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Significance of Laboratory and Radiologic Findings for Differentiating Between Septic Arthritis and Transient Synovitis of the Hip

Sung Taek Jung, M.D., Sung Man Rowe, M.D., Eun Sun Moon, M.D., Eun Kyoo Song, M.D., Taek Rim Yoon, M.D., and Hyoung Yeon Seo, M.D.

Study conducted at Chonnam National University Hospital, Gwangju, Korea

Summary: Although significant differences exist in the methods of treatment and prognoses of septic coxitis and transient synovitis in children complaining of acute hip pain, similar symptoms are present in these two diseases at the early stages, and differential diagnosis is difficult. To differentiate between these two diseases, the authors evaluated the clinical, serologic, and radiologic findings and tried to determine factors that could be used as diagnostic criteria. The authors performed a retrospective study by evaluating medical records, plain hip radiographs, and clinical findings in 97 patients with transient synovitis and 27 patients with septic arthritis. Univariate analysis showed significant differences in body temperature, serum WBC count, and ESR and CRP levels of the two patient groups. Plain radiographs showed a displacement or blurring of periarticular fat pads in all patients with acute septic arthritis, and multivariate regression analysis showed that body temperature >37°C, ESR >20 mm/h, CRP >1 mg/dL, WBC >11,000/mL, and an increased hip joint space of >2 mm were independent multivariate predictors of acute septic arthritis. The authors conclude that the independent multivariate predictors are effective indices for the differential diagnosis of acute septic coxitis and transient synovitis. **Key Words:** Differential diagnosis—Septic coxitis—Transient synovitis.

The most immediate concern of physicians presented with a child having acute joint disease is the differentiation of septic involvement of the joint and benign nonbacterial joint disease. A thorough history and physical examination frequently fail to separate the two, especially during the early clinical course. Children with acute hip pain may seem to have the same problem to many physicians. Differentiating septic arthritis and transient synovitis of the hip in children is not easy but it is essential, since the two clinical entities have different treatments and different potentials for negative sequelae. Septic arthritis is treated with operative drainage and antibiotics, whereas transient synovitis is usually self-limiting and is treated symptomatically (1,5,8,11,22,24, 26). The complications of septic arthritis include osteonecrosis, growth arrest, and sepsis, whereas transient synovitis usually has a benign clinical course (3,6,12,13, 15,21,25,27). Since poor outcomes in septic arthritis have been associated with a delay in diagnosis, early, accurate diagnosis is indispensable (9,10,14,18,20). Empirically, clinicians have used various clinical, laboratory, and radiographic variables to distinguish between septic arthritis and transient synovitis. The purpose of this study was to identify diagnostic variables that differentiate septic hip and transient synovitis.

Address correspondence and reprint requests to Sung Taek Jung, Department of Orthopedics, Chonnam National University Hospital, Hakdong 8, Gwangju, Korea (e-mail: stjung@chonnam.ac.kr).

From Department of Orthopedics, Chonnam National University Hospital, Gwangju, Korea

MATERIALS AND METHODS

A retrospective review of the medical records and plain radiographs of children with acute hip pain was conducted at a single institution. Records from 97 patients with transient synovitis and 27 with septic arthritis were identified. The diagnosis of transient synovitis of the hip (97 patients) was made on the basis of clinical and laboratory findings and improved clinical manifestations by analgesics and bed rest alone. The diagnosis of septic arthritis of the hip (27 patients) was made on the basis of clinical and laboratory findings, and this was confirmed by culture with arthrotomy between December 1988 and February 2001. Cases were reviewed by all of the authors prior to inclusion in the study. Patients who met all of the following criteria were included: limp, or the presence of hip, thigh, or knee pain, in whom physical examination localized the pathology to the hip; restriction in the range of passive motion of the hip; single joint involvement; no history of significant

trauma; radiographs that showed no fractures or bony abnormalities; no evidence of invasive bacterial infection at another site, such as meningitis or cellulitis; and no history of significant chronic or recurrent arthritis, rheumatologic disease, bone or joint disease, or immunosuppressive illnesses, including malignancies, renal failure, inflammatory bowel disease, or any illness that had been treated with immunosuppressive or anti-inflammatory medications. Information obtained from all patients included age, gender, temperature, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), serum white blood cell (WBC) count, differential platelet count, hematocrit, and plain AP radiographs.

The demographic data of the patients in the two groups are summarized in Table 1. The mean age of patients with septic arthritis was 5 years and 7 months (range 1 month to 15 years); the mean age of patients with transient synovitis was 6 years and 7 months (range 17 months to 19 years). Age, gender, and site distribution were no different in the two groups. On plain radiographs, the definition and location of fatty layers such as the medial iliopsoas layer and the immediate lateral (the "capsular" layer) with respect to the hip joint were analyzed (Fig. 1). It was decided that displacement of the fatty layers should be regarded as occurring only away from the joint. The "joint space" was measured directly on radiographic film without correcting for magnification (see Fig. 1). Identical measurements were made on both sides.

Statistical analyses were performed using the Student *t* test for univariate analysis for stepwise multiple logistic regression analysis and for receiver operating characteristic (ROC) analysis.

RESULTS

Univariate analysis

Patients with septic arthritis differed significantly ($P < 0.05$) from those with transient synovitis in terms of initial body temperature (37.7° vs. 36.6°), serum WBC count (18,200/mm^3 vs. 8,200/mm^3), neutrophils (62.5% vs. 46.0%), lymphocytes (27.5% vs. 41.2%), ESR (79.2 vs. 20.3 mm/h), and CRP (10.1 vs. 0.66 mg/dL). However, platelet counts and hematocrit values were not different (Table 2). Univariate analyses showed the relative risk (RR) of septic arthritis to transient synovitis as follows: temperature >37°, RR 79.6; ESR >20 mm/h, RR 17.2; ESR >40 mm/h, RR 42.4; CRP >1 mg/dL, RR 87.0; and WBC >11,000 cells/mL, RR 35.9 (Table 3).

Patients with septic arthritis differed significantly ($P < 0.05$) from those with transient synovitis with regard to difference in the distance of the joint spaces in affected and nonaffected hips (mean 4.0 mm affected vs. 1.2 mm unaffected). Twenty-two patients with transient synovitis did not show displacement of the periarticular fat pads, whereas all patients with septic arthritis of the hip showed blurring and/or displacement of the periarticular fat pads (Table 4).

TABLE 1. *Patient data*

	Transient synovitis	Septic arthritis
Cases	97	27
Mean age	6.7 yrs (17 mo–19 yrs)	5.7 yrs (1 mo–15 yrs)
Gender (M/F)	71/26	18/9
Site (R/L)	50/47	13/14

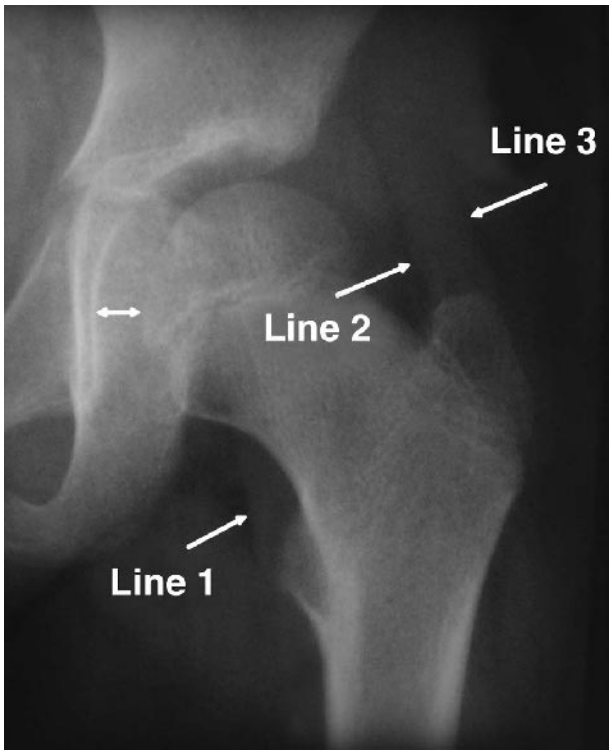

FIG. 1. The definition of distance of medial joint space and the fatty layers. Line 1 is the medial iliopsoas layer, line 2 the immediate lateral capsular layer, and line 3 the intergluteal fatty layer.

Multivariate analysis and ROC analysis

We identified five independent multivariate indicators for differentiation (Table 5): temperature >37°, ESR ≧20 mm/h, CRP ≧1 mg/dL, serum WBC count >11,000 cells/mm^3 (i.e., 11.0 × 10^9 cells per liter), and a joint space difference of >2 mm. Adjusted odds ratio, *P* values, and 95% confidence intervals were calculated.

Algorithm for the probability of septic arthritis

An algorithm was written to allow a determination of the probability of septic arthritis based on the 32 possible

TABLE 2. *Univariate analyses of transient synovitis versus septic arthritis for clinical and laboratory findings*

	Transient synovitis	Septic arthritis	*P* value
Temperature (°C)	36.6 ± 0.3	37.7 ± 0.8	<0.001
WBC (cells/mL)	8,200 ± 1,800	18,200 ± 9,800	<0.001
Neutrophil (%)	46.0 ± 10.9	62.5 ± 22.4	0.001
Lymphocyte (%)	41.2 ± 10.1	27.5 ± 20.1	0.002
ESR (mm/h)	20.3 ± 17.2	79.2 ± 42.7	<0.001
CRP (mg/dL)	0.66 ± 1.3	10.10 ± 6.86	<0.001
Platelet (10^3/mL)	322 ± 75	347 ± 143	0.367
Hematocrit (%)	35.8 ± 2.2	35.1 ± 3.7	0.399

Data are given as average ± SD.

TABLE 3. *Relative risk of septic arthritis versus transient synovitis by clinical and laboratory findings*

	Transient synovitis (%)	Septic arthritis (%)	Relative risk	95% Confidence interval	*P* value
Temperature >37°C	3 (3.1)	21 (77.8)	79.63	20.62–307.52	<0.001
ESR >20 mm/h	40 (41.2)	25 (92.6)	17.19	3.85–76.78	<0.001
ESR >40 mm/h	6 (6.2)	20 (20.6)	42.38	12.85–139.79	<0.001
CRP >1 mg/dL	7 (7.2)	24 (88.9)	87.00	21.42–353.42	<0.001
WBC >11,000 cells/mL	6 (6.2)	20 (74.1)	35.92	11.32–113.97	<0.001

combinations (2 × 2 × 2 × 2 × 2) of the five binary independent multivariate predictors (Table 6). ROC trend analysis indicated a very strong relationship between the number of these factors indicating septic arthritis and the likelihood of septic arthritis (Fig. 2). The area under the ROC curve was 0.986, indicating the excellent diagnostic performance of this group of five multivariate predictors for septic arthritis.

DISCUSSION

The differentiation of septic arthritis and transient synovitis of the hip in children is difficult, since these conditions often have similar presentations: an atraumatic, acute hip pain, with progressive symptoms and signs of fever, a limping gait and a limited range of motion, joint effusion, and abnormal laboratory findings. As a result, clinicians have used different empirical variables to help differentiate septic arthritis and transient synovitis. Bennett and Namnyak emphasized the WBC count in children of >3 years (2). Morrey et al. (20), Klein et al. (16), and Chen et al. (4) focused on an elevated ESR. However, because these case series of children with septic arthritis did not include a comparative group of children with transient synovitis, the authors were unable to establish differences between the two groups or to determine the diagnostic performance of assorted variables. Various clinical, laboratory, and radiographic results have been found to have poor diagnostic utility for distinguishing between septic arthritis and transient synovitis in children because of the mentioned substantial overlap between the two conditions. Molteni retrospectively reviewed 97 cases of so-called nonspecific arthritis and 37 cases of septic arthritis of various joints, including the hip, knee, ankle, elbow, and wrist (19). Del Beccaro et al. also found that overlap between the presenting variables impeded the differentiation of septic arthritis and transient synovitis in children's hips (7). Although the ESR was significantly ($P < 0.05$) different in the two groups, a substantial overlap made it a poor discriminator. In general, septic arthritis patients appeared to be more ill with fever and chills and less able to bear weight; they also tended to have an elevated ESR, leukocytosis, and an altered peripheral blood differential. However, as found in previous studies, the two groups overlapped substantially; thus, differentiation is difficult based on individual variables in isolation.

The "joint space" as seen on radiographic film represented the nonossified part of the femoral head and the articular cartilage, but this was a poor approximation to the true joint space. Moreover, the septic arthritis group showed larger joint space distances than the transient synovitis group. The present investigation showed that septic arthritis is associated with more joint effusion, the femur may be dislocated, and therefore the "joint space" may be increased. Capsular swelling or joint effusion may easily affect the "capsular" fat pad, since the pad is in direct contact with the joint capsule. Reichmann (23) added that in the case of joint inflammation, topographic conditions allow edema to spread into the intramuscular fat pads. The iliopsoas and "capsular" fat pad signs were, however, of very low diagnostic value in indicating joint effusion, as were painful hips with or without effusion. The present investigation showed that septic arthritis is more associated with the displacement or disruption of the fat pad, and that this may be due to an inflammatory reaction in the joint. However, these changes should be carefully observed on well-checked radiographs with comparison of the nonaffected hip joint.

Kocher et al. (17) reported a similar retrospective study for differentiating the two diseases. They used four independent multivariate predictors: history of fever, non-weight-bearing, 40 mm/h for ESR, and 12,000 cells/mL for WBC. Two of their four predictors were not

TABLE 4. *Univariate analyses of transient synovitis and septic arthritis for radiologic findings*

	Transient synovitis	Septic athritis	*P* value
Difference of joint space distance	1.23 ± 1.10	4.00 ± 3.08	<0.01
Fat pad			
Line 1	45 (47.4%)	23 (85.2%)	
Line 2	37 (38.9%)	21 (77.8%)	
Line 3	29 (30.5%)	20 (74.1%)	
No change	22 (23.2%)	0 (0%)	

TABLE 5. *Multivariate analyses for five independent predictors*

Multivariate predictor	*P* value	Adjusted odds ratio	95% Confidence interval
Temperature (>37 °C)	0.018	11.572	1.521–88.056
ESR (>20 mm/h)	0.079	17.330	0.716–419.243
CRP (>1.0 mg/dL)	0.033	10.565	1.205–92.627
WBC (>11,000 cells/mL)	0.008	18.893	2.121–168.271
Difference of joint space distance (>2 mm)	0.312	2.934	0.365–23.599

TABLE 6. *Algorithm for probability of septic arthritis*

Temp (>37°C)	ESR (>20 mm/h)	CRP (>1.0 mg/dL)	WBC (>11,000 cells/mL)	Difference of joint space distance (>2 mm)	Predictive probability of septic arthritis (%)
Y	Y	Y	Y	Y	99.1
Y	Y	Y	Y	N	97.3
Y	Y	Y	N	Y	84.8
Y	Y	Y	N	N	65.5
Y	Y	N	Y	Y	90.9
Y	Y	N	Y	N	77.2
Y	Y	N	N	Y	34.5
Y	Y	N	N	N	15.2
Y	N	Y	Y	Y	85.9
Y	N	Y	Y	N	67.4
Y	N	Y	N	Y	24.3
Y	N	Y	N	N	9.9
Y	N	N	Y	Y	36.5
Y	N	N	Y	N	16.4
Y	N	N	N	Y	2.9
Y	N	N	N	N	1.0
N	Y	Y	Y	Y	90.1
N	Y	Y	Y	N	75.6
N	Y	Y	N	Y	32.5
N	Y	Y	N	N	14.1
N	Y	N	Y	Y	46.2
N	Y	N	Y	N	22.7
N	Y	N	N	Y	4.3
N	Y	N	N	N	1.5
N	N	Y	Y	Y	34.4
N	N	Y	Y	N	15.2
N	N	Y	N	Y	2.7
N	N	Y	N	N	0.9
N	N	N	Y	Y	4.7
N	N	N	Y	N	1.7
N	N	N	N	Y	0.3
N	N	N	N	N	0.1

quantitative data. In the current study, the multivariate analysis performed included body temperature, ESR, CRP, WBC, and distance difference of the joint space. These variables were found to be significant by univariate analysis. We decided to use the following reference values: 20 mm/h for ESR, 1.00 mg/dL for CRP, 11,000 cells/mL for WBC, and 2 mm for joint space difference. ESR was affected by variable factors; there were 34 (35%) hips with transient synovitis, and 5 (19%) hips with septic arthritis in the range from 20 to 40 mm/h. The degree of overlap between the two groups by ESR was substantial, and it was difficult to decide on a reference ESR value for group differentiation. The associated *P* values were >0.05 in both ESR and difference of joint space, and the 95% confidence intervals were 0.716 to 419.243 for ESR and 0.365 to 23.599 for distance difference of joint space by five independent multivariate analysis. However, by ROC analysis, the area under the curve was 0.986; that is, analysis using five independent variables had excellent diagnostic performance. When independent factors other than joint space difference were used, according to multivariate regression analysis, the probability of diagnosing acute septic coxitis was 98.8%, and the ROC analysis had 0.985 of area. By adding the radiographic findings, a higher predictive probability was obtained. Had more patients with septic arthritis been enrolled, we would probably have obtained a better odds ratio and 95% confidence interval for ESR and joint space difference.

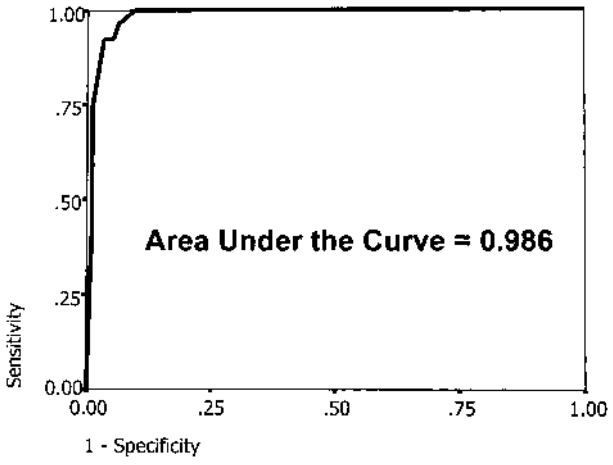

FIG. 2. Receiver operating characteristic curve of the simplified clinical prediction algorithm for septic arthritis.

In the present investigation, we found that patients with four or five predictors had a high probability of having septic arthritis of the hip and were candidates for further study by MRI or by aspiration, given the likelihood that subsequent arthrotomy and drainage were likely to be needed. Patients with a low probability of

septic arthritis of the hip (i.e., negative for four or five predictors) were appropriate candidates for careful observation without aspiration. Future directions of this work include the prospective evaluation of the diagnostic performance of our prediction algorithm and its prospective validation in other clinical settings.

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