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ORIGINAL ARTICLE

Clinical and Radiological Differentiation of Septic Arthritis and Transient Synovitis of the Hip

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ABSTRACT

Objective: *To distinguish septic arthritis (SA) and transient synovitis (TS) of the hip based on clinical, laboratory, and imaging parameters.*

Methods: *Hospital records of all paediatric patients with painful hip effusion referred for ultrasound-guided joint aspiration between January 2008 and February 2016 in a regional hospital in Hong Kong were retrospectively reviewed. Confirmed SA was defined as positive Gram's stain or joint-aspirate culture, and presumed SA was defined as positive blood culture and a high joint-aspirate white cell count (>50,000 /mm^3). TS was defined as negative joint-aspirate analysis. Multivariate analysis of the clinical, laboratory, and imaging parameters of the SA and TS groups was performed using logistic regression.*

Results: *Of 32 patients included, seven and 25 were confirmed or presumed to have SA and TS, respectively. Predictors for SA were body temperature of ≥38.5ºC (odds ratio [OR] = 18, p = 0.02), serum C-reactive protein (CRP) level of ≥10 mg/l (OR = 7.9, p = 0.03), and an ultrasound finding of predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess (OR = 19, p = 0.01). Increasing effusion thickness had borderline significance in predicting SA (OR = 18.6 for each cm, p = 0.095). The receiver operating characteristic curve evaluating the test performance of effusion thickness in predicting SA had an area under the curve of 0.691. At an effusion thickness cutoff of 7.5 mm, sensitivity and specificity in prediction of SA was 71% and 56%, respectively.*

Conclusion: *Ultrasonography is useful for predicting SA among paediatric patients with acute hip pain and joint effusion. Predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess, increasing effusion thickness, high fever, and high serum CRP level are predictive of SA of the hip. Treatment should be prompt to avoid complications.*

Key Words: *Arthritis, Infectious; Hip joint; Synovitis; Ultrasonography*

中文摘要

髖關節化膿性關節炎和短暫性滑膜炎的臨床和放射學鑒別

錢永恩、謝健燊

目的：根據臨床、實驗室和醫學影像參數來區分化膿性髖關節炎（SA）和短暫性髖關節滑膜炎（TS）。

方法：回顧2008年1月至2016年2月期間所有患有髖關節疼痛及積液並接受超聲引導抽取關節液及接

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受關節液分析的兒童。確認的SA被定義為革蘭氏染色或關節液細菌培養呈陽性，而假設的SA被定義為血培養呈陽性和高關節液白血球數（>50,000 / mm³）。TS被定義為關節液分析呈陰性。SA和TS組的臨床、實驗室和醫學影像參數作多變量邏輯回歸分析。

結果：32例中，7例確診或推定有SA，25例確診或推定有TS。與SA有關聯的因素包括體溫≥38.5ºC（比值比[OR] = 18，p = 0.02）、血清C-反應蛋白（CRP）水平≥10 mg/l（OR = 7.9，p = 0.03）和超聲發現前股凹處滑膜增厚（OR = 19，p = 0.01）。關節積液厚度增加可以粗略預測SA（OR為每厘米18.6，p = 0.095），接收者操作特徵曲線下面積為0.691。關節積液厚度值為7.5 mm時，預測SA的靈敏度和特異性分別為71%和56%。

結論：超聲檢查能在急性髖關節疼痛和積液的兒童中預測SA。主要滑膜增厚、積液厚度增加、高燒和高血清CRP水平能預測髖關節SA。及時治療能避免併發症。

INTRODUCTION

Distinguishing septic arthritis (SA) from transient synovitis (TS) of the hip in a limping child is challenging. Their presentation is similar but treatment and prognosis are different. TS is a benign self-limiting condition of unknown aetiology and is a diagnosis of exclusion. SA is a bacterial infection that requires emergency treatment. Clinician-initiated studies have endeavoured to differentiate the two conditions in terms of clinical and laboratory parameters.[1-5] Fever, failure to bear weight, previous health care visit, raised erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) were the common predictors of SA.[2,4] Ultrasound is useful to detect joint effusion and help evaluate SA.[5-10] Nonetheless ultrasound features to distinguish SA from TS have not been identified. In a previous study, ultrasound was considered insufficient to distinguish SA from TS of the hip in children.[6]

This study aimed to identify imaging features and validate the findings of prior studies on differentiating clinical and laboratory parameters for SA and TS of the hip in children.

METHODS

The institutional review board approved this retrospectively study. Patients aged ≤18 years who presented with painful hip effusion to a regional hospital in Hong Kong between January 2008 and February 2016 and subsequently underwent ultrasound-guided hip-joint aspiration and joint-aspirate analysis were identified through the Radiology Information System. Patients who had no joint-aspirate analysis, or those diagnosed with other inflammatory causes (e.g. juvenile idiopathic arthritis) were excluded from the analysis.

Confirmed SA was defined as positive Gram's stain or joint-aspirate culture, and presumed SA was defined as positive blood culture and a high joint-aspirate white cell count (>50,000 / mm³).[1-5] TS was defined as negative joint-aspirate analysis following exclusion of SA and other inflammatory causes e.g. juvenile idiopathic arthritis.

Data were retrieved from electronic patient records and included age, gender, date of presentation, duration of symptoms, history of fever, weight-bearing status, history of trauma, body temperature, CRP level, ESR, serum white blood cell count and differential, platelet count, blood culture results, and joint aspirate analysis (including Gram's stain, cell count, differential, and culture of joint aspirate). A history of fever was defined as an oral temperature of >38.5°C in the week before presentation. Weight-bearing status was determined on the basis of the clinical history; non-weight bearing was defined as inability or refusal to bear weight despite support.[1-4]

Ultrasound Assessment

The hip joint was assessed using a Philips iU22 (Philips Medical Systems, Andover, MA, USA) with linear transducer (12-5 MHz L12-5 transducer) for musculoskeletal application. Patients were placed in a supine neutral position. Longitudinal images of the anterior joint capsule of the hip joint were acquired. The ultrasonographic-histological correlation of the hip joint has been described by Robben et al.[11]

The anterior joint capsule of the hip joint occupies the space between the iliopsoas muscle and femoral neck. It consists of an anterior layer and a posterior layer, each measuring 2 to 4 mm in thickness, separated by the anterior recess of the joint space. The inner surface of the two layers is lined by synovial membrane. In a

normal hip joint with collapsed anterior joint recess, these two isoechoic layers oppose each other with a thin echogenic reflection situated in between, called the 'stripe sign' (Figure 1). A small amount of physiological synovial fluid in the anterior joint recess can be seen in a normal joint. On the contrary, in the presence of joint effusion, the two layers are well delineated (Figures 2 and 3).

Images were independently reviewed by two radiologists (with 11 and 4 years of experience) on the Picture Archiving and Communication System workstation. Data on the thickness of the anterior and posterior layers of the hip joint capsule, as well as thickness of anterior joint recess (effusion) in the anterior femoral capsule were collected. Vascularity information of the articular soft tissues was not analysed as they were not obtained in a standardised manner (i.e. some by colour Doppler and others by power Doppler). In case of discrepancy, the radiologists reviewed the images again together and

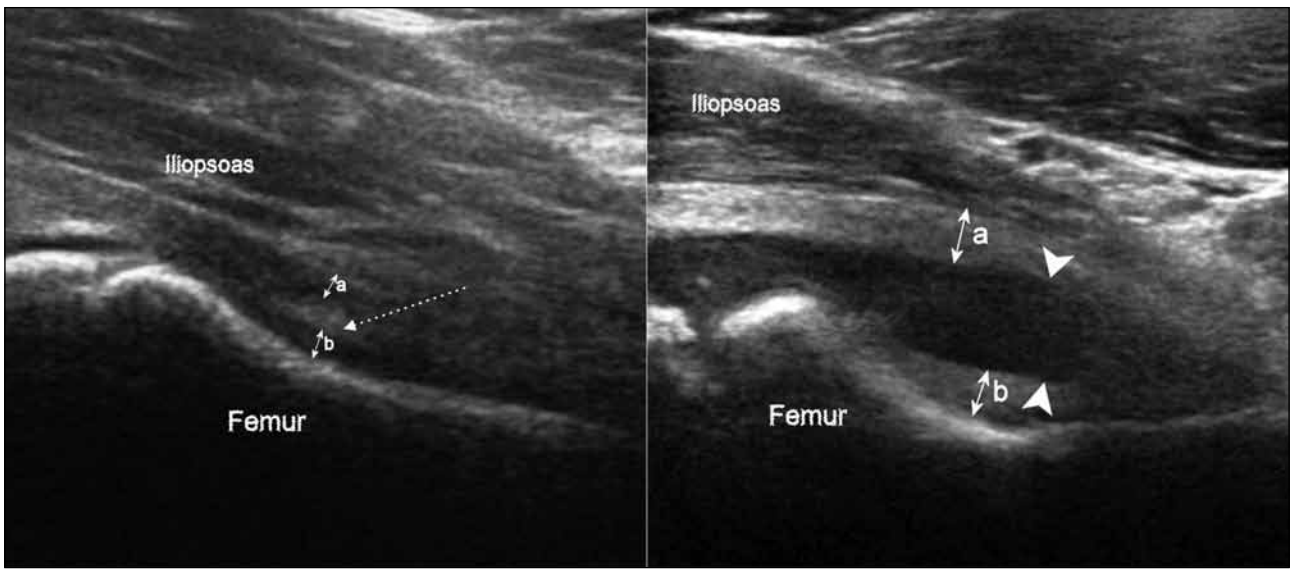

Figure 1. Normal sonographic image of a paediatric hip: the anterior joint capsule lies deep to the iliopsoas muscle and consists of an anterior layer (a) and a posterior layer (b) separated by a thin echogenic line (dotted arrow). These two layers are separated in the presence of joint effusion (arrowheads).

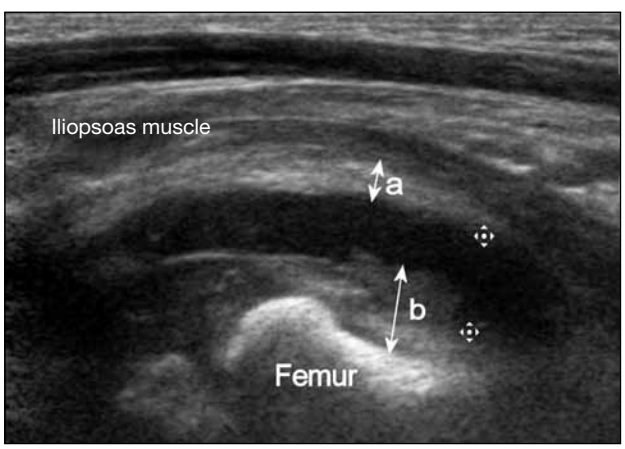

Figure 2. Ultrasound image of a patient with septic arthritis showing the total thickness of anterior and posterior layers of the anterior hip joint capsule (distance a+b) exceeding that of joint effusion (cursors).

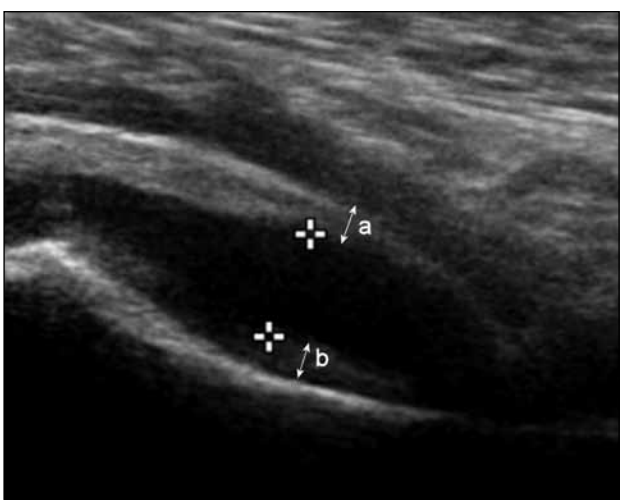

Figure 3. Ultrasound image of a patient with transient synovitis showing predominant joint effusion (cursors) relative to synovial thickening (distance a+b).

reached a consensus.

Statistical Analysis

Baseline characteristics of the two groups were compared using the Chi-square test and *t*-test for categorical and continuous variables, respectively. Univariate and multivariate logistic regression analyses with backward selection were used to assess the association between SA and clinical, laboratory, and sonographic parameters. Adjusted odds ratios (ORs) and 95% confidence intervals were derived with the method of maximum likelihood. Statistical significance was determined by the likelihood ratio Chi-square test when a p value was <0.05. A receiver operating characteristic (ROC) curve was used to assess the performance of increasing thickness of anterior joint recess (effusion) on ultrasonography in diagnosing SA. Statistical analysis was performed using the SPSS software (version 16.0; SPSS, Chicago [IL], US).

RESULTS

A total of 33 patients underwent ultrasound-guided hip joint aspiration. With the exception of one patient who had juvenile idiopathic arthritis, seven patients were confirmed or presumed to have SA and 25 patients were considered to have TS. They were 26 boys and 6 girls aged from 14 months to 15 years (mean, 5.9 years).

Of the seven patients with SA, six had a positive joint-aspirate culture or Gram's stain and a negative blood culture, and one had a positive blood culture and high joint-aspirate white cell count but negative joint-aspirate culture or Gram's stain. Organisms isolated on culture included *Streptococcus pneumoniae* (n = 2), *Staphylococcus aureus* (n = 2), and *Pseudomonas stutzeri* (n = 1). Two patients had positive Gram's stain of joint aspirate (one with Gram-positive bacilli and the other with Gram-negative bacilli) although their joint-aspirate culture was negative.

Predictors of SA were body temperature of ≥38.5ºC (OR = 18, p = 0.023), serum CRP level ≥10 mg/l (OR = 7.92, p = 0.031), and predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess (OR = 19, p = 0.012, Figure 2) [Table]. For TS, the opposite tended to apply (i.e. the thickness of joint effusion exceeded that of the total thickness of anterior and posterior joint capsule layers) [Figure 3]. Increasing joint effusion thickness was associated with SA with borderline significance (OR = 18.59, p = 0.095). Nonetheless, increasing discrepancy between thickness of the anterior and posterior layers of the joint capsule (i.e. distance a minus b in Figures 2 and 3) did not predict SA.

The ROC curve for effusion thickness at the anterior femoral recess on ultrasonography in reference to SA is shown in Figure 4. The area under the curve was 0.691, indicating that increasing hip effusion demonstrated satisfactory performance in the diagnosis of SA. At a joint effusion thickness cutoff of 7.5 mm, sensitivity and specificity in prediction of SA was 71% and 56%, respectively.

DISCUSSION

There are validated clinical parameters to differentiate

Table. Clinical, laboratory, and ultrasonographic parameters of septic arthritis and transient synovitis.

Parameter	Odds ratio	95% Confidence interval	p Value
Clinical			
Body temperature ≥38.5ºC	18	1.48-218.95	0.023
Long symptom duration	0.97	0.82-1.12	0.688
Presence of flu symptoms	1.13	0.21-6.14	0.892
Non-weight bearing of affected limb	0.54	0.10-2.94	0.671
Laboratory			
Serum C-reactive protein level ≥10 mg/l	7.92	1.21-51.8	0.031
Erythrocyte sedimentation rate ≥40 mm/h	4	0.3-53.47	0.295
Serum white cell count ≥12 x 10^9/l	2.89	0.51-15.77	0.234
Predominant neutrophilia	1.07	0.85-1.36	0.559
Ultrasonography			
Predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess	19	1.89-190.92	0.012
Increasing effusion thickness at anterior recess of hip joint (for every 1 cm)	18.59	1.60-573.67	0.095
Increasing discrepancy in thickness of the anterior and posterior layers of joint capsule	1.87	0.34-10.25	0.472

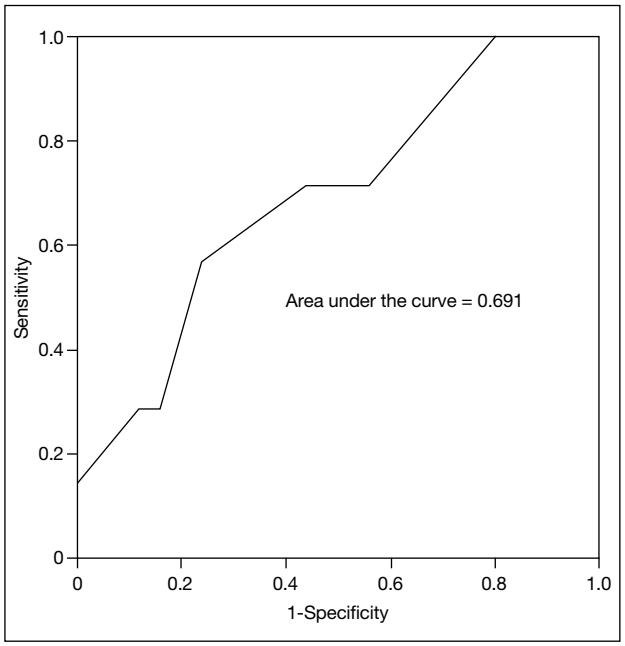

Figure 4. Receiver operating characteristic curve for hip effusion thickness on ultrasonography in prediction of septic arthritis.

SA from TS.[1-5] Concordant with previous studies, in our study predictors of SA were the presence of high fever and elevated serum CRP level. Nonetheless, SA was not associated with non–weight bearing of the affected limb, symptom duration, serum ESR, or serum white blood cell count.

Weight-bearing status has an element of subjectivity as it depends on the patient's tolerance to pain. The assessment can be problematic in infants due to difficulties in communication. This may explain the deviance from prior study results.

Serum CRP level is almost always the highest at the time of admission in patients with bacteraemic disease, whereas ESR reaches a maximum several days after hospital admission.[12] This is independent of age, aetiology, and nature and length of the disease.[12] As the laboratory parameters of our patients were obtained at the first presentation, those with SA tended to have significantly elevated CRP level, with ESR level comparable to those with TS. Moreover, ESR and serum white blood cell count are well-known non-specific markers of inflammation and can be elevated in both infective and inflammatory conditions.

Ultrasonography has superior sensitivity in detecting SA.[13] Our study further differentiated the two conditions from a sonographic perspective. We identified some sonographic parameters indicative of SA, particularly predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess. This is in accordance with the findings in a magnetic resonance imaging study of septic versus non-septic joints.[14] Effusion was more commonly encountered in non-septic than septic arthritis (82% vs. 79%), whereas synovial thickening was more prevalent in septic than non-septic arthritis (68% vs. 55%).[14] Similar observations were also reported in an ultrasound study of the anterior joint capsule of normal hips and of TS hips.[11] In patients with TS, thickening of both joint capsule layers was not significant in the symptomatic hips, compared with the asymptomatic side.[11] Therefore, the thickened anterior joint capsule in TS was suggested to be predominantly due to effusion.[11] Nevertheless, the study did not compare the degree of capsular layer thickening or effusion in TS and SA.

In the pathophysiology of SA, joint effusion occurs through increased synovial circulation combined with synovial oedema.[15] Compared with TS, SA is postulated to result in more florid inflammation leading to synovial hyperaemia and oedema, as well as increased joint capsule thickening and joint effusion. Joint effusion is the secondary effect of synovial hypertrophy and may not be the predominant feature at presentation. This might explain our observation of predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess in patients with SA. In our study, joint effusion of >7.5 mm in thickness may represent severe joint inflammation and potentially SA.

As the synovial membrane lines the inner surface of the fibrous joint capsule layer, which forms only a minute portion of capsule layer, its thickening in TS cannot be appreciated on ultrasonography.[11] We postulate that synovial thickening in TS is less extensive than in SA, and the effusion in TS could be attributed to an unknown process in addition to synovial hypertrophy. Further radiological-pathological correlation studies are required to verify our findings.

Our study was limited by the small sample size as SA of the hip is uncommon in our locality. Older case data were lost during an upgrade of our electronic radiology information system. Owing to the retrospective nature of the study, some sonographic images were not obtained in a standardised manner. Vascularity of the hip joint

could not be accurately compared, as the means of assessment (colour Doppler vs. power Doppler) varied among operators. Some patients with SA may have been excluded, especially those with a more benign clinical course (i.e. minimal joint effusion that did not warrant aspiration).

CONCLUSION

Ultrasonography is useful in predicting SA among paediatric patients with acute hip pain and joint effusion. Predominant synovial (capsular) thickening relative to joint effusion thickness at the anterior femoral recess, increasing thickness of the anterior joint capsule, high fever, and high serum CRP level are predictors of SA. Increased joint effusion thickness (>7.5 mm) should alert radiologists to the possibility of SA. A constellation of these clinical and sonographic findings should prompt early ultrasound-guided aspiration and prophylactic antibiotic treatment while awaiting culture results.

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