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Review

Anterior chest wall non-traumatic diseases: a road map for the radiologist

Susanna Guerrini[1], Giulio Bagnacci[2], Antonio Barile[3], Ernesto La Paglia[4], Francesco Gentili[5], Luca Luzzi[6], Nicola Giordano[7], Antonella Fioravanti[8], Francesca Bellisai[8], Luca Cantarini[8], Luca Volterrani[2], Bruno Frediani[8], Maria Antonietta Mazzei[2]

[1] Unit of Diagnostic Imaging, Department of Radiological Sciences, University of Siena, Azienda Ospedaliero-Universitaria Senese, Siena, Italy; [2] Unit of Diagnostic Imaging, Department of Medical, Surgical and Neuro Sciences and of Radiological Sciences, University of Siena, Azienda Ospedaliero-Universitaria Senese, Siena, Italy; [3] Department of Biotechnology and Applied Clinical Sciences, University of L'Aquila, L'Aquila, Italy; [4] Unit of Diagnostic Imaging, Humanitas Cellini, Torino, Italy; [5] Section of Radiology, Department of Medicine and Surgery, Azienda Ospedaliera Universitaria di Parma, Parma, Italy; [6] Thoracic Surgery Unit, Department of Medical, Surgical and Neuro Sciences, University of Siena, Azienda Ospedaliero-Universitaria Senese, Siena, Italy; [7] Scleroderma Unit, Internal Medicine, Department of Medical, Surgical and Neuro Sciences, University of Siena, Azienda Ospedaliero-Universitaria Senese, Siena, Italy; [8] Unit of Rheumatology, Department of Medical, Surgical and Neuro Sciences, University of Siena, Azienda Ospedaliero-Universitaria Senese, Siena, Tuscany, Italy

Summary. The anterior chest wall (AWC) non-traumatic pathologies are largely underestimated, and early detection through imaging is becoming increasingly important. This paper aims to review the major non-traumatic ACW pathologies, with a particular interest in imaging features and differential diagnosis. (www.actabiomedica.it)

Keywords: anterior chest wall, ultrasound, magnetic resonance imaging, computed tomography, DECT, sternocostoclavicular joint.

Introduction

The anterior chest wall (AWC) non-traumatic pathologies are largely underestimated. Both the ACW joints and bone structures can be subject to infective, degenerative, inflammatory, malformative, or oncologic diseases, that could present with the same symptoms (1-5). In this context, early detection through imaging is becoming increasingly important. This paper aims to review the major non-traumatic ACW pathologies, with a particular interest in imaging features and differential diagnosis.

Essential Anatomy of Anterior Chest Wall

Knowledge of the anatomy of the ACW is fundamental for a correct interpretation of imaging features. *Sternocostal Joint (SCOJ)* is composed of the costochondral cartilage from the second rib and their articulation with the sternum (manubrium and body). It contains an interarticular ligament and two synovial membranes, similar to the costovertebral joints (6).

Manubriosternal Joint (MSJ) is an amphiarthrodial joint comprising two hyaline cartilage-covered surfaces separated by a fibrocartilaginous disk that is anchor by dorsal and ventral ligaments covering the surfaces of the joint. In about 30% of people, the absorption of the disk results in synovial joint conversion (6).

Sternoclavicular Joint (SCJ) is a diarthrodial saddle-shaped synovial joint composed by the sternal end of the clavicle, the clavicular notch of the manubrium, and the cartilage of the first rib (7). Between the two articular surfaces, there is a fibrocartilaginous disk that separates the joint into two distinct synovial cavities (8). The joint capsule consists of a fibrous outer layer and an inner synovial membrane (7, 8).

Imaging

Imaging is becoming increasingly important in the early diagnosis, to start a customized treatment, and during follow-up of ACW pathologies (9, 10). Multimodality imaging may be required in some cases for a proper assessment of different pathological features (11-15). Due to its wide availability and low costs (16-17), X-Ray (XR) represents the first-line imaging investigation, with standard and special projections (above all Rockwood or serendipity) that can assess bone structural changes, even if limited by the overlapping of vertebrae and ribs, the congenital oblique orientation of SCJ and the inability to delineate the soft tissues (6, 18). *Digital tomography (DT),* using a single pass of the radiographic generator over a digital detector, obtains a sequence of multiple digital X-ray images (9) of the ACW overcoming both overlapping phenomena and limitations caused by congenital oblique orientation. Even if XR/DT permit a differential diagnosis with unilateral involvement and could demonstrate the enlargement of the articular cavity (suggestive for inflammatory disease) or the presence of cortical bone interruption (suggestive for neoplastic lesion), other imaging modalities are often necessary (18). *Ultrasound (US)* and *Magnetic Resonance Imaging (MRI)* have focused on the demonstration/quantification of pathologies affecting the synovia and allow early diagnosis of inflammatory arthropathies (9, 19-20). These imaging methods can also be applied for interventional purposes (21-25); for example, aspiration of the joint under US can help to isolate organisms or demonstrating crystals. Moreover, *contrast-enhanced US (CEUS)* and MRI can demonstrate the presence of active inflammation and quantify inflammation or neoplastic processes (2, 26,27). MRI seems to be superior to US/CEUS in the assessment of bone tissue inflammation (marrow edema and osteitis), bone erosion, and cartilage loss in association with its panoramic view (26,28,29). *Computed Tomography (CT)* is most indicated for bone destruction/ossification or in cases of malformations (30,31). However, thanks to the introduction of *Dual-Energy CT (DECT)* technology, it could also identify/quantify marrow edema, allowing to demonstrate active inflammation and accurate differential diagnosis in crystal-deposition arthropathy (presence and type of crystal) (32-35).

Whole-body bone scintigraphy (58), using technetium 99m-labeled diphosphonate, provides information about the whole skeleton in a single examination, and it is usually used to diagnose inflammatory changes in the ACW when there is a suspicion about the involvement of other areas (6, 36).

Medical History

ACW can be affected alone or in systemic pathologies; for this reason, a complete medical history including laboratory tests should be made, before any imaging evaluation, in order to contribute the differential diagnosis (**tab. 1**) (8, 18).

Major pathologies of the anterior thoracic wall

Osteoarthritis

Osteoarthritis (OA) is the most common condition affecting the SCJ, less frequently the MSJ, presenting with local pain/swelling and limited motion of arms/shoulders (particularly high elevation with crepitus) (8). OA is typically bilateral and asymmetric, with right-sided predominance (7). It is common in advanced age; however, there are some predisposing factors, such as manual labor (8). XR/DT and CT (more sensitive) can demonstrate subchondral sclerosis, cysts, osteophytes, and joint space narrowing (37, 38). US highlights the presence of joint distention, hyperemia, and cortical irregularity. The matches findings on MRI are low-signal intensity on all sequences in the areas of subchondral sclerosis and foci of hyperintense signal on T2-weighted images (T2WI) in the areas of cystic changes and edema (26).

Rheumatoid Arthritis

The SCJ rate of involvement in patients affected by rheumatoid arthritis (RA) is variable (1% to 43%), whereas the MSJ rate is about 27%, according to the percentage of synovial conversion (6, 8). Symptoms include swelling, tenderness, crepitus, and painful limitation of movements; the diagnosis is confirmed by

Table 1. Main features of non-traumatic ACW diseases

Disease	*Sex*	*Age (y)*	*Site*	*Side*	*Pain*	*Laboratory*	***Radiographic changes***
Osteoarthritis	M=F	>40	SCJ	B	+	Normal	Sclerosis, osteophytes
Rheumatoid arthritis	F>M	Any	SCJ, MSJ	B	+	+RF, +ANA	Often unremarkable
Seronegative spondyloarthropathies	M>F	<40	SCJ, MSJ	U	Not frequent	+HLA-B27	Erosions, cysts
Sonozaki syndrome	M>F	<40	SCJ, SCOJ	U	Not frequent	–HLA-B27	Diffuse sclerosis
SAPHO syndrome	M>F	30-60	SCJ, SCOJ, MSJ	B	+	↑ESR, –reumatologic marker	Sclerosis, enthesopathic bone formation
Crystal Deposition Arthropathy	M>F	>40	SCJ	U	+++	+BRFC, –BRFC	Calcification of soft tissue
Condensing osteitis	F>M	25-40	Medial end of the clavicle	U	+	Normal	Medial clavicle enlargement, marrow obliteration
Friedrich's disease	F>M	Any	Medial end of the clavicle	U	+	Normal	Irregular end of medial clavicle
Tietze's syndrome	F>M	20-50	II-IV costochondral junctions	U	+	Oten normal	hypertrophy and calcification of the costal cartilages
Septic Artritis	M=F	Any	SCJ	U	+++	↑WBC, ↑ESR, ↑CRP	Sclerotic, lytic, or mixed lesions
Neoplasm	M=F	Any	Any	U	+	Normal, ↑neoplastic markers	Bone enlargement, mass, cortical bone interruption

B = bilateral, U = unilateral, ANA = antinuclear antibodies, BRFC = birefringent crystals, CRP = C-reactive protein, ESR = erythrocyte sedimentation rate, RF = rheumatoid factor, WBC = white blood cell count, + = elevated levels or presence of, ++ = moderate elevation, +++ = marked elevation, – = not seen or absence of.

anti-cyclic citrullinated peptide serum testing (37, 39, 40). Isolated involvement is not impossible; however, polyarticular disease and bilaterality are common. The pathologic process of RA includes synovial inflammation, pannus formation, bony erosions, degeneration of the intra-articular disk, and joint space narrowing (8). In the very early phase of involvement, XR is generally unremarkable, whereas US could detect synovial inflammation, pannus formation (hypoechoic and non-compressible), and intraarticular synovial blood perfusion using the power Doppler technique; it could also detect irregularity of cortical bone surface (41, 42). Contrast-enhancement MRI (CE-MRI), is the primary technique in the early phase of the disease, demonstrating marrow edema (a factor strictly related with prognosis), synovial inflammation with joint effusions containing rice bodies (suggestive of RA). CT shows tiny bony erosions and joint destruction in the full-blown disease but could also be useful in the early phase if performed with DECT technique (35).

Seronegative Spondyloarthropathies

The ACW can also be affected in seronegative spondyloarthropathies (SSpA) (38). The prevalence of the involvement and the site may vary according to the type of SSpA: *psoriatic arthritis* has a predilection for the SCJ (50% of cases), whereas MSJ has a high incidence involvement (80%) in *ankylosis spondylitis* (6, 7). The onset is usually before age 40 years, and diagnosis could be confirmed by the detection of HLA-B27 in association with a clinical history of dermatologic/ gastrointestinal symptoms and absence of serum autoantibodies. Symptoms are usually unilateral (swelling, tenderness, and pain) (8). Structural changes (osseous hyperostosis, enthesophytes) can be detected by XR or CT. CT could demonstrate marginal erosions of the sternum, clavicle, or both, as well as subchondral erosion and sclerosis, whereas MRI is needed for detecting early changes, such as marrow edema and enthesitis (**fig. 1**). MRI is also useful in the follow-up of patients to differentiate

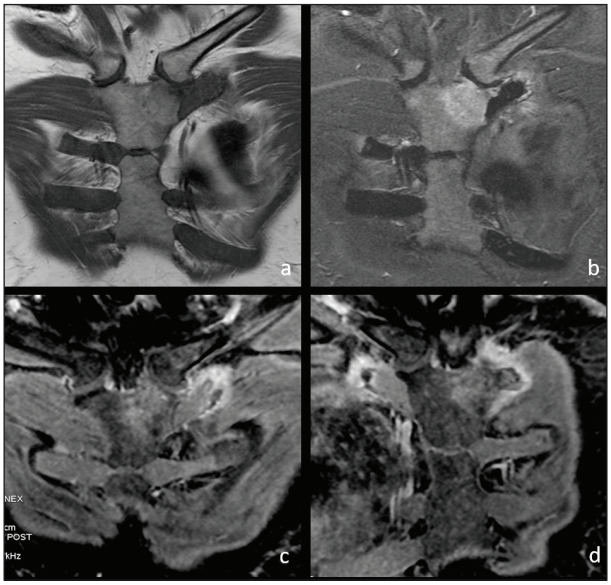

Figure 1. MRI examination of a 38y old female with psoriasis and pain and swelling of the left SCJ. She told the same symptoms a few years earlier, at the controlateral SCJ. MRI showed fat deposition (T1 weighted image, a) and marrow edema (T2 weighted image, b) of the subchondral bone of the manubrium and signs of enthesitis on the costochondral cartilage of the first rib and on the inner portion of the end of the clavicle (T2 weighted image, b, and T1 gradient echo image with fat saturation after contrast media administration, c and d). Signs of enthesitis were also present on the costochondral cartilage of the first rib on the right side (d). The MRI diagnosis, confirmed by clinical and laboratory data, was AWC involvement in psoriatic arthritis.

active from chronic forms and to manage other joints involvement (axial skeleton or sacroiliac joints) (28, 43, 44). The end-stage appearance of the SCJ consists of ankylosis of the sternoclavicular or costosternal joints (45). The *Sonozaki syndrome* (SS), also known as pustulotic arthro-osteitis (PAO), belongs to the group of psoriatic arthritis; however, no relation with antigen HLA-B27 was observed (46). CT could detect the periosteal reaction of the clavicles in the early phase, inflammatory enthesopathy of the costoclavicular ligament, arthritis of the SCJ, and erosive and sclerotic processes of the MSJ. MRI and DECT can quantify the activity of the inflammation, better characterizing soft-tissue and bone involvement (47). Whether the SAPHO (Synovitis–acne–pustulosis–hyperostosis–osteitis) syndrome represents a clinical entity by itself or should be considered a subset within the family of SSpA [due to the frequent affliction of the axial skeleton (91%), enthesitis, and inflammatory bowel diseases], is still unknown (7, 48, 49). It includes symptoms of the Sonozaki syndrome, chronic recurrent multifocal osteomyelitis of bone marrow and bones (CRMO), focused acne, and others (7). SCJ, SCOJ, and MSJ are most commonly affected (70 to 90%); bilateral involvement is the most frequent, but symptoms can be unilateral. The middle-aged women are preferred (49). In adults after at least three months of disease, XR findings can be characteristic represented by expanded bone, sclerosis, osteolysis, periosteal reaction, and enthesopathic new bone formation; MRI might be required to detect subclinical lesions (low signal intensity corresponding to the sclerotic bone and areas of high signal intensity on T2WI due to marrow edema/osteitis) (48, 49).

Crystal Deposition Arthropathy

Both gout and calcium pyrophosphate dehydrate deposition (CPPD) disease can involve the SCJ (37). Symptoms can be acute pain and swelling; sometimes, it can present with swelling alone, mimicking a tumor (7). Aspiration of swollen joint and following evaluation under polarizing light microscopy allows the correct diagnosis (50). The prevalence of CPPD crystal deposition in the SCJ is 17% and increases with patient age (50). XR is often negative in the early phase of the disease. In the superficial portion of the joint, US is sensitive in the individuation of CPPD (fibrocartilages and tendons crystal deposition) and gouty tophi in subcutaneous tissues or tendons that appear as hyperechoic with a heaped-up appearance (37). MRI is used to assess inflammation, bone erosions, cartilage damage, and tophi, with low signal intensity on T1WI and iso- to high signal intensity on T2WI (7). DECT represents the best imaging modality to diagnose crystal deposition arthropathy differentiating the type of crystal by analyzing specific attenuation characteristics, and showing marrow edema and/or erosions (34, 51).

Condensing osteitis

Condensing osteitis (CO), also known as aseptic enlarging osteosclerosis, is a rare condition character-

ized by sclerosis and enlargement of the medial end of the clavicle not involving the SCJ (52). Predisposing factors are mechanical stress, trauma, infections, and female sex (20–60 years of age) (8). Symptoms are local swelling, with no inflammatory skin changes, and pain on arm abduction with typical unilateral involvement. CO does not affect other anterior chest wall joints, thus differentiating it from SAPHO (7). XR and CT findings include homogeneous dense sclerotic patch and enlargement in the medial end of the clavicle, limited to the inferior margin, with sparing of the SCJ, without periosteal reaction or bony erosion (52). On MRI, it presents low-signal intensity on T1WI and low or intermediate signal on T2WI with occasionally interspersed areas of bright signal and bone/peri-osseous enhancement.

Tietze's syndrome

Tietze's syndrome (TS), also known as costochondritis, affects from the second to fourth costochondral junctions (rarely the SCJ and the SCOJ) with hypertrophy and calcification of the costal cartilages (in most cases only one costal cartilage is involved) (7). TS is defined as a benign, painful, non-suppurative, self-limiting (resolve within days to weeks) disease, with localized swelling over the interested area (Tietze's area) (53). Females are affected more than males (2:1 ratio) between twenty and fifty years of age. The diagnosis is primarily clinical however MRI is the imaging of choice to show cartilaginous, joints and bone abnormalities (focal cartilage enlargement and edema of both cartilage and subchondral bone, vivid and rapid contrast enhancement of the cartilage and peri-articular structures involved) and to exclude other differential diagnoses (8, 53). XR and CT can show hypertrophy and calcification of the costal cartilages, but they are less accurate than MRI.

Septic arthritis

Septic arthritis (SA) of the SCJ is frequently associated with a preexisting disease or risk factors (sepsis, infected subclavian central lines, recent sternal trauma, diabetes mellitus, human immunodeficiency virus (HIV) infection, renal dialysis, and intravenous drug abuse); it is rarely isolated (1% of all SA). Most patients are male (8). Symptoms are pain, swelling, and tenderness, associated with fever, chills, or night sweats. SA can rapidly evolve with severe complications (osteomyelitis, abscess or phlegmon and mediastinitis), and the most common isolated organism is Staphylococcus aureus, followed by Pseudomonas, Brucella, and E.Coli (7). A culture of aspirate/tissue sample with imaging gives the diagnosis. XR may highlight the presence of sclerotic, lytic, or mixed lesions but may be less sensitive than DECT that can show erosions, widening, periosteal reaction, and marrow edema in the acute phase, or sclerosis, in chronic phase. MRI and US are more specific and should be considered the imaging modality of choice; US can guide fluid aspiration (8).

Other non-traumatic pathologies involving the ACW

Among less common diseases, particular attention should be given to primary or secondary tumors such as Ewings sarcoma, lymphomas, fibrous tumors, and metastases (54). Rare benign conditions are hemophilic pseudotumor, a complication of hemophilia that may affect the proximal clavicle, Paget's disease, neuropathic arthropathy of the SCJ, secondary to syringomyelia, Friedrich's disease (or spontaneous aseptic osteonecrosis of the medial end of the clavicle), synovial osteochondromatosis and ganglion cysts. SCJ changes have also been described with other systemic pathologies such as polymyalgia rheumatica, primary and secondary hyperparathyroidism (with the erosion of the medial clavicle) and hemodialysis-related amyloidosis (6, 8, 55). Congenital deformities can also affect the ACW and are caused by anomalies of chest wall growth, leading to sternal depression or protrusion, or related to failure of the normal spine or rib development (56). Patients should be first imaged with XR or directly address to the best diagnostic techniques, CT or MRI, for assessing the degree of the involvement, the differential diagnosis, and treatment planning (56).

Conclusion

The ACW can be affected by multiple non-traumatic diseases, and most of these conditions present with the same symptoms. The radiologists should be aware of the AWC anatomy, prevalence, and site of involvement, as well as imaging features and possibilities.

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Correspondence:
Susanna Guerrini
Unit of Diagnostic Imaging, Department of Radiological Sciences, University of Siena,
Azienda Ospedaliero-Universitaria Senese, Siena, Italy
Viale Bracci 16, 53100, Siena, Italy.
Tel. +39 3273512629 - Fax +39 0577 586147
E-mail: guerrinisus@gmail.com