MAR Pediatrics (2025) 5:10

Research Article

Computed Tomography (CT) Scanning of the Head before Lumbar Puncture in Children with Suspected Meningitis: A Prospective Observational Study

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Received: 13 Jan 2025

Published: 01 Mar 2025

Abstract:

Background: *Cranial computed tomography (CT) scan is a commonly performed neuroimaging prior to lumbar puncture (LP) in children with suspected meningitis to rule out intracranial hypertension or space occupying lesions. The purpose of this study was to assess the accuracy of physicians' prediction of CT abnormal cerebral findings in pediatric meningitis.*

Subjects and methods: *A prospective observational study design was performed over a 12-month period. Eligible patients were admitted to the emergency department (ED) where two physicians filled a structured questionnaire independently before undergoing cranial CT scan and prior to LP.*

Results: *In this study, 72 patients met the inclusion criteria with a mean age of 7.04 ± 3.38 years. The mean physicians' prediction score of abnormal CT findings was 6.0 ± 3.0 vs.2.48 ± 2.01 of no abnormalities (difference 3.5 ± 1.0 (95% CI: 1.5, 5.5; p= 0.001). Relative risk of CT abnormalities associated with decreased level of consciousness was 7.33 (95% CI: 1.5, 33.67), Glasgow coma scale was 23.3 (95% CI: 7.7, 70.7), and abnormal posture was 8.9 (95% CI: 1.9, 41.7). Apart from mild headache (2.8%), vomiting (2.8%), dizziness (4.2%), no serious complications related to LP procedure have been reported.*

Conclusion: *Physician's clinical decision could predict absence of abnormal findings on cranial CT scan before LP in children with suspected meningitis. Our results suggest that LP could be performed with avoidance of CT scanning of the head in pediatric meningitis provided the presence of normal consciousness level, Glasgow coma scale ≥13 and normal neurologic examination.*

Keywords: *Meningitis; Computerized tomography; Lumbar puncture; Children.*

Abbreviations: *CT (Computerized tomography), LP (Lumbar puncture), ED (Emergency department).*

Introduction

Meningitis remains one of the most common life-threatening infections in the pediatric population. Early diagnosis and initiation of treatment can reduce morbidity and mortality due to meningitis (1). The rational for management of meningitis has generaly been including lumbar puncture to confirm the presence of the disease and helps to identify the cause of infection. One of the complication that's concerning physcian is brain

herniation, which can be sometimes fatal (2). The challenge usually faced by clinicians is how to identify patients who have signs of meningitis and at-risk of cerebral herniation following LP procedure. Therefore physcians order CT Scan brain prior LP procedure; though studies have shown that normal CT scan of the brain doesn't rule out raised intracranial pressure (2).

Although the association between lumbar puncture and cerebellar herniation is unproven, fatal brainstem herniation remains a recognized and feared complication of LP; thus justifying the concern underlying the procedure (1). Attempts to select and streamline the group of patients on the basis of clinical features for an initial cranial CT prior to subjecting them to LP are encouraging (3).

An absorbed dose of 2.4 millisievert could be resulted from natural back ground radiation to which the population is exposed annually(4). Diagnostic imaging is by far the main source of artificial radiation; nearly 50% from CT scanning. The cumulative radiation result from exposure to a single CT head scan is equivalent to 8 months' natural background radiation(4). There is limited data available regarding the role of radiation resulting from diagnostic imaging in the raised risk of malignancy. The carcinogenic effect of a single exposure to CT scan can persist for many years (5).

The justification for the use of cranial CT before LP in pediatric patients with meningitis is lacking (6). The primary objective of this study was to assess the physicians' prediction of CT abnormalities prior to LP in patients with suspected meningitis. The secondary objectives were to estimate the frequency of CT abnormalities in patients with suspected meningitis and the association between clinical findings and CT abnormalities.

Patients and Methods

A prospective observational study design was used. Approval to perform this study was obtained from the ethical and review board, Hamad Medical Corporation. Pediatric emergency center Al-Sadd at Hamad Medical Corporation is the main pediatric ED in the state of Qatar with approximately 300,000 visits annually. It has a total capacity of 64 observation beds providing most of the inpatient facilities. Patients usually get admitted to the ED's short stay infirmary unit if they require further observation and decision-making. All patients 2 to 14 years old presenting to our pediatric emergency center with suspected meningitis during the period from October 2013 to September 2014, were evaluated by two pediatric emergency physicians in the short stay unit. After obtaining an informed written consent from staff physicians, they were independently asked to complete a constructed questionnaire before sending the patient for CT scan. Doctors in the observation area completed the questionnaire survey regarding history, phyiscal exam, and predication of CT abnormality. Questionnaires then were collected prior to the CT scan and LP. Numerical rating scale for prediction of CT abnormal findings

was used and ranged from 0 to a maximal value of 10, a value of "0" for no abnormalities and a value of "10" for worst possible CT abnormalities.

All CT scans had been read by pediatric neuroradiologist; to verify abnormal findings and to determine presence of increased intracranial pressure. Safety concerns had been reported in every patient subjected to LP procedure.

Statistical Analysis

Categorical and continuous data values were expressed as frequency (percentage) and mean ± SD or median and range as appropriate. Descriptive statistics were used to summarize demographic, laboratory, radiological and other clinical characteristics of the patients. The Kolmogorov-Smirnov (K-S) test or Q-Q Plot as appropriate was used to test for normality of the data. Quantitative data were analyzed and compared using unpaired t test or Mann Whitney U test as appropriate depending on the results of the normality test. Associations between two or more qualitative or categorical variables were examined and assessed using the Chi-square ($\chi 2$) test or Fisher exact test as appropriate. Risk ratio (RR) along with 95% CI was computed to determine an association between the various clinical findings and CT scan abnormalities in children presented with suspected meningitis. Intra-class correlation coefficient (ICC) and Bland-Altman plot were computed and constructed to assess the inter-observer variability between two physicians measuring prediction score (to determine of CT abnormalities) used for clinical purposes. All P values presented were two-tailed, and P values <0.05 was considered as statistically significant. All Statistical analyses were done using statistical packages SPSS 22.0 (SPSS Inc. Chicago, IL).

Results

A cohort of 72 (47 males) children was presented to our pediatric emergency center with signs and symptoms of meningitis and was admitted to the short stay infirmary unit. Their mean age was 7.04 ± 3.38 years, which ranged from 2.0 to 13.9 years. The frequency and percentage of findings from history, physical examination, and neurologic assessment were presented in Table 1. Three patients were known to have nephrotic syndrome (2 receiving mycophenolate in addition to prednisolone, and one child receiving no medication) and one child with macrocephaly. Abnormal CT findings were found in 5 patients out of 72 (6.9%) presented with suspected meningitis and in whom LP was not performed. Associations were found between cranial CT scan abnormal findings and decreased level of consciousness with relative risk 7.33 (95% CI: 1.5, 33.67; P< 0.001), Glasgow coma scale <13 with a relative risk 23.3 (95% CI: 7.7, 70.7; p< 0.0001), and abnormal posture with relative

risk 8.9 (95% CI: 1.9, 41.7; p= 0.003) (Table 3). No associations were found between CT abnormalities and other clinical findings. The mean physicians' prediction of CT head abnormalities was higher in children in whom abnormal findings were found in CT scan 6.0 ± 3.0 vs. 2.48 ± 2.01in whom no abnormal findings found in CT scan (difference 3.5 ± 1.0 (95% CI: 1.5, 5.5; p=0.001) (Table 3). The interrater agreement of prediction score measured by physician 1 and physician 2 was confirmed using Bland Altman Plot which indicating a very strong agreement (Figure 1). The final diagnosis of meningitis was found in 46 (63.9%) patients (Table 4). Post-LP complications reported were fewer and mild in the form of headache (2.8%), vomiting (2.8%) and dizziness (4.2%). No herniation or serious complications had been reported in any child subjected to LP procedure. During the study period, 18 children presented to our pediatric emergency center with suspected meningitis for which LPs were performed without prior CT scanning of the head. Physical and neurologic examinations were normal and no complications had been reported in these children.

Table 1: Clinical characteristics of children presented with suspected meningitis (N = 72).

History of coexisting conditions:	**n (%)**	**Neurologic findings:**	**n (%)**
Underlying illnesses	1 (1.4)	Alert	66 (91.7)
CNS disease	1 (1.4)	Abnormalities in posture	5 (6.9)
Immuno-compromised state	2 (2.8)	Abnormalities in respiratory pattern	1 (1.4)
Presenting symptoms:		Pupillary changes	2 (2.8)
Headache	63 (87.5)	Papilledema	1 (1.4)
Fever	67 (93.1)	Absent oculocephalic reflex	0 (0)
Vomiting and nausea	59 (81.9)	Answers 2 consecutive questions correctly	65 (90.3)
Skin rash	3 (4.2)	Follows 2 consecutive commands correctly	65 (90.3)
Photophobia	28 (38.9)	Abnormal language	3 (4.2)
Diplopia	2 (2.8)	Gaze palsy	1 (1.4)
Neck pain or stiffness	35 (48.6)	Abnormal visual field	1 (1.4)
New onset seizure (within 1 week)	8 (11.1)	Cranial nerve palsy	0 (0)
Focal motor symptoms	4 (5.6)	Motor paralysis	0 (0)
Focal sensory symptoms	1 (1.4)	**Investigation findings:**	
Signs at presentation:		>5 White cells/ml of CSF	46 (63.9)
Glasgow Coma Scale ≥13	70 (97.2)	Pathogens identified in CSF	5 (6.9)
Temperature ≥38ºC	54 (75.0)	Pathogens identified in blood	3 (4.2)
Hypotension	1 (1.4)	Abnormal CT findings	5 (6.9)

Table 2: Associations between the clinical findings and CT scan abnormalities in children presented with suspected meningitis (N = 72).

Characteristics	**Risk ratio (95% CI)**	**P value**
Decreased level of consciousness	7.33 (1.5, 33.67)	< 0.001
Glasgow coma scale <13	23.3 (7.7, 70.7)	< 0.0001
Abnormal posture	8.9 (1.9, 41.7)	0.003
Photophobia	1.05 (0.19, 5.9)	0.958
New onset seizure	2.0 (0.26, 15.76)	0.512

Table 3: Physicians' prediction scores of CT abnormalities in children with suspected meningitis using numeric a numeric ranking scale from "0" to "10".

Characteristics	**Predicted scores, mean ± SD**	**Difference (95% CI)**	**P value**
CT scan with normal findings	2.48 ± 2.01	3.5 ± 1.0 (1.5, 5.5)	0.001
CT scan with abnormal findings	6.0 ± 3.0		

Table 4: Final diagnosis of children presented to ED with suspected meningitis (N = 72).

Diagnosis	**n (%)**
Meningitis	56 (77.7)
Viral meningitis	3 (4.2)
Tuberculosis meningitis	1 (1.4)
Encephalitis	1 (1.4)
Viral syndrome	4 (5.6)
Pharyngitis	2 (2.8)
Brain mass	1 (1.4)
Bilateral choroid plexus cyst	1 (1.4)
Sinusitis	3 (4.2)

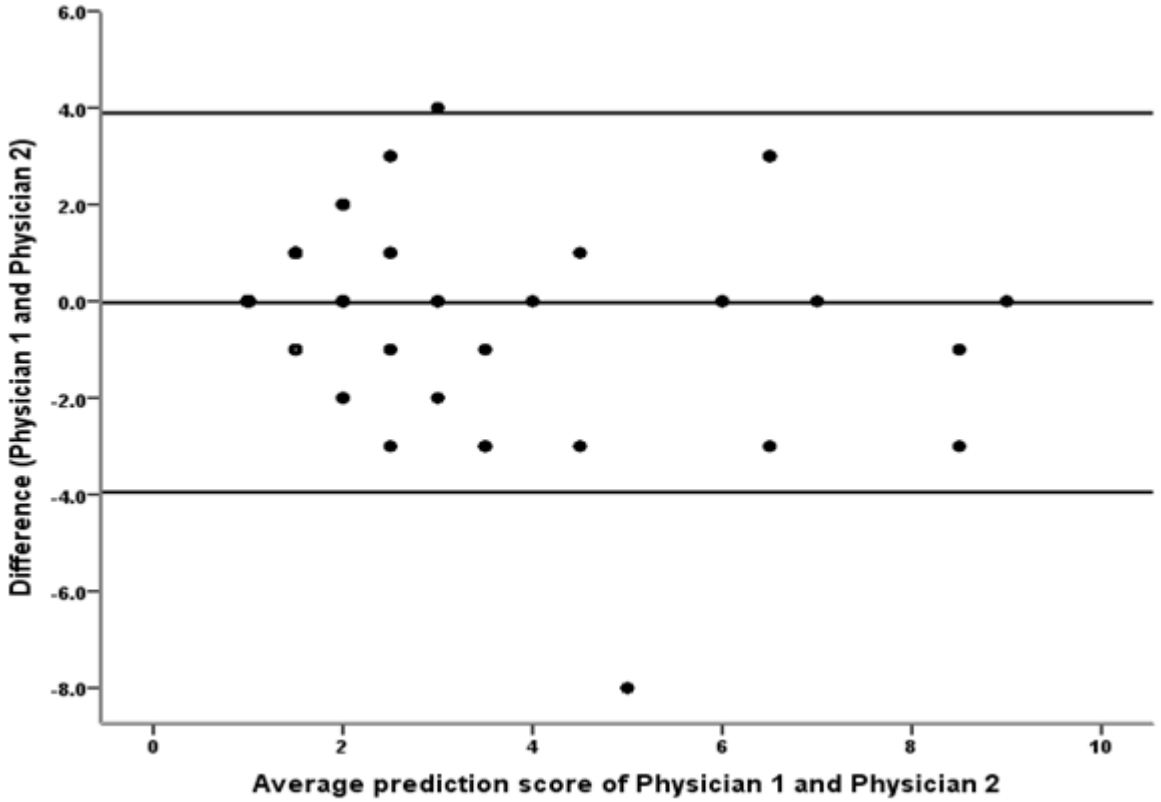

Figure 1: Bland Altman Plot: Prediction score measured by Physician 1 and Physician 2.

Interpretation of Figure 1: The limits of Figure 1 show a comparison of prediction score measured by physician 1 and physician 2. Here the mean difference was −0.029 with 95% CI −3.54 to 3.49. Thus physician 1 tends to give a lower reading, ranging from −3.54 to 3.49. Despite this, the limits of disagreement are considerably low (high agreement) and hence both physicians provide similar values measuring prediction score used for clinical purposes. We also compared the results of measurements by two physicians (raters) by conducting an interrater accuracy test. The intraclass correlation coefficient for these 2 physicians was 0.82 (95% CI: 0.71 to 0.89), indicating a very strong agreement.

(1-3, 5-14)

Discussion

Emergency physicians are still not comfortable to perform LP study without CT scan in children with suspected meningitis, especially those who have closed anterior fontanel. The results of our study revealed increased risk of CT abnormal findings in the presence of abnormal neurologic findings. Also, physicians' decision can predict abnormal CT findings in CT head scan before LP.

The study suggested that CT scan of the head is recommended before LP when there are signs and symptoms of increased intracranial pressure. Husban et al. prospectively reported a cohort of adult patients with suspected meningitis in whom abnormal neurologic findings were associated with increased likelihood of having cranial CT abnormal findings (1).The study by Greig et al. (5) found that clinical assessment can be reliably predict those children having normal findings on CT scan of the head before LP. Normal neurologic and funduscopic examination has a high sensitivity and negative predictive values as accurate predictors of normal CT findings in adults with suspected subarachnoid hemorrhage (5). A normal CT does not rule out the risk of herniation and that herniation may occur in meningitis even when a lumbar puncture is deferred (7, 8)Although lumbar punctures have been safely performed in patients with mass effect, current opinions nevertheless agree that findings of mass effect or impending herniation on a CT constitute clear contraindications to LP (7).

Conclusions

The findings of our study reassuring that physicians' clinical assessment can be reliable to predict those patients who have a decreased likelihood of having abnormal findings on CT, and thus at low risk of herniation following LP. In children with suspected meningitis, CT scan could be avoided, provided that there is no change in patient's consciousness level and having normal neurologic examination.

Funding: No funding was received for this study.

Financial Disclosure: The authors have no financial relationships relevant to this article to disclose.

Conflict of Interest: The authors have no conflicts of interest relevant to this article to declare.

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