Assessment of crystal deposition diseases with High Resolution Ultrasound

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Learning objectives

To know how High-Resolution Ultrasonography (HR-US) can detect, characterize and even manage crystal deposition disorders affecting joints and extra-articular soft tissues.

Background

Crystal deposition diseases are varied metabolic disorders due to the precipitation of crystals into the connective tissues. The three common crystals are monosodium urate (MSU), calcium pyrophosphate dihydrate (CPPD), and hydroxyapatite (HA).

Plain X-Rays is the standard assessment tool. However radiographs can be normal at earlier stages. MRI is relatively insensitive.

Atypical presentations with both methods may be misleading, wrongly suggesting other diseases like inflammation, infection or tumour.

HR-US may contribute to the diagnosis of crystal deposition disorders by showing highly suggestive signs, even in the early stages of the disease.
1. GOUT

Long time hyperuricemia leads to MSU crystal deposition within joints and subcutaneous soft tissues; the disease remains asymptomatic over many years, but in the long run, it is responsible for chronic synovitis with acute flares and tophus formation.

The first metatarsal joint is the main target of the disease. Clinical and radiological presentation may be atypical: many patients never experienced any symptom in their first toe, and gout can manifest as a monoarthritis of the knee, wrist or ankle, or as a chronic polyarthritis mimicking rheumatoid arthritis.

The main radiographic findings are intra-articular bone erosions and soft tissue swelling corresponding to tophi. However radiographic signs occur only in advanced stages, because MSU crystals are radiolucent and erosions appear only years after the onset of symptoms. Moreover erosions are demonstrated by conventional X-rays only if they are located in a plane that is tangential to the radiographic beam.

HR-US is therefore an alternative imaging tool for assessing gout because of its capacity to analyze articular cartilage and peri-articular soft tissues.

1.1 Cartilaginous abnormalities
On HR-US images, the normal cartilage is characterized by an anechoic layer limited superficially by a thin hyperechoic margin and in depth by a thicker hyperechoic margin representing the cortex of the underlying bone. (figure 1) on page 7

In patients with untreated gout, MSU deposits appear as thickening of the superficial margin which can be diffuse or focal (figure 2). on page 8 This feature is named "the double contour sign". In normal cartilage, the superficial margin is better visualised when the US beam is perpendicular to the chondral surface, due to anisotropic effect; the double contour sign is less or not sensitive to anisotropic effect, so it is visible whatever the angle of the beam is.

Double contour sign is easily depicted in the cartilage of the femoral condyles and trochlea, but it can be detected in other sites such as metacarpal and metatarsal heads.

1.2 Synovial abnormalities

In patients with acute flare-up of gout, US can demonstrate synovial hypertrophy with hyperechoic punctate foci representing MSU aggregates, giving the synovium a "snowstorm" appearance (figures 3-5). The same findings may be seen within the synovial fluid, where hyperechoic spots of variable sizes and shapes are floating and moving when pressure is applied on the skin with the probe (sonopalpation).

1.3 Tophi (figures 6-8)

HR-US appearance of a tophaceous deposit in a soft tissue is an irregular heterogeneous mass containing hypoechoic and hyperechoic areas. A central anechoic zone can be seen, due to liquid containt. Ancient tophi may be responsible for a diffuse posterior acoustic attenuation; on the other hand, calcifications producing hyperechoic foci with acoustic shadowing are an uncommon finding. Power Doppler often reveals vascular signal within the tophi, which is a sign of inflammatory reaction.

2 CALCIUM PYROPHOSPHATE DIHYDRATE (CPPD) DEPOSITION DISEASE

CPPD deposition disease is a common disorder among elderly people. The clinical presentation is variable: asymptomatic articular and para-articular calcifications, acute
monoarthritis, rapidly destructive arthropathy, chronic poly-arthritis with intermittent recurrent attacks.

Calcification of the hyaline cartilage and fibrocartilage is the main radiographic finding of this condition. Calcifications of synovium, bursae, tendons and ligaments are also frequent.

HR-US is able to demonstrate CCPD deposits because of their high reflectivity.

2.1 Hyaline cartilage calcifications (figures 9-10)

On HR-US images, cartilaginous CPPD deposits appear as hyperechoic spots, millimetric is size, within the substance of the cartilage, non generating acoustic shadowing. The crystal deposition may be diffuse or focal. As in gout, the main locations where CPPD deposits can be seen are femoral condyles and trochlea, metacarpal heads and metatarsal heads. HR-US can detect punctate foci of crystal deposits when they are too small to be shown by X-rays.

2.2 Fibrocartilaginous calcifications

This finding can be demonstrated in menisci and triangular fibrocartilage of the wrist. CPPD aggregates appear as thin hyperechoic spots within the substance of the fibrocartilage (figure 11). on page 15

2.3 Intra-articular and para-articular abnormalities

Intra articular aggregates are responsible for a hyperechoic area, of round or oval shape, with sharp limits and acoustic shadowing, floating in synovial recesses, bursae, or in tendon sheets. Calcifications can be included in articular capsule, ligaments, tendons or in a thickened synovium.

A joint mouse is a large calcification mobile in the joint cavity (figures 12-13).
In patients with acute attack of arthritis, HR-US reveals synovial hypertrophy with hyperemia detectable with Power Doppler US. This finding is not specific as it may be encountered in other inflammatory conditions such as rheumatoid arthritis. The detection of characteristic calcifications by HR-US allows the diagnosis of CPPD deposition disease (figures 14-16).

3 CALCIUM HYDROXYAPATITE (HA) DEPOSITION DISEASE

HA deposition disease mainly involves peri-articular tissues, especially the tendons. This condition is best recognized as "calcifying tendinitis" or "calcifying periarthrits". The shoulder tendons are the most common site of deposition, but numerous tendons of hand, foot, knee and hip can be affected.

When the deposit is strictly intratendinous, the disease is often asymptomatic. Impingement syndrome and tendinitis occur when the calcification enlarges; the rupture followed by the resorption of the deposit produces painful attack leading to progressive disappearance of the calcification. Intrabursal evacuation of the deposit may occur.

Calcifying tendinitis can produce erosion of bone beneath the tendinous insertion; sometimes the erosion is filled with intraosseous calcium deposit.

The diagnosis of calcifying tendinitis is based on plain films which can evaluate the size and location (tendinous or bursal) of the calcification, and the bone erosions. Sometimes the calcifications are difficult to appreciate since they are hidden by overlapping bony structures.

As for chondrocalcinosis, HA deposition disease may involve joints, producing acute arthritis or chronic arthropathy.

The US appearance of calcifying tendinosis depends on the stage of the disease. Three main types of calcium deposits are described. During the formative phase, tendinous calcifications appear as well-defined hyperechoic foci with acoustic shadowing (type I) (figures 17-18). During the resorptive phase, the calcification is less hyperechoic, ill-defined, and the acoustic shadowing is faint (type II) or absent (type III) (figures 19-21). The deposits usually lie in the distal portion of the tendon, near the insertion on the bone. Their shapes are variable, ranging from ovoid or irregular clusters to thin hyperechoic intratendinous stripes corresponding to calcific enthesopathy (figure 22). On page 24.
In patients with acute painful attack, the calcifications are surrounded by Power Doppler hyperemia (figures 23-24).

Intrabursal migration of a tendinous HA aggregate is usually seen in shoulder; US shows wall thickening of the subacromial bursa which is filled by hyperechoic liquid containing calcium (fig 25-26).

Migration of intratendinous deposit into the bone produces cortical erosion containing hyperechoic material in continuity with the tendinous calcification. (figures 27-28-29 and figure 30 on page 32)

4 INTERVENTIONAL PROCEDURES

When fluid is found within a joint or a bursa, US-guided aspiration can be performed, allowing to rule out infection and to identify crystals in the fluid. In addition, US can be used to guide therapeutic injection of corticosteroid (figure 31). on page 33 Percutaneous treatment of calcifying tendinitis can also be performed under sonographic guidance.

Images for this section:
Fig. 1: Normal cartilage (femoral condyle, longitudinal posterior scan)
Fig. 2: The double contour sign (femoral condyle, longitudinal posterior scan)
Fig. 3: Anteroposterior radiograph: erosion of the distal end of the ulna.
Fig. 4: Longitudinal HR-US scan: carpal synovitis with snowstorm appearance. R = radius. L = lunate. C = captate. T = tendons of the extensor digitorum muscle.
**Fig. 5:** Power Doppler image: hyperemia within the thickened synovium.

**Fig. 6:** Longitudinal dorsal scan: heterogeneous mass (arrows) covering the dorsal aspect of the joint. Note the double contour sign (arrowheads) in the cartilage of the metacarpal head (M).
Fig. 7: Transverse scan.

Fig. 8: Power Doppler image (fig 8) : hyperemia within the tophus.
Fig. 9: Anteroposterior radiograph: meniscal (arrow) and cartilaginous (arrowhead) calcifications.
**Fig. 10:** Longitudinal UR-US scan over the posterior aspect of the medial condyle: multiple punctate hyperechoic foci within the cartilage (arrows).
**Fig. 11:** HR-US lateral longitudinal scan: diffuse hyperechoic appearance of the lateral meniscus (arrows).

**Fig. 12:** Lateral radiograph: ovoid calcification adjacent to the first phalangeal head (arrowhead). Note the intra-articular calcific deposits (arrow).
Fig. 13: Longitudinal dorsal HR-US scan: the joint mouse is revealed as an hyperechoic focus with acoustic shadowing, in the dorsal recess (arrowhead). Note the intra-articular calcific deposits (arrow).
**Fig. 14:** Anteroposterior radiograph: trapezometacarpal joint narrowing with subchondral osseous sclerosis (black arrows) and a soft tissue calcification above the trapezium (white arrow).

**Fig. 15:** Longitudinal HR-US scan along the trapezometacarpal joint: hypoechoic thickening of the synovium containing an hyperechoic focus with acoustic shadowing (arrow) representing synovial calcium deposit.
Fig. 16: Power Doppler image: hyperemia within the thickened synovium.
**Fig. 17**: Anteroposterior radiograph: dense calcification above the greater tuberosity (arrow).
Fig. 18: Longitudinal HR-US scan: well-defined hyperechoic focus with acoustic shadowing (arrow) within the supraspinatus.
Fig. 19: Anteroposterior radiograph: juxtacortical calcification adjacent to the lateral proximal femoral shaft.
Fig. 20: Longitudinal HR-US scan: ill-defined calcium deposits without acoustic shadowing (arrowheads), at the insertion of the gluteus maximus. C = femoral cortex.
Fig. 21: Transverse HR-US scan. C = femoral cortex.
Fig. 22: Supraspinatus HA deposition with a stripe apppearance (arrow). GT = greater tuberosity.
Fig. 23: Long axis HR-US scan: large ill-defined calcification (arrowheads) within the supraspinatus. GT = greater tuberosity.
Fig. 24: Power Doppler image: vascular signal surrounding the calcium deposit.
**Fig. 25:** Anteroposterior radiograph shows a small calcification in the region of the supraspinatus (arrowhead) and a large calcification adjacent to the lateral cortex of the humeral shaft (arrow).
**Fig. 26:** Longitudinal HR-US scan reveals a large calcific deposit migrated in the subacromial bursa (arrowheads). GT = greater tuberosity.
Fig. 27: Anteroposterior radiograph shows ill-defined calcifications in the region of the supraspinatus (arrowhead), and a rounded opacity in the greater tuberosity (arrow).
**Fig. 28:** Coronal CT reconstruction reveals a cortical erosion of the greater tuberosity, in continuity with a deep cavity filled by calcific material (arrow).
**Fig. 29:** HR-US scan demonstrates the calcification of the supra-spinatus (arrowheads), extending into the intraosseous cavity (arrow).
Fig. 30
Fig. 31: Calcifying tendinitis of the supraspinatus. US guided corticosteroid injection in the subacromial bursa.
Conclusion

Crystal deposits are easy to detect with HS-US. The pattern of crystal deposition is remarkably different according to the crystal composition (MSU, CPPD or HA). Knowledge of ultrasonographic features of crystal deposition diseases greatly helps the management of patients, especially when other imaging methods are unconclusive. Therefore, HR-US is likely to become the main imaging tool for detection and characterization of crystal deposition diseases.

Personal Information

References


