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Research Article

Ultrasound-guided intrathecal anesthesia: Does scanning help?

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KEYWORDS

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Abstract Intrathecal anesthesia is widely used for many surgical procedures. Multiple attempts at needle placement may cause various complications and patient dissatisfaction.
Aim: To use a preprocedure ultrasound-guided surface marking, using a midline transverse interlaminar ultrasound view at L4–5 interspace, to guide needle insertion, aiming to decrease needle attempts.
Subjects and methods: Ninety patients ASA I–II, scheduled for intrathecal anesthesia, were included in the study. Patients were randomly allocated to one of 2 groups. Group I was the ultrasound group and Group II was the surface landmark group. For each block, we recorded patient's and spine characteristics, number of needle attempts, and patient satisfaction, time for establishing landmarks by preprocedure ultrasound scanning or palpation, time to perform spinal anesthesia, and total time to perform the whole procedure.
Results: Successful first needle attempt was in (80%) in ultrasound group (I) and 17 (37.8%) in surface landmark group (II). Needle redirection attempts were 7 (15.6%) in group I and 16 (35.5%) in group II. Second attempt was in 2 (4.4%) in group I and 5 (11.1%) in group II. Third attempt was observed only in group II in 7 (15.6%). There was a significantly more time needed to establish landmarks and complete spinal anesthesia in group I compared to group II (8.7 ± 1.0 vs 5.4 ± 0.4, respectively). Patient's satisfaction was significantly higher in group I (95.6%) than group II (77.8%).
Conclusion: Preprocedure ultrasound scanning improved the first needle attempt success rate, decreased redirection or further attempts, and gave better patient satisfaction.

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1. Introduction

Intrathecal anesthesia is widely used for many surgical and endoscopic procedures. Multiple attempts at needle placement may cause patient discomfort, higher incidence of spinal hema-

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toma [1,2], postdural puncture headache [3,4], and trauma to neural structures [5].

Accurate preoperative prediction of potential difficulty can help to reduce the incidence of multiple attempts, rendering the technique more acceptable and less risky to the patient [6].

In a recent feasibility study of ultrasound-guided spinal anesthesia in patients undergoing total joint replacement, Chin et al. consistently identified and marked the interlaminar spaces using ultrasound imaging, using longitudinal parasagittal (LP) view followed by probe rotation to transverse midline view at L2 moving in a cephalad–caudad direction down to L5 space [7].

In a trial to improve the ability to perform intrathecal anesthesia with minimal attempts of needle placement at the right interspace, a higher success rate, and thus better patient satisfaction, an ultrasound-guided surface marking, using a proposed easier and time-saving technique of midline longitudinal view combined with a midline transverse interlaminar ultrasound views to reach L4–5 interspace, and to guide needle insertion, was carried out in this study.

2. Methods

In this study, we investigated the impact of an ultrasound-guided technique on the ease of performing spinal anesthesia in patients with normal surface anatomic landmarks. The study was conducted between January 2013 and March 2013 at the Medical Research Institute Hospital, Alexandria University. Approval for the study was obtained from the Medical Research Institute Hospital Ethics committee, and written informed consent was obtained from all patients. We designed a prospective observational study in patients undergoing intrathecal anesthesia. Ninety patients ASA I–II, age from 20–60 years, scheduled to receive intrathecal anesthesia were included in the study. Exclusion criteria were patient allergic to drug, neurologic disease, coagulopathy, cardiac, obese, or hypertensive patients. The 90 patients were randomly allocated to receive lumbar intrathecal anesthesia at L4–L5 interspace. They were randomly divided into 2 equal groups, each of 45 patients using sealed envelopes. Group I was the ultrasound group and Group II was the surface landmark group. All study procedures were performed in a block room at least 30 min before procedure.

Standard monitors (three-lead electrocardiogram, noninvasive blood pressure, and pulse oximetry) were applied, intravenous access was established and 1 mg intravenous midazolam, and 50 μg fentanyl was administered for anxiolysis to all study patients. Group I was the ultrasound group and included 45 patients. Group II was the surface landmark group and included 45 patients. For each block, we recorded patient's characteristics (age, gender, body mass index), examining each patient ability to flex the spine adequately (good/bad); defined as actively flexing the spine in the sitting decubitus position to the maximum extent possible by drawing the knees to the chest and flexing the neck, quality of anatomical landmarks palpation (good/bad); defined as palpable spinous processes are described as good, while inability to palpate spinous process is designated as difficult, and clinically and radiologically examining the morphology of the lumbar curvature (convex; defined as normal curvature of the lumbar spine/rectilinear; a slight anterior curvature of the lumbar spine/concave; an abnormal anteriorly convex curvature of the lumbar spine), number of needle attempts, and patient satisfaction with the block procedure, rated by patients immediately after completion of administration of the spinal anesthesia, on a 5-point scale (5 = very good, 4 = good, 3 = satisfactory, 2 = unpleasant, 1 = very unpleasant). Time for establishing landmarks by ultrasound scanning or palpation to identify the L4–L5 space, time taken to complete spinal anesthesia (from introducing spinal needle till delivery of anesthetic), and total procedure time (time to establish landmarks + time to complete spinal anesthesia) were also recorded. Our outcome was the degree of difficulty found in performing the neuroaxial block classified as easy or difficult depending on the number of attempts needed to identify the right space using a preprocedure ultrasound skin marks.

We used a midline longitudinal approach to reach L5–S1 and then rotating the probe while in place 90° to a transverse midline at the level of L5–S1 interspace moving upwards to reach the L4–L5 interspace. Before sterilization, a preprocedure scan is done for each patient in the sitting position. Before the spinal anesthesia, ultrasound imaging of the lumbar spine was performed by an anesthesiologist with experience with more than 30 ultrasound-guided neuroaxial blocks, using a Sonosite S-Nerve (Sonosite, Bothell, WA) ultrasound machine and a low-frequency (2–5 MHz) curved-array probe. The probe is first placed in the midline to obtain a longitudinal view with a slight tilt. The gap between the continuous line below and a short line above on the screen, together with viewing the anterior longitudinal ligament-anterior dura complex, marks the lumbosacral junction (Fig. 1). The probe is then rotated in the midline 90° to obtain transverse interlaminar view of L5–S1. The probe moves up to get the L4–L5 interspace (Fig. 2). Viewing the spine shadow, articular process, transverse process, and with a slight tilting of the probe to obtain best image to view posterior complex, cauda equine, and anterior complex. The achieved tilt is used as a guide to needle direction and route. The L4–5 space was identified and centered on the ultrasound screen. Skin marks were made at the

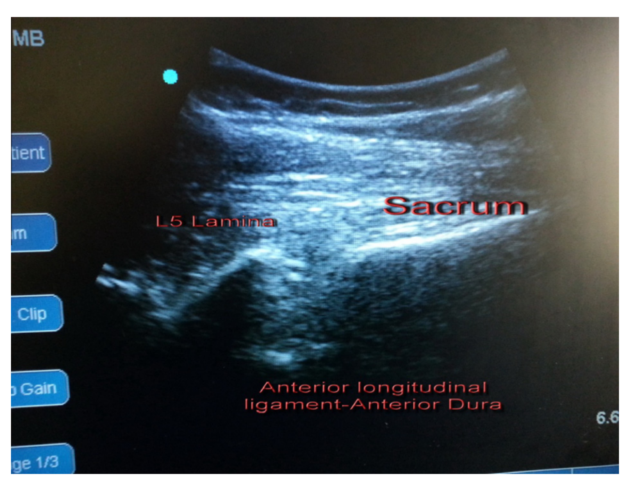

Figure 1 The probe is first placed in the midline to obtain a longitudinal view. The gap between the continuous line below and a short line above on the screen, together with viewing the anterior longitudinal ligament-anterior dura complex, marks the lumbosacral junction.

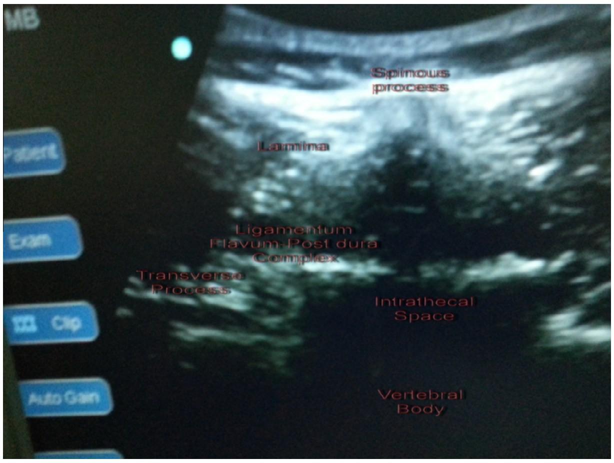

Figure 2 The probe is then rotated in the midline 90° to obtain +6 transverse interlaminar view of L5–S1. The probe moves up to get the L4–L5 interspace. The L4–5 space is centered on the screen.

midpoint of the probe's long and short edges. The intersection of these two marks provides an appropriate needle insertion point for a midline approach to intrathecal space at that level (Fig. 3). Following sterilization, 2 ml of xylocaine 2%, is given at the point of the intersection, followed by placing the 25 G Quincke spinal needle at the point of intersection, with an anterior direction and slight cephalad angulation (Fig. 4). Once dural puncture was achieved and on obtaining a CSF, 15 mg 0.5% hyperbaric bupivacaine with 25 μg fentanyl was given slowly over 15 s, and the attempt is considered a success-

Figure 3 Skin marks were made at the midpoint of the probe's long and short edges. The intersection of these two marks provides an appropriate needle insertion point for a midline approach to intrathecal space at that level.

Figure 4 A 25 G Quincke spinal needle is introduced at the point of intersection, with an anterior direction and slight cephalad angulation compatible with the probe's slight cephalad tilt.

ful attempt. While contacting bone was considered a failed attempt and was followed by incomplete withdrawal of the needle to redirect it, this defines a redirection attempt. Complete withdrawal of the needle and performing another puncture define a second attempt.

3. Statistical analysis

Statistical analysis was done by SPSS version 18.0 for analyzing the collected data. The following statistical measures were used:

- Descriptive statistics including range, mean, and standard deviation were used to describe different characteristics.
- Kolmogorov–Smirnov test was used to examine the normality of data distribution.
- Univariate analyses including *t*-test and Mann–Whitney test were used to test the significance of results of quantitative variables. Moreover, Chi-square test, Monte Carlo test, and Fisher's exact test were used to test the significance of results of qualitative variables.
- The significance of the results was at the 5% level of significance.

4. Results

As regards the patient characteristics, age ranged from 22 to 56 with a mean of 34.7 ± 3.1 years in group I. However, it ranged from 25 to 59 with a mean of 35.1 ± 3.3 years in group II. Regarding gender, male to female ratio was 27:18 in group I and 19:26 in group II with no statistically significant difference between both groups. As regards the body mass index (BMI), it ranged from 24.2 to 34.8 with a mean of 24.2–34.8 kg/m^2. In group II, it ranged from 23.5 to 34.2 with a mean of 26.8 ± 2.1 kg/m^2. There were no significant differences in the patient characteristics between the study groups. (Table 1) (see Tables 2–4).

Concerning the spine characteristics, ability to flex the spine was 30 (66.7%) in group I, compared to 29 (64.4%) in group II, with insignificant difference between the two studied

Table 1 Demographic data of studied patients in the studied groups.

	Group I (n = 45)	Group II (n = 45)	Significance
Age (year)			
Min–max	22–56	25–59	t = 0.593
Mean ± SD	34.7 ± 3.1	35.1 ± 3.3	P = 0.555
Gender			
Male	27 (60.0%)	19 (42.2%)	X^2 = 2.85
Female	18 (40.0%)	26 (57.8%)	P = 0.092
BMI (kg/m²)			
Min–max	24.2–34.8	23.5–34.2	t = 1.895
Mean ± SD	24.2–34.8	26.8 ± 2.1	P = 0.061

t: t-test X^2.
Chi-square test.

Table 2 Characteristics of spines among the studied groups of patients.

Characteristics of spines	Group I (n = 45)		Group II (n = 45)		Significance
	No.	%	No.	%	
Ability to flex spine					
Good	30	66.7	29	64.4	X^2 = 0.05
Bad	15	33.3	16	35.6	P = 0.824
Morphology of lumbar curve					
Convex	30	66.7	28	62.2	X^2 = 0.19
Rectilinear	15	33.3	17	37.8	P = 0.659
Quality of landmark palpation					
Good	37	82.2	28	62.2	X^2 = 4.49
Bad	8	17.8	17	37.8	P = 0.034*

X^2: Chi-square test.
* Significant at $P \leqslant 0.05$.

Table 3 Success of spinal anesthesia attempts and patient satisfaction among the studied groups of cases.

Success of spinal anesthesia attempts	Group I (n = 45)		Group II (n = 45)		Significance
	No.	%	No.	%	
Success of attempt					
Successful first attempt	36	80.0	17	37.8	X^2 = 16.57
Not successful	9	20.0	28	62.2	P < 0.0001*
Redirection	7	15.6	16	35.5	X^2 = 9.18 P = 0.002*
Second attempt	2	4.4	5	11.1	^{FE}P = 0.088
Third attempt	0	0.0	7	15.6	^{FE}P = 0.0009*
Patient satisfaction					X^2 = 6.15 P = 0.013*
Satisfied	43	95.6	35	77.8	
Unsatisfied	2	4.4	10	22.2	
Very good	13	28.9	6	13.3	^{MC}P = 0.038*
Good	23	51.1	22	48.9	
Satisfied	7	15.6	7	15.6	
Unsatisfied	2	4.4	2	4.4	
Very unsatisfied	0	0.0	8	17.8	

X^2: Chi-square test.
^{FE} P: Fisher's exact test.
^{MC} P: Monte Carlo test.
* Significant at $P \leqslant 0.05$.

groups. As regards the morphology of the spine, it was convex in 30 (66.7%) patients in group I, compared to 28 (62.2%) in group II. There were no significant differences between the two groups. Regarding the quality of landmark palpation, it was good in 37 (82.2%) patients compared to 28 (62.2%) in group II, with significant better quality of palpation in group I.

Success of the spinal attempts was evaluated where 36 patients (80%) had successful first time attempt in group I, com-

Table 4 Duration of procedure conducted among the studied groups of cases.

Duration of procedure (min)	Group I (n = 45)	Group II (n = 45)	Significance
Time to establish landmark			
Min–max	4.0–7.0	0.5–1.0	Z = 8.265
Mean ± SD	5.1 ± 0.9	0.8 ± 0.2	P < 0.0001*
Time needed to complete procedure			
Min–max	3.0–4.0	4.0–5.0	Z = 7.293
Mean ± SD	3.0–4.0	4.6 ± 0.5	P < 0.0001*
Total procedure time			
Min–max	7.0–11.0	4.5–6.0	Z = 8.215
Mean ± SD	8.7 ± 1.0	5.4 ± 0.4	P < 0.0001*

Z: Mann–Whitney test.
* Significant at $P \leqslant 0.05$.

pared to 17 (37.8%) in group II, with significant better outcome in group I (P < 0.0001). Regarding the redirection attempts, 7 (15.6%) patients had redirection attempts in group I, compared to 16 (35.5%) in group II, again with significant difference between the two groups. In second attempt, it was needed in 2 (4.4%) patients in group I, compared to 5 (11.1%) in group II, with insignificant difference between both study groups. As regards the third attempt, 7 (15.6%) patients had a third attempt in group II, with none at group I. There was a significant difference between the two groups.

Considering the patient satisfaction, the satisfied patients constituted 43 in group I, (95.6%), compared to 35 (77.8%) in group II, with significant difference between the two groups.

As regards the time needed to establish the landmark, it ranged from 4.0 to 7.0 with a mean of 5.1 ± 0.9 min in group I. In group II, it ranged from 0.5 to 1.0 with a mean of 0.8 ± 0.2 min. There was a significantly less time needed to establish landmarks in group II compared to group I. Regarding the time needed to perform the spinal anesthetic, it ranged from 3.0 to 4.0 with a mean of 3.6 ± 0.4.0 min in first group, compared to 4.0–5.0 with a mean of 4.6 ± 0.5 in group II. As regards the total procedure time, it ranged from 7.0 to 11.0 with a mean of 8.7 ± 1.0 min in group I. In group II, it ranged from 4.5 to 6.0 with a mean of 5.4 ± 0.4 min. There was a significantly more total procedure time needed in group I compared to group II.

5. Discussion

This study showed that our proposed ultrasound scanning prior to spinal anesthesia is clinically feasible procedure reducing needle attempts and therefore better patient satisfaction.

Regarding the spine characteristics, the ability to flex the back was good in 66.7% of patients in group I, while 64.4% in group II with no significant differences between the two groups. The morphology of lumbar spine by clinical as well as radiological examination was normally convex in 66.7% and 33.3% rectilinear in group I, while convex in 62.2% and 37.8% rectilinear in group II with no significant differences between the two groups. In agreement with our results, DeOliveira et al. showed that straight back is a not an optimum position to perform spinal block and that one of the important factors for successful spinal anesthesia is the ability to flex the spine [8]. Fisher et al. also stated that a flexed back for subarachnoid block is considered mandatory because of widening of the interspinous space in this setting [9]. Moreover, Hocking et al. showed that an abnormal spinal curvature can be a cause of block failure [10].

Several studies have used ultrasonography to localize the lumbar epidural space for the placement of epidural anesthesia. Preprocedural scanning showed similar benefits when applied to obstetric epidural catheter insertion. It increases success rates among novices, reduces needle insertion attempts, and block-associated pain, and increases patient satisfaction [11,12]. This was observed in our study; patient's satisfaction was significantly more in group I; 95.6%, compared to 77.8% in group II.

Redirection attempts were significantly less needed among ultrasound group (15.6% vs 35.5% in surface landmark group). It was reported by Grover et al. that redirection attempts they encountered were 60% attempts using surface landmark technique which is much higher than the incidence encountered in the current study [13]. Similar high results were obtained by Biswas et al. who had a 52.5% redirection attempts in a recent study [14]. Meanwhile, Chin et al. reported a 22% redirection attempts in non-obese patients using ultrasound scanning, which is near to the current study [7].

The need for a second attempt was needed in 4.4% of patients in ultrasound group (group I), which was significantly lower than group II (11.1%). Chowdhury et al. reported a 28% successful second attempt using surface landmark [15]. Meanwhile, Chin et al. had only an incidence of 11% successful second attempt in non-obese patients using ultrasound scanning [7]. These results are in agreement with the current study. However, on the other hand, an incidence of 7% need for a successful second attempt was reported by Shah et al. using surface landmark technique [16].

Time to establish landmark using ultrasound scanning was significantly longer (5.1 ± 0.9 min) than using the traditional surface landmark palpation (0.8 ± 2 min). In agreement, Chin et al. stated in his study that more time was required to establish landmarks in ultrasound group (U/S) compared to landmark group (LM) (6.7 ± 3.1 min ultrasound group vs LM group, 0.6 ± 0.5 min; P < 0.001) [17], denoting shorter time needed in our results. However, a recent study conducted by Conroy et al. (2013) reported a relatively shorter time to establish landmarks by ultrasound than ours (4.4 ± 2.6 min) [18].

The significantly longer time for landmark scanning using ultrasound has led to significantly more total time for the procedure in ultrasound group (8.7 ± 1.0 min) compared to landmark group (group II) (5.4 ± 0.4 min). In agreement with our results, Weed et al. reported a total procedure time using the traditional landmark approach of 4.8 ± 4.4 min [19]. Moreover, Tessler et al. reported a total procedure time using the landmark approach 4.4 ± 3.2 min [20].

On the other hand, more time was needed in the study conducted by Chin et al. [17], where the total time in the ultrasound group was 13.3 ± 7.1 min, while 8.8 ± 8.2 min in the landmark group.

In conclusion, preprocedure ultrasound imaging of the lumbar spine using combined longitudinal and transverse interlaminar view provides easier, clinically feasible, and more accurate access that can facilitate spinal anesthesia with higher first needle attempt success rate, less needle redirection or additional needle attempts, and higher patient satisfaction. This demonstrates the importance of routinely applying the ultrasound scanning preoperatively for better quality of spinal anesthesia performance and better patient satisfaction.

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