Hernias of the chest wall.
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First described by Roland in 1499 [1] and classified by Morel-Lavallée in 1845 [2], lung herniation is defined as displacement of lung parenchyma outside the thoracic cavity through a defect in the chest wall, diaphragm, mediastinum or thoracic outlet [3]. In the literature, there have been fewer than 400 reported cases of chest wall hernias, the majority of which concern herniation through an intercostal space. The current classification divides lung hernias according to their etiology into congenital or acquired, with the latter comprising traumatic, spontaneous or pathologic herniation (table); of these, hernias secondary to blunt chest trauma are now the most common.

**Etiology of lung herniation**

**Congenital hernias**

Congenital hernias of the chest wall are rare with experience limited to case reports and small series [4]. They are found either at the thoracic inlet or less frequently through an intercostal space. Supraclavicular herniation results from attenuation or absence of the conical fibrous dome of endothoracic fascia blending with the deep cervical fascia (Sibson’s fascia) [3]; the
herniated lung passes into the neck between the scalene and sternocleidomastoid muscles. On the other hand, congenital intercostal lung herniation may occur either anteriorly, at one of the costochondral junctions, or laterally due to the lack of development of an intercostal muscle in combination with weakness of the endothoracic fascia.

**Traumatic hernias**

**Blunt trauma**

Non-penetrating injuries to the thoracic cage may result in multiple rib fractures with interruption of the endothoracic fascia, intercostal muscles and costal cartilages to produce a defect through which acute or chronic lung herniation may occur. The major cause of traumatic lung herniation today is a compression injury sustained during a motor vehicle crash, particularly in those restrained by a 3-point shoulder harness [5]; this has led it to be included as a potential component of the ‘seatbelt syndrome’ [6]. The shoulder strap passes diagonally across the chest in either direction, depending on the occupant’s position within the vehicle. Injuries occur along the path of the strap and chest wall hernias are most commonly parasternal, through a defect created by costochondral separation at multiple levels (figure 1) [6,7]. Associated injuries include sternal, clavicle and rib fractures including a flail segment, pneumothorax, pulmonary contusion or laceration and hepatosplenic injury [8]. The elderly are at increased risk of chest wall injury and its complications due to their diminished muscle mass, reduced chest wall compliance, limited cardiopulmonary reserve, osteopenia and other co-morbidities [9]. However, the introduction of advanced safety features such as airbags and restraints that regulate energy transmission to the occupant, through pre-tensioners and load-limiters [10], are likely to reduce the overall incidence of chest wall injuries, although rear seat passengers and those in older vehicles will remain at greater risk.
Penetrating trauma

Intercostal hernias may develop at the site of stab or gunshot wounds to the chest but more often result from surgical incisions with a thoracotomy or thoracoscopy. Overall, post-operative lung herniation occurs in a tiny percentage of patients who undergo a thoracic surgical incision and results from failure to adequately close the incision with secure approximation of the ribs to seal off the intercostal space [4]. When this is not achieved or the closure breaks down due to infection, delayed wound healing or pericostal suture rupture, the lung may herniate through the resulting defect (figure 2) [11]. In the largest reported experience of chest wall hernias, Seder and colleagues at the Mayo Clinic identified obesity, chronic obstructive pulmonary disease (COPD), oral steroid use and diabetes mellitus as potential risk factors for poor tissue healing leading to post-thoracotomy dehiscence and herniation through the chest wall [12]. Early or late failure of primary chest wall surgery may result in chronic hernia development, such as following chest wall reconstruction or correction of pectus excavatum [13].

However, perhaps counter-intuitively, herniation is more common after thoracoscopy [14,15] or mini-thoracotomy [16] rather than formal posterolateral thoracotomy, perhaps due to less meticulous closure of the defect (figure 3) [4]. Several groups have reported lung hernias occurring after an anterior mini-thoracotomy for minimally invasive cardiac surgery [17,18] with left internal mammary artery (LIMA) harvesting predisposing to local ischaemia and poor wound healing [19] and fracture or avulsion of the costal cartilages resulting in chest wall instability [20]. In addition, lung herniation has also been reported in a patient with a chronic cough following LIMA harvest via a sternotomy due to intercostal muscle weakness, atrophy and delayed rupture [21].
Spontaneous hernias

A spontaneous lung hernia occurs at a site of localized weakness in the thoracic cage without an antecedent injury and is prompted by a sudden rise in intrathoracic pressure such as coughing, sneezing, singing, heavy lifting or blowing into a musical instrument [3,22]. These hernias almost invariably occur anteriorly, medial to the costochondral junction where there is only a single layer of intercostal muscle, most commonly involve the lower rib cage and are usually associated with a fracture of the rib or cartilage [22,23]. In their review of the literature, Brock and Heitmiller found that spontaneous anterior lung hernias occur with equal frequency on both sides of the chest and follow an episode of coughing, sneezing or abnormal motion; patients are exclusively male, usually older smokers with a history of underlying pulmonary disease and may be obese [22]. Weissberg and Refaely reported one case of a spontaneous supraclavicular lung hernia in a middle-aged woman with COPD but it is unknown whether this was a truly spontaneous hernia or the late presentation of a congenital hernia [4].

Pathologic hernias

Any condition that results in destruction of a localized area of the chest wall may lead to subsequent lung herniation. Munnell described a number of such pathologies including abscess of the chest wall or breast, empyema necessitatis, primary or secondary malignant tumors invading the chest wall and tuberculosis osteitis [3]. However, nowadays these conditions are invariably treated with surgery or radiotherapy early in the disease process such that progression to chest wall destruction and herniation is mostly limited to areas of developing countries where access to healthcare is inadequate.
Clinical presentation and management

The presentation of lung hernias of the chest wall is variable, often according to the etiology, from the acute onset of severe symptoms to a late presentation many years after an initial injury; indeed, some congenital hernias may present for the first time in adulthood [4]. The diagnosis can often be made on the history and physical examination alone although imaging is essential for preoperative confirmation and surgical assessment.

Symptoms and signs

Clinically, lung herniation may or may not be symptomatic but most often presents as a tender, subcutaneous soft tissue mass that enlarges when intrathoracic pressure is raised. Symptoms include pain and/or tenderness (50-85% of cases), dyspnea, cough and an intermittent bulging at the site of herniation [4,12]. The onset may be insidious or follow an acute episode of coughing, sneezing or constipation [22]. Whilst lung incarceration is uncommon, it typically presents with severe pain and there may be respiratory compromise [24]. Patients may have a recent or past history of trauma or previous thoracic surgery, chronic lung disease, obesity, diabetes mellitus, smoking, steroid use, chronic infection or malignancy [3,12]; however, some patients will have no identifiable co-morbidities. Unusual symptoms include dysphagia or neuralgic arm pain due to nerve root compression with supraclavicular herniation [25].

Signs of chest wall herniation include bulging on coughing or straining, often with an impulse or a palpable defect in the thoracic cage (figure 4). The presence of an overlying thoracic surgical scar may also provide a clue to the underlying diagnosis. Following recent
or acute trauma, there may be localizing signs of injury including the thoracic ‘seatbelt sign’, a linear ecchymosis of the skin across the chest in the line of a restraint [6]. There may be an associated ipsilateral pneumothorax, surgical emphysema, hemothorax or pleural effusion resulting in reduced air entry on auscultation.

**Investigations**

The diagnosis of a chest wall hernia should be confirmed by radiologic examination. Standard and oblique plain radiographs remain valuable, for example to identify separation of the ribs during postoperative follow-up, which may precede symptoms [11]. However, computed tomography (CT) is the investigation of choice, with rapid image acquisition whilst the patient performs a Valsalva maneuver considered the gold standard [14]. Herniation is diagnosed by the presence of a portion of the lung parenchyma protruding beyond the thoracic cage through a defect. CT provides valuable information for operative planning, particularly with multiplanar image reconstructions (figure 5), to delineate the size and location of the chest wall defect, the extent of lung herniation, the presence of associated injuries and exclude possible complications such as strangulation. Other modalities such as fluoroscopy and ultrasound can also be used to diagnose lung herniation; the latter may be particularly useful in the emergency room when a patient with major chest trauma is too unstable to transport to the CT scanner [26].

**Treatment**

Management of a lung hernia is determined by symptoms, location and size. Asymptomatic hernias, particularly supraclavicular hernias in the thoracic inlet, require no intervention. Pain, increasing size and signs of impending incarceration, such as difficulty in reducing the hernia, are the main indications for surgery [4]. The risk of incarceration is increased in
small, rigid defects and should prompt early intervention; surgery for cosmesis may also be justified.

Most supraclavicular lung hernias remain asymptomatic but occasionally, symptoms may occur and repair should be performed. A transthoracic approach is preferred as the risk of recurrence is lower than with a transcervical approach [27] and may be amenable to thoracoscopic repair [28]. If the endothoracic (Sibson’s) fascia is intact, a hernia sac is present which must be dissected free prior to repair of the defect; if not, only closure of the defect after reduction of the hernia is indicated. Both direct suture repair [28] and bovine pericardium patch reinforced with biological glue have been reported [25].

In contrast, repair is indicated in almost all intercostal lung hernias, including congenital hernias that present during adulthood [4]. Conservative management should only be considered in patients with chronic herniation and multiple co-morbidities, including advanced lung disease and morbid obesity, or who decline surgery; a binder may provide symptomatic relief but most will continue to enlarge over time and should remain under clinical and radiographic follow-up.

Many techniques have been described for the repair of chest wall hernias, using open [3], thoracoscopic [29] or a combination of approaches [30]. At initial assessment, the portion of herniated lung parenchyma should be inspected to identify whether it has been strangulated and become necrotic; if non-viable, the affected tissue should be resected as a wedge using a stapler device. Small chest wall defects can usually be closed by direct suture and fixation of the adjacent ribs with pericostal or intracostal sutures [4,11]. Larger defects require the use of autologous tissue or synthetic mesh to close the hernia orifice. Munnell advocated the use of
musculofascial tissue flaps developed from the intercostal neurovascular bundle, perhaps with elevation of periosteal flaps or even mobilization of adjacent ribs [3]. Whilst this approach has the advantage of avoiding foreign material and potentially reducing the risk of infection, often the surrounding tissues have also been traumatized and may be of insufficient quality or mobility to aid repair. Nowadays in chest wall hernia repair, as in abdominal hernia surgery, the most common technique is to use a synthetic mesh, bridging the intercostal space and fixed around the margin of the defect (figure 6) [31]. A variety of materials have been reported including high density polyethylene (Marlex), polyglactin (Vicryl), polypropylene (Prolene), polyethylene terephthalate (Dacron), polytetrafluoroethylene (PTFE, Teflon) and expanded PTFE (Gortex). Composite materials have also been used such as a sandwich of Marlex mesh filled with methyl methacrylate cement [19]. During wound closure, muscle and subcutaneous tissue may need to be mobilized over the mesh to provide protection for the repair. In their series, Seder and colleagues performed primary repair in 18 patients and prosthetic mesh repair in 9 patients, finding no difference in perioperative complications between groups [12]. Indeed, as the mesh leads to the formation of a fibrous capsule, if it were to become infected and require late removal, the remaining capsule would usually be sufficient to prevent recurrence of the hernia. More recently, extracellular matrix patches have been used to repair chest wall defects including hernias; these provide a scaffold for infiltration by recipient cells, leading to incorporation within the repair and in time may become the material of choice [32]. Other techniques have been reported including the use of stainless steel wires [6] or titanium bars, plates and screws [33,34] but the advantages of rigid fixation over flexible mesh repair is not established and is likely to be more expensive [12].
In summary, hernias of the chest wall are classified according to etiology into congenital, traumatic, spontaneous and pathologic. Pain is the prevailing symptom and should precipitate surgical repair, most commonly using a synthetic mesh.

Acknowledgement: We thank the late Thomas W. Shields whose chapter on lung hernias in the 7th edition of his book formed the basis of this chapter.
Table 1. Classification of lung hernias of the chest wall

Modified from Morel-Lavallée A, 1845-1847 [2]

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<tr>
<th>Category</th>
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<td>Intercostal</td>
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Figure legends

Figure 1. CT of the chest showing right parasternal lung herniation, rib fracture and hemothorax related in seat belt restraint in a high-speed motor vehicle crash. (From Rice D, Bikkasani N, Espada R, Mattox K, Wall M. Seat belt-related chondrosternal disruption with lung herniation. *Ann Thorac Surg* 2002;73:1950-1. With permission.)

Figure 2. CT of the chest demonstrating lung parenchyma protruding through a defect in the anterior chest wall following anterior thoracotomy. (From Athanassiadi K, Bagaev E, Simon A, Haverich A. Lung herniation: a rare complication of minimally invasive cardiothoracic surgery. *Eur J Cardiothorac Surg* 2008;33:774-6. With permission.)

Figure 3. CT of the chest revealing herniation of the lingula through a chest wall defect at the site of a previous thoracoscopy port. (From Temes RT, Talbot WA, Green DP, Wernly JA. Herniation of the lung after video-assisted thoracic surgery. *Ann Thorac Surg* 2001;72:606-7. With permission.)


Figure 6. Intraoperative photographs of a) the identification of the chest wall defect shown in figure 2, and b) fixation of a Vicryl patch to the rib margins with interrupted sutures. (From Athanassiadi K, Bagaev E, Simon A, Haverich A. Lung herniation: a rare complication of minimally invasive cardiothoracic surgery. *Eur J Cardiothorac Surg* 2008;33:774-6. With permission.)
References


