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The Current Use of Lumbar Puncture in a General Paediatric Unit

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Abstract

Aim

This study evaluated the use of Lumbar Puncture (LP) in a general paediatric unit over a 3-year period.

Methods

Index patients, who had a successful LP, were identified from the microbiology database and failed LP procedures were identified from a chart review of the serum PCR database. Data abstracted included 1) patient age, 2) LP indication, 3) LP procedure outcome; classified as atraumatic, traumatic or failed, 4) grade of doctor undertaking the procedure and 5) the final diagnosis.

Results

We identified 104 paediatric patients, of whom 29(27.9%) were neonates. LP was indicated for the evaluation of acute undifferentiated illnesses, with 33 (31.7%) patients having fever without source beyond the neonatal period and 16 (15.4%) being neonates with fever. A CSF sample was obtained in 96 (92.4%) patients, with 71 (73.9%) being atraumatic. Successful LP was undertaken by Consultants in 4 (4.1%), Registrars in 83 (86.5%) and SHOs in 9 (9.4%) patients. 14 (14.6%) patients had positive CSF cultures with an additional 23 having positive cultures or serology (9 blood cultures, 11 urine cultures and 3 positive serum PCR).

Conclusion

Skill in LP performance is still required, to evaluate acute undifferentiated illness, in general paediatric units and ancillary methods to aid SHOs with LP skill development is desirable.

Introduction

Lumbar puncture (LP) and the analysis of cerebrospinal fluid (CSF) is required for the evaluation of acute undifferentiated febrile illnesses in children. LP is also utilised to investigate certain neurological diseases, to administer intrathecal medications, and it forms part of the treatment protocol for specific malignancies.

With the introduction of enhanced immunisation regimens, the incidence of invasive bacterial disease is declining[1,2] and as such, LP is becoming a low-frequency procedure. However, it remains an expected competency for Basic Specialist Trainees (BST) in Paediatrics[3].

The aim of this study was to assess the current use of LP in a general paediatric unit which provides secondary level hospital care.

Methods

With ethical approval from the Mayo University Ethics Committee, a retrospective observational study was conducted in patients under 15 years, who required LP during the 3-year period from 2014 to 2016 inclusive. During the 3-year study period approximately 5,000 babies delivered, and 4,600 medical paediatric patients were admitted to our hospital.

Patients who underwent LP, with successful acquisition of CSF samples, were identified from the microbiology database. Patients who had LP attempted, with no CSF acquisition, were identified through a chart review of all patients in whom a serum polymerase chain reaction (PCR) was performed during the study period.

We are confident that this database allowed us to identify those patients who had a failed LP; as prior to undertaking a LP, the need to exclude sepsis is discussed with the parent. Having voiced concerns with regards to potential sepsis or meningitis, should procedure be unsuccessful, a serum PCR is obtained.

Soon after birth, some neonates have a partial sepsis work up performed, if they are experiencing symptoms of respiratory distress or if they are born to mothers who have prolonged rupture of their membranes, prior to commencing antibiotic therapy. In this sepsis work-up, a full blood count, C-reactive protein and blood cultures are routinely performed. However, LP is not done as part of the sepsis work up in our unit.

Data abstracted from each patient's chart included 1) the patient's age, 2) the primary indication for the LP, 3) the procedure outcome (classified as 'successful', 'traumatic' or 'failed'), 4) the number of LP attempts undertaken, 5) the outcome of the CSF analysis, 6) the grade of the doctor performing the procedure (Consultant, Registrar or Senior House Officer), and 7) the patient's final diagnosis.

LP was performed aseptically, in accordance with the standard health service guidelines. The following definitions were utilised A) 'Successful LP' was the procurement of a viable CSF sample for analysis B) 'Failed LP' was inadequate CSF acquisition for analysis, following needle insertion and C) 'Traumatic LP' was the finding of >400 RBC/mm^3 in the CSF sample[4].

Results

One hundred and four children, under the age of 15 years, underwent LP during the study period. Patients were aged as follows: 0-7 days, 21 (20.2%); 8-28 days, 8 (7.7%); 29 days to 1 year, 41(39.4%); >1 year-5 years, 18 (17.3%); >5 years, 16 (15.4%).

Indications for LP were the 1) presence of fever without focus beyond the neonatal period (n=33, 31.7%), 2) evaluation of a febrile neonate (n=16, 15.4%), 3) perception of 'septic appearing patient' (n=18, 17.3%), 4) evaluation of suspected meningitis (n=16, 15.4%), and 5) assessment of a non-specific febrile illness (n=21, 20.2%).

A viable CSF sample was obtained in 96 patients (92.4%). 71 (73.9%) of these were atraumatic and 25 (26.1%) were traumatic. 4 LPs (4.1%) were carried out by Consultants, 83 (86.5%) by Registrars and 9 (9.4%) by Senior House Officers (SHO). Documentation relating to the number of attempts made to secure the CSF sample could not be clarified in single operator procedures.

Eight (7.7%) patients had unsuccessful LP performance and these were classified as failed procedures. 3 (37.5%) underwent 1 attempt, 3 (37.5%) had 2 attempts and 2 (25%) had 3 attempts. The initial LP attempt was undertaken by an SHO in 3 patients, a Registrar in 2 patients and a Consultant in 3 patients. Following Consultant review, none were subjected to further LP attempts.

In those with a successful LP, 14 (14.6%) patients had a positive CSF PCR; however, 23 other patients had evidence of infection with 9 positive blood cultures, 11 positive urine cultures and 3 patients had a positive PCR test (see table 1).

Positive CSF Culture (n=14)	**Positive Blood Culture (n=9)**	**Positive Urine Culture (n=11)**	**Positive Serum PCR (n=3)**
Enterovirus (n=10)	Group B streptococcus (n=6)	Escherichia coli (n=10)	Meningococcus B (n=2)
Human Herpesvirus-6 (n=1)	Streptococcus pneumoniae (n=2)	Klebsiella (n=1)	Enterovirus (n=1)
Streptococcus pneumoniae (n=1)	Escherichia coli (n=1)		
Neisseria meningitidis (n=1)			
Human Parechovirus (n=1)			

Table 1: Positive Results in patients with Successful LP (n=37)

Of the 67 patients with a negative CSF PCR, negative blood cultures and negative urine cultures (including those 8 patients with a failed LP), the following were the final diagnoses: unspecified viral syndrome (n=39); gastroenteritis (n=17); bronchiolitis (n=5); laryngotracheobronchitis (n=2); myocarditis (n=1); argininosuccinic aciduria (n=1); Addison's disease (n=1); immune thrombocytopenic purpura (ITP) (n=1). For patients diagnosed with myocarditis, argininosuccinic aciduria, Addison's disease and ITP, it was their first presentation to the hospital.

Discussion

This study represents an evaluation of the use of LP in infants, children and adolescents, presenting with acute undifferentiated illnesses to a general paediatric unit. A viable CSF sample was obtained in 96 (92.4%) patients and 25 (24%) samples were traumatic, using our predefined definition[4]. Most successful LPs were performed by Registrars (n=83, 86.5%), the majority of whom had trained outside of Ireland and had achieved this competency in their native countries (India, Pakistan, Sudan and Romania). In a study by Nigrovic[5] of 1459 LPs, 952 (66%) were successful after the first attempt and 875 (60%) were atraumatic; however, a definition of 500 RBC/mm^3 was used. The higher success rate of 68.3% in obtaining atraumatic CSF samples, in this study, reflects the competency of the registrars who performed the procedures.

Traumatic lumbar puncture is associated with inappropriate antibiotic use, elevated treatment cost, and significant discomfort for patients.[6,7] Following a traumatic LP, the presence of red blood cells in the sample complicates the interpretation of CSF microscopy.[8] For this study, traumatic LP was defined as the presence of >400 RBC/mm^3 in the CSF sample.[4] Using the same definition, the Glatstein et al.[4] study of 127 LPs demonstrated that 24% of paediatric LPs were traumatic on the first attempt and this increased to 50% where more than one attempt was made. We found that 25 (26%) were traumatic on the first attempt and this increased to 60% where more than one attempt was made. This suggests that the addition of other factors, such as the presence of increasing patient distress, increases the risk of traumatic LP with further attempts.

Our data shows that a high proportion of infectious aetiologies account for the final diagnoses of the study cohort. 3 (2.8%) patients had a positive serum PCR, 9 (8.65%) had a positive blood culture and 11 (10.5%) had a positive urine culture. In those with successful LP, there were 14 (14.5%) patients with a positive CSF PCR. Therefore, LP remains an important test in the evaluation of the acutely unwell paediatric patient.

Current practice provides limited learning opportunities for SHOs in LP performance, with only 9 (8.65%) LPs undertaken by SHOs during the study period. As a competency-based curriculum is integrated into Basic Specialist Training in Paediatrics[3], an alternate paradigm needs to evolve in order to enhance skill acquisition in LP.

LP performance is improved by correct positioning, appropriate technique, ultrasound guidance LP (USGLP) and enhanced operator's skill.[9-11] To aid skill development, simulated deliberate practice and USGLP could be introduced. Point of care USGLP is a feasible adjunct to current practice, which would generate an ancillary skill set for NCHDs. Kim et al.[10] found that USGLP was associated with increased confidence amongst trainees in identifying an LP insertion site, as it allows the user to comfortably identify anatomical landmarks via static or dynamic imaging. If more than one attempt is made, US recognises the presence of a haematoma, thereby reducing the risk of traumatic LP.[10] A systematic review by Olowoyeye et al.[11] found that US reduced the risk failed LP, when compared with palpation method (risk ratio = 0.68 (95% CI 0.25 to 1.80; p=0.43, NNT 14.7)). Although this was not considered statistically significant, US significantly reduced the risk of a traumatic tap when compared to the traditional palpation method (RR=0.53, 95% CI 0.33 to 0.83, NNT= 8.3).[12] Simulated practice can also improve LP competency.[12,13] With iterative cycles of performance, the learner can try, fail and adapt technique in a safe setting. Kessler et al.[12] demonstrated that the number needed to teach is two. They also highlighted the 'low level of experience and skill' in LP amongst trainees.[12] This suggests that the traditional model of 'see one, do one, teach one' is inadequate and a move towards other teaching modalities, as outlined, is required.

Point-of-care ultrasound (POCUS) is becoming an essential skillset for paediatricians. Incorporation of POCUS in clinical care enhances the traditional practice model, whereby clinicians can make dynamic decisions within the immediate clinical setting. Its scope of practice has diagnostic, resuscitative and procedural applications e.g. focused cardiac, lung and renal assessment, LP guidance, incision and drainage.[13,14] In a 2018 survey, 85.4% of paediatric emergency training centres in the United States offered a dedicated training program for POCUS[15]. The American Academy of Pediatrics recommends a structured curriculum, which includes didactic training sessions, bedside and hands-on workshops, image evaluation and one-to-one feedback. This is to be followed by 'longitudinal experience' and competency assessment. Although the American College of Emergency Physicians[16] recommends a 4-8 hour training course for single or combination applications, with the successful completion of at least 25 procedures in each modality, there are limited publications on paediatric POCUS and it is not known what level of training is required to establish competency. Despite its widespread integration in many countries, on an ad hoc basis, a standardised educational programme has yet to be established in Ireland. The challenges facing the integration of this into basic specialist training includes lack of training for faculty, effective collaboration with imaging services, quality assurance and the co-ordination of dedicated training days[17,18]

The strength of this study was the retrospective approach, broad inclusion criteria and design that ensures all subjects who underwent LP were captured and correlated with the final diagnosis. For all patients, parents were counselled on the indication for LP and in the event of unsuccessful LP, alternative investigation strategies were utilised. Its limitations included the relatively small number of procedures per year, thus necessitating a three-year review and the unavailable documentation relating to the number of LP attempts made in single operator procedures.

LP plays an important role in the investigation of patients with acute undifferentiated illness in general paediatric units. The integration of ancillary tools such as USGLP and simulation into practice would enhance skill acquisition for junior trainees.

Declaration of Conflicts of Interest:
The authors declare that they have no conflict of interests in this article.

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