Ortopedia *Traumatologia* **Rehabilitacja**
© MEDSPORTPRESS, 2008; 2(6); Vol. 10, 99-110

Crystal-Associated Synovitis – Ultrasonographic Feature and Clinical Correlation

Danela Fodor[1(A,B,C,D,E,F)], Adriana Albu[1(A,B,C,D,E,F)], Claudia Gherman[2(A,B,C,D,E,F)]

[1] 2nd Internal Medicine and Rheumatology Department, "Iuliu Hatieganu" University of Medicine and Pharmacy, Cluj-Napoca, Romania
[2] 2nd 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 contuour 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 entheseal 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. Milwakee 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

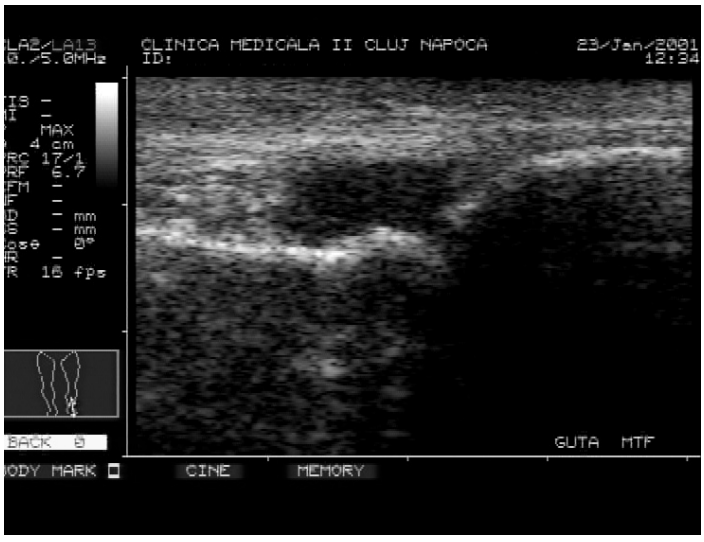

Fig. 1. Longitudinal US of the first metatarsophalangeal (MTF) joint. Intraarticular fluid strictly anechoic in the first gouty attack

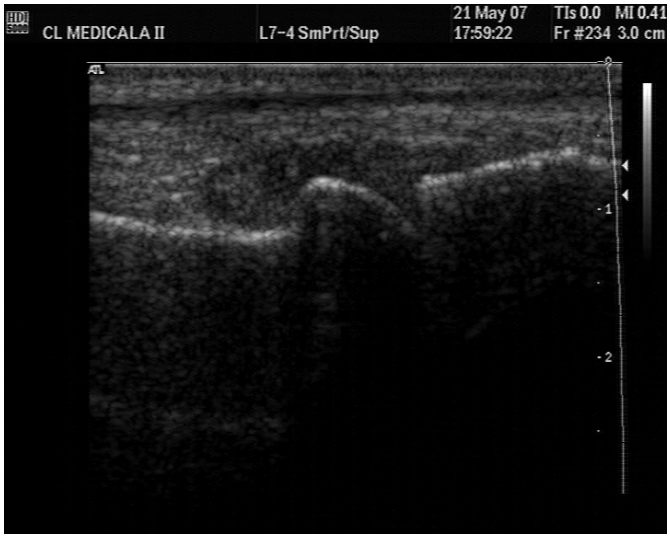

Fig. 2. Proliferated synovium in MTF I joint after repeated gouty attacks

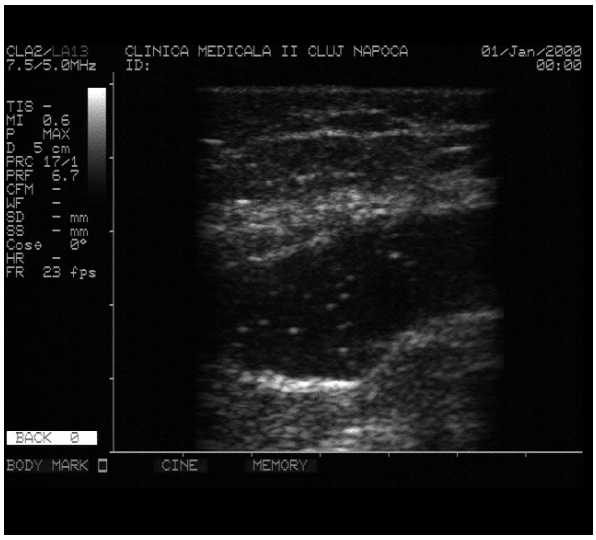

Fig. 3. Hypoechoic fluid with hyperechoic and floating spots in the knee joint

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.

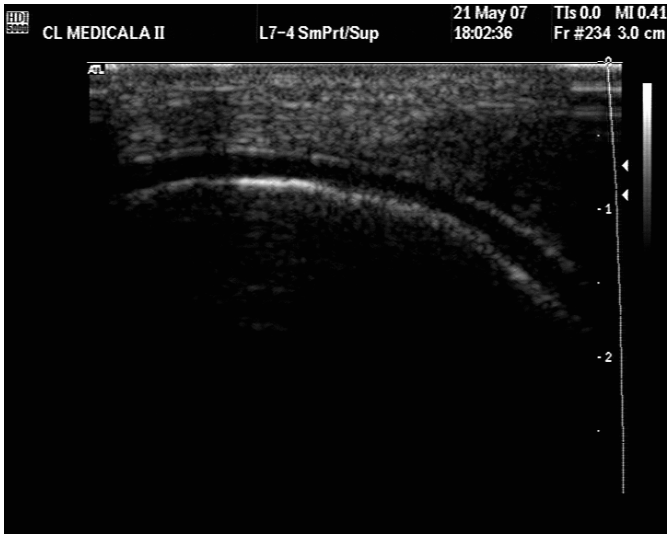

Fig. 4. Longitudinal US of the medial femoral condyl: increase hyperechoic interface between cartilage – joint space (double contour sign)

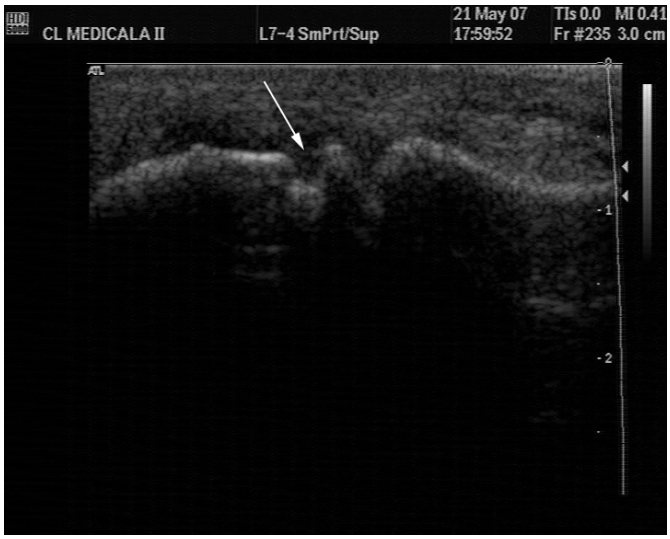

Fig. 5. Bone erosion on the metatarsal head (arrow)

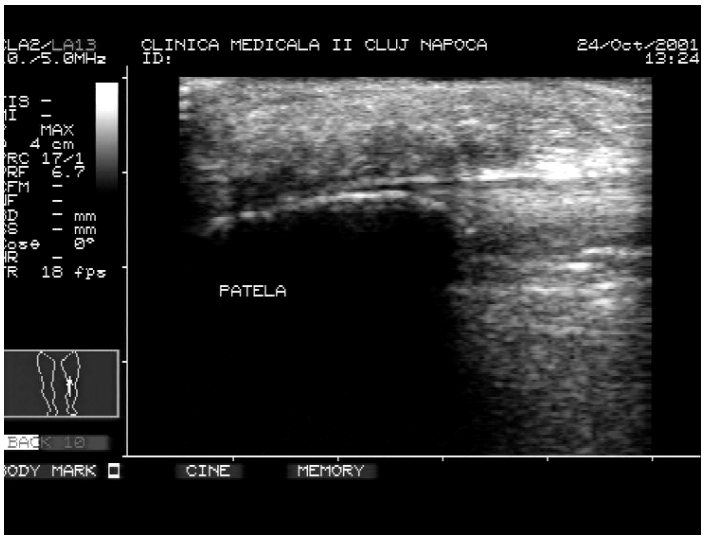

Fig. 6. Prepatellar bursitis filled with proliferate synovium

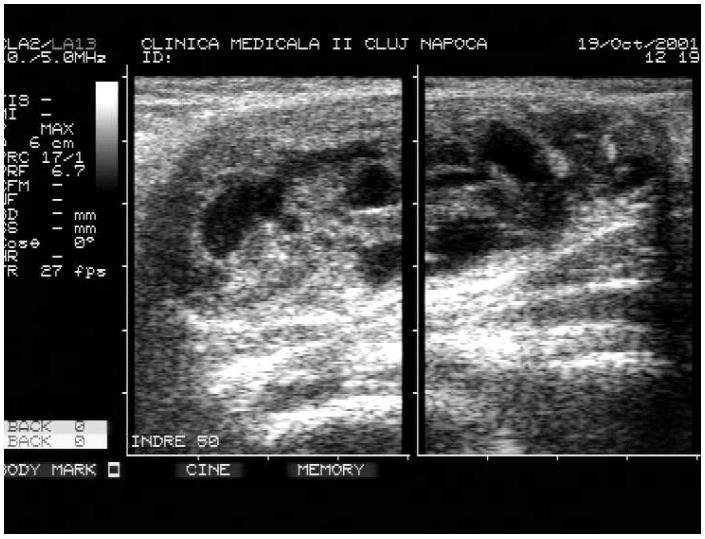

Fig. 7. Popliteal cyst of medium size with mixed content. SUM crystals were demonstrated in the fluid

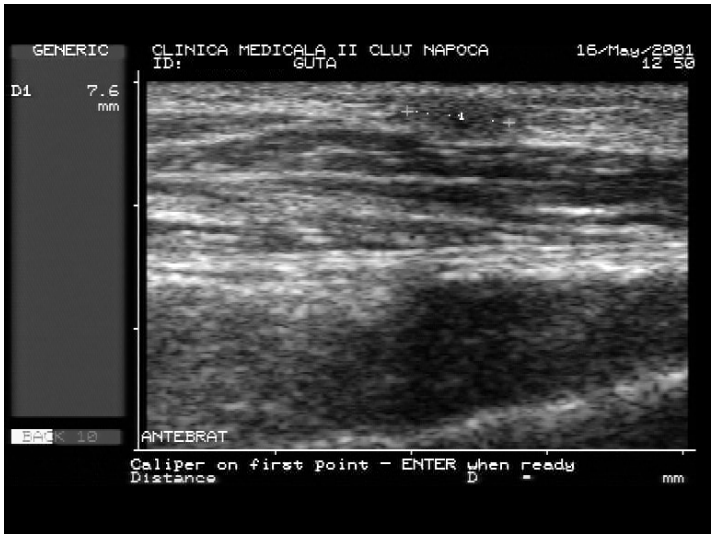

Fig. 8. Recent tophus near the elbow

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). Intratendinouns 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

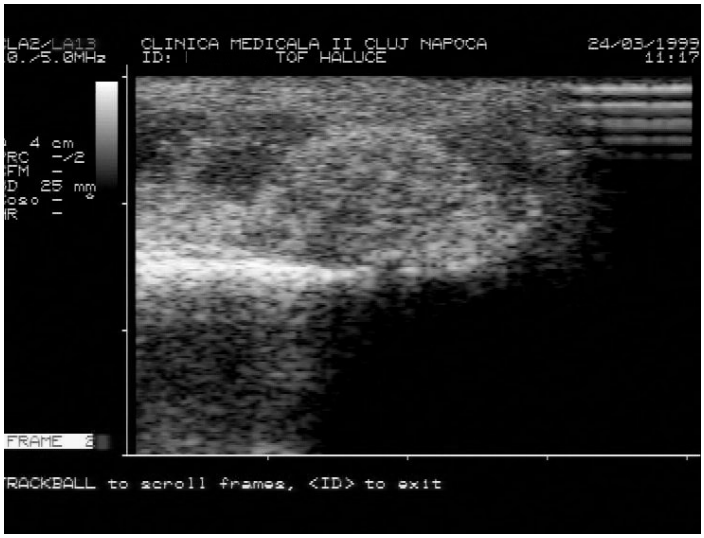

Fig. 9. Echogenic and homogenous tophus near first MTF joint

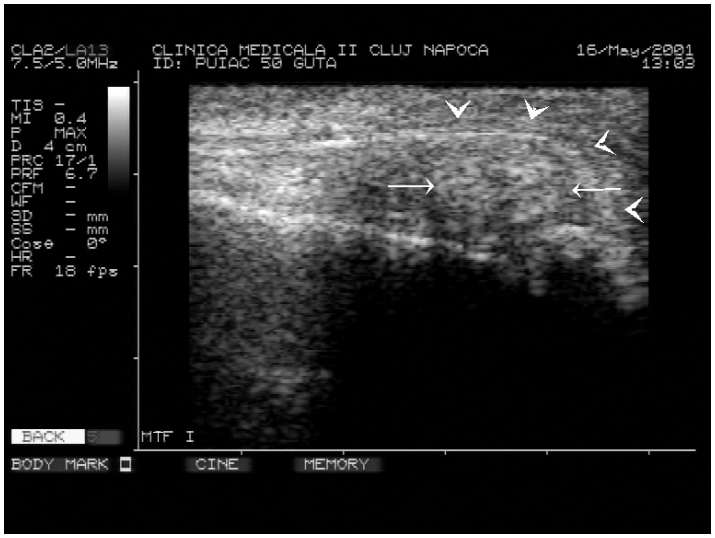

Fig. 10. Tophus (between arrows) near MTF I dislocating extensor digitorum longus tendon (arrowhead)

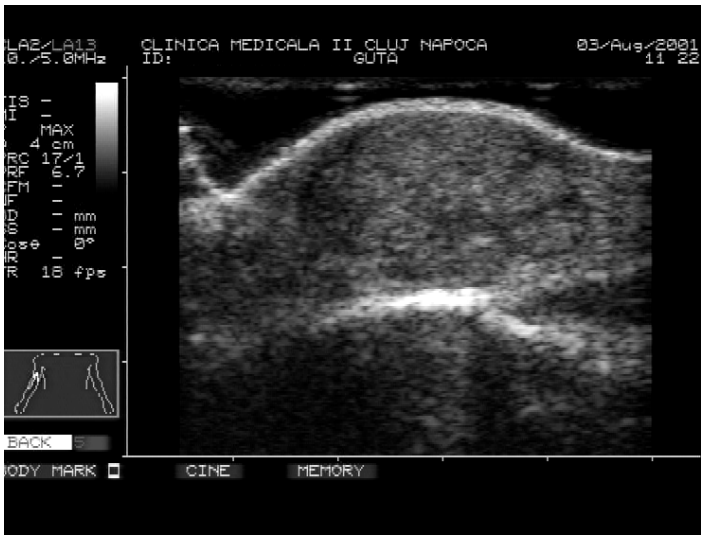

Fig. 11. Pseudotumoral tophus near elbow

is an inflammatory reaction around, the deposit become hypoechoic, with flu limits and posterior shadow (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 hypoechogenities, 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 patellar 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 probably the most common intrinsic crystal to be associ-

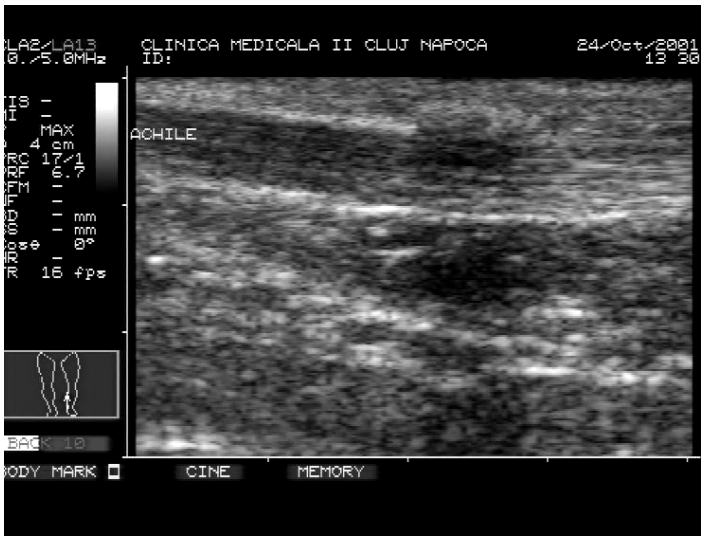

Fig. 12. Tophus in Achille's tendon producing alteration of the fibrillar structure

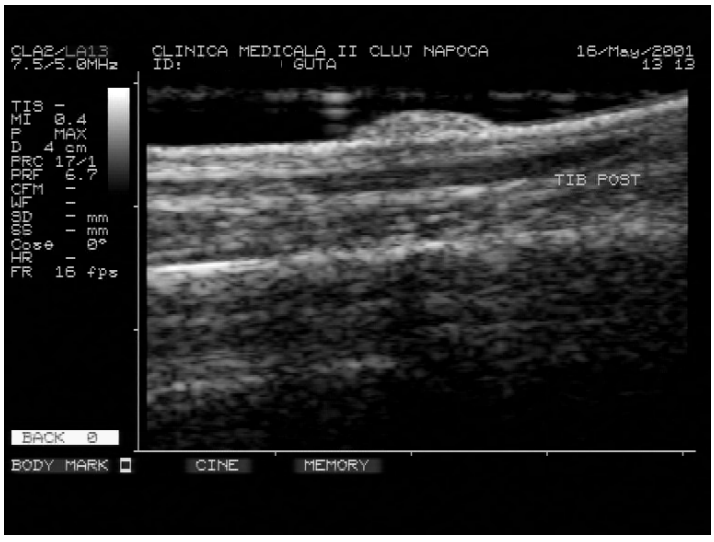

Fig. 13. Simple deposition of SUM in the superficial layer of the skin

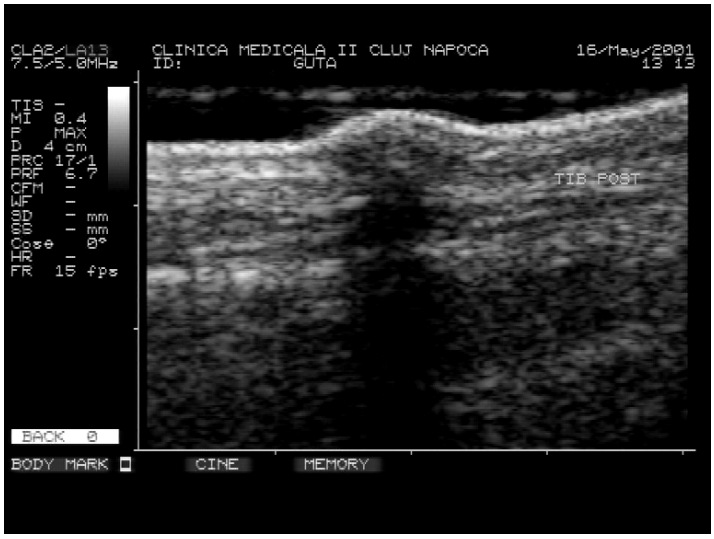

Fig. 14. Deposition of SUM in the skin with inflammatory reaction

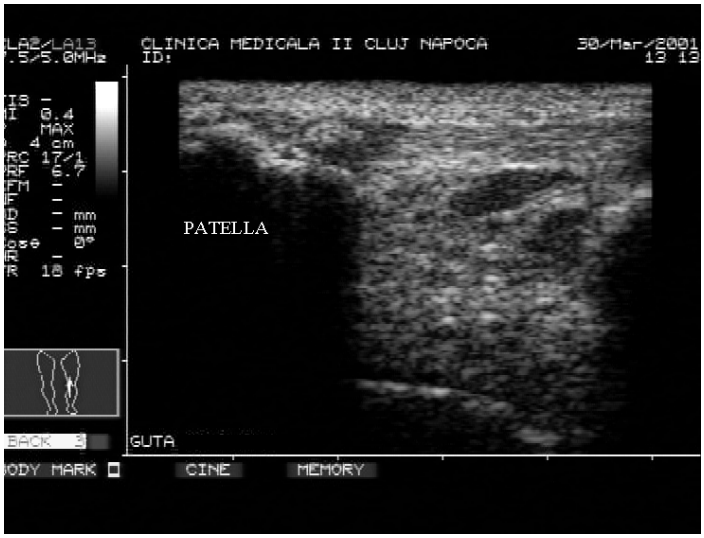

Fig. 15. Enthesopathy at the superior insertion of the patellar tendon

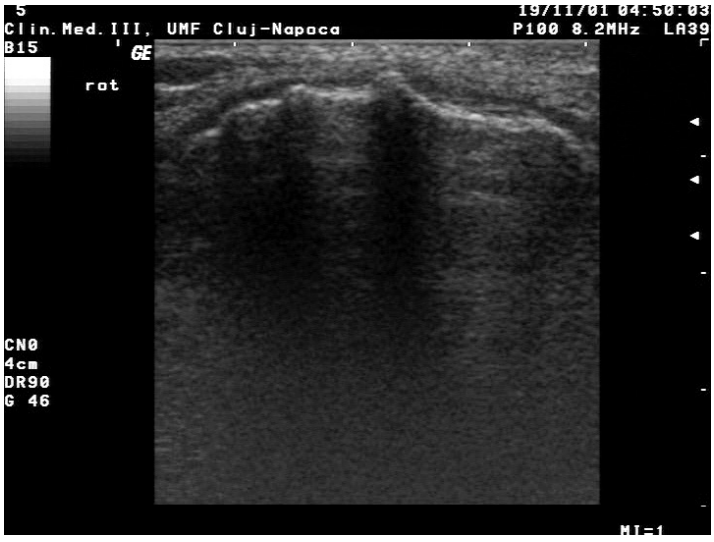

Fig. 16. Irregularities of the anterior surface of the patella

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 pseudogout. 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 femural 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 thophus-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

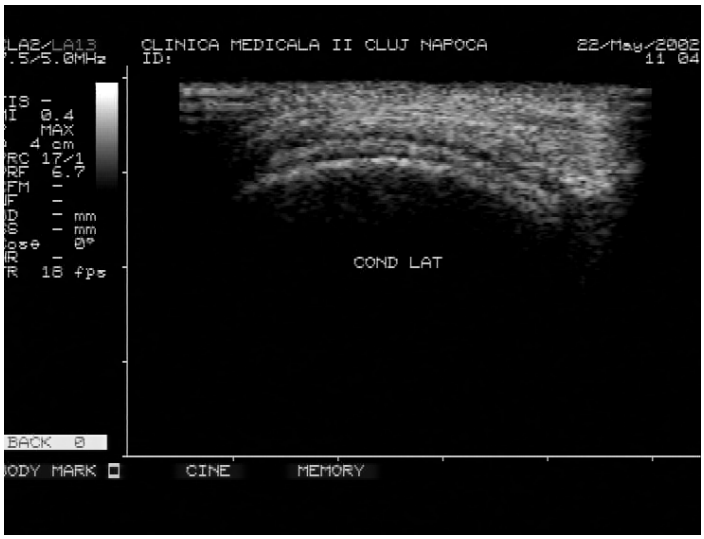

Fig. 17. Longitudinal US of the lateral femural condyl: hyperecoic band inside of the hyaline cartilage in CPPD disease patient

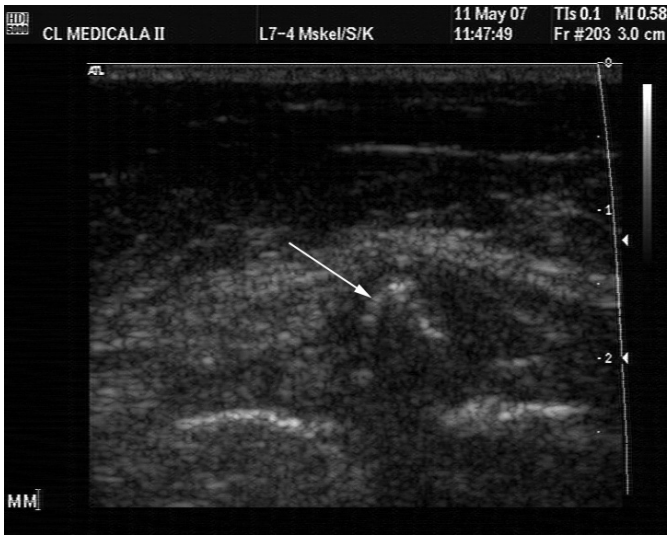

Fig. 18. Longitudinal US of the medial meniscus: hyperechoic spots due to CPPD deposition

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 stautus. The resorbtive 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 casese 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

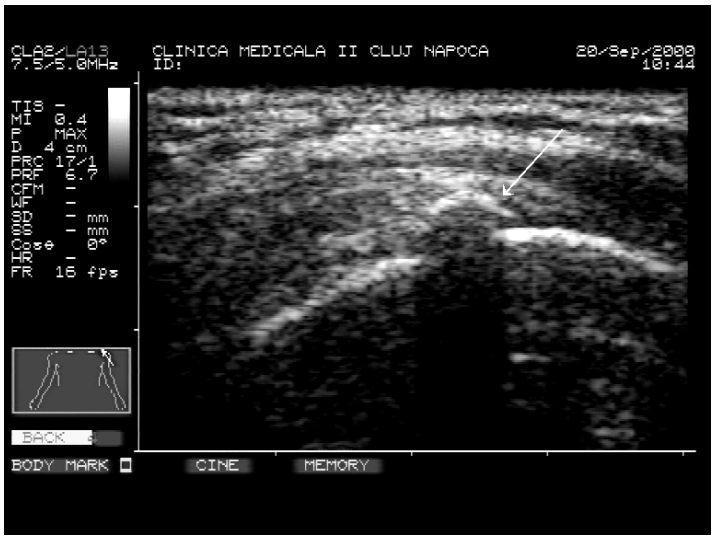

Fig. 19. Arc-shaped calcification (arrow) of the supraspinatus tendon

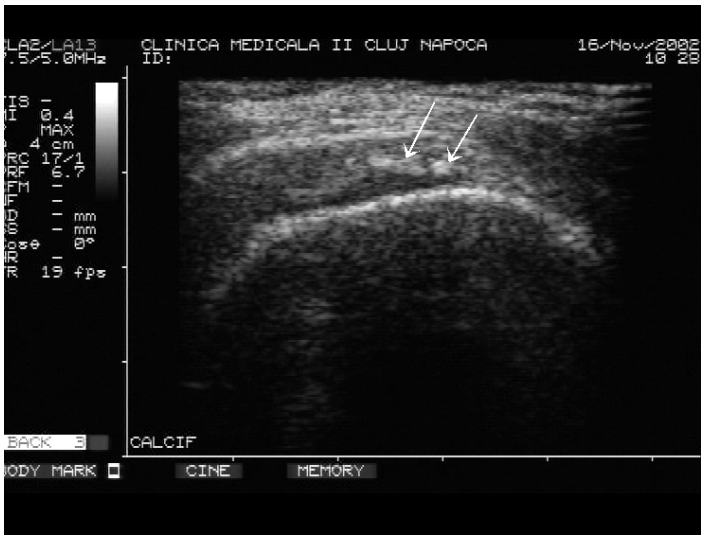

Fig. 20. Fragmented calcifications (arrows) of the supraspinatus tendon

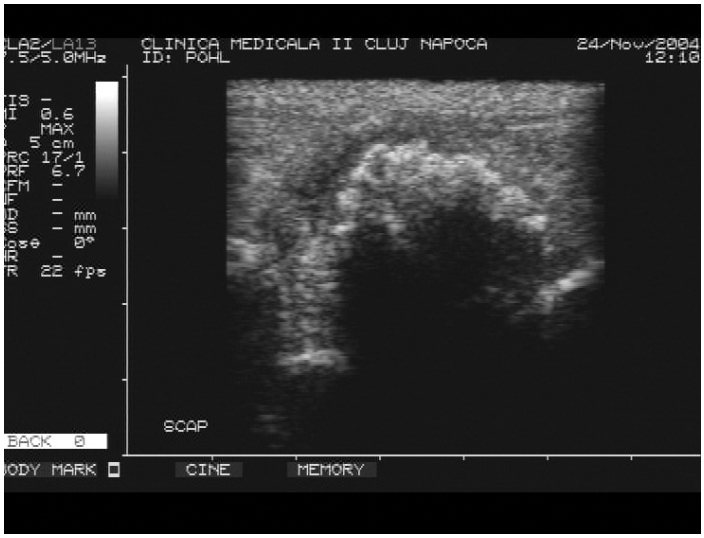

Fig. 21. Massive calcification of the rotator cuff in a patient with Charcot neuroarthropathy

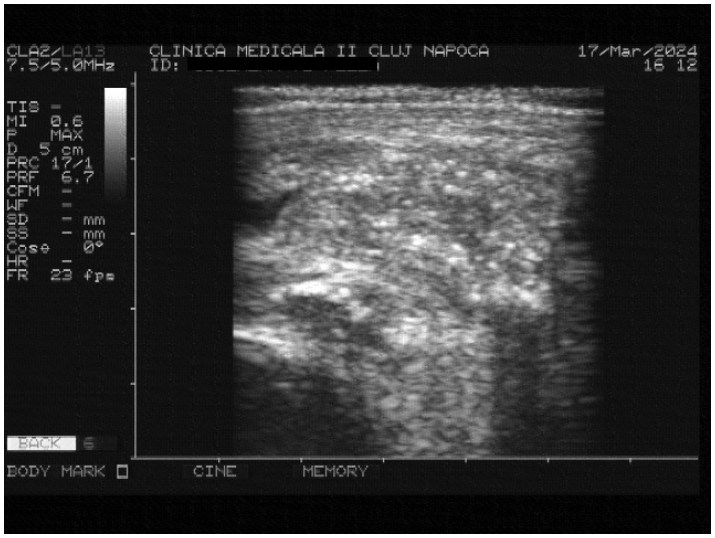

Fig. 22. Transverse US of the subdeltoid bursa in a 73 year female patient with Milwakee shoulder. The bursa is filled with a hyperechoic and inhomogeneous material with calcification inside, producing posterior shadow

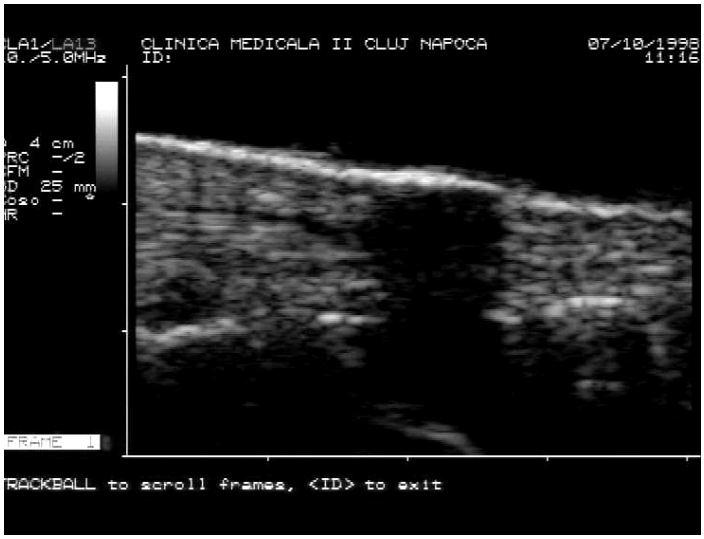

Fig. 23. Calcification in the superficial layer of the skin in a scleroderma patient

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 ultrasonografic 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

1. Kelly WN, SchumacherHR. Gout. In Kelly-Harris-Ruddy-Sledge Textbook of Rheumatology 4th ed. WB Saunders Company, 1993, 1291-330.
2. Moskovitz RW. Diseses associated with deposition of calcium pyrophosphate or hydroxyapatite. In Kelly-Harris-Ruddy-Sledge Textbook of Rheumatology 4th ed. WB Saunders Company, 1993, 1337-52.
3. Olivieri F, Punzi L. L'inflammazione articolare da microcristalli. Reumatismo 2003; 55 (1): 16-27.
4. Gerster LC, Landry M, Duvoisin B, Rappoport G. Computed tomography of the knee joint as an indicator of intraarticular tophi in gout. Arthritis Rheum 1996; 39: 1406-9.
5. Gerster LC, Landry M, Dufrense L, Meuwlz JY. Imaging of tophaceous gout: computed tomography provides specific images compared with magnetic resonance imaging and ultrasonography. Ann Rheum Dis 2002; 61: 52-4.
6. Wright SA, Filippucci E, McVeigh C, et al. High resolution ultrasonography of the 1st metatarsal phalangeal join in gout: a controlled study. Ann Rheum Dis Online First, published december 2006 as 10.1136/ard. 2006.062802. Available form URL: http://ard.bmj.com/cgi/rapidpdf/ard.2006.062802v1
7. Rumbaltelli L, Fiocco U, et al. Prospective sonographic and arthroscopic evaluation of proliferative knee joint synovitis. J Ultrasound Med 1994; 13: 855-62.
8. Chen CKH, Chung CB, Yeh L, et al. Carpal tunnel syndrome caused by tophaceous gout: CT and MR imaging features in 20 patients. ARJ 2000; 175: 655-9.
9. Mahoney PG, Lames PD, Howell CJ, et al. Spontaneous rupture of the Achilles tendon in a patient with gout. Ann Rheum Dis 1981; 40: 416-8.
10. Recht MP, Seragini F, Kramer J, et al. Isolated or dominant lesions of the patella in gout: a report of seven patients. Skeletal Radiol 1994; 23: 113-6.
11. Frediani B, Filippou G, Falsetti P, et al. Diagnosis of calcium pyrophosphate dihydrate crystal deposition disease: ultrasonographic criteria proposed. Ann Rheum Dis 2005; 64: 638-40.
12. Fam AG. Calcium pyrophosphate crystal deposition disease and other crystal deposition diseases. Curr Opin Rheumatol 1992; 4 (4): 574-82.
13. Chiou HJ, Chou YH, Wu JJ, et al. Evaluation of calcific tendonitis of the rotator cuff. Role of color doppler ultrasonography. J Ultrasound Med 2002; 21: 289-95.
14. Halverson PB. Crystal deposition disease of the shoulder (including calcific tendonitis and Milwaukee shoulder syndrome). Curr Rheumatol Rep 2003; 5 (3): 244-7.
15. Jensen KL, Williams GR, Russell IJ, Rockood CA. Rotator cuff tear arthropathy. J Bone Joint Surg 1999; 9: 1312-22.
16. Maldonado I, Prasad V, Reginato AJ. Oxalate crystal deposition disease. Curr Rheumatol Rep 2002; 4 (3): 257-64.

Liczba słów/Word count: 2745 **Tabele/Tables:** 0 **Ryciny/Figures:** 23 **Piśmiennictwo/References:** 16

Adres do korespondencji / Address for correspondence
Danela Fodor, M.D., Ph.D.
Clinica Medicala II
2-4 Clinicilor street, 3400, Cluj-Napoca Romania, e-mail dfodor@umfcluj.ro

Otrzymano / Received 08.10.2007 r.
Zaakceptowano / Accepted 13.01.2008 r.