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Pre- Procedure Paramedian Ultrasound-Guided versus Anatomical Landmarks Spinal Anesthesia in Elderly Patients Undergoing Lower Limb Surgeries

Hadeer Mustafa Abd Elfattah*, Zeinab Ibrahim El-Hossary , Ekram Fawzy Sayouh & Manal Salah-ElDin Farmawy

Anesthesia and Surgical Intensive Care Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt.

Corresponding author: Hadeer Mustafa Abd Elfattah, Email: hadeeeermustafa@gmail.com

Co author : MSfarmawy@medecine zu edu eg

Abstract

Background: Ultrasonography is considered a useful technique for lumbar neuraxial block. The usage of ultrasonography has a potential in finding the best route through the anatomy of the lumbar vertebrae. The current study aims to compare between pre-procedure paramedian ultrasound- guided and anatomical landmarks spinal anesthesia in elderly undergoing lower limb surgeries in Zagazig University hospitals.

Methods: This prospective clinical trial study included 72 patients that were divided randomly into two equal groups, Group C: spinal anesthesia was given by the paramedian anatomical landmarks-guided technique and Group S: spinal anesthesia was given by pre-procedure paramedian ultrasound-guided technique.

Results: There was a statistical significance decrease in mean arterial blood pressure at 5, 10 and 15 min after the onset of spinal anesthesia compared to the baseline readings within each group (p-value <0.05) . While the heart rate is not significantly

decreased compared to the baseline (p-value >0.05). The rate of dural puncture success on the 1st needle insertion trial was higher in group S compared with group C (p-value <0.05). The number of needle insertion attempts , needles passes and needle redirection in this study were significantly lesser in group S than in group C and the depth was deeper in group C compared to group S (p-value <0.05).

Conclusion: The ultrasound-guided showed significantly decreased number of successful needle insertion compared with anatomical landmarks spinal anesthesia. There were remarkable effects on pain reduction and patient satisfaction in elderly patients. Thus, the current study suggested that usage of ultrasonography had potential effect in guiding spinal anesthesia.

Keywords: Ultrasound-Guided, Spinal Anesthesia, Lower Limb Surgeries.

Introduction:

Neuraxial anesthesia remains a preferable technique in elder population due to lower side effects as deep venous thrombosis and postoperative cognitive dysfunction. It has a superior perioperative and postoperative pain control and less opioid consumption [1].

There are spinal changes that occur as age grows in various degrees**.** These changes often cause spinal anesthesia to be difficult to perform in elderly patient**s** [2]**,** [3]. In the conventional technique, the performance of spinal anesthesia has been relies essentially on the anatomical landmarks palpation [4]. The spinal anesthesia could be performed using many approaches like, paramedian, lumbosacral and midline [5]. In elderly patients, The paramedian approach is preferable because of many degenerations in the spines' structural elements [6].

The paramedian spinal anesthesia requires expertise, as it may be associated with technical difficulties such as multiple needle passes and prolonged procedure time [7]. Multiple attempts and needle redirections leading to hazardous complications [8]

, [9]. These complications may include post-anesthesia headache, bloody tap, epidural hematoma, parathesia and neurological injuries [10], [11].

Ultrasonography (US) has brought a revolutionary improvement in anesthesiology [12]. Ultrasound examination prior to neuraxial blocks improves the successful rate of first try it also, minimizes the number of punctures [13], [14]. It also improves the quality of analgesia, reduces the procedure related complications and improves patient satisfaction [2].

The current study was designed to assess whether paramedian ultrasound guided spinal anesthesia can be better than anatomical anesthesia in elderly patient seheduled for lower limb surgeries.

1. Patients and Methods:

This randomized clinical trial study was performed at Zagazig University Hospital after approval of Institutional Review Board (IRB),No (ZU-IRB-6397/9-9-2020) After the approval of regional ethical committees, the informed consent was approved and signed by the patients. The study has been conducted in line with the code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. The study was in the form of clinical trial which was prospectively randomized and controlled. The technique of the study was described to the patients. The patients were coded and the procedure photos were only applied to the site of the study.

The study population was randomized using an independent data manager and the cases were slitted equally with 1:1 ratio (36 in each group) generated by a computer randomization program. Group C (control group): cases were allocated to go through spinal anesthesia by the paramedian anatomical landmarks-guided technique. Group S: the patients were allocated to go through spinal anesthesia by pre-procedure

paramedian ultrasound-guided technique. Contraindication to spinal anesthesia was considered as : previous infection of the site of injection, bleeding tendency and uncorrected hypovolemia, pervious back surgery, abnormal spinal anatomy, allergy to local anesthetics used, advanced cardiac, liver and renal disease, peripheral neuropathy and patient withdrawal were excluded from the study

Preoperative preparation:

All cases were visited in the ward at the night before the operation and full history was taken. Physical examination included; mental status, chest, abdominal and cardiological examination. Full laboratory investigations were ordered included: (fasting blood sugar level, kidney function tests, liver function test, serum electrolytes and coagulation profile e.g., PT, PTT, INR) and 12 leads ECG was revised. All patients were nil orally before the operation for 6 hours.

Procedure:

On arrival to the operating room, standard monitoring was applied to all patients , including pulse oximetry, electrocardiogram (ECG) and noninvasive blood pressure (NIBP) . The basal readings of heart rate (HR), mean arterial blood pressure (MAP) and arterial oxygen saturation (SpO2) were obtained.. IV cannula '18-guage' was inserted and lactated ringer solution (6 ml / kg) was given as a preload volume before spinal anesthesia. Patients were randomly allocated to one of 2 groups:

Group C anatomical landmarks paramedian spinal anesthesia :

1- The back of the patient was sterilized with betadine10% solution.

2- “Tuffier‟s” line was a line drawn across the iliac crest that crosses the body of L_4 or L_4-L_5 interspace. This is a helpful landmarks for the placement of spinal anesthesia**.**

3- The caudal tip of the L_4 spinous process was identified, the finger was moved 1 cm inferior and lateral to it to locate the needle insertion point

4-Needle insertion was in a cephalad and medial direction, with the needle angled 10°–15° toward the midline and 10°–15° in the cephalad direction. If contact was made with the lamina, the needle should be adjusted in a cephalad direction to reach the subarachnoid space and obtain the CSF.

Group S paramedian ultrasound-guided spinal anesthesia followed the following protocol **(Figure 1):**

(1) The pre-procedural US paramedian spinal anesthesia was carried out in a non-sterile manner. Spinal procedure was carried out under sterile condition with the cases in the sitting position.

(2) Ultrasound-guided paramedian spinal anesthesia was carried out using the transverse spinous process view.

(3) The ultrasound gel was put on the patient's back and the machine settings of probe frequency, depth, gain, and focus were appropriately regulated to get the best image quality [5].

(4) The ultrasound probe was put in a horizontal direction with the center of the probe placed in the midline over the cases' L_4 spine **(Figure 1,A).** and was manipulated in a cephalad caudad direction . When the ultrasound beam was placed over a spinous process, the tip of the spinous process appeared as a superficial hyperechoic „cap" surrounding a tall dense acoustic shadow [15] **(Figure 1,B).**

(5) The dark area was centered in ultrasound screen and skin marks were obtained at two points **.**

(A)The midpoint of the long edge of the probe, which corresponds to the neuraxial midline

(B) The midpoint of the short edge of the probe, which correspond to the location of the spinous process in the transverse plane **(Figure 1,C)**

(6) Any remaining gel was wiped off and the marks were extended to intersect. The crossing of these two marks indicated the location of the spinous process tip **(Figure 1,D).**

(7) The marking steps were duplicated for two following spinous processes (L_4 and L_5), with the interlaminar space anticipated to in the middle **(Figure 1,D).**

(8) After identifying the midline and the spinous processes of L_{4-5} lumbar spines , the point of spinal needle insertion was at a point approximately 1cm superior to the transverse line of the lower spinous process and 1 cm lateral to the midline **(Figure 1,D).**

(9) The skin back was Sterilized with betadine 10 % solution and spinal anesthesia was given **(Figure 1,E).**

(10) The needle-insertion depth was evaluated by evaluating the distance from the posterior complex which appeared as a hyperechoic line to the skin **(Figure 1,F).**

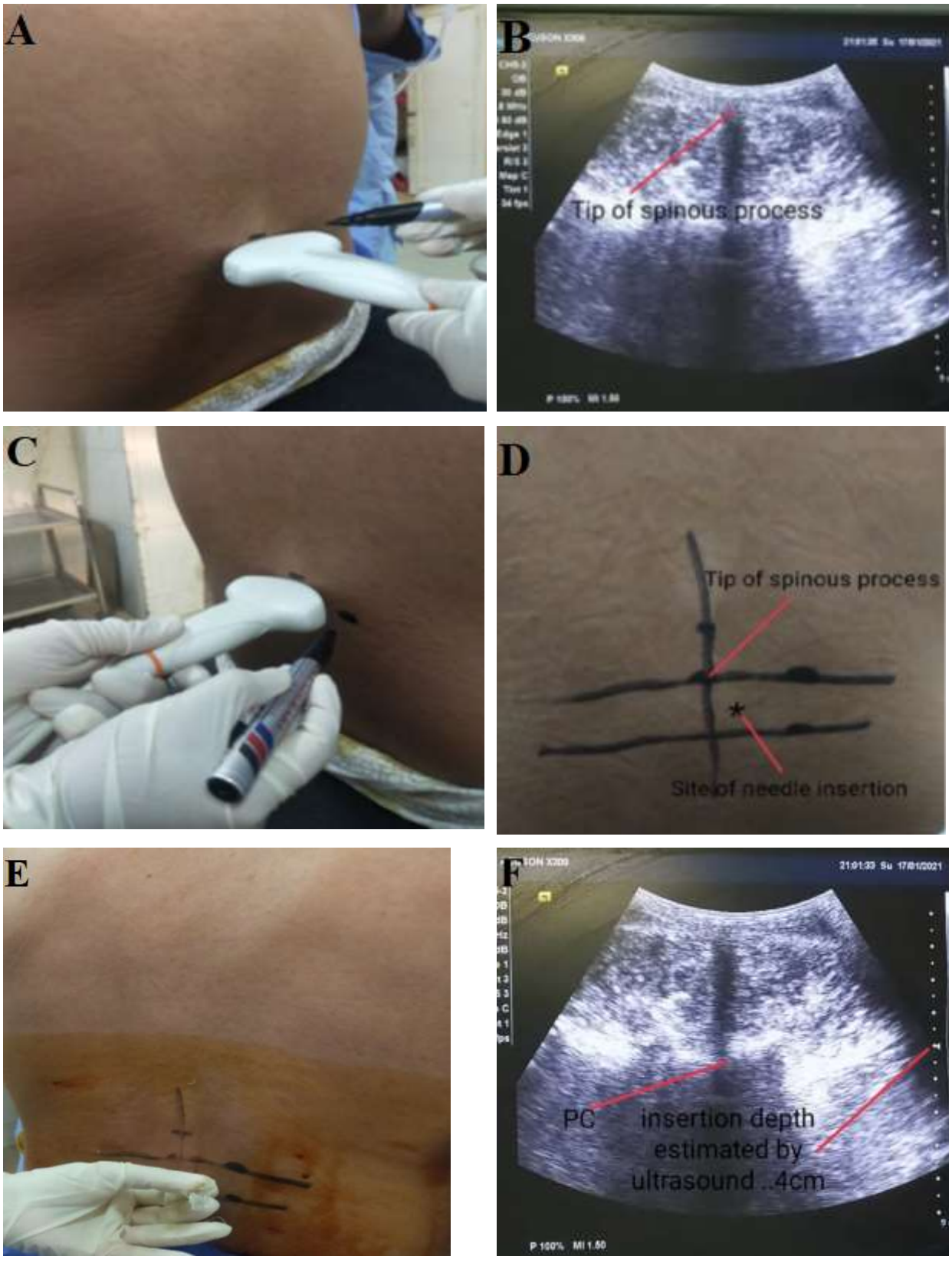
A
B
Tip of spinous process
C
D
Tip of spinous process
*
Site of needle insertion
E
F
PC
insertion depth
estimated by
ultrasound ..4cm

Figure 1. Ultrasound guiding of the spinal anesthesia, (A): Skin marking of the tip of spinal process, (B): The superficial hyperechoic surrounding a tall dense acoustic shadow resembling the tip of the spinous process. (C): Skin marking the midpoint of the short edge of the probe, which resembles the location of the spinous process in the transverse plane. (D): Marking process at two consecutive spinous processes. (E): Needle insertion site. (F): The utrasound-guided needle insertion.

No more than 3 attempts were permitted to the operator.

For the anatomical landmarks group: alternative space was used. For ultrasound group anatomical landmarks in the same space was used, if failed alternative space was used and it was considered as failed spinal anesthesia.

Patients of both groups were monitored continuously for heart rate (HR), arterial O_2 saturation (SpO_2 %) and mean arterial blood pressure (MAP) and the readings were recorded every 5 minutes in the first 15 minute then every 15 minutes during the first hour of surgery then every 30 min till the end of surgery. If bradycardia occurred (HR <60 beats /minute), atropine was given intravenously by dose of 0.04 mg/kg IV. If hypotension occurred (MAP decreased by 20 % of baseline reading), IV fluid and ephedrine was given by dose of 5 mg IV administered slowly. It may be repeated after 5 to 10 minutes if necessary.

The assessment of the procedure was collected according to the following protocol:

(1) The successful spinal anesthesia on the first needle insertion attempt and the number of needle insertion trial required for successful spinal anesthesia. Also, the number of needles passes and the time taken for identification of interspace and to perform spinal anesthesia.
(2) The pain score of block evaluated by patients just after the end of spinal anesthesia [16]. The degree of satisfaction with the anesthesia was evaluated

by cases just after the end of carrying out of the spinal anesthesia, on a 1-3 points scale (1: un satisfactory 2: satisfactory 3: excellent) [17].

(3) Postoperative HR, MAP and SpO_2 % were recorded every 30 minutes for one hour. Postoperative complications (bloody tap, post dural puncture headache, back pain and parathesia).

2. Statistical analysis:

Statistical analysis was performed using SPSS software version 27 (IBM, 2020). Data were presented in figures and tables. Quantitative variables were presented as mean, median, range and standard deviation. Qualitative variables were presented as frequencies and proportions. Shapiro-Wilk test was used to determine the distribution characteristics of variables and variance homogeneity. Pearson‟s chisquared test and fisher‟s exact test were used to analyze qualitative data as appropriate. Student‟s t-test and Mann-Whiney U test were used to analyze quantitative variables as appropriate. A P-value of ≤ 0.05 was accepted as statistically significant.

3. Results:

In this study 100 geriatric patients were assessed for eligibility 28 patients were excluded as 15 patients were not meeting inclusion criteria, 10 patients refused to participate and 3 patients for different reasons .72 patients whom were included in our study were randomized to 2 equal groups 36 patients in each group **(Figure 2).**

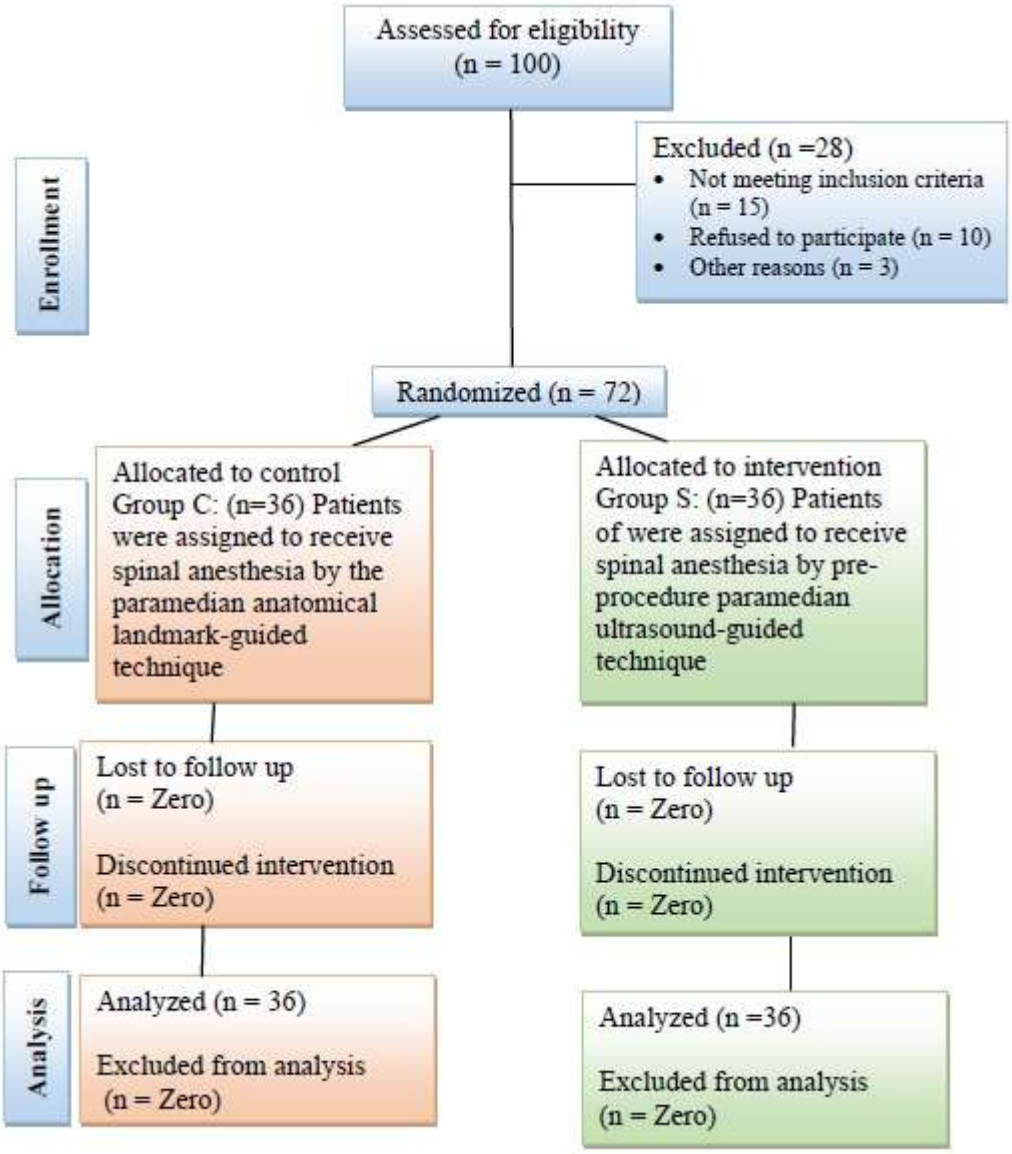

Figure 2. CONSORT flow chart of the study.

Patients and surgical characteristics of the study were comparable and did not show any significant difference regarding patients characterstics, BMI, ASA classification, type and duration of surgery ($P > 0.05$) **(Table 1).**

Table 1. Patients characteristics of the studied groups

Variables	**Group C (n=36)**	**Group S (n=36)**	**P**
Age (years): Mean ± SD	69.0 ± 3.6	68.9 ± 3.2	0.9
Gender, no. (%): Male	26 (72.2%)	24 (66.7%)	0.6
Female	10 (27.8%)	12 (33.3%)	
BMI (Kg/m^2): Mean ± SD	21.6 ± 3.6	21.6 ± 3.1	0.9
ASA class, no. (%): II	23(63.9%)	30 (83.3%)	0.09
III	13 (36.1%)	6 (16.7%)	
Type of surgery, no.			
(%): Debridement	8 (22.2%)	9 (25.0%)	0.9
Fixation	13(36.1%)	12 (33.3%)	
Abscess	7 (19.4%)	6 (16.7%)	
Amputation	6 (16.7%)	6 (16.7%)	
Angioplasty	2 (5.6%)	3 (8.3%)	
Duration of surgery (hours): Median (Range)	2.0 (1.0 – 3.0)	2.0 (1.0 – 3.0)	0.9

Group S: Pre-procedure paramedian ultrasound-guided group. Group C: Paramedian anatomical landmarks-guided group, BMI: body mass index, SD: standard deviation, no.: number, ASA: American Society of anesthesiologists**.**

Regarding MAP in the studied groups there was a statistical highly significant decrease in MAP at 5, 10 and 15 min in both groups while there was not significantly different at any time of the follow up period ($p>0.05$) (Figure 3,A).

Regarding heart rate (HR), the studied groups did not show any statistically significant difference at any time of the follow up period compared to the baseline was not significantly different (Figure 3,B).

Regarding SpO_2 %: the relationship between the studied groups, or within each group at any time of the follow up period did not show any significant difference.

(A) Mean arterial blood pressure (mmHg) at different times of the studied groups.

(B) Heart rate (beat/min) at different times of the studied groups.

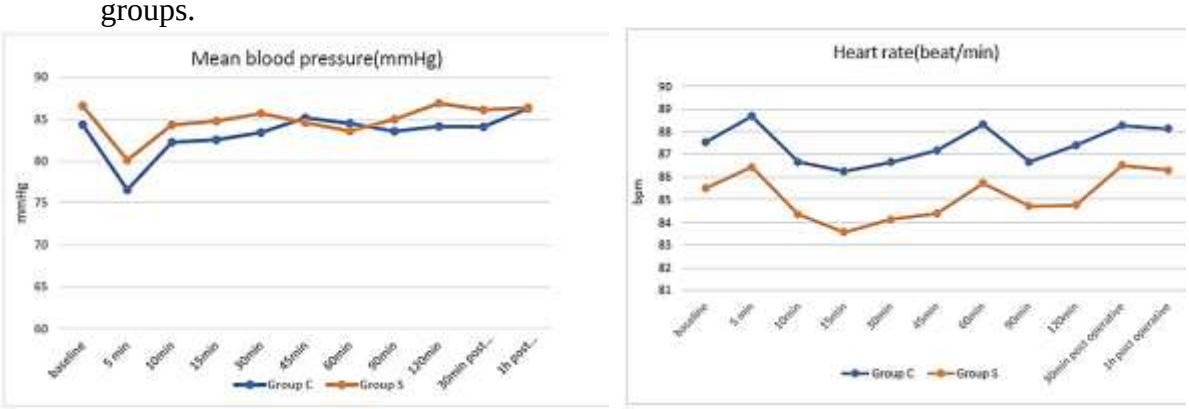

Figure 3. Hemodynamic parameters, (a) Mean Arterial Blood Pressure (mmHg) in the two studied groups, (b) Heart Rates(beat /min) in the two studied groups.

Regarding the rate of success of spinal anesthesia on the 1st needle insertion trial there was significant difference between the groups of the study. Group S had higher 1st insertion attempt success rate (75 %) compared to group C (36.1 %) **(Table 2).**

Regarding the number of needle insertion tries for successful dural puncture there was statistically highly significant difference between the two studied groups. Group S had less number of needle insertion attempts (one attempt in 30 patients, two attempts in 6 patients and no 3 attempts occurred in any patient) compared to group C (one attempt in 13 patients , two attempts in 13 patients and three attempts in 10 patients) (P-value < 0.05) **(Table 2).**

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Regarding to the number of needles passes and redirections there was statistically significant decrease in the number of needle passes in group S which recorded (one needle pass attempt in 21 patients, 2 attempts in 6 patients and 3 attempts in 3 patients) compared to group C in which 9, 16, 8 patients showed one, two and three needle pass attempts respectively (P-value < 0.05) **(Table 2).**

Regarding to the time taken to identify the interspace it was statistically highly significant longer in group S (4.3 ± 1.2 min) vs (2.5 ± 0.8 min) in group C (P-value < 0.05) **(Table 2).**

Regarding the needle insertion depth there was statistically significant difference between two groups as group C had deeper needle insertion depth compared to group S (It was 6.1 ± 1.1 cm in group C Vs 5.6 ± 1.1 cm in group S) (P-value < 0.05) (Table 3).

Regarding to the time taken to go through spinal anesthesia it was statistically significant longer in group C (4.4 ± 1.2 min) compared to (3.7 ± 1.1min) in group S (P-value < 0.05) **(Table 2).**

The total procedure time was statistically significant longer in group S (8.0 ± 1.1 min) than group C (6.9 ± 1.7 min) (P-value < 0.05) **(Table 2).**

Table 2. Intraoperative technical characteristics in the studied groups

Variable	Group C (n=36)	Group S (n=36)	P
The rate of successful dural puncture in the 1st needle insertion attempet n (%):			
Yes	13 (36.1%)	27 (75.0%)**	<0.001
No	23 (63.9%)	9 (25.0%)	
No. of needle insertion attempts, no. (%):			
1 attempt	13 (36.1%)	30 (83.3%)**	
2 attempts	13 (36.1%)	6 (16.7%)	<0.001
3 attempts	10 (27.8%)	0 (0.0%)	
No. of needle pass no. (%):			
0 attempts	3 (8.3%)	6 (16.7%)*	
1 attempt	9 (25.0%)	21 (58.3%)*	0.006
2 attempts	16 (44.4%)*	6 (16.7%)	
3 attempts	8 (22.2%)*	3 (8.3%)	
Time taken to identify the interspace (min.) Mean ± SD	2.5 ± 0.8	4.3 ± 1.2**	<0.001
Time of spinal anesthesia(min) Mean ± SD:	4.4 ± 1.2*	3.7 ± 1.1	0.01
Total procedure time (min)Mean ± SD:	6.9 ± 1.7	8.0 ± 1.1*	0.003
Needle insertion depth (cm)Mean ± SD:	6.1 ± 1.1*	5.6 ± 1.1	0.04

Group S: Pre-procedure paramedian ultrasound-guided technique, Group C: Paramedian anatomical landmarks-guided technique, **: highly significant. *: Significant, SD: standard deviation, min: minute: cm: centimeter, no.: number.

Regarding block associated pain score there was statistically significant decrease in group S (mean=3) compared to group C (mean=5) ($p< 0.05$). Patient satisfaction score was significantly increased in group S (58,3 % of patients showed excellent score, 33.3 % were satisfied and 8.3 % were unsatisfied) compared to group C (none of the patients recorded excellent satisfaction score, 30.6 % were satisfied and 69.4 % were unsatisfied) (P-value <0.05) **(Table 3).**

Table 3. Intraoperative block associated pain score and patient satisfaction in the studied groups

Variable	Group C (n=36)	Group S (n=36)	P
Block associated painscore: Median (Range)	5 (3 – 7)	3 (1 – 4)**	<0.001
Patient satisfaction, n (%):			
1 = Unsatisfactory	25 (69.4%)	3 (8.3%)	<0.001
2 = Satisfactory	11 (30.6%)	12 (33.3%)**	
3 = Excellent	0 (0.0%)	21 (58.3%)**	

Group S: Pre-procedure paramedian ultrasound-guided technique, Group C: Paramedian anatomical landmarks-guided technique, n: number, **: highly significant.

Regarding the postoperative complications: bloody tap and post dural puncture headache was not significantly different between two the groups (p-value > 0.05). Meanwhile there was significant decrease in back pain in group S (11.1 %) than in group C (36.1 %) (p-value < 0.05). None of the cases developed parathesia or radicular pain.

4. Discussion:

The degenerative spinal disease of elderly patients specially with narrowed interspinous spaces due to ossification of the interspinous ligaments. The interlaminar spaces are also narrowed as a result of the hypertrophy of the facet joints. In elderly patients, there is difficulty in guiding a needle into the vertebral canal [2].

The ultrasound usage had been reported to refine the rate of success of spinal anesthesia as it increases the first needle passes success rate and decrease number of needle position and redirections [13], [14].

This study was performed to differentiate the positivity between pre-procedure ultrasound guided and anatomical landmarks guided paramedian spinal anesthesia in geriatric patients going through lower limbs surgeries. The perioperative MAP, HR and SpO_2 showed no significant difference between the studied groups. But there was a statistical significance decrease in MAP at 5, 10 and 15 min after the onset of spinal anesthesia compared to the baseline readings within each group. While the HR is not significantly decreased compared to the baseline.

These results were comparable with the results of **Hofhuizen et al., 2019** [15] in their study of the hemodynamic effect of spinal aesthesia in elders. They concluded that blood pressure had significant decrease after the onset of spinal anesthesia in elderly patients.

The present study assumed that the rate of success of dural puncture on the 1st needle insertion try was higher in group S compared to group C. These results were compatible with the opinions of a study carried out by **Kampitak et al., 2018** who compared the pre-procedure paramedian spinal anesthesia guided with ultrasound and anatomical landmark-guided paramedian spinal anesthesia for total knee or hip arthroplasty in geriatrics [16].

Similar results were documented by **(Uyel and Kilicaslan) 2021**. They carried out a study to compare between pre-procedure ultrasonography and anatomical landmarks-guided midline spinal anesthesia in geriatric cases with abnormal spinal anatomy. They found that the rate of success to go through site of anesthesia at the first needle insertion try was significantly higher in the sonar guided group than in the other group [17].

The number of needle insertion try and the number of needles passes and redirection in this study are less in group S compared to group C.

On the contrary to our findings **Srinivasan et al., 2018** reported that the routine uses of paramedian spinal anesthesia guided by ultrasound did not decrease the number of passes or tries in reaching successful dural tap. They used the inter space between L_5–S_1, which is a wider space than we used, this difference may be attributed to that the comparison was done between different approaches. The pre- procedure ultrasound-guided spinal anesthesia was done in the paramedian approach, while the landmark-guided spinal anesthesia was done in the midline approach [18]. Previous study compared the spinal anesthesia with different approaches. They use the oblique paramedian sagittal view versus the transverse spinous process view used in ours [19].

Not surprisingly, the results of this study showed that more time was needed in order to identify landmarks by ultrasound –guided group compared to the palpation of anatomic landmarks- guided group . Moreover, a longer time for the procedure was needed for the ultrasound-guided procedure and undergone spinal anesthesia than the anatomical landmarks spinal anesthesia.

In another study by **Park et al., 2020** who compared ultrasound- assisted with the anatomical landmarks spinal anesthesia in cases with abnormal spinal anatomy , they found that the total procedure time was not statistically significant between the two groups. This disagreed with our results as the total procedure time was longer [19]. This may be explained by that this study includes patients with scoliosis and abnormal back anatomy. So anatomical landmarks technique had longer time than that performed in elderly patients in our study. However, the controversy of the results may be due to different speeds of the operators, which depends on their experience in the adjustment of the US machine and achieving the best image of the interspace and have not related to the technique itself.

The results of the current study reveals that the needle insertion depth was deeper in group C compared to group S.

Group S recorded less block-associated pain score and more patient satisfaction score than Group C. These results may be explained by that all the cases got successful dural puncture with complete sensory loss by the block.

In **2013 , Abelhamid and Mansour** tried to know if ultrasound scanning could help in intrathecal anesthesia. They concluded that patient's satisfaction showed significant difference between anatomical landmarks and ultrasound-guided [20].

However, the postoperative complications in the present study are comparable regarding bloody tap and PDPH in the two study groups. Meanwhile the postoperative back pain was less in group S compared to group C. This is because neuraxial ultrasonography facilitates the performance of spinal anesthesia regarding decreased redirection or further tries and the first needle try success rate.

Previous studies reported findings similar to that of the present study [19]. Others reported different results[17], [19]. This may be explained by the increased needle insertion attempts, needle pass and redirection due to abnormal spinal anatomy in the 1st study and difficult anatomy in the 2nd one.

5. Conclusion:

Pre-procedure ultrasound examination can facilitate spinal anesthesia in elderly patients, regarding the first-attempt success, minimizing the number of needles passes and puncture tries, improving patient satisfaction and decrease post operative back pain irrespective to longer total procedure time. Pre-procedure ultrasound technique has a clinical benefit and it is superior to the traditional anatomical landmarks-guided spinal anesthesia in elderly patients.

Disclosure statement

The authors declare that they have no conflict of interest.

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