Postoperative Blood Loss Including Hidden Blood Loss in Early and Late Surgery Using Percutaneous Pedicle Screws for Traumatic Thoracolumbar Fracture

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Abstract:

Introduction: Some reports revealed that hidden blood loss (HBL) during surgery for traumatic thoracolumbar fracture cannot be ignored, even when using a percutaneous approach. Using percutaneous pedicle screws (PPS) for traumatic thoracolumbar fracture, this study aimed to compare estimate blood loss (EBL), including HBL, between early and late fixation.

Methods: This investigation was a retrospective study. In the present study, data from 39 patients who underwent posterior spinal stabilization using PPS for single-level thoracolumbar fracture have been included. We divided the patients into an early group (group E) (n=20) in whom surgery was conducted within 3 days of fracture and a late group (group L) (n=19) in whom surgery was conducted more than 3 days after fracture. We evaluated hemoglobin (Hb) on the day of injury, and 1, 3 or 4, and 7 days after surgery, EBL, HBL, and transfusion requirement.

Results: Hb on day 1 (group E: 12.2±1.7 g/dL, group L: 12.3±1.6 g/dL) was significantly less than that on the injured day (group E: 14.2±1.7 g/dL, group L: 13.9±1.7 g/dL) in both groups. The values of Hb and EBL were not significantly different at any time between the two groups. HBL (group E: 487±266 mL, group L: 386±305 mL) was not significantly different between the two groups. No patients required transfusion in either group.

Conclusions: EBL in early fixation using PPS for traumatic thoracolumbar fracture is not significantly different compared with that in late surgery from days 1 to 7 postoperatively. Early fixation using PPS for traumatic thoracolumbar fracture does not result in negative outcomes any more than those in late surgery in terms of blood loss.

Keywords:

Thoracolumbar fracture, Postoperative blood loss, Hidden blood loss, Percutaneous pedicle screw, Early surgery

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Introduction

In general, early surgery for traumatic thoracolumbar fracture decreases complications and morbidity compared with late surgery[1-4]. These results lead to a "spine damage control (SDC)" concept[5,6]. By contrast, intraoperative blood loss during surgery for traumatic thoracolumbar fracture cannot be ignored[7], especially at the early acute phase of surgery. Using percutaneous pedicle screws (PPS) for fixation of traumatic thoracolumbar fracture has been found to result in less visible intraoperative blood loss than conventional open surgery[8-10]. However, some reports revealed that hidden blood loss (HBL) during surgery for traumatic thoracolumbar fracture cannot be ignored, even when using a percutaneous approach[11-13]. Using PPS for traumatic thoracolumbar fracture, this study aimed to compare blood loss, including HBL, between early and late fixation.

Materials and Methods

The medical ethics committee of our hospital approved the present study. All patients provided informed consent to use all patient data. This investigation was a retrospective study. In the present study, data from 39 patients who underwent posterior spinal stabilization using PPS for single-level traumatic thoracolumbar fracture due to high-energy trauma, such as a fall, traffic accident, or sports between February 2013 and May 2020 have been included. Exclusion

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criteria included age over 70 years, osteoporotic or pathological vertebral fracture, patients with other trauma requiring surgery, those with hemothorax requiring a chest drain, those who underwent spinal stabilization for multilevel spinal fractures, and dislocation fracture, those with severe paralysis that requires the fracture site to be opened for reduction or decompression, and lack of data. Surgery was indicated for fractures associated with neurological deficit, a large degree of axial compression (>50%), >20 degrees of angulation, or posterior tension band disruption. Surgery was conducted on the earliest day convenient for the surgeon, anesthesiologist, and operating room availability. At surgery, PPSs were inserted using fluoroscopy, and vertebroplasty using hydroxyapatite blocks was conducted when the fractured vertebral body remained compressed while the patient was in a prone position. Early surgery was defined as that within 3 days after trauma[1-4]. We divided the patients into an early group (group E) (n=20) in whom surgery was conducted within 3 days of fracture and a late group (group L) (n=19) in whom surgery was conducted more than 3 days after fracture. We evaluated the demographics of patients (age, sex, height, weight, location of the injured vertebra, fracture type (AO classification)[14], and vertebral body compression ratio (VBCR=anterior vertebral height/posterior vertebral height)[15], surgical data (range of stabilization and vertebroplasty), intraoperative blood loss (IBL), hemoglobin (Hb) on the day of injury, and 1, 3 or 4, and 7 days after surgery, Hb change, estimated blood loss (EBL), HBL, and transfusion requirement. EBL was calculated by blood volume from the Nadler formula[16] and Hb change[11,17]. The formula used was as follows:

Women's blood volume (L)=height $(m)^3$×0.356+weight (kg)×0.033+0.183

Men's blood volume (L)=height $(m)^3$×0.367+weight (kg)×0.032+0.604

Hb_{loss} (g)=Blood volume (L)×{Hb_{inj} (g/L)−Hb_{post} (g/L)}+26.5 (g)×(transfusion unit)

EBL (mL)={Hb_{loss} (g/L)/Hb_{inj} (g/L)}×1000

HBL (mL)=$EBL_{day\ 1}$ (mL)−IBL (mL)

Hb_{inj}: Hb on injured day, Hb_{post}: Hb on 1, 3 or 4, and 7 days after surgery, $EBL_{day\ 1}$: EBL on day 1

Statistical analysis

All data are expressed as mean±standard deviation. A Mann-Whitney U test, chi square test, Student t test, and Fisher exact test were used to compare age, height, weight, injured level, stabilized range, vertebroplasty, IBL, Hb, Hb change, EBL, and HBL. Differences with $p<0.05$ were considered to be significant. All statistical analyses were conducted using IBM SPSS Statistics for Windows (version 22; IBM Corp, Armonk, NY).

Results

No significant differences were found in the demographics between the two groups (Table 1). IBL (group E: 103±106 mL, group L: 56±57 mL) was not significantly different between the two groups ($p=0.35$) (Table 1). Hb on day 1 (group E: 12.2±1.7 g/dL, group L: 12.3±1.6 g/dL) was significantly less than that on the day of injury (group E: 14.2±1.7 g/dL, group L: 13.9±1.7 g/dL) in both groups ($p<0.01$) (Fig. 1, 2). Hb on days 3-4 did not change significantly in either group (group E: 12.4±1.7 g/dL, group L: 12.4±1.7 g/dL) from levels on day 1 (Fig. 1, 2). Although Hb on day 7 (12.4±1.5 g/dL) did not increase compared with that of days 3-4 in group L, that of group E (12.4±1.5 g/dL) increased significantly compared with that of days 3-4 in group E (Fig. 1, 2). However, the values of Hb were not significantly different at any times between the two groups (Table 1). Although EBL on days 1 and 3-4 of group E (day 1: 590±267 mL, days 3-4: 551±289 mL) tended to be greater than that of the L group (day 1: 441±301 mL, days 3-4: 398±369 mL), no significant differences between the two groups exist. (Table 1, Fig. 3). In group E, EBL of day 7 (380±205 mL) was significantly less than that on days 3-4 ($p=0.01$). By contrast, in group L, EBL of day 7 (416±356 mL) showed no change from that of days 3-4. EBL on day 7 was not significantly different between groups (group E: 380±205 mL, group L: 416±356 mL). EBL was not significantly different at any time between the two groups (day 1 and days 3-4: $p=0.21$, day 7: $p=0.91$) (Table 1, Fig. 3). HBL (group E: 487±266 mL, group L: 386±305 mL) was not significantly different between the two groups ($p=0.35$) (Table 1). No patients required transfusion in either group.

Discussion

The role of HBL in orthopedic surgery has gained increasing attention since Sehat et al first proposed the concept in 2000[18]. HBL is caused by the extravasation of blood into tissues in substantial amounts, presence of residual blood in the joint, and blood loss due to hemolysis[19]. In traumatic thoracolumbar fracture, the clinical importance of HBL has been reported[11-13]. The rate of HBL in surgery for traumatic thoracolumbar fracture has been reported as 65%-74% and is especially high in surgery using PPS compared with that using a paraspinal or conventional open approach[12]. Therefore, considering not only IBL but also EBL including HBL in surgery for traumatic thoracolumbar fracture is necessary, especially in surgery using PPS. EBL, IBL, and HBL in surgery using PPS are lower than those using a paraspinal or conventional open approach[12]. EBL in surgery for traumatic thoracolumbar fracture using a conventional open method was over 1000 mL[11], when calculating EBL using the same formula as used in this study. In the present study, EBL in surgery using PPS was 590 mL in group E and 441 mL in group L. These results indicated that EBL in surgery using PPS was less than that using a conventional open method, which is consistent with a previous report[12].

To our knowledge, a comparison of blood loss including HBL between early and late fixation using PPS for trau-

Table 1. Patient Background and Perioperative Outcomes in Each Group.

Variable	Group E (n=20)	Group L (n=19)	
Age (years)	45.9±16.3	46.3±17.3	N.S.* (p=0.95)
Sex (M: male, F: female)	M 15, F 5	M 13, F 6	N.S.* (p=0.73)
Height (cm)	168.0±8.2	164.1±6.8	N.S.* (p=0.11)
Weight (kg)	65.5±14.7	59.7±12.2	N.S.* (p=0.35)
Injured level	T3: 1	T10: 1	N.S.* (p=0.71)
	T12: 4	T12: 2	
	L1: 9	L1: 8	
	L2: 5	L2: 6	
	L4: 1	L3: 1	
		L4: 1	
Fracture type	A2: 0	A2: 1	N.S.* (p=0.38)
	A3: 8	A3: 4	
	A4: 3	A4: 7	
	B1: 3	B1: 2	
	B2: 6	B2: 5	
VBCR**	0.65±0.09	0.67±0.14	N.S.* (p=0.89)
Stabilized range	1above1below: 12	1above1below: 13	N.S.* (p=0.74)
	2above2below: 8	2above2below: 6	
Vertebroplasty	Yes 10, No 10	Yes 9, No 10	N.S.* (p>0.99)
Intraoperative blood loss (ml)	103±106	56±57	N.S.* (p=0.35)
Hb on injured day (g/dl)	14.2±1.7	13.9±1.7	N.S.* (p=0.45)
Hb on Day 1 (g/dl)	12.2±1.7	12.3±1.6	N.S.* (p=0.87)
Hb on Days 3–4 (g/dl)	12.4±1.7	12.4±1.7	N.S.* (p=0.86)
Hb on Day 7 (g/dl)	12.9±1.6	12.4±1.5	N.S.* (p=0.23)
Hb change Day 1 (g/dl)	2.0±0.9	1.6±1.1	N.S.* (p=0.29)
Hb change Days 3–4 (g/dl)	1.8±0.9	1.5±1.4	N.S.* (p=0.18)
Hb change Day 7 (g/dl)	1.3±0.7	1.5±1.4	N.S.* (p=0.87)
Estimated blood loss Day 1 (ml)	590±267	441±301	N.S.* (p=0.12)
Estimated blood loss Days 3–4 (ml)	551±289	398±369	N.S.* (p=0.12)
Estimated blood loss Day 7 (ml)	380±205	416±356	N.S.* (p=0.91)
Hidden blood loss (ml)	487±266	386±305	N.S.* (p=0.35)
Transfusion rate	0%	0%	

N.S. *: not significant (p>0.05)
VBCR**: vertebral body compression rate

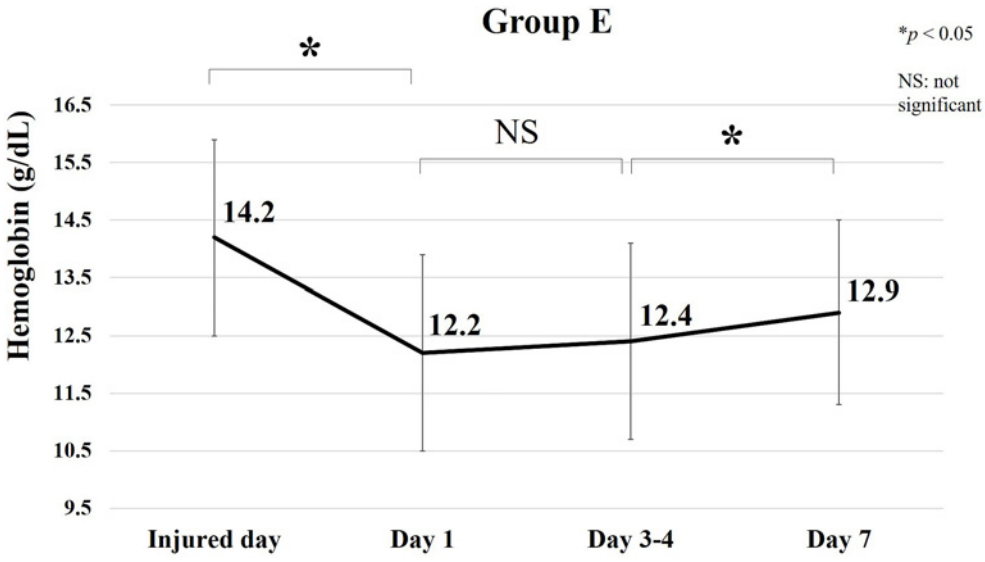

Figure 1. Hemoglobin change in group E.

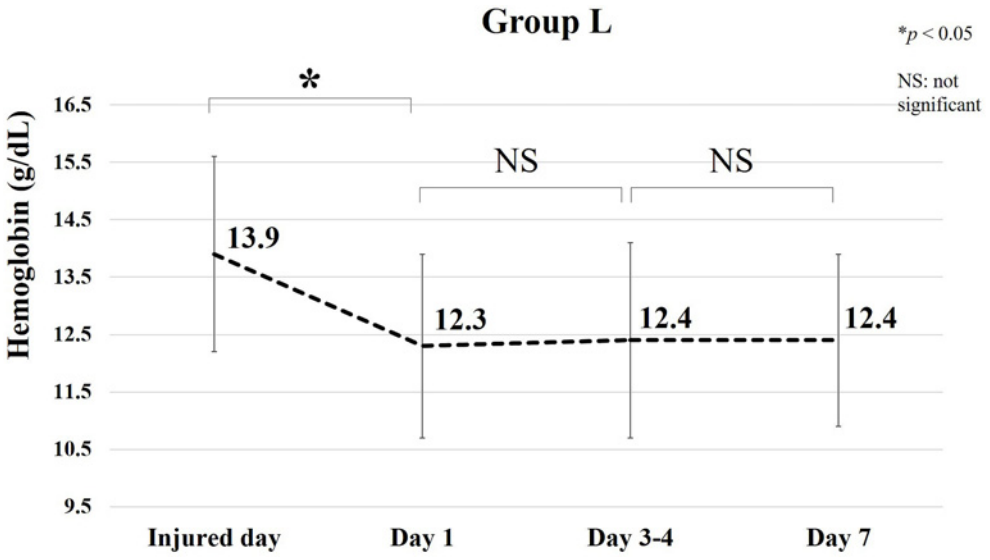

Figure 2. Hemoglobin change in group L.

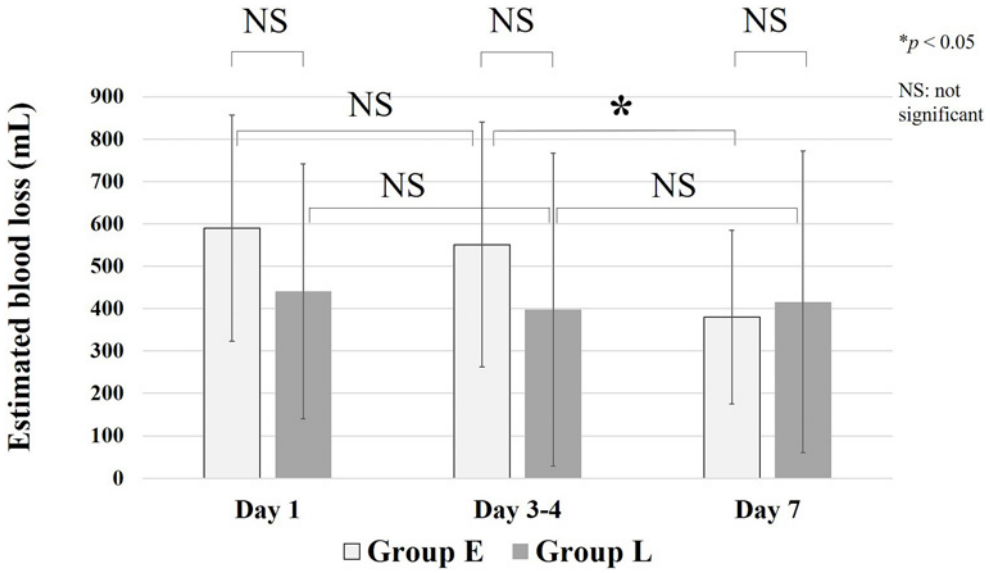

Figure 3. Estimated blood loss volume from admission to the 1st, 3rd or 4th, and 7th days after surgery.

matic thoracolumbar fracture has not been reported. Compared with late surgery, early surgery might generate a difference in EBL. The results of the present study showed that, although Hb on day 1 was significantly less than that on the day of injury in both groups, IBL, Hb change day 1, EBL day 1, and HBL were not significantly different between the two groups. Moreover, the difference did not result in negative clinical outcomes such as requiring transfusion or symptomatic hypotension. To our knowledge, no reports of the course of EBL after surgery for traumatic thoracolumbar fracture exist. Here, we reported the course of EBL from days 1 to 7 after surgery. Although EBL in early surgery at days 1 and 3-4 postoperatively tended to be greater than that after late surgery, the differences were not significant and no patients required transfusion during that period. The difference in EBL at days 1 and 3-4 postoperatively between the two groups was not clinically important. Furthermore, EBL in early surgery at 7 days postoperatively was similar to that in the late surgery group. To conclude, early fixation using PPS for traumatic thoracolumbar fracture does not result in negative outcomes any more than those in late surgery in terms of blood loss, although this conclusion is limited by the small sample size and tendency for high blood loss in either instance.

There are some limitations in the present study. The sample size is small. If sample size was bigger, some variables might be significantly different between the groups. SDC is effective, especially in the case of polytrauma with a high injury severity score[1,5]. Because, in the present study, we examined the blood loss of surgery for traumatic thoracolumbar fracture, and polytrauma patients have many factors related to bleeding, comparing groups with the same parame-

ters is challenging. Therefore, the present study did not compare blood loss including HBL between early and late fixation using PPS for traumatic thoracolumbar fracture in patients with polytrauma patients. To understand the blood loss in surgery using PPS for traumatic thoracolumbar fracture in polytrauma patients, further study is required.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Ethical Approval: This study was approved by Toyama Prefectural Central Hospital review board (No.5880).

Author Contributions: Takeshi Sasagawa: conception and design of the study, collection and analysis of data, and critical revision of the article for important intellectual content

Yosuke Takeuchi and Ikuo Aita: collection of data

Informed Consent: Informed consent was obtained from all participants in the present study.

References

1. Scaramuzzo L, Tamburrelli FC, Piervincenzi E, et al. Percutaneous pedicle screw fixation in polytrauma patients. Eur Spine J. 2013; 22(6):S933-8.
2. Bellabarba C, Fisher C, Chapman JR, et al. Does early fracture fixation of thoracolumbar spine fractures decrease morbidity or mortality? Spine (Phila Pa 1976). 2010;35(9):S138-45.
3. Chipman JG, Deuser WE, Beilman GJ. Early surgery for thoracolumbar spine injuries decreases complications. J Trauma. 2004; 56(1):52-7.
4. Kerwin AJ, Griffen MM, Tepas JJ 3rd, et al. Best practice determination of timing of spinal fracture fixation as defined by analysis of the national trauma data bank. J Trauma. 2008;65(4):824-30.
5. Stahel PF, Flierl MA, Moore EE, et al. Advocating "spine damage control" as a safe and effective treatment modality for unstable thoracolumbar fractures in polytrauma patients: a hypothesis. J Trauma Manag Outcomes 2009;3(1):6.
6. Stahel PF, VanderHeiden T, Flierl MA, et al. The impact of a standardized "spine damage-control" protocol for unstable thoracic and lumbar spine fractures in severely injured patients: a prospective cohort study. J Trauma Acute Care Surg 2013;74(2):590-6.
7. Verlaan JJ, Diekerhof CH, Buskens E, et al. Surgical Treatment of Traumatic Fractures of the Thoracic and Lumbar Spine: A Systematic Review of the Literature on Techniques, Complications, and Outcome. Spine (Phila Pa 1976). 2004;29(7):803-14.
8. Sun XY, Zhang XN, Hai Y. Percutaneous versus traditional and paraspinal posterior open approaches for treatment of thoracolumbar fractures without neurologic deficit: a meta-analysis. Eur Spine J. 2017;26(5):1418-31.
9. McAnany SJ, Overley SC, Kim JS, et al. Open versus minimally invasive fixation techniques for thoracolumbar trauma: a meta-analysis. Global Spine J. 2016;6(2):186-94.
10. Lehmann W, Ushmaev A, Ruecker A, et al. Comparison of open versus percutaneous pedicle screw insertion in a sheep model. Eur Spine J. 2008;17(6):857-63.
11. Wang W, Duan K, Ma M, et al. Tranexamic acid decreases visible and hidden blood loss without affecting prethrombotic state molecular markers in transforaminal thoracic interbody fusion for treatment of thoracolumbar fracture-dislocation. Spine (Phila Pa 1976). 2018;43(13):E734-9.
12. Chen ZX, Sun ZM, Jiang C, et al. Comparison of hidden blood loss between three different surgical approaches for treatment of thoracolumbar fracture. J Invest Surg. 2019;32(8):755-60.
13. Yin M, Chen G, Yang J, et al. Hidden blood loss during perioperative period and the influential factors after surgery of thoracolumbar burst fracture: a retrospective case series. Medicine (Baltimore). 2019;98(13):e14983.
14. Vaccaro AR, Oner C, Kepler CK, et al. AO Spine thoracolumbar spine injury classification system: Fracture description, neurological status, and key modifiers. Spine (Phila Pa 1976). 2013;38(23): 2028-37.
15. Sadiqi S, Verlaan JJ, Lehr AM, et al. Measurement of kyphosis and vertebral body height loss in traumatic spine fractures: an international study. Eur Spine J. 2017;26(5):1483-91.
16. Nadler SB, Hidalgo JH, Bloch T. Prediction of blood volume in normal human adults. Surgery. 1962;51(2):224-32.
17. Ju H, Hart RA. Hidden blood loss in anterior lumbar interbody fusion (ALIF) surgery. Orthop Traumatol Surg Res. 2016;102(1):67-70.
18. Sehat KR, Evans R, Newman JH. How much blood is really lost in total knee arthroplasty?. Correct blood loss management should take hidden loss into account. Knee. 2000;7(3):151-5.
19. Liu X, Zhang X, Chen Y, et al. Hidden blood loss after total hip arthroplasty. J Arthroplasty. 2011;26(7):1100-5.