# Intercostal lung herniation - The role of imaging

Efstathios E. Detorakis[1,2*], Emmanuel Androulidakis[1]

*1. Department of Radiology, CT and MRI unit, Euromedic International, Heraklion, Crete, Greece*

*2. Department of Radiology, CT unit, University hospital of Heraklion, Crete, Greece*

* **Correspondence:** Efstathios E. Detorakis, MD, 15 Iktinou str. 71305, Heraklion, Crete, Greece
(*edetorakis@hotmail.com*)

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ABSTRACT

Extrathoracic lung hernias can be congenital or acquired. Acquired hernias may be classified by etiology into traumatic, spontaneous, and pathologic. We present a case of a 40-year-old male with a history of bronchial asthma and a blunt chest trauma who presented complaining of sharp chest pain of acute onset that began after five consecutive days of vigorous coughing. Upon physical examination a well-demarcated deformity overlying the third intercostal space of the left upper anterior hemithorax was revealed. Thoracic CT scan showed that a portion of the anterior bronchopulmonary segment of the left upper lobe had herniated through a chest wall defect. The role of imaging, especially chest computed tomography with multiplanar image reconstructions and maximum (MIP) and minimum intensity projection (MinIP) reformats can clearly confirm the presence of the herniated lung, the hernial sac, the hernial orifice in the chest wall, and exclude possible complications such as lung tissue strangulation.





## CASE REPORT

### CASE REPORT

A 40-year-old male presented to the pulmonary medicine department complaining of sharp chest pain of acute onset starting after five consecutive days of vigorous coughing and well localized in the anterior, upper half of his left chest wall. Chest pain initially was well tolerated and less intense but became worse and relentless the day before his visit to the emergency center. On arrival, he was slightly dyspneic and discomfort was exacerbated by deep breathing, coughing or movement. His past medical history included a seat belt-related blunt chest trauma eight years ago.

Among the first pathologies we had to exclude in a patient with chest pain is a myocardial infarction, pulmonary embolism or even pulmonary edema. Patient's vital signs like blood pressure, heart rate and oxygen saturation were all normal and chest pain was not retrosternal.

Upon physical examination a well-demarcated deformity overlying the third intercostal space of the left upper anterior hemithorax was detected. The deformity that was round-shaped, raised and palpable presented spontaneous reduction during inhalation while, on auscultation breath sounds could be clearly heard within it. The remainder of his physical exam was unremarkable and vital signs were normal on admission.

In regard to the superficially localized palpable chest wall lump further diagnostic investigation was focused.

Diagnostic imaging workup began with a posteroanterior and lateral view chest x-ray, revealing an ovoid shape area of increased radiolucency comparing to normal lung parenchyma at the level of the left upper hemithorax that seemed to contain vascular markings (Fig. 1). To further characterize the radiograph abnormalities, a subsequent computed tomography (CT) scan of the thorax was performed (General Electric LightSpeed VCT 64-slice CT scanner, GE Healthcare, USA). Chest CT scan was performed on emergency basis and due to the patient's bronchial asthma history no intravenous contrast media was administered. The following scan parameters were used: 2 mm slice thickness; 1.15 pitch; 100 mAs; 120 kV, in lung (width/level of 1500/-699 HU) and mediastinal (width/level of 350/30 HU) window settings in axial plane. Furthermore, multiplanar reconstruction images (MPR) in coronal and sagittal planes were performed.

Chest CT images acquired during inspiration showed that a portion of the anterior bronchopulmonary segment of the left upper lobe parenchyma had herniated through a chest wall defect in the upper left anterior chest wall (Fig. 2). In addition, images were acquired on expiration (width/level 1500/-599) and Valsalva maneuver where herniated lung portion seemed that protruded beyond the rib cage (Fig. 3). The dimensions of the herniated lung parenchyma were calculated 5.45cm axially x 2cm antero-posteriorly x 4.7cm craniocaudally.

Maximum (MIP) and minimum intensity projection (MinIP) images were acquired in order to exclude any case of vessel or bronchial tree compression, respectively, of the herniated lung portion (Fig. 4). Volume-rendered 3D reconstructions (VRT) were also performed creating an overview of the intercostal lung hernia protruding subcutaneously as a well-circumscribed round lump through an upper left chest wall defect created by a costochondral junction fracture and subsequent intercostal muscle tear (Fig. 5).

Upon diagnosis of an acquired intercostal lung herniation, the patient was transferred to a thoracic surgery center where the lung was surgically examined. The herniated lung tissue was reduced and the chest wall defect was repaired with an expanded Gore-Tex® (polytetrafluoroethylene) patch. The patient made a full recovery (Fig. 6).

## DISCUSSION

Lung hernia is an uncommon entity and is defined as the protrusion of the pulmonary tissue and pleural membranes beyond the confines of the thoracic cavity through an abnormal opening in the chest wall, diaphragm or mediastinum [1,2]. The first public description and classification dates back to 1845 according to Morel-Lavallée, who collected 32 cases and created a very comprehensive and the most widely accepted lung hernia classification based on both the etiology and anatomic location [3](Table 1 and 2).

According to the anatomic location, lung herniation can be divided in cervical, thoracic, diaphragmatic or mediastinal [3]. Classification by etiology can be congenital or acquired [3]. Congenital hernias are usually associated with costal or cartilage malformations such as rib or intercostal hypoplasia or from attenuation of the endothoracic fascia [4,5]. They occur either at the thoracic inlet or at the intercostal spaces, where weakness of the fascia is usually combined with absence of the intercostal muscles. However, the thoracic cage has inherent weakness anteriorly near the sternum, medial to the costochondral junction, and posteriorly, near the vertebral bodies, where there is a single layer of intercostal muscles [6,7].

Most of congenital hernias present in childhood, but sometimes they may be asymptomatic and present later in life [8].

Acquired lung hernias may be divided into traumatic, spontaneous, and pathologic. The mechanism of acquired lung hernias involves intercostal muscle weakness in combination with conditions that increase intrathoracic pressure such as coughing and heavy weight lifting. Predisposing factors include both environmental and operative trauma, chronic obstructive pulmonary disease, inflammatory or neoplastic processes and chronic steroid use [6,9].

The majority of acquired lung hernias result from blunt or penetrating chest trauma, or from preceding operative procedure with inadequate closure of the herniated lung [10]. Traumatic hernias may appear immediately after injury or be delayed for years [11]. Postoperative intercostal hernias are reported more commonly in literature after less extensive surgical procedures, such as video assisted thoracoscopy (VAT), than after major thoracic interventions that are usually followed by meticulous thoracotomy closure [9,10,12,13,14,15]. Spontaneous lung hernias usually develop as a consequence of a sudden increase of intrathoracic pressure such as during intense coughing, sneezing, musical instrument or glass blowing or strenuous lifting in addition to localized weakness of the thoracic wall resulting in rib or cartilage fracture [7,16,17,18].

Pathologic hernias are the least common variety and usually represent sequelae of chest wall or breast pathology such as abscess or empyema necessitans (transpleural spread of an infected pleural collection that may erode the adjacent chest wall), malignant tumors, and tuberculous osteitis [7].

According to the previously stated classification, our case corresponds to an acquired lung herniation of a combined traumatic and spontaneous origin. The blunt chest trauma initially created a costochondral junction dissociation, as well as subsequent intercostal muscle tear that led to a local impairment of the thoracic wall. For many years, this chest wall defect remained neglected due to unremarkable symptoms to the patient, until an exacerbation of bronchial asthma with protracted coughing, provoked a sudden increase of intra-thoracic pressure and consequent protrusion of pulmonary tissue and pleural membranes beyond the confines of the thoracic wall (Fig. 5).

The differential diagnosis of a painful palpable chest wall lump also includes subcutaneous emphysema, bronchopleural fistula, chest wall lipoma, abscess, cutaneous metastasis as well as delayed seroma or pectoralis major tendon rupture, especially after a chest wall trauma [19](Table 3). Subcutaneous emphysema is usually depicted as multiple subcutaneous radiolucent areas in plain chest radiography, hyperechoic subcutaneous regions with dirty posterior shadowing in ultrasound and air-density subcutaneous regions in chest CT (-1000 Hounsfield units, HU). In case of a bronchopleural fistula an air-fluid level that typically extends from pleural cavity to the chest wall will be seen in chest radiograph and areas of low attenuation that appear to communicate directly with a disrupted visceral pleura, usually from a tumor or empyema. Ultrasound is of little value in showing the fistula directly and may show only pleural fluid collections [21]. A seroma will be mostly radiopaque in chest radiograph, hypoechoic with lack on internal vascularity and posterior acoustic enhancement in ultrasound and a circumscribed water-density area in thoracic CT (0 HU). In case of pectoralis major tendon rupture and muscle retraction, posteroanterior chest radiography may reveal the loss of muscle shadow, while musculoskeletal ultrasound can demonstrate the loss of continuity of the tendon fibers and /or the presence of intra-muscular haematoma. MRI and not CT can reliably identify the injury to the muscle and pectoralis tendon, where signs of partial or complete tendon tear may be detected (tendon retraction, detachment of tendon's insertional fibers, periosteal stripping, haematoma)[22]. A chest wall lipoma is usually moderately radiolucent on chest radiograph, but on ultrasound examination may range from hyperchoic to anechoic, depending on the degree of connective tissue and other reflective interfaces present within the lesion. Chest CT will show a fat density lesion, with attenuation ranging from -250 to -50 Hounsfield units (HU) [23].

Upon clinical examination, the most common presentation of a lung herniation is a soft, tender, subcutaneous mass that may protrude on physical strain or coughing. Often, the signs of lung herniation may be subtle and in absence of a palpable mass, Valsalva maneuver performance may be necessary to elicit findings of this disorder, by increasing the intrathoracic pressure, making appear a lump that corresponds to the herniated lung portion [16].

Early clinical diagnosis may be difficult since the symptoms of lung herniation appear to overlap those resulting from intercostal neuritis or neuralgia. Chest pain associated with lung herniation most likely results from parietal pleural irritation. The parietal, and not the visceral pleura, has pain fibers and is innervated predominantly by the intercostal nerves [24].

A plain chest radiograph, especially on Valsalva maneuver, may be the first approach to the diagnosis of an intercostal lung hernia. Herniation may be missed on routine chest radiography unless is at a true tangent to the X-ray beam [25].

Even though normally aerated lung parenchyma is not visible as a discreet structural entity with ultrasonography, lately transthoracic ultrasound has been considered useful and a much promising tool in the diagnosis of various lung and chest wall diseases (pneumothorax, lung consolidation, atelectasis) [25,26]. In cases where a CT scanner is not immediately available transthoracic ultrasound may be also useful, together with chest radiograph, as a first approach in the diagnosis of an intercostal lung herniation[26]. Hence, in such case, the aerated lung tissue of the palpable intercostal lump, due to its high acoustic impedance, must be intensively hyperechoic and may cause shadowing, excluding other chest wall pathologies from the differential diagnosis list like haematomas, lipomas and other soft tissue lesions.

Chest computed tomography (CT) images may demonstrate the herniated lung, the hernial orifice in the chest wall, the hernial sac, as well as their anatomic relation with the pectoral and intercostal muscles. Multiplanar reconstruction images (MPR) in axial, sagittal and coronal planes may be of crucial importance because they better define the exact location and size of the chest wall defect, as well as the dimensions of the herniated lung tissue [25,27,28]. Minimum intensity projection (MinIP) is a data visualization method that enables detection of low-density structures in a given volume. It is a particularly useful algorithm for analyzing the bronchial tree and may be helpful excluding bronchial occlusion regarding large and medium caliber bronchi (Fig.4a). Also, maximun intensity projection images (MIP) especially in axial, coronal and sagittal reformats, may be important in order to exclude strangulation of pulmonary tissue as well as infarction of pulmonary vessels (Fig.4b). In cases where the hernia orifice is of small diameter and the lung tissue appears really compressed (not in our case where the hernia orifice was wide) contrast enhanced chest CT must be mandatory (CT pulmonary angiography protocol). Hence, the absence of contrast within the vessels of the herniated lung on contrast-enhanced CT can be taken as an indication of strangulation and therefore of imminently at-risk lung or already non-viable lung [28].

Volume rendered 3-dimensional reconstructions (VRT) provide an overview of the chest pathology and can be extremely useful for the assessment of the disease extent which is important for surgical planning and management (Fig.5).

When the herniated lung is of small dimensions and not so obvious on inspiratory chest CT scan, an expiratory scan with Valsalva maneuver may make the lung portion further protrude along the hernial orifice, establishing the final diagnosis of lung herniation.

True hernias of the lung seldom heal spontaneously. Therefore, surgical treatment is usually needed [29]. There is still no consensus on surgical treatment of lung herniation. It may be performed immediately (primary) or after a delay (secondary) and depends on the clinical condition of the patient [30]. Treatment of symptomatic lung hernia is surgical and is determined by factors such as size and pain, incarceration or strangulation of lung tissue, and paradoxical respiration with poor ventilation [25]. In minor cases of traumatic lung hernia a more conservative management may be needed [31].

## TEACHING POINT

In cases of intercostal lung herniation chest CT using multiplanar reconstructions (MPR) and maximum (MIP) and minimum intensity projection images (minIP) can clearly confirm the existence, the extent and condition of herniated lung tissue, while volume rendering reconstructions (VRT) may be helpful for surgical planning.

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FIGURES

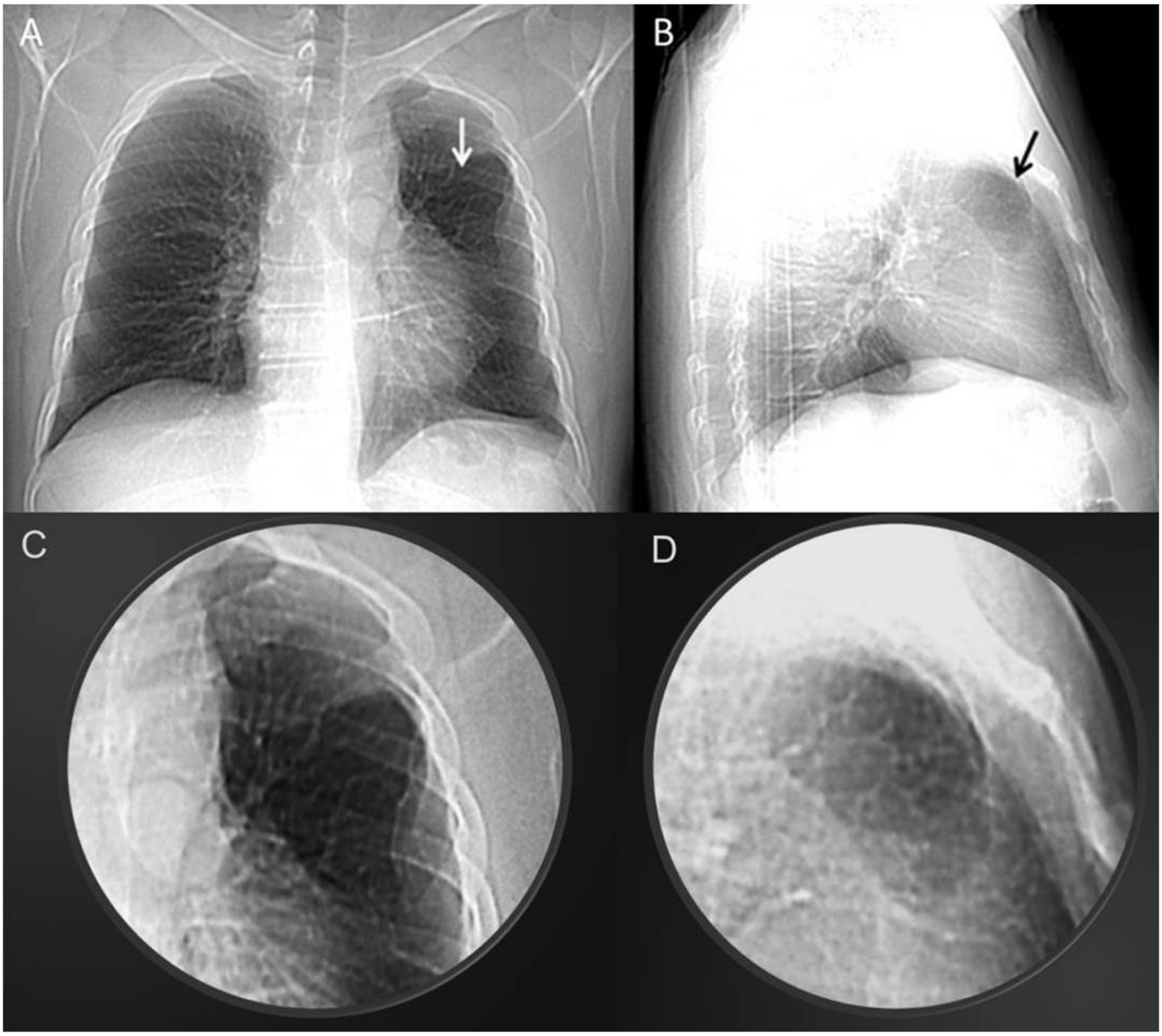


**Figure 1:** 40 year old male with intercostal lung herniation. Scout view from chest CT. (A) Frontal view showed an area of increased radiolucency in the left upper lobe (white arrow). Lateral view (B) showing a well-circumscribed ovoid shape radiolucent lesion in the left hemithorax (black arrow). (C) and (D) show magnified views of frontal (A) and lateral view (B), respectively, confirming the presence of a radiolucent area in left upper lobe containing vascular markings.

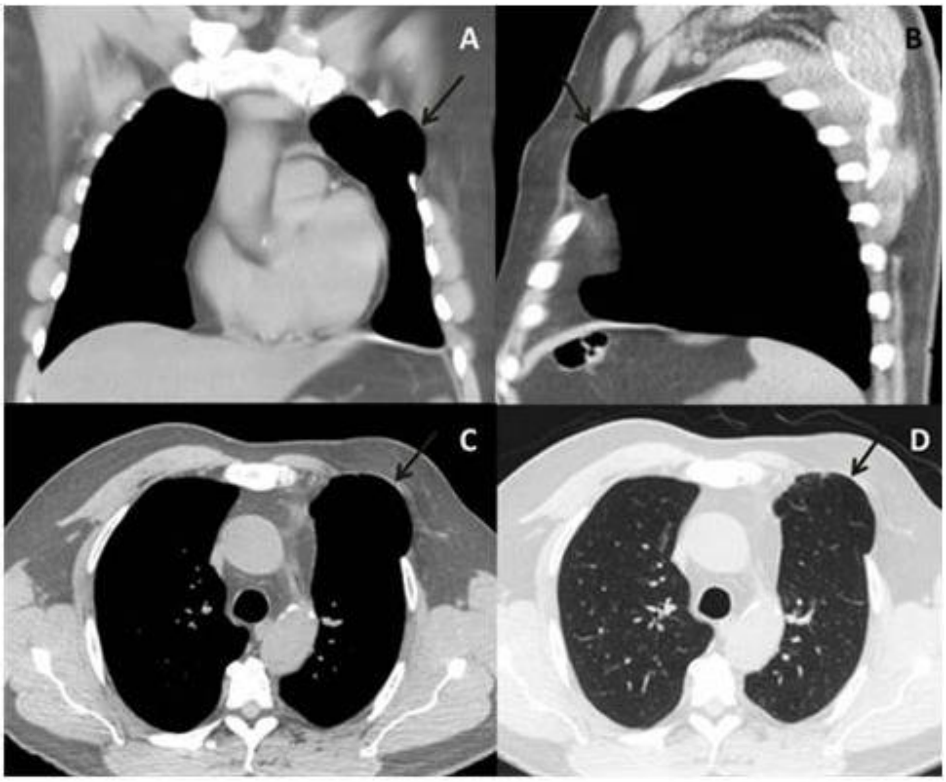


**Figure 2:** 40 year old male with intercostal lung herniation. Non-enhanced inspiratory chest computed tomography, mediastinal window, width/level of 350/30 HU, in coronal (A), sagittal (B) and axial plane (C) showing a region of air density in continuity with the left upper lobe protruding through a chest wall defect (black arrow). In the lung window, axial plane, width/level of 1500/-699 HU (D), the region proved to contain lung markings, belonging to the anterior bronchopulmonary segment of the left upper lobe (black arrow). The dimensions of the herniated lung parenchyma were calculated 5.45cm axially x 2cm antero-posteriorly x 4.7cm craniocaudally.
(Protocol: GE LightSpeed VCT 64, 100 mAs; 120 kV, 1.3 mm slice thickness; 1.15 pitch)

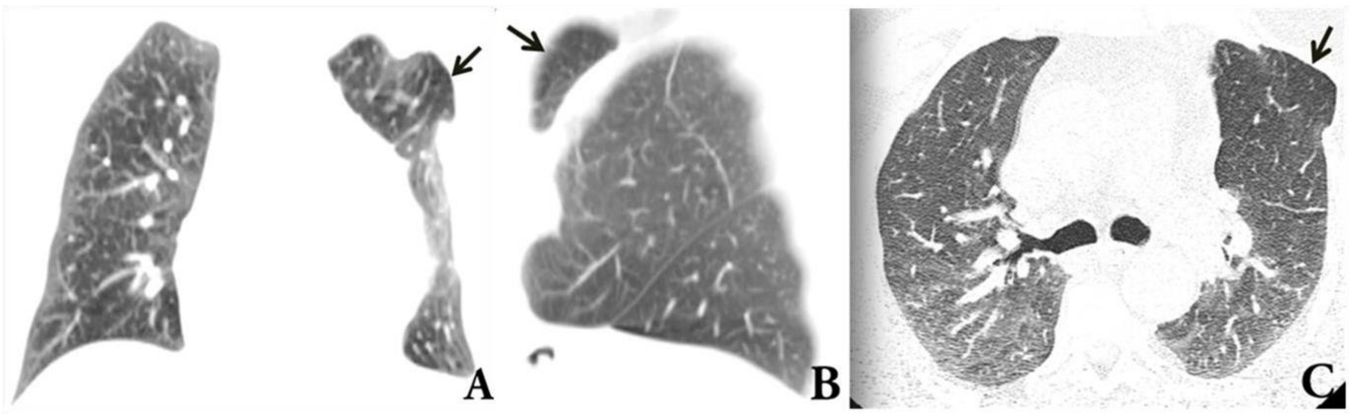


**Figure 3:** 40 year old male with intercostal lung herniation. Expiratory chest computed tomography, lung window (width/level of 1500/-599 HU) with Valsalva maneuver, in coronal (A), sagittal (B) and axial plane (C) where the herniated lung portion seems to protrude beyond the rib cage through a chest wall defect (black arrows).
(Protocol: GE LightSpeed VCT 64, 100 mAs; 120 kV, 1.3 mm slice thickness; 20mm spacing)

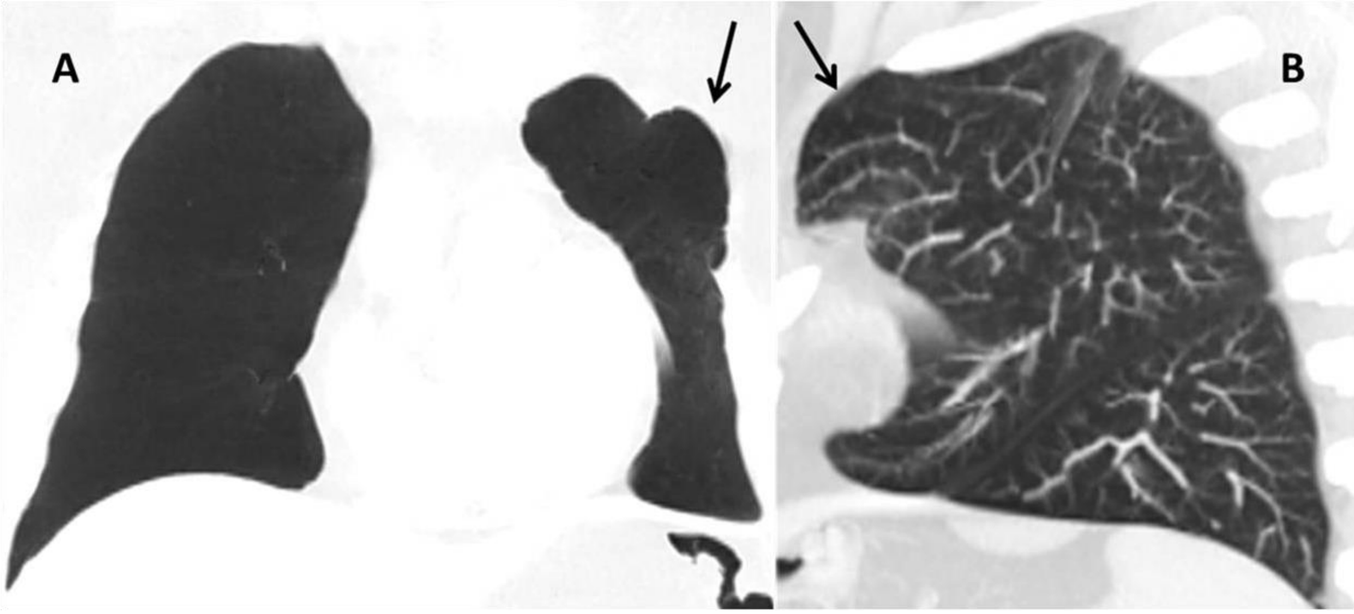


**Figure 4:** 40 year old male with intercostal lung herniation. Minimum intensity projection (MinIP, width/level of 668/-733 HU) in coronal plane (A) demonstrate no obvious signs of bronchial tree compression at the level of the lung herniation (black arrows). In maximum intensity projection (MIP, width/level of 1009/-488 HU) in sagittal plane (B) the herniated lung parenchyma shows no obvious signs of vessel compression or lung tissue strangulation (black arrows).
(Protocol: GE LightSpeed VCT 64, 100 mAs; 120 kV, 1.3 mm slice thickness; 1.15 pitch)





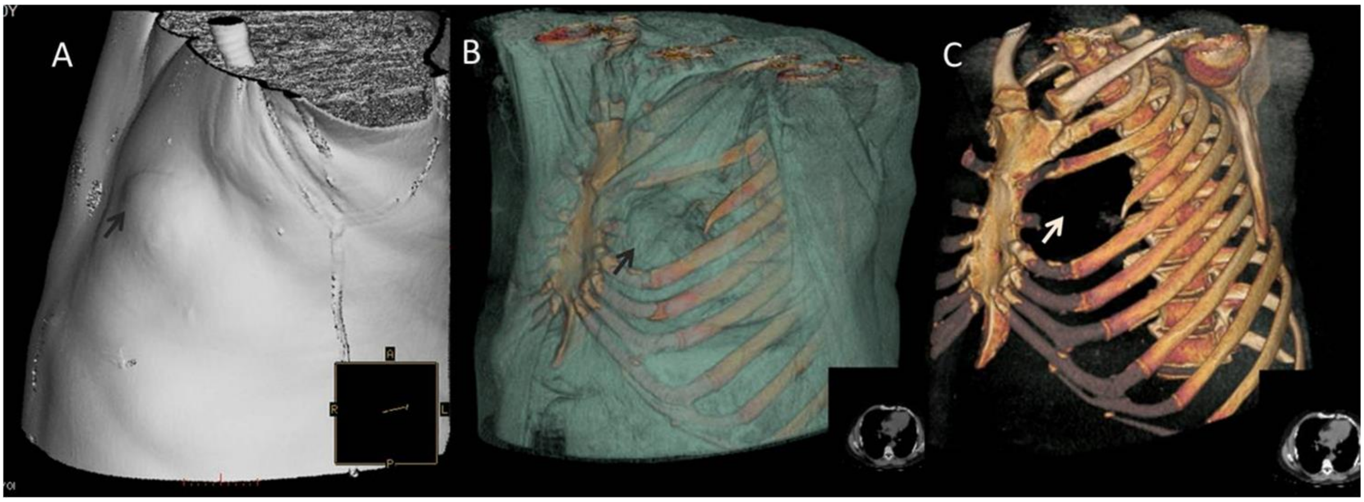


**Figure 5:** 40 year old male with intercostal lung herniation. Volume-rendered 3D reconstructions (VRT) in sagittal oblique plane presenting an overview of the intercostal lung hernia (A), protruding subcutaneously as a left upper chest wall well-circumscribed round area (black arrow), through a chest wall defect that corresponds to the hernial orifice (B) (black arrow), created by a costochondral junction fracture (white arrow) with subsequent intercostal muscle rupture (C).

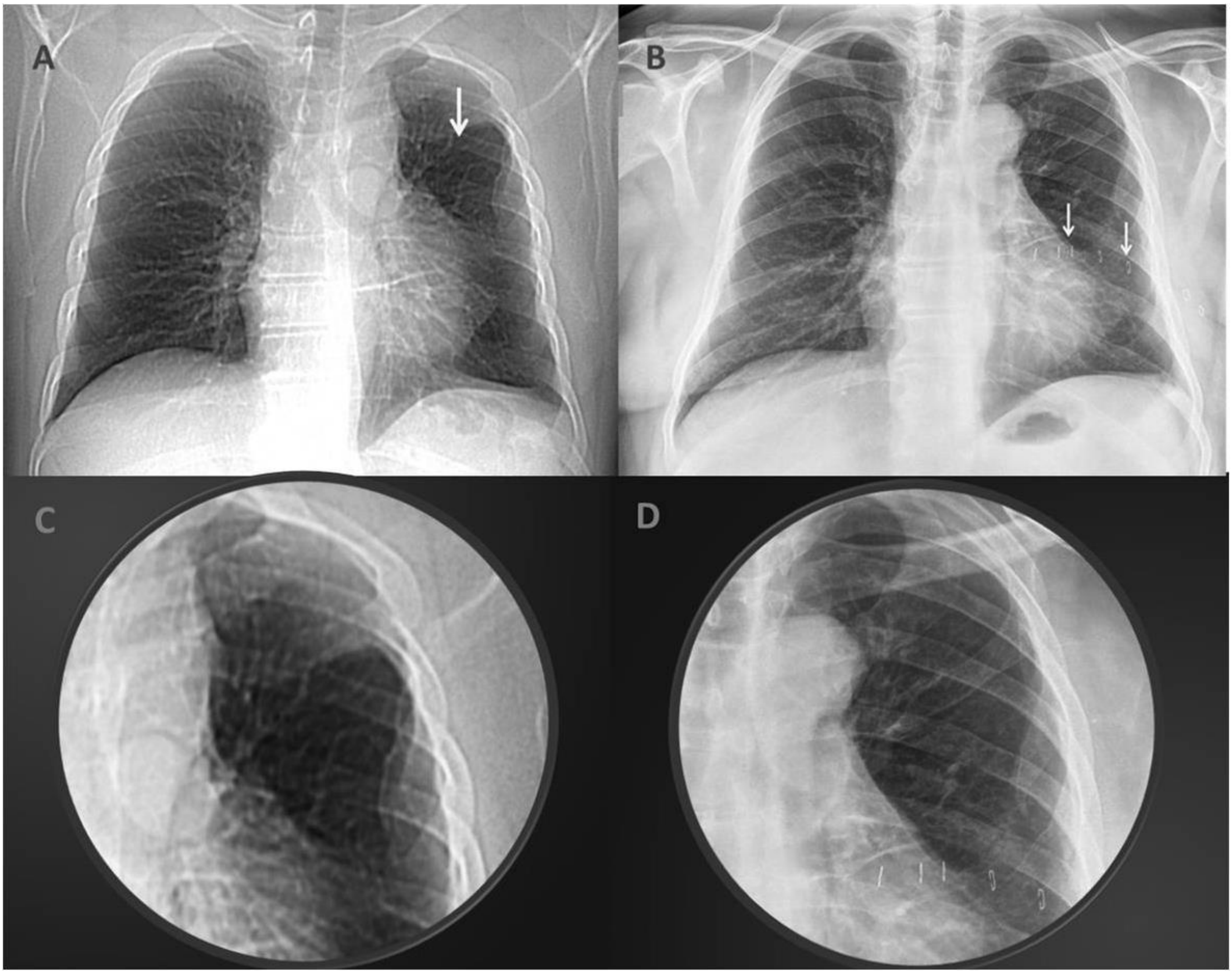


**Figure 6:** 40 year old male with intercostal lung herniation. Scout view from chest CT showing the herniated lung (white arrow) before (A) and (B) conventional postero-anterior chest radiography, 120kV, 500mA, after surgical repair of the chest wall defect (surgical clips, white arrows). Magnified views of the lung herniation before surgery where an area more radiolucent than normal lung parenchyma is depicted in the left upper lobe containing vascular markings (C) and after surgical repair (D) where left lung has normal and uniform radiolucency.

| | **Classification of lung hernias** |
|---|---|
| **Anatomic location** | • Cervical<br>• Thoracic<br>• Diaphragmatic<br>• Mediastinal |
| **Etiology** | • Congenital<br>• Acquired<br>-Traumatic<br>-Spontaneous<br>-Pathological<br>-Postsurgical |

**Table 1:** Classification of lung hernias (Morel-Lavallée modified[1,2,3,27])

| | |
|---|---|
| **Etiology** | May be congenital or acquired. Acquired hernias may be classified by etiology into traumatic, spontaneous, and pathologic. |
| **Incidence** | First described in the 16th century, less than 400 cases of lung herniation have been reported in literature. |
| **Gender ratio** | There is no gender predominance. |
| **Age predilection** | There is no age predilection. |
| **Risk factors** | Congenital or acquired disruption of the enclosed chest wall mostly from chest trauma (multiple rib fractures or separation of the costochondral joints and/or intercostal muscle rupture) that leads to lung herniation. |
| **Treatment** | Surgical approach is needed with lung hernia reduction and mesh repair of chest wall defect. |
| **Prognosis** | Complete recover if promptly diagnosed and surgically treated. |
| **Findings on imaging** | Chest radiograph and chest wall ultrasound may be helpful as a first diagnostic approach but chest CT may be helpful for the final diagnosis, showing a lung portion protruding beyond the thoracic cage through a chest wall defect. |

**Table 2:** Summary table of intercostal lung herniation

| ENTITY | X-RAY | ULTRASOUND | CT |
|---|---|---|---|
| **Intercostal lung hernia** | Radiolucent area in the chest wall. | Intensively hyperechoic region in the chest wall. | Part of lung parenchyma protruding through a chest wall defect. |
| **Lipoma** | Moderately radiolucent area. | May range from hyperechoic to anechoic depending on the degree of connective tissue and other reflective interfaces present within the lesion. | Lesion with adipose tissue density (from -250 to -50 HU). |
| **Delayed seroma** | Radiopaque chest wall lesion. | Hypoechoic circumscribed area. | Water-density circumscribed area in the chest wall. |
| **Subcutaneous emphysema** | Radiolucent subcutaneous areas, usually multiple. | Hyperechoic subcutaneous regions. | Hypodense, air-density subcutaneous regions. |
| **Bronchopleural fistula** | An air-fluid level that typically extends from pleural cavity to the chest wall. | May show only pleural fluid collections – of little value in showing the fistula directly. | Areas of low attenuation lung consolidation that appear to communicate directly with an obvious disrupted visceral pleura (usually from a tumor or empyema). |
| **Pectoralis major tendon rupture** | Can reveal loss of the pectoralis major shadow. | MSK ultrasound can demonstrate intra-muscular injury or loss of continuity of the tendon (tear location). | Can outline the muscle, but has difficulty visualizing the distal soft tissue of the pectoralis (MRI reliably identify injury to the muscle and distal tendon). |
| **Abscess** | Radiopaque lesion, may have air-fluid level at its center and thick walls. | Intermediate echogenicity. In case of fluid-air level internal areas of low and high echogenicity may be detected. | A soft tissue density lesion with hypodense center due to liquefactive necrosis or a cavitary lesion with thick walls containing a high density liquid, with or without air density areas |
| **Metastases** | Radiopaque lesion. | Intermediate echogenicity. | A soft tissue density lesion. In some cases may have a hypodense center due to central necrosis. |

**Table 3:** Differential Diagnosis table for intercostal lung hernia

## ABBREVIATIONS

CT = computed tomography
MinIP = minimum intensity projection
MIP = maximum intensity projection
MPR = multiplanar reconstruction
VRT = volume rendering technique


## KEYWORDS

Intercostal lung hernia; computed tomography; image reformats