

Patient- and Operator-Related Factors Associated With Difficult Lumbar Epidural Catheter Placement: A Retrospective Observational Study

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Review began 10/11/2026

Review ended 10/22/2026

Published 10/25/2026

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DOI: 10.7759/cureus.118561

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Abstract

Background

Lumbar epidural catheter placement is widely used for perioperative analgesia in lower abdominal, pelvic, and lower extremity surgery; however, the procedure may be technically challenging and may require multiple skin punctures. In this study, we defined difficult placement as requiring two or more skin punctures and aimed to identify patient- and operator-related factors associated with difficult lumbar epidural catheter placement.

Methods

In this retrospective observational study, we analyzed consecutive patients who underwent lower abdominal, pelvic, or lower extremity surgery under general or spinal anesthesia combined with lumbar epidural anesthesia. Difficult lumbar epidural catheter placement was defined as requiring two or more skin punctures. Patient- and operator-related factors associated with difficult placement were evaluated using multivariable logistic regression analysis. The multivariable model included age, body mass index (BMI), and years of anesthesiology experience. To account for within-operator correlation arising from multiple procedures performed by the same operator, cluster-robust standard errors were calculated using the individual operator as the clustering unit.

Results

Of 111 consecutive patients who underwent lumbar epidural catheter placement between April 8, 2021, and July 31, 2026, two were excluded because of insufficient documentation, leaving 109 patients for analysis. Difficult placement occurred in 31 (28.4%) patients. In the multivariable logistic regression analysis, older age was independently associated with difficult placement (adjusted odds ratio, 1.03 per year; 95% confidence interval, 1.002-1.058; $p=0.037$). In contrast, BMI (adjusted odds ratio, 1.06 per kg/m^2 ; 95% confidence interval, 0.980-1.142; $p=0.151$) and years of anesthesiology experience (adjusted odds ratio, 0.99 per year; 95% confidence interval, 0.945-1.042; $p=0.763$) were not independently associated with difficult placement. In the univariate analysis, BMI and puncture approach were significantly associated with difficult placement. Difficult placement was also associated with longer procedure time and greater skin-to-epidural space distance. Lumbar puncture level was not significantly associated with difficult placement.

Conclusions

Older age was independently associated with difficult lumbar epidural catheter placement. In contrast, no significant associations were observed for BMI or years of anesthesiology experience. However, the magnitude of the association between age and difficult placement was modest, and the clinical significance and predictive utility of age remain uncertain. The paramedian approach was more frequently used in patients with difficult placement; however, this association may have been influenced by the selection of the puncture approach according to anticipated procedural difficulty.

Categories: Anesthesiology

Keywords: age, body mass index, difficult catheter placement, epidural catheter placement, lumbar epidural anesthesia, operator experience

Introduction

Lumbar epidural anesthesia (LEA) provides effective perioperative analgesia for lower abdominal, pelvic, and lower extremity surgery and contributes to reduced opioid consumption and enhanced postoperative recovery. However, in patients with difficult epidural catheter placement, multiple puncture attempts may increase patient discomfort [1], and an increased number of procedural attempts and prolonged procedure time have been reported to be associated with accidental dural puncture and postdural puncture headache [2]. Furthermore, improper epidural catheter placement or inadequate analgesia may adversely affect

How to cite this article

Tanimoto S, Shakuo T, Hirai K, et al. (October 25, 2026) Patient- and Operator-Related Factors Associated With Difficult Lumbar Epidural Catheter Placement: A Retrospective Observational Study. Cureus 18(10): e118561. DOI 10.7759/cureus.118561

postoperative pain control and perioperative management. Therefore, identifying factors associated with difficult epidural catheter placement before the procedure is clinically important. Previous studies have reported that a high body mass index (BMI) is associated with greater skin-to-epidural space distance, an increased number of puncture attempts, prolonged procedure time, and a lower success rate of epidural anesthesia; these associations have also been reported in obstetric settings, including labor epidural analgesia [3–5].

We previously reported that older age, higher BMI, and fewer years of operator experience were independently associated with difficult thoracic epidural catheter placement [6]. However, the thoracic and lumbar spine differ in the angulation of their spinous processes. The pronounced caudal angulation of the midthoracic spinous processes can restrict access to the interspinous spaces during needle insertion, potentially making thoracic epidural puncture more technically challenging than lumbar epidural puncture [7,8]. Therefore, it remains unclear whether the factors associated with difficulty in thoracic epidural catheter placement are similarly associated with difficulty in lumbar epidural catheter placement. In this study, difficult lumbar epidural catheter placement was defined as requiring two or more skin punctures. The primary objective was to identify patient- and operator-related factors associated with difficult lumbar epidural catheter placement. In addition, we conducted exploratory descriptive analyses of procedure-related characteristics, including puncture approach, procedure time, skin-to-epidural space distance, and lumbar puncture level, according to the presence or absence of difficult placement.

Materials And Methods

In this retrospective observational study, we included consecutive patients who underwent lower abdominal, pelvic, or lower extremity surgery under general or spinal anesthesia combined with LEA at Showa Medical University Northern Yokohama Hospital from April 8, 2021, to July 31, 2026. For LEA, the attending anesthesiologist selected an appropriate lumbar puncture level according to the type of surgery and performed the procedure using either the midline or paramedian approach.

Study endpoints

The primary endpoint was the presence or absence of difficult lumbar epidural catheter placement. Difficult placement was defined, based on the definition of difficult epidural puncture used in a previous study [1], as requiring two or more skin punctures. Data on patient characteristics, surgical procedures, and lumbar epidural catheter placement were collected. Patients' overall physical status was assessed using the American Society of Anesthesiologists Physical Status classification (ASA-PS) [9]. Patient-related factors included age, sex, height, weight, BMI, ASA-PS, pregnancy, and a history of spinal disease.

Obesity was defined as BMI ≥ 25 kg/m² in accordance with the criteria of the Japan Society for the Study of Obesity [10]. Obesity was not classified by severity because BMI was treated as a continuous variable in the multivariable analysis. Spinal diseases included lumbar disc herniation, spinal canal stenosis, osteoporosis, or other lumbar spine disorders.

Operator-related factors included years of anesthesiology experience, which served as a surrogate measure of procedural experience. The identity and years of anesthesiology experience of the initial operator were recorded for each patient. These data were used in the statistical analysis, regardless of whether a supervising anesthesiologist subsequently took over the procedure. For descriptive purposes, years of anesthesiology experience were categorized as junior (1–2 years), mid-level (3–9 years), or senior (≥ 10 years). In the multivariable analysis, years of anesthesiology experience were treated as a continuous variable to avoid information loss due to categorization.

Procedure-related factors included the time required for lumbar epidural catheter placement, the number of skin punctures, the skin-to-epidural space distance, lumbar puncture level, puncture approach, and the presence or absence of LEA-related complications. The puncture approach was recorded as the midline or paramedian approach used for successful catheter placement. The initially selected approach and any changes in approach during the procedure were not systematically documented. Comparisons of procedure-related characteristics between patients with and without difficult placement were conducted as exploratory descriptive analyses.

Lumbar epidural catheter placement

Epidural puncture and catheter placement were performed using the Perifix® Standard Kit (continuous epidural anesthesia catheter kit with NRFit® connector, PSK-S1000RN; B. Braun, Melsungen, Germany), which included an 18-gauge, 80-mm Tuohy epidural needle. Patients were placed in the lateral decubitus position, and epidural puncture was performed using a Tuohy needle. Entry of the needle tip into the epidural space was confirmed using the loss-of-resistance technique with saline. No standardized criteria were established for the initial selection of the midline or paramedian approach or for switching between approaches during the procedure. These decisions were made by the anesthesiologist performing the procedure based on clinical judgment. For the paramedian approach, the needle insertion angle and direction of advancement were not standardized and were determined by each operator based on clinical

judgment and anatomical landmarks. Specific insertion angles were not systematically recorded. A supervising anesthesiologist could take over the procedure based on their clinical judgment, without predefined criteria regarding the number of skin punctures required before operator crossover. The total number of skin punctures was counted for each patient, regardless of whether operator crossover occurred. Difficult placement was defined as requiring two or more skin punctures, irrespective of operator crossover. Each new skin puncture was counted as one puncture attempt, whereas changes in needle direction during the same skin puncture were not counted as additional attempts. The lumbar puncture level was recorded as the lumbar intervertebral level at which epidural catheter placement was successful.

Statistical analysis

Continuous variables were presented as mean $\pm$ standard deviation or median (interquartile range), depending on their distribution. In the univariate analysis, age, height, BMI, years of anesthesiology experience, and lumbar puncture level were categorized and compared using Pearson's chi-squared test. Skin-to-epidural space distance and procedure time were compared using the Wilcoxon rank-sum test. Other categorical variables were compared using Pearson's chi-squared test or Fisher's exact test, as appropriate. To evaluate the independent associations of patient- and operator-related factors with difficult lumbar epidural catheter placement, multivariable logistic regression analysis was performed with difficult placement (≥ 2 skin punctures) as the dependent variable. Given the relatively small sample size and the limited number of difficult placement events (31 cases), the number of explanatory variables included in the multivariable logistic regression model was restricted to three to reduce the risk of overfitting and unstable parameter estimates. Age, BMI, and years of anesthesiology experience were selected based on their clinical relevance and associations reported in previous studies. In the multivariable analysis, age, BMI, and years of anesthesiology experience were treated as continuous variables. The multivariable logistic regression model was fitted using the `glm()` function in R with a binomial family and logit link. To account for within-operator correlation arising from multiple procedures performed by the same initial operator, cluster-robust standard errors were calculated using the initial operator as the clustering unit. The cluster-robust variance-covariance matrix was estimated using the `vcovCL()` function from the `sandwich` package, with the HCO estimator and a finite-cluster correction (`cadjust = TRUE`). Adjusted odds ratios (aORs) were obtained by exponentiating the regression coefficients, and 95% confidence intervals (CIs) and two-sided p-values were calculated using Wald z-tests based on cluster-robust standard errors.

All tests were two-sided, and a p-value < 0.05 was considered statistically significant. Statistical analyses were performed using R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 111 consecutive patients who underwent lower abdominal, pelvic, or lower extremity surgery under general or spinal anesthesia combined with LEA were enrolled. Of these, two patients were excluded because of incomplete procedural documentation, including missing information on the number of skin punctures and/or lumbar puncture level, leaving 109 patients for the final analysis. A total of 31 anesthesiologists were identified as initial operators. The median number of procedures per initial operator was 3 (interquartile range, 2.0–4.5; range, 1–9).

Baseline characteristics are shown in Table 1. The mean age was 49.0 ± 17.0 years, the mean height was 158.0 ± 6.7 cm, and the mean BMI was 24.1 ± 4.6 kg/m². Forty-three (39%) patients had obesity (BMI ≥ 25 kg/m²). Regarding procedure-related factors, the mean procedure time was 9.6 ± 5.4 minutes; the mean number of puncture attempts was 1.54 ± 1.08 ; the mean skin-to-epidural space distance was 4.67 ± 0.90 cm; and the median lumbar puncture level was 2.0 (2.0–3.0).

Variables	N=109 ¹
Experience (years), mean ± SD	5.0 ± 8.0
Age (years), mean ± SD	49.0 ± 17.0
Height (cm), mean ± SD	158.0 ± 6.7
Weight (kg), mean ± SD	60 ± 13
BMI (kg/m ²), mean ± SD	24.1 ± 4.6
Time (min), mean ± SD	9.6 ± 5.4
Lumbar puncture level, median (IQR)	2.00 (2.00, 3.00)
Attempts, mean ± SD	1.54 ± 1.08
Depth (cm), mean ± SD	4.67 ± 0.90
Surgical procedure	
C-section	2 (1.8%)
Hip	27 (25%)
Inguinal	1 (0.9%)
Knee	14 (13%)
Lower limb	6 (5.5%)
Uterus	59 (54%)
¹ Mean ± SD; median (Q1, Q3); n (%)	

TABLE 1: Baseline patient and procedural characteristics

IQR, interquartile range; SD, standard deviation.

The most common surgical procedures were uterine surgery in 59 (54%) patients, hip surgery in 27 (25%) patients, and knee surgery in 14 (13%) patients.

The primary endpoint -- difficult placement (≥2 skin punctures) -- was observed in 31 of 109 (28.4%) patients. Procedure-related complications occurred in four of 109 (3.7%) patients and included accidental dural puncture and bleeding during the procedure.

The results of the univariate analysis comparing patient characteristics and procedure-related factors according to the presence or absence of difficult placement are shown in Table 2. Age, sex, height, ASA-PS status, pregnancy, years of anesthesiology experience, lumbar puncture level, and a history of spinal disease or surgery were not significantly associated with difficult placement ($p>0.05$). In contrast, BMI was significantly associated with difficult placement ($p=0.033$). The prevalence of obesity in patients with and without difficult placement was 58% (18/31) and 32% (25/78), respectively.

		Procedural difficulty (attempts)			
Characteristic	Total (N=109) ¹	1 attempt (N=78) ¹	2 or more attempts (N=31) ¹	Test statistic ²	p-value ²
Age (years)				2.72	0.257
<40	50 (46%)	38 (49%)	12 (39%)		
40-64	29 (27%)	22 (28%)	7 (23%)		
≥65	30 (28%)	18 (23%)	12 (39%)		
Sex				0	>0.999
Female	96 (88%)	69 (88%)	27 (87%)		

Male	13 (12%)	9 (12%)	4 (13%)		
Height (cm)				1.14	0.567
<155 cm	38 (35%)	25 (32%)	13 (42%)		
155-164 cm	54 (50%)	41 (53%)	13 (42%)		
≥165 cm	17 (16%)	12 (15%)	5 (16%)		
BMI (kg/m ²)				6.83	0.033
Underweight (<18.5)	10 (9.2%)	9 (12%)	1 (3.2%)		
Normal (18.5-24.9)	56 (51%)	44 (56%)	12 (39%)		
Obese (≥25)	43 (39%)	25 (32%)	18 (58%)		
ASA-PS				4.39	0.111
1	41 (38%)	34 (44%)	7 (23%)		
2	66 (61%)	43 (55%)	23 (74%)		
3	2 (1.8%)	1 (1.3%)	1 (3.2%)		
Pregnancy	59 (54%)	47 (60%)	12 (39%)		0.055
Experience (years)				1.22	0.544
Junior (1-2 yrs)	66 (61%)	49 (63%)	17 (55%)		
Mid-level (3-9 yrs)	28 (26%)	20 (26%)	8 (26%)		
Senior (≥10 yrs)	15 (14%)	9 (12%)	6 (19%)		
Lumbar puncture level				6.24	0.101
L1	20 (18%)	15 (19%)	5 (16%)		
L2	49 (45%)	33 (42%)	16 (52%)		
L3	36 (33%)	29 (37%)	7 (23%)		
L4	4 (3.7%)	1 (1.3%)	3 (9.7%)		
Approach				11.7	<0.001
Midline	99 (91%)	76 (97%)	23 (74%)		
Para	10 (9.2%)	2 (2.6%)	8 (26%)		
History of spinal disease/surgery	3 (2.8%)	3 (3.8%)	0 (0%)		0.557
Depth to epidural space (cm)	4.50 (4.00, 5.00)	4.05 (4.00, 5.00)	5.00 (4.50, 6.00)	644	<0.001
Procedure Time (min)	8.0 (6.0, 11.0)	7.0 (6.0, 9.0)	14.0 (9.0, 21.0)	523	<0.001
¹ n (%); median (Q1, Q3)					
² Pearson's Chi-squared test; Wilcoxon rank sum test; Fisher's exact test. Pearson's χ^2 test (χ^2 statistic) was used for age, sex, height, BMI, ASA-PS, experience category, lumbar puncture level, and approach. Fisher's exact test was used for pregnancy and history of spinal disease/surgery; no conventional test statistic is reported for Fisher's exact test. The Wilcoxon rank-sum test (W statistic) was used for depth to the epidural space and procedure time. Approach refers to the approach used for successful catheter placement.					

TABLE 2: Univariate analysis of factors associated with lumbar epidural puncture difficulty

ASA-PS, American Society of Anesthesiologists Physical Status classification; BMI, body mass index.

The distribution of puncture approaches differed significantly according to the presence or absence of difficult placement ($p < 0.001$). The midline and paramedian approaches were used in 74% and 26% of cases, respectively, in the difficult placement group and in 97% and 2.6% of cases, respectively, in the control

group. In contrast, the lumbar puncture level was not significantly associated with difficult placement ($p=0.101$). Skin-to-epidural space distance was greater in the difficult placement group (5.00 (4.50-6.00) cm) than in the non-difficult placement group (4.05 (4.00-5.00) cm; $p<0.001$). Procedure time was also longer in the difficult placement group (14.0 (9.0-21.0) minutes) than in the non-difficult placement group (7.0 (6.0-9.0) minutes; $p<0.001$).

The results of the multivariable analysis are shown in Table 3. In the multivariable logistic regression analysis with difficult placement as the dependent variable, older age was independently associated with difficult placement (aOR, 1.03; 95% CI, 1.002-1.058; $p=0.037$). In contrast, BMI (aOR, 1.06; 95% CI, 0.980-1.142; $p=0.151$) and years of anesthesiology experience (aOR, 0.99; 95% CI, 0.945-1.042; $p=0.763$) were not significantly associated with difficult placement.

Characteristic	Adjusted odds ratio	z-value	95% CI	p-value
Age, years	1.03	2.081	1.002, 1.058	0.037
BMI, kg/m ²	1.06	1.436	0.980, 1.142	0.151
Experience, years	0.99	-0.302	0.945, 1.042	0.763

TABLE 3: Multivariable logistic regression analysis of factors associated with lumbar epidural puncture difficulty

BMI, body mass index; CI, confidence interval.

Discussion

In this study, we investigated patient- and operator-related factors associated with difficult lumbar epidural catheter placement, defined as requiring two or more skin punctures. Difficult placement occurred in 31 of 109 (28.4%) patients. In the univariate analysis, BMI and puncture approach were significantly associated with difficult placement. In contrast, in the multivariable analysis, including age, BMI, and years of anesthesiology experience, only older age was independently associated with difficult placement. The lumbar level at which catheter placement was successful was not significantly associated with difficult placement. Patients with difficult placement also had a greater skin-to-epidural space distance and a longer procedure time.

Older age was independently associated with difficult lumbar epidural catheter placement (aOR, 1.03; 95% CI, 1.002-1.058; $p=0.037$). Age-related morphological changes in the lumbar spine may affect the technical difficulty of epidural puncture. In older patients, multiple age-related changes, including narrowing of the interspinous and interlaminar spaces, ligament ossification, and facet joint hypertrophy, may make advancement of the needle into the epidural space more difficult [11]. A computed tomography (CT) study reported that the available needle maneuvering space for midline neuraxial puncture decreased significantly with age at all spinal levels, with the greatest age-related difference observed in the lumbar region [12]. Our findings are consistent with these studies. Hameed et al. evaluated the L2-S1 levels using CT and reported that the prevalence of ligamentum flavum calcification, interspinous ligament calcification, and spinous process contact increased with age [13]. Spinous process contact was most frequently observed at L4-5, whereas the absence of posterior epidural fat and the presence of fatty tissue in the midline, superficial to the ligamentum flavum, were more commonly observed at L5-S1. These findings suggest that anatomical factors impeding the advancement of an epidural needle in the lumbar spine can vary according to age and puncture level.

The proportion of patients with obesity was higher in the difficult placement group (58% vs. 32%), and univariate analysis showed a significant association between BMI and difficult placement ($p=0.033$). In contrast, in the multivariable model in which BMI was considered a continuous variable together with age and years of anesthesiology experience, BMI was not independently associated with difficult placement (aOR, 1.06; 95% CI, 0.980-1.142; $p=0.151$). Obesity and higher BMI are associated with difficult epidural puncture [4,5], and higher BMI has been associated with a greater skin-to-epidural space distance [3]. These associations have also been reported in obstetric settings, including during labor epidural analgesia. In addition, BMI is associated with the number of puncture attempts, whereas the palpability of surface landmarks is associated with first-attempt success. The distance from the skin to the epidural or subarachnoid space has been associated with both outcomes [14]. These factors may be interrelated. Skin-to-epidural space distance was significantly greater in the difficult placement group. BMI may reflect anatomical characteristics relevant to epidural puncture, such as the skin-to-epidural space distance, but may not independently predict procedural difficulty in this study.

Regarding operator experience, previous studies have reported associations with the first-attempt success rate and the number of puncture attempts in epidural anesthesia [15]. In contrast, the results showed no independent association between years of anesthesiology experience and difficult placement (aOR, 0.99; 95% CI, 0.945-1.042; $p=0.763$). Thoracic epidural puncture has been reported to have a lower first-attempt success rate and to require more puncture attempts and needle redirections than lumbar epidural puncture [7]. Lumbar epidural catheter placement may thus be technically less difficult than thoracic epidural catheter placement, which may have made differences related to operator experience less apparent. In contrast, a previous study on thoracic epidural catheter placement showed that more years of anesthesiology experience were independently associated with a lower likelihood of difficult placement [6]. However, the conflicting results may be due to differences in patient characteristics, sample size, number of difficult placement cases, and statistical methods. In particular, the present study used cluster-robust standard errors with the individual operator as the clustering unit. Therefore, the discrepancy between these two studies may reflect differences in cohort characteristics, analytical methods, and technical difficulty between thoracic and lumbar puncture.

The paramedian approach was significantly associated with difficult placement ($p<0.001$). However, previous studies comparing the midline and paramedian approaches for lumbar epidural catheter placement reported fewer technical problems, such as repeated puncture attempts and difficulty identifying the epidural space, with the paramedian approach [16], as well as a shorter catheter insertion time [17]. The association between the paramedian approach and difficult placement does not necessarily indicate that this approach increases procedural difficulty. Rather, it may reflect confounding by indication if the paramedian approach was preferentially selected in patients anticipated to have difficult placement, or a change from the midline to the paramedian approach after difficulty had already been encountered.

The lumbar level at which epidural catheter placement was successfully achieved was not significantly associated with difficult placement ($p=0.101$). However, the anatomical space available for LEA has been reported to vary according to the intervertebral level. Bae et al. evaluated the interlaminar spaces at L3-4, L4-5, and L5-S1 using ultrasonography and reported that interlaminar height was greatest at L5-S1, while right-left asymmetry was observed even at the same level within the same patient [18]. Furthermore, a three-dimensional CT-based anatomical analysis demonstrated that puncture-related parameters, including interlaminar space area, effective dural sac area, and traversing nerve root area, varied across lumbar levels and differed across age groups [19]. These results suggest that the difficulty of LEA may be influenced by the intervertebral level and other factors, including local anatomy and age-related changes. No clear association was observed between the lumbar level at which catheter placement was successfully achieved and difficult placement. However, the number of cases was unevenly distributed across puncture levels, and successful placement at L4 was uncommon; therefore, no definitive conclusions can be drawn regarding the relationship between lumbar puncture level and procedural difficulty.

Procedure time was significantly longer in the difficult placement group than in the non-difficult placement group (14.0 vs. 7.0 minutes, $p<0.001$), and skin-to-epidural space distance was also greater (5.00 vs. 4.05 cm, $p<0.001$). The skin-to-epidural space distance is associated with the technical difficulty of epidural anesthesia [14]. In addition, an increased number of puncture attempts, prolonged procedure time, and greater skin-to-epidural space distance are associated with complications such as accidental dural puncture and post-dural puncture headache [2]. The prolonged procedure time and greater skin-to-epidural space distance may represent clinically important characteristics of difficult placement. However, because neither variable was assessed before catheter placement, their value for predicting difficult placement before the procedure could not be established.

Our findings suggest that increasing age is associated with difficult lumbar epidural catheter placement, defined as requiring two or more skin punctures. However, the magnitude of this association was modest, and its clinical significance remains uncertain. Furthermore, because predictive performance was not evaluated, our findings do not establish age as a clinically useful predictor of procedural difficulty. Procedural planning may benefit from consideration of patient-specific clinical and anatomical characteristics, including BMI, surface anatomical landmarks, and spinal morphology. In patients in whom difficult placement is anticipated, preprocedural ultrasonographic assessment, including identification of the puncture level, midline, and intervertebral spaces, and estimation of the skin-to-epidural space distance, may be useful for procedural planning [20].

Limitations

This study had several limitations related to the study design, procedural factors, assessment of patient and operator characteristics, outcome definition, and study comparability.

The retrospective, single-center observational design limits causal inference and may restrict the generalizability of our findings to other institutions and patient populations with different characteristics. The sample size was relatively small, with 109 patients included in the analysis and 31 cases of difficult placement, limiting the number of patient- and operator-related factors that could be evaluated simultaneously. Although the multivariable model was restricted to three explanatory variables to reduce the risk of overfitting, the limited number of difficult placement events may have affected the stability of the

adjusted estimates. Furthermore, adjustment for potential confounding factors was limited, and residual confounding from unmeasured or unadjusted variables cannot be excluded.

The small sample size and limited number of difficult placement events also restricted our ability to evaluate subgroup-specific associations, including those involving specific spinal pathologies, obstetric versus non-obstetric patients, and individual lumbar puncture levels. In addition, the absence of statistically significant associations for BMI and years of anesthesiology experience should not be interpreted as evidence that clinically meaningful associations do not exist.

Although increasing age remained significantly associated with difficult placement, the magnitude of this association was modest, with a CI close to unity. Moreover, because predictive performance was not evaluated, the clinical significance and potential predictive utility of age remain uncertain.

Finally, the study population included patients with different clinical backgrounds and surgical indications, which may have influenced the results.

The initial puncture approach and any subsequent changes in approach were determined by the operator's clinical judgment without standardized criteria. Only the approach used for successful catheter placement was recorded; the initially selected approach and any changes during the procedure were not documented. The paramedian approach was recorded as the final successful approach in 10 patients. Therefore, we could not distinguish between patients in whom the paramedian approach was selected initially and those in whom it was adopted following difficulty with the midline approach. Furthermore, the needle insertion angles and advancement directions for the paramedian approach were neither standardized nor systematically documented, potentially introducing operator-dependent procedural variability that could not be adequately evaluated. Confounding by indication cannot be excluded, and the observed association between the paramedian approach and difficult placement should not be interpreted as evidence of a causal effect.

Furthermore, the lumbar puncture level was the level at which epidural catheter placement was successful, rather than the initially selected puncture level. Accordingly, the present findings cannot directly evaluate the effect of selecting a specific lumbar intervertebral level on the difficulty of epidural catheter placement.

The assessment of spinal condition was based on medical history, and the presence and severity of spinal deformities or age-related changes were not quantified. In addition, the palpability of surface anatomical landmarks such as the spinous processes, the degree of back flexion, preoperative CT findings, and ultrasonographic findings were not assessed. These anatomical factors may have contributed to the association between age and difficult placement and to the association between BMI and difficult placement observed in the univariate analysis. The statistical power to evaluate the association between spinal disease and difficult placement was limited because only a small number of patients had a history of spinal disease or surgery. Although years of anesthesiology experience were used as a surrogate measure of operator experience, this variable does not directly reflect the cumulative number of lumbar epidural catheter placements performed, the frequency of performing the procedure, or technical proficiency. Because the identity of the anesthesiologist who ultimately completed catheter placement was not recorded, we could not evaluate the potential influence of operator crossover on the observed association between operator experience and difficult placement.

Importantly, difficult placement was operationally defined as requiring two or more skin punctures. Although this definition provides an objective and reproducible measure, it captures only one aspect of technical difficulty and does not account for other clinically relevant difficulties, such as repeated needle redirection within the same skin puncture, bone contact, or resistance during catheter insertion. Therefore, our findings should be interpreted specifically as factors associated with multiple skin punctures rather than as factors associated with all aspects of technical difficulty during lumbar epidural catheter placement. In addition, the study population and analytical methods differed from those used in our previous study of thoracic epidural catheter placement, and the two studies were not designed to directly compare the difficulty of thoracic and lumbar epidural puncture. The differences in associated factors observed between the two studies cannot be attributed solely to differences in the puncture site.

Conclusions

In this retrospective study of 109 patients who underwent lumbar epidural catheter placement, older age was independently associated with difficult placement. No significant independent associations were observed for BMI or years of anesthesiology experience, and the lumbar level at which catheter placement was successfully achieved was also not significantly associated with difficult placement. The paramedian approach was more frequently used in the difficult placement group, although this association may have been influenced by patient selection related to the choice of puncture approach. Patients with difficult placement also had longer procedure times and greater depth to the epidural space. However, the association between age and difficult placement was modest, and the clinical relevance and predictive utility of age require further investigation.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Shota Tanimoto, Tomoharu Shakuo, Ken Hirai, Sae Ono, Megumi Hashimoto, Kenji Shida

Acquisition, analysis, or interpretation of data: Shota Tanimoto

Drafting of the manuscript: Shota Tanimoto

Critical review of the manuscript for important intellectual content: Tomoharu Shakuo, Ken Hirai, Sae Ono, Megumi Hashimoto, Kenji Shida

Supervision: Megumi Hashimoto, Kenji Shida

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. SHOWA Medical University Research Ethics Review Board issued approval 2026-0358. This retrospective observational study was approved by the SHOWA Medical University Research Ethics Review Board (approval number: 2026-0358). **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

We would like to thank Editage (www.editage.jp) for English language editing.

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