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CONTINUING EDUCATION

DUAL ENERGY CT: ADDED VALUE IN GOUTY ARTHRITIS*

J. Spermon, C.F. Van Dijke[1]

Gouty arthritis is an inflammatory reaction as a result of monosodium urate crystal deposition in synovial fluid and periarticular soft tissue. It is the most common form of inflammatory arthritis with an estimated prevalence of 5 per 1000 in the USA. Clinical diagnosis is difficult and definite diagnosis with positive urate crystal aspiration often is made late in the disease process. Dual energy computer tomography (DECT) is a relative new non-invasive imaging modality that is able to distinguish urate crystals from calcium in soft tissue and synovial fluid. In this case report we describe the potential of DECT in gout by clarifying the technical background and present two cases in which DECT confirms the clinical diagnosis and shows the extend of the disease. Although more extensive studies should be done to validate DECT in diagnosing gout, the preliminary results in diagnosing gout, determining the extensiveness and monitoring therapy are promising.

Key-word: Gout.

Gout is the most common form of inflammatory arthritis. In about 90% it presents as monoarticular arthritis, often starting at the first metatarsophalangeal joint. Four gradually stages of gout can be distinguished: first of all asymptomatic hyperuricemia, then the first presentation of acute gouty arthritis with clinical symptoms of pain and swelling. This is followed by intercritical gout with interval attacks and when left untreated it finally leads to chronic tophaceous gout with permanent joint damage and sometimes even kidney failure.

Incidence rates are estimated to 5 per 1000 in the US (1). This makes gout the most common form of inflammatory arthritis in adult men. The prevalence of gout is much higher in men, with peak prevalence beyond the 4th decade, than in women, who develop gout mainly in the postmenopausal period.

In this case report we present two cases of gout in which DECT had a crucial role in diagnosing gout and showing the extend of the disease. The basic technical principles of DECT are outlined and the practical usefulness of DECT is presented.

Gout is a disease that occurs as a response to monosodium urate crystals deposition in periarticular soft tissue, joints and subchondral bone with secondary destruction of joints and bones. Hyperuricemia is the underlying cause, in 80-90% this is due to high level of uric acid renal reabsorption. Ultimately, a period of elevated serum uric acid leads to crystallization in the form of monosodium urate (ionized extracellular uric acid). Crystal deposition in joints leads to an inflammation reaction with secondary bone lesions, periarticular soft tissue deposits results in inflamed granulomatous tissue, eventually forming tophi. In extended disease tophi can be found in kidney and even heart valves (2).

Although gout is a result of hyperuricemia, only a small percentage of patients with high levels of uric acid develop the disease. Moreover, patients with clinical acute arthritis without having gout can be presented with hyperuricemia (3).

To date, visualizing urate crystals in synovial fluid by polarizing microscopy is the gold standard (4). However, crystals are frequently found in synovial fluid from their uninflamed -and thus clinically difficult to examine- joints (5). Moreover, it has been shown that on initial examination of synovial fluid in patients with acute gout, urate crystals can be absent (6). An explanation could be that in some cases the inflammation starts with deposition of urate crystals in the periarticular soft tissue instead of synovium fluid. With a sensitivity of 85%, the reliability of the analyses has been questioned (7, 8).

Imaging modalities like ultrasound, MRI and CT can be of additional value in clinical suspected gout, but are not sufficient to differentiate gout from clinical similar diseases like rheumatic arthritis or pseudo gout (9). Unlike the standard imaging modalities, which demonstrate the anatomic structures, DECT, a relatively new modality, is able to demonstrate uric acid crystals in synovial fluid and periarticular tissue.

Material end methods

Dual energy CT (DECT)

Tissue attenuation depends on the level of X-ray absorption during CT scanning. Absorption of X-ray depends on photon energy from defined kV of the X-ray beam and the atomic number of the exposed tissue. Attenuation of tissue with different atomic numbers has a different energy dependence. Changing the kV setting results in an alteration of photon energy and a corresponding attenuation modification of the tissue that is scanned. However tissue attenuation not only will change by altering kV settings, it also depends on the tissue that is scanned due to difference in photoelectric effect (10).

DECT from Siemens – SOMATOM definition flash® – uses two energy different X-ray sources, 80-140 kV, running simultaneously. Tissue with a high atomic number shows a higher attenuation change between 80 kV and 140 kV compared to tissue with lower atomic number. The provided attenuation data are loaded in post processing software. In gout post processing protocol soft tissue is

From: 1. Department of Radiology, Alkmaar Medical Centre, Alkmaar, The Netherlands. *Address of correspondence:* Drs J. Spermon, resident radiology, M.D., Arthur van Schendelstraat 153, NL-3511 MB Utrecht, The Netherlands. E-mail: j.spermon@mca.nl
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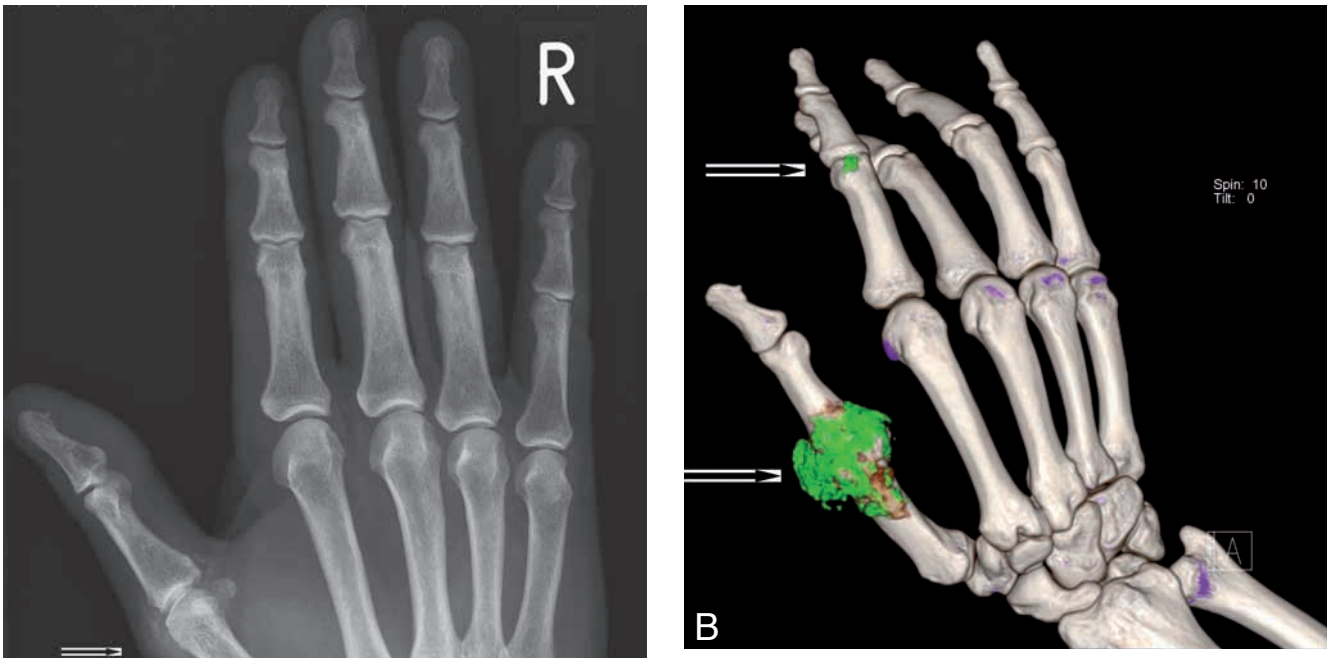


Fig. 1. — Gout right hand. A. Radiograph showing non-calcified soft tissue mass at the MCP-1 joint without any osseous changes. B. DECT demonstrating large deposition of uric acid crystals at MCP-I and small deposition PIP digit 2 (uric acid crystals in green).

used as baseline to differentiate uric acid crystals form calcium. Calcium is made out of elements with high atomic numbers and therefore show high attenuation difference, while uric acid crystals are made of elements with low atomic numbers (H,C,N,O) thus showing low attenuation difference. The results are then plotted in a figure, showing tissue with high attenuation difference above the soft-tissue baseline and tissue with low attenuation difference below this line.

Scan parameters in our institution are: 1 sec rotation time and 0,7 pitch, two tubes (80 kV-250 mAs; 140 kV-125 mAs), collimation 40 × 0,6 2 mm thickness with 2 mm increment reconstructed to 0,75 mm with 0,4 increment. After reconstruction three series of data are given (80 kV, 140 kV and mixed 50/50%), the latter only for viewing purposes.

Results

Case 1

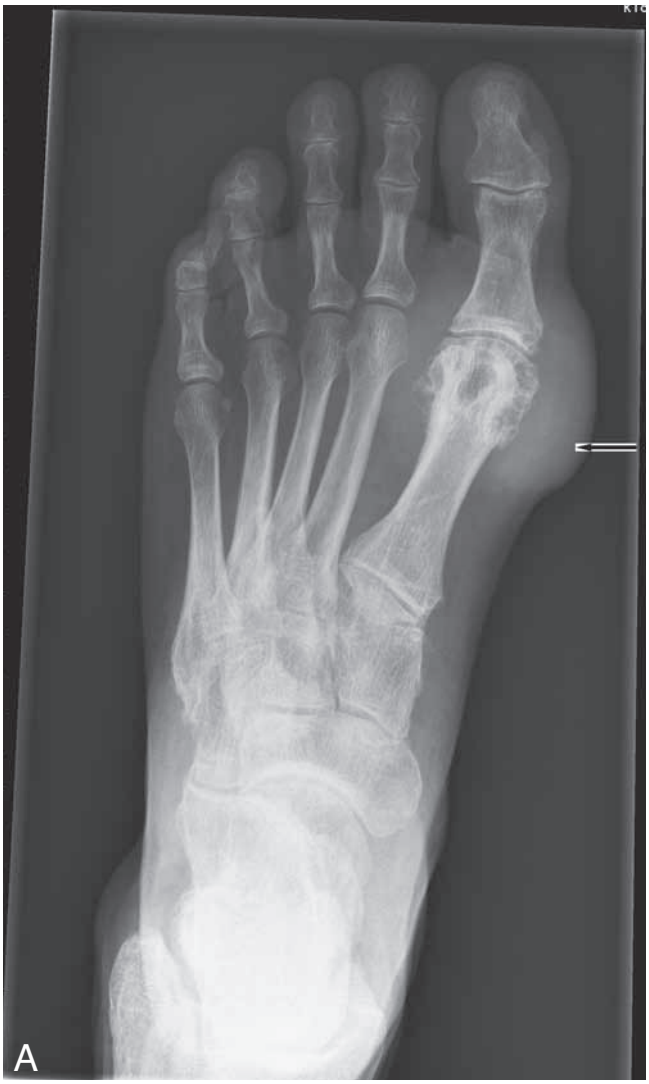
65-year-old male without history of arthritis presented at the emergency department with a swollen right thumb due to a progressive mass at the metatarsophalangeal joint. Medical history reveals hypercholesterolemia, high intake of purine and alcohol. Laboratorial analyses revealed normal uric acid level of 0.4mmol/l. Radiograph of the right hand showed a non-calcified soft tissue mass at the MCP-1 joint without any osseous changes (Fig. 1A). DECT revealed evident deposition of uric acid crystals at the MCP-1 as well as at the PIP digit 2 (Fig. 1B). Aspiration of joint fluid demonstrated uric acid crystals, no bacterial species were identified.

Case 2

58-year-old male with a previous gout attack in 2006, suffering several years of painful swollen toes of the feet and hand. He was presented at the rheumatologist office with a right foot that had been painful for several weeks, especially the second and third digits. At physical examinations a large palpable mass of 5 to 3 cm at the MTP joint of both feet was observed. On clinical grounds the diagnosis of recurrent gout was made. Radiograph of the right foot showed erosive changes of the bone of the MTP-1 with a large soft tissue mass (Fig. 2A). DECT was performed to determine the extensiveness of the gout which displayed a large deposition of uric acid crystals at MTP-1, but, though smaller, also at the PIP and DIP of digit 1,2, 3 and 5 and also at the ankle joint (Fig. 2B, uric acid depositions in green). No blood samples were analyzed, but aspiration of the tophi demonstrated uric acid crystals, which confirmed the diagnosis.

Discussion

Definite and early diagnosis of gout is obligatory not only to exclude



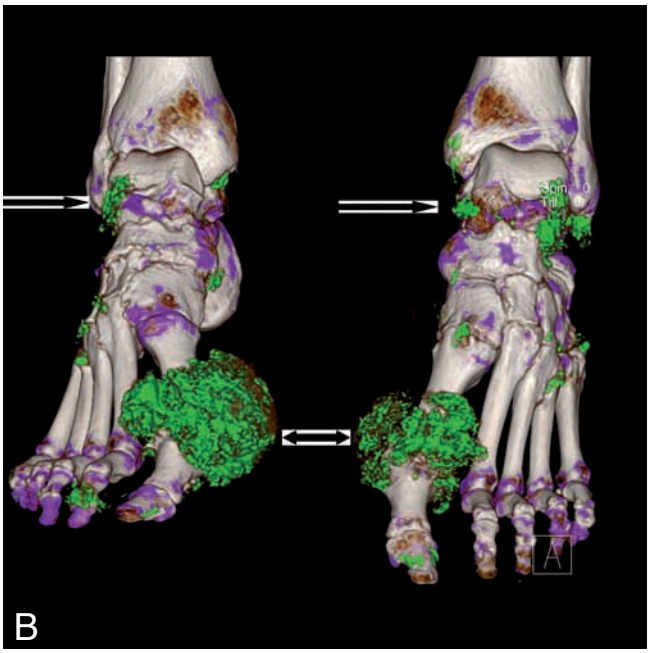


Fig. 2. — Extended gout of both feet and ankles. A. Radiograph showing erosive changes with soft tissue mass at MTP-I left foot. B. DECT revealing extensive gouty disease with multiple depositions of uric acid crystals in both feet and ankles (uric acid crystals in green).

alternative diagnosis but also to start with the necessary medication in the earliest stage of the disease in order to prevent serious side effects of the possibly wrong medications and functional impairment of gouty arthritis and tophy. To date, demonstrating uric acid crystals in synovial fluid or topheous tissue is the gold standard in the diagnosis of gout disease. However, more extensive studies should be performed to determine the reliability of the synovial analysis. Besides, one should be skilled at joint aspiration because demonstrating of uric acid crystals in synovial fluid can be challenging and not always feasible (11).

In this case report we demonstrated the potential additional value of a non-invasive imaging modality-to display uric acid crystals in joints and surrounding soft tissue as well as the extent of the gouty arthritis. Untreated patients with nonproven gout will almost all have uric acid crystals during the intercritical period in previously inflamed joints (12). In this context DECT could have a beneficial value evaluating uric acid crystal depositions before clinical symptoms are apparent and even been used for late establishment of the diagnosis.

Chronic hyperuricemia can lead to uric acid stones in the urinary tract resulting in nephrolithiasis. Additionally, uric acid crystal deposition can be found in renal medullary interstitium forming tophi and eventually, though rare, this may lead to chronic urate nephropathy (13). DECT is able to distinguish gouty nephrolithiasis from other forms of nephrolithiasis and also to identify renal (micro-)tophy before nephropathy is apparent (14).

Tophus regression is considered mandatory in the treatment of gout, but despite adequate treatment tophi still can contribute to chrondolysis (15). Monitoring of therapy effect on tophi number and volume would be worthwhile and different methods of tophus assessment have been reviewed (16). Using DECT for quantification of tophi is possible and has been reported (17, 18).

Extensive studies should be performed to assess the reliability of this relatively new imaging to diagnose gout. Recent attempts to study the diagnostic accuracy have recently been published. In a retrospective study 31 patients were selected and a total accuracy of DECT versus aspiration proved to be 94%. However sample size was small and selection bias appeared to be a real limitation of study (19). As this study shows, radiologists should be trained to learn about the artifacts in order to maximize the observer reliability. But of the most importance should be to determine the cutoff point for the detection of uric acid crystals by DECT before extensive prospective studies are performed. In a recent published prospective validation study 6 out of 40 (15%) proven gout patients had false negative scans, potentially due to urine lowering therapy (20).

How about the radiation dose? When scanning two peripheral joints in our institution the amount of

radiation did not exceed the 0,5 mSv pro person – in contrast, an average person in the U.S. receives an effective dose of about 3 mSv. This is in agreement with recent published data (20).

Finally, with future research one should take into account the cost-benefit ratio of DECT in gouty arthritis.

Conclusion

DECT is a promising non-invasive imaging modality that can be applied in the diagnosis of acute and intercritical gout and to determine the extent of the disease, but could also play a role in monitoring the disease in treated patients and evaluating nephrogenic complications. However, more and extensive research should be performed to determine the reliability, accuracy and cost-benefit ratio of DECT in gouty arthritis.

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