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Original article

Ultrasound abnormalities in septic arthritis are associated with functional outcomes

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ABSTRACT

Objectives: To describe the ultrasound abnormalities seen in septic arthritis and to assess their associations with clinical, biological, and radiological outcomes.
Methods: We prospectively included 34 patients with septic arthritis of a native joint (knee, $n=19$; shoulder, $n=6$; hip, $n=4$; ankle, $n=3$; or wrist, $n=2$). Ultrasonography was performed to record synovial-membrane thickness and vascularity, joint effusion, and abnormalities of adjacent soft tissues, at baseline then 4 days, 2 weeks, and 3 months later. Motion-range limitation of the affected joint was evaluated after 3 months. Radiography was performed at inclusion and after 3 months.
Results: Mean age was 63.7 ± 17.6 years. After 3 months, 20 (58.8%) patients had motion-range limitation with worsening of the total radiological score ($P<0.001$). The proportion of patients with synovitis was very high initially (96.4% at baseline, 96.3% after 4 days, and 100% after 2 weeks) then diminished to 77.8% after 3 months ($P=0.051$). Synovial-membrane thickness was significantly higher after 4 days and 2 weeks compared to baseline (median, +17.3% and +20%, respectively; $P=0.015$) and was significantly lower after 3 months compared to the earlier time points (median, −31.5%, $P=0.015$). A positive Doppler signal was common at baseline ($n=18$, 64.3%) then significantly less so after 3 months ($n=7$, 25.9%; $P=0.04$). An unchanged or higher Doppler grade after 2 weeks compared to baseline was associated with motion-range limitation at last follow-up ($P=0.033$).
Conclusion: We report the first study on ultrasound evidence of synovitis, joint effusion, and soft tissue alterations at baseline and over time in patients with septic arthritis. Persistent synovitis and joint effusion 3 months after starting antibiotic therapy was not associated with treatment failure. However, Doppler signal changes over the first 2 weeks were associated with the 3-month functional outcome.

1. Introduction

Septic arthritis is a severe life- and function-threatening condition with a 1-year mortality rate of up to 10% and residual functional impairments in 30 to 50% of cases [1–3]. The incidence of septic arthritis is low, with only 4–10 new diagnoses per 10,000 population in Europe. Imaging studies contribute crucially to the optimal management of septic arthritis, thereby diminishing the risk of permanent functional loss. At present, magnetic resonance imaging (MRI) is the most informative method. Thus, MRI assesses the severity of the synovitis and can detect a joint effusion, bone and/or cartilage destruction, an abscess, and/or bone edema. MRI had 75% specificity and nearly 100% sensitivity for diagnosing concomitant abscess formation, cellulitis, or myositis [4,5]. No sign is diagnostic, however, and even the joint effusion may be lacking, particularly in small joints [6]. The signs most closely associated with treatment efficacy in several studies were the size of the joint effusion and the presence of an abscess. Synovial-membrane thickening, cellulitis, and bone edema may persist even after eradication of the infection [7]. Disadvantages of MRI are high cost and limited availability on an emergency basis in some settings.

Ultrasonography of the bone and joints has been developing at a fast pace in recent years. Rheumatologists now receive training in ultrasonography, which has become an integral part of their diagnostic armamentarium. Ultrasonography is currently used in the management of septic arthritis to confirm the presence of a joint

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effusion and to guide the joint aspiration or synovial biopsy, particularly when the effusion is small or the joint deep (e.g., hip). Ultrasonography has high sensitivity and specificity for joint effusions. Nevertheless, the contribution of ultrasonography to the management of acute arthritis has been assessed only in a pediatric study of hip arthritis, in which normal ultrasound findings made a diagnosis of septic arthritis highly unlikely [8]. In addition, ultrasonography offers higher resolution compared to the 1-mm resolution of MRI. The usefulness of ultrasonography is probably underestimated. In our experience with inflammatory joint disease, ultrasonography performs as well as MRI for assessing the size of the joint effusion, severity of the synovitis, and presence of bone and cartilage destruction. Advantages of ultrasonography are simplicity, ready availability, absence of radiation, low cost, and feasibility at the bedside. Ultrasonography should prove particularly helpful given that the synovial pannus correlates with the functional outcome.

The primary objective of this study was to describe the ultrasound abnormalities seen in patients with septic arthritis. We evaluated synovial-membrane thickness and vascularity; presence of a joint effusion, loculation, and/or erosions; and involvement of the adjacent soft tissues (muscle abscess and/or cellulitis) at baseline then after 4 days, 2 weeks, and 3 months. The secondary objective was to look for associations linking these ultrasound abnormalities to the clinical, biological, and ultrasonographic outcomes.

2. Methods

2.1. Patient selection

A multicenter prospective, descriptive, and exploratory study was conducted in adults with septic arthritis of the shoulder, elbow, wrist, hip, knee, or ankle. The patients were recruited between January 2014 and July 2015 at the rheumatology, infectious diseases, and orthopedic surgery departments of three centers in France (in Nantes, la Roche-sur-Yon, and Saint-Nazaire, respectively).

The diagnosis of septic arthritis relied either on positive joint-fluid or blood-sample cultures or, when cultures were negative, on suggestive histological and/or radiological findings combined with inflammatory properties of the joint fluid. Exclusion criteria were one or more implants within the joint, age younger than 18 years, guardianship, and pregnancy. In each center, standard management protocols were followed. Antibiotics were given routinely and surgery was performed as dictated by local practice. The ultrasound findings were not used to guide treatment decisions. At baseline, patients received clear appropriate information and were asked to state that they had no objections to the study. Approval was obtained from the appropriate ethics committee before study initiation.

2.2. Clinical assessment at baseline and during follow-up

The study follow-up was 3 months, with visits at baseline (when antibiotic therapy was started) then 4 days, 2 weeks, and 3 months later. At each visit, the patients completed a visual analog scale (VAS) for pain. Characteristics of the patients, antibiotic treatment, and surgical treatment were collected at each visit. At the 3-month visit, joint range of motion was measured and the Short Form-36 (SF-6) was completed [9].

2.3. Ultrasound assessment at baseline and during follow-up

The ultrasound examinations were performed by 7 radiologists, with 2 to 7 years of experience. Three ultrasound machines were used: Esaote My Lab 70, Philips, and GE Healthcare Logic. Frequency and pulse repetition frequency were adjusted to the depth of the joint. Standardized slice planes were defined for each joint by consensus during the study implementation meeting held with the 7 radiologists [10,11]: hip: anterior longitudinal; knee: suprapatellar longitudinal and medial and lateral suprapatellar transverse; ankle: longitudinal through the talocrural joint; shoulder: posterior transverse and anterior longitudinal; wrist: transverse through the distal radioulnar joint and longitudinal through the radiocarpal joint.

Ultrasonography of the affected joint was performed at all four time points (baseline, 4 days, 2 weeks, and 3 months. At each ultrasound examination, the data listed below were recorded:

- evidence of synovitis, defined as an abnormal intraarticular zone, of low echogenicity compared to the subcutaneous fat, which could not be displaced and was not substantially affected by compression [12], with or without high signal by power Doppler;
- greatest synovial-membrane thickness, in millimeters, defined as the thickness of the hypoechoic zone after compression to expel the fluid seen as an anechoic zone; starting in the plane of reference for the joint being examined, the probe was displaced to identify the point of maximal synovial thickness; for joints with more than one plane of reference (shoulder, wrist, and knee), the greatest synovial thickness value was recorded;
- percentage change in synovial thickness after 4 days, 2 weeks, and 3 months compared to baseline in each patient;
- presence of a Doppler signal from the synovial membrane, with its grade (0–3) and changes over time versus baseline in each patient;
- evidence of a joint effusion defined as an abnormal intraarticular zone that was hypoechoic (compared to the subcutaneous fat) or anechoic, displaceable, affected by compression, and not the site of a power Doppler signal;
- presence of erosions and intraarticular loculation;
- soft tissue involvement: cellulitis and/or muscle abscess

2.4. Radiographic assessment at baseline and after 3 months

Radiographs of the affected joint were taken at baseline and after 3 months. Grading of joint-space-narrowing and erosions was according to the Sharp score as modified by van der Heijde [13]. The grades for joint-space-narrowing were:

- 0: normal;
- 1: focal or doubtful narrowing;
- 2: narrowing over less than 50% of the joint space;
- 3: narrowing over more than 50% of the joint space;
- 4: ankylosis.

The grades for erosions were:

- 0: none;
- 1: small;
- 2: large but not extending beyond an imaginary line separating the bone into two halves;
- 3: large and extending beyond an imaginary line separating the bone into two halves;
- 4: involvement of half the bone;
- 5: collapse.

2.5. Statistics

Qualitative variables were described as *n* (%) and quantitative variables as mean ± SD. Quantitative variables were compared by applying the *t* test for paired data if normally distributed and the Wilcoxon test otherwise. Friedman ANOVA was used for comparisons of several median values and Fisher's test for comparisons