

Attitudes and Practices of Lumbar Puncture among Students, Interns, and Residents of the Pediatric Department of the Mohammed VI University Hospital Center of Oujda, Morocco

Hasnae Elhaddadi^{1,2*}, Ayyad Ghanam^{1,2}, Hind Zahiri^{1,2}, Amal Hamami^{1,2}, Aziza Elouali^{1,2}, Abdeladim Babakhouya^{1,2}, Maria Rkain^{1,2}

¹Department of Pediatrics, University Hospital Center Mohammed VI, Oujda, Morocco

²Faculty of Medicine and Pharmacy, Mohammed First University, Oujda, Morocco

Email: *Hasnae.elhaddadi6@gmail.com, Ayadghanam@gmail.com, Zahiri.hind1@gmail.com, Hamami.amal16@gmail.com, Azizaelouali2@gmail.com, Babakhouya1980@gmail.com, Rkainm@yahoo.com

How to cite this paper: Elhaddadi, H., Ghanam, A., Zahiri, H., Hamami, A., Elouali, A., Babakhouya, A. and Rkain, M. (2024) Attitudes and Practices of Lumbar Puncture among Students, Interns, and Residents of the Pediatric Department of the Mohammed VI University Hospital Center of Oujda, Morocco. *Open Journal of Pediatrics*, **14**, 598-608.

<https://doi.org/10.4236/ojped.2024.143058>

Received: April 1, 2024

Accepted: May 19, 2024

Published: May 22, 2024

Copyright © 2024 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution-NonCommercial International License (CC BY-NC 4.0).
<http://creativecommons.org/licenses/by-nc/4.0/>



Open Access

Abstract

Introduction: Even though lumbar puncture (LP) represents an important tool in the diagnosis of certain neurological diseases, this procedure is little practiced by our students. We aimed to evaluate the attitudes and practices of students, interns, and residents about LP, and to assess their feelings about how this procedure is taught. **Materials and Methods:** We conducted a cross-sectional study of 160 participants, using an anonymous questionnaire, to evaluate the attitudes and practices of students, interns and residents in the pediatrics department concerning lumbar puncture. **Results:** Half of the participants had never performed LP, usually because of the risk involved or lack of confidence, while 20% had performed it more than 4 times. None of the participants had learned to perform the procedure through simulation sessions, while (42%) had learned it under the supervision of a senior physician and had not been able to perform it successfully the first time. Most participants inform the patient about the procedure before performing it. Only 44% of participants acknowledged that LP can be performed under local anesthetic. The sitting position (60%) was by far the most commonly used. Most LPs were performed for diagnostic purposes. Most participants stated that the pediatric ward and the pediatric emergency department are among the departments that perform LP most frequently, and that they would be interested in taking part in simulated lumbar puncture sessions in children in the future. **Conclusion:** The results of our study show that LP is perceived by students as a risky procedure that is difficult to perform. Teachers should re-

consider how this technical procedure is taught, by integrating simulation on mannequins into student training.

Keywords

Lumbar Puncture, Learning, Healthcare Simulation, Stress, Clinical Competency

1. Introduction

Lumbar puncture (LP) is an invasive medical procedure, sometimes necessary, for the diagnosis of many pathologies, particularly neurological ones [1]. It involves the removal of cerebrospinal fluid (CSF) from the lumbar subarachnoid space for diagnostic and/or therapeutic purposes [2]. In this procedure, CSF is withdrawn from the lumbar region by inserting an atraumatic needle between the spinous processes of two adjacent lumbar vertebrae until it reaches the subarachnoid space. To avoid damage to the spinal cord, the sample should be taken between the 3rd and 4th vertebrae, or between the 4th and 5th vertebrae, where the spinal cord no longer exists [3].

Lumbar puncture (LP) plays a crucial role in pediatric medicine. The cerebrospinal fluid analysis from LP is instrumental in diagnosing infections, inflammatory conditions, subarachnoid hemorrhages, demyelinating syndromes, and aiding in the management of pseudotumor cerebri. This procedure provides valuable insights into neurological disorders, guiding appropriate treatment strategies [4]. Lumbar puncture requires patient consent, compliance with asepsis rules, mastery of the procedure, and knowledge of contraindications and iatrogenic complications. The use of appropriate, atraumatic needles with non-sharp tips reduces the incidence of post-lumbar puncture syndrome, an iatrogenic complication characterized by postural headaches [5]. It is one of the most challenging procedures in medicine, as its success depends not only on the skill of the physician but also on the size, anatomy, and comfort of the patient [6]. Until recently, medical training for this procedure typically involved the “see one, do one, and teach one” learning model, where a trainee’s first attempt takes place in a real-life, high-stakes environment [7]. As a result, novice operators’ stress levels were elevated before and during PL completion compared to subjects with prior experience [8].

Simulation technology using lumbar puncture simulators is effective in improving operator education and experience in technical gestures such as the case of LP practice [9] [10]. It has been reported to improve students’ theoretical knowledge and autonomy, as well as their success rate and confidence in performing LP [10]. However, while simulation is becoming a necessary part of medical learning and study, it is far more resource-intensive than traditional learning [7]. Our study aimed to evaluate the skills of students from the Oujda Faculty of Medicine and Pharmacy, interns, and residents assigned to the pedia-

tric department, in the practice of LP during their internship. To this end, we conducted this descriptive study with them to assess their experiences of learning lumbar puncture in pediatrics.

2. Materials and Methods

Study design: a cross-sectional study was conducted to evaluate the attitudes and practices of students, interns and residents in the pediatrics department concerning lumbar puncture.

Study setting and population: the Oujda Faculty of Medicine and Pharmacy came into being in 2008, thanks to the will of His Majesty King Mohammed VI, may God assist him, who wanted the Oriental region to enjoy all the autonomy it deserves and needs, particularly in terms of socio-economic and educational infrastructure. It is one of Morocco's eleven public higher education establishments for medicine and pharmacy. It is affiliated to the Mohamed I University of Oujda. Every year, the Oujda Faculty of Medicine and Pharmacy welcomes over 300 Moroccan students from Oujda and neighboring towns, as well as foreign students, notably Tunisians, students from the Middle East and sub-Saharan Africans, all of them supervised by a team of teaching staff. After passing the baccalaureate and the entrance exam to the Faculty of Medicine and Pharmacy in Oujda, the curriculum is divided into 3 cycles: the 1st cycle consists of the first two years. The 2nd cycle lasts 3 years. The 3rd cycle, 2 years, corresponds to the internship. After defending the thesis, the student obtains the diploma of Doctor of Medicine.

Students' practical activities and internships are carried out at the Mohammed VI University Hospital in Oujda, which is affiliated to the Ministry of Health and Social Protection. The center comprises four hospitals: the Hospital for Specialties, the mother and Child Hospital, the Hassan II Oncology Center and the Hospital for Mental Health and Psychiatric Diseases. The pediatrics department is located in the mother and child hospital, and receives students from the Oujda faculty of medicine and pharmacy, interns and residents pursuing their pediatrics specialty.

The study included 160 participants. The inclusion criteria were: all OJUDA Faculty of Medicine and Pharmacy students (4th and 6th years) doing their medical studies and hospital internship in the pediatrics department, as well as all interns and residents pursuing their Pediatrics specialty.

Variables: variables included age of participant, gender, level of medical education, faculty of study, number of lumbar punctures performed, reasons for not performing lumbar puncture, methods of learning the lumbar puncture procedure (by supervision, by simulation, other...), indications for lumbar puncture (diagnostic or therapeutic), contraindications, informing the patient about the procedure, the preferred position for performing the procedure, complications encountered, departments that perform lumbar puncture more frequently, and learning how to perform lumbar puncture in children using simulation.

Data collection tool: data was collected in a structured manner using a pre-established questionnaire.

Data collection: the questionnaire was anonymous and included general information (age, sex), information on medical education (level of medical education, learning methods, etc.), and information on lumbar puncture training and its importance (number of LPs performed, reasons why they were not performed, success or failure on the first attempt, indications and contraindications for LPs, and complications, etc.).

Sample size: the sample size was calculated using a single proportion. All questionnaires were usable, the response rate was 100%, so we obtained a number of responses equal to the size of the population studied. Using a 95% confidence level, the margin of error was 0%, reflecting the degree of certainty of the margin of error.

Data analysis: data were coded with SPSS version 24 and analyzed with Statistica version 7.1. Variables with missing data were excluded from the analysis. The dependent variable was the number of lumbar punctures performed by our participants. Independent variables included demographic variables, level of education and method of learning lumbar puncture. Descriptive analysis was performed, with categorical variables (gender, etc.) expressed as frequencies, and numerical variables (age, etc.) presented as means. Analytical statistics were used to measure the association between independent and dependent variables. using univariate analysis.

3. Results

3.1. Demographic Characteristics Analysis

Out of a total of 160 participants, women predominated (60%), male participants presented only 40%. The most common age group was between 20 and 25 years (62%), the age distribution of participants is shown in **Figure 1**. Our participants were divided between interns (6%), residents (26%), 6th-year students (20%) and 4th-year students (48%), **Table 1** summarizes the distribution of students, interns and residents assigned to the pediatrics department by gender and level of medical study. The majority of participants were graduates and students of the Oujda Faculty of Medicine and Pharmacy.

3.2. Practice of Lumbar Puncture Analysis

Half of the participants had never performed an LP (56%), while (20%) had done so more than 4 times, **Figure 2** shows the distribution by number of lumbar punctures performed. The risk associated with performing lumbar puncture (33%), lack of confidence (27.2%), lack of patient compliance (11%), and other unspecified reasons for 18 participants (28.8%) were the reasons reported by participants who had never performed LP. Participants who had performed at least one LP (44%) were unable to do so successfully the first time. On average, boys performed more LPs than girls, whatever the participant's level of education or sta-

tus. All participants said they had never learned to perform this procedure during the simulation sessions, while (42%) had learned it under the supervision of a senior doctor (**Table 2**).

Most lumbar punctures were performed on patients aged between 2 and 5 years, with a percentage of 67%. Most participants (80%) said they informed the patient about the procedure and its importance before performing it. Only 44% of participants acknowledged that LP can be performed under local anesthetic or sedation. Local anesthesia by anesthetic patch was used rarely in our patients, with a percentage of 13%. Only 3 patients benefited from the procedure under general anesthetic in the operating room. On a technical level, most participants preferred the half-seated position to perform the procedure (60%). Two-thirds of LPs performed by our participants were for diagnostic purposes (65%), notably to check for meningitis or meningoencephalitis, or to measure intracranial pressure. A third of the LPs performed were for therapeutic reasons, in particular: iterative lumbar puncture or intrathecal injection. The complications most frequently encountered following LP were traumatic LP (62%) and headache (22%), rarely pain in the lower limb due to nerve root damage. Sixty percent (60%) of the participants stated that the pediatric department and pediatric emergency department are among the departments that perform the LP procedure most frequently (**Table 3**), and they are interested in taking part in simulation sessions on LP in children in the future.

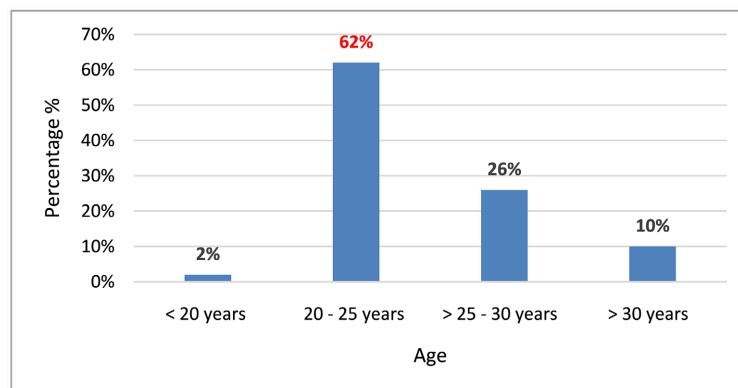


Figure 1. Age distribution of students, interns and residents assigned to the pediatrics department of the Mohammed VI University Hospital in Oujda (Morocco) (n = 160).

Table 1. Distribution of students, interns and residents assigned to the pediatrics department of the Mohammed VI University Hospital, by gender and level of study (n = 160).

Level of education	Gender		Total
	Male	Female	
Resident	6	35	26% (41 participants)
Intern	4	4	6% (8 participants)
6th-year student	13	20	20% (33 participants)
4th-year student	41	37	48% (78 participants)
Total	40% (64 participants)	60% (96 participants)	100%

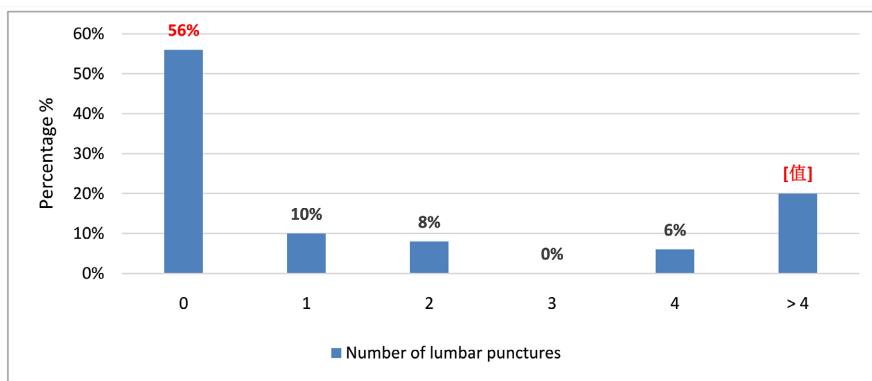


Figure 2. Distribution of students, interns and residents assigned to the pediatrics department of the Mohammed VI University Hospital according to the number of lumbar punctures performed in Oujda (Morocco) (n = 160).

Table 2. Percentages of students who practiced or learned lumbar puncture, those who were supervised, those who successfully performed their first lumbar puncture, and those who provided information to the patient before lumbar puncture.

The practice of lumbar puncture	Yes	No
Lumbar puncture practiced	44%	56%
Lumbar puncture learned by simulation method	0%	100%
Lumbar puncture supervised by a senior	42%	58%
Lumbar puncture successful 1st time	0%	100%
Patient informed	80%	20%

Table 3. Frequency of lumbar puncture according to hospital department solon the participants in our study (n = 160).

Department	Pediatrics	Pediatric emergencies	Neurology	Internal medicine	Intensive care - anesthesia	Total
Percentage (%)	28%	31%	26%	12%	3%	100%
Number of patients (n)	45	49	42	20	4	160

4. Discussion

The importance of lumbar puncture as a key diagnostic tool for neurological diseases is well established. It is often used to exclude intracranial infection in febrile children, by enabling cerebrospinal fluid analysis, it can provide crucial information for diagnosis and guide treatment [11]. In our study, all participants affirmed that lumbar puncture is an important procedure, but the results of our study tend to show that this practical procedure is little practiced and poorly taught to our students during their internships; indeed, almost 48% of them declared that they had learned to perform LP without being supervised by a senior doctor, while 18% had never learned to perform this procedure, the vast majority of the latter being in their 4th year of medical studies. The study by Barr *et al.* reported that out of a total of 644 students in their 4th year of medical studies, 57% had never performed a single lumbar puncture and that boys were often more experienced and confident than girls [12], with results similar to those of

our study. Barr's study also demonstrated that medical students are underexposed to common medical procedures and feel uncomfortable performing them, a trend that has worsened over the last 25 years [12]. The study by Lammers *et al.* reported that of the 83% of participants who had already performed LPs during their training; only 40% of these were supervised on their first attempt, the study concluded that most first-year residents need direct and close supervision from their seniors until they fully master the LP technique [13]. In New Zealand, LP is an important examination that is routinely performed in emergency and neurology departments; the study by Alamri *et al.* reported that medical students in Australia and New Zealand do not often have the chance to perform it during their basic training [14]. Although pediatric residents were tasked with teaching students the lumbar puncture procedure far more frequently, the study by Breakey, Vicky R *et al.* reported that they reported fewer training opportunities during residency [15].

In our study, the reasons why participants never performed a lumbar puncture were: lack of patient compliance, the risks associated with the procedure, lack of self-confidence, and 28.8% abstained from answering. The same reasons were reported by Abderrahmane Moulaye in a study of students at the Nouakchott Faculty of Medicine [3]. According to Guillaume Ficheux, the concerns reported by students were of three kinds: fear of complications, notably pain (49%), but also neurological sequelae (18%), aseptic errors and nosocomial infections (9%), traumatic puncture (8%), post-PL syndrome (4%) or needle breakage during the procedure (one student); followed by fear of failure of the procedure (39%); finally, apprehension linked to lack of experience and theoretical knowledge for a procedure perceived as complicated [6].

To assess parents' attitudes towards lumbar puncture in children, the study by Aslıhan Sahin *et al.* reported that the rate of acceptance of an LP by parents performed by pediatric specialists was 7.1 times higher than that of parents informed by residents [16]. In Santen *et al.*'s study of 202 patients, most refused to have their first LP performed on them by a resident. They felt that this could have implications for medical training and patient consent [17]. In the same sense, Williams *et al.* reported that there is a risk of compromising the training of students and future doctors if patients refuse the LP procedure performed by a student for the first time. According to the same author, the acceptance rate for first-time LPs was 52% for students, 62% for interns, and 66% for residents [18]. Several studies have demonstrated that the use of virtual reality and simulation methods in lumbar puncture training improves teaching and provides an immersive environment for a better learning experience for students in medical training [10] [19] [20] [21].

In Ireland, Sinéad Lydon *et al.* reported that the simulation-based lumbar puncture teaching program achieved behavioral fluency in lumbar puncture in pediatric trainees. Thus, at the end of training, the performance of these participants was equivalent to or better than that of senior pediatricians [19]. According to Agathe Vrillon *et al.*, the use of 180-degree 3D stereoscopic video in lum-

bar puncture training for 168 participants (108 novice third-year medical students and 60 residents) could increase knowledge retention and skill acquisition in association with simulation training [7]. Similarly, in a study conducted on a pediatric department in Canada, Hugh J. McMillan *et al.* demonstrated the usefulness of speech therapy simulation methods combined with an interactive training session in improving residents' procedural skills and reducing anxiety and stress levels [22]. The study by Jeffrey H. Barsuk *et al.* found improved skills in internal medicine residents who learned lumbar puncture using simulation learning methods, compared with neurology residents who were trained traditionally [23]. Many other studies have shown that students benefit from innovative learning experiences through simulation, and not only acquire skills in the given task but are also made confident and prepared to deliver real care, without danger or discomfort to the patient, thus contributing to improving the quality and safety of care [24] [25] [26] [27].

5. Conclusion

Understandably, lumbar puncture can be perceived as a difficult, potentially painful, and risky procedure, sometimes causing anxiety and stress; whose complications, although rare, can prove serious; this is because they are not sufficiently trained to perform such a procedure. Simulation-based learning methods have become an essential training tool for healthcare professionals, enabling them to significantly improve medical students' skills in performing lumbar punctures.

5.1. What Is Already Known on This Topic

- Lumbar puncture is a relatively frequent procedure, potentially painful, sometimes anxiety-provoking, and whose complications, although rare, can be serious; it is perceived by students as a difficult and potentially risky procedure;
- It is a highly useful diagnostic procedure, but not without side effects and potential complications;
- The success rate in real-life conditions is higher for students who have received simulator training; simulation significantly improves medical students' performance in performing lumbar punctures.

5.2. What This Study Adds

- This practical gesture is poorly taught to our students during their internships;
- The doctors in charge of training students are not doing enough to improve the way they teach and learn this technical procedure, and thus perfect their students' skills;
- Today, simulation is an essential and indispensable training method for the healthcare professions, enabling a significant improvement in the performance of medical students in performing lumbar punctures.

Authors' Contributions

Conception and writing of the article: Hasnae Elhaddadi.

Conflicts of Interest

Authors declared they have no conflicts of interest.

References

- [1] Cognat, E., Berengère, K., Paul, Z., Belbachir, A. and Paquet, C. (2020) Recommandations HAS Ponction Lombaire. *Revue Neurologique*, **176**, S114. <https://doi.org/10.1016/j.neurol.2020.01.317>
- [2] Chevallier, S., Monti, M., Michel, P. and Vollenweider, P. (2008) Ponction Lombaire. *Revue Médicale Suisse*, **4**, 2312-2318. <https://doi.org/10.53738/REVMED.2008.4.177.2312>
- [3] Moulaye, A., *et al.* (2019) Évaluation des étudiants, internes et résidents sur la pratique de la ponction lombaire au cours des stages hospitaliers. *Pan African Medical Journal*, **33**, Article No. 56. <https://doi.org/10.11604/pamj.2019.33.56.16986>
- [4] Bonadio, W. (2014) Pediatric Lumbar Puncture and Cerebrospinal Fluid Analysis. *The Journal of Emergency Medicine*, **46**, 141-150. <https://doi.org/10.1016/j.jemermed.2013.08.056>
- [5] Zetlaoui, P.J. (2020) Ponction Lombaire. *EMC-Neurologie*, **13**, 1-12.
- [6] Roos, K.L. (2003) Lumbar Puncture. *Seminars in Neurology*, **23**, 105-114. <https://doi.org/10.1055/s-2003-40758>
- [7] Vrillon, A., Gonzales-Marabal, L., Ceccaldi, P.-F., Plaisance, P., Desrentes, E., Paquet, C. and Dumurgier, J. (2022) Using Virtual Reality in Lumbar Puncture Training Improves Students Learning Experience. *BMC Medical Education*, **22**, Article No. 244. <https://doi.org/10.1186/s12909-022-03317-7>
- [8] Henriksen, M.J.V., Wienecke, T., Kristiansen, J., Park, Y.S., Ringsted, C. and Konge, L. (2018) Opinion and Special Articles: Stress When Performing the First Lumbar Puncture May Compromise Patient Safety. *Neurology*, **90**, 981-987. <https://doi.org/10.1212/WNL.0000000000005556>
- [9] Gaubert, S., Blet, A., Dib, F., Ceccaldi, P.-F., Brock, T., Calixte, M., *et al.* (2021) Positive Effects of Lumbar Puncture Simulation Training for Medical Students in Clinical Practice. *BMC Medical Education*, **21**, Article No. 18. <https://doi.org/10.1186/s12909-020-02452-3>
- [10] Akaishi, Y., Okada, Y., Lee-Jayaram, J., Seo, J.S., Yamada, T. and Berg, B.W. (2020) Validity Evidence of a Task Trainer for Normal and Difficult Lumbar Puncture: A Cross-Sectional Study. *Medicine*, **99**, e22622. <https://doi.org/10.1097/MD.00000000000022622>
- [11] Schulga, P., *et al.* (2015) How to Use... Lumbar Puncture in Children. *Archives of Disease in Childhood-Education and Practice*, **100**, 264-271. <https://doi.org/10.1136/archdischild-2014-307600>
- [12] Barr, J. and Graffeo, C.S. (2016) Procedural Experience and Confidence among Graduating Medical Students. *Journal of Surgical Education*, **73**, 466-473. <https://doi.org/10.1016/j.jsurg.2015.11.014>
- [13] Lammers, R.L., *et al.* (2005) Competence of New Emergency Medicine Residents in the Performance of Lumbar Punctures. *Academic Emergency Medicine*, **12**, 622-628.

<https://doi.org/10.1197/j.aem.2005.01.014>

- [14] Alamri, Y.A. (2012) Medical Students Performing Lumbar Punctures: Are We Doing Enough? *New Zealand Medical Journal*, **125**, 89-93.
- [15] Breakey, V.R., et al. (2007) Pediatric and Emergency Medicine Residents' Attitudes and Practices for Analgesia and Sedation during Lumbar Puncture in Pediatric Patients. *Pediatrics*, **119**, e631-e636. <https://doi.org/10.1542/peds.2006-0727>
- [16] Sahin, A., et al. (2023) Parental Attitudes about Lumbar Puncture in Children with Suspected Central Nervous System Infection. *Pediatric Emergency Care*, **39**, 661-665. <https://doi.org/10.1097/PEC.0000000000003015>
- [17] Santen, S.A., Hemphill, R.R., McDonald, M.F. and Jo, C.O. (2004) Patients' Willingness to Allow Residents to Learn to Practice Medical Procedures. *Academic Medicine*, **79**, 144-147. <https://doi.org/10.1097/00001888-200402000-00010>
- [18] Williams, C.T. and Fost, N. (1992) Ethical Considerations Surrounding First Time Procedures: A Study and Analysis of Patient Attitudes toward Spinal Taps by Students. *Kennedy Institute of Ethics Journal*, **2**, 217-231. <https://doi.org/10.1353/ken.0.0108>
- [19] Lydon, S., Reid McDermott, B., Ryan, E., O'Connor, P., Dempsey, S., Walsh, C. and Byrne, D. (2019) Can Simulation-Based Education and Precision Teaching Improve Paediatric Trainees' Behavioural Fluency in Performing Lumbar Puncture? A Pilot Study. *BMC Medical Education*, **19**, Article No. 138. <https://doi.org/10.1186/s12909-019-1553-7>
- [20] Zhao, J., Xu, X., Jiang, H. and Ding, Y. (2020) The Effectiveness of Virtual Reality-Based Technology on Anatomy Teaching: A Meta-Analysis of Randomized Controlled Studies. *BMC Medical Education*, **20**, Article No. 127. <https://doi.org/10.1186/s12909-020-1994-z>
- [21] Mansoory, M.S., Khazaei, M.R., Azizi, S.M. and Niromand, E. (2021) Comparison of the Effectiveness of Lecture Instruction and Virtual Reality-Based Serious Gaming Instruction on the Medical Students' Learning Outcome about Approach to Coma. *BMC Medical Education*, **21**, Article No. 347. <https://doi.org/10.1186/s12909-021-02771-z>
- [22] McMillan, H.J., Writer, H., Moreau, K.A., Eady, K., Sell, E., Lobos, A.T., Grabowski, J. and Doja, A. (2016) Lumbar Puncture Simulation in Pediatric Residency Training: Improving Procedural Competence and Decreasing Anxiety. *BMC Medical Education*, **16**, Article No. 198. <https://doi.org/10.1186/s12909-016-0722-1>
- [23] Barsuk, J.H., Cohen, E.R., Caprio, T., McGaghie, W.C., Simuni, T. and Wayne, D.B. (2012) Simulation-Based Education with Mastery Learning Improves Residents' Lumbar Puncture Skills. *Neurology*, **79**, 132-137. <https://doi.org/10.1212/WNL.0b013e31825dd39d>
- [24] AlShammari, A., et al. (2018) Evaluation of Effectiveness of a Paediatric Simulation Course in Procedural Skills for Paediatric Residents—A Pilot Study. *The Journal of the Pakistan Medical Association*, **68**, 240-246.
- [25] Mills, D.M., et al. (2013) Simulation Training as a Mechanism for Procedural and Resuscitation Education for Pediatric Residents: A Systematic Review. *Hospital Pediatrics*, **3**, 167-176. <https://doi.org/10.1542/hpeds.2012-0041>
- [26] Goldman, M.P., Rudd, A.V., Baum, S.C., Nagler, M., Weiss, D.L., Gross, I.T. and Auerbach, M.A. (2022) Formative Assessments Promote Procedural Learning and Engagement for Senior Pediatric Residents on Rotation in the Pediatric Emergency Department. *MedEdPORTAL*, **18**, Article 11265. https://doi.org/10.15766/mep_2374-8265.11265

- [27] Srivastava, G., *et al.* (2012) An Educational Video Improves Technique in Performance of Pediatric Lumbar Punctures. *Pediatric Emergency Care*, **28**, 12-16.
<https://doi.org/10.1097/PEC.0b013e31823ed5ed>