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Comparison of lumbar puncture location with bedside ultrasonography and palpation in adult patients admitted to the emergency room

Acil servise başvuran yetişkin hastalarda lomber ponksiyon yerinin yatak başı ultrasonografi ve palpasyon ile karşılaştırılması

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Abstract

Purpose: Lumbar puncture (LP) is a medical procedure in which a cerebrospinal fluid sample is taken for biochemical, microbiological and cytological examination. The aim of our study was to compare the ultrasonography (USG) method to the palpation method in determining the location of LP.

Methods: 203 patients were included in the study. In the study, specifying location manually or with USG was performed by the same emergency medicine resident with USG certificate who completed his 4th year. LP points were determined and marked firstly by ultrasound and then the manual method while the patients were in the left and right lateral decubitus and sitting positions.

Results: The USG method was found to be significantly more successful than the manual method in determining the LP location (p=0.012). The USG method was found to be significantly more successful in determining the LP site than the manual method, especially when the LP site was identified in the sitting position (p=0.031). In other positions, no difference was observed between the two groups (Right p=1, Left p=0.500). Body Mass Index (BMI) affects success during site location with USG (p=0.0001). Likewise, BMI affected the success in identifying the LP site by the manual method (p=0.0001). The USG method was found to be significantly more successful than the manual method in determining the LP site in patients with BMI>25 (p=0.012).

Conclusion: During the detection of LP location by palpation or USG, as the BMI increased, the duration of the determination of location increased significantly, too. LP site can be identified by the USG in patients whose LP site cannot be specified by palpation. In addition, the USG is more successful in obese individuals in terms of locating the LP site.

Key words: Lumbar puncture, ultrasonography, manual method, lateral decubitus, sitting position.

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Özet

Amaç: Lomber ponksiyon (LP) biyokimyasal, mikrobiyolojik ve sitolojik inceleme için beyin omurilik sıvısı örneğinin alındığı tıbbi bir işlemdir. Çalışmamızda, LP'nin yerini belirlemede ultrasonografi (USG) yöntemiyle palpasyon yöntemini karşılaştırmayı amaçladık.

Gereç ve yöntem: Çalışmaya 203 hasta dahil edildi. Çalışmada, USG sertifikası olan 4. yılını tamamlayan aynı acil tıp asistanı tarafından manuel veya USG ile yer belirlemesi yapıldı. Hastalar sol ve sağ lateral dekübitus ve oturma pozisyonunda iken önce ultrason daha sonra manuel yöntemle LP noktaları belirlendi ve işaretlendi.

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Bulgular: USG yönteminin LP yerleşimini belirlemede manuel yöntemden anlamlı derecede daha başarılı olduğu bulundu (p=0,012). LP bölgesinin belirlenmesinde, USG yöntemi özellikle oturma pozisyonunda, manuel yönteme göre anlamlı olarak daha başarılı olduğu bulunmuştur (p=0,031). Diğer pozisyonlarda iki grup arasında fark gözlenmedi (Sağ p=1, Sol p=0,500). Vücut Kitle İndeksi (VKİ) USG ile alanın yer tayini sırasındaki başarıyı etkiledi (p=0,0001). Benzer şekilde, VKİ, LP bölgesini manuel yöntemle tanımlamadaki başarıyı etkilemiştir (p=0,0001). Vücut Kitle İndeksi>25 olan hastalarda LP alanının belirlenmesinde USG yönteminin manuel yöntemden anlamlı derecede daha başarılı olduğu bulundu (p=0,012).
Sonuç: Palpasyon veya USG ile LP yer tayininde, VKİ arttıkça, yer bulma süresi önemli ölçüde artmıştır. Lomber ponksiyon yeri palpasyon ile belirlenemeyen hastalarda USG tarafından tanımlanabilir. Ek olarak, USG, obez bireylerde LP sahasının bulunması açısından daha başarılıdır.

Anahtar kelimeler: Lomber ponksiyon, ultrasonografi, manuel yöntem, lateral dekübit, oturur pozisyon.

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Introduction

Lumbar puncture (LP) is a medical procedure in which a cerebrospinal fluid sample is taken for biochemical, microbiological and cytological examination [1, 2]. Heinrich Quincke stands out as the first scientist to describe the anatomical localization of the LP site (the junction between iliac crests and vertebral spinous processes) [1], while Bogin is the person who suggested in 1971 that the location of LP could be specified with ultrasound guidance [3].

In emergency and intensive care services, LP is routinely performed. Traditionally, the LP site is detected by palpation. Besides, anatomical variations, such as back or waist surgery and scoliosis, may bring about a change in the position of markers used during palpation, and LP may fail in such cases [4-6]. Failed LP may adversely affect the treatment process and comfort of the patient. Therefore, the main purpose of identifying the correct location of LP is to achieve successful puncture as well as preventing traumatic injury, nerve injury, pain and epidural hematoma around the soft tissue [7-9]. In some studies, point-of-care ultrasound (POCUS) was used to specify the location of LP by ultrasound, and then the success of the intervention was analyzed [10].

The aim of our study was to compare the ultrasonography (USG) method to the palpation method in determining the location of LP.

Materials and methods

Study type

Before setting out to conduct the study, ethics committee approval with the number 2015/16 was obtained on September 17, 2015 from the chair of Non-interventional Clinical Researches Ethics Board of Pamukkale University. Ours is an equivalence study.

Study population

The patients with green triage who presented to the Emergency Medicine Department of Pamukkale University Medical Faculty Hospital between 01.10.2015-01.03.2016 were included in the study after the inclusion and exclusion criteria were evaluated.

A total of 47.654 people presented to the emergency department of Pamukkale University Medical Faculty Hospital. Of all these patients, 24.546 patients had green triage code with no monitoring requirements. Admitted during busy hours of emergency service, 17.790 patients were not asked if they would like to participate in the study due to the congestion, and thus they were not included in the study. Of the remaining patients, 172 were pregnant and 124 were immobilized. 6257 patients did not agree to participate in the study (Figure 1). 203 patients were included in the study.

Selection of participants

Patients aged 18 years or older who presented to the adult emergency department of Pamukkale University Medical Faculty Hospital, followed up in the non-monitored room, and fulfilled the pre-specified criteria were admitted to this study. Written informed consent was obtained from those agreeing to participate in the study.

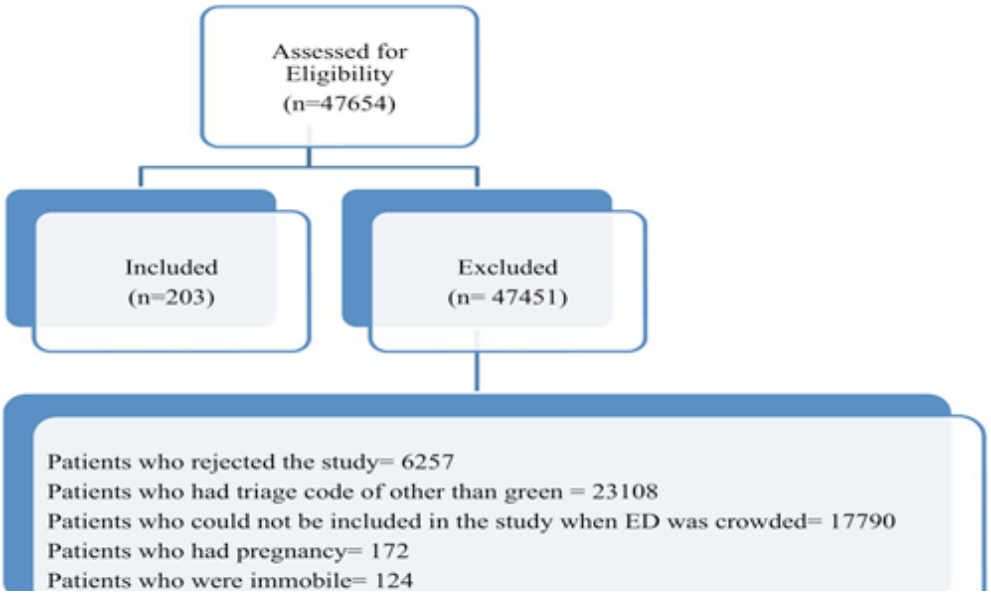

Figure 1. Flow chart of the patients

Admission and randomisation

The present study employed a simple randomization method. Blind to the study, a resident worked out the randomization schedule via a computer. Every patient eligible for the study was given a study number.

Inclusion-exclusion criteria

The fact that the volunteers were over 18 years, had green triage code, and agreed to participate was the inclusion criterion of the study. Being under 18 years, pregnant, immobilized as well as having non-green triage code and disagreeing to participate constituted the exclusion criteria.

Study protocol

In the study, specifying location manually or with USG was performed by the same emergency medicine resident with USG certificate who completed his 4th year. The LP site in the participating patients was determined and marked first by ultrasound and then by manual LP either through the lateral decubitus, a standard LP position, or through the fetal position achieved by bringing the two knees closer to the head in a sitting position. The practitioners themselves, namely the participating patients, selected one of the right or left lateral decubitus and sitting positions. In the aftermath of the markings, the following characteristics were recorded in the patient's study form: demographics, BMI, inclusion or exclusion criteria, anatomical localization of the site where the LP will be performed, location and distance of the localization determined by ultrasound to the location determined by palpation, seconds of site location through ultrasound and palpation.

The time for site location was determined as follows: after the practitioner was given a proper position in the USG method, the stopwatch was started upon his command "I am ready", with the USG device on and with the transducer in his hand, and the stopwatch was stopped once the marking was over. In the same way, the procedure was started with the command and ended with the marking in the manual method, too. The markings were made with a pen without leaving any stain, whereas the measurements with a ruler. During the site location process, whichever level of L3-4, L4-5, or L5-S1 was detected by the participants was noted down. During the study, no material or method was used which would impair the skin integrity of the participants or cause complications.

USG method

In the USG procedure performed in the study, Terason uSmart 3200T model and linear probe (transducer) with 15L4 code belonging to the device were used [11]. During the site location where the LP will be performed, while the patient was lying in the lateral decubitus position, the midline was fixed, based on the

spinous process, when the probe was in the horizontal position in the USG imaging (Figure 2a, 2b), and a line parallel to the ground plane was drawn from the midline (Figure 2c, 2d). Afterwards, the spinal space was detected by turning the probe to the longitudinal plane, and a line vertical to the floor was drawn on the patient. The intersection point of the two lines drawn was identified as the intervention site (Figure 2e). The same marking method was repeated in the sitting position, and the site was fixed in the sitting position, too.

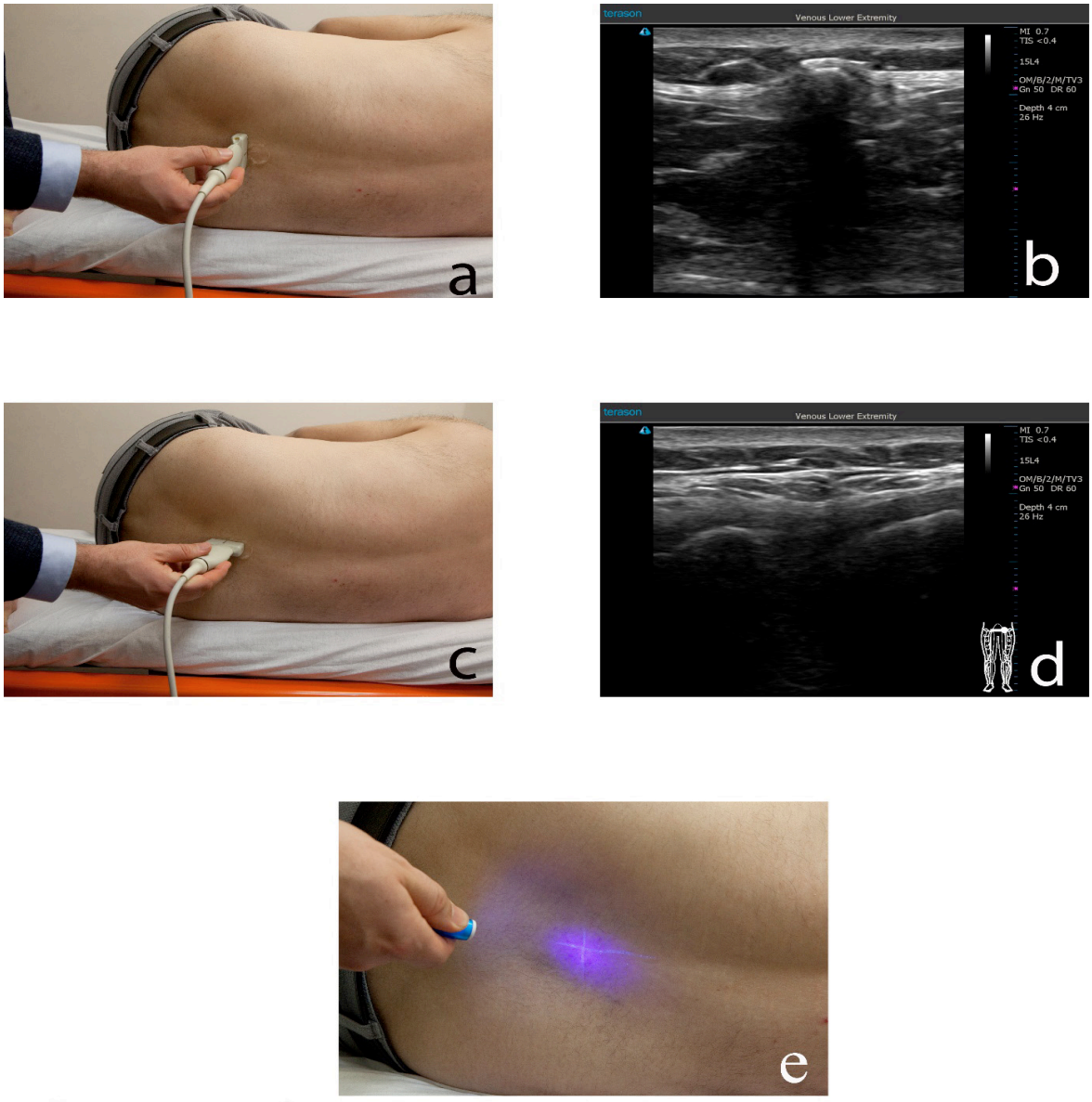

Figure 2. Patient positions and ultrasonographic views

Manual method

In the procedure of specifying the puncture site, we placed our 4th and 5th fingers on the spina iliaca anterior superior (right and left iliac crest) of the patient and identified the middle point with our thumbs [12]. The midline of the spinous processes found here was accepted as the intervention site (Figure 3).

Failure criteria

In both methods, the failure criteria were set as the inability of the practitioner to detect the intervention location within five minutes [10].

Primary and secondary outcome

The primary outcome of the study is the correct detection of the LP site in a larger number

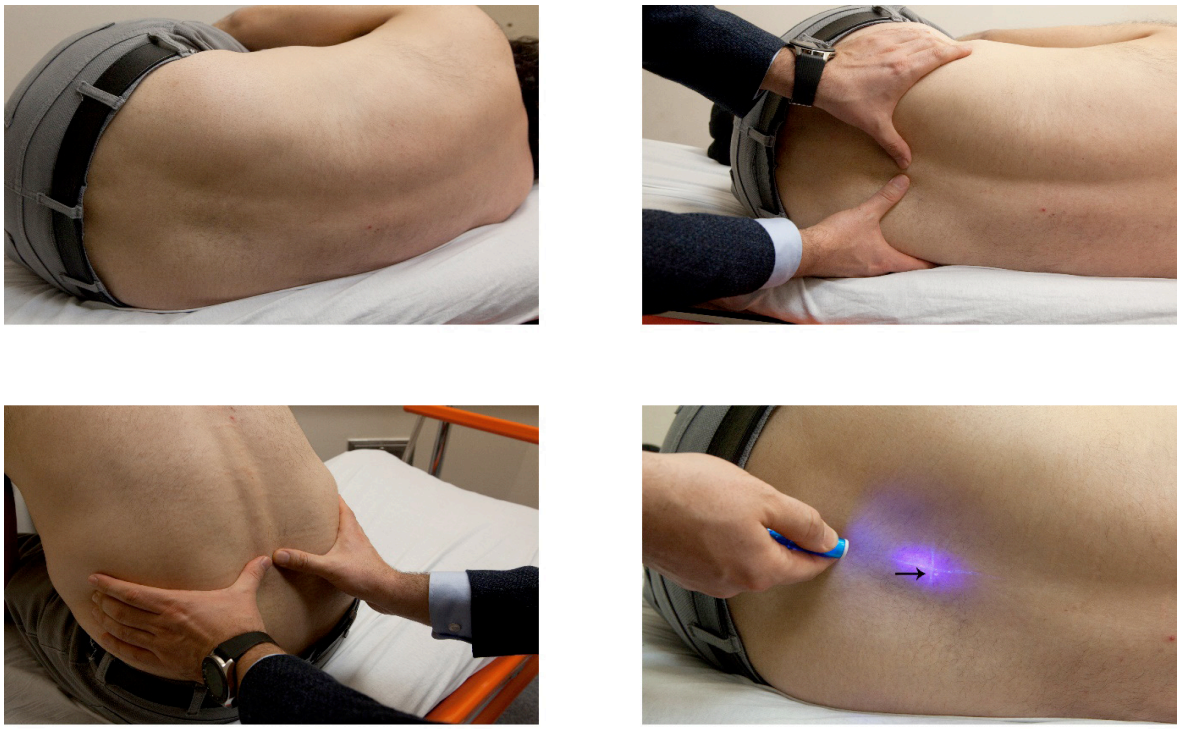

Figure 3. Marking the lumbar puncture point by manual method

of patients by USG method. On the other hand, one of the secondary outcomes is that accurate detection time of LP with USG method is shorter than palpation method. The current study determines for which patients identifying the location of the LP by ultrasound would be more suitable, in the case of emergency doctors.

Statistical analysis

In accordance with the calculations made, at least 194 people should be included in the study in order to obtain 80% power size at 95% confidence level. According to the BMI made during the analysis, those with weak and normal body were classified as BMI<24,9, while those with BMI=25-29.9 as overweight, and those with BMI>30 as obese [13].

The data set was analyzed in the Statistical Package for Social Sciences (SPSS) 24.0 software program (Armonk, NY; IBM Corp.). McNemar test was used for the analysis of dependent and categorical variables, while *Chi square* test was preferred to analyze independent and categorical variables. Paired Samples T-test was used to analyze dependent, parametric, continuous data, whereas dependent, nonparametric and continuous data were analyzed with Wilcoxon Signed Rank test. Prior to the time analyses, Kolmogorov-Smirnov test was run to analyze whether the groups had normal distribution. Independent Samples T-test was used for data with normal distribution in the time analysis within the groups, while Mann-Whitney U test was run for the data with non-normal distribution. The value of $p<0.05$ was considered significant. When the power size of the study's results (95% success compliance) was examined, it was calculated that we reached 99.9% power size at 95% confidence level.

Results

Of all the patients included in the study, 102 (50.2%) were male and 101 (49.8%) were female. Their mean age was 44.37±18.25; the mean height was 166.82±8.8 cm; the average weight was 70.62±11.80 kg; and the mean BMI was 25.4±4.17 kg/m^2. Of all the participants, 101 (49.75%) had a BMI of<25, 76 (37.43%) with a BMI of 25-30 and 26 (12.82%) with a BMI of>30 (Table 1). There is no patient had back or waist surgery.

In order to detect the LP sites, 85 patients (41.87%) selected the right lateral decubitus position, while 79 (38.92%) preferred left lateral decubitus position, and 39 (19.21%) chose the sitting position. The LP site was identified from L3-L4 level in 163 (78.81%) patients, from L4-L5 level in 37 (18.22%) patients, and from the

L5-S1 level in 3 (1.5%) patients (Table 1).

189 (93.1%) patients successfully identified the site location with both USG and manual method. 3 (1.5%) patients could not identify the LP site successfully with either method. The success rate with manual method was 93.59% whereas that of USG was 98.03% (Table 2).

In the light of the data concerning successful site location by USG and manual method to determine the LP site, the former turned out to be significantly more successful than the latter in identifying the LP location (p=0.012) (Table 2).

In identifying the LP site by USG, the right lateral decubitus, left lateral decubitus or sitting of LP position did not affect the success (p=0.844). On the other hand, position factor affected the success rate in specifying the LP site by manual method, and the failure rate in the manual method significantly increased in the sitting position (p=0.005). The USG method was found to be significantly more successful in determining the LP site than the manual method, especially when the LP site was identified in the sitting position (p=0.031). In other positions, no difference was observed between the two groups (Right p=1, Left p=0.500) (Table 2).

BMI affects success during site location with USG (p=0.0001). All of the 4 patients who failed to identify the LP site by USG were in the group with a BMI>30. Likewise, BMI affected the success in identifying the LP site by the manual method (p=0.0001). 5 patients who failed by manual method were in the group with BMI=25-30 range, while 8 patients were in the group with BMI>30. In both methods, all of the patients with BMI<25 successfully determined the LP location. The USG method was found to be significantly more successful than the manual method in determining the LP site in patients with BMI>25 (p=0.012) (Table 2).

The time for identifying LP site by USG was 17.79±10.18 seconds, whereas that of the manual method was 13.91±8.08 seconds. The time to specify LP site by USG proved longer than the manual method (p=0.0001). The time for finding the LP location from L3-L4 level was 17.38±10.13 seconds in USG and 14.16±8.64 seconds in the manual method, although that of L4-L5 level was 19.57±10.60 seconds in USG and 12.39±3.70 seconds in the manual method. There was a difference between the two methods in L3-L4 level and L4-L5 level in terms of time for identifying LP site (p=0.001, p=0.001, respectively). In the USG method, the time for locating LP was found to be 14.97±7.80 seconds in the BMI<25 group and 20.71±11.48 seconds in the BMI>25 group. By contrast, in the manual method, the time for locating LP was 12.09±5.71 seconds in the BMI<25 group and 16.06±9.72 seconds in BMI>25 group. In both BMI groups, successful site location by USG turned out to last longer than the manual method (p=0.0001 and p=0.003, respectively).

Table 1. Baseline characteristics of study population

Gender n (%)		M=102 (50.2%)	W=101 (49.8%)
Age (mean±SD)		44.37±18.25	
BMI (mean±SD)		25.4±4.17	
BMI (kg/m^2) n (%)	<25	101 (49.75%)	
	25-29.9	76 (37.43%)	
	>30	26 (12.82%)	
Position	Left Lateral Decubitus	79 (38.92%)	
	Right Lateral Decubitus	85 (41.87%)	
	Sitting Position	39 (19.21%)	
Interspinous Space	L3-L4	160 (78.81%)	
	L4-L5	37 (18.22%)	
	L5-S1	3 (1.47%)	

Table 2. Success of the two methods

		USG		Manual Method		[b]*p* Value
		Unsuccessful n (%)	Successful n (%)	Unsuccessful n (%)	Successful n (%)	
Position	Left Lateral Decubitus	1 (1.19%)	83 (98.81%)	3 (3.57%)	81 (96.43%)	0.500
	Right Lateral Decubitus	2 (2.5%)	78 (97.5%)	3 (3.75%)	77 (96.25%)	1
	Sitting Position	1 (2.56%)	38 (97.44%)	7 (17.94%)	32 (82.06%)	0.031
[a]*p* Value		[a]0.844		[a]0.005		[c]0.12
BMI	<25	0 (0%)	101 (100%)	0 (0%)	101 (100%)	1
	>25	4 (3.92%)	98 (96.08%)	13 (11.6%)	99 (88.4 %)	0.012
[a]*p* Value		[a]0.0001		[a]0.0001		[c]0.012
Inter Spinous Space	L3-L4	1 (0.61%)	162 (99.39%)	3 (1.84%)	160 (98.16%)	0.016
	L4-L5	2 (5.4%)	35 (94.6%)	9 (24.32%)	28 (75.68%)	0.625
	L5-S1	1 (33.33%)	2 (66.67%)	1 (33.33%)	2 (66.67%)	1
[a]*p* Value		[a]0.0001		[a]0.0001		[c]0.012
Total		4 (1.97%)	199(98.03%)	13 (6.41%)	190 (93.59%)	[d]0.012

[a]*p* values are in-group p values and they are derivated from x^2 test.
[b]*p* values are derivated from McNemar test that is analysed between groups.
[C]*p* values are derivated from McNemar test that is a total analyse between two groups fort his situation.
[d]*p* value is derivated from McNemar test. It is a total success analyse *p* value.

In both groups, position did not affect the time for LP location (for the manual method p=0.118, for USG p=0.482). The time for locating LP by USG was longer than the manual method in the right lateral decubitus, left lateral decubitus and sitting position (p=0.007, p=0.0001, p=0.042, respectively) (Table 3).

Table 3. Time data of the two groups

		USG	Manual Method	[b]*p* Value
Procedure Time		17.79±10.18	13.91±8.08	0.0001
Position & Time	Left Lateral Decubitus	16.80±8.53	15.52±9.63	0.0001
	Right Lateral Decubitus	18.46±10.14	13.05±6.32	0.007
	Sitting Position	18.36±13.09	11.81±6.78	0.042
[a]*p* Value		0.118	0.482	
BMI & Time	<25	14.97±7.80	12.09±5.71	0.0001
	>25	20.71±11.48	16.06±9.72	0.003
[c]*p* Value		0.0001	0.003	
Inter Spinous Space & Time	L3-L4	17.38±10.13	14.16±8.64	0.001
	L4-L5	19.57±10.60	12.39±3.70	0.001
[c]*p* Value		0.694	0.051	

[a]*p* values are in-group p values and they are derivated from paired t test.
[b]*p* values are derivated from Wilcoxon Signed Rank test that is analysed between groups.
[c]p values are in-group p values and they are derivated from Mann-Whitney U test.

Discussion

In recent years, a large and growing body of literature has compared USG and the manual method in LP location. In the pertaining literature, the success rate of USG was reported to be higher than that of the manual method in identifying LP site. Moreover, ultrasound was reported to boost LP success rates while reducing total procedure time [14-17]. In a meta-analysis by Gottlieb et al. [17], USG had a success rate of 91.4% with adults, while that of the manual method was 87.7%, indicating that the USG increased the success rate in LP location. Although the LP location rates of both methods are somewhat higher in our study than other studies, the fact that USG achieved higher success overlaps with these studies. Given that the success of LP location was emphasized rather than interference success in our study, the success rates of USG and the manual method were found to be somewhat higher than the data in the literature.

In LP practice, one of the right and left lateral decubitus or sitting positions can be selected. Further, positioning of the patient and interspinal distance is key to success [18]. The studies investigating the effect of position on LP success were mostly conducted in infants. For instance, it was reported that the study with the patients aged between 1 and 22 carried out by Nigrovic et al. [19] did not find a significant success rate for positioning, while sitting and lying position was equal in the success of LP in the study by Glastein et al. [20]. In the existing literature, there are also studies reporting that the interspinal distance is increased in sitting position compared to the lateral decubitus position [17, 21-24]. In contrast, our study suggests that positioning does not affect the success when USG and the manual method are analyzed as within-groups. Especially in sitting position, USG proved to be more successful than the manual method. Our study supports the studies suggesting that interspinal distance and, indirectly, success will increase in sitting position.

Although it is well-known that obesity is a health problem all over the world, it is becoming increasingly difficult to detect the marking points on the backs of these people by palpation [5, 25]. The efficacy of ultrasound has been demonstrated in groups whose palpation was designated as difficult [26]. Especially patients with a BMI of >30 are characterized as a difficult LP scenario [27]. In the study by Stifler et al. [28], the patients were grouped as normal, overweight and obese according to BMI. While anatomical signs were hard to detect in 5% of the patients with normal BMI, this rate was 33% in overweight and 68% in obese patients. In 16 of 21 patients in whom markings were difficult to detect with palpation, ultrasound could accurately detect all of these signs. As a result, ultrasound has identified all the signs that should be observed in 75% of obese patients [28]. In addition, the study by Edwards et al. [29] reported that the rate of failure in patients with BMI>35 was noticeably increased. Ferre et al. [10] stated that although the BMI increase made the palpation of marking points more difficult, this condition did not affect the detection by ultrasound. Nomura et al. [30] also reported that USG rose to prominence in patients with BMI> 30 and that USG was successful in all obese patients. When it comes to our study, it was noteworthy that the patients for whom site location could not be performed with USG or the manual method had BMI>25. The fact that all the patients whose site location could not be practised by USG and 61.53% of those whose site location could not be practised by the manual method had BMI>30 in our study also supports the studies suggesting that the location of LP site became more difficult and the success rate decreased as BMI increased.

In quite a recent meta-analysis published by Gottlieb et al. [17], 12 studies have been analyzed, and the time for successful LP intervention accompanied by USG turns out to be shorter than that of the successful LP intervention with the manual method in all these studies. The total LP procedure time was approximately 2 minutes shorter with USG. In the study by Mofidi et al. [15], LP location and intervention time with USG were shorter than the manual method. In this study, although the intervention time lasted longer in patients with a high BMI, the time for LP intervention with USG was shorter than that of the manual method. In our study, as BMI increases, the time for LP location is extended in both methods. Since we intended only to identify the correct LP location by USG and the manual method and did not perform any intervention, our data for time duration cannot be compared with the ones

in the related literature. Because the manual method is a traditional one, the physician's considerable experience of the manual method may have brought about this difference. Though LP position and the change of the detection level affected the success of LP site location, they did not have an effect on procedure time.

Limitations

Some limitations are inherent in this study. For example, LP intervention was not practised in our study, and only the LP site location success and the duration along with the factors affecting them were taken into consideration. Whether the person who assisted when performing LP got the patient to be in the correct and proper position was ignored in the present study.

As a conclusion, during the LP location by palpation or ultrasound, as the BMI increased, the duration of location increased significantly, too. LP site can be identified by the ultrasound device in patients whose LP site cannot be specified by palpation. In addition, the ultrasound device is more successful in obese individuals in terms of locating the LP site.

In some emergency cases, LP should be performed in the emergency service. Although the markers of the LP site by ultrasound are specific, the ultrasound device has not been incorporated into routine procedures in LP procedure. Further, the ultrasound device can reduce the interventions to be made blindly. In the light of the findings obtained in this study, emergency physicians should be exposed to ultrasound training, and its use should be extended.

Conflicts of interest: The authors declare no potential conflicts of interest.

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Contributions of the authors to the article

A.Y. and O.C. designed the main idea and hypothesis of the study. A.Y. and O.C. developed the theory and organized the material and method section. R.S., H.S. and A.S. performed the evaluation of the data in the results section. The discussion section of the article was written by A.Y., O.C. and R.S., M.O., M.S., I.T. and B.E. reviewed the article, made the necessary corrections and approved. In addition, all authors discussed the entire study and confirmed its final version.