhang et al^[20] had calculated that patients who undergo single level open TLIF

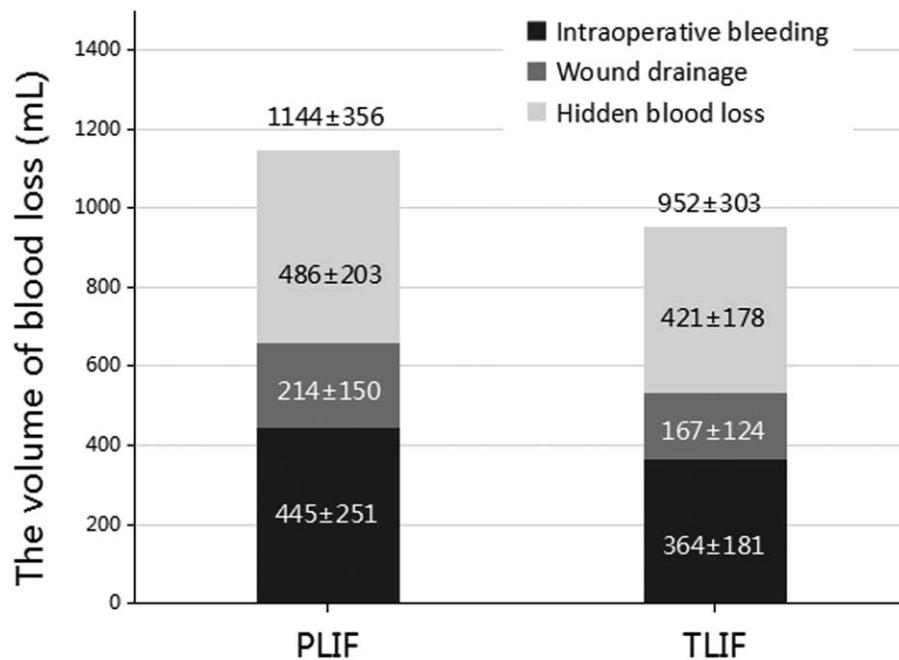


Figure 1. The mean volume of blood loss between 2 groups.

have 742 mL total blood loss. Smorgick et al^[14] also found that the percentage of HBL had no concern with the number of surgical levels. In the study, we have obtained identical consequences.

Our study illuminated that TLIF by Wiltse approach has less surgical time than those with PLIF ($P = .038$). Meanwhile, the total blood loss and hidden blood loss were significant difference between both groups ($P = .000$, $P = .044$). This phenomenon may be contributed to the difference of subperiosteal dissection paraspinous muscles, heavy retraction of muscular tissue, and decompression region. The PLIF by Wiltse approach^[25,26] is performed through subperiosteal dissection paraspinous muscles over lamina and the facet joint, with wide laminotomy, resection of the ligamentum flavum, and whole removed of the cranial lamina. While TLIF is a modification of the PLIF by Wiltse approach^[25,27] involving dissect paraspinous muscles from partial lamina, less retraction of muscular tissue and unilateral hemifacetectomy of the inferior and superior facets with removal of the interarticularis so as to access the lateral aspect of disc. TLIF technique has less neurological complications, because this approach is less retraction of the dura and nerves. Whereas, there is no significant difference between both groups ($P = .263$).

Where can we find the hidden blood loss? Some previous literatures have argued the source of HBL. However, no final conclusion has reach a consensus about this theme. The mainstream opinion considered that the HBL may be ascribed to blood hemolysis, extravasation of the blood into the tissues during the operation, and blood losses during postoperative hospitalization with the continuous blood loss.^[28–30]

Nevertheless, our study has several drawbacks. It includes the inherent limitations of a retrospective study: selection bias. Our results need to be confirmed with large number case in multi-center. We evaluated postoperative Hct at the second or the third day as a reference after operation^[13]; however, the fluid shift is

hemodynamically instable, which is resulting to underestimate the HBL.

5. Conclusions

In conclusion, our study has elaborated that the volume of HBL is lower in open TLIF than that in PLIF by Wiltse approach, which may be a large proportion of TBL and also seriously underestimated in posterior lumbar fusion surgery. With regards to spinal surgeons, comprehensive understanding of the concept of HBL is extremely important to avoid potential complications and improve patient rehabilitation perioperatively.

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Author contributions

DXF and FL conceived and designed this study together, WH and XGT collected the data, ZhYL and LPZh provided advice on the data analysis, DXF and JPK involved surgical treatment, FL and DXF wrote the manuscript, DXF, JPK and FL revised this manuscript. All the authors have read and approved the final manuscript.

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