



Cardiothoracic Imaging

Cough-induced costal cartilage fracture

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ARTICLE INFO

Keywords:

Costal cartilage fracture
Chest pain
Interchondral joint
Computed tomography

ABSTRACT

We present two cases of atraumatic costal cartilage fracture secondary to violent coughing. Although costal cartilage fractures due to trauma and bony rib fractures due to violent coughing have been described, to our knowledge there have been no prior reported cases of cough-induced costal cartilage fracture. It is important for radiologists to consider costal cartilage fractures, which are often more subtle than osseous injuries, in patients with chest pain, and understand that they may not always be preceded by direct trauma. Identifying this injury is clinically important and will prevent patients from undergoing unnecessary examinations to rule out a cardiac cause of chest pain or a pulmonary embolism.

1. Introduction

Chest pain and upper abdominal pain are common presenting complaints in both the emergency room and primary care settings with musculoskeletal sources comprising a significant percentage of cases [1–3]. In the setting of trauma, musculoskeletal injury is the immediate diagnostic consideration, however the diagnosis may be less obvious in the absence of overt trauma. Rib fractures, diaphragm rupture, and muscular hematomas have all been described following violent fits of coughing [4–6]. Costal cartilage fractures are uncommon injuries that have been described after high energy blunt trauma, such as in athletes playing contact sports, however to our knowledge there have been no reports of cough-induced costal cartilage fracture [7–10]. We present two cases of atraumatic costal cartilage fracture secondary to violent coughing and propose anatomic and physiologic explanations for this injury.

2. Case presentation

2.1. Case 1

A 65-year-old man with type 2 diabetes, hyperlipidemia, and a 20 pack-year smoking history presented to the emergency department with a 2-week history of non-productive cough and new right-sided abdominal wall pain that began suddenly after a relentless coughing fit. He had been seen two days prior at an outside hospital where a right

upper quadrant ultrasound was negative. The pain was described as sharp, non-radiating, and exacerbated by coughing episodes. On physical exam, he was focally tender over a right anterior lower rib. Routine labs were normal including an INR of 1.

Chest radiography showed a small right pleural effusion. CT of the chest, abdomen, and pelvis showed a fracture of the right 8th rib costal cartilage with surrounding hematoma, a small right pleural effusion, and right lower lobe atelectasis versus pneumonia (Fig. 1a–e). Pulmonary embolism was suspected clinically but not present on CT. The patient was discharged home with instruction to take Tylenol as needed for pain and follow up with his primary care physician in 1 week. He returned to the emergency department one day later with worsening right upper abdominal wall pain and worsening ecchymosis at the site of tenderness. His hemoglobin had dropped from 13.4 to 9.9 g/dl, and he was admitted to the hospital. CT angiography of the abdomen failed to identify an active bleed but demonstrated increased size of the abdominal wall hematoma and a new hemothorax (Fig. 1f). He was transfused one unit of packed red blood cells and a chest tube was placed. He subsequently underwent video assisted thoracoscopic surgery (VATS) for hematoma evacuation and was discharged home four days later after an unremarkable post-operative course. At a follow-up visit two months after discharge, his symptoms had completely resolved.

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Received 27 January 2019; Received in revised form 2 March 2019; Accepted 12 March 2019

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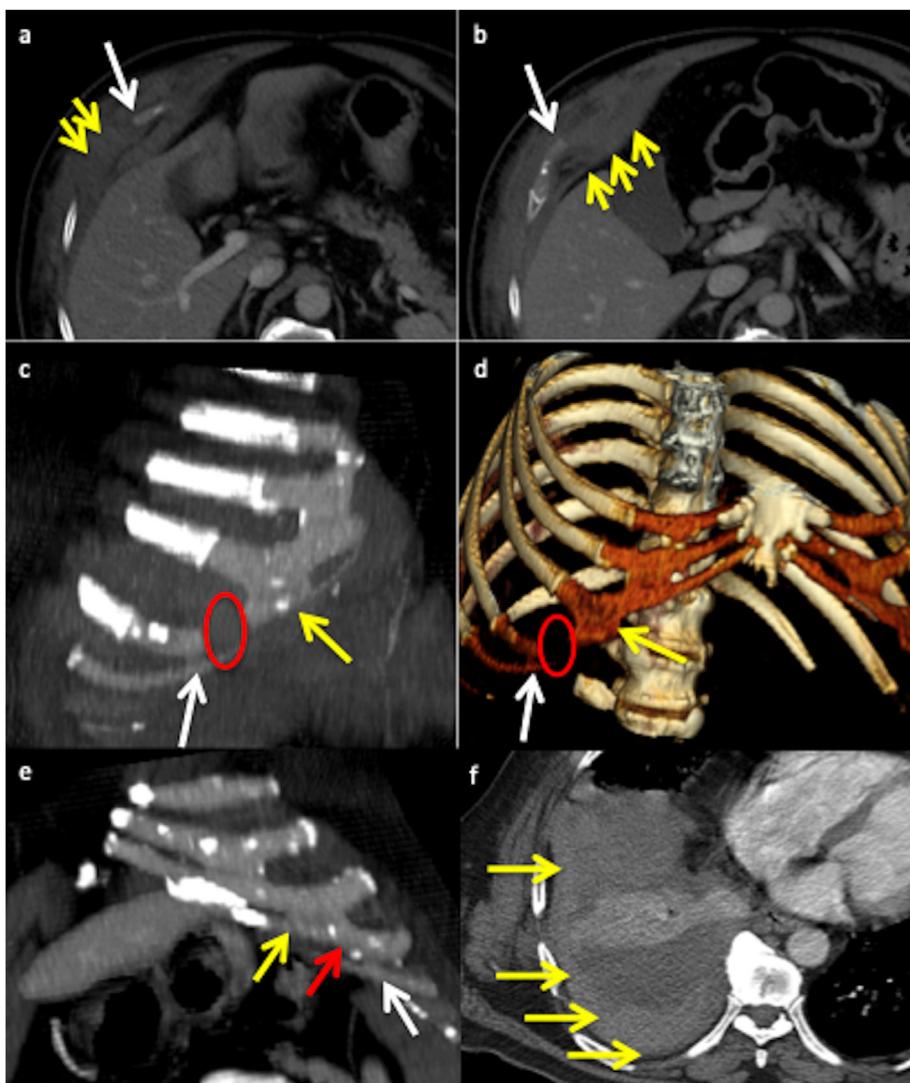


Fig. 1. Atraumatic right 8th rib costal cartilage fracture.

Axial contrast-enhanced CT images (a and b) demonstrate the fractured right 8th rib costal cartilage (white arrows) and adjacent hematoma (yellow arrows). A curved reformat (c) and oblique 3D reformat (d) demonstrate the fracture gap (red oval) between the intact 7th–8th rib (yellow arrow) and 8th–9th rib (white arrow) interchondral joints. A curved reformat of the normal left side (e) shows the intact 8th rib costal cartilage (red arrow) between the 7th–8th rib (yellow arrow) and 8th–9th rib (white arrow) interchondral joints. An axial image from a contrast-enhanced CT one day after the initial CT (f) shows a hemothorax (yellow arrows) probably due to injury to the musculophrenic vessels and laceration of the pleura. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2.2. Case 2

A 60-year-old man with history of asthma presented to his pulmonologist with an asthma exacerbation and was started on oral prednisone. Three days later, during a violent fit of coughing, he felt a sudden pop in his left lower anterior chest followed by sharp stabbing pain made worse with breathing. After developing ecchymosis over his left anterior chest wall, he presented to an urgent care center and was referred to our outpatient imaging facility. A CT of the chest, abdomen, and pelvis demonstrated a fracture of the left 8th rib costal cartilage and atelectasis versus pneumonia at his left lung base (Fig. 2). Prednisone was discontinued and oral antibiotics were started due to concern for pneumonia. The pain began to improve after one week and was fully resolved by two weeks. At one-year follow up, there was no complication or recurrence of symptoms.

3. Discussion

Many patients, including those with chronic obstructive pulmonary disease and asthma, are prone to vigorous coughing fits that can result in a variety of musculoskeletal injuries [11]. Previously described injuries include rib fracture, diaphragm rupture, and muscular hematoma [12,13]. As in the presented cases, costal cartilage fracture is another potential cough-induced injury that has not been previously reported.

Unlike the costal cartilages of ribs 1–7 (the “true” ribs), the costal

cartilages of ribs 8–12 (the “false” ribs) do not directly attach to the sternum. Instead, the 8th and 9th rib costal cartilages – and sometimes the 10th – articulate with the above cartilage, forming interchondral joints. Costal cartilages 6 and 7 frequently have interchondral joints in addition to chondrosternal articulations. Ribs 11 and 12 usually have no osseous or cartilaginous attachment anteriorly.

Interchondral joints are usually synovial – though they may lack a capsule – and are bound together by strong fibrous bands [14]. The interchondral joint is located just lateral to the chondrosternal joint at ribs 6 and 7 and farther lateral at each more inferior rib level (Fig. 3). Laxity of the interchondral joints has been implicated as a cause of “slipping rib syndrome,” in which respiratory movements cause one of ribs 8–10 to slip under the more superior rib, irritating an intercostal nerve [15–17].

The costal cartilages serve as attachment sites for the intercostal muscles and the internal and external oblique musculature of the abdomen. During coughing and strenuous activity, forceful contraction of the internal oblique muscles pull inferiorly on the rib cage and can lead to a rib or costal cartilage fracture, tearing of a muscle from its rib or costal cartilage insertion, or tearing of a muscle itself (Fig. 3) [18–20].

Potential sites of costal cartilage fracture are through the cartilage or at the costochondral, chondrosternal, or interchondral joints [9,10]. A recent review of costal cartilage fractures determined that mid-chondral injuries of the 7th rib are the most common cartilage fractures after trauma [9,10]. In the two cases presented above, both injuries

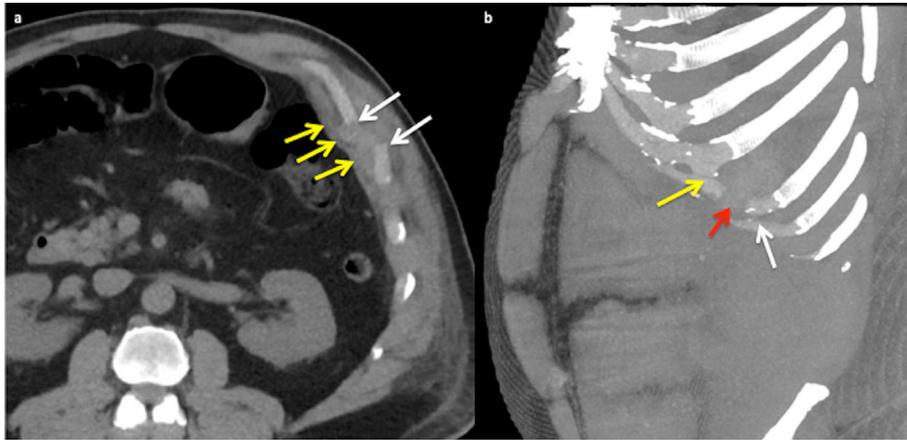


Fig. 2. Atraumatic left 8th rib costal cartilage fracture – Axial non-contrast CT image (a) shows the fractured 8th rib costal cartilage (white arrows) and surrounding abdominal wall hematoma (yellow arrows). An oblique sagittal maximum intensity projection (b) shows the fracture of the 8th rib costal cartilage (red arrow) between the intact 7th–8th rib (yellow arrow) and 8th–9th rib (white arrow) interchondral joints. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

were mid-chondral fractures through the 8th rib costal cartilage between the 7th–8th and 8th–9th rib interchondral joints. We propose that this location is a site of relative weakness, more mobile than the costal cartilages of the true ribs and located between two strongly reinforced interchondral joints.

Chest radiography is typically the initial imaging examination to evaluate for the cause of chest or upper abdominal pain. Although an associated pneumothorax or pleural effusion can be seen, costal cartilage fractures cannot be diagnosed on chest radiography unless there is a discontinuity of chondral calcifications, which are not present in most patients. For patients with right upper quadrant pain, ultrasound will typically be the next diagnostic step but will also be unrevealing unless specifically targeted to the body wall.

On CT, a costal cartilage fracture presents as a discontinuity of the cartilage, which is higher in attenuation than soft tissue but lower in attenuation than bone. Hematoma surrounded the cartilage fracture in the two presented cases, and one patient also had a pleural effusion. Shallow inspiration due to pleuritic chest pain may result in atelectasis, which could be confused for pneumonia. Ultrasound and MRI can be helpful in cases that require further evaluation after CT, though both

exams must be specifically targeted to the area of concern to improve diagnostic yield [8,9,21–23]. Follow-up imaging should document resolution of any hematoma to exclude an underlying mass. Barring complications such as pneumothorax or hemothorax, costal cartilage fractures should heal with conservative treatment.

In a recent series of patients with costal cartilage fractures after chest trauma, pneumothorax was present in 66% of cases and hemothorax was present in 52% of cases [9]. One of the above patients developed a hemothorax prompting return to the hospital, blood transfusion, chest tube placement, and surgical evacuation. The injured vasculature may have been the musculophrenic artery and/or vein, which run on the inferior medial aspect of the 6th–10th rib costal cartilages (Fig. 3) and travel adjacent to the undersurface of the 8th rib costal cartilage at the fracture sites in the presented cases. It is unclear why only one of the presented patients developed a hemothorax considering the fractures occurred in the same location. It is possible that there were similar injuries to the vasculature in both cases, but one patient lacerated his pleura, allowing bleeding into the chest, whereas the other hematoma was limited by tamponade within the more confined space of the abdominal sheath. Interestingly, both of the above

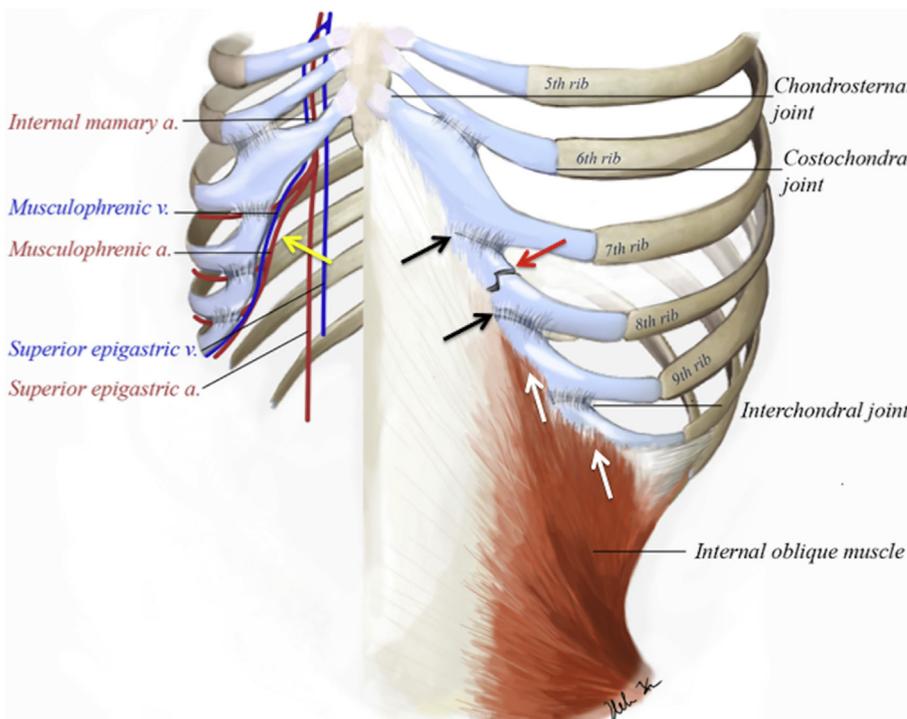


Fig. 3. An anatomic diagram demonstrates the site of the fracture in our cases. Fracture occurred at the 8th rib costal cartilage (red arrow) between the 7th–8th and 8th–9th rib interchondral joints (black arrows). The mechanism of injury is likely strong contraction of the internal oblique muscle, which inserts on the undersurface of the 9th–12th rib costal cartilages (white arrows) and relative weakness of the 8th rib costal cartilage between the strongly reinforced 7th–8th and 8th–9th rib interchondral joints. The musculophrenic vessels (yellow arrow) travel in close proximity to the fracture site. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

patients presented with ecchymosis of the body wall, which could have been a clue to the presence of a musculoskeletal injury.

Because unusual musculoskeletal injuries are not typically the top diagnostic considerations in the absence of trauma, it is important for radiologists and other clinicians to be aware of cough-induced costal cartilage fractures. The acute onset of symptoms mimics other causes of chest and abdominal pain such as pulmonary embolus, cholecystitis, diverticulitis, and renal colic. Recognizing and accurately describing a costal cartilage fracture is of great clinical importance, as it will prevent patients from undergoing additional imaging examinations such as right upper quadrant ultrasound, gallbladder scintigraphy, or CT angiography or undergoing additional cardiac work up. The correct diagnosis also helps the referrer be prepared for potential delayed complications such as hemothorax.

4. Conclusion

The above cases are, to our knowledge, the first reported cases of cough-induced costal cartilage fractures. In the absence of trauma, costal cartilage fracture may be an overlooked injury clinically and on imaging when evaluating for more common causes of acute pain. It is therefore important for radiologists to identify this unsuspected injury and understand that it may not be preceded by trauma.

Conflict of interest

The authors declare that they have no conflict of interest.

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