



Review Article

Point-of-Care Ultrasound Could Streamline Workflow of Limping Children Presenting to the Pediatric Emergency Department

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Abstract

Objective: This study assessed whether the use of hip Point of Care Ultrasound (POCUS), enabling bedside evaluation of hip effusion, among limping children presenting to the Pediatric Emergency Department (PED) contributed to shortening the length of stay and reduced the use of auxiliary tests. **Methods:** This retrospective study included children ages 1-18 years who presented to the PED in a single medical center between 2015-2019, with a chief complaint of limping and who underwent hip POCUS. The control group included children who underwent evaluation without the use of hip POCUS. The primary measurement was total length of stay in the PED and the use of imaging and blood work. **Results:** A total of 220 patients were included in the study group and 191 in the control group. The groups were similar in epidemiologic characteristics and clinical presentation. The ED Length of Stay in the POCUS group was significantly shorter than the control group ($p < 0.0001$), especially among children with a diagnosis of transient synovitis. Use of auxiliary tests was also significantly reduced in the POCUS group. **Conclusions:** Using hip POCUS when evaluating patients presenting to the PED with a complaint of limping or limb pain reduced the length of stay and decreased the use of auxiliary tests, especially among children with a diagnosis of transient synovitis.

Keywords: POCUS; Ultrasound; Pediatric; Limping; Emergency department

Abbreviations: EDLOS: Emergency Department length of stay; PED: Pediatric Emergency Department; POCUS: Point of Care Ultrasound; TS: Toxic synovitis; US: Ultrasound

Introduction

Background: Limp, leg pain, and the inability to bear weight are common complaints encountered in the Pediatric Emergency Department (PED). Many of these patients are found to have pain localized in the hip. The differential diagnosis can range from self-limited conditions, such as transient synovitis to medical emergencies: bacterial infections (septic hip) and

malignancies; Toxic Synovitis (TS) or transient synovitis is one of the common causes accounting for about 0.4% to 0.9% of pediatric emergency department visits. It is a benign, self-limited condition [1]. Assessing limping among children and toddlers may be challenging, due to the limited history and the difficulty in locating pain on physical examination. Hence, auxiliary tests such as X-ray, blood work and ultrasound (US) are often used even in children whose final diagnosis is benign [2]. The use of Point of Care Ultrasound (POCUS) has increased in recent years and has become an important clinical tool for assessing a variety of medical conditions [3-5]. The use of hip POCUS in the PED allows emergency physicians to identify hip effusions, focusing an otherwise broad differential diagnosis, directing further management, and decreasing the time to definitive diagnosis and

treatment [6-8]. There is little information on the use of hip POCUS in the PED, as well as on its effect on Emergency Department length of stay (EDLOS) and the effect on the use of auxiliary exams. This application could allow emergency physicians to identify hip effusions among children with hip pain more quickly, narrowing an otherwise broad differential diagnosis, directing further management, and decreasing time to definitive diagnosis and treatment. In the current study, we sought to evaluate the effect of hip POCUS on the management of children admitted to the PED due to limping or lower limb pain in terms of EDLS and the reduction of auxiliary test usage. We were most interested in the effect on the group of children with the diagnosis of Transient Synovitis, because the reduction of auxiliary tests usage and decreasing the EDLOS could improve the quality of care among patients with a common and self-limited condition.

Materials and Methods

Study design and setting

This retrospective cohort study was conducted in a secondary-care, university-affiliated hospital PED in <blinded>, providing care for approximately 33,000 children annually. Hip POCUS is routinely performed at our PED since January 2017, as part of a patient's clinical evaluation, by trained pediatric emergency physicians, certified to perform the exam. POCUS examinations were performed using Zonare One Pro (Mindray, Shenzhen China) with the patient lying supine, the hip in a neutral position and the linear probe positioned in an oblique sagittal plane, parallel to the femoral neck.

Selection of Participants

Children presenting to the PED, ages 1-18 years, from 2015 through 2016 due to limping or limb pain were defined as the PRE group and those presenting from 2017 through 2019 who underwent hip POCUS were defined as the POST group. In the "POST" group, the primary ED physician performed the POCUS examination. Using standard technique with the patient lying supine and the linear probe positioned parallel to the femoral neck in the sagittal plane. The presence or absence of hip effusion was determined by identifying the synovial space and measuring the distance between the anterior surface of the femoral neck and the posterior surface of the iliopsoas muscle for both legs. A measurement greater than 5 mm or greater than 2 mm difference from the contralateral hip was considered positive for hip effusion; in agreement with standard radiology texts.

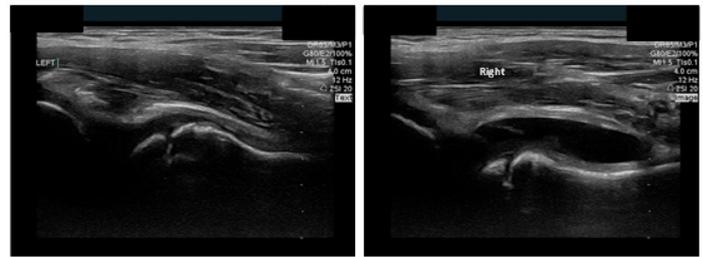


Figure 1: A. Normal hip POCUS showing the synovial space, bony architecture and muscle bodies. B- Hip POCUS demonstrating joint effusion. There is an anechoic fluid collection between the anterior surface of the femoral neck and the posterior surface of the iliopsoas muscle (white arrow).

Data Collection

We reviewed the electronic medical records of all children, ages 1-18 years, who presented to the PED due to a chief complaint of limping or lower limb pain from January 2015 through December 2019. We excluded children with: Diagnoses involving another joint (ankle or knee); trauma cases that caused limping such as bone fracture, foreign body, lacerations of the lower limb; or children with a known rheumatologic diagnosis that caused joint inflammation. The following data were obtained from the electronic medical records: age (months), gender, ethnicity, clinical data- (fever, duration of symptoms, history of recent trauma, recent febrile illness, hip joint tenderness in physical examination, results of laboratory tests, imaging, and orthopedic counseling), and final diagnosis. EDLOS was defined as the time from the opening of the administrative file to discharging home or admitting the patient to the inpatient department.

Outcomes

Primary outcome: EDLOS of children presenting to the PED with the main complaint of limping or limb pain in both the "PRE" group and the "POST" group.

Secondary outcome: Use of x-rays, laboratory tests, formal US and orthopedist consultation among children presenting to the PED with a limp or a limb pain in the "PRE" group, and in the "POST" group.

Statistical analysis

Data were analyzed using SPSS statistics, version 25. Descriptive statistics were presented as mean and standard deviation for numeric variables and as prevalence and percentage

for categorical variables. The chi-squared test was used to compare categorical variables. Metric variables were checked for normal distribution (Shapiro-Wilk test) and analyzed with t test for normally distributed data and with Mann-Whitney test for non-normal distributions. Two-way ANOVA was used to analyze how the interactions between groups (PRE/POST) and the diagnosis of transient synovitis (TS/other) contributed to the variance of EDLOS. The Bonferroni adjustment was used in post hoc analysis of simple effects. Multiple regression analysis was used to evaluate the contribution of each auxiliary test to the variance of EDLOS.

Results

Characteristic of Study population

According to the medical records from 2015 through 2019, a total of 152,505 children were admitted to the PED at <blinded>, of whom 2,236 complained of limping or limb pain. Among them, 1675 were excluded from the study because their diagnosis did not match the medical records, they had other clear diagnoses involving the lower limbs, a history of trauma or a known rheumatologic disease. There were 191 patients in the PRE group (children who did not undergo hip POCUS) of whom 134 were diagnosed with transient synovitis (TS). An additional 220 children underwent hip POCUS as part of their clinical evaluation and comprised the POST group. Among them, 174 were diagnosed with TS (Figure 2).

The patient's epidemiologic and clinical characteristics are outlined in Table 1. There were no significant differences between the two study groups with respect to age, gender, ethnic origin (Jewish, arab), or history of recent illness (e.g., cough, runny nose, diarrhoea, or fever). The most common diagnosis in both groups (PRE and POST) was TS, slightly more common among the POST group (78%) as compared to 70% in the PRE group (p = 0.049). The prevalence of septic hip was similar in both groups (7.9% vs. 9.5%, respectively; p = 0.54; (Table 2).

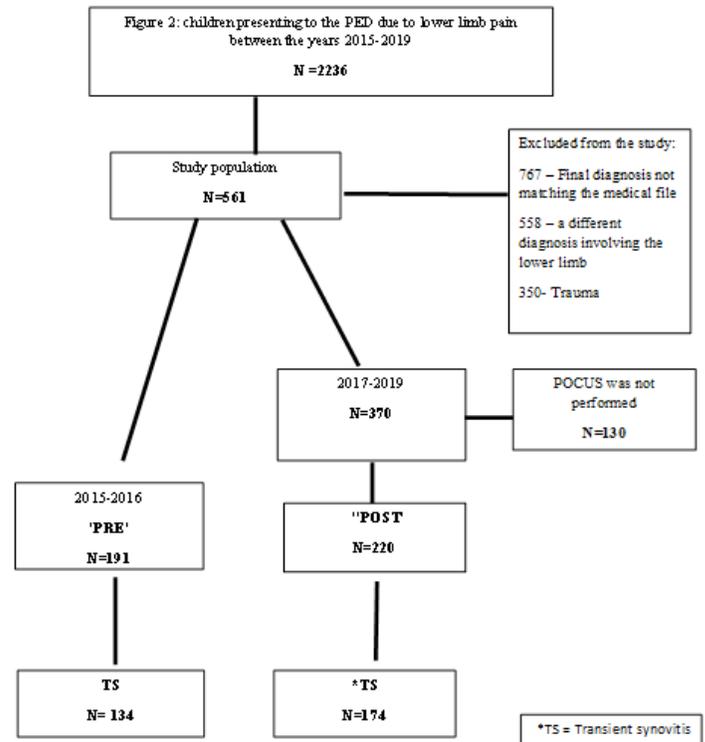


Figure 2: Children presenting to the PED due to lower limb pain between the years 2015-2019.

Characteristic	p-value	POST N=220 (%)	PRE N=191 (%)
Age (range, years)	6.9±3.1	6.3±2.9	0.067
Gender – male	142 (74.3%)	159 (72%)	0.636
Jewish	161 (84.3%)	180 (81.8%)	0.561
Duration of symptoms (days)	3.4±13.4	2.6±3.6	0.47
Fever	18 (9.4%)	23 (10.5%)	0.728
Hospitalization	24 (12.6%)	23 (10.5%)	0.614

Table 1: Comparison of the demographic and clinical characteristics of the 2 groups.

Diagnosis	PRE N=191 (%)	POST N=220 (%)	P-value
Transient synovitis	(70.2) 134	(78) 173	0.049
Septic hip	(7.9) 15	(9.5) 21	0.545
*SCFE	0	(2.2) 5	0.187
Other	(22) 42	(24) 10.9	0.002

*SCFE: Slipped capital femoral epiphysis

Table 2: Diagnoses of children admitted to the PED due to limping between the years 2015-2019.

Main results

Emergency department length of stay (EDLOS)

EDLOS was significantly shorter among the POST group than in the PRE group (158 minutes vs. 213 minutes respectively, $p < .001$) (Table 3). Multivariate analysis revealed a significant connection between the diagnosis of TS and the study group (“PRE” or “POST”) ($p < .001$): children with TS in the POST group had significantly shorter EDLOS as compared to the PRE group (138 minutes vs. 206 minutes, respectively; $p < .001$), while children with other diagnoses had similar EDLOS in the POST and PRE groups (228 minutes vs. 227 minutes, respectively; $p = .934$; Table 3 and Figure 3).

Diagnosis	PRE	POST	P-value
Transient Synovitis	206 min	138 min	$< .001$
Other diagnosis	227 min	228 min	.934
Total	213 min	158 min	$< .001$

Table 3: Length of stay in both study groups by diagnosis.

Use of auxiliary tests

Significantly fewer of the POST group children had X-ray exams compared with the PRE group (45% vs. 30%, respectively; $p < .01$). While the results were similar among children with TS (27% vs. 43% respectively, $p < .01$), there was no significant difference in performing x-ray exams among children with diagnoses other than TS (43% vs. 49%, respectively, $p = 0.504$). Similar results were demonstrated in performing blood tests, which were significantly less frequent in the POST group than the in the PRE (34% vs. 60%, respectively; $p < .001$). While these results were similar among children with TS (24% vs 54%, respectively; $p < .001$), there was no significant effect among children with diagnoses other than TS (70% vs. 75%, respectively; $p = .550$). Formal hip ultrasound (performed by a radiologist) was performed significantly less often in the POST group than in the PRE group (5% vs. 22%, respectively, $p < .001$). This difference was apparent in children with TS, as well as in children with other diagnoses. Orthopedic surgeons were consulted significantly less frequently in the POST group than in the PRE group (6% vs. 30%, respectively; $p < .001$). This difference was similar among children with TS, was well among children with other diagnoses (Table 4).

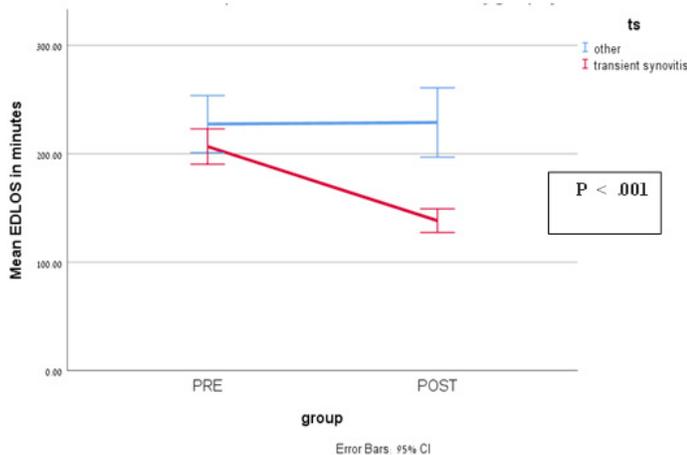


Figure 3: Significant interaction between the diagnosis of TS and both study groups regarding EDLOS.

Test	Variable	PRE n=191 (%)	POST n=220 (%)	p-value
X-ray	Transient Synovitis	58 (43%)	46 (27%)	<.001
	Other diagnosis	28 (49%)	20 (43%)	0.504
	Total sample	86 (45%)	66 (30%)	<.001
Laboratory tests	Transient Synovitis	72 (54%)	41 (24%)	<.001
	Other diagnosis	43 (75%)	33 (70%)	0.55
	Total sample	115 (60%)	74 (33%)	<.001
Formal US	Transient synovitis	20 (15%)	3 (1.7%)	<.001
	Other diagnosis	21 (37%)	7 (15%)	<.05
	Total sample	51 (21.5%)	10 (4.5%)	<.001
Orthopedic consultation	Transient Synovitis	33 (25%)	5 (2.9%)	<.001
	Other diagnosis	24 (42%)	8 (17%)	<.05
	Total sample	134 (70%)	13 (5.9%)	<.0001

Table 4: Rate of use of auxiliary tests in both study groups by diagnosis.

To evaluate the relative contribution of each factor in predicting EDLOS, a linear regression analysis was performed, with laboratory tests, formal US, orthopaedic consultation, X-ray and study groups as predictor variables and EDLOS as the predicted variable. The results indicated that laboratory tests explained 30.1% of the variance in EDLOS ($\beta=.507$, $p<.000$), formal US explained 7.3% of the variance ($\beta=.212$, $p<.000$), orthopedic consultation explained 4.5% of the variance ($\beta=.171$, $p<.000$), and X-ray explained 0.1% of the variance ($\beta=.079$, $p<.05$). The study group (PRE and POST) did not have a relative contribution to the EDLOS after controlling for all other factors ($\beta=.030$, $p=.411$), suggesting that the effect of POCUS on EDLOS is mediated by the rate of use of auxiliary tests (Table 5).

Variable	Beta	Partial η^2	p-value
Laboratory tests	0.507	0.301	0
Formal US	0.212	0.073	0
Orthopedic consult	0.171	0.045	0
X-ray	0.079	0.001	0.035
Group	0.03	0.001	0.411

Table 5: Multiple linear regression analysis of auxiliary tests and group (PRE vs. POST) predicting EDLOS. Beta represents the relative contribution of each factor, and partial η^2 represents the percent of variance explained by each factor.

Discussion

The results of this study show a significantly shorter length of stay in the PED among limping children who underwent hip POCUS as part of their evaluation in the ED. This is probably

due to reduced use of auxiliary tests and consultations, especially among children with the diagnosis of TS. In the current study, EDLOS was almost an hour shorter among patients who underwent hip POCUS in comparison to children who presented with the same complaint who did not undergo hip POCUS as part of the PED evaluation. Decreased EDLOS is crucial for reducing ED crowding and may result in improved quality of care and a decrease in overall health care costs [9,10]. Several studies have shown a positive effect on EDLOS and improved workflow and use of resources in the PED as a result of the use of POCUS. Kim et al. examined children who underwent an evaluation for intussusception in the PED. Their study showed that the use of POCUS contributed to shortening the time for diagnosis and treatment. Similarly, Lin et al. demonstrated that using POCUS to evaluate children who presented to the PED due to skin and soft tissue infections significantly reduced the EDLOS [11,12]. As far as we know, there is little data on the effect of using hip POCUS on the length of stay among children admitted to the PED, mostly case reports and small case series [13,14]. Shavit et al. published a series of 5 cases in which hip POCUS was used by PED staff as part of an evaluation of children with a limp. They reported that in most cases it contributed to shortening the stay in PED, as well as to fewer blood tests [15]. A study by Tsung et al. that included several cases where children underwent hip POCUS in the PED found that the exam contributed to the discharge of at least one of the children with the diagnosis of TS from the PED [16]. A study by Viera et al demonstrated that pediatric emergency physicians were able to identify hip effusion among pediatric patients with good sensitivity (80%) and specificity (98%). Although their findings suggested that PED physicians were able to accurately identify hip

effusion using hip POCUS, they did not examine the effect of its use on the overall evaluation of their patients in the ED [7].

A review article by Takundwa et al discussed the evaluation of Hip Pain and Management of Toxic Synovitis, With the increased availability of POCUS and suggests that it can be used as an adjunct in the workup [8]. To our knowledge, this is the first study to evaluate the effects of hip POCUS on a large group of children presenting to the PED due to limping or pain in the lower limb. We found that the mean EDLOS among children undergoing hip POCUS was 157 minutes, compared with 212 minutes in children who did not. This resulted in almost an hour shorter average hospital stay ($p < 0.0001$). The most common diagnosis among children in the current study was TS, as reported in previous studies [17]. TS is a clinically based diagnosis of a self-limiting disease. However, considering the difficulty in locating the pain and obtaining a medical history from nonverbal children and in view of the likely differential diagnoses (hip infection, fracture), the attending physician will sometimes choose to perform additional auxiliary tests to establish a diagnosis. These tests involve pain, radiation, and prolong the patient's hospital stay. In the current study, we found that the effect of using hip POCUS was most significant in shortening EDLOS among children with TS, most likely due to the use of fewer auxiliary tests, such as blood tests. Hip POCUS is a fast, non-painful examination that can augment the treating physician's ability to clinically evaluate the patient and make a prompt diagnosis, especially among children with a benign diagnosis, such as TS; alleviating the need to perform additional diagnostic procedures such as blood tests and X-rays. Reducing the use of painful, anxiety provoking laboratory tests, and X-rays involving radiation exposure, especially among the pediatric population, is considered standard of care. In addition to improving children's quality of care, Hip POCUS decreases hospital LOS and by that may additionally contribute to saving ED resources. The current study was limited by its retrospective nature and the comparison of two groups of patients in two different time periods. Although there was no difference between the groups in terms of epidemiological and disease characteristics, a randomized prospective study would allow comparisons and more reliable results. All the POCUS examinations performed were reviewed by a lead ED POCUS physician. However, they were not compared to an ultrasound examination performed by a radiologist. The study was conducted in a PED, where the entire medical staff and fellows are qualified to perform POCUS tests in various applications and use the test frequently. The use of POCUS in other institutions may be more limited and make it difficult to implement the results of the current study.

In conclusion, we found that the use of hip POCUS as part of the initial evaluation of children who present to the PED due to limping or lower limb pain contributed to shortening the EDLOS

by reducing the use of auxiliary tests, especially among children diagnosed with transient synovitis.

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