Journal of Research in Clinical Medicine

J Res Clin Med, 2020, 8: 20
doi: 10.34172/jrcm.2020.020
https://jrcm.tbzmed.ac.ir

TUOMS PRESS

Original Article

Ultrasound guided lumbar puncture reduces failed punctures, spent time and number of attempts in emergency department

Mahboub Pouraghaei[1], Mohammadkazem Tarzamani[2], Payman Moharramzadeh[1], Sahar Nikniaz[1], Soraiya Karimian[3], Moloud Balafar[1*]

[1]Emergency Medicine Research Team, Tabriz University of Medical Sciences, Tabriz, Iran
[2]Radiology Department, Tabriz University of Medical Sciences, Tabriz, Iran
[3]Physical Therapy and Rehabilitation Department, Dokuz Eylul University, Izmir, Turkey

Article info

Article History:
Received: 28 Jan. 2020
Accepted: 9 Apr. 2020
e-Published: 27 May 2020

Keywords:
- mergency department
- Lumbar puncture
- Ultrasonography

Abstract

Introduction: The present study was an attempt to evaluate the role of ultrasonography on decreasing the number of attempts, failed punctures, time needed to perform the procedure and patients' pain.

Methods: This study is a prospective case-control. Patients were divided in two groups randomly. A two-dimensional probe was used to localize intervertebral space in the ultrasound guidance (US group). In manual palpation (MP group) however, insertion level was determined using the standard technique by manual palpation. The number of attempts (needle insertion) required for a successful tap and successful/unsuccessful attempts were considered as the primary outcome measures.

Results: Male patients with an average age of 44.08 ± 15.83 years accounted for 60% (30 individuals) of the population. Success rate was 92% in the US group and 34% in the MP group ($P<0.001$). It took 79.64 ± 19.91 and 85.4 ± 11.62 minutes to identify the proper location in US and MP groups respectively ($P=0.21$). In the first attempt, it took 6.33 ± 0.95 and 6.87 ± 0.7 minutes to collect cerebrospinal fluid (CSF) in US and MP groups respectively ($P=0.02$). Average time taken to localize the sites in two attempts were 8.28 ± 2.44 and 13.17 ± 3.32 in US and MP groups respectively ($P<0.001$). Average number of attempts made in the US and MP groups were 1.08 ± 0.27 and 1.64 ± 0.66 ($P<0.001$) respectively.

Conclusion: Ultrasonography has reduced the time needed for locating puncture to collect CSF, pain management in patients, determining the number of attempts, and defining the risk of traumatic puncture. Moreover, this technique is characterized by a higher success rate. Using ultrasonography in obese patients and people with lumbar problems is more important.

Introduction

Lumbar puncture (LP) is a common procedure to collect cerebrospinal fluid (CSF).[1] CSF analysis allows diagnosis of some life threating conditions such as central nervous system (CNS) infections and subarachnoid hemorrhage. It also plays a role in the treatment of benign intracranial hypertention.[2,3] We assume LP as an easy procedure, however sometimes it's difficult.[4] Several attempts may be needed to perform a successful LP, which can cause trauma and incorrect results (especially in subarachnoid hemorrhage assessment). Also we may need to consult other physicians that can leads to a delay in diagnosis.[5,6] The needle is usually inserted between L3-L4 or L4-L5 intervertebral spaces. The patients should be in supine or lateral decubitus positions. We usually find spinal levels by palpation with a high success rate. Palpation is operator dependent, which leads to more failed attempts especially performed by inexpert residents and clinicians.[7-9] It is also difficult to find spinal levels in the following patients: elder, overweight, with a history of orthopedic surgeries and those with degenerative changes and deformities.[10,11] Since 40 years ago, use of ultrasonography is becoming more popular in daily practice among neurologists and anesthesiologists.[12,13] Recently researchers use ultrasonography to improve results of LP.[14,15] This technique gives us information including the proper location of needle insertion, angel to approach subarachnoid space and depth of needle insertion needed to collect CSF. Ultrasound guided LP have become popular among emergency physicians for diagnostic evaluations.[16] This study aims to evaluate the role of ultrasonography on decreasing the number of attempts, failed punctures, time

***Corresponding Author:** Moloud Balafar, Email: m.balafar@yahoo.com

needed to perform the procedure and patients' pain. We also assessed our hypothesis separately in obese patients.

Methods

Study design and patients

The present study is designed to characterize a prospective and case-control study. The population of the study included all patients referring to the emergency department (ED) of Imam Reza hospital, Tabriz, Iran during March 2013–March 2014. Fifty patients who were candidate for LP due to any medial indications were enrolled. Our exclusion criteria were as follows: age under 18 years old, low consciousness level, having contraindications for LP (such as local infections and severe vertebral column malformations), history of spinal surgery and reluctance to take part in the study. Patients were divided into two groups randomly by serially opening the numbered envelopes containing a group's name. Envelopes were prepared by an investigator who was not participated in the study. In order to find landmarks and L4-L5 intervertebral space, the researcher used the bedside ultrasound guidance for the first group (US group) and manual palpation for the second group (MP group).

Another investigator enrolled patients and recorded data when notified by a phone call about a patient needed LP. All punctures were performed by same experienced emergency medicine physicians.

Technique

All the patients were subjected to standard ED evaluation and care. After obtaining a written consent form patient, they were assigned to two groups. In US group, a two dimensional 7.5 MHz linear array probe (General Electric, USA) was applied on the midline lower back at L4-L5 level to localize intervertebral space. Tuffier's line was used to determine the height of the landmark's site. This line is actually an imaginary horizontal line that interconnects the superior iliac crests. The midline was then identified in a transverse plane with the probe. The intervertebral space was located by scanning in the longitudinal plane directly over the midline. Repetitive pattern of crescent-shaped hyper echoic appearance as well as acoustic shadowing, as leading characteristics of the dorsal spinous process, were used as landmarks to identify the process. Structures such as the thecal sac and ligamentum flavum which lied in deeper tissues were not visualized. In the next step, a surgical pen was used to mark the midpoint between the dorsal spinous processes as the ultrasound landmark for the intervertebral space. Preprocedural prepping and draping was carried out in the usual sterile fashion and LP was then applied on the localized site. In the US group, real time ultrasound was applied to guide the needle.

In the MP group, insertion level was determined using the standard technique by manually palpating the back in order to find the spinal level of the palpated iliac crest as well as the dorsal spinous processes. Patients were then prepped and draped sterilely. Spinal needles (18 to 22 gauge, and 3.5 inches in long) were used to perform lumber puncture. The operator was allowed to choose the needle gauge at their own discretion. In case of failure to collect CSF, operator was allowed to use LPs at a different intervertebral space. In the US group, the operator was required to repeatedly apply US at the new intervertebral level. In both groups, the operator was free to stop the procedure at his/her own discretion in cases of failure.

Outcome measures

Demographic data such as gender, age, body mass index (BMI) and some procedural data such as patient's position and intervertebral space used for LP were recorded. Primary outcome measures included the frequency of attempts (insertions) to ensure a successful tap and determine whether each attempt was successful or not. Success of an attempt was defined as collection of adequate non-traumatic CSF sample (at least 1 mL of non– traumatic CSF sample containing up to 500 red blood cells per high-power field when it is assured that bleedings induced by diagnostic measures won't find their way into the CSF). Failure was defined as not retrieving CSF on first insertion. The time taken in each procedure including time to determine insertion site in each group and time from inserting the needle till obtaining adequate the CSF, regardless of the traumatic or non-traumatic LP or whether the procedure induces pain (rated using a 10-cm visual analog scale) were considered as the secondary outcomes. We also considered patients with BMI of 30 or more as obese and compared these patients with non-obese ones for mentioned outcome measures.

Data analysis

Data collection was performed during the LP application. In the next step, the collected data were introduced into a central database. Data associated with continuous variables were expressed as mean ± standard deviation (SD) for continuous variables and those associated with categorical variables were expressed as rate (%). Mann-Whitney U test and χ^2 test were used to compare the nonparametric values of both groups and *t* test was used to compare the parametric values of the groups. One-way analysis of variance (ANOVA) was used to compare nonparametric values between more than two groups. *P* values below 0.05 were considered statistically significant. All analyses were performed using SPSS 17.0 software for Windows.

Results

In a one-year period we analyzed data of fifty patients underwent LP including 30 men and 20 women. Each study group consisted of 25 patients. The mean age was 44.08 ± 15.83 years old. No significant differences were observed in both groups in term of age, sex, BMI,

positioning of the patients and intervertebral space used for puncture. Demographic and puncture related characteristics of two groups are shown in Table 1. As you see failure and dry tap rates, average time to localize the site of insertion to collect CSF at first try and total times are much higher in MP group. Besides, average number of attempts and VAS pain scale are significantly higher in MP group. Procedural success as our primary outcome was 92% in US and only 36% in MP group ($P<0.001$). Average number of needle insertions as the other primary outcome was 1.08 ± 0.27 in US and 1.64 ± 0.48 in MP group ($P<0.001$). As our secondary outcomes, average total time (overall) was 75.62 ± 8.93 sec in US and 91.47 ± 7.83 sec in MP group ($P<0.001$). Average pain scale was 4.64 ± 1.22 cm in US and 6.12 ± 0.66 cm in MP group ($P<0.001$). We also analyzed patients in subgroups and divided them based on their obesity status (Table 2). Then, we compared obese and non-obese patients in each group. We also compared obese patients of two groups as well as non-obese ones (Table 3). By comparing obese and non-obese patients in each group, although duration and failure rate were generally lower in non-obese ones, we found that there is no significant difference between these two groups whether LP is performed ultrasound-guided or conventionally. In contrast, comparing obese and non-obese patents in two groups separately showed that using ultrasound might have a huge impact on the results. Duration and failure rates were significantly lower in US patients either in obese or non-obese patients. These results somehow leave aside the effects of obesity on failure rates and duration; and demonstrate the importance of using ultrasound in localizing puncture site and route.

Table 1. Patients' characteristics

Factors		US group	MP group	*P* value
Age, (y)		43.4 ± 15.86	44.7 ± 16.09	0.76
Male (%)		14 (56%)	16 (64%)	0.56
BMI (kg/m^2)		26.96 ± 2.68	26.85 ± 1.2	0.86
Obesity (%)		10 (40%)	7 (28%)	0.61
Failure (%)		2 (8%)	16 (64%)	< 0.001*
Dry Taps (%)		0	2 (8%)	< 0.001*
Picore (%)		1 (4%)	0	0.94
Position	Upright (%)	3 (12%)	22 (88%)	0.23
	Recumbent (%)	0	25 (100%)	
Vertebral interspace	L_4-L_5 (%)	25 (100%)	0	
	L_5-S_1 (%)	23 (92%)	2 (8%)	0.23
Loc. Time (First Try), sec		72.64 ± 11.59	84.2 ± 8.25	< 0.001*
CSF Time (First Try), sec		6.3 ± 0.99	6.87 ± 0.7	0.02*
Total Time (in first try), sec		75.62 ± 8.93	91.47 ± 7.83	< 0.001*
Total Time (overall), sec		81.52 ± 19.74	144.47 ± 40.27	< 0.001*
Needle insertion attempts		1.08 ± 0.27	1.64 ± 0.48	< 0.001*
Pain VAS, cm		4.64 ± 1.22	6.12 ± 0.66	< 0.001*

Data are reported as Mean ± SD or number (%)
BMI = Body Mass Index, CSF = Cerebrospinal Fluid, Loc. Time = Localization Time VAS = Visual Analogue Scale
* P is two-sided significant

Table 2. Comparison of Obese and non-obese patients in each group

		Obese	Non-Obese	*P* value
US group	Failure (%)	2 (20%)	0	0.15
	Loc. Time (First Try), sec	75.2 ± 13.38	70.93 ± 10.36	0.37
	CSF Time (First Try), sec	6.74 ± 1.16	6 ± 0.76	0.06
	Total Time (in first try), sec	78.44 ± 11.23	73.74 ± 6.8	0.2
	Total Time (overall), sec	93.19 ± 26.74	73.74 ± 6.8	0.01*
	Needle insertion attempts	1.2 ± 0.42	1	0.07
	Pain VAS, cm	4.9 ± 1.59	4.46 ± 0.91	0.39
MP Group	Failure (%)	6 (85.7%)	10 (55.6%)	0.35
	Loc. Time (First Try), sec	85.83 ± 7.9	80 ± 8.16	0.11
	CSF Time (First Try), sec	6.96 ± 0.61	6.64 ± 0.91	0.32
	Total Time (in first try), sec	92.79 ± 8.25	88.07 ± 5.82	0.18
	Total Time (overall), sec	155.71 ± 33.86	140.1 ± 42.58	0.39
	Needle insertion attempts	1.87 ± 0.37	1.55 ± 0.51	0.17
	Pain VAS, cm	6.42 ± 0.53	6 ± 0.68	0.15

Data are reported as Mean ± SD or number (%)
CSF = Cerebrospinal Fluid, Loc. Time = Localization Time VAS = Visual Analogue Scale
* P is two-sided significant

Discussion

Diagnostic LP, a common procedure in EDs, is usually performed conventionally by palpation using surface landmarks and imaginary lines.[17] Duniec et al showed that conventional method is misleading in more than 30% of cases. They also found concordance rate of 64% between clinical examinations and using ultrasound.[18] Failure to find the proper site for LP may lead to unwillingness of practitioners to perform LP, difficult CSF collection and patients' discomfort and dissatisfaction. Adding evidences regards effects of patients' higher BMI on these parameters, and causes vitality of the problem to become more concrete. Therefore ultrasound imaging has become increasingly popular in emergency settings for diagnostic and therapeutic objectives. Moreover, ultrasound-assisted procedures are commonly used in many daily practices such as ultrasound-guided LP.[19,20] Schlotterbeck et al investigated the applicability of ultrasound as a means to improve epidural and spinal anesthesia in the adults. They applied US to detect the appropriate site for insertion of anesthetic catheters.[21] Several studies have demonstrated the feasibility of ultrasound for lumber spine imaging and detection of landmarks.[22-25]

Ultrasound-guided LP has already been addressed in the previous studies especially the pediatric ones. Coley et al evaluated ultrasound-guided LP in infants and neonates. They had an acceptable success rate using this modality (15 out of 26).[26] As it was mentioned, studies in adults are very limited and in some of them no preference is reported for ultrasound. Pisupati and colleagues studied 66 individuals and reported no difference between ultrasound imaging and palpation. However, they did reported an almost significant difference in subgroup analysis of patients with difficult or impossible to palpate landmarks.[27] Nomura et al reported that there was no

Table 3. Comparison of patients of two group based on their obesity status

		US	MP	*P* value
Obese	Failure (%)	2 (20%)	6 (85.7%)	0.01*
	Loc. Time (First Try), sec	75.2 ± 13.38	85.83 ± 7.9	0.02*
	CSF Time (First Try), sec	6.74 ± 1.16	6.96 ± 0.61	0.85
	Total Time (in first try), sec	78.44 ± 11.23	92.79 ± 8.25	0.02*
	Total Time (overall), sec	93.19 ± 26.74	155.71 ± 33.86	0.001*
	Needle insertion attempts	1.2 ± 0.42	1.87 ± 0.37	0.005*
	Pain VAS, cm	4.9 ± 1.59	6.42 ± 0.53	0.02*
non obese	Failure (%)	0	10 (55.6%)	0.001*
	Loc. Time (First Try), sec	70.93 ± 10.36	80 ± 8.16	0.02*
	CSF Time (First Try), sec	6 ± 0.76	6.64 ± 0.91	0.03*
	Total Time (in first try), sec	73.74 ± 6.8	88.07 ± 5.82	0.01*
	Total Time (overall), sec	73.74 ± 6.8	140.1 ± 42.58	> 0.001*
	Needle insertion attempts	1	1.55 ± 0.51	> 0.001*
	Pain VAS, cm	4.46 ± 0.91	6 ± 0.68	> 0.001*

Data are reported as Mean ± SD or number (%)
CSF = Cerebrospinal Fluid, Loc. Time = Localization Time VAS = Visual Analogue Scale
* P is two-sided significant

significant difference between the traumatic LPs, number of attempts, duration of procedure, and patients' comfort. However, they showed that using US could facilitate the procedure.[28]

Our study demonstrates the substantial role of ultrasound to find appropriate site of puncture to reduce failure and time needed to perform the procedure. Also we showed that using this technique would result in less pain associated with LP due to fewer numbers of tries to collect enough CSF. Interestingly we found out that with or without obesity, use of ultrasound will definitely lead to more favorable results in terms of duration of localization and collecting CSF, success rate, patients' pain and number of attempts. Peterson et al. showed that US guided LP is associated with more benefits such as timesaving in ED. They reported that emergency physicians can apply US-guided LP in cases where blind needle insertion based on surface landmark guidance is difficult or impossible to apply.[17] Mofidi et al evaluated and divided 80 patients in two groups: ultrasound guided LP group and manual palpation LP group. They showed that using ultrasound would reduce the pain and duration of the procedure especially in patients with higher BMI.[29]

Conflict of Interest Disclosure
Authors have no conflict of interest.

Ethical Approval
This study was accepted by the Ethics Committee of Tabriz University of Medical Sciences with the code of IR.TBZMED.REC.91/3-7/6 and it was registered at Iranian Registry of Clinical Trials (identifier: IRCT2013102511067N3).

Authors' Contribution
MP, Study design; MT, study guide and manuscript critic; PM, supervise; SK, consultant; SN, writing; MB, Data Gathering and analysis.

Acknowledgments
Special thanks to all emergency department staffs.

Funding
This article was not supported by any funding organization.

Informed Consent
informed consent were filled by all patients or relatives.

References

1. Kooiker JC. Spinal puncture and cerebrospinal fluid examination. In: Roberts JR, Hedges JR, eds. Clinical Procedures in Emergency Medicine. 3rd ed. Philadelphia, PA: WB Saunders Co; 1998. p. 1054-77.
2. Mintegi S, Benito J, Astobiza E, Capapé S, Gomez B, Eguireun A. Well appearing young infants with fever without known source in the emergency department: are lumbar punctures always necessary? Eur J Emerg Med. 2010;17(3):167-9. doi: 10.1097/MEJ.0b013e3283307af9.
3. Delerme S, Castro S, Viallon A, Boutoille D, Bendahou M, Riou B, et al. Meningitis in elderly patients. Eur J Emerg Med. 2009;16(5):273-6. doi: 10.1097/MEJ.0b013e3283101866.
4. Shah KH, Richard KM, Nicholas S, Edlow JA. Incidence of traumatic lumbar puncture. Acad Emerg Med. 2003;10(2):151-4. doi: 10.1111/j.1553-2712.2003.tb00033.x.
5. Shah KH, Edlow JA. Distinguishing traumatic lumbar puncture from true subarachnoid hemorrhage. J Emerg Med. 2002;23(1):67-74. doi: 10.1016/s0736-4679(02)00464-x.
6. Mazor SS, McNulty JE, Roosevelt GE. Interpretation of traumatic lumbar punctures: who can go home? Pediatrics. 2003;111(3):525-8.
7. Locks Gde F, Almeida MC, Pereira AA. Use of the ultrasound to determine the level of lumbar puncture in pregnant women. Rev Bras Anestesiol. 2010;60(1):13-9. doi: 10.1016/s0034-7094(10)70002-7.
8. Boon JM, Abrahams PH, Meiring JH, Welch T. Lumbar puncture: anatomical review of a clinical skill. Clin Anat. 2004;17(7):544-53. doi: 10.1002/ca.10250.
9. Broadbent CR, Maxwell WB, Ferrie R, Wilson DJ, 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.
10. Barash PG. Anaesthesia and orthopedic burgery. Clinical anaesthesia. JB Lippincott Company. 1989;1163.
11. Larsen R. Znieczulenie u pacjentów w wieku podeszłym. Anestezjologia. Urban i Partner. 1996;718. Availbale from: https://medbook.com.pl/ksiazka/pokaz/id/1030/tytul/anestezjologia-larsen-k%C3%BCbler-elsevier-urban-&-partner
12. Furness G, Reilly MP, Kuchi S. An evaluation of ultrasound imaging for identification of lumbar intervertebral level. Anaesthesia. 2002;57(3):277-80. doi: 10.1046/j.1365-2044.2002.2403_4.x.
13. Watson MJ, Evans S, Thorp JM. Could ultrasonography be used by an anaesthetist to identify a specified lumbar interspace before spinal anaesthesia? Br J Anaesth. 2003;90(4):509-11. doi: 10.1093/bja/aeg096.
14. Ferre RM, Sweeney TW. Ultrasonographic identification of anatomic structures relevant to lumbar puncture.

Ann Emerg Med. 2004;44(4 Suppl):S62. doi: 10.1016/j.annemergmed.2004.07.204.
15. Sandoval M, Shestak W, Stürmann K, Hsu C. Optimal patient position for lumbar puncture, measured by ultrasonography. Emerg Radiol. 2004;10(4):179-81. doi: 10.1007/s10140-003-0286-3.
16. Tibbles CD, Porcaro W. Procedural applications of ultrasound. Emerg Med Clin North Am. 2004;22(3):797-815. doi: 10.1016/j.emc.2004.04.010.
17. Peterson MA, Abele J. Bedside ultrasound for difficult lumbar puncture. J Emerg Med. 2005;28(2):197-200. doi: 10.1016/j.jemermed.2004.09.008.
18. Duniec L, Nowakowski P, Kosson D, Łazowski T. Anatomical landmarks based assessment of intravertebral space level for lumbar puncture is misleading in more than 30%. Anaesthesiol Intensive Ther. 2013;45(1):1-6. doi: 10.5603/ait.2013.0001.
19. Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. Acad Emerg Med. 2002;9(8):800-5. doi: 10.1111/j.1553-2712.2002.tb02168.x.
20. Euerle B. Spinal puncture and cerebrospinal fluid examination. In: Roberts JR, Hedges JR, eds. Clinical Procedures in Emergency Medicine. Vol 4. Philadelphia, PA: WB Saunders Co; 2004. p. 1197-222.
21. Schlotterbeck H, Schaeffer R, Dow WA, Touret Y, Bailey S, Diemunsch P. Ultrasonographic control of the puncture level for lumbar neuraxial block in obstetric anaesthesia. Br J Anaesth. 2008;100(2):230-4. doi: 10.1093/bja/aem371.
22. Chen CP, Tang SF, Hsu TC, Tsai WC, Liu HP, Chen MJ, et al. Ultrasound guidance in caudal epidural needle placement. Anesthesiology. 2004;101(1):181-4. doi: 10.1097/00000542-200407000-00028.
23. Moon SH, Park MS, Suk KS, Suh JS, Lee SH, Kim NH, et al. Feasibility of ultrasound examination in posterior ligament complex injury of thoracolumbar spine fracture. Spine (Phila Pa 1976). 2002;27(19):2154-8. doi: 10.1097/00007632-200210010-00015.
24. Watson MJ, Evans S, Thorp JM. Could ultrasonography be used by an anaesthetist to identify a specified lumbar interspace before spinal anaesthesia? Br J Anaesth. 2003;90(4):509-11. doi: 10.1093/bja/aeg096.
25. Lam WW, Ai V, Wong V, Lui WM, Chan FL, Leong L. Ultrasound measurement of lumbosacral spine in children. Pediatr Neurol. 2004;30(2):115-21. doi: 10.1016/j.pediatrneurol.2003.07.002.
26. Coley BD, Shiels WE 2nd, Hogan MJ. Diagnostic and interventional ultrasonography in neonatal and infant lumbar puncture. Pediatr Radiol. 2001;31(6):399-402. doi: 10.1007/s002470100453.
27. Pisupati D, Heyming TW, Lewis RJ, Peterson MA. Effect of ultrasonography localization of spinal landmarks on lumbar puncture in the emergency department. Ann Emerg Med. 2004;44(4 Suppl):S83. doi: 10.1016/j.annemergmed.2004.07.272.
28. Nomura JT, Leech SJ, Shenbagamurthi S, Sierzenski PR, O'Connor RE, Bollinger M, et al. A randomized controlled trial of ultrasound-assisted lumbar puncture. J Ultrasound Med. 2007;26(10):1341-8. doi: 10.7863/jum.2007.26.10.1341.
29. Mofidi M, Mohammadi M, Saidi H, Kianmehr N, Ghasemi A, Hafezimoghadam P, et al. Ultrasound guided lumbar puncture in emergency department: time saving and less complications. J Res Med Sci. 2013;18(4):303-7.