Acta Paediatrica

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BRIEF REPORT OPEN ACCESS

Risk Factors for Traumatic Lumbar Puncture in Children With ALL

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Received: 7 April 2025 | **Revised:** 11 June 2025 | **Accepted:** 13 June 2025

Funding: This work was supported by the Foundation of Pediatric Research, Finland (Grant number 200204), the State Research Funding, Finland (11028), Hedström's and Ländell's Foundation, Sweden, and Finnish Cultural Foundation (00231066).

Keywords: acute lymphoblastic leukaemia | medical education | TLP

Lumbar puncture (LP) is needed for diagnosis and treatment in children with acute lymphoblastic leukaemia (ALL), the most frequent paediatric cancer [1]. Traumatic LP (TLP) in the first diagnostic puncture may worsen the prognosis [2]. Risk factors for TLP in children with ALL include previous TLP, age ≤1 year, thrombocytes < 50–100/μL, fewer days since the previous LP, elevated body mass index (BMI) and inexperience [2, 3]. Simulation training of LPs may enhance the learning experience of medical students [4]. It is not known whether medical students perform more TLPs compared to physicians. At Uppsala University Children's Hospital, students perform non-diagnostic LPs always when present during their clinical practice at paediatric oncology ward on 8th semester of medical education. These LPs are performed under propofol sedation in operation theatre providing optimal circumstances for learning this important clinical procedure. We studied risk factors for TLP in the first diagnostic punctures and whether LPs performed when medical students are present increase the incidence of TLP in non-diagnostic punctures in children with ALL.

Children ($n = 135$) with ALL diagnosed during 2008–2019 were identified in the Swedish Childhood Cancer Register (NOPHO-ALL2008 database) [5]. Three children were excluded due to missing data. TLP was defined as ≥10 erythrocytes/μL cerebrospinal fluid (CSF). Diagnosis date, age, sex, length and weight were retrieved from medical records. BMI was calculated using age-appropriate standards. Central nervous system (CNS) status was defined based on white blood cell count and blasts in CSF. Coagulation values APTT (> 42 s = abnormal) and PT INR (> 1.2 = abnormal) were tested on a clinical basis. The first diagnostic LPs were only performed by physicians with varying procedural experience from residents to specialists. Students were expected to be present and primary LP performers under physicians' supervision every weekday except summer and winter holidays (1 June–31 August and 22 December–7 January), Labour Day (1 May), the first week of each paediatric course (lecture week) and Fridays (lecture days). The curriculum dates did not change during the study period.

Descriptive values were described in numbers (n), percentages (%), mean (standard deviation, SD) and median (interquartile range, IQR). Independent samples t-test, Mann–Whitney U-test and cross-tabulation were used for comparative analyses. The incidence of traumatic non-diagnostic LPs for both time periods (medical students present or not) was calculated and compared. The analyses were performed using SPSS 28.0. $p < 0.05$ was considered statistically significant.

132 children (boys $n = 76$, 57.6%) were included. The median age at diagnosis was 4 years (IQR 7) with a median BMI of 16.6 (IQR 2.5, data missing for one child). Totally, 1413 LPs were performed with a mean 10.7 (SD 5.9) LPs/child. The incidence of TLPs in

Abbreviations: ALL, acute lymphobastic leukaemia; APTT, activated partial thromboplastin time; BMI, body mass index; CNS, central nervous system; CSF, cerebrospinal fluid; IQR, interquartile range; LP, lumbar puncture; PT INR, prothrombin time test, international normalised ratio; SD, standard deviation; TLP, traumatic lumbar puncture.

first diagnostic LPs was 13.1%, while the overall incidence was 18.4%. In first diagnostic LPs ($n = 130$), the evaluated risk factors did not affect the incidence of TLPs (Table 1). In non-diagnostic LPs ($n = 1283$), there was no difference in the incidence of TLPs when medical students were present or not (19.1% vs. 18.7%).

The incidence of non-diagnostic TLPs corresponded to the previously reported incidence of 17.9% in children with ALL [2]. The incidence was lower in first diagnostic LPs, which were performed with special awareness of the potential negative effect of TLPs on prognosis, than in subsequent procedures. This finding is consistent with a recent report with somewhat higher rates of TLPs than in our study [3]. Age, BMI, coagulation values or CNS status did not affect the incidence of TLPs in first diagnostic LPs, in contrast to earlier literature [2]. We found no difference in the incidence of TLPs between time periods when medical students were present or not.

A major strength of this study was the long data collection time. A clear limitation was that we lacked access to operating room documentations. Thus, we could not confirm that all LPs were performed by medical students, nor did we have information about failed LP attempts by them. In such cases, the procedure would have been performed by the supervising physician after the first attempt. Nonetheless, the incidence of TLPs did not increase when medical students were present. This observation seems to support supervised non-diagnostic LPs in children with ALL in medical education. However, prospective follow-up studies, with detailed procedure information including the number of punctures performed by students, are needed to confirm this assumption.

TABLE 1 | Risk factors for traumatic lumbar puncture (TLP) in first diagnostic lumbar punctures (LPs) in 130 children with acute lymphoblastic leukaemia.

Evaluated risk factors for TLP	Non-traumatic LPs, % (*n*)	Traumatic LPs, % (*n*)	*p*
First diagnostic LPs performed by physicians	86.9 (113)	13.1 (17)	
Age			0.3
< 1 year	5.3 (6)	11.8 (2)	
≥ 1 year	94.7 (107)	88.2 (15)	
Body mass index			0.4
Underweight (< 5th percentiles)	5.4 (6)[a]	11.8 (2)	
Healthy (5–85th percentiles)	73.2 (82)[a]	76.5 (13)	
Overweight (85–95th percentiles)	11.6 (13)[a]	0.0 (0)	
Obese (> 95th percentiles)	9.8 (11)[a]	11.8 (2)	
Coagulation values			1.0
Normal APTT and normal PT INR	72.3 (73)[b]	68.8 (11)[a]	
Abnormal APTT and normal PT INR	10.9 (11)[b]	12.5 (2)[a]	
Normal APTT and abnormal PT INR	12.9 (13)[b]	12.5 (2)[a]	
Abnormal APTT and abnormal PT INR	4.0 (4)[b]	6.3 (1)[a]	
Central nervous system status			0.3
CNS1, < 5 white blood cells without blasts	93.8 (105)[a]	82.4 (14)	
CNS2, < 5 white blood cells with blasts	3.6 (4)[a]	5.9 (1)	
CNS3, ≥ 5 white blood cells with blasts	2.7 (3)[a]	11.8 (2)	

Abbreviations: APTT, activated partial thromboplastin time; PT INR, prothrombin time test, international normalised ratio.
[a]Data missing for 1 child.
[b]Data missing for 12 children.

Author Contributions

S.S.: drafted the initial manuscript, carried out the final analyses, and critically reviewed and revised the manuscript for its intellectual content. **A.H.:** conceptualized and designed the study, coordinated and supervised data collection, and critically reviewed and revised the manuscript. **V.M.:** carried out the initial analyses and critically reviewed and revised the manuscript. **C.E.:** conceptualized and designed the study, coordinated and supervised data collection, and critically reviewed and revised the manuscript.

Acknowledgements

We would like to thank Jenna Anderson for valuable comments and language editing.

Ethics Statement

This study has ethical approval from the Swedish Ethical Review Authority (decision number 2022-04230-01).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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