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Predictive Factors of Difficult Spinal Anesthesia

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ABSTRACT

Introduction: Spinal anesthesia was a commonly used anesthetic technique in surgical procedures, but its administration was often challenging in certain patients. This study aimed to identify predictive factors associated with difficulties in spinal anesthesia administration.
Methods: This study employed a prospective analytical observational design with a cross-sectional approach, involving 418 patients who underwent spinal anesthesia procedures at Dr. Sardjito General Hospital between October 2024 and January 2025. The analyzed variables included age, BMI, history of previous spinal injections, history of spinal surgery, visibility of the spinous process, palpability of the spinous process, lumbar anatomical abnormalities, and interspinous L3-4/L4-5 characteristics. The data were analyzed using the Chi-Square test and logistic regression.
Results: Logistic regression analysis indicated that poor visibility of the spinous process increased the likelihood of difficulty by 2.21 times (P<0.01; OR 2.21; CI 1.40-3.47), lumbar anatomical abnormalities increased the likelihood by 1.87 times (P=0.01; OR 1.87; CI 1.16-3.02), and the L3-4 interspinous space was 2.08 times more difficult to access compared to the L4-5 interspinous space (P<0.01; OR 2.08; CI 1.32-3.28). Although significant results were observed in the bivariate analysis, high BMI, moderate BMI, history of repeated spinal injections, and spinous process palpability did not demonstrate an independent effect on procedural difficulty.
Discussion: Factors such as poor spinous process visibility, lumbar anatomical abnormalities, and interspinous L3-4/L4-5 characteristics were found to be associated with difficulties in spinal anesthesia administration. These findings were consistent with previous studies indicating that spinous process visibility, lumbar anatomical abnormalities, and interspinous characteristics influenced the success of spinal anesthesia. This study also revealed that although age and a history of previous spinal surgery were analyzed, they did not significantly contribute to procedural difficulty.
Conclusion: The factors influencing the difficulty of spinal anesthesia were poor spinous process visibility, lumbar anatomical abnormalities, and interspinous L3-4/L4-5.

Keywords: Difficult spinal, predictive factors, spinal anesthesia.

Introduction

Spinal anesthesia is a widely used regional anesthetic technique in surgical procedures, particularly in operations involving the lower body. This technique involves the injection of local anesthetic into the subarachnoid space surrounding the spinal cord, blocking nerve fibers responsible for transmitting pain sensations. Although spinal anesthesia is generally accepted and effective, a number of patients experience difficulties during its implementation, which can lead to complications or failure of the procedure. The factors that were previously researched for spinal anesthesia difficulties included body mass index (BMI), a history of repeated spinal injections, anatomical abnormalities, and the visibility and palpability of the spinous process. Several previous studies have indicated that obesity and anatomical abnormalities, such as scoliosis and kyphosis, increase the difficulty in accessing the subarachnoid space, with a higher risk of needle failure and increased use of alternative anesthetic techniques such as general anesthesia.[1,2]

In the existing literature, various predictive factors of difficulty in spinal anesthesia have been explored; however, a deeper understanding of the interaction between these factors remains limited. Previous studies have noted that obesity increases the barriers to identifying anatomical landmarks, which in turn raises the number of punctures required and the risk of other complications.[3,4] Additionally, a history of repeated spinal injections in patients has also been shown to increase the likelihood of difficulties in subsequent procedures.[5] However, gaps still exist in understanding how these factors comprehensively interact to increase the difficulty of spinal anesthesia procedures.

This study aims to identify predictive factors associated with difficulty in administering spinal anesthesia. The main focus of this research is to analyze the influence of age, BMI, history of repeated injections, history of lumbar laminectomy, visibility of the spinous process, palpability of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5 on the difficulty of the spinal anesthesia procedure. Through this research, it is hoped that new insights will be provided, helping healthcare professionals better prepare for more effective spinal anesthesia procedures and reduce the potential risks of complications.

Methods

This study was analytical observational prospective research with a cross-sectional approach aimed at identifying predictive factors associated with difficulties in administering spinal anesthesia. The study design was chosen because it provides a snapshot of the population at a specific point in time, making it suitable for measuring prevalence and testing associations between risk variables and outcomes. The focus of this study was on the association between specific factors (such as age, BMI, history of repeated injections, history of lumbar laminectomy, visibility of the spinous process, palpability of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5) and the difficulty of spinal anesthesia procedures.

The sample size for this study was 418 patients who underwent spinal anesthesia at RSUP Dr. Sardjito. This sample size was calculated based on a prior estimate of the prevalence of difficulty in spinal anesthesia, accounting for potential data loss during data collection. Justification for the sample size was performed using statistical power calculations to detect significant differences between the tested variables. These calculations assumed that Type I and Type II errors would be considered, and that missing data during the study would not exceed 10%.

The target population consisted of patients undergoing spinal anesthesia at RSUP Dr. Sardjito from October 2024 to January 2025. The sample frame was derived from the target population using consecutive sampling, where patients meeting the inclusion and exclusion criteria were enrolled consecutively. While the sample frame did not encompass the entire target population, the sample was expected to remain representative of the broader population undergoing spinal anesthesia. The selection process followed strict criteria to avoid potential

selection bias. Patients who met the inclusion and exclusion criteria were included in this study using consecutive sampling. The inclusion criteria were patients aged 18 years and above with ASA I or II status who underwent spinal anesthesia. The exclusion criteria were patients who were allergic to local anesthetics or those with medical conditions that would prevent participation in the study. The sample selection process was conducted consecutively based on the availability of patients meeting these criteria, while considering potential selection bias.

The variables analyzed in this study were factors suspected to be associated with difficulty in spinal anesthesia procedures, including age, BMI, history of repeated injections, history of lumbar laminectomy, visibility of the spinous process, palpability of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5. Data were collected from patient medical records and physical examinations to assess the visibility and palpability of the spinous process and lumbar anatomical abnormalities. All measurements were conducted using standardized procedures to ensure the consistency and reliability of the collected data.

To ensure the validity of the measurements, the instruments used to assess the variables in this study were those previously tested in clinical practice. The researchers also conducted a kappa test to standardize the perception of data collection, both from anamnesis and physical examination, during the spinal anesthesia procedure. Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 30.0. The statistical test used was the Chi-Square test to assess the relationship between categorical variables (such as the visibility of the spinous process and the history of repeated injections) and difficulties in spinal anesthesia procedures. Logistic regression was employed to analyze the relationship between predictive factors and difficulties in spinal anesthesia procedures, as well as to control for the influence of other variables that may affect the results.

In this study, statistical significance was determined using a p-value with a significance level (α) set at 0.05. The p-value indicates the probability that the observed results occurred by chance if the null hypothesis (no difference or relationship) is true. If the p-value is less than 0.05, the null hypothesis is rejected, indicating a statistically significant difference. Conversely, if the p-value is greater than 0.05, the null hypothesis cannot be rejected, implying there is insufficient evidence to conclude a significant difference or relationship. Additionally, a 95% confidence interval was used to provide a clearer picture of the precision of the estimates. This interval indicates the range within which the true population value is expected to lie with 95% confidence. If the confidence intervals of two groups do not overlap, it can be concluded that there is a significant difference between the groups, whereas overlapping intervals suggest no significant difference. Type I error (false positive) was set at 5%, meaning there is a 5% chance of rejecting the true null hypothesis, while Type II error (false negative) was controlled at 20%, reflecting the likelihood of failing to detect a true difference.

This study received approval from the Health Research Ethics Committee (KEPK) of the Faculty of Medicine, Public Health, and Nursing, Gadjah Mada University, under the number KE/FK/1124/EC/2024, as well as permission from the management of RSUP Dr. Sardjito for conducting the research under the number DP.04.03/D.XI.2/20594/2024. All procedures in this study were conducted in accordance with the applicable ethical guidelines.

Results

The data collected in this study involved 473 patients; however, 55 patients had incomplete data, and were categorized as non-responders and subsequently excluded from the analysis. The non-responder category was analyzed by comparing it with the other data. Based on this analysis, it was concluded that the characteristics of the non-responder patients were sufficiently represented and did not affect the outcome of the study. This study analyzed data from 418 patients who underwent spinal anesthesia. The characteristics of the respondents are presented in Table 1. The majority of patients were female (96.4%), and most were aged 40-60 years

Table 1. Characteristics of Respondents

Variable	n	%
>60 years old	124	29.7
40-60 years old	247	59.1
18-39 years old	47	11.2
Gender		
Female	403	96.4
Male	15	3.6
BMI		
High BMI (>30 kg/m2)	39	9.3
Moderate BMI (18,5-30 kg/m2)	322	77.0
Low BMI (<18.5 kg/m2)	57	13.6
History of repeated spinal injection		
Yes	134	32.1
No	284	67.9
History of lumbar laminectomy		
Yes	13	3,1
No	405	96.9
Visibility of spinous process		
Not visible	164	39,2
Visible	254	60,8
Palpability of spinous process		
Not palpable	33	7.9
Palpable	385	92.1
Lumbar anatomical abnormalities		
Yes	105	25.1
No	313	74.9
ASA physical status		
I	183	43.8
II	235	56.2
Operating room		
Brachytherapy	393	94,0
GBST	25	4,0
Interspinous L3-4/L4-5		
L3-4	259	62,0
L4-5	159	38,0

Table 2. Frequency Distribution of Difficulty with Spinal Anesthesia in Respondents

Variable	n	%
Difficult spinal anesthesia	160	38.1
Not difficult spinal anesthesia	260	61,9
Total	420	100

(59.1%), with a significant portion undergoing brachytherapy (94.0%). This finding represents a limitation of the study, as there is potential selection bias that may influence the gender representation in the sample. In addition to the aforementioned selection bias, other types of bias such as measurement bias and recall bias

Table 3. Relationship Between Independent Variables and Difficult Spinal Anesthesia

Variable	Difficult Spinal Anesthesia		Not Difficult Spinal Anesthesia		Statistical Test	
	n	%	n	%	P Value	Odds Ratio
Age						
>60 years old	46	37,1	78	62,9	0,26	0,62 (0,31-1,21)
40-60 years old	90	36,4	157	63,6		0,60 (0,32-1,12)
18-39 years old	23	48,9	24	51,1		1
BMI						
High BMI (>30 kg/m2)	22	56,4	17	43,6	0,04	2,59 (1,12-5,99
Moderate BMI (18,5-30 kg/m2)	118	36,6	204	63,4		1,16 (0,64-2,10)
Low BMI (<18.5 kg/m2)	19	33,3	38	66,7		1
History of repeated spinal injection						
Yes	63	47,0	71	53,0	<0,01	1,74 (1,14-2,64)
No	96	33,8	188	66,2		1
History of lumbar laminectomy						
Yes	5	38,5	8	61,5	1,00	1,02 (0,33-3,17)
No	154	38,0	251	62,0		1
Visibility of spinous process						
Not visible	86	52,4	78	47,6	<0,01	2,73 (1,81-4,12)
Visible	73	28,7	181	71,3		1
Palpability of spinous process						
Not palpable	19	57,6	14	42,4	0,02	2,38 (1,16-4,89)
Palpable	140	36,4	245	63,6		1
Lumbar anatomical abnormalities						
Yes	49	46,7	56	53,3	0,04	1,62 (1,03-2,53)
No	110	35,1	203	64,9		1
Interspinous L3-4/L4-5						
L3-4	118	45,6	141	54,4	<0,01	2,41 (1,57-3,71)
L4-5	41	25,8	118	74,2		1

Table 4. Logistic Regression Results

No	Variable	P Value	Odds Ratio	95% CI
1	High BMI (>30 kg/m2)	0.27	1.73	0.66-4.53
	Moderate BMI (18,5-30 kg/m2)	0.91	1.04	0.55-1.95
2	History of repeated spinal injection	0.06	1.54	0.99-2.41
3	Visibility of spinous process	<0.01	2.21	1.40-3.47
4	Palpability of spinous process	0.59	1.25	0.55-2.83
5	Lumbar anatomical abnormalities	0.01	1.87	1.16-3.02
6	Interspinous L3-4/L4-5	<0.01	2.08	1.32-3.28

may have also been present. A total of 38.0% of patients experienced difficulty during the spinal anesthesia procedure. Among the patients who encountered difficulties, 102 required one additional puncture with redirection, while 12 patients required more than two punctures, and the procedure was then continued by the chief resident or the attending consultant. The average number of punctures for patients who experienced difficulty was 1.18.

Bivariate analysis showed that several independent factors had a significant relationship with difficulty in spinal anesthesia. The selected variables included BMI, history of repeated spinal injections, visibility of the spinous process, palpability of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5. However, age and history of previous lumbar laminectomy did not show a significant effect on the difficulty of the spinal anesthesia procedure.

Logistic regression analysis indicated that visibility of the spinous process had a significant impact on the difficulty of spinal anesthesia. With a value of (P<0.01; OR 2.21; CI 1.40-3.47), the inability to visualize the spinous process increased the likelihood of difficulty during the procedure by 2.21 times. The very small p-value (<0.01) demonstrated that the visibility of the spinous process was a highly significant variable in determining the level of difficulty in spinal anesthesia. Additionally, lumbar anatomical abnormalities showed a significant effect, with a value of (P=0.01; OR 1.87; CI 1.16-3.02). Lumbar anatomical abnormalities increased the likelihood of difficulty in spinal anesthesia by 1.87 times. Furthermore, Interspinous L3-4/L4-5 showed significant results, with a value of (P<0.01; OR 2.08; CI 1.32-3.28). This finding indicated that patients who underwent spinal anesthesia at the Interspinous L3-4/L4-5 of L3-4 were more likely to experience difficulty during the procedure compared to those at the Interspinous L3-4/L4-5 of L4-5.

The results of this study indicated that factors such as visibility of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5 played an important role in the difficulty of the spinal anesthesia procedure, while BMI, history of repeated injections, and palpability of the spinous process did not have a significant impact.

Discussion

This study aimed to identify predictive factors associated with difficulties in the spinal anesthesia procedure. The results indicated that factors such as the visibility of the spinous process, lumbar anatomical abnormalities, and Interspinous L3-4/L4-5 significantly influenced the difficulty of spinal anesthesia. These findings are consistent with previous studies that have shown that anatomical factors and patients' medical history play a crucial role in the success of spinal anesthesia procedures.[2,4]

Although this study employed consecutive sampling, selection bias remains an important consideration in interpreting the results. The patient selection process conducted at a single hospital may limit the generalizability of these findings to a broader population. Selection bias could also occur if the characteristics of patients at this particular hospital differ significantly from the general population, potentially affecting the conclusions drawn from this study. Therefore, further research with a multi-center design is needed to expand the applicability of these results.

Regarding the variables that were not significant, it is important to first examine the two variables—age and previous lumbar laminectomy history—that showed no significance in the bivariate analysis. Although these factors are theoretically relevant in influencing the outcome of spinal anesthesia, the analysis revealed that both patient age and prior history of lumbar laminectomy did not have a significant impact. Older age groups and patients with a history of lumbar laminectomy did not show a significant relationship with difficulty in the procedure (P=0.26 and P=1.00). Further analysis showed that the odds ratio (OR) for age groups >60 years (OR 0.62; CI 0.31–1.21) and 40-60 years (OR 0.60; CI 0.32–1.12) were compared to patients aged 18-39 years. For patients with a history of lumbar laminectomy, the OR was 1.02 (CI 0.33–3.17) compared to those without such a history.

Before further discussion, it is important to understand how each of the non-significant variables was analyzed and its result. The non-significant variables in the logistic regression analysis were BMI (both high and moderate), history of repeated spinal injections, and palpability of the spinous process. A previous review found that high BMI was associated with difficulty in the spinal anesthesia procedure. However, this study found that BMI did not play a significant role in complicating spinal anesthesia. Patients with high BMI had logistic regression analysis results (P=0.44; OR 1.45; CI 0.57–3.71), while those with moderate BMI had logistic regression results (P=0.78; OR 0.92; CI 0.50–1.70). This study reinforces the idea that a high BMI does not necessarily increase the risk of difficulty in the procedure.

This study also examined the history of repeated spinal injections as a non-significant predictor of difficulty in subsequent spinal anesthesia. The logistic regression analysis yielded a value (P=0.06; OR 1.54; CI 0.99–2.41). This factor is theoretically important because patients who experienced difficulties in the previous spinal procedure are likely to have challenging anatomical characteristics, such as undetected scoliosis, narrow subarachnoid space, or other persistent conditions. Del Buono et al. (2021) found that a history of difficult spinal anesthesia increased the likelihood of recurrent difficulty by approximately threefold.

The practical implication is clear: if the first procedure is difficult, subsequent procedures are likely to face similar challenges due to persistent anatomical deformities, such as lumbar osteophytes, scoliosis, or factors like obesity. On the other hand, Atashkhoei et al. (2019) found that a history of previous spinal anesthesia did not have a significant effect on obstetric populations, which can be explained by the low number of obstetric patients who had undergone previous procedures. This result might be associated with this study, given that it predominantly involved female patients. In general, a history of repeated punctures serves as a warning signal for the operator to be cautious of potential difficulties and plan for alternative strategies.[2,4]

The quality of the anatomical landmarks on the back, whether through inspection or palpation, is a clinical indicator that directly affects the ease of the spinal anesthesia procedure. A clearly visible and palpable lumbar spinous process typically indicates patients with a slender body or clear anatomy, facilitating the spinal procedure. In contrast, if these landmarks are difficult to visualize or palpate, it may indicate excess soft tissue (as seen in obese patients) or anatomical changes, potentially increasing procedural difficulty. The palpability of the interspinous space, which was not palpated in this study, did not show statistical significance in logistic regression analysis (P=0.59; OR 1.25; CI 0.55–2.83), suggesting that palpation is not an independent predictor of difficulty in spinal anesthesia.

In this study, superior visibility was found to be a more effective method for identifying landmarks compared to palpation. In clinical practice, anesthesiologists often use palpation of the spinous process as an initial assessment before performing the puncture. If the spinous process is difficult to palpate, special techniques or assistive tools such as ultrasound may be necessary to enhance procedural success. Literature also notes that excess adipose tissue, edema, or hyperkyphosis in the elderly can obscure palpation of the spinous process or even cause it to "disappear." Therefore, this variable is crucial in determining the difficulty level of spinal anesthesia and is often included in prediction models for spinal anesthesia difficulty. The accuracy of palpating the spinous process in determining the correct puncture site reached 69.2% when compared to lumbar radiographs, emphasizing the importance of palpability in the success of spinal anesthesia.[3,6]

The study also identified factors that complicate spinal anesthesia related to patient characteristics. It was found that the first puncture was more difficult in patients with poor visibility of the spinous process (P<0.01; OR 2.21; CI 1.40–3.47). Del Buono et al. (2021) reported that an invisible spinous process increased the risk of difficulty by approximately 2.5 times. Previous studies have also shown that patients with poor anatomical markers

are up to 22 times more likely to experience complications during the procedure. Accurate preoperative predictions regarding visibility and palpability of the spinous process can help reduce the frequency of repeated punctures, increase procedural success rates, and decrease the risk of complications.[4,7]

Physical examination of the visibility and palpability of the spinous process remains a significant and essential method for evaluating the difficulty level of the spinal anesthesia procedure. This assessment can be conducted systematically, relying on the experience and precision of the examiner. The palpability of the spinous process, in the context of physical examination, provides important indications regarding the challenges that may be encountered when performing the neuroaxial block. A clearly palpable spinous process is often associated with the successful first attempt of spinal anesthesia. However, factors such as obesity and anatomical anomalies may affect the accuracy of palpating the spinous process. Obesity, for instance, can lead to adipose tissue buildup, obscuring the spinal landmarks. Additionally, anatomical anomalies such as scoliosis or vertebral deformities can alter the normal spinal structure, making it difficult to accurately identify the vertebrae. These conditions potentially increase the likelihood of failure or difficulty in performing spinal anesthesia. Nevertheless, physical examination of the visibility and palpability of the spinous process remains a valid, practical, and objective method for assessing the difficulty of the spinal anesthesia procedure. Variables such as palpability and the quality of spinal landmarks act as significant predictors of procedural success. The experience and precision of healthcare providers during the examination play a critical role in improving the accuracy of these assessments, which in turn can support more effective procedural planning and reduce the risk of complications.

Lumbar anatomical abnormalities, such as scoliosis, hyperlordosis, or kyphosis, are significant factors in determining the difficulty level of spinal anesthesia, as confirmed in this study. These spinal deformities can shift the orientation of the spinous process and obstruct access to the intervertebral space, causing mechanical difficulties in performing lumbar puncture. For example, scoliosis can shift the spinal canal, requiring the operator to adjust the angle of the puncture or use a paramedian approach, which still presents challenges.

In this study, it was found that patients with lumbar anatomical abnormalities had (P=0.01; OR 1.87; CI 1.16–3.02), indicating that patients with spinal deformities were 1.87 times more likely to experience difficulty in the spinal anesthesia procedure compared to patients without anatomical abnormalities. This makes anatomical abnormalities one of the strongest risk factors for spinal anesthesia difficulty based on multivariate analysis, second only to the visibility of the spinous process. Del Buono et al. (2021) also noted that patients with spinal deformities had (OR 4.46; CI 2.47–8.03) for experiencing difficulty in the spinal anesthesia procedure, making it one of the largest risk factors. Other studies, such as those by Karim et al. (2023), have also incorporated the degree of deformity into the Difficult Spinal-Arachnoid Puncture (DSP) score, showing that this factor predominantly influences the prediction of procedural difficulty.[3,4,8]

In this study, it was found that patients with lumbar anatomical abnormalities were more likely to experience difficulty in spinal anesthesia compared to those without such abnormalities. As patients age, the risk of spinal abnormalities increases due to degenerative changes, which can lead to anterolisthesis, axial compression, intervertebral disc bulging, endplate degeneration, retrolisthesis, lumbar spondyloarthrosis, and lumbar spondylosis. These conditions can make it difficult to reach the subarachnoid space and increase the likelihood of requiring repeated punctures. However, some studies, including one by Sugiarto and Marpaung (2021), found no association between degenerative lumbar abnormalities and difficulty in spinal anesthesia.

These inconsistencies could be due to differences in study population characteristics or methodological variations.[3] This anatomical

challenge can persist, particularly in patients with conditions such as osteoarthritis, scoliosis, or other anatomical abnormalities affecting the spinal structure, making subsequent neuroaxial block procedures in spinal anesthesia more difficult. The continuation of these challenges demands careful planning and the implementation of advanced techniques to improve the success of anesthesia procedures. Although persistent anatomical challenges can complicate the performance of spinal anesthesia, advancements in imaging and visualization technology provide promising solutions. Therefore, comprehensive evaluation and the use of the latest technology are crucial to ensure safe and effective neuroaxial anesthesia, particularly in patients with spinal deformities that can add complexity to the procedure.

Diagnostic examinations such as CT scans and MRIs play a vital role in identifying and assessing the degree of spinal deformity before spinal anesthesia. CT scans provide detailed visualization of bony structures, while MRIs excel in evaluating soft tissues, intervertebral discs, and degenerative changes. The combination of both modalities can assist anesthesiologists in performing more accurate preoperative assessments. If significant anatomical abnormalities are detected, adjunct techniques such as spinal ultrasound can be used to map the anatomy before injection, minimizing the risk of procedure failure. Logistic regression analysis indicated that needle insertion at the L3-4 level resulted in more difficult spinal anesthesia compared to L4-5 ($P<0.01$; OR 2.08; CI 1.32-3.38). This outcome may be attributed to several anatomical differences between L3-4 and L4-5. At the L3-4 level, the spinous process tends to be more upright compared to the more inferior spinous process at L4-5. Additionally, the subarachnoid-to-subcutaneous distance is slightly shorter at L3-4 than below. This highlights the importance of selecting the appropriate interspinous location in spinal anesthesia procedures. Nevertheless, other confounding factors still influence the procedure. Therefore, understanding the anatomical differences between L3-4 and L4-5 can help minimize risks and improve the success rate of spinal anesthesia.[9] Although this study contributes valuable insights, there are several limitations that should be considered. First, the cross-sectional design of the study limits the ability to draw causal conclusions regarding the relationship between predictive factors and the difficulty of spinal anesthesia. Further research with cohort or experimental designs is needed to strengthen these findings. Second, this study was conducted at a single hospital, which may limit the generalizability of the findings to a broader population. Multi-center studies that include hospitals from various regions or countries would provide a wider perspective and strengthen the external validity of the research findings. This study received approval from the Health Research Ethics Committee of the Faculty of Medicine, Public Health, and Nursing at Gadjah Mada University and complied with all applicable ethical guidelines. The authors declare that there are no conflicts of interest related to this research.

Conclusion

The predictive factors influencing the difficulty of spinal anesthesia were spinous process visibility, lumbar anatomical abnormalities, and interspinous L3-4/L4-5. Variables that were not predictive factors for difficult spinal anesthesia included age groups, BMI groups, history of repeated spinal injections, history of lumbar laminectomy, and spinous process palpability. Based on the results obtained in this study, these factors influencing difficulty can be used as clinical guidelines in preparing high-risk patients for difficult spinal anesthesia. For patients identified with these risk factors, preparation with ultrasonography as an additional tool should be considered to enhance procedural success. This includes optimizing modifiable factors such as patient positioning techniques and selecting the most suitable type of needle. These measures can help reduce the number of repeat attempts and minimize other complications, ultimately improving patient comfort. For future research, it is recommended to explore additional factors that may affect the difficulty of spinal anesthesia procedures.

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Conflict of Interest
The authors declare no conflicts of interest.

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