Original Investigations

Comparison Between Dual-Energy Computed Tomography and Ultrasound in the Diagnosis of Gout of Various Joints

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Rationale and Objectives: Dual-energy computed tomography (DECT) and ultrasound are both used to assess gouty arthritis. The present study was designed to compare the diagnostic accuracy of DECT and ultrasound in detecting monosodium urate (MSU) crystal deposition in various joints.

Materials and Methods: This study enrolled 40 patients diagnosed with acute gouty arthritis. All affected and contralateral joints were scanned (128 in total) using both DECT and ultrasound to determine the MSU deposition in upper limbs (wrist and elbow) and lower limbs (the first metatarsophalangeal joints, ankles, and knee). The MSU crystal accumulation detected by each method was compared for various joints.

Results: The 128 scanned joints included 52 of the upper limbs and 76 of the lower limbs. For the upper limbs, the percentage of MSU crystal accumulation detected by DECT (22/52, 42.3%) was significantly higher than that by ultrasound (10/52, 19.2%; *P* = .0027). The detection rates of the two methods for the lower limbs were similar (*P* = .3173).

Conclusions: For detection of MSU crystal deposition in the upper limb joints, DECT was superior to ultrasound, whereas there was no difference between the two methods for the lower limbs. Therefore, ultrasound can be used for primary screening, and DECT afterward. Although the modalities are similar in making the initial diagnosis, DECT is far superior at displaying the anatomic extent of the disease.

Key Words: Gout; gouty arthritis; dual-energy CT; ultrasound.

Gouty arthritis (gout) is a form of inflammatory arthritis, most prevalent among middle-aged to elderly men and postmenopausal women. It is characterized by abnormal purine metabolism, hyperuricemia, and subsequent abnormal deposition of monosodium urate (MSU) crystals (1). The incidence of gout is increasing; the number of cases increased by approximately two per 1000 during the 10-year period between 1990 and 1999 (2). The disease affects about 3.9% of the population in the United States and 1.4% of the population in the United Kingdom and Germany (3,4). Although the prevalence is relatively low in China (reportedly 1.14%) (5), the country still suffers a significant disease burden because of its large population.

The pathogenesis of gout remains to be elucidated. Long-term deposition of MSU crystals in the joints leads to damage to articular cartilage and bone (6,7) and may result in organ dysfunction, especially renal impairment and cardiac diseases (8,9). Clinical outcomes can be severe, limiting daily activity and impairing the quality of life of gout patients.

The diagnosis of gout largely depends on clinical manifestations and laboratory tests. When a patient presents with podagra (gout of the big toe) or acute monoarticular arthritis at the extremities with increasing serum uric acid, a diagnosis of gout is clear. However, in most acute gout cases, tophi (MSU crystal deposits under the skin) may not be found and some patients show normal serum uric acid. Moreover, hyperuricemia does not necessarily imply gout. Thus, a clinical manifestation may not be sufficient for a definitive diagnosis of gout. There is an urgent need for a reliable diagnostic technique in the clinic.

MSU crystals in articular tophi can be detected using a variety of methods such as polarized microscopy, x-ray examination, computed tomography, and magnetic resonance

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imaging. However, each of these techniques suffers from certain limitations that influence the accuracy of the diagnosis. For example, the polarized microscope necessitates an invasive biopsy, and its true-positive rate is suboptimal (4). X-ray and computed tomography images can reveal joint erosions and larger tophi but not microcrystals at the early stage of the disease, and their sensitivity is relatively low (10,11). Although better results can be obtained using magnetic resonance imaging, with clear visualization of synovial changes, articular impairment, and tophi size, its specificity is low and its routine application is still limited because of its high cost (12).

Recently, ultrasound and dual-energy computed tomography (DECT) have gained substantial interest in the field of gout diagnosis for their accuracy and sensitivity in assessing MSU crystals (13–16). Various hyperechoic enhancements in ultrasound can help reveal MSU crystal deposition in articular cavities. Typical ultrasound findings include the double-contour sign, which indicates crystal deposition on the cartilage surface, the starry sky sign caused by crystal accumulation in synovial fluid, and mixed echogenicity signals from tophi within the articular cavity and surrounding soft tissues (14,17,18). DECT uses two x-ray tubes with different energies simultaneously during a single acquisition. The material-specific differences in attenuation between the two x-ray energies help classify the chemical composition of the object (19,20), and the differences in energy absorption properties of MSU crystals, bone, and soft tissue are easily identified in DECT images. Researchers have also demonstrated DECT's superiority in assessing crystal deposits, tophus volume, and articular impairment compared to other methods (21).

DECT is capable of identifying lesions in complicated anatomic structures and small crystals, but ultrasound is comparable in terms of diagnostic sensitivity. Moreover, ultrasound is favored over DECT because of the radiation exposure and higher cost associated with the latter (4,22). Although there are reports on the differential diagnostic sensitivity for gout between the two methods (23), no study on different joints has been reported. To the best of our knowledge, no studies have been published that compare the diagnostic accuracy of DECT and ultrasound in detecting MSU crystal deposition in various joints. Such a study would offer valuable guidance for selecting the method of imaging in clinical practice. In the present study, we compared the accuracy of DECT to that of ultrasound in detecting MSU crystals in the upper and lower extremities of patients with suspected gout.

MATERIALS AND METHODS

Patients

The present study was reviewed and approved by the Institutional Review Board of local Hospital. We prospectively enrolled patients who had received diagnoses of acute gouty arthritis in our hospital from 2012 to 2013, and all patients provided written informed consent before participating in this study.

A diagnosis of acute arthritis of primary gout (eg, joint swelling, acute pain, and skin temperature increase) was confirmed when at least six of the 12 criteria of the American College of Rheumatology were satisfied (24), and at least one of the involved joints was attacked within the previous 2 weeks. Gout was confirmed as the presence of urate deposition by polarization microscope or surgical pathology. Patients with other joint diseases that may be associated with gout, such as psoriatic arthritis and infected arthritis, were excluded. The area to be scanned was determined based on the location of acute arthritis. All joints were assessed bilaterally. Patients presenting macroscopic tophi at the scanned joints were excluded from the study.

When the attack occurred at the toe or ankle, the first metatarsophalangeal (MTP) joint and ankle were both evaluated. When the attack occurred at the wrist, the radiocarpal and carpometacarpal joints were assessed. The corresponding joints were evaluated when the attack occurred at the knee or elbow.

Dual-energy computed tomography

DECT was performed using a Somatom Definition Flashv DECT scanner (Siemens Healthcare, Erlangen, Germany). All patients were scanned in supine position. The acquisition parameters were tube A, 140 kVp/70 mAs; tube B, 80 kVp/300 mAs; collimator, 64 × 0.6 mm; gantry rotation time, 0.5 seconds; pitch, 0.7; and reconstruction slice thickness, 1 mm with 0.7 mm spacing. The images were analyzed using Siemens Syngo Dual Energy software (Siemens Healthcare). The software used color-coding to display different objects, characterized by the density measurements at the two x-ray energy levels. The MSU crystals are displayed in green (Fig 1). The DECT images were evaluated independently by two radiologists blinded to the ultrasound results. The DECT was recorded as positive if MSU crystal deposition was detected at the scanned joints.

Ultrasound

A physician with expertise and experience in musculoskeletal ultrasound performed the ultrasounds for all the patients using a MyLab30 VET (Esaote, Milan, Italy) with a 4–13 MHz probe for the knees and a 10–18 MHz probe for wrists, elbows, ankles, and MTP. The ultrasound scans were performed within 24 hours of the DECT scans, and the scanned locations were the same as those for DECT. The images that showed either the double-contour sign or abnormal intra-articular inhomogeneous material with a cloudy appearance (Fig 2a and b) were further evaluated by two independent physicians blinded to the DECT results. Final ultrasound results were