December 2016 Imaging Case of the Month

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Clinical History: A 47-year-old woman presented for medical evaluation prior to trans-sphenoid hypophysectomy for pituitary adenoma for Cushing syndrome. The patient had an extensive past medical history, including kidney minimal change disease treated with corticosteroids between 5-7 years previously (no longer on corticosteroid therapy), type II diabetes mellitus, focal segmental glomeruloscleroosis on renal biopsy, morbid obesity, gout, obstructive sleep apnea on continuous positive airway pressure (CPAP) supplemented with oxygen for the previous 8 years, hypertension, and recent-onset atrial fibrillation, as well as a history of several pneumonias, perhaps related to chronic immunosuppression. Her past surgical history included bilateral partial knee replacement, lower extremity vein ablation, and breast reduction. Her medication list was extensive, including allopurinol, anti-hypertensives, anti-depressants, colchicine, oxygen, and Tacrolimus, among others, including over-the-counter medications.

Laboratory data, include white blood cell count, coagulation profile, and serum chemistries were within normal limits. Oxygen saturation on room air was 95%.

Frontal and lateral chest radiographs (Figure 1) were performed. A previous chest radiograph performed 2 years earlier is presented for comparison (Figure 2).

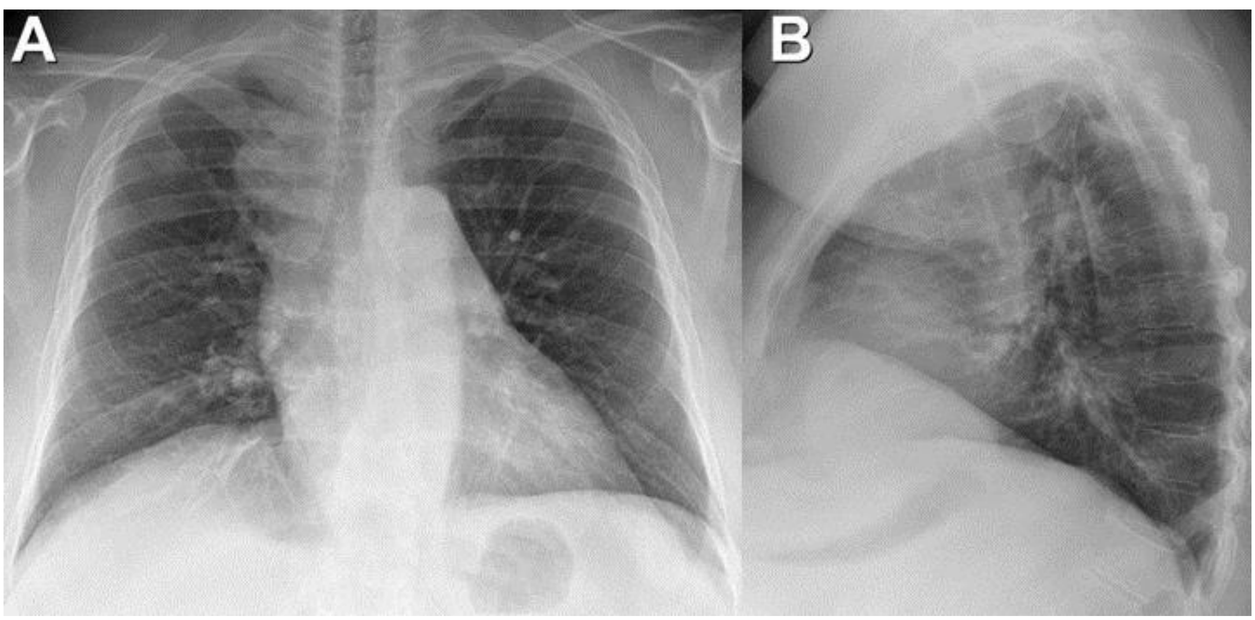

Figure 1. Frontal (A) and lateral (B) chest radiography.

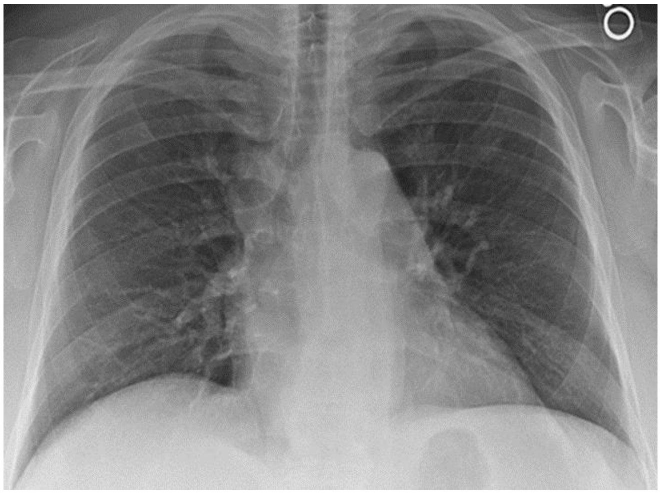

Figure 2. Frontal chest radiography performed 2 years prior to presentation.

Which of the following statements regarding the chest radiograph is ***most accurate***?

1. Frontal and lateral chest radiography appears normal
2. Frontal and lateral chest radiography shows a mass projected over the right paratracheal region
3. Frontal and lateral chest radiography shows asymmetric hyperlucency affecting the right thorax
4. Frontal and lateral chest radiography shows basal reticulation suggesting possible fibrotic disease
5. Frontal and lateral chest radiography shows cardiomegaly only, but is unchanged from prior

Correct!

2. Frontal and lateral chest radiography shows a mass projected over the right paratracheal region

Frontal and lateral chest radiograph shows increased soft tissue projected over the right paratracheal region, new from the prior examination, but difficult to localize on the lateral projection. The lung volumes are relatively normal and there is no evidence of basal reticulation to suggest the presence of fibrotic lung disease. There may be some hyperlucency affecting the thorax, but the relatively lucent side of the thorax is on the left, not the right, and this observation is likely the result of subtle patient rotation towards a left anterior oblique position. The heart size is upper-normal, not clearly changed from previous.

Which of the following would be ***most useful*** for the evaluation of this patient?

1. Contrast-enhanced thoracic CT
2. Flexible fiberoptic bronchoscopy
3. Mediastinoscopy
4. Pulmonary function testing
5. Repeat frontal chest radiography

Correct!
1. Contrast-enhanced thoracic CT

Repeat frontal chest radiography is not likely to be beneficial as the abnormality detected at presentation chest radiography is very unlikely to represent artifact. Pulmonary function testing could prove useful for physiologic assessment, but it is unlikely that pulmonary function testing would provide information that would either localize the lesion detected at presentation chest radiography or indicate its etiology. Either mediastinoscopy or flexible fiberoptic bronchoscopy may play a role in the evaluation of this patient, but further efforts to localize the lesion prior to invasive interventions are required. In this regard, thoracic CT, preferably performed with intravenous iodinated contrast, would be the most useful procedure to provide information regarding the etiology of the chest radiographic findings.

The patient underwent unenhanced CT of the thorax (Figure 3).

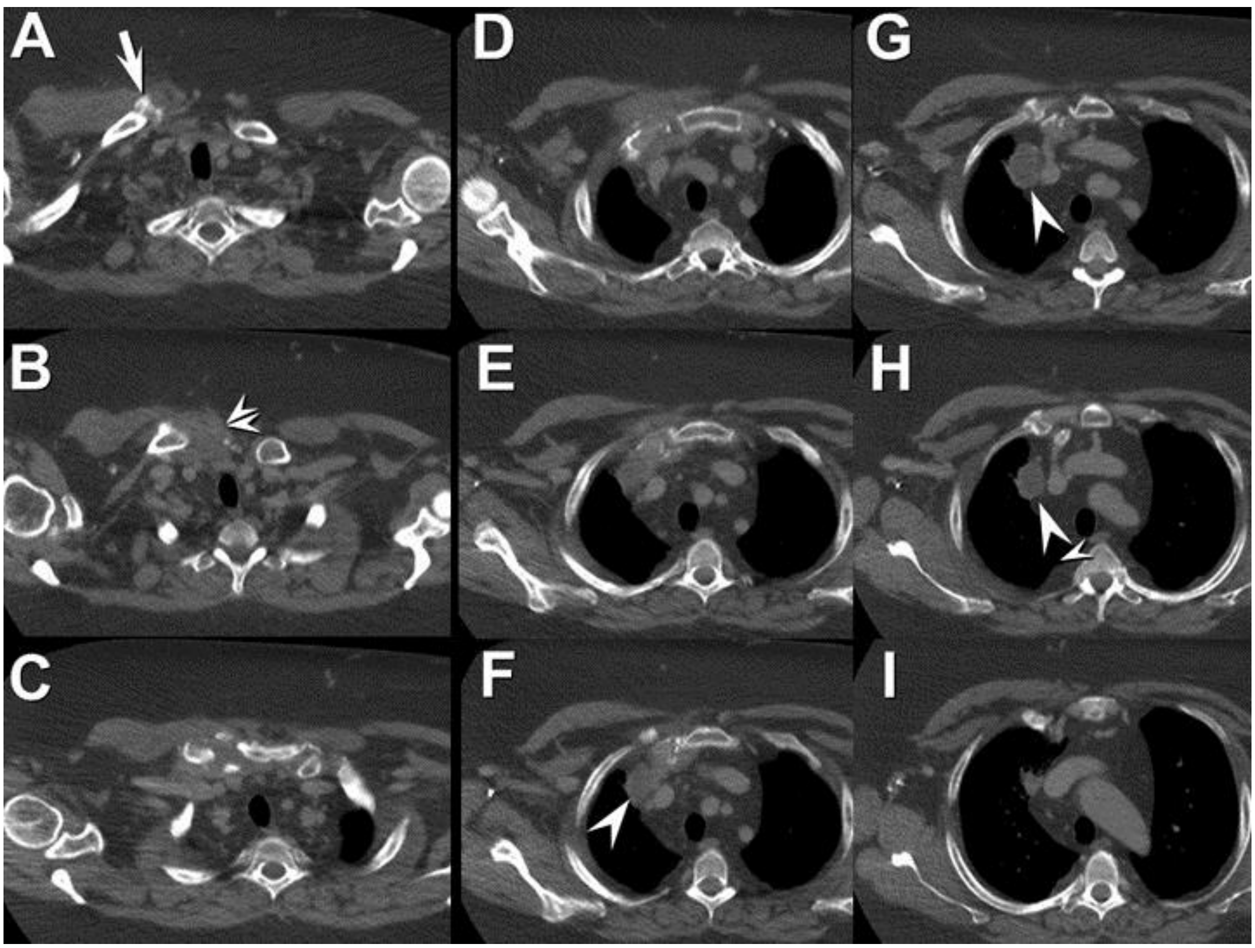

Figure 3. Axial unenhanced thoracic CT

Which of the following is ***correct*** regarding the description of the thoracic CT findings?

1. CT shows a focal lesion projecting into the right superior mediastinum
2. CT shows loculated pleural fluid and thickening in the right anterior-superior thorax
3. CT shows multifocal mediastinal lymphadenopathy
4. CT shows that an aneurysm of the right brachiocephalic vein accounts for the chest radiographic abnormality
5. CT shows that the lesion seen at chest radiography is a variant pericardial recess

Correct!

1. CT shows a focal lesion projecting into the right superior mediastinum

Unenhanced thoracic CT shows a low attenuation focus (single arrowhead) projecting into the right superior mediastinum adjacent to the right brachiocephalic vein, accounting for the finding at presentation chest radiography. No pleural abnormality is seen and the great arteries and veins appear normal. Aside from the lesion itself, there are no features to suggest mediastinal lymph node enlargement. The pericardium is normal and no significant fluid collection is seen. In particular, the location of the lesion is too cranial to represent a pericardial recess, even a normal variant pericardial recess, such as the so-called “high-riding” right paratracheal superior pericardial recess. Of note, periosteal reaction involves the right clavicular head (arrow), and prominent asymmetric soft tissue is seen around the right clavicular head as well (double arrowheads).

Which of the following differential diagnostic considerations is ***least appropriate*** for the imaging findings in this patient?

1. Abscess
2. Foregut duplication cyst
3. Metastatic lymphadenopathy
4. Myeloma
5. Primary mediastinal sarcoma

Correct!
2. Foregut duplication cyst

The *least* likely etiology for the observed radiographic findings among those listed is a foregut duplication cyst. While foregut duplication cysts can enlarge, which indicates that the mere lack of visualization of the abnormality on the previous chest radiograph does not absolutely exclude this diagnosis, foregut duplication cysts typically grow slowly; the marked change over a 2-year period would be highly unusual for a foregut duplication cyst. In contrast, such rapid change would not be unusual for the other choices listed. Additionally, a foregut duplication cyst would not expected to be associated with the chest wall abnormalities also seen in this patient, and the margins of the soft tissue / fluid collection in the mediasitnum in this patient are somewhat irregular and associated with visible peripheral wall thickening; both findings atypical for an uncomplicated foregut duplication cyst. In contrast, an abscess, particularly arising from the chest wall or sterno-clavicular joint (septic arthritis) certainly could present with the combination of osseous destruction / fragmentation associated with a low attenuation soft tissue and fluid focus projecting into the mediastinum. Metastatic lymphadenopathy could certainly result in both the chest wall and soft tissue findings, as could a primary neoplasm of the chest wall, such as multiple myeloma. Finally, although exceedingly rare, primary mediastinal sarcomas can present with soft tissue lesions in this location [particularly if the abnormality arose from the adjacent right brachiocephalic vein in this patient], and could cause adjacent chest wall invasion with osseous destruction.

Which of the following would be ***most useful*** for further evaluation of this patient?

1. Chamberlain procedure
2. Dual-energy thoracic CT
3. Flexible fiberoptic bronchoscopy
4. Mediastinoscopy
5. Upper endoscopy

Correct!
2. Dual-energy thoracic CT

Mediastinoscopy is useful for assessing lesions found in particular mediastinal locations, typically the right paratracheal and anterior subcarinal spaces. The lesion in this patient, however, is located well lateral of the right paratracheal space, with the right brachiocephalic vein obstructing access to the lesion, from the standard supra-cervical mediastinoscopy approach, as well. Bronchoscopy can visualize and possibly sample lesions in close proximity to the central airways, but this lesion is located several centimeters away from the trachea and could not be reached with bronchoscopic biopsy techniques. In an analogous fashion, esophageal endoscopic ultrasound is an excellent tool for visualizing and possibly biopsying lesions in close proximity to the esophagus, such as lymph nodes or masses in the left paratracheal space (2L and 4L), subcarinal space (station 7), periesophageal spaces (station 8), and aorto-pulmonary window (station 5). However, this lesion is clearly remote from the esophagus and could not be assessed with upper endoscopy. A Chamberlain procedure, or left anterior mediastinotomy, is useful for sampling left mediastinal lesions, such as those in the prevascular, left para-aortic and aorto-pulmonary window region spaces, but the lesion in this patient is remote from these locations and could not be accessed with this technique.

Dual-energy CT is a recently introduced technique that provides information regarding how substances behave when exposed to x-ray beams of different energies. Knowledge of how a particular substance behaves when exposed to x-ray beams of differing energies can provide information regarding tissue composition. Basically, x-ray beam energy is maximally absorbed when the K-edge values of the tissue exposed to the x-ray beam are close to the energy of the x-ray beam; in this case, the interaction known as the *photoelectric effect* is enhanced. The photoelectric effect refers to the ejection of an electron from the innermost K-shell of an atom by an incident x-ray photon, and only occurs when the incident x-ray photon has enough energy to overcome the binding energy of the K-shell electrons in the exposed tissue. The term “K-edge” refers to the spike in CT attenuation observed, owing to increased photoelectric interactions, when the energy of the x-ray beam is just greater than the K-shell binding energy of the exposed tissue. In contrast, when the K-edge of the tissue exposed to x-ray energy is remote from the energy of the x-ray beam, the atomic interaction known as *Compton scatter* is favored. Because K-edge values for various elements are known, exposing tissues to x-ray beams of differing energy can provide for the detection of certain substances in biological tissues, including iodine, calcium, and uric acid. In the case of iodine, dual-energy CT techniques can be employed to create “virtual unenhanced” images by subtracting iodine the blood pool of enhanced studies; in a similar vein, calcium can be subtracted from the tissues as well; removal of calcium can be useful improve vascular assessment at CTA, or to create chest radiographic images with the osseous structures “subtracted” from the images, thereby eliminating superimposition of bone over the lungs on a chest radiograph. A number of dual-energy CT applications have been developed, including renal stone composition (differentiating uric acid stones from other renal stones), adrenal nodule characterization, improved detection of hypervascular hepatic lesions, as well as detection of perfusion defects related to pulmonary embolism, among others.

The patient underwent dual-energy thoracic CT (Figures 4 and 5) using a dual-source CT scanner, with the tube potential of one tube set at 80 kV and the other at 140 kV.

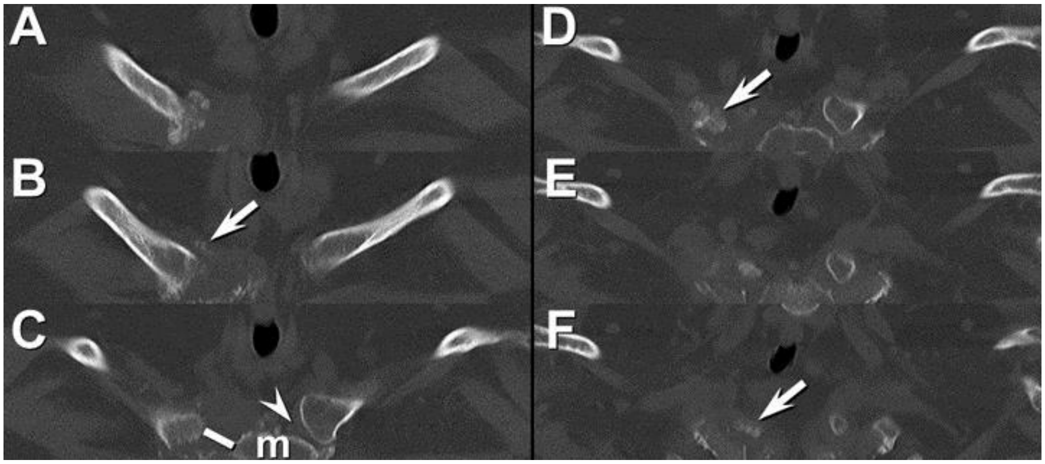

Figure 4. Coronal maximum intensity projection images from a dual-energy thoracic CT study again show destructive changes centered on the right sterno-clavicular joint, evidenced by periosteal reaction and osseous destruction and fragmentation (arrow) associated with widening of the right sterno-clavicular joint space (line in C) compared with the normal sterno-clavicular joint space on the left (arrowhead). m= manubrium.

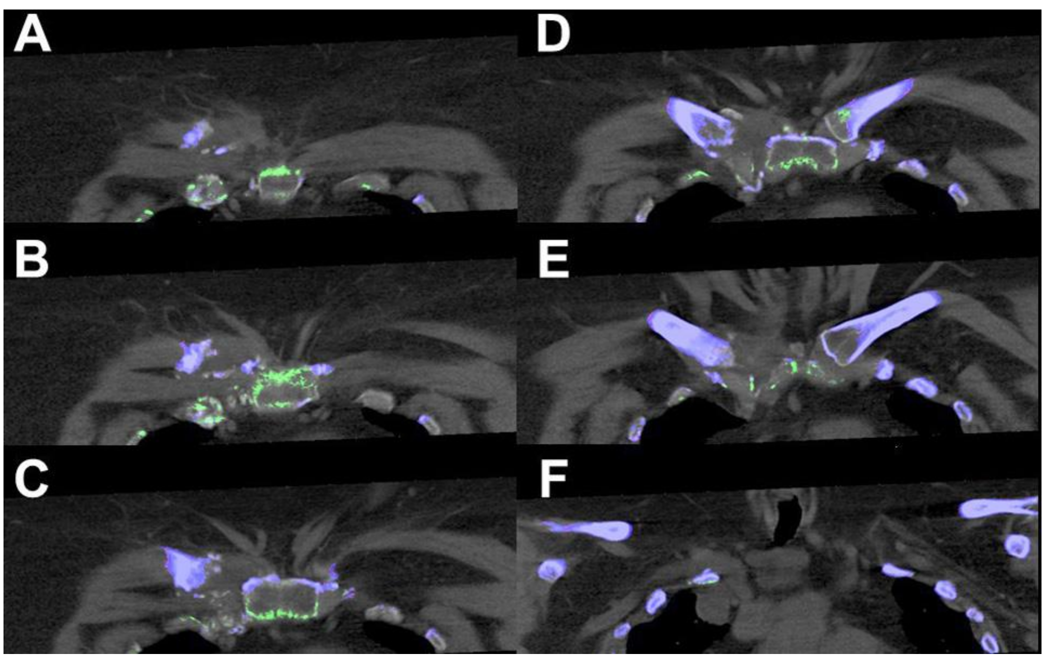

Figure 5. Coronal dual-energy thoracic CT examination shows right sterno-clavicular joint space widening and fragmentation with clavicular head irregularity and erosion; the green-color coding indicates the presence of monosodium urate crystal deposition.

The use of differing tube potentials (energies) exploits the kV-dependent nature of CT attenuation (reflected as CT numbers expressed as Hounsfield units), and allows materials of differing atomic numbers to be distinguished. Post-processing allows materials of differing atomic number to be coded as different colors to facilitate visual recognition. Using this methodology, monosodium urate crystal deposition is detectable and was coded as a green color using the post-processing software.

Given this information, among the choices listed, which is the ***most likely*** diagnosis to explain the imaging findings?

1. Metastases
2. Osteoarthritis
3. Septic arthritis of the sterno-clavicular joint
4. Sterno-clavicular joint arthritis due to calcium pyrophosphate deposition (a.k.a. “pseudogout”)
5. Sterno-clavicular joint arthritis due to gout

Correct!
5. Sterno-clavicular joint arthritis due to gout

While the joint space irregularity, fragmentation, and soft tissue mass with internal fluid all certainly could reflect septic arthritis with adjacent soft tissue infection, and perhaps less likely, but still possible, metastatic disease (which uncommonly directly affects the joint space, thereby simulating the appearance of arthritis) the dual-energy CT findings, which allow material decomposition, clearly show the presence of monosodium urate crystals in the affected joint space, consistent with gout. The dual-energy CT findings do not show the presence of calcium pyrophosphate crystal deposition, but do show that a crystal deposition disease is present, with this latter finding arguing against osteoarthritis.

The patient underwent aspiration of the right sterno-clavicular joint space, which revealed monosodium urate crystals under polarizing microscopy (intracellular and extracellular, needle-shaped, negatively birefringent crystals) within the affected tissues, consistent with arthritis due to gout. No evidence of infection or malignancy was seen. The patent also underwent radiography of the hand with dual-energy CT of the hand (Figure 6) which also showed soft tissue gouty tophi with gouty arthritis.

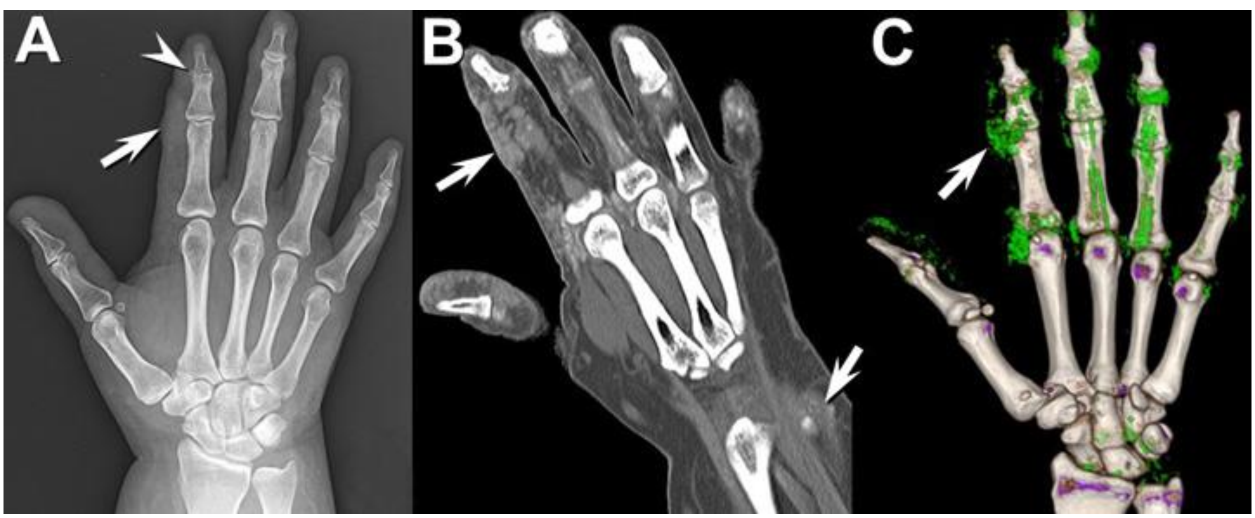

Figure 6. Radiograph (A), maximum intensity projection CT (B) and dual-energy CT (C) shows para-articular soft tissue swelling (arrows) due to gout tophi (coded green on the dual-energy CT study in C. Note that some green over nails and skin calluses is artefactual and does not necessarily reflect crystal deposition. To appreciate the para-articular soft tissue swelling compare the thickness of the soft tissues of the distal interphalangeal joint space region of the index finger with the adjacent middle finger in A. Degenerative change of the distal interphalangeal joint of the index finger (arrowhead), evidenced by joint space narrowing, is due to gout.

Diagnosis: Sterno-clavicular gouty arthritis

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