

Comparative Study of the Usage of Closed Suction and Nonsuction Drains in Cervical Laminoplasty

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Abstract:

Introduction: Although previous studies reported the clinical significance of drains in lumbar surgery, their role in and effects on the clinical outcomes of cervical spine surgery remain unclear. The present study compared the clinical outcomes of cervical laminoplasty (CLP) using a closed suction drain (CSD) and closed nonsuction drain (CNSD).

Methods: Prospectively recorded surgical data on consecutive patients who underwent CLP at a single institution between 2014 and 2020 and were followed up for at least 1 year were examined. CSD was used prior to January 2018, and CNSD has since been employed. One hundred patients who underwent surgery before and after the change in drain type (the CSD and CNSD groups, respectively) were selected for analysis. Primary outcome measures were the drainage amount, blood count, and fluid collection at the surgical site defined by magnetic resonance images. The Japanese Orthopaedic Association (JOA) score for the cervical spine was also evaluated as a functional outcome.

Results: No significant differences were observed in demographic, baseline clinical, or surgical data between the CSD and CNSD groups. The drainage amount was significantly greater in the CSD group than in the CNSD group (224 vs. 143 mL, $P < 0.001$). Hemoglobin and hematocrit levels were significantly decreased in the CSD group than in the CNSD group. Medium or large fluid collection was significantly more common in the CNSD group than in the CSD group. No significant differences were observed in the number of surgical site infections, the formation of symptomatic hematoma, or JOA scores between the two groups.

Conclusions: The use of CNSD in CLP decreased the drainage amount and maintained the hemoglobin level compared with that of CSD. Although no patients developed symptomatic hematoma, the amount of epidural fluid collected was larger in the CNSD group than in the CSD group.

Keywords:

drain, closed suction drain, closed non-suction drain, cervical laminoplasty, hematoma, surgical site infection, complication

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Introduction

Closed suction drains (CSD) have been used in spinal surgery to prevent the formation of postoperative hematomas and infections¹⁾. However, this is controversial because the number of complications associated with the use of drains is high²⁾. Nevertheless, many surgeons continue to customarily use drains³⁾. Randomized control studies (RCTs) were recently performed, and evidence was obtained on the use of drains at the lumbar level^{4,5)}; however, limited information is currently available on the effects of using or not using drains in posterior surgery on the cervical spine, which may

be attributed to suction drains being employed to reduce the potential risk of spinal cord damage caused by the formation of hematomas and, ultimately, serious disability.

We used CSD in posterior surgery on the cervical spine. However, we encountered a case in which a large amount of bleeding (drainage) occurred as soon as the suction pressure of the drain was applied immediately after surgery despite minimal intraoperative bleeding. Although the surgical wound was immediately opened and examined, no obvious bleeding point was identified. Therefore, our institution changed the use of CSD to that of closed nonsuction drains (CNSD) in posterior surgery on the cervical spine. The pre-

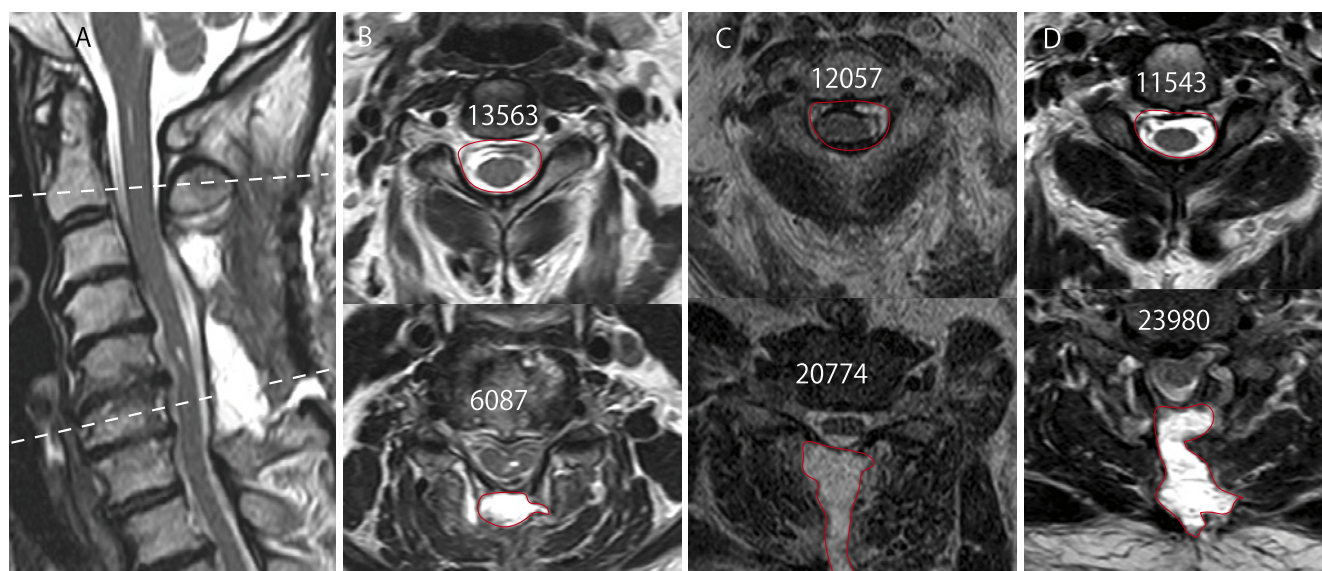


Figure 1. Fluid collection areas were measured using T2-weighted magnetic resonance images. In all axial images, an image of the largest fluid collection area was selected, and the area of fluid collection was compared with that of the canal space at the C2 vertebral body (the C2 area) (A, sagittal view). The fluid collection area was defined as small when the area of fluid collection was smaller than the C2 area (B), medium when the fluid collection area was larger than the C2 area and smaller than twice the size of the C2 area (C), and large when the fluid collection was larger than twice the size of the C2 area (D).

sent study investigated and compared the postoperative complications and clinical outcomes of posterior surgery on the cervical spine using the two types of drains (CSD and CNSD).

Materials and Methods

Patients

The present study was performed with approval from the local Institutional Ethics Committee.

Patients who underwent cervical laminoplasty (CLP) without instrumentation were included in the present study. A list of consecutive patients was extracted from the prospectively recorded surgery list between 2014 and 2020, and their clinical data were retrospectively reviewed. We excluded patients with severe liver function failure, hemophilia, platelet abnormalities, active malignancy, and intraoperative dural tears; those who were <20 years old; and those who were followed up for <1 year. When the records of patients were checked, CSD was accidentally used for one patient after the drain was changed to CNSD, and, thus, this patient was also excluded. Therefore, 100 consecutive patients were extracted before and after the drain type was changed (CSD and CNSD groups, respectively), and these two groups were compared.

Primary outcome measures were the drainage amount, blood counts before and after surgery, and postoperative complications, including surgical site infection, the formation of symptomatic hematomas, C5 palsy, and the need for blood transfusion. Fluid collection at the surgical site was evaluated using magnetic resonance images (MRI) taken 10-

14 days after surgery. All T2-weighted axial views were examined, and the area of fluid collection adjacent to the epidural space was measured using ImageJ64 software (version 1.46r; NIH, Bethesda, MD). The largest fluid collection areas were categorized as small, medium, and large relative to the area of the canal space of the C2 vertebra (the C2 area). The fluid collection area was defined as small when it was smaller than the C2 area, medium when it was larger than the C2 area and smaller than twice the size of the C2 area, and large when it was larger than twice the size of the C2 area (Fig. 1). To assess disease severity, Japanese Orthopaedic Association (JOA) scores for the cervical spine⁶⁾ before and 1 year after surgery were evaluated.

Potential risk factors affecting clinical outcomes, including sex, age, body mass index (BMI), smoking, comorbidities (diabetes, rheumatoid arthritis, dialysis, and hypertension), blood pressure on admission, surgical data, and blood counts, were analyzed.

Blood tests and calculation of total and hidden blood loss

We included patients with blood counts tested within 3 weeks before and 7-10 days after surgery, at which time hemodynamic stability was expected to be achieved⁷⁾. Patients with blood transfusion or dialysis, or both, were excluded. Therefore, 78 patients in the CSD group and 90 in the CNSD group were analyzed. Hemoglobin levels before and after surgery (Hb_{pre} and Hb_{post} , respectively) and the hematocrit level before and after surgery (Hct_{pre} and Hct_{post} , respectively) were recorded. The average of Hct_{pre} and Hct_{post} was also calculated (Hct_{ave}).

Patient blood volume (PBV) was estimated using the formula reported by Nadler⁸⁾. Total blood loss (TBL) was cal-

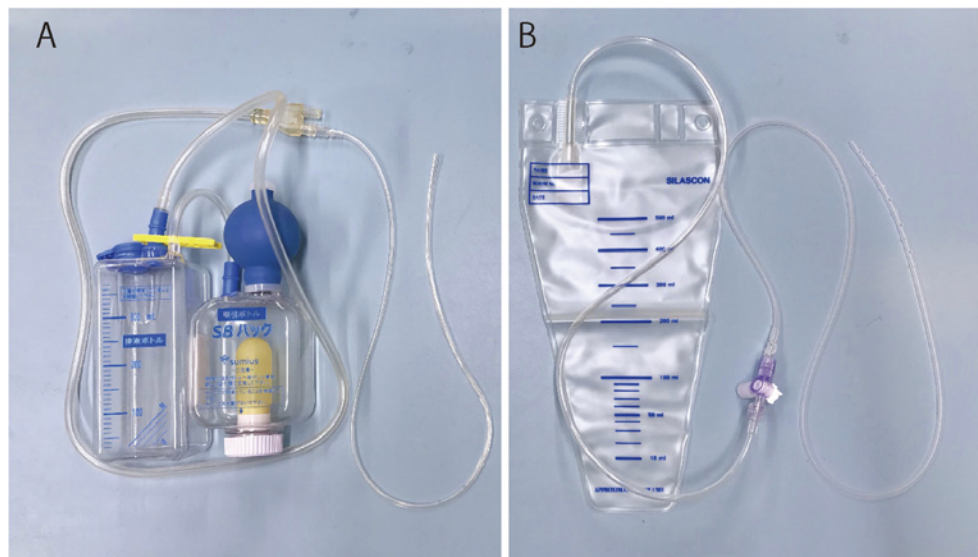


Figure 2. A, The closed suction drain used before January 2018. B, The closed nonsuction drain used after January 2018.

culated using the Gross equation⁹⁾, and hidden blood loss (HBL) was also calculated⁷⁾.

$$\text{PBV (mL)} = (k_1 \times \text{height (m)}^3 + k_2 \times \text{weight (kg)} + k_3) \times 1000$$

For men, $k_1=0.3669$, $k_2=0.03219$, and $k_3=0.6041$

For women, $k_1=0.3561$, $k_2=0.03308$, and $k_3=0.1833$

$$\text{TBL (mL)} = (\text{PBV} \times (\text{Hct}_{\text{pre}} - \text{Hct}_{\text{post}})) / \text{Hct}_{\text{ave}}$$

$\text{HBL (mL)} = \text{TBL} - \text{estimated blood loss at surgery} - \text{drainage amount}$

Surgical procedure for open door laminoplasty

All patients underwent open door laminoplasty as previously reported¹⁰⁾. Briefly, the patient's head was fixed with a Mayfield head clamp in the prone position. Using a midline skin incision, the lamina surface was exposed. The center of the lamina was split using a high-speed diamond bar with a diameter of 3 mm. A bony groove was created on the medial side of the facet joint using a diamond bar with a diameter of 5 mm, and the lamina was opened bilaterally. The open lamina was fixed using a suture anchor inserted into the lateral mass¹¹⁾. Partial laminectomy was added to the caudal and cranial sides of the opened laminae in a case-dependent manner. A single drainage tube was placed before wound closure. Before January 2018, an SB tube (Sumitomo Bakelite, Co., Ltd., Tokyo, Japan) was used (CSD, Fig. 2A), which is the same tube type to the Jackson-Pratt drainage tube¹⁾. SILASCON (Kaneka Medical, Co., Ltd., Osaka, Japan) has since been employed (CNSD, Fig. 2B) and has same tube type to the Jackson-Pratt drainage tube. Drainage tubes were removed 24-36 hours after surgery in all patients. Patients were allowed to start rehabilitation after drainage tube removal by using a soft cervical orthosis for 2 weeks.

Statistical analysis

A *t*-test was used for comparisons between two groups when normality was confirmed, and the Mann-Whitney *U* test was used for those without normality. Fisher's exact test

was employed to analyze the frequencies of variables. Changes in Hb, Hct, and JOA scores were verified using repeated measures analysis of variance. To predict the drainage amount, a multivariable linear regression analysis was used to examine the relationships between the drainage amount and independent variables using the stepwise elimination of variables. A multivariable logistic regression analysis was performed to assess the influence of possible risk factors on the size of hematomas (small or medium and large). The 95% confidence interval of the odds ratio was calculated. A *P* value <0.05 was considered significant in all analyses. All calculations were performed using R (R for 2.14.1 GUI 1.43).

Results

Demographic and baseline clinical data are shown in Table 1. No significant differences were observed in any items, including age, BMI, smoking, antiplatelet or anticoagulant drug use, comorbidities, and blood pressure, between the two groups. The most common index pathology was cervical spondylotic myelopathy in both groups, accounting for >80% of cases.

Clinical results of surgery

As shown in Table 2, no significant differences were observed in any surgical parameters, including the number of levels decompressed, surgical times, or estimated blood loss, between the CSD and CNSD groups. Postoperative complications included C5 paralysis in four patients each, SSI in one patient each, and blood transfusion in one patient each in the CSD and CNSD groups; however, no patient developed symptomatic hematoma. The amount of drainage was significantly greater in the CSD group than in the CNSD group (224 vs. 143 mL) (Fig. 3). Epidural fluid collection was evaluated in 70 and 79 patients in the CSD and CNSD

Table 1. Comparison of Demographic and Clinical Data between Patients Using Suction Drain and Those Using Nonsuction Drain.

	CSD group	CNSD group	P
Number of patients	100	100	
Sex			
Male	66	67	1
Female	34	33	
Age±SD (years)	68.7±11.9	69.6±10.7	0.56
BMI±SD	23.9±4.5	24.3±4.9	0.51
Smoking			0.94
Current	14	12	
Former	32	32	
Never	54	56	
Diabetes	18	23	0.38
Hypertension	43	51	0.36
Antiplatelet or coagulant drug	30	25	0.53
Rheumatoid arthritis	2	6	0.17
Dialysis	4	1	0.37
Pathology			0.38
CSM	83	89	
OPLL	8	3	
Trauma	3	4	
Others	6	4	
BP–systolic at admission±SD (mmHg)	131 (20.7)	135 (18.0)	0.17
BP–diastolic at admission±SD (mmHg)	76.2 (11.0)	76.2 (12.9)	0.98

CSD, closed suction drain; CNSD, closed nonsuction drain; SD, standard deviation; BMI, body mass index; CSM, cervical spondylotic myelopathy; OPLL, ossification of posterior longitudinal ligament; BP, blood pressure

groups, respectively. Small and medium to large fluid collection areas were significantly more common in the CSD and CNSD groups, respectively. No significant differences were observed between baseline and 1 year postoperative JOA scores between the two groups.

Regarding blood counts, Hb_{pre} and Hct_{pre} did not significantly differ between the CSD and CNSD groups; however, Hb_{post} and Hct_{post} were significantly decreased in the CSD group than in the CNSD group (Fig. 4). TBL was also significantly greater in the CSD group than in the CNSD group. The difference in TBL between the two groups (93 mL, N=168) was similar to that in the drainage amount between the two groups (81 mL, N=200), and HBL was similar in the CSD and CNSD groups (96.1 vs. 80.0 mL, P=0.60).

Analysis of factors affecting the drainage amount

A multiple regression analysis identified the drain type (t value=6.3) and number of decompressed levels (t value=5.6) as factors affecting the drainage amount (Table 3). BMI and male sex were also risk factors for increases in the drainage amount.

Analysis of factors affecting the amount of epidural fluid collection

As shown in Table 4, low systolic blood pressure at admission and the use of CNSD were risk factors for medium

or large epidural fluid collection in the univariable analysis. In the multivariable regression analysis, only the use of CNSD was identified as an independent significant risk factor for medium or large epidural fluid collection.

Discussion

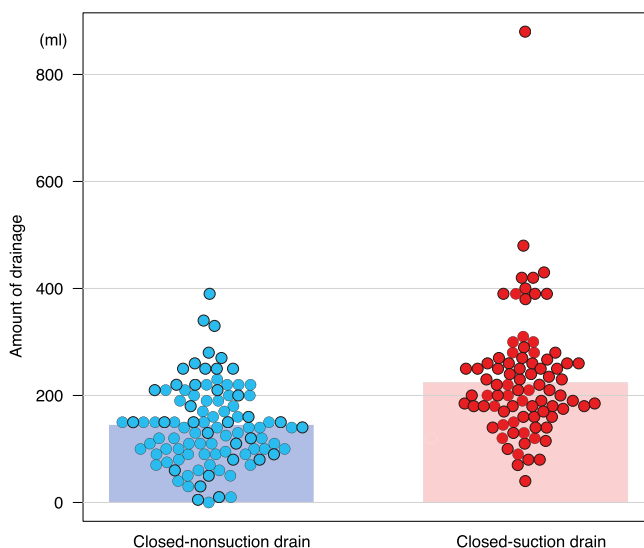
This is the first study to report differences in clinical outcomes between different types of drains, CSD and CNSD, after CLP. One of the strengths of the present study is that MRI was performed on 75% of patients in the early postoperative period, and, thus, the amount of epidural fluid collection was examined. Furthermore, the type of drain was not selected on the basis of the preferences of surgeons, but changed over time. Therefore, the CSD and CNSD groups were assumed to be homogeneous, but differed according to the time of surgery. To ensure that similar surgical techniques were performed, only CLP was included in the present study; patients on whom posterior instrumentation was performed were excluded. No significant differences were observed in the backgrounds of these patients, including demographic data and comorbidities, or surgical factors, such as the number of levels decompressed and estimated blood loss.

The present results showed a mean difference of 81 mL in the postoperative drainage volume between 100 patients in the CSD group and 100 patients in the CNSD group. Al-

Table 2. Comparison of Clinical Data between Patients Using Suction Drain and Those Using Nonsuction Drain.

	CSD group	CNSD group	P value
Number of patients	100	100	
Number of levels decompressed $\pm$ SD	4.4 $\pm$ 1.0	4.3 $\pm$ 1.0	0.40
Surgical time $\pm$ SD (min)	87.1 $\pm$ 28.0	84.2 $\pm$ 30.1	0.50
Estimated blood loss $\pm$ SD (mL)	28.3 $\pm$ 42.1	24.6 $\pm$ 45.3	0.55
Drainage amount $\pm$ SD (mL)	224 $\pm$ 115	143 $\pm$ 74	<0.001
Complications			
C5 palsy	4	4	1.0
Surgical site infection	1	1	1.0
Symptomatic hematoma	0	0	1.0
Blood transfusion	1	1	1.0
JOA score (preoperative)	11.2	11.5	0.36†
JOA score (1-year postoperative)	14.4	14.3	<0.0001*
Blood test and calculation	N=78	N=90	
Hb _{pre} $\pm$ SD (g/dL)	13.6 $\pm$ 1.5	13.7 $\pm$ 1.5	0.0028†
Hb _{post} $\pm$ SD (g/dL)	12.2 $\pm$ 1.4	12.7 $\pm$ 1.4	<0.0001*
Hct _{pre} $\pm$ SD	40.4 $\pm$ 4.3	40.5 $\pm$ 4.0	0.00026†
Hct _{post} $\pm$ SD	36.1 $\pm$ 3.8	37.6 $\pm$ 3.9	<0.0001*
Total blood loss $\pm$ SD (mL)	338 $\pm$ 188	245 $\pm$ 191	0.0024
Hidden blood loss $\pm$ SD (mL)	96.1 $\pm$ 206	80.0 $\pm$ 194	0.60
Epidural fluid collection	N=70	N=79	
Small	29	17	0.033
Medium	27	40	
Large	14	22	

CSD, closed suction drain; CNSD, closed nonsuction drain; SD, standard deviation; Hb_{pre}, hemoglobin count before surgery; Hct_{pre}, hematocrit before surgery; Hb_{post}, hemoglobin count after surgery; Hct_{post}, hematocrit after surgery; JOA, Japanese Orthopaedic Association; *, Time (preoperative and postoperative) effect; †, Time $\times$ Factor effect

**Figure 3.** Average value and distribution of drainage volumes between patients with closed nonsuction and suction drains.

though no significant differences were observed in Hb_{pre} and Hct_{pre} between the two groups, both Hb_{post} and Hct_{post} were significantly lower in the CSD group than in the CNSD group. TBL calculated from Hct was also higher in the CSD

group by an average of 93 mL, which was similar to the difference noted in the postoperative drainage volume, suggesting that the difference in TBL was derived solely from differences in the postoperative drainage volume between the CSD group and CNSD group. HBL did not significantly differ between the two groups, which supports this result. CLP had a short surgical time and low intraoperative blood loss, with only one patient in each group requiring a blood transfusion. Postoperative Hb levels were slightly higher in the CNSD group than in the CSD group, which suggests the superiority of CNSD. In the present study, differences in Hb_{post} and Hct_{post} were significant but small and, thus, may not have significant clinical implications. However, in highly invasive surgeries, such as posterior fixation, these differences may increase and affect clinical outcomes. Conversely, postoperative wound fluid collection was significantly larger in the CNSD group than in the CSD group, and the multivariate analysis also identified the use of CNSD as a significant risk factor for medium to large fluid collection. Symptomatic hematomas were not detected in either group; however, because they infrequently occur in CLP, this result needs to be confirmed in a larger study. Regarding infection, one case of infection was found in each group, and this also needs to be verified in a larger case series. Regarding func-

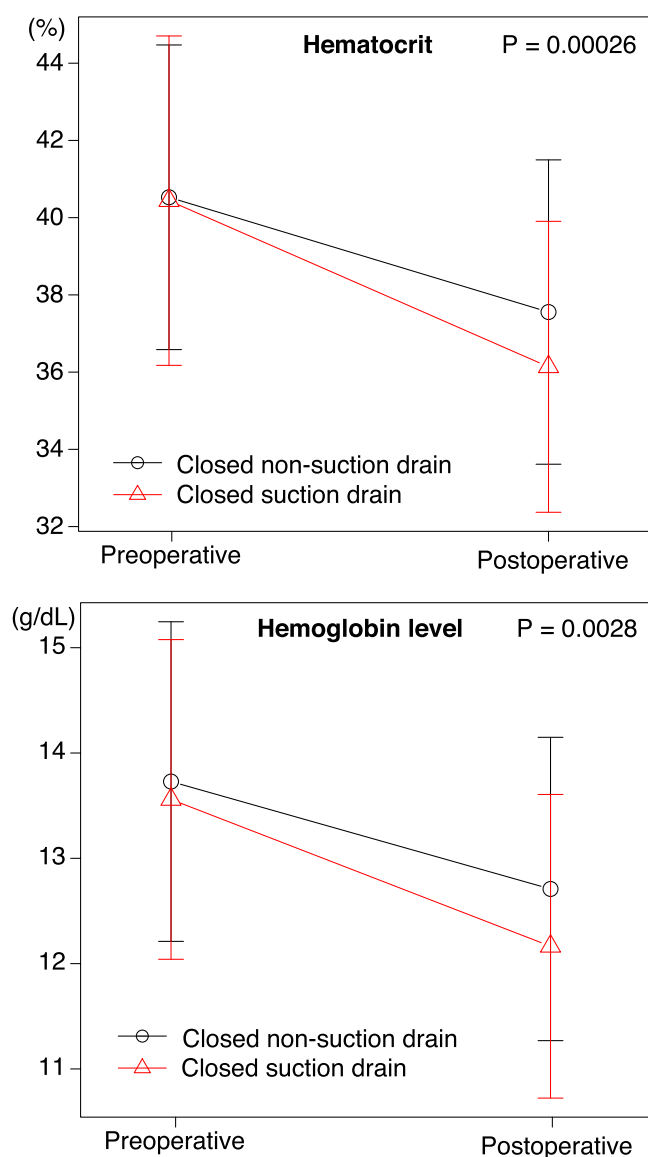


Figure 4. Changes in the hematocrit (upper panel) and hemoglobin levels (lower panel).

tional outcomes, no significant differences were observed in JOA scores between the two groups before and after surgery, and the type of drainage did not appear to affect clinical outcomes at 1 year after surgery.

The limitation of the present study is its retrospective nature; therefore, the same surgeons did not perform surgery, and there may have been omissions in data, such as comorbidities and medication. Additionally, because the timing of blood collection was not consistent, blood collection data were only examined in 168 cases (84% of all cases). This was also the case for MRI, which was performed on 75% of patients. Another limitation is the small number of cases with complications, such as infection and symptomatic epidural hematoma. We estimated the incidence of each to be approximately 1%, and even if we assume an incidence error of 0.5% with a 95% confidence interval, we need approximately 1500 cases in each group.

The placement of CSD reduces the amount of blood accu-

mulating in a closed wound, which theoretically inhibits the formation of hematomas, wound-healing complications, and infection¹²⁾. In contrast, the presence of drains may lead to bacterial invasion and increased infection rates with prolonged indwelling¹³⁾. Limited information is currently available on the use of drains at the cervical or thoracic spine in which the spinal cord resides. A previous study compared the outcomes of 324 patients with and 176 without drains following surgery for adolescent idiopathic scoliosis, which does not generally require decompression, and found no significant differences in infection rates, including early and late infections. Conversely, because the number of cases requiring blood transfusion was higher in the group using drains, it was concluded that the use of drains is a risk factor for blood transfusion¹⁴⁾. Regarding posterior surgery on the cervical spine, Herrik et al.¹⁵⁾ conducted a retrospective study on 1799 patients and found fewer reoperations for SSI in the group with drains than in the group without drains after adjustments for the presence of diabetes and number of operative levels; however, the reoperation rate for hematomas did not significantly differ between the two groups. These studies were retrospective and did not eliminate selection bias regarding the use of drains.

In the lumbar spine, an RCT on 28 patients each with and without suction drains in minimally invasive transforaminal lumbar interbody fusion reported a shorter hospital stay of 1 day without drains; however, other clinical outcomes did not significantly differ⁵⁾. Gubin et al.⁴⁾ performed RCT on the use of drains in posterior lumbar surgery at multiple levels of the lumbar spine; in their analysis of 161 cases, they noted that TBL was greater and significantly more cases required blood transfusion in the drain group. Conversely, postoperative aspiration was significantly more common in the no-drain group; however, no significant differences were observed in wound complications, such as infection.

The lack of RCT on the use of drains in posterior surgery on the cervical spine is due to concerns regarding the worsening of neurological symptoms due to the potential formation of hematomas in the absence of drains. In the present study, the use of CNSD was confirmed to decrease TBL. However, postoperative epidural fluid collection was larger in the CNSD group, and, thus, the risk of hematoma-induced paralysis may be higher in those without drains than in those with drains. The present results suggest that CNSD is useful for decreasing TBL without increasing the risk of complications, such as wound infection and formation of hematomas.

Conclusions

The use of CNSD in CLP has the potential to decrease the postoperative drainage amount and TBL. Although there was no difference in the incidence of perioperative complications such as symptomatic hematoma or surgical site infection, the amount of epidural fluid collected was larger in the CNSD group than in the CSD group.

Table 3. Multiple Regression Analysis to Estimate the Amount of Drainage.

Variables	Estimates	Std. error	t value	P
BMI	4.3	1.5	2.8	0.0054
Num. decompressed level	35.3	6.3	5.6	<0.001
CSD (vs. CNSD)	80.1	12.7	6.3	<0.001
Male (vs. Female)	48.6	13.6	3.6	<0.001

BMI, body mass index; CSD, closed suction drain; CNSD, closed nonsuction drain

Table 4. Analysis of Factors Affecting the Amount of Epidural Fluid Collection.

	Univariable analysis			Multivariable analysis		
	Small	Medium or Large	P	Odds ratio	95%CI	P
Number of patients	46	103				
Sex			0.094			
Male	26 (65%)	73 (72%)		2.1	0.77–5.6	0.15
Female	20 (35%)	30 (28%)		Control		
Age±SD (years)	71.5±10.7	69.5±11.3	0.31	Not included		
BMI±SD	24.3±4.7	23.9±3.7	0.53	0.97	0.84–1.1	0.52
Smoking			0.88	Not included		
Current	5 (11%)	13 (13%)				
Former	16 (35%)	32 (31%)				
Never	25 (54%)	58 (56%)				
Diabetes	7 (15%)	25 (24%)	0.28	1.8	0.55–5.8	0.33
Hypertension	22 (48%)	46 (45%)	0.73	0.72	0.28–1.8	0.48
Antiplatelet or coagulant drug	15 (33%)	27 (26%)	0.44	0.94	0.34–2.6	0.89
BP–systolic at admission±SD (mmHg)	138.8±16.9	132.9±17.0	0.050	1.0	0.97–1.0	0.94
BP–diastolic at admission±SD (mmHg)	77.9±11.5	75.7±11.6	0.28	Not included		
Number of levels decompressed±SD	4.2±1.1	4.4±1.0	0.31	1.4	0.91–2.3	0.12
Drainage amount±SD (mL)	182±131	183±91	0.99	Not included		
Estimated blood loss±SD (mL)	28.8±56.9	19.0±26.9	0.15	Not included		
Hb _{pre} ±SD (g/dL)	13.2±1.6	13.9±1.5	0.044	1.3	0.95–1.8	0.10
Hct _{pre} ±SD	39.5±4.2	41.2±4.0	0.045	Not included		
CNSD	17 (37%)	62 (60%)	0.013	2.86	1.3–6.1	0.0061

SD, standard deviation; BMI, body mass index; BP, blood pressure; Hb_{pre}, hemoglobin count before surgery; Hct_{pre}, hematocrit before surgery; CNSD, closed nonsuction drain

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

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Author Contributions: BO: Conceptualization, Methodology, Data Curation, and Writing-Original draft preparation. SF, TS, and KM: Visualization, Investigation, and Writing-Reviewing and Editing. SM: Supervision, Reviewing, and Editing.

Ethical Approval: This study was approved by the institutional review board of Kyoto University (R2364).

Informed consent of the patients was not required since this was a retrospective study that used anonymous clinical data. In addition, we used the Opt-out method, which guaranteed the opportunity to refuse to participate in the study after knowing about the conduct and objectives of the study on our website.

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