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LANDMARKS-GUIDED COMPARED TO ULTRASOUND-GUIDED FOR SPINAL ANESTHESIA IN ELDERLY: SYSTEMATIC-REVIEW AND META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

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Abstract

Introduction: *Spinal anesthesia is a challenging procedure, especially in the elderly population. The ultrasound-guiding is reported to provide additional information to facilitate the procedure. To date, there has been no meta-analysis in this field.*

The study aimed to *systematically review and compile a meta-analysis to examine the efficacy of ultrasound-guiding compared to the palpation of anatomical landmarks in spinal anesthesia procedures performed for elderly patients.*

Methods: *A systematic literature search from PubMed, Cochrane Library, and Clinicaltrial.gov was conducted to find randomized controlled trials study which comparing ultrasound-guiding and anatomical landmarks of spinal anesthesia in geriatric population. Meta-analysis was performed according to PRISMA guidelines. The continuous and dichotomous data, respectively, are using the calculation of mean differences with inverse variance, and Odds Ratio using the Mantel-Haenszel method.*

Results: *Four studies with a total of 436 patients met the criteria. Based on the analysis, landmark-guided have more number of attempts [IV -0.66, 95%CI=(-1.20, –0.13), p=0.01], and higher number of passes [IV -1.43, 95%CI=(-2.68, –0.18), p=0.03], compared to ultrasound-guided. Ultrasound-guided has success rate of first attempt [OR 3.37, 95%CI=(1.17, 9.73), p=0.02], and success rate of first passes [OR 3.60, 95%CI=(1.39, 9.29), p=0.008], which is significantly higher when compared to landmark-guided. Ultrasound-guided had a longer duration of procedure than landmark-guided which was statistically significant [IV 59.14, 95%CI=(4.58, 113.70), p=0.03].*

Conclusion: *The ultrasound-guiding for spinal anesthesia in elderly is recommended. This approach should be considered as the standard of care, given its potential to improve technical efficacy in conducting spinal anesthesia in particular populations.*

Keywords: *anesthesia, elderly, landmark, spinal, ultrasound.*

Introduction

Spinal anesthesia is a procedure for administering anesthetic drugs to relieve pain in patients who will undergo surgery by injecting local anesthetic drugs into the cerebrospinal fluid in the subarachnoid space [*Butterworth J et al., 2018*]. Currently, spinal anesthesia has become one of the main areas of anesthesia and regional anesthesia. Traditionally, the exact site of needle insertion is located by palpating the ana-

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tomic landmarks. It is recognized that the method of palpation of such landmarks can be challenging. Spinal anesthesia needs to be done with a special approach, especially in some groups of patients who are unable to perform flexion at all, such as pregnant, elderly, or obese patients. In the aging process, there will be various typical findings that may not be found in young-adult patients, elderly patients also have many special characteristics that distinguish them from other populations. This condition makes spinal anesthesia relatively more difficult in elderly patients, who also often have abnormal anatomy [*Uyel Y, Kilicaslan A, 2021*]. Given the challenges and complications associated with performing spinal anesthesia, particularly in the elderly population, the use of ultrasound-guiding (USG) may provide additional information to facilitate the procedure. Although there have been several recommendations for the use of ultrasound in cases of patients with technical difficulties during spinal anesthesia [*Ansari T et al.,2014; Sahin T et al.,2014*] , still, ultrasound-guiding has not been widely applied. Another study stated ultrasound-guiding yields limited benefit to patients without predictable difficulty, and may take longer to perform than palpation of landmarks [*Gambling D. R.2011*].

Many studies have analyzed the efficacy of ultrasound-guiding compared with landmark palpation methods in spinal anesthesia on several populations [*Perlas A. 2016*]; however, given the heterogeneity in their criteria. There has been no meta-analysis in the elderly population, limited by the small number of trial studies. In addition, since this study has been carried out, many trials have been published. We aimed to carry out a systematic review and meta-analysis to examine the efficacy of ultrasound-guided compared to the palpation of anatomical landmarks in spinal anesthesia on elderly. To optimize the weighting of study outcomes, we used analyses of randomized controlled trials to increase the validity of our study.

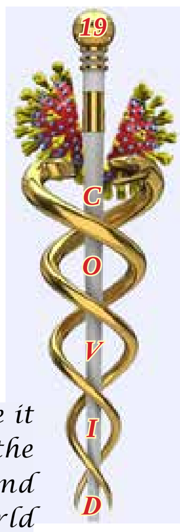
MATERIAL AND METHODS

The approach method in the systematic review was started by using The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol, followed by a meta-analysis.

Systematic Search: A systematic search for literature published in journals was conducted using the PubMed database, Clinicaltrial.gov, and Cochrane Library. The search was conducted in the last ten years until October 2021. All studies with randomized controlled trials (RCTs) comparing ultrasound-guided and landmark-guided in spinal anesthesia were included in the study. The search in this study followed the appropriate keywords for each database. Further exploration was done through reading the entire contents of the studies that have been used.

Inclusion and exclusion criteria: The initial selection was done by sorting out titles, abstracts, and keywords that matched the inclusion criteria of this study. Randomized controlled trials (RCTs) comparing ultrasound-guided and landmark-guided directly in elderly patients undergoing spinal anesthesia procedures and studies with two or more arms met the inclusion criteria. We excluded studies that did not use English with the aim of avoiding bias and misunderstanding when extracting data. In addition, research that is not a randomized controlled trial, such as observational designs (cohort, case-control, and cross-sectional), commentary, editorial, review study, case report/case series, research that is only in the form of abstracts, research on animals and in-vitro studies were included in the exclusion criteria.

Study Selection and Data Extraction: The study selection process in this study used guidelines from the PRISMA flowchart. Five authors contributed to the study selection and data extraction. If there are problems and disagreements, they will be resolved by discussion. Data extraction carried out in each study were: Name and year of author, research location, study design, number of samples, type of surgery, level of competence from the operator, and the outcome. Data extraction from each study will be included in the tabulation. The obtained data were then inputted using Review Manager 5.4 software for analysis. All



To overcome it is possible, due to the uniting the knowledge and will of all doctors in the world

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studies that met the criteria were analyzed in the outcome section. Outcomes include the number of attempts, number of passes, the success rate on the first attempt, the success rate on first passes, and total procedure duration. Number of attempts represent the frequency with which the needle is withdrawn from the skin and reinserted. Number of passes represent the withdrawal moves and adjustment (redirection) without removing the needle from the skin [*Srinivasan K.-K. et al., 2018*].

Statistical Analysis: Continuous data (number of attempts, number of passes, and total procedure duration) were presented using the mean difference with a 95% confidence interval (CI); a p-value below 0.05 was considered statistically significant. Dichotomous data (success rate on the first attempt, and success rate on first passes) were presented using an odds ratio (OR) with 95% CI; p-value below 0.05 was considered statistically significant. Heterogeneity between studies was calculated using I^2; if $I^2>50\%$, it was considered statistically high heterogeneity, and a random-effects model was applied. If $I^2<50\%$, then the fixed effect model is applied to this meta-analysis. Statistical analysis using RevMan 5.4 for Windows software is presented in the form of forest plots and descriptive narratives.

Risk of Bias: The risk of bias in each study that meets the inclusion criteria uses the Cochrane Risk of Bias Tools In For Randomized Trial 2 method, which divides the risk of study bias based on the randomization process, deviation from the intervention, allocation concealment, blinding process, missing outcome data, measurement and selection of research results. (Fig. 1)

RESULTS

There were four studies and 436 patients included in our study. Data extracted from these studies included the number of attempts, number of passes, the success rate on the first attempt, the success rate on first passes, and total time required to perform spinal anesthesia procedures. Detailed information about the characteristics of each study included in our study is presented in Table.

Based on the risk analysis of bias, the overall study risk was moderate. Analysis of the risk of bias using the Cochrane Risk of Bias Tools for Randomized Trials method 2. All studies that fall into the research inclusion criteria describe the process of randomizing samples into each intervention group adequately. In a study design from Uyel T. and *Kilicaslan A (2021*), neither the patient nor the anesthesiologist was blinded, whereas in other study, only patients were blinded [*Rizk M 2019; Park S et al., 2019; Qu B et al., 2020*].

OUTCOME ANALYSIS

Number of attempts: The number of attempts for spinal anesthesia is calculated in units of times. There are four studies that compare the number of attempts for puncture with ultrasound-guided and landmark-guided methods. In the forest plot analysis, the combination of the four studies had statistically high heterogeneity with I^2 = 74% (P = 0.008). Therefore, a random effect statistical model is used to determine the results of the study. The analysis showed a significant difference, where landmark-guided had a higher number of attempts than ultrasound-guided, which was statistically significant [IV -0.66, 95% CI = (-1.20, – 0.13), p = 0.01] (Fig.2).

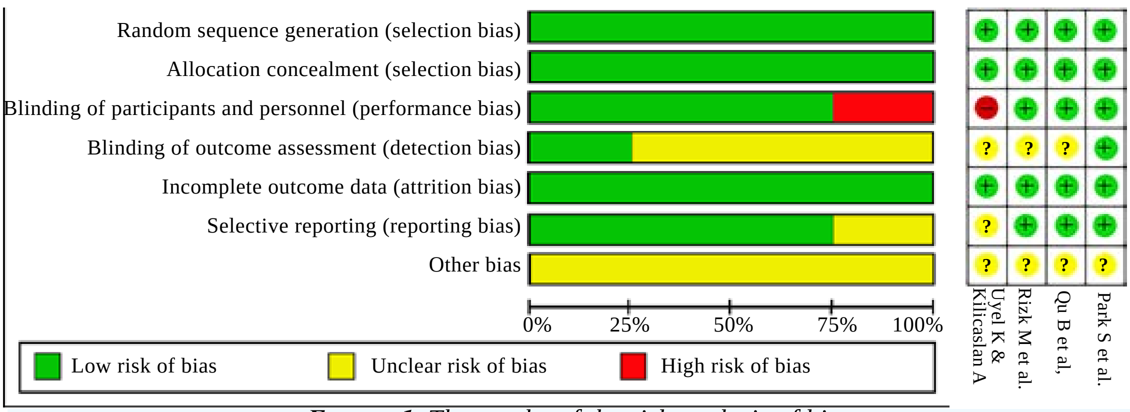

FIGURE 1. *The results of the risk analysis of bias*

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TABLE

Comparison characteristics of studies that meet the inclusion criteria paramedian technique for spinal anesthesia and received outcome

Sample	Type of Surgery	Location	Operator competences
Characteristics of studies by Qu B et al., 2020			
Ultrasound (40); Landmark (40) ≥ 65 years old	Elective hip fracture surgery	Guangzhou, China	experienced anesthesiologist in neuroaxial USG
OUTCOME: First-pass success rate. first-attempt success rate; the number of needle insertion attempts; the number of needle passes; and total time; adverse reactions, complications; and patient satisfaction score			
Characteristics of studies by Rizk M et al, 2019			
Ultrasound (60); Landmark (60) > 60 years old	Heterogenous elective surgery (urology, orthopedic, and general surgery)	Beirut, Libanon	novice residents who have performed less than five spinal attempts since the beginning of their residency
OUTCOME: Rate of successful puncture on the first needle insertion attempt; the number of needle insertion attempts; the number of needle passes; time is taken to perform; patient satisfaction, periprocedural pain score, the success of spinal anesthesia, and complications.			
Characteristics of studies by Uyel K, Kilicaslan A, 2021			
Ultrasound (78); Landmark (78) > 65 years old	elective orthopedic lower extremity surgery.	Konya, Turkey	experienced anesthesiologist in neuroaxial USG
OUTCOME: First needle insertion attempt successfulness, number of needle insertion attempts; needle redirections, time taken to establish landmarks, total procedure time, needle pain score; patient satisfaction, complications related to spinal anesthesia.			
Characteristics of studies by Park S et al, 2019			
Ultrasound (40); Landmark (40) > 60 years old	Elective orthopedic surgery	Seoul, South Korea	experienced anesthesiologist
OUTCOME:The number of needle passes and needle-insertion attempts; time for identifying; time for administering spinal anesthesia; incidence of radicular pain, paraesthesia and blood tap by the spinal needle; periprocedural pain score; periprocedural discomfort score; level of sensory block.			

Study or Subgroup	Ultrasound-guided Mean	SD	Total	Landmark-guided Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI, Year
Park S etal., 2019	1	1.75	60	1	1	60	27.6%	0.00 [-0.51, 0.51] 2019
Rizk M et al., 2019	1	1	40	1.5	4	40	11.8%	-0.50 [-1.78, 0.78] 2019
Qu B et al., 2020	1	1	40	2	0.25	40	32.6%	-1.00 [-1.32, 0.68] 2020
Uyel Y., Kilicaslan A., 2021	1	1	78	2	2	78	28.0%	-1.00 [-1.50, 0.50] 2021
Total (95%) CI			218			218	100%	-0.66 [-1.20. -0.13]
Heterogeneity: Tau² = 020; Chi ² =11.74 df = 3 (P=0.008); I² = 74%								
Test for overal effect Z=2.44 (P=0.01)								

Mean Difference IV, Random, 95% CI,

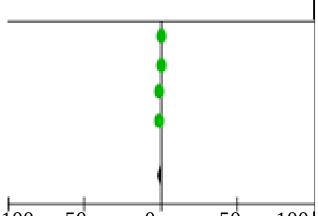

FIGURE 2. Forest plot of number of attempt

Number of passes: The number of passes for spinal anesthesia is calculated in units of times. There are four studies comparing the number of passes of ultrasound-guided and landmark-guided punctures. In the Forest plot analysis, the combination of the four studies had statistically high heterogeneity with $I^2 = 98\%$ (P = 0.00001). Therefore, a random effect statistical model is used to determine the results of the study. The analysis showed a significant difference, where landmark-guided had more number of passes than ultrasound-guided, which was statistically significant [IV -1.43, 95% CI = (-2.68, – 0.18), p = 0.03] (Fig.3)..

SUCCESS RATE OF FIRST ATTEMPT: Differences in the success rate of the first attempt between ultrasound-guided and landmark-guided were found

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Study or Subgroup	Ultrasound-guided			Landmark-guided				Mean Difference
	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI, Year
Park S etal., 2019	1	2.25	40	4.5	5.75	40	17.0%	-3.50 [-5.41, -1.59] 2019
Rizk M et al., 2019	2	1	60	2	0.688	60	27.8%	0.00 [-0.31, 0.31] 2019
Qu B et al., 2020	1	0.25	40	3	0.5	40	28.1%	-2.00 [-2.17, -1.83] 2020
Uyel Y., Kilicaslan A., 2021	2	1.5	78	3	1.5	78	27.1%	-1.00 [-1.47, -0.53] 2021
Total (95%) CI			218			218	100%	-1.43 [-2.68, -0.18]
Heterogeneity:	Tau² = 1.45; Chi ² =132.09 df = 3 (P<0.00001); I² = 98%							
Test for overal effect	Z=2.23 (P=0.03)							

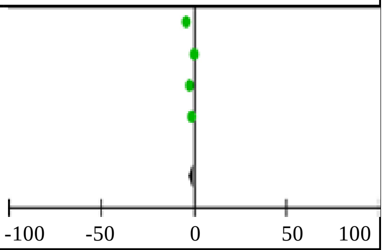

FIGURE 3. *Forest plot of number of passes*

in 4 studies. In the forest plot analysis, the combination of the four studies had statistically high heterogeneity with $I^2 = 83\%$ (P = 0.0007). Therefore, a random effect statistical model is used to determine the results of the study. The analysis showed that the success rate of the first attempt was statistically significant, in which the ultrasound-guided had a higher number than the landmark-guided [OR 3.37, 95% CI = (1.17, 9.73), p = 0.02] (Fig.4).

SUCCESS RATE OF FIRST PASSES: There are four studies comparing the success rate of first passes between ultrasound-guided and landmark-guided.

Study or Subgroup	Ultrasound-guided		Landmark-guided			Odds Ratio
	Events	Total	Events	Total	Weight	M-H, Random, 95% CI, Year
Park S etal., 2019	33	40	13	40	23.6%	9.79 [3.43, 27.99] 2019
Rizk M et al., 2019	44	60	46	60	25.8%	0.84 [0.37, 1.92] 2019
Qu B et al., 2020	34	40	17	40	23.4%	7.67 [2.63, 22.36] 2020
Uyel Y., Kilicaslan A. 2021	58	78	42	78	27.3%	2.49 [1.26, 4.89] 2021
Total (95%) CI		218		218	100%	3.37 [1.17, 9.73]
Total events	169		118			
Heterogeneity:	Tau² = 0.95; Chi ² =17.16 df = 3 (P=0.0007); I² = 83%					
Test for overal effect	Z=2.25 (P=0.02)					

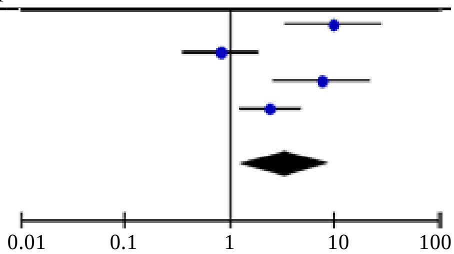

FIGURE 4. Forest plot of success rate of first attempt

In the forest plot analysis, the combination of the four studies had statistically high heterogeneity with $I^2 = 79\%$ (P = 0.003). Therefore, a random effect statistical model is used to determine the results of the study. The analysis showed statistically significant difference between the two groups, with ultrasound-guided showing a higher success rate of first passes than landmark-guided [OR 3.60, 95% CI = (1.39), 9.29, p = 0.008] (Fig.5).

DURATION OF PROCEDURE: The duration of the procedure for performing spinal anesthesia is calculated in units of the second (s). There are four studies comparing the duration of the procedure for performing spinal anesthesia with ultrasound-guided and

Study or Subgroup	Ultrasound-guided		Landmark-guided			Odds Ratio
	Events	Total	Events	Total	Weight	M-H, Random, 95% CI, Year
Park S etal., 2019	19	60	15	60	26.2.3%	1.39 [0.63, 3.09] 219
Rizk M et al., 2019	26	40	7	40	23.2.3%	8.76 [3.09, 24.84] 2019
Qu B et al., 2020	28	40	8	40	23.3.3%	9.33 [3.34, 26.10] 2020
Uyel Y., Kilicaslan A., 2021	28	78	18	78	27.3%	1.87 [0.93, 3.76] 2021
Total (95%) CI		218		218	100%	3.60 [1.39, 9.29]
Total events	101		48			
Heterogeneity:	Tau² = 0.73; Chi ² =14.05 df = 3 (P<0.003); I² = 79%					
Test for overal effect	Z=2.64 (P=0.008)					

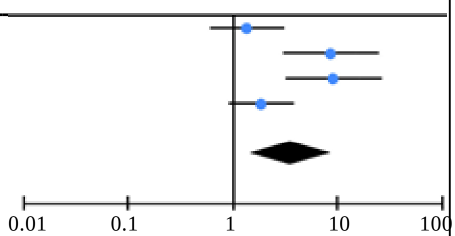

FIGURE 5. *Forest plot of success rate of first passes*

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Study or Subgroup	Ultrasound-guided Mean	SD	Total	Landmark-guided Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI, Year	
Park S etal., 2019	181.5	44.75	40	92.5	81.75	40	28.2%	89.00 [60.12, 117.88]	2019
Rizk M et al., 2019	116.3	98.12	60	87.24	79.51	60	27.8%	29.08 [-2.88, 61.04]	2019
Qu B et al., 2020	608.2	196.9	40	440.3	240.1	40	15.7%	167.9 [71.67, 264.13]	2020
Uyel Y., Kilicaslan A., 2021	134.3	79.6	78	135.8	101	78	28.3%	-1.50 [-30.04, 27.04]	2021
Total (95%) CI			218			218	100%	59.14 [4.58, 113.70]	

Heterogeneity: Tau² = 2526.01; Chi² =26.29 df = 3 (P<0.00001); I² = 89%

Test for overal effect Z=2.12 (P=0.03)

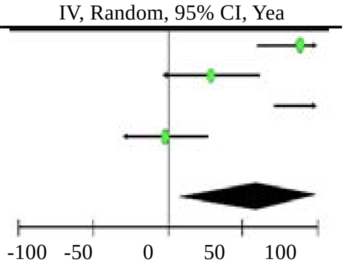

FIGURE 6. *Forest plot duration of procedure*

landmark-guided methods. In the forest plot analysis, the combination of the four studies had statistically high heterogeneity with I^2 = 89% (P = 0.00001). Therefore, a random effect statistical model is used to determine the results of the study. The analysis a significant difference, where ultrasound-guided had a longer duration of procedure than landmark-guided, which was statistically significant [IV 59.14, 95% CI = (4.58, 113.70), p = 0.03] (Fig. 6).

DISCUSSION

Spinal anesthesia procedure in certain population, such as elderly or geriatric patients, is challenging, mainly due to significant technical difficulties [*Rabinowitz A et al. 2007*]. Conventional spinal anesthesia generally relies on an approach through surface anatomic landmarks. However, this technique or approach is something that can be difficult, when performed in geriatric patients, who were common population with degenerative changes in the spine [*Chin K et al., 2011*].

Elderly patients are often found to have lumbar degeneration, scoliosis, or previous spinal surgery, making it difficult for clinicians to palpate landmarks during spinal anesthesia procedures [*Uyel Y, Kilicaslan A, 2021*]. Several difficulties have been reported associated with the use of spinal anesthesia in elderly patients. In the geriatric patient population, clinicians generally find it difficult to mark the point of insertion. This is due to the needle puncture landmarks that can change due to tissue distortion (skin that is easy to move and loose in the elderly) [*Rizk M 2019*]. Other risk factors reported to predict difficulty with spinal anesthesia procedures are the patient's ability to flex their back. Spinal anesthesia in geriatric patients often encounters problems because patients have difficulty achieving such optimal body position [*Chin K. J 2018*]. This limitation in body position ultimately causes the interlaminar space to be relatively narrow [*Qu B et al., 2020*].

Our systematic review and meta-analysis have shown that ultrasound improves technical efficacy to identify the needle insertion point and perform the spinal anesthesia procedure. However, the time required to perform spinal anesthesia procedures is longer when using ultrasound guidance. Furthermore, it is possible that the perceived delay in the completion of spinal anesthesia procedures when using ultrasound may preclude clinicians from incorporating it into their routine practice, particularly in regional anesthesia, where timely performance may be required [*Young B et al., 2021*].

The analysis results in this meta-analysis study indicate that ultrasound-guiding improves the technical performance of spinal anesthesia in this particular group of elderly patients. The potential of preprocedural ultrasound to improve the operator's technical ability to place spinal anesthesia, may reduce the incidence of failure of analgesia or anesthesia, and reduce intra-operative pain scores. It has been hypothesized that decreasing the number of skin punctures and needle diversion may decrease the development of hematoma and the rate of post operative back pain [*Wilkes D et al. 2017*]. In addition, many reported cases of spinal hematoma have been associated with tap bleed and difficult or traumatic neuraxial placement [*Young B et al., 2021*].

Our study has several limitations. There are several factors such as variations in operator competence, type of surgery, to the level of anatomical difficulty that can affect the outcome of spinal anesthesia procedures. In previous study, Rizk et al [*Rizk M 2019*], reported that spinal anesthesia in the elderly population is less difficult and easier

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than expected, thus affecting the level of benefit from the use of ultrasound. The complications that occurred in these studies were not clearly explained. To avoid bias and errors in data extraction, we only take the outcome data which are reported in all reviewed journals. Some of the included trials are at risk of performance and detection bias, leading to a decrease in the quality of the evidence.

CONCLUSION

In conclusion, the use of ultrasound-guiding increases the techinical efficacy of spinal anesthesia procedure. Therefore, future trials should explore the effect of ultrasound-guiding in elderly patients with certain and more specific characteristic that have the potential to predict difficulty with spinal anesthesia procedures. Further randomized controlled trial (RCT) studies with larger samples are needed.

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