RESEARCH

EVALUATING THE ROLE OF VERTEBRAL ANATOMY EXAMINATION BY ULTRASONOGRAPHY BEFORE ADMINISTERING SPINAL ANESTHESIA IN GERIATRIC PATIENTS: A PROSPECTIVE RANDOMIZED TRIAL

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Abstract

Introduction: This study evaluated the importance of examining neuraxial anatomy by preprocedural ultrasonography to ensure effective spinal anesthesia administration, which can be technically challenging in geriatric patients owing to their physiological and pathological conditions.

Materials and Methods: Geriatric patients with an American Society of Anesthesiologists' physical classification of I–III undergoing elective surgery under spinal anesthesia were included. The patients were divided into two groups: the anatomical landmark-guided group and the ultrasound-assisted group. Spinal block application times, number of attempts and number of needle redirections were recorded.

Results: Among the studied patients, 29 and 30 patients were included in the anatomical landmark-guided group and the ultrasound-assisted group groups, respectively. There was no significant difference in the mean age of the patients in the ultrasound-assisted group (74.6 ± 7.41 years) and the anatomical landmark-guided group (75.6 ± 7.52 years). Assisted procedure time and total operative time were significantly shorter in the anatomical landmark-guided group than in the ultrasound-assisted group ($p<0.001$ and $p<0.05$, respectively); however, spinal application times and number of trials and needle redirections were significantly lower in the ultrasound-assisted group than in the anatomical landmark-guided group ($p<0.05$ and $p<0.05$, respectively).

Conclusion: Preprocedural ultrasonography before spinal anesthesia administration increases the first-attempt success rate and decreases the number of attempts and needle redirections in geriatric patients.

Keywords: Geriatrics; Anesthesia, Spinal; Ultrasonography

INTRODUCTION

With improvements in the health care system and patient care services worldwide, life expectancy has increased, and the proportion of elderly people is gradually increasing. According to the World Health Organization, patients over the age of 65 years are defined as geriatric patients (1, 2). Many geriatric patients have more than one chronic disease and at least one disease that requires surgery. Due to existing comorbidities, spinal anesthesia is usually preferred to protect the airway and cognitive functions, especially in lower extremity and lower abdominal surgeries, in geriatric patients. Studies have shown that the incidences of deep vein thrombosis and pulmonary embolism and the amount of postoperative bleeding are lower when spinal anesthesia is administered instead of general anesthesia (3, 4).

The failure rate of spinal anesthesia in geriatric patients ranges between 8% and 14%. High failure rates can be attributed to difficulty in administering spinal anesthesia due to physiological and pathological changes such as disk degeneration, decrease in bone mass, facet joint hypertrophy, spinal degeneration, spinal deformities, ossifications in spinal ligaments, and narrowing of the interspinous spaces (5). Therefore, because multiple attempts at administering spinal anesthesia are required in geriatric patients, complications such as postdural headache, neurological damage, spinal hematoma, and bloody cerebrospinal fluid (CSF) often occur (5, 6). Ultrasonography (USG) is a noninvasive, portable and radiation-free imaging modality that is prominently used in clinical practice. Its widespread use and easy accessibility make USG a suitable method for examining neuraxial blocks.

The aim of this study was to evaluate the effect of examining neuraxial anatomy by preprocedural USG examination on the effectiveness of spinal anesthesia in geriatric patients, which is challenging due to physiological and pathological conditions.

MATERIALS AND METHODS

This prospective and randomized controlled study was approved by the Ethical Committee of Osmangazi University (decision number: 2020/39). Patients were informed about the study protocol, and verbal and written informed consent was obtained. Patients with an ASA physical classification of I-III, who were 65 years and older and underwent an elective operation under spinal anesthesia were included in the study. Patients in whom spinal anesthesia was contraindicated, including those with histories of an allergy to local anesthesia, coagulation disorder, infection at the site of intervention, and lumbar surgery, and those who were unwilling to participate in the study were excluded. Patients in both groups were taken to the operating room and underwent standard monitoring (electrocardiogram, pulse oximetry, and noninvasive blood pressure). Intravenous cannulation was performed, and intravenous drip of normal saline was connected. The patients in both groups were placed in a sitting or lateral decubitus position, depending on the type of anesthesia desired.

Patients were divided into two groups based on the preprocedural examination method used: the anatomical landmark-guided group (ALGG) and the ultrasound-assisted group (UAG). Imaging was performed using a convex probe [Philips Medical Systems, Seattle, WA, United States] in both groups. The "Covidien Devon Skin Marker with a Regular Tip" was used for skin marking. A computer-generated table of random numbers and the closed envelope method were used for the randomization of patients to these two groups.

ALGG: After positioning the patient, the upper border of the iliac crest and the spinous processes of the vertebrae were palpated and marked. The location of the L4–L5 was estimated by extending the mark on the upper border of the iliac crest transversely to the vertebral column. One level above or below the spinous processes was palpated,

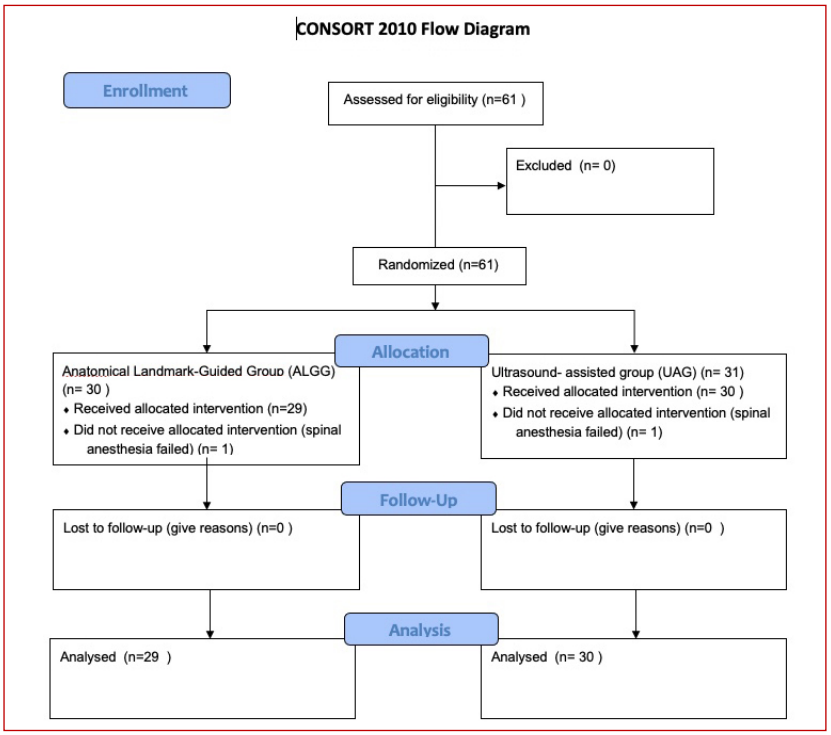

Figure 1. CONSORT flow diagram of the patients

and the most appropriate entry site, either L3-4 or L4-5, was determined by the practitioner. These points were marked straight over the transverse line and then connected to each other by a vertical line to determine the entry point. After ensuring sterile conditions, spinal anesthesia was administered to the patients. While maintaining the same position, the level of the spinal needle entry site was checked with the convex probe of the USG to determine the distance between the intrathecal space and the skin (Figure 1).

UAG: After positioning the patient, the convex probe of the USG was placed transversely over the sacrum and advanced to the cephalus, and the location of the L4-5 was detected. The image was moved to the center of the screen. The midpoint of the top edge and side edge of the probe were marked with a tissue pen. After determining the distance between the intrathecal space and the skin (ID), the upper mark was extended caudally, and the lateral mark was extended straight toward the vertebral column. The intersection point of the two lines was considered the entry point. The image was sharpened by tilting the probe. The entry angle of the spinal needle was determined based on the angle at which the image was the sharpest. After sterile conditions were ensured, spinal anesthesia was administered (Figure 2).

The patients in both groups were placed in the surgical position, and the study was terminated after the spinal block's success was evaluated. USG imaging and spinal blocking were performed by the same person (A.I). A maximum of three attempts at the same level and five attempts in total were allowed. Spinal anesthesia procedures that could not be performed after 5 attempts were recorded as failed spinal anesthesia. In the case of blood tap by the spinal needle, another interspinous interval was used. In a failed block, a paramedian approach and general anesthesia were applied before the surgery.

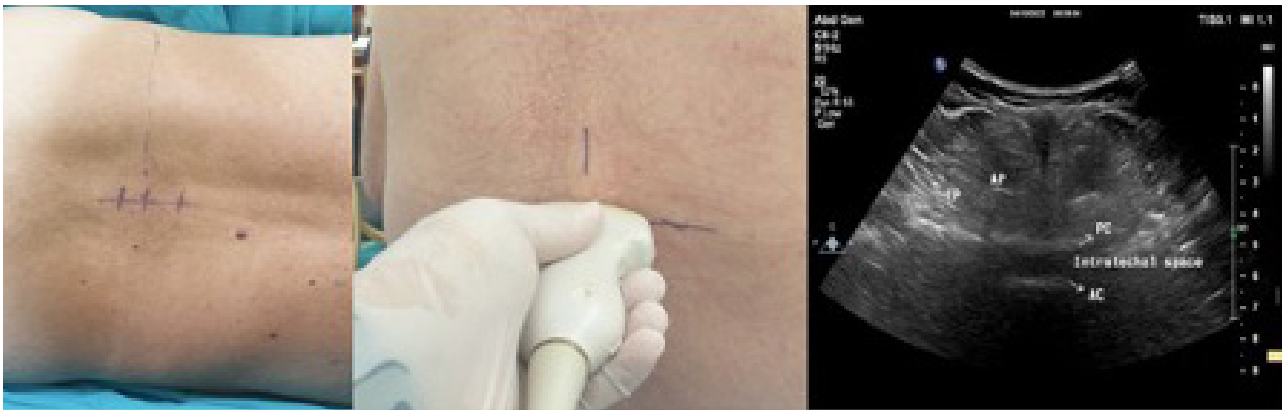

Figure 2. Anatomical marking, USG marking and USG image

Spinal block application time (SAT), the number of attempts, and the number of needle redirections were recorded for each patient. SAT was defined as the time lapsed between the entry of the needle into the skin until the appearance of clear CSF. The number of attempts was defined as the number of times the needle entered the skin. The number of needle redirections was defined as the number of times the needle was directed cephalad caudally or laterally under the skin without being removed. Anatomical marking time (AMT) was recorded for the ALGG, and ultrasound-assisted marking time (UMT) was recorded for the UAG.

Sample Size and Statistical Analysis

The research was based on the comparison of two independent groups, and an independent samples t test was used in the background for power analysis. With 80% power and a 5% type I error rate, the minimum sample size was calculated as 27 people per group and 54 people in total (5).

For statistical analysis of the findings obtained in the study, we used the Statistical Package for Social Sciences for Windows 24.0 program. Mean, standard deviation, median, minimum–maximum values, and interquartile range (IQR) were used to present descriptive statistics.

Pearson chi-square and Fisher's exact tests were used to compare 2 × 2 cells. The conformity of the variables to a normal distribution was analyzed by histograms and the Shapiro–Wilk test.

Independent samples t tests were used to evaluate normally distributed parametric independent variables. One-way ANOVA was used to analyze normally distributed independent variables in more than two groups. The Mann–Whitney U test was used to evaluate nonnormally distributed nonparametric independent variables. The Kruskal–Wallis analysis test was used to evaluate nonnormally distributed independent variables in more than two groups.

The relationship between variables was evaluated using the Pearson correlation test and Spearman correlation test for normally distributed parametric and nonnormally distributed nonparametric data, respectively. The statistical significance level was set at $p < 0.05$.

RESULTS

Of the 59 patients who were included in the study, 30 and 29 patients were added to the UAG and ALGG, respectively. However, spinal anesthesia could not be performed in one patient in each group. These patients were recorded as having failed spinal anesthesia (Figure 1).

Table 1. Demographic Data

		UAG (n:30)			ALGG (n:29)			p
		n		%	n		%	
*Sex	Female	9		30	11		37.9	0.52
	Male	21		70	18		62.1	
*BMI Group	Underweight	2		6.7	1		3.5	0.73
	Normal weight	11		36.7	13		44.8	
	Overweight	17		56.6	15		51.7	
		n	**Range Avg**	**IQR**	**n**	**Range Avg**	**IQR**	**p**
**Age (year)		30	28.60	12	29	31.45	10	0.52
**BMI (kg/m^2)		30	30.82	6	29	29.16	9	0.71
		n	**Mean**	**ss**	**n**	**Mean**	**ss**	**p**
***ID (cm)		30	5.17	0.57	29	5.17	0.62	0.37

*Chi Square Test **Mann-Whitney U Test, *** Independent-Samples T Test

UAG: Ultrasound-Assisted Group, ALGG: Anatomical Landmark-Guided Group BMI: Body Mass Index, ID: Intrathecal Distance, cm: centimeter, kg: kilogram

The study sample included geriatric patients with a mean age of 75.12 ± 0.96 years. The mean age of the patients in the UAG and in the ALGG was 74.6 ± 7.41 and 75.6 ± 7.52 years, respectively, with no statistical significance (Table 1). The ASA classes of the preoperative patients were I in 6.8% (n: 4), II in 42.4% (n: 25), and III in 50.8% (n: 30). There was no statistically significant difference between the groups in terms of surgical operation or level and position of spinal anesthesia (Table 2).

Assisted procedure time and total operative time were significantly shorter in the ALGG than in the UAG ($p < 0.001$ and $p < 0.05$, respectively); however, spinal application times were significantly shorter in the UAG than in the ALGG ($p < 0.05$). The number of attempts and the number of needle redirections were significantly lower in the UAG than in the ALGG ($p < 0.05$; Table 3).

The success rates of the spinal block at the first attempt were 93% (n = 28) and 69% (n = 20) in the UAG and the ALGG, respectively. The probability of success at the first attempt was also higher in the UAG than in the ALGG ($p < 0.05$; Table 2). Although the spinal block was effective, general anesthesia was induced after 35 minutes in one patient in the UAG due to patient noncompliance.

The correlation analysis of AMT data showed a moderately significant positive correlation between AMT and SAT ($r = 0.381$; $p < 0.05$) and a significant positive correlation between AMT and total time ($r=0.608$; $p<0.001$).

Table 2. Characteristics of Blocks

		UAG (n:30)		ALGG (n:29)		p
		n	%	n	%	
Type of surgery	Orthopedic Surgery	11	36.7	17	58.6	0.52
	Urological Surgery	17	56.6	7	24.1	
	Other Surgical Procedures	2	6.7	5	17.3	
Interspace level used for dural puncture	L 3-4	0	0.0	4	6.8	0.052
	L 4-5	30	100.0	25	93.2	
Patient Position	Sitting	15	50.0	14	48.3	0.89
	Lateral decubitus	15	50.0	15	51.7	
Blood Tap By The Spinal Needle	No	29	96.7	24	82.8	0.09
	Yes	1	3.3	5	17.2	
Electric-Like Feeling	No	27	90.0	27	91.5	0.51
	Yes	3	10.0	2	8.5	
Number of attempts	One	28	93.3	20	69.0	0.016[a]
	More than one	2	6.7	9	31.0	

[a] $p<0.05$

Table 3. Characteristics of the procedure

	UAG (n:30)			ALGG (n:29)			p
	n	Range Avg	IQR	n	Range Avg	IQR	
APT (sec)	30	42.82	11.70	29	16.74	9.45	<0.001[β]
SAT (sec)	30	24.70	11.68	29	35.48	25.05	0.016[a]
Total Time (sec)	30	34.48	30.23	29	25.36	30.70	0.041[a]
Number of Attempts	30	26.33	0	29	33.79	1	0.014[a]
Number of Needle Redirections	30	25.67	1	29	34.48	1	0.026[a]

Mann-Whitney U Test
[a] $p<0.05$, [β] $p<0.001$
APT: Assisted procedure time, SAT: Spinal block application time, sec: Second

The correlation analysis of UMT showed no significant correlation between UMT and age, body mass index (BMI), ID, SAT, number of attempts, and number of guidance ($p > 0.05$), while a significant positive correlation was found between UMT and total time ($r = 0.593$; $p = 0.001$).

The correlation analysis of ID and demographic characteristics of the patients revealed a moderately significant negative correlation between age and ID ($r = 0.288$; $p < 0.05$) and a moderately significant positive correlation between ID and height ($r = 0.270$; $p < 0.05$), weight ($r = 0.433$, $p < 0.001$), and BMI ($r = 0.301$; $p < 0.05$). There was no significant difference in intrathecal distances between BMI groups ($p > 0.05$).

After marking the spinal intervention site, the predicted anatomical level was checked with USG in ALGG ($n = 29$). The level was correctly predicted in 22 patients (75.9%), and incorrectly predicted in seven patients (24.1%).

No significant difference was found between the groups in terms of blood tap by the spinal needle and electric-like feeling during spinal anesthesia ($p > 0.05$). The incidence of blood tap by the spinal needle increased as the number of spinal anesthesia attempts increased ($p < 0.05$). Electric-like feelings increased as the number of attempts and number of redirections increased ($p < 0.05$).

DISCUSSION

This study focuses on proposing a suitable method for administering spinal anesthesia in geriatric patients, which can otherwise be challenging owing to their physiological and pathological conditions. The mean age of the studied patients was 75.12 ± 0.96 years, which was higher than the age range included in the previous studies that investigated the use of preprocedural USG for spinal anesthesia in geriatric patients. It was found that neuraxial ultrasonography improved spinal anesthesia effectiveness in geriatric patients. It was observed that using USG could decrease the procedure time and number of attempts and redirections required for spinal anesthesia and increase the total procedure time with increased assisted procedure time.

The number of geriatric patients seeking health care services is increasing worldwide, leading to anesthesiologists developing special care techniques for elderly patients. Such patients needing surgery require a higher level of perioperative care due to the tendency of multiple comorbid chronic diseases increasing the risk of postoperative complications (7). The most appropriate anesthetic technique for geriatric patients is still controversial. Although spinal anesthesia can reduce the risks of postoperative and intraoperative complications, shorten the hospital stay, and decrease the risk of in-hospital mortality, there was no significant difference in postdischarge and 30-day mortality when compared to those associated with general anesthesia (7-9). However, a shorter hospital stay and fewer complications have made spinal anesthesia more cost effective than general anesthesia (10).

Spinal anesthesia is the most commonly used regional anesthesia technique, particularly in orthopedic, urological, and obstetric anesthesia. The increasing number of attempts and redirections decreases patient satisfaction, and also increases the likelihood of spinal anesthesia-related complications such as low back pain, postspinal headache, neurological damage, and spinal and epidural hematoma (11, 12). Therefore, reducing the number of attempts during spinal anesthesia will be beneficial in preventing complications and increasing patient satisfaction.

Different approaches for administering spinal anesthesia in geriatric patients have always interested anesthesiologists due to the growing elderly population and the challenges faced by patients. Different approaches have been introduced to overcome this challenge. Rabinowitz

et al. reported that the paramedian approach was more successful than the median approach in continuous anesthesia in geriatric patients (13). Park et al. showed that neuraxial ultrasonography in the paramedian approach improved spinal anesthesia performance in elderly patients (14).

With advances in ultrasound technology and the widespread use of USG in anesthesia applications, the use of USG for neuraxial blocks has become popular among anesthesiologists. In this study, we compared the effectiveness of preprocedural USG examination of neuraxial anatomy and the classic anatomical marking method on the success of spinal anesthesia in geriatric patients scheduled for spinal anesthesia. Failure to reach the subarachnoid space within the recommended number of attempts and needle redirections was defined as failed spinal anesthesia. Spinal anesthesia could not be performed in one patient in the ALGG and in the UAG, and general anesthesia was initiated for these patients. There was no significant difference between the groups in terms of the incidence of failed spinal anesthesia.

In a meta-analysis, Jiang et al. evaluated the first-attempt success of preprocedural neuraxial ultrasonography in obstetric patients. It was reported that ultrasonography improved the first-attempt success rate only in patients who were difficult to palpate (15). As palpation is difficult due to the anatomy of geriatric patients, the first-attempt success rate of spinal anesthesia was significantly higher with USG, which was similar to the observed success rate with UAG in this study.

The preferred intervertebral spaces for spinal anesthesia are L4–5, L3–4, and L5–S1. Although the medulla spinalis usually ends at L1–2, Soleiman et al. showed that the medulla spinalis can extend to the L3 vertebra and is usually at a lower level in elderly patients (16). The level determined by anatomical landmarks may differ from the predicted level. In a study by Broadbent et al. that evaluated the ability of anesthesiologists to estimate the lumbar interval with magnetic resonance, the correct estimation was made in only 29% of cases. In 51% of cases, the marked range was one level above the correct range (17). Furness et al. showed that the use of USG and palpation in determining the intervertebral level provided 71% and 27% accuracy, respectively (18). Inadequate anatomical landmarks and the medulla spinalis terminating at a more caudal level with increasing age may lead to complications during intrathecal injections. In the present study, intrathecal injections were made outside the predicted range with ultrasonography in 24.1% of spinal anesthesia procedures that were performed with the guidance of anatomical landmarks. This relatively low rate may be related to the experience and expertise of our surgeons who administer spinal anesthesia. Although studies have shown that ultrasonography is more successful in detecting the correct range than anatomical landmarks, it should be noted that ultrasonography is not completely reliable. This suggests that USG-assisted spinal anesthesia may prevent possible complications by identifying a safe intervertebral space.

In studies wherein the vertebral axis was examined from the longitudinal and transverse axes, the mean time required to identify the vertebral axis with USG was 95 seconds in patients with abnormal spinal anatomy and 117 seconds in elderly patients in whom the paramedian approach was used (14,19). In the present study, only the transverse axis was evaluated in a mean time of 42 seconds. The first-attempt dural puncture success rate is similar to that in previous studies, and the total procedure time is shorter, suggesting that the use of USG in clinical practice for spinal anesthesia will gain prominence.

The effect of USG guidance in spinal anesthesia on the success of first-attempt punctures and the number of attempts and needle redirections is still controversial. In the study by Lim et al. that evaluated the use of USG before spinal anesthesia

procedures in the general population, USG did not significantly reduce the number of successful first-attempt punctures or the number of attempts and needle redirections (20). While Marvan et al. (21) obtained similar results, Srinivasan et al. (22) compared the classic anatomical landmark method with the paramedian approach from L5–S1 and the USG-assisted method and showed that USG did not reduce the number of attempts or needle redirections for successful puncture; however, the first-attempt success rate was higher in the USG-assisted method. Contrary to these results, the success rate of USG at the first attempt in elderly patients and in patients with lumbar scoliosis and a history of previous lumbar surgery was higher and the number of attempts and redirections was lower (19,23). This discrepancy among various studies may be due to differences in the patient groups that were studied and the practitioner's experience in the use of USG. Therefore, patients aged ≥ 65 years for whom such procedures were challenging in terms of positioning and physiopathological changes were selected in the present study. In the UAG, the rate of successful spinal anesthesia on the first attempt was higher than that in the ALGG, and the number of attempts and needle redirections was significantly lower.

In this study, the marking time for spinal anesthesia was significantly shorter in the ALGG than in the UAG. However, spinal anesthesia was performed in a significantly shorter time in the UAG. Although the longer marking time was partially compensated by a shorter duration of spinal anesthesia in the UAG, the total procedure time was significantly shorter in the ALGG than in the UAG. In a study by Chin et al. conducted on adults with a BMI>35 kg/m^2 and difficult anatomical landmarks such as poor spinous process palpation, moderate to severe lumbar scoliosis, or with a history of lumber spinal surgery, marking time and total time were longer in the USG, but spinal anesthesia was performed in a shorter time (24). Park et al. compared anatomical landmarks and USG-assisted paramedian spinal anesthesia in geriatric patients and found that while the marking and total times were longer, the time taken for spinal anesthesia was shorter in the USG-assisted method, which was similar to the result obtained in this study. In contrast, a previous study demonstrated that adults with an abnormal spinal anatomy exhibited similar total procedure times in both groups. Although administering spinal anesthesia can be complicated in older patients, lateral curvatures and rotational changes in the spine of patients with scoliosis and unclear or even absent anatomical landmarks in patients with a history of lumbar spinal surgery can make this procedure more complicated and require more time (14, 19).

In our study, it was observed that the duration of spinal analgesia and the number of attempts increased in the geriatric patients in the ALGG, whose anatomical marking time was prolonged. There was a moderate positive correlation among the anatomical marking time, the duration of spinal application, and the number of attempts. The importance of the quality of anatomical landmarks for the success of spinal anesthesia was previously emphasized by Filho et al. (6). Therefore, more effort and time were required for spinal anesthesia in patients with palpation difficulty, which was an expected result. In the UAG, no significant correlation was found among the marking time, time taken for spinal anesthesia, and number of attempts. Therefore, the results suggest that USG reduces the time taken and number of attempts for spinal anesthesia, especially in patients in whom anatomical landmarks are difficult to identify.

The use of USG during spinal anesthesia can guide the practitioner by showing the distance of the intrathecal space. Şahin et al. compared USG and classic anatomical landmark methods in obese and nonobese pregnant women and found that the intrathecal distance was significantly larger in the obese group than in the nonobese pregnant

women (25). In this study, no significant difference was found in the BMI groups in terms of intrathecal distance, but there was a moderate positive correlation between BMI and intrathecal space. The lack of a significant difference between BMI groups may be attributed to the lower average BMI values in this study than those included in the study by Şahin et al. Nevertheless, there was a moderate negative correlation between age and intrathecal space. The intrathecal space is closer to the skin in geriatric patients, suggesting that reviewing the needle entry site and direction before increasing the needle depth during unsuccessful spinal anesthesia attempts can prevent possible trauma.

In their study comparing the USG-assisted method with the anatomical landmark-guided paramedian method, Park et al. found no significant difference between the groups in terms of electric-like feeling, paresthesia, and blood tap by the spinal needle (14). Similarly, no significant difference was found between the groups with respect to electric-like feeling and blood tap by the spinal needle. However, in this study, the likelihood of developing radicular pain increased as the number of attempts and redirections increased, and encountering blood tap by the spinal needle increased as the number of attempts increased. Complications of spinal anesthesia are rare, and the sample size of the present study was insufficient to evaluate the rate of complications between the groups, which explains the lack of a significant difference between the groups. It is theoretically correct that USG can reduce the number of attempts and redirections, resulting in fewer complications of spinal anesthesia, such as low back pain, postspinal headache, neural damage, and spinal and epidural hematoma, which are risk factors for multiple interventions. However, further studies with large patient populations are needed to validate this.

There are a few limitations of this study. Due to the nature of the study, patients who were examined by USG imaging and administered spinal anesthesia could not be blinded. For practicality, the intrathecal distance was only transversely maintained with a convex USG probe. Longitudinal, paramedian or simultaneous spinal anesthesia was not preferred. In the UAG, the angle of probe insertion into the skin during imaging was based on the anesthesiologist's memory and not on measurements.

In conclusion, our results show that neuraxial USG facilitates spinal anesthesia application in elderly patients. Compared with preprocedural anatomical landmarks, USG has a high first-attempt success rate and requires fewer attempts and needle redirections. The reduced number of attempts and needle redirections is expected to lead to a reduction in the complications of this procedure. Randomized controlled trials with larger patient groups are required to validate these results.

Conflicts of interest

The authors certify that there are no conflicts of interest with any financial organization regarding the material discussed in the manuscript.

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None to declare

Authors' contributions

All authors have read and approved the final version of the manuscript.

REFERENCES:

1. Bose R. Physiology and Anesthesia for Elderly Patients. In: Ehrenfeld JM, Urman RD, Segal S (Eds). Anesthesia Student Survival Guide: A Case-Based Approach. Springer New York Dordrecht Heidelberg London, 2010. p. 369-80.
2. Organization WH. Psychogeriatrics: report of a WHO scientific group [meeting held in Geneva from 19 to 23 October 1970]. [Internet] Available from: https://apps.who.int/iris/handle/10665/40993/ global_health.pdf. Accessed:25.10.2022.

3. Memtsoudis SG, Sun X, Chiu Y-L, et al. Perioperative Comparative Effectiveness of Anesthetic Technique in Orthopedic Patients. Anesthesiology. 2013;118(5):1046-58. DOI: 10.1097/ALN.0b013e318286061d

4. Rodgers A, Walker N, Schug S, et al. Reduction of postoperative mortality and morbidity with epidural or spinal anaesthesia: results from overview of randomised trials. Bmj. 2000;321(7275):1493. DOI: 10.1136/bmj.321.7275.1493

5. Narkhede HH, Kane D, Parekh V, Hemantkumar I. A cohort study of anatomical landmark-guided midline versus pre-procedure ultrasound-guided midline technique of spinal anesthesia in elderly patients undergoing orthopedic surgery. Journal of Anaesthesiology, Clinical Pharmacology. 2019;35(4):522. DOI: 10.4103/joacp.JOACP_396_17

6. de Oliveira Filho G, Gomes H, Da Fonseca M, Hoffman J, Pederneiras S, Garcia J. Predictors of successful neuraxial block: a prospective study. European Journal of Anaesthesiology (EJA). 2002;19(6):447-51. DOI: 10.1017/s0265021502000716

7. Lim B-G, Lee I-O. Anesthetic management of geriatric patients. Korean journal of anesthesiology. 2020;73(1),8-29. DOI: 10.4097/kja.19391

8. Chen DX, Yang L, Ding L, Li SY, Qi YN, Li Q. Perioperative outcomes in geriatric patients undergoing hip fracture surgery with different anesthesia techniques: A systematic review and meta-analysis. Medicine. 2019;98(49). DOI: 10.1097/MD.0000000000018220

9. Helwani MA, Avidan MS, Abdallah AB, et al. Effects of regional versus general anesthesia on outcomes after total hip arthroplasty: a retrospective propensity-matched cohort study. JBJS. 2015;97(3):186-93. DOI: 10.2106/JBJS.N.00612

10. Memtsoudis SG, Poeran J, Zubizarreta N, et al. Do hospitals performing frequent neuraxial anesthesia for hip and knee replacements have better outcomes? Anesthesiology: The Journal of the American Society of Anesthesiologists. 2018;129(3):428-39. DOI: 10.1097/ALN.0000000000002299

11. Charuluxananan S, Sriprajittichai P, Sirichotvithyakorn P, Rodanant O, Kyokong O. Factors related to patient satisfaction regarding spinal anesthesia. Journal of the Medical Association of Thailand= Chotmaihet thangphaet. 2003;86:S338-43.

12. Rhee WJ, Chung CJ, Lim YH, Lee KH, Lee SC. Factors in patient dissatisfaction and refusal regarding spinal anesthesia. Korean journal of anesthesiology. 2010;59(4):260-264. DOI: 10.4097/kjae.2010.59.4.260

13. Rabinowitz A, Bourdet B, Minville V, et al. The paramedian technique: a superior initial approach to continuous spinal anesthesia in the elderly. Anesthesia & Analgesia. 2007;105(6):1855-7. DOI: 10.1213/01.ane.0000287655.95619.fa

14. Park S-K, Yoo S, Kim WH, Lim Y-J, Bahk J-H, Kim J-T. Ultrasound-Assisted vs. landmark-guided paramedian spinal anaesthesia in the elderly: a randomised controlled trial. European Journal of Anaesthesiology (EJA). 2019;36(10):763-71. DOI: 10.1097/EJA.0000000000001029

15. Jiang L, Zhang F, Wei N, Lv J, Chen W, Dai Z. Could preprocedural ultrasound increase the first-pass success rate of neuraxial anesthesia in obstetrics? A systematic review and meta-analysis of randomized controlled trials. Journal of Anesthesia. 2020: 34(3), 434-444. DOI: 10.1007/s00540-020-02750-6

16. Soleiman J, Demaerel P, Rocher S, Maes F, Marchal G. Magnetic resonance imaging study of the level of termination of the conus medullaris and the thecal sac: influence of age and gender. Spine. 2005;30(16):1875-80. DOI: 10.1097/01.brs.0000174116.74775.2e

17. Broadbent C, Maxwell W, Ferrie R, Wilson D, Gawne-Cain M, Russell R. Ability of anaesthetists to identify a marked lumbar interspace. Anaesthesia. 2000;55(11):1122-6. DOI: 10.1046/j.1365-2044.2000.01547-4.x

18. Furness G, Reilly M, Kuchi S. An evaluation of ultrasound imaging for identificationof lumbar intervertebral level. Anaesthesia. 2002;57(3):277-80. DOI: 10.1046/j.1365-2044.2002.2403_4.x

19. Park S-K, Bae J, Yoo S, et al. Ultrasound-Assisted Versus Landmark-Guided Spinal Anesthesia in Patients with Abnormal Spinal Anatomy: A Randomized Controlled Trial. Anesthesia & Analgesia. 2020;130(3):787-95. DOI: 10.1213/ANE.0000000000004600

20. Lim Y, Choo C, Tan K. A randomised controlled trial of ultrasound-assisted spinal anaesthesia. Anaesthesia and intensive care. 2014;42(2):191-8. DOI: 10.1177/0310057X1404200205

21. Rizk MS, Zeeni CA, Bouez JN, et al. Preprocedural ultrasound versus landmark techniques for spinal anesthesia performed by novice residents in elderly: a randomized controlled trial. BMC anesthesiology. 2019;19(1):208. DOI: 10.1186/s12871-019-0882-8

22. Srinivasan KK, Leo A-M, Iohom G, Loughnane F, Lee PJ. Pre-procedure ultrasound-guided paramedian spinal anaesthesia at L5–S1: Is this better than landmark-guided midline approach? A randomised controlled trial. Indian journal of anaesthesia. 2018;62(1):53. DOI: 10.4103/ija.IJA_448_17

23. Geng J, Chen X, Wang X, Guo X, Li M. Ultrasound imaging increases first-attempt success rate of neuraxial block in elderly patients. Zhonghua yi xue za zhi. 2016;96(43):3459-63. DOI: 10.3760/cma.j.issn.0376-2491.2016.43.004

24. Chin KJ, Perlas A, Chan V, Brown-Shreves D, Koshkin A, Vaishnav V. Ultrasound imaging facilitates spinal anesthesia in adults with difficult surface anatomic landmarks. Anesthesiology: The Journal of the American Society of Anesthesiologists. 2011;115(1):94-101. DOI: 10.1097/ALN.0b013e31821a8ad4

25. Sahin T, Balaban O, Sahin L, Solak M, Toker K. A randomized controlled trial of preinsertion ultrasound guidance for spinal anaesthesia in pregnancy: outcomes among obese and lean parturients. Journal of anesthesia. 2014;28(3):413-9. DOI: 10.1007/s00540-013-1726-1