Crystal-Associated Synovitis – Ultrasonographic Feature and Clinical Correlation

Danela Fodor\textsuperscript{1(A,B,C,D,E,F)}, Adriana Albu\textsuperscript{1(A,B,C,D,E,F)}, Claudia Gherman\textsuperscript{2(A,B,C,D,E,F)}

\textsuperscript{1} 2\textsuperscript{nd} Internal Medicine and Rheumatology Department, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania
\textsuperscript{2} 2\textsuperscript{nd} Surgical Department, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania

SUMMARY

The aim of this paper is to describe the ultrasonographic findings in rheumatologic pathology due to crystal deposition. There are four main types of crystals involved: monosodium urate, calcium pyrophosphate dihydrate, basic calcium phosphate (hydroxyapatite), and calcium oxalate.

In gout the joint fluid is anechoic only at the first gouty attack; afterwards the synovium begins to proliferate. Double contour sign, a focal or diffuse enhancement of the superficial margin of the articular cartilage is a specific finding. Bursitis has chronic features from the beginning. The ultrasonographic aspect of tophi depends on their age and size (at first small, hypoechoic and homogenous nodules, then echoic with hyperechoic edges and finally pseudotumoral, inhomogeneous). The depositions in the superficial layer are hyperechoic, well delimited only in the absence of inflammatory reaction. The depositions at the enthesal level are leading to the gouty enthesopathy. In knee involvement irregularities of the anterior surface of patella are found.

In chondrocalcinosis the most important ultrasonographic signs are the thin hyperechoic band, parallel to the surface of the hyaline cartilage and the punctuated pattern of the fibrocartilage.

In hydroxyapatite associated disease, calcifications are frequent in the shoulder or in the great trochanter of the hip, with aspects depending of the calcification phase. Milwaukee shoulder is an advanced form of this pathology, associated with rotator cuff arthropathy.

Oxalate crystal deposition disease is seen rarely, in patients with primary hyperoxaluria and in patients with end-stage renal disease.

Therefore ultrasonography is useful in characterize the articular and juxta-articular alterations in crystal related diseases.

Key words: locomotor system, joint diseases, diagnostics
BACKGROUND

Musculoskeletal ultrasonography (US) is a rapidly evolving technique that is gaining popularity in the evaluation and treatment of joint and soft-tissue disease. US has a number of advantages which makes it attractive as an imaging tool: accessibility, lack of radiation exposure, low cost, short scanning time, ability to perform dynamic real-time examination and, very important, is a patient friendly technique. In rheumatology US has two main roles, being used both for diagnostic and therapeutic procedures (fluid collection aspiration, corticosteroid injections, needle biopsy). Today US is consider as an extension diagnostic fingers for the rheumatologist, an extension of physical examination and thus an important part of the equipment for each rheumatology department.

One of the most frequent situations that a rheumatologist is confronted with in daily practice is the crystal deposition pathology. The types of crystals associated with joint disease include monosodium urate, calcium pyrophosphate dihydrate, basic calcium phosphate (including hydroxyapatite), and calcium oxalate. The attacks of acute arthritis are the characteristic clinical manifestations. These attacks of articular inflammation are one of the most painful situations in rheumatology. In time, repetitive episodes produce a chronic arthropathy with important destructive lesions in articular or juxta-articular spaces [1,2,3].

GOUT

Gout is a term representing a heterogeneous group of diseases found exclusively in humans, characterized by long time increasing of serum urate concentration resulting into tissular deposition of sodium urate monohydrate (SUM). The crystals of SUM are demonstrable in and around the joints (cartilage, epiphyses, synovial membrane, tendons or ligaments). These aggregated deposits produce local necrosis and, excepting for the avascular tissues, the inflammatory response can lead to a fibrous proliferation [1].

The positive diagnosis of gout is possible only after the evidence of intracellular SUM crystals in leukocytes from synovial fluid or inside tophi. The most important imaging examination is radiology, which can identify bony erosions, soft tissue swelling and soft tissue densities due to the tophi. Computed tomography and magnetic resonance imaging have been used in a few studies [4,5] for tophi evaluation or for the study of enthesopathy, but these methods cannot be used as routine examinations. Ultrasonography is the first imaging technique for kidney evaluation in gouty patients. The usefulness of the method in the characterization of articular and juxtaarticular involvement is not clearly defined but in a recent paper the authors demonstrated that ultrasonography is able to detect more erosions than x-ray in the first metatarsophalangeal joint [6].

The pathological findings that can be ultrasonographically identified in gout are joint effusions, erosions, bursitis, enthesopathies and tophi.

Intraarticular fluid is strictly anechoic (simple joint effusion) only at the first gouty attack of the joint (Fig. 1). From the second attack the synovium begins to proliferate in a small, medium or high degree depending on the joint involved and the intensity of the attack (Fig. 2). The intraarticular fluid becomes hypoechoic (old collection with inflammatory pattern and numerous SUM crystals) and frequently hyperechoic spots (less than 1 mm) are seen.
inside the effusion (Fig. 3). In the cases evolving for more than 10 years, the entire joint cavity is filled with proliferated synovium. The proliferation does not have a specific character – unlike the patterns described in rheumatoid arthritis [7], for instance. In cases with SUM deposition in the cartilage, the double contour sign is frequent encountered, a focal or diffuse enhancement of the superficial margin of the articular cartilage, with reflectivity independent of angulations of the ultrasound beam [6] (Fig. 4). The bone erosions (Fig. 5), step-down lesions in the bone contour, detectable in at least two perpendicular plans, are positive correlated with the numbers of gout attacks [6].

At the level of periarticular bursae (prepatellar, olecranon, pes anserine) the bursitis has chronic features of inflammation from the beginning. The walls are thick, poorly delimited from the surrounding tissues and the cavity is always filled with proliferated synovia (Fig 5). There is not a good correlation with the adjacent joint involvement. Peritendinous bursae (infrapatellar, preachillian) are inflamed only in cases of concomitant tendon pathology.

The popliteal cysts (Baker's cysts) can be detected in more than half of the patients with knee involvement. They are typically located around the medial head of gastrocnemius muscle. Most of the cysts are small, under 5 cm, with or without proliferated synovia; in this setting, complications are rare (Fig. 7). Because some of the patients, especially the elderly ones, also have knee osteoarthritis, the differential diagnosis between gouty or degenerative cyst can only be made by searching for SUM crystals in the cystic fluid.
Fig. 4. Longitudinal US of the medial femoral condyl: increase hyperechoic interface between cartilage – joint space (double contour sign)

Fig. 5. Bone erosion on the metatarsal head (arrow)

Fig. 6. Prepatellar bursitis filled with proliferate synovium
Tophaceous deposits become clinically apparent after a variable number of gout attacks. By ultrasonography the early detection is possible and an efficient therapeutic intervention could be started. The tophi have an ultrasonographical aspect depending on their age and size. At the very beginning the tophi are nodular, small, hypoechoic and homogenous structures – soft tophi (Fig. 8). As they grow up they become more echogenic, with hyperechoic edges and well differentiated from the surrounding tissues, but still homogenous (Fig. 9). They can dislocate the normal structures of the area (Fig 10) or even compress them (tendons, vessels, nerves, bone). For example there are cases with carpal tunnel syndrome caused by tophaceous gout [8]. In this stage a clear differentiation from rheumatoid nodules is difficult [4]. After years the tophi could gain a pseudotumoral form and become dishomogenous - hard or mixed tophi (Fig. 11), even with calcification foci. An hypoechoic halo can appear if there is an inflammatory reaction around the tophus (clinically easy to detect). Intraindivious tophi (Fig 12) can be found more frequently inside the patellar and Achilles tendons. They are hypoechoic and dishomogenous, producing focal alteration of the fibrillar structure of the tendon and generating a posterior shadow. These lesions are minimal resistance areas and spontaneous tears can occur [9].

The deposition of SUM in the superficial layers of the skin creates macroscopically a yellow deposit with a discreet bulge of the skin surface. By ultrasonography this deposition appears as a hyperechoic structure, with a clear contour, without disturbing the normal surrounding structures (Fig 13). When there
Fig. 9. Echogenic and homogenous tophus near first MTF joint

Fig. 10. Tophus (between arrows) near MTF I dislocating extensor digitorum longus tendon (arrowhead)

Fig. 11. Pseudotumoral tophus near elbow
is an inflammatory reaction around, the deposit be-
come hypoechoic, with flu limits and posterior sha-
dow (Fig. 14).

In gout the SUM crystals can also aggregate at
the insertion of the tendons or ligaments (enthesis)
leading to the gouty enthesopathy (Fig. 15). This can
occur at any level, but is more frequently found
around patella, (in the superior part, at quadriceps
tendon insertion and in the inferior part, at patellar
tendon insertion) and around calcaneus (at Achilles
tendon and plantar fascia insertions). Irregularities of
bone surface are discreet, but tendon alterations
(thickness, fibrillar structure disorganisation, focal hy-
poechogenities, irregular borders) are obvious. These
findings are encountered only in chronic tophaceous
gout.

Apart from alteration due to enthesopathy, the
patella can often have irregularities of the anterior
surface in the absence of tophi (Fig. 16). Osteolytic
lesion or intrapatellar tophi were described in the
radiological literature but these are unusual findings
[10]. Possibly the fact that the patella is included
between the quadriceps tendon fibers (which pass
either anteriorly or laterally, continuing with the pa-
tellar tendon) and the presence of prepatellar bursa,
frequently inflamed, may partly explain this alteration.

CALCIUM PYROPHOSPHATE
DIHIDRAT CRYSTAL DEPOSITION
DISEASE
Calcium pyrophosphate dihidrat (CPPD) is prob-
ably the most common intrinsic crystal to be associ-
Fig. 14. Deposition of SUM in the skin with inflammatory reaction

Fig. 15. Enthesopathy at the superior insertion of the patellar tendon

Fig. 16. Irregularities of the anterior surface of the patella
ated with arthropathy in clinical practice. CPPD crystal deposition is confined to hyaline cartilage, fibrocartilage (chondrocalcinosis) and areas of chondroid metaplasia (i.e., degenerated areas of tendons, ligaments, and joint capsule) within the joint. Shedding of these crystals into the joint space may trigger an acute inflammatory arthritis, known as pseudo-gout. The knee is the most common site followed by wrist, shoulder, ankle and elbow [2,3].

In the acute attacks of the disease the ultrasonographic findings are similar with the first gout attack. In time CPPD calcification appear as hyperechoic deposit with different patterns. The crystal deposition in the cartilage (frequently observed in the femoral cartilage of the knee) is found as a thin hyperechoic band, parallel to the surface of the hyaline cartilage (Fig. 17). In the menisci or in the triangular fibrocartilage of the wrist there is a punctuated pattern (Fig. 18), composed of several thin hyperechoic spots [11]. There are rare reports of extra-articular CPPD deposition or tophus-like deposits [12] and periarticular inflammation like tendinitis, bursitis or tophi are uncommon presentations. The chronic pyrophosphate arthropathy appears, occasionally severely destructive.

**BASIC CALCIUM PHOSPHATE CRYSTAL DEPOSITION DISEASE**

In response to basic calcium phosphate deposition, most frequently hydroxyapatite (HA), acute, subacute or chronic bursitis and tendonitis are well known to occur. The common areas of involvement

---

**Fig. 17.** Longitudinal US of the lateral femoral condyl: hyperechoic band inside of the hyaline cartilage in CPPD disease patient

**Fig. 18.** Longitudinal US of the medial meniscus: hyperechoic spots due to CPPD deposition
include the shoulder, great trochanter of the hip, lateral epicondyle of the elbow or wrist tendons [2,3].

One of the most frequent localisation of HA deposits is the rotator cuff (Fig. 19, 20, 21) The morphology of calcifications had been divided into 4 types: arc-shaped with clear shadowing, fragmented or punctuated, with or without shadowing, nodular, without shadow and cystic, a bold echogenic wall with an anechoic area, weak internal echoes or layering content [13]. The first type of calcification is in formative phase and the lasts are in the resorptive status. The resorptive phase is the painful phase of the calcific tendonitis, calcific tendonitis being a dynamic process [14].

There is an association between rotator cuff arthropathy and intraarticular presence of HA crystals. These cases are known as Milwaukee shoulder (apatite-associate destructive arthropathy) which mainly affects elderly women and are characterized by intraarticular or periarticular deposition of hydroxyapatite crystals (Fig. 22) and rapid destruction of the rotator cuff and the glenohumeral joint [15].

Interstitial calcinosis with deposition of variably sized of HA may also appear in patients with scleroderma or dermatomyositis (Fig. 23).

Quite frequently, the crystal depositions are mixed.

**OXALATE CRYSTAL DEPOSITION DISEASE**

Oxalate crystal deposition disease is seen rarely, in patients with primary hyperoxaluria and in patients with end-stage renal disease managed with long-term dialysis. Oxalate crystal deposits are found mainly in kidneys, bone, skin, and vessels, and less...
Fig. 21. Massive calcification of the rotator cuff in a patient with Charcot neuroarthropathy.

Fig. 22. Transverse US of the subdeltoid bursa in a 73 year female patient with Milwaukee shoulder. The bursa is filled with a hyperechoic and inhomogeneous material with calcification inside, producing posterior shadow.

Fig. 23. Calcification in the superficial layer of the skin in a scleroderma patient.
often inside the joints. Musculoskeletal and systemic manifestations of oxalate crystal deposition disease are not specific and may be confused with the other crystal deposition diseases [16].

In conclusion US is a useful tool for imagistic investigation of patients with crystal-associated pathology. Some of the aspects are specific, allowing a correct diagnosis only by ultrasonographic findings. In all the cases a correlation with the clinical manifestations is needed. Also, ultrasound-guided percutaneous interventional procedures allow fluid aspiration, solid tissue biopsy or therapeutic infiltration in a safety mode.

REFERENCES