

ORIGINAL ARTICLE

Diagnostic utility of laboratory tests in septic arthritis

S F Li, C Cassidy, C Chang, S Gharib, J Torres

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See end of article for authors' affiliations

Correspondence to:
Dr S F Li, Department of
Emergency Medicine, Jacobi
Medical Center, 1400
Pelham Parkway S, Bronx,
NY 10461, USA;
siuf@verizon.net

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Background: Septic arthritis remains a challenging diagnosis in which the doctor often relies on laboratory tests. **Objective:** To examine the diagnostic utility of three ancillary tests—namely, white blood cells (WBC), erythrocyte sedimentation rate (ESR) and the WBC in the joint fluid (jWBC)—using likelihood ratios (LRs) and receiver operating characteristic (ROC) curves.

Methods: This was a retrospective cohort study at the Jacobi Medical Center. Medical charts of patients who had undergone arthrocentesis were included. Patients who had “dry taps” were excluded from the study. Patients were considered to have septic arthritis if they had a positive arthrocentesis culture or operative findings. The primary outcomes of this study were the sensitivities, specificities, LR(+) and LR(–) values of the laboratory tests for septic arthritis. The performance characteristics of the laboratory tests were analysed using ROC curves.

Results: 156 patients were enrolled, 16 (10%) had septic arthritis. The sensitivities for WBC, ESR and jWBC were 0.75, 0.75 and 0.50, and the specificities were 0.55, 0.11 and 0.88, respectively. The LR(+) values were 1.7, 0.84 and 4.0, and the LR(–) values were 0.46, 2.4 and 0.57, respectively. In ROC curve analysis, jWBC was the best test (area under the curve (AUC) 0.75, 95% confidence interval (CI) 0.58 to 0.92), followed by WBC (AUC 0.69, 95% CI 0.57 to 0.80) and ESR (AUC 0.55, 95% CI 0.37 to 0.74). A cut-off of jWBC = 17 500 maximised sensitivity and specificity on the ROC curve.

Conclusions: jWBC was the best diagnostic test for septic arthritis, WBC and ESR were poor tests. However, no test was diagnostic, and the clinician must be careful with patients with a potential septic joint.

Septic arthritis is a disease associated with serious morbidity to the patient and a diagnostic challenge to the doctor. The causes of monoarticular arthritis are numerous, with septic arthritis being the most important entity. The diagnosis is rarely established by the history and physical examination, and the clinician is led to rely on ancillary tests, specifically the white blood cell (WBC) count from peripheral blood, the erythrocyte sedimentation rate (ESR) and the WBC count of the joint fluid (jWBC). Although septic arthritis is known to be associated with elevations in these ancillary tests, previous studies have found that they are insufficiently sensitive to rule out septic arthritis.^{1–29} Unfortunately, most of these studies are limited in their nature as case-series studies,^{1–8 10–28} and are unable to comment beyond sensitivity. In fact, there are few studies which have examined the diagnostic utility of these ancillary tests in septic arthritis using positive and negative likelihood ratios (LR(+)) and LR(–)) or receiver operating characteristic (ROC) curves.^{29–31} The purpose of our study was to examine the diagnostic utility of these three tests in patients with septic arthritis, using LRs and ROC curves.

METHODS

Study design, setting and population

This was a retrospective cohort study at the Jacobi Medical Center. We searched the hospital medical database for adult and paediatric patients who had undergone arthrocentesis from January 1998 to October 2004. The study was approved by the Committee on Clinical Investigations, Albert Einstein College of Medicine.

Study protocol and measurements

The medical charts were reviewed for demographic (age, sex), clinical (operative findings, diagnoses) and laboratory data (WBC, ESR, jWBC, culture results). Patients who had “dry taps” were excluded from the study. In our laboratory, WBC >11 × 10³ cells/mm³ and ESR >20 mm/h were considered high.

For the purposes of this study, jWBC >50 000 cells/mm³ was considered high. Patients were considered to have septic arthritis if they had a positive arthrocentesis culture or operative findings consistent with septic arthritis (ie, frank pus). Chart reviewers underwent a training session before data collection. In all, 40 (26%) charts were cross-reviewed to determine inter-rater reliability.

Data analysis

The primary outcomes of this study were the sensitivities, specificities, LR(+) and LR(–) values of the laboratory tests for septic arthritis. The performance characteristics of the laboratory tests were analysed using ROC curves. Inter-rater reliability was determined using simple agreement. Data were analysed using Microsoft Excel X for Mac (Redmond, Washington, USA) and SPSS for Windows 11.5.0 (Chicago, Illinois, USA).

RESULTS

The database identified 188 patients who had undergone arthrocentesis during the study period. We excluded 32 patients because they had dry taps, leaving 156 patients in the final analysis. The mean age was 53 (range 1–97) years, with 13% paediatric patients and 56% males. In all 16 (10%) patients had septic arthritis confirmed by arthrocentesis culture or operative findings. The remaining patients had a myriad of diagnoses, the most common being gout (33%), osteoarthritis (9%), traumatic effusion (6%) and pseudogout (5%). No specific diagnosis was given to 36 (23%) patients. Inter-rater reliability was excellent (simple agreement 96%, 95% confidence interval (CI) 94% to 98%).

Abbreviations: AUC, area under the curve; ESR, erythrocyte sedimentation rate; jWBC, WBC in the joint fluid; ROC, receiver operating characteristic; WBC, white blood cells; S F Li, C Cassidy, C Chang, S Gharib, J Torres

Table 1 Diagnostic utility of laboratory tests for septic arthritis

| | n | Sensitivity | Specificity | LR(+) | LR(-) |
|------------|-----|----------------------|---------------------|--------------------|--------------------|
| WBC | 156 | 0.75 (0.48 to 0.93)* | 0.55 (0.46 to 0.63) | 1.7 (1.2 to 2.3) | 0.46 (0.19 to 1.1) |
| ESR | 107 | 0.75 (0.43 to 0.95) | 0.11 (0.05 to 0.19) | 0.84 (0.60 to 1.2) | 2.4 (0.76 to 7.4) |
| jWBC† | 127 | 0.50 (0.21 to 0.79) | 0.88 (0.80 to 0.93) | 4.0 (1.9 to 8.6) | 0.57 (0.32 to 1.0) |
| All tests‡ | 156 | 1.0 (0.79 to 1.0) | 0.24 (0.17 to 0.31) | 1.3 (1.2 to 1.4) | 0 (0 to 13) |
| jWBC§ | 127 | 0.83 (0.52 to 0.98) | 0.67 (0.57 to 0.75) | 2.5 (1.8 to 3.6) | .25 (0.07 to 0.89) |

ESR, erythrocyte sedimentation rate; jWBC, white blood cells in the joint; LR, likelihood ratio; WBC, white blood cells.

*95% confidence interval.

†using jWBC \geq 50 000.

‡if any of the three test counts are raised.

§using jWBC \geq 17 500; cut-off which maximised sensitivity and specificity, retrospective analysis.

All patients had data on WBC count, 107 patients had data on ESR and 127 patients on jWBC. The mean (standard deviation (SD)) of the WBC count was $12 (7.2) \times 10^3$ cells/mm³; ESR was 72 (39) mm/h and jWBC was 26 000 (38 000) cells/mm³. In all, 75 (48%) patients had a raised WBC count, 94 (60%) had a raised ESR, 20 (13%) had a raised jWBC count, and 14 (9%) patients had a positive joint fluid culture.

Table 1 shows the sensitivities, specificities and LR values of elevations in WBC, ESR and jWBC levels for patients with septic arthritis. The sensitivities of WBC, ESR and jWBC were 0.75, 0.75 and 0.50; the specificities were 0.55, 0.11 and 0.88; the LR(+) values were 1.7, 0.84 and 4.0, and the LR(-) values were 0.46, 2.4 and 0.57, respectively. All patients with septic arthritis had at least one abnormality in WBC, ESR or jWBC; thus the combined sensitivity of all three tests was 100%.

Figure 1 shows the performance characteristics of WBC, ESR and jWBC, as summarised by ROC curves. The area under the curve (AUC) values for WBC, ESR and jWBC were 0.69 (95% CI 0.57 to 0.80), 0.55 (95% CI 0.37 to 0.74) and 0.75 (95% CI 0.58 to 0.92), respectively. For jWBC, the diagnostic cut-off that maximised the combination of sensitivity and specificity was a jWBC count of 17 500 cells/mm³, with a sensitivity of 83% (95% CI 0.52 to 0.98), a specificity of 67% (95% CI 0.57 to 0.75), an LR(+) value of 2.5 (95% CI 1.8 to 3.6) and an LR(-) value of 0.25 (95% CI 0.07 to 0.89).

DISCUSSION

The WBC, ESR and jWBC values showed considerable variation in diagnostic utility for septic arthritis. The sensitivities of the three ancillary tests were fair at best, with a range from 0.50 to 0.75. The specificities were variable: the specificity of ESR was extremely poor at 0.11, whereas that of jWBC was rather good at 0.88. The LR(+) values of WBC and ESR were poor (1.7 and 0.84, respectively), but the LR(+) value of jWBC approached respectability at 4.0, with a 95% CI upper limit of 8.3. The LR(-) values of all three tests were poor, with a range from 0.46 to 2.4. If we were to use a reference standard of 10 as a "good" LR(+) and 0.10 as a "good" LR(-), then none of the three tests had "good" LR(+) or LR(-) values in this study, inclusive of the 95% CIs.

The combined sensitivity of all three tests was 100%, but the combined specificity was low (0.24), and coupled with the sample size of this study, the combined LR(-) value was insufficiently powerful to effectively rule out a septic joint, as indicated by the upper limit of the 95% CI, which was greater than 1.0 (95% CI 0 to 13).

The best diagnostic test, based on the results of ROC curves, was the jWBC, followed by WBC and ESR. The AUC for the jWBC ROC curve was 0.75, indicating a fair to good diagnostic test. The upper limit of the AUC was 0.92, indicating that it may be an excellent test. ESR was a poor diagnostic test with an AUC of 0.55, and WBC was a fair diagnostic test with an AUC of 0.69.

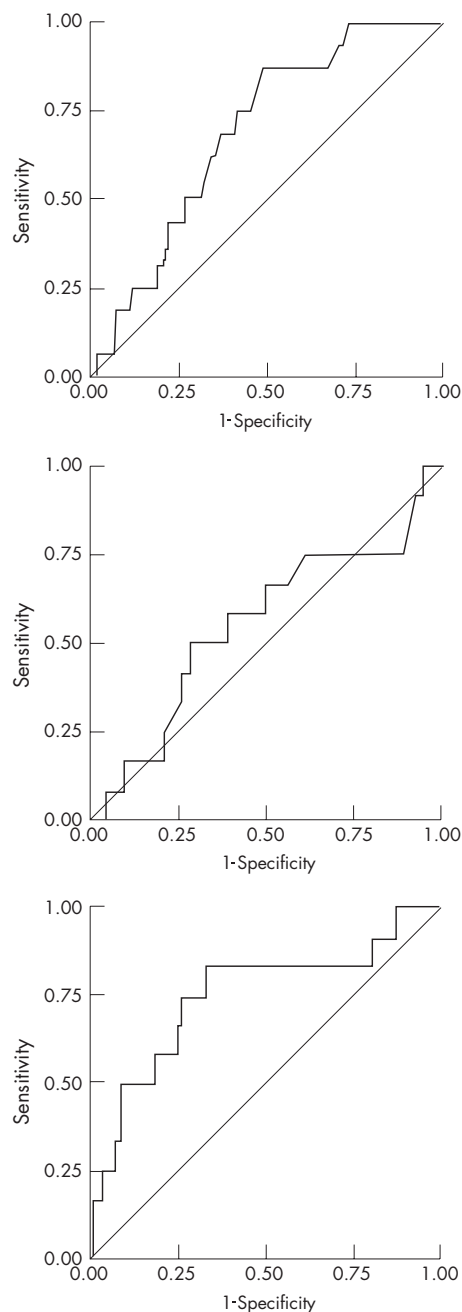


Figure 1 Receiver operating characteristic curves for white blood cells, erythrocyte sedimentation rate and WBC in the joint fluid for septic arthritis.

The upper limit cut-off for jWBC count in the diagnosis of septic arthritis has never been clearly established. Medical folklore and emergency medicine texts have suggested cut-offs of 2000, 10 000 or 50 000.³²⁻³⁴ In our ROC analysis, the jWBC curve makes a turn at jWBC counts of 15 000–20 000 cells/mm³, with 83% sensitivity and 60–67% specificity. The diagnostic cut-off that maximised the combination of sensitivity and specificity was a jWBC count of 17 500 cells/mm³, with a sensitivity of 83% and a specificity of 67%. In comparison with a jWBC cut-off of 50 000 cells/mm³, a jWBC cut-off of 17 500 cells/mm³ improves on sensitivity by sacrificing some specificity. Consequently, a jWBC cut-off of 17 500 cells/mm³ may allow the clinician to rule out a septic joint (LR(–) 0.25, 95% CI 0.07 to 0.89), which is the principal concern of clinicians.

The results of our ROC curve analysis must be interpreted with caution. Although our findings regarding sensitivity, specificity and LRs were consistent with many earlier studies,¹⁻³¹ our findings based on ROC curve analysis may be unique and need to be validated. In our search of the literature, our study may be the first to examine these diagnostic tests in septic arthritis with ROC curve analysis. Thus, our ROC curve results may not be generalisable, given the variations in laboratories and patient populations.

Limitations

- A portion of our sample did not have data on all diagnostic tests. For instance, nearly one third of the sample did not have an ESR data.
- There may be sampling bias in our study as we selected patients using reported arthrocentesis results. Presumably, patients were chosen to undergo arthrocentesis or operative intervention based on clinical suspicion.
- We did not collect data on comorbid illnesses or antibiotic usage, which may be significant variables in the demographics and outcome of our patient population.
- The sample size of the study was relatively small, and it limited our ability to comment on some of our findings with statistical confidence, such as the potential ability of the combined tests to rule out septic arthritis, as evidenced by the wide 95% CI associated with the LR(–) (table 1).
- We used a stringent definition of septic arthritis in our study, and some patients with a possible septic joint may be excluded by our case definition (eg, a patient with positive blood cultures and a hot joint, but negative joint fluid culture).

CONCLUSION

As adjuncts in the diagnosis of septic arthritis, WBC and ESR are poor tests, whereas the jWBC count is a fairly good test. However, none of these tests are perfect, and the clinician should be conservative in approaching the patient with a hot joint.

Authors' affiliations

S F Li, C Cassidy, C Chang, S Gharib, J Torres, Department of Emergency Medicine, Jacobi Medical Center, Bronx, New York, USA

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