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Imaging of acquired transdiaphragmatic fistulae and communications

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ABSTRACT

Acquired diaphragmatic defects occur secondary to trauma, infection, surgery or neoplasm. These defects can lead to abnormal thoraco-abdominal fistulous communications also. Examples of surgically created diaphragmatic defects are omental, colonic interposition and vascular grafts. Regardless of etiology, these transdiaphragmatic communications provide a direct path for spread of pathology between the abdomen and thorax. If left untreated and unrecognized, these fistulae portend a high morbidity and mortality. Subtle but important diagnostic clues can be present on imaging. This pictorial essay describes commonly encountered imaging findings seen with acquired transdiaphragmatic communications. This knowledge will improve diagnostic confidence of the interpreting radiologist in acute situations and confounding clinical scenarios.

1. Introduction

Transdiaphragmatic communications are thought to be rare with < 100 cases reported in the literature for some of these entities. Fistulae represent abnormal communications between two epithelium-lined surfaces and can be congenital or acquired in etiology [1]. When these occur across the diaphragm, abdominal disease processes can extend into the thorax and vice versa. Over the following paragraphs, we will discuss acquired transdiaphragmatic communications, which can occur in the form of fistulae, hernias, iatrogenic or surgically created conduits.

Diagnosis of transdiaphragmatic fistulae (TDF) is often difficult (Fig. 1A–F). Clinically, pleural fluid analysis often provides the first clue to identification of these fistulae with gastrointestinal pathogens, acidic, biliary or pancreatic contents identified in the pleural fluid aspirate. Associated radiographic findings are often subtle. A multidisciplinary approach is central to disease identification and therapeutic planning. Besides cross-sectional imaging such as CT and MRI, occasionally other imaging modalities such as fluoroscopy and nuclear medicine can have an important role in the definitive diagnosis.

This pictorial essay is a description of the characteristic imaging findings of these under recognized entities. In this essay we will discuss epidemiology and treatment strategies where appropriate (Table 1).

2. Acquired transdiaphragmatic fistulae (TDF)

2.1. Hepatothoracic fistula

2.1.1. Description

Hepatothoracic fistulae, commonly right-sided, represent abnormal communications between the liver and thorax. These can be classified as hepatopleural, hepatopulmonary, biliopleural or bronchobiliary [2]. The bronchobiliary fistulae representing the most severe of these abnormal communications. Although considered rare, their true incidence is not well known. These can be discovered on imaging, typically in patients with recurrent or non-resolving thoracoabdominal disease processes.

2.1.1.1. Etiology and pathogenesis. Hepatothoracic fistulae occur secondary to infection (including, but not limited to Hydatid disease, Amebiasis and Actinomycosis), iatrogenic causes (post-radiofrequency ablation, radiation therapy or hepatic resection), trauma or biliary tract obstruction due to tumors, infection or stenosis [3]. Bile is a potent irritant when present outside bile ducts or gastrointestinal tract [4].

Hydatid disease is a parasitic infestation by *Echinococcus granulosus* or *Echinococcus multilocularis* (tapeworms). The incidence of transdiaphragmatic involvement in hydatid disease is between 0.6 and 16%

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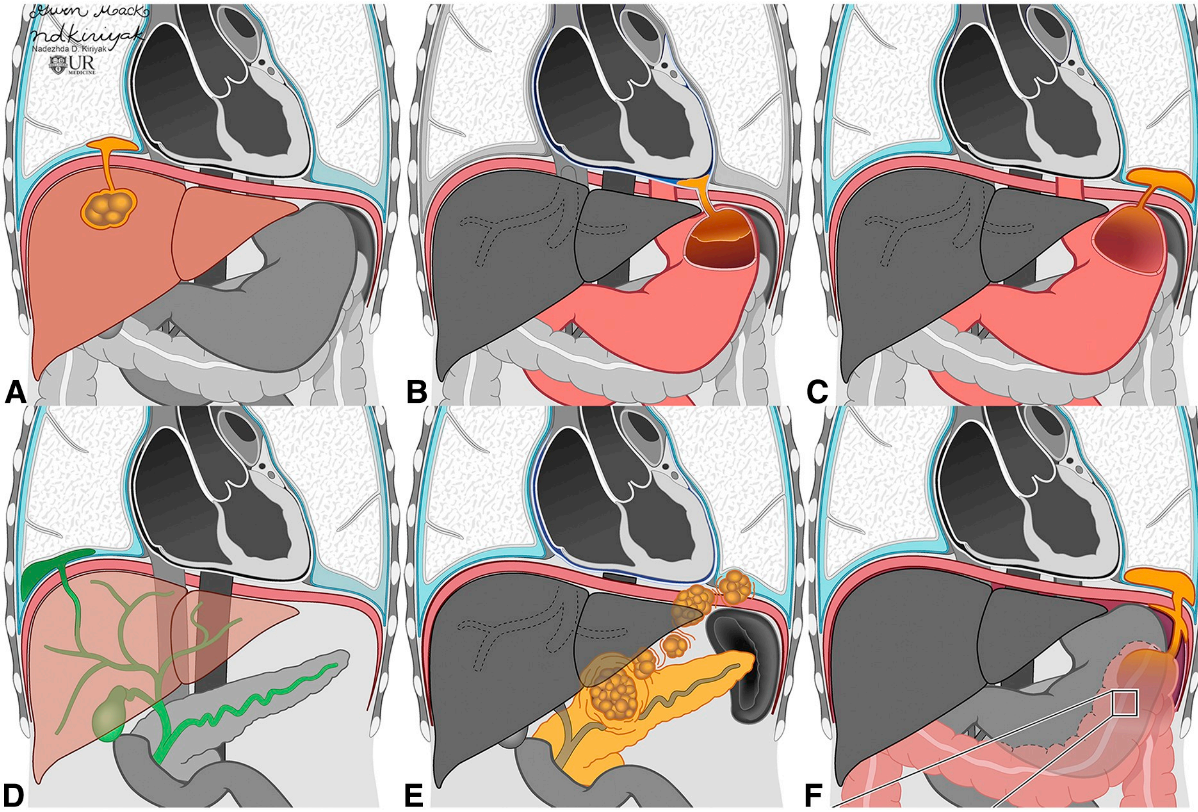

Fig. 1. Illustrations demonstrating the different types of trans diaphragmatic fistulae: hepatopleural fistula (A), gastropericardial fistula (B), gastropleural fistula (C), biliopleural fistula (D), pancreaticopleural fistula with pseudocyst (E), colopleural fistula (F).

Table 1
Summary of acquired transdiaphragmatic communications and most common imaging findings.

Fistula	Types	Etiology	Imaging findings*
Hepatothoracic	Hepatopleural Hepatopulmonary Biliopleural Biliobronchial	• Infections (hydatid, amoebiasis, bacterial, actinomycosis) • Injury (blunt, penetrating, iatrogenic) • Neoplasm (primary, metastatic)	• Pleural effusion or air fluid collection, infradiaphragmatic extension • Pneumonia • Hourglass lesion straddling diaphragm (hydatid) • Soft tissue mass continuous with lung consolidation (actinomycosis) • Contrast extravasation into biliary tree, pleura, lung, bronchi
Gastrothoracic	Gastropleural Gastropericardial Gastroaortic	• Surgery (bariatric, esophagectomy with gastric pull through, Nissen fundoplication) • Injury (trauma, perforation after stenting) • Peptic ulcer • Malignancy • Aortic penetrating ulcerations or ruptured aneurysm	• Left pleural effusion • Hydropneumothorax • Contrast extravasation into pleural space with upper GI or CT exam • Diaphragmatic discontinuity ± gastric content in the thorax • Loss of fat plane between aorta and stomach (on CT) • Intragastric contrast extravasation from aorta
Colothoracic	Colopleural	• Infectious or inflammatory bowel disease (including perforated diverticulosis) • Pulmonary infections (actinomycosis/TB) • Malignancy • Penetrating injury • Abdominal surgery	• Pleural effusion or hydropneumothorax • Contrast extravasation into pleural space • Subdiaphragmatic air ± fluid collection • Air-containing tract with focal discontinuity of diaphragm • Pericolic stranding on CT or increased fluid signal on MRI
Pancreatothoracic	Pancreaticopleural	• Chronic pancreatitis • Pseudocyst • Surgical pancreatic resections/percutaneous pseudocyst drainage • Trauma	• Focal opacity on CXR (pseudocyst) • Loculated fluid traversing diaphragm on CT/MRI • Signs of acute/chronic pancreatitis
Nephrothoracic	Nephropleural	• Percutaneous renal surgery/nephrolithotomy • Perinephric abscess • Trauma	• Non resolving ipsilateral pleural effusion • Excreted contrast in pleural effusion on CT urography • Tracer accumulation in pleural cavity with Tc-99m DTPA renography
Transdiaphragmatic	Intrapericardial Hiatal hernia	• Trauma (blunt, penetrating) • Iatrogenic (pleuropericardial window, transdiaphragmatic conduits/drains, vascular grafts) • Infection (diverticular abscess)	• Intrathoracic air/fluid level due to bowel herniation on chest x-ray or CT • Homogeneous opacity with liver/spleen herniation on CXR

Legend: * - a fistulous tract can be found on cross-sectional imaging (CT, MRI, MRCP) on some occasions in all listed communications; CXR – chest x-ray.

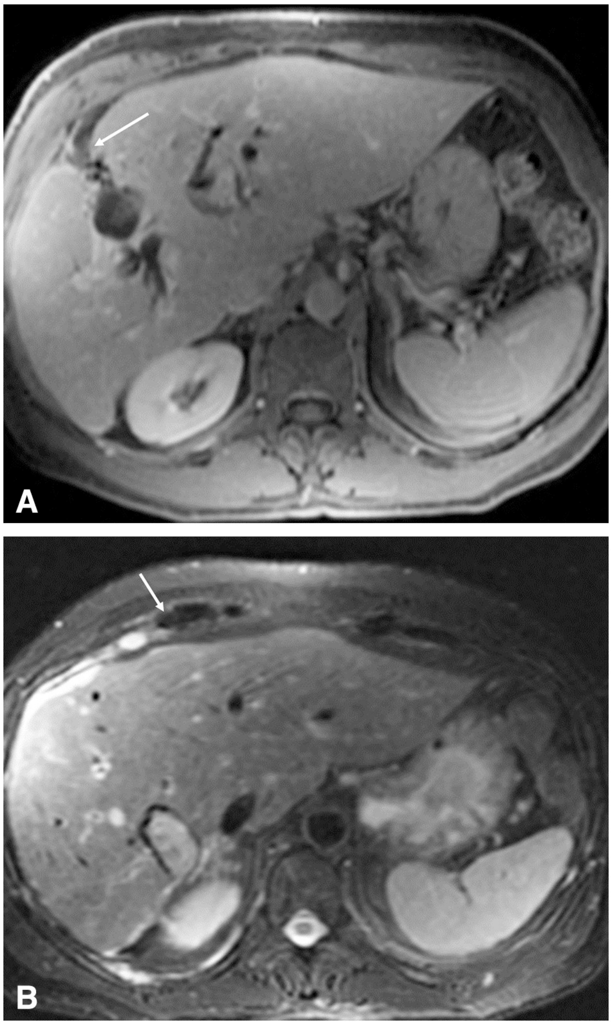

Fig. 2. Ruptured hepatic hydatid cyst. 49 y/o male with history of resected hydatid cyst presented with new upper abdominal pain. MRI (A, B) identifies the hepatopleural communication (white arrow).

[5]. In adults, liver is the most common site of involvement, followed by lungs [6]. In children however, lungs represent the most common site of involvement [7]. Untreated hydatid cysts near the dome of diaphragm adjacent to the bare area of liver can rupture into thorax (Fig. 2A, B). Complications include pneumothoraces, hydropneumothoraces, empyemas, pleural/bronchial fistulae and pericarditis [6].

Amebiasis is a parasitic infection arising secondary to *Entamoeba histolytica*. It is endemic in subtropical and tropical countries. Hepatic involvement follows intestinal infestation [8]. Pleuropulmonary involvement arises secondary to hepatic amebiasis [9]. The incidence of pleuropulmonary involvement is 20% in patients with amebic liver abscess [10]. In endemic regions, pleuropulmonary amebiasis constitutes the most common cause of nontraumatic empyema thoracis [11].

The bacterium *Actinomyces* is the pathogen underlying actinomycosis - a spectrum of infectious manifestations involving multiple organs. The cervicofacial region is the most common site for these infections [12]. Pulmonary actinomycosis is seen in upto 15% of the patients with underlying emphysema, bronchitis, bronchiectasis and in alcoholics. Clinical and imaging findings of actinomycosis can be confused for malignancy. Chest wall involvement can occur secondary to contiguous extrapulmonary extension of infection [13]. Transdiaphragmatic extension of disease, with consequent transdiaphragmatic fistulization can also occur (Fig. 3A, B).

Primary or metastatic tumors represent the most common etiology for bronchobiliary fistulae [14]. Clinically, bilioptysis, the presence of bile in the sputum is diagnostic for these fistulae [15]. Associated mortality is high, possibly contributed to, at least in part, by delay in diagnosis. In one case series examining outcomes in patients with bronchobiliary fistula due to hydatid disease, mortality rates of 12.2% have been reported [16]. In the developed world, hepatothoracic fistulization occurs most commonly secondary to iatrogenic causes [17]. Such fistula can occur secondary to gunshot injury (Fig. 4A, B), stab wounds or inadvertent diaphragmatic injury after surgery.

2.1.2. Imaging findings

On chest radiographs presence of pleural effusion, hydropneumothorax and pneumonia in a patient with known hepatic disease may offer the first clue towards radiographic diagnosis of a TDF. On CT, presence of a complex fluid collection with or without air on both sides of diaphragm should alert the interpreting radiologist to potential underlying diaphragmatic defects and fistulae. Coronal T2-weighted and intravenous contrast-enhanced MRI can be useful in identifying these fistulae. Hydatid cysts can manifest as an hourglass shaped lesion straddling the diaphragm [18]. On CT, thoracic actinomycosis may present as a soft tissue mass, possibly with central low-attenuation, contiguous to pulmonary disease. Associated empyema, rib/vertebral destruction and/or fistula formation may be seen [13].

Abnormal extension of biliary contrast into the pleural space, lung parenchyma or bronchi on percutaneous transhepatic cholangiography is diagnostic of biliothoracic fistulae. Such suspicious findings on percutaneous cholangiography can be confirmed by a CT, which better identifies the presence of biliary contrast within the pleural space, lung or bronchial tree, and thereby outlines the location, size and course of the TDF (Fig. 5A, B, Movie 1). Hepatobiliary scintigraphy with technetium-99m iminodiacetic acid (HIDA) is the diagnostic test of choice for biliary fistulae [19] and demonstrates presence of radiotracer in the pleural space, lung parenchyma or within the bronchi (Movie 2).

2.1.3. Treatment

Hepatothoracic fistulae can spontaneously close after endoscopic or percutaneous drainage of the biloma or abscess [20]. Prolonged drainage may occasionally be necessary. Surgery is the treatment of choice for chronic fistulae, and for those associated with clinical deterioration, respiratory compromise or uncontrolled sepsis. Ruptured hydatid cyst requires thoracofrenectomy. Ruptured amoebic, bacterial or fungal abscesses can initially be conservatively treated with chest tube drainage, percutaneous transhepatic drainage and drug therapy. If conservative management fails, surgical resection may be required. For bronchobiliary fistulae, initial noninvasive management is recommended, with invasive approach resorted to when noninvasive approaches fail [14]. Surgical resection requires complete excision of the intrathoracic and sub diaphragmatic portions of the fistula. The diaphragm may need to be buttressed with intercostal muscles or pericardial fat pad [21].

2.2. Gastrothoracic fistula (GTF)

2.2.1. Description

GTF represent rare, abnormal direct communications between the stomach and pleura (Fig. 6A, B) or pericardium [22]. Rarely, a direct communication between the stomach and aorta (aortogastric fistula) can occur (Fig. 7) [23].

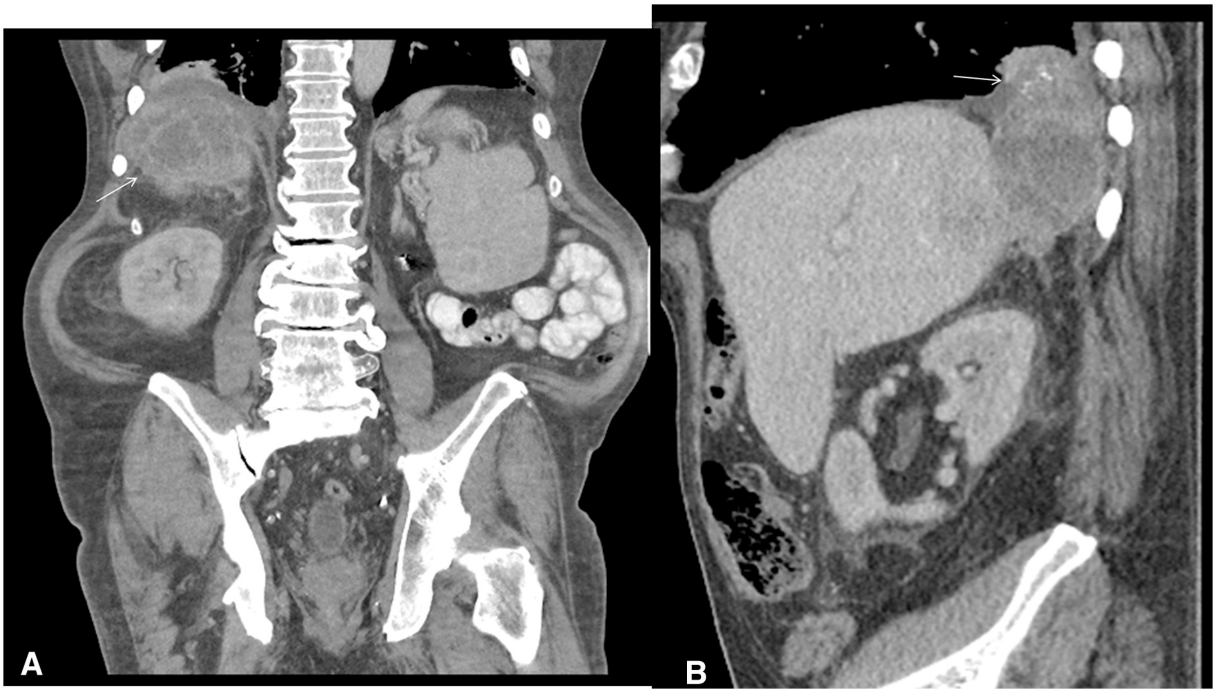

Fig. 3. Actinomycosis infection with Transdiaphragmatic spread of infection. Coronal (A) and sagittal (B) contrast enhanced CT images in a 64 y/o male with slowly progressive right upper abdomen pain and chronic cough presenting with a heterogeneously enhancing calcified lesion extending across the right diaphragm to involve both the pleural and peritoneal spaces.

2.2.1.1. Etiology and pathogenesis. GTF can form in patients with history of prior gastric surgery such Nissen fundoplication, bariatric surgery or gastric transposition grafts (stomach pull up) for esophageal cancer. Other etiologies include penetrating injury, peptic ulcer disease, malignancy or post-stereotactic radiation therapy [24–26]. Aortogastric fistulas can form in patients with ruptured aortic aneurysm [27], penetrating aortic ulcers, gastric ulcers [28], gastric tumors, after esophagostomy [29] or after perforation of an esophageal stent [30]. Incidence of aortoenteric fistula is estimated to be 0.04 to 0.07% [31].

2.2.2. Imaging findings

Chest radiographs can identify left side pleural effusion, hydropneumothorax or empyema in patients with a GTF. Upper G.I. contrast radiography with water soluble contrast can identify the presence of oral contrast in the pleural space confirming the GTF. However more commonly these fistulas can be first suspected on CT being obtained to evaluate for other causes of thoracoabdominal disease. A non-contrast CT can identify a focal discontinuity in the diaphragm with gastric contents extending from gastric lumen into the pleural space. CT with oral contrast can identify the presence of oral contrast in the pleural space. Use of intravenous contrast helps in better delineation of the mucosal defect and can also outline the fistulous tract. Pleural fluid aspirate confirms the acidic contents in these fistulas.

Patients with acute aortogastric fistulas present with acute onset of epigastric or thoracic pain and hematemesis. Radiographs may be completely unremarkable or may demonstrate mediastinal widening. CT can identify loss of fat planes between stomach near the gastroesophageal junction and adjacent aorta. Initial noncontrast CT may identify high density within the stomach indicate of Gastro aortic fistula with active bleeding or clot. CT with intravenous contrast can demonstrate aortic contrast extending into the stomach. Direct catheter angiography can confirm the active contrast extravasation.

2.2.3. Treatment

Acute GTF from ruptured intrathoracic portions of stomach benefit from early surgical repair [32]. Aorta gastric fistulas can be initially treated with endovascular stent graft [33] and proton pump inhibitor therapy [34]. Once the patient stabilizes, more definitive treatment and surgical repair is performed.

2.3. Colothoracic fistula

2.3.1. Description

Colopleural fistula represents internal communication between the large bowel and thorax. This can result in a fecal hydropneumothorax (Fig. 8A, B, Movie 3).

2.3.1.1. Etiology and pathogenesis. Colothoracic fistulas are rare with only a few case reports in the literature [35]. These can be secondary to inflammatory bowel disease such as Crohn's, malignant tumors, perforated diverticulosis, penetrating injury, prior abdominal surgery, pulmonary infections such as Actinomycosis and Tuberculosis. These can also occur as a complication in a previously herniated large bowel [35–37]. These fistulas are more commonly on the left side, likely due to presence of liver on the right side [38]. This results in an exudative effusion which on aspiration reveals a dirty fluid with feculent odor. Microbiologic examination of such a fluid can be polymicrobial on gram stain and culture.

2.3.2. Imaging findings

Chest radiographs can identify pleural effusion or hydropneumothorax in patients with colothoracic fistula. Contrast enema using water-soluble contrast can identify rectal contrast within the pleural space and is diagnostic for these fistulas. Thoracoabdominal CT comprises the first line of evaluation in this subset of patients. On CT, subdiaphragmatic extra luminal air, ipsilateral complex

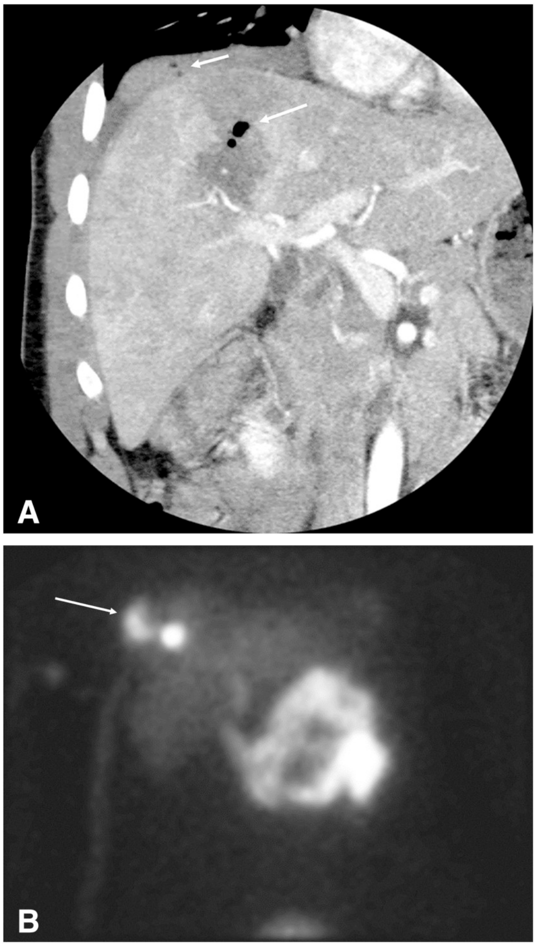

Fig. 4. Biliothoracic fistulae. Biliary-pleural-bronchial fistula secondary to gunshot injury to the lower chest/upper right abdomen. Coronal CT (A) in a patient with injury from high velocity projectile identifies hemothorax, lung & liver laceration. A periportal fluid collection suggests biliary injury and biloma. In addition, there is air in the hemothorax and biloma (white arrows). Subsequently obtained HIDA scan (B) with 5.1 mCi of Tc-99m Choletec identifies both the biloma and the presence of radiotracer in the right pleural space (white arrow) confirming the hepatopleural fistula.

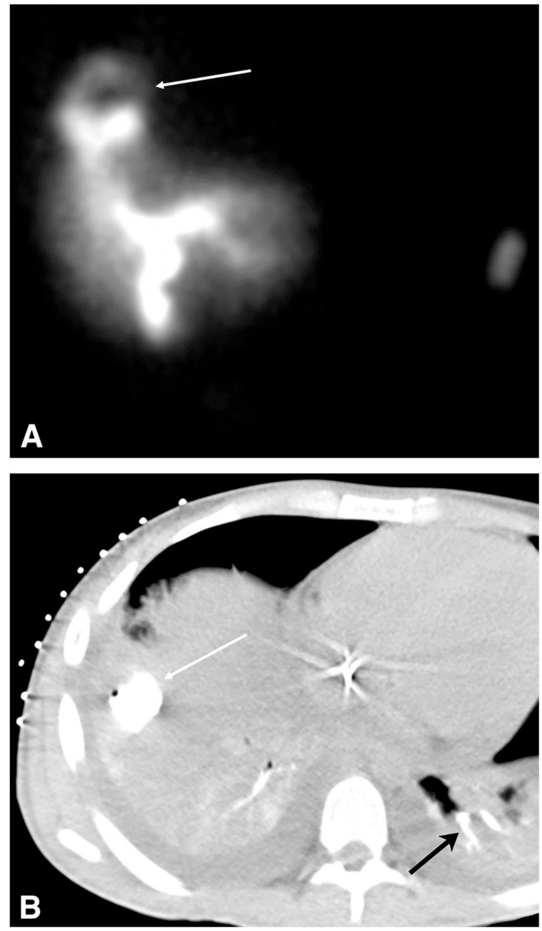

Fig. 5. Bronchobiliary fistula. Axial CT (A) obtained immediately after a tube cholangiography in a patient with cholangiocarcinoma identifies presence of contrast injected through the tube within the right thorax (white arrow). In addition, contrast can also be seen in the bilateral lower lobe bronchi. Presence of a biliothoracic fistula was confirmed on a subsequent HIDA scan (B).

hydropneumothorax, identification of air-containing tract with focal discontinuity of the diaphragm constitute the diagnostic clues. Delayed images from CT obtained after the oral contrast has reached the colon or CT obtained after administration of rectal contrast can also be useful in identifying these fistulas. When both CT and contrast enema exams are being considered, it is best to perform CT first since barium within the pleural cavity can cause significant streak artifacts limiting the diagnostic yield of a CT [1]. MRI can be a useful adjunct in identifying small fistulas and pericolic inflammation.

2.3.3. Treatment

These fistulae may require aggressive drainage of pleural and abdominal collections with treatment of any underlying infection. Interval surgery after the acute disease has resolved may require a combined transthoracic and transabdominal resection with repair of the diaphragmatic defect.

2.4. Pancreaticothoracic fistula

2.4.1. Description

Pancreaticopleural fistula (PPF) represents abnormal communication between the pancreas and thorax. This is a rare complication of chronic pancreatitis [39]. PPF can also occur after surgical pancreatic resections, percutaneous drainage for a pseudocyst or after abdominal trauma [40].

Pseudocysts can extend into the mediastinum or pleural cavity [41]. Presence of elevated amylase and lipase within the pleural fluid clinches the diagnosis (Fig. 9A, B, Movie 4).

2.4.1.1. Etiology and pathogenesis. PPF is a rare entity with mostly case reports in the literature. PPF can present with pleural effusions, pleural or mediastinal pseudocysts [42]. Incidence of pleural effusion due to PPF in patients with pancreatitis is $< 1\%$ [43]. These fistulas form secondary to leak of pancreatic enzymes from an incompletely formed or ruptured pseudocyst. These fistulas can present as pleural effusions which are more common on the left side [42]. PPF can extend from the abdomen into thorax either through the esophageal/aortic hiatus or directly through the diaphragm.

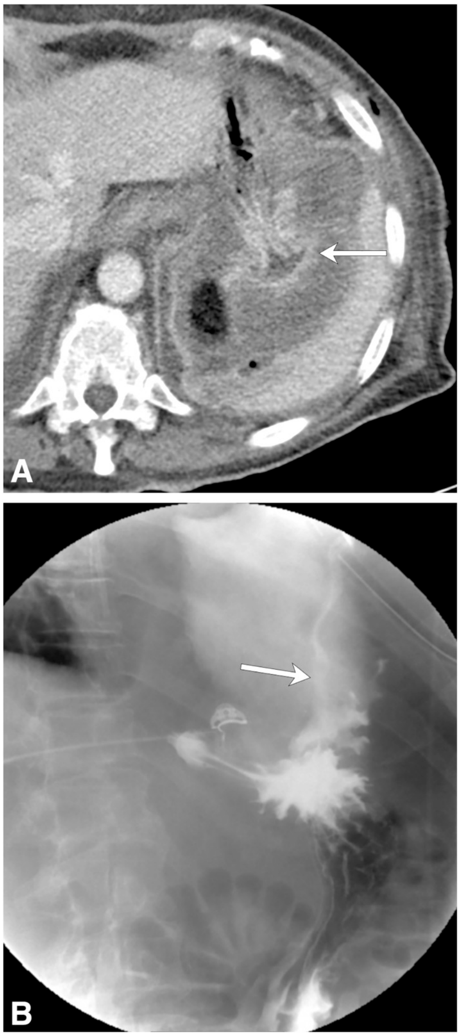

Fig. 6. Gastropleural fistula. Axial CT with intravenous contrast in the ED (A) demonstrates high density pleural effusion with gastric communication across the diaphragm (white arrow) in the region of the patient's pain. Upper GI series obtained with water soluble contrast (B) shows free flow of oral contrast from the stomach into the thorax (white arrow) confirming the fistula.

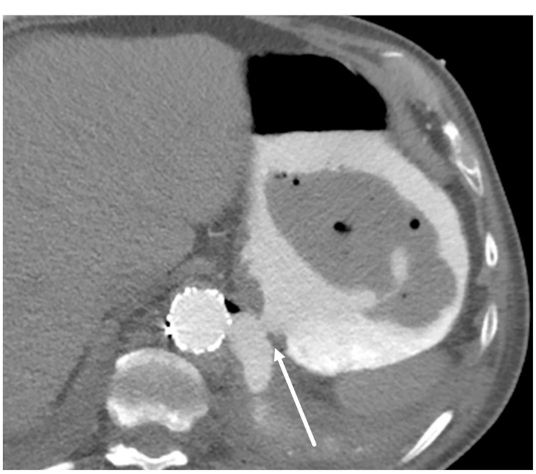

Fig. 7. Gastroaortic fistula. Axial CT with oral and intravenous contrast (A) identifies presence of oral contrast within the left pleural space and surrounding the descending thoracic aorta with the endovascular graft. These findings confirm an aortogastric fistula.

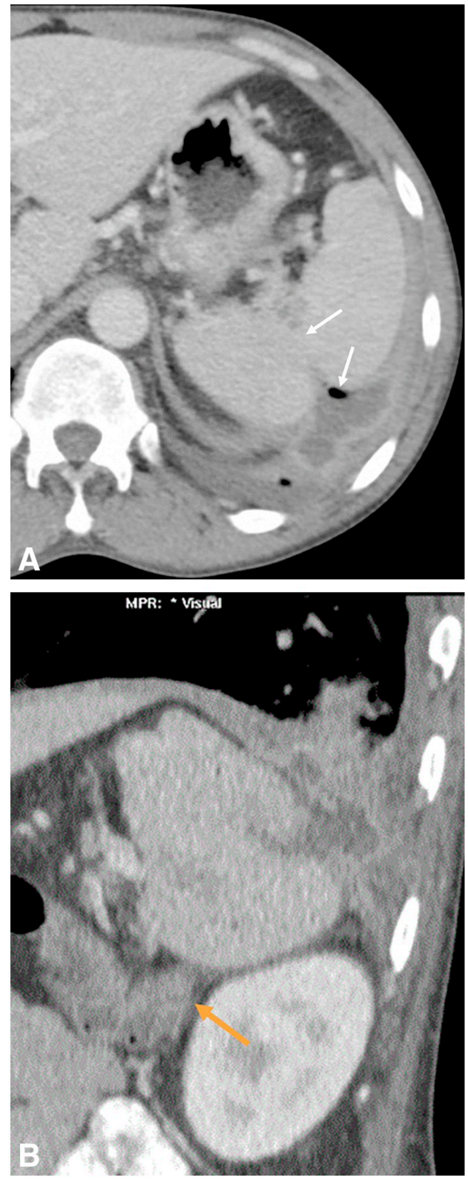

Fig. 8. Colopleural fistula. Axial (A) & sagittal oblique (B) images of a CT obtained in a 33 y/o patient with Crohn's disease presenting with left upper quadrant pain demonstrate thickening of splenic flexure (arrow), air in the spleen, perisplenic fluid collection, thickened left diaphragm, left pleural fluid collection with focal specks of air. Close inspection demonstrate that this is a fistula extending from splenic flexure into the pleural space. These findings are consistent with colopleural fistula.

2.4.2. Imaging findings

Thoracic pseudocysts manifest radiographically as a well-defined homogenous opacity in the mediastinum or pleura. On CT or MRI, a loculated pancreatic pseudocyst which traverses the diaphragm to extend into the mediastinum or pleura may be seen [44]. Additional signs of acute or chronic pancreatitis including peripancreatic inflammation, pancreatic duct dilation and intraductal calculi may also be present. MRI can identify subtle fistulas or intradiaphragmatic portions of a dissecting pseudocyst. Magnetic resonance cholangiopancreatography (MRCP) can reveal possible injury of the pancreatic duct with fistula formation. MRCP is considered the noninvasive diagnostic test of choice to delineate these fistulas [45]. Endoscopic cholangiopancreatography is reserved for cases that may need therapeutic intervention such as stent placement or pseudocyst drainage.

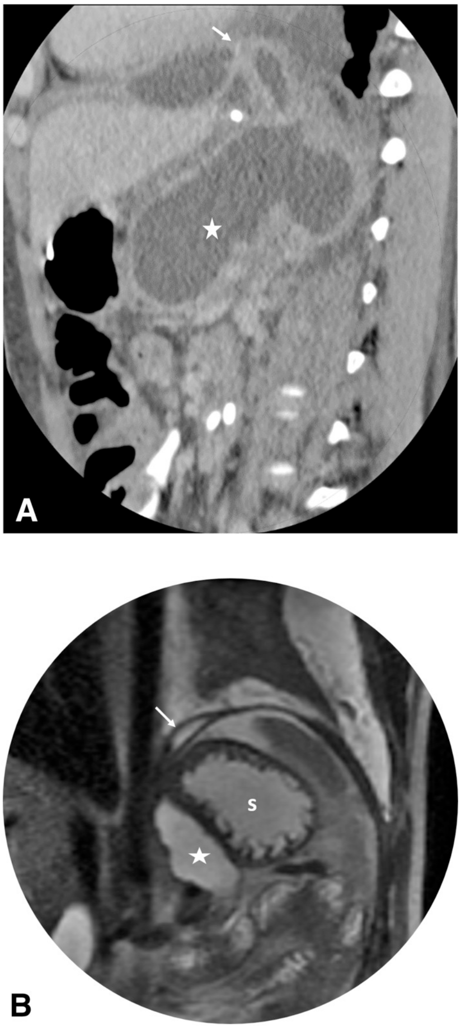

Fig. 9. Pancreaticopleural fistula. Sagittal oblique contrast-enhanced CT (A) image in a patient with recurrent pancreatitis and non-resolving pancreatic pseudocyst identifies a pseudocyst (asterisk) with extension across the diaphragm into the left pleural cavity (white arrow). Subsequently obtained MRCP (B) clearly identifies the intra-diaphragmatic portion of this dissecting pancreatic pseudocyst (white arrow) above the stomach (S) and separate from the pseudocyst (asterisk).

2.4.3. Treatment

Pancreatic ductal injury with pseudocyst formation requires multidisciplinary approach for treatment [46]. Initial treatment is with octreotide (for exocrine suppression) and ERCP- guided stenting of the fistulous pancreatic duct. Pseudocyst drainage can be accomplished internally into the esophagus or stomach by endoscopic stent placement or externally by imaging guided catheter placement. Surgical repair is reserved for patients who fail conservative management, or develop complications such as hemorrhage, rupture or pancreatic necrosis [44].

2.5. Nephrothoracic fistula

Nephrothoracic fistula (NTF) is rare fistulous tracts between the kidney and the thoracic cavity, most commonly the pleural space. NTF can be seen as a complication of percutaneous renal surgery [47], percutaneous nephrolithotomy [48], perinephric abscess or trauma. In patients with recent urinary tract surgery, perinephric abscess or injury, diagnosis of NTF can be suspected with in context of a nonresolving ipsilateral pleural effusion on chest radiograph. Excretory or delayed phase of an intravenous contrast enhanced CT urography can identify intrapleural extension of excreted contrast, suggesting a urinothorax. Diuretic renography using Tc-99m diethylenetriamine pentaacetic acid can confirm this fistula when the excreted radiotracer accumulates in the pleural cavity [49].

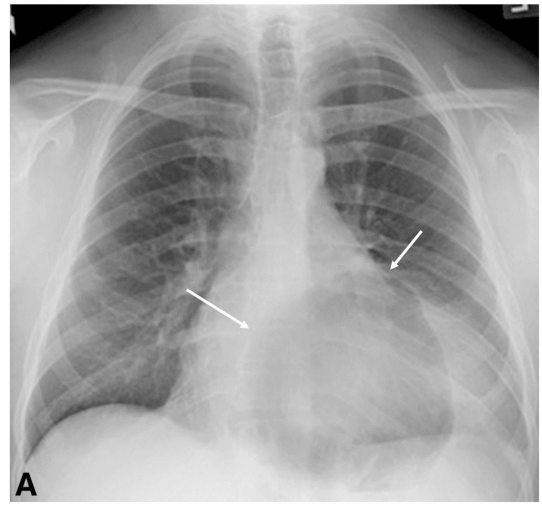

Fig. 10. Frontal radiograph (A) from patient with prior history of cardiac transplant demonstrate retrosternal lucency projecting over the cardiac silhouette (white arrows). On the subsequently obtained chest CT gastric herniation into pericardium was identified which was consistent with intra-diaphragmatic pericardial hernia.

Fig. 11. Intrapleural herniation of liver. Sagittal SSFP image in a different patient (B) with remote history of gunshot injury identify herniation of segment 8 of liver into thorax. The presence of right posterior branch of portal vein confirms this as hepatic herniation (white arrow) and not a pleural mass. This is consistent with posttraumatic intrapleural diaphragmatic hernia.

2.5.1. Treatment

NTF is initially treated conservatively with tube thoracostomy or serial thoracentesis [50]. Percutaneous nephrostomy or ureteric stent placement may be required if pelvicalyceal system or ureters are also dilated.

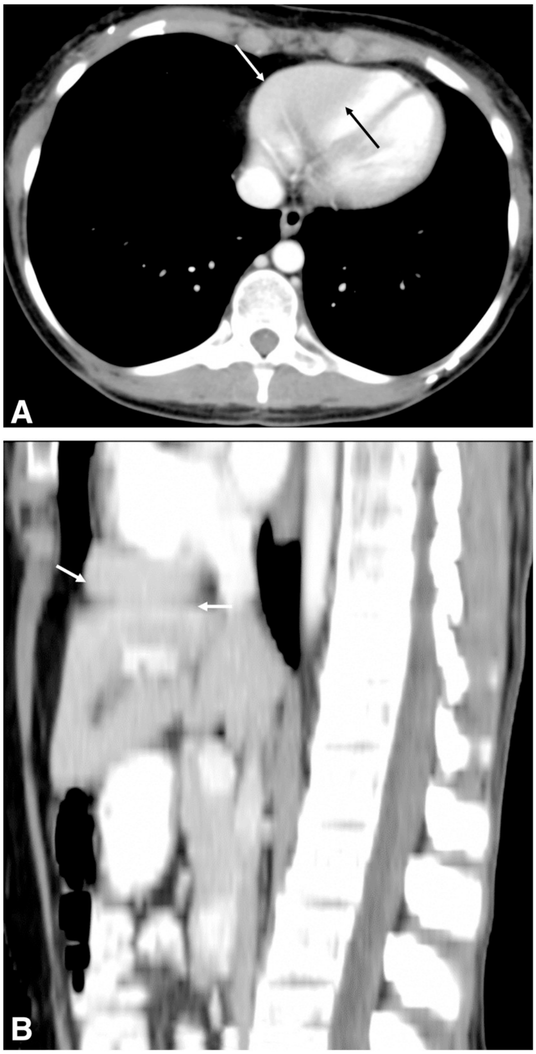

Fig. 12. Axial (A) and sagittal (B) contrast-enhanced CT in a patient presenting with chronic retrosternal heaviness and remote history of blunt abdominal trauma identifies herniation of liver into the pericardium with extensive compression on the right ventricle (white arrows). This is consistent with an intrapericardial diaphragmatic hernia.

Fig. 14. Axial prone noncontrast CT obtained in a patient with recent history of splenectomy and ultrasound-guided drain placement in the surgical bed identifies the pigtail catheter traversing the left pleural space (white arrow), before extending across the left diaphragm into the postoperative fluid collection. This is consistent with an iatrogenic transdiaphragmatic communication.

2.6. Acquired diaphragmatic hernias

2.6.1. Description

Diaphragmatic hernias occur through defects in the central tendon or the peripheral portions of the diaphragm. They can be mediastinal or intrapleural. Excellent review articles on congenital and other intrapleural diaphragmatic hernias exist [51–53]. In this review article, we will limit our discussion only to imaging of acquired diaphragmatic hernias and their complications seen in adults.

2.6.1.1. Etiology and pathogenesis. Incidence of post-traumatic diaphragmatic hernia is 3–7% in cases of abdominal or thoracic trauma [54]. Post-traumatic hernias can be mediastinal, intrapleural or mixed mediastinal-pleural, if the underlying tear is complex. Hiatal hernias are the commonest diaphragmatic hernias in adults with an estimated prevalence of > 50% in the western population over the age of 50 years [55,56]. Intrapericardial diaphragmatic hernia (IDH) are rare types of acquired diaphragmatic hernias [57] that can be seen as a sequela of blunt abdominal injury or may represent a rare complication of pleuropericardial window surgery [58,59]. In patients with blunt

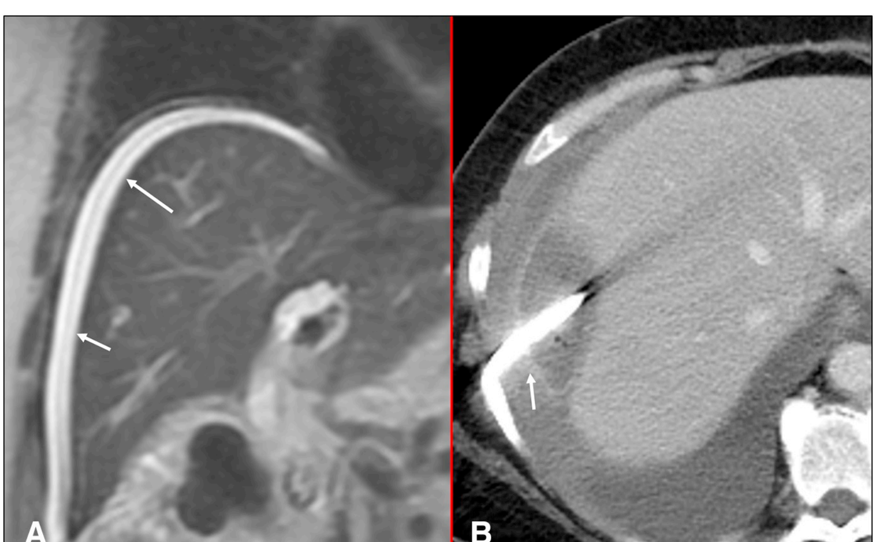

Fig. 13. Coronal T2 weighted MRI (A) in a patient with neutropenia identifies a subcapsular hepatic abscess (white arrow). The patient presented with new pleural effusion and a follow up axial contrast-enhanced CT identifies the percutaneous catheter placed for drainage extending across the right pleural space before entering the subcapsular abscess (white arrow). There is now a new right pleural effusion (posterior to the bare area of liver) when compared to the pre-procedure MRI. This is likely also secondary to the transdiaphragmatic communication.

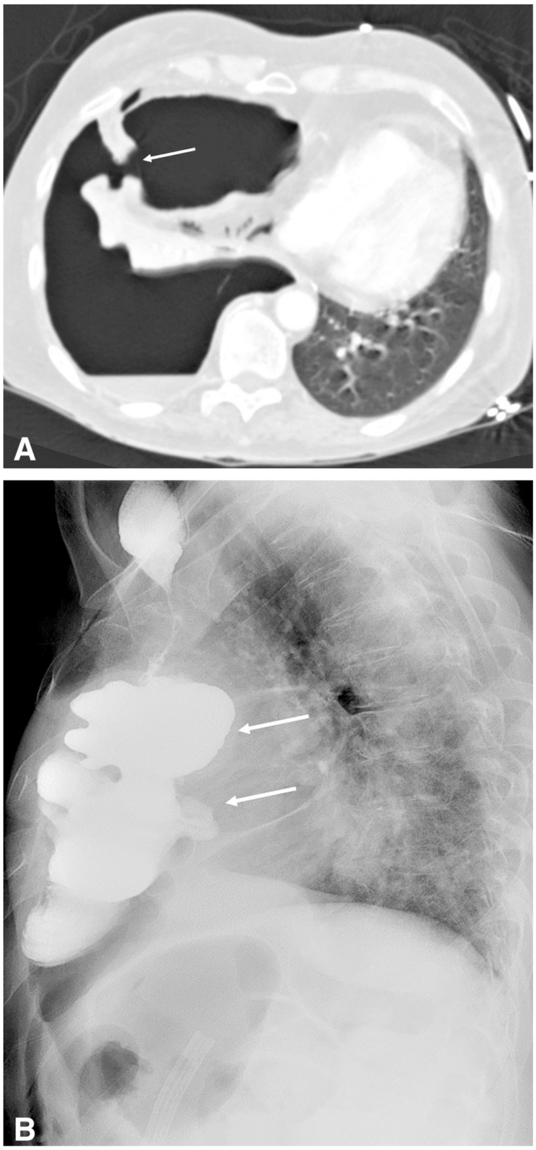

Fig. 15. Colonic interposition graft. Axial contrast-enhanced CT (A) in a patient with prior history of esophageal and gastric injury due to ingestion of corrosive fluid and subsequent colonic interposition graft identifies a large right hydropneumothorax with focal perforation of the colon conduit (white arrow). This patient was treated with pleural and peritoneal drains. Given the rich blood supply of the colonic conduit, this perforation healed over time. Follow-up lateral radiograph from an upper gastrointestinal series (B) clearly demonstrates the retrosternal conduit (white arrow) with no spillage of contrast into the pleural space.

abdominal injury with diaphragmatic injuries, herniation of small or large bowel loops can be seen besides that of solid organs such as spleen or liver.

2.6.2. Imaging

Chest radiographs may demonstrate presence of intrathoracic air-fluid level indicative of bowel herniation into thorax. In patients with pericardial hernia, such an air-fluid level is retrosternal (Fig. 10). Herniation of viscera such as liver or spleen can appear as a homogenous opacity in the thorax abutting the diaphragm. These can be confirmed with contrast enhanced CT or MRI. Liver can herniate into the pleural space (Fig. 11) or pericardium (Fig. 12A, B).

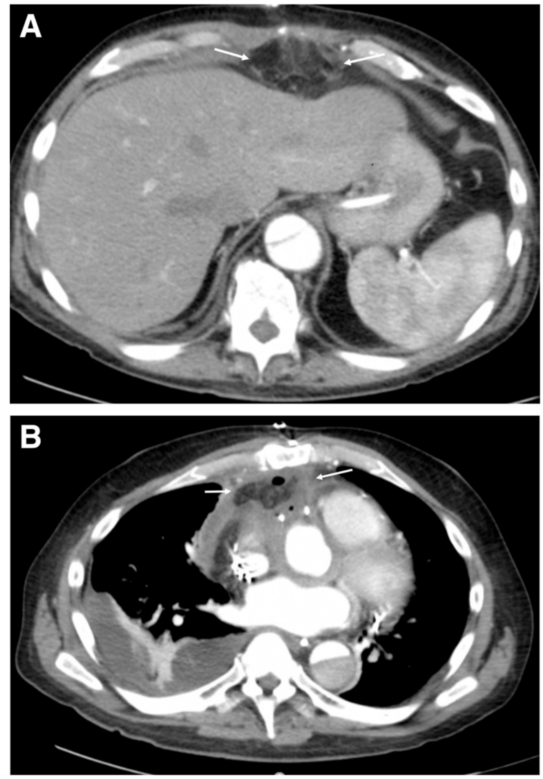

Fig. 16. Omental mediastinal graft. Axial contrast-enhanced CT images (A, B) in a patient with type A thoracic aortic aneurysm with dissection and post-repair of ascending thoracic aorta with surgical graft. This patient had multiple episodes of graft infections for which a retrosternal omental graft was surgically placed around the ascending aortic conduit (white arrow). These grafts buttress the anastomosis and decrease recurrent infections.

2.7. Iatrogenic

Iatrogenic transdiaphragmatic communication can occur secondary to inadvertent placement of percutaneous transabdominal drains across the thoracic cavity or from surgically created conduits. These abdominal drains (Fig. 13A, B), catheters or tubes (Fig. 14) traverse the low lying pleural space before reaching the intended intraabdominal organ or abscess/fluid collection. Surgically created diaphragmatic defects can be seen with omental, colonic interposition and vascular grafts. Colonic interposition graft is a functional and durable esophageal substitute for esophageal reconstruction (Fig. 15A, B, Movie 5). Usually the left colon is used due to isoperistaltic reconstruction and better mobility of the graft [60]. If these conduits perforate or there is dehiscence of the anastomosis, the ingested food can extend into the pleural space causing hydropneumothorax and empyema. In patients with chronic mediastinal infection and aortic surgery or prosthetic valves, omental grafts are sometimes used to protect the prosthesis and minimize risk of recurrent infection (Fig. 16A, B, Movie 6) [61]. Standard aorto-femoral bypass surgery usually involves retroperitoneal aorto-femoral reconstruction. In some patients however an extra-anatomic ascending aortic bypass graft may be used with a properitoneal or subcutaneous approach [62]. Rarely patients with intellectual or mental disabilities may ingest foreign bodies that can erode through stomach or duodenum and extend across the diaphragm into the thoracic cavity (Fig. 17A, B).

2.8. Miscellaneous

Diverticular abscess can extend from the peritoneum or retroperitoneum into the pleural cavity [63]. These abdominal abscesses can

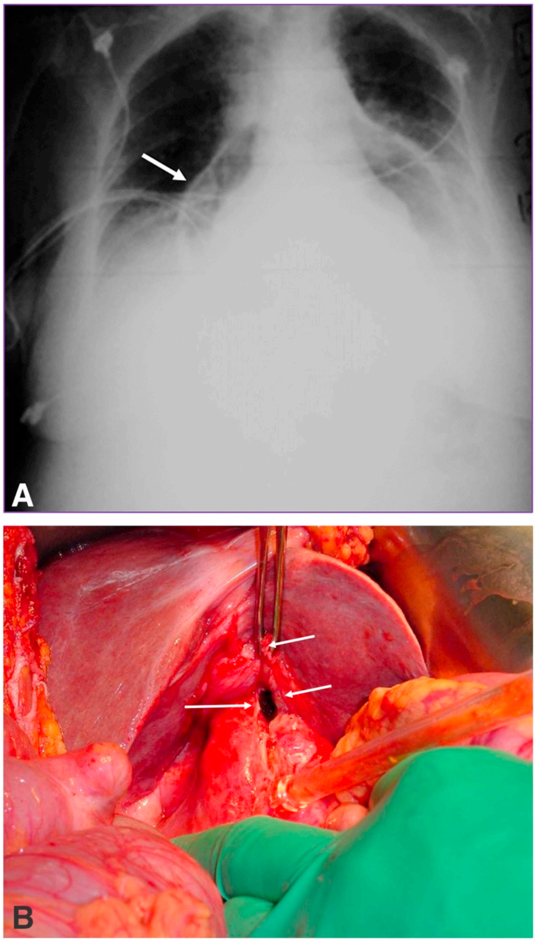

Fig. 17. Foreign body with perforation. Frontal radiograph (A) in a patient with intellectual disability and history of progressively increasing upper abdominal pain identifies a retrosternal air-fluid level (white arrow). Emergent surgery identified a fistulous communication between duodenum and pericardium (B). Image courtsey of Dr Jones and Dr Wandtke of URMC, Rochester.

extend either through natural fenestrations within the diaphragm or by erosion with fistula formation.

Thoracic splenosis can be secondary to auto implantation of splenic tissue in patients with trauma to diaphragm and spleen. These may present as slowly growing pulmonary or pleural masses (Fig. 18A, B) on CT or MRI. On MR, these are hypointense on T1, hyperintense on T2 and show restricted diffusion [64]. Technetium (Tc) 99-m heat damaged RBC or Tc 99-m sulfur colloid scan are useful to confirm these masses to be ectopic splenic tissue and will prevent unnecessary invasive procedures [65,66].

3. Conclusion

Transdiaphragmatic communications can present as thoracic manifestations of abdominal diseases. Identification of these acquired transdiaphragmatic communications may require more than one imaging modality and a multidisciplinary approach for treatment. Although the transdiaphragmatic fistulas can be difficult to diagnose, some of these have characteristic imaging appearances. The interpreting radiologist needs to be aware of these as they can be the etiology for a persistent pleural effusion, empyema or hydropneumothorax. CT yields valuable information about the complications of such fistulas such as pulmonary abscess, subdiaphragmatic abscess etc. making it an important imaging modality for not only identification but also management of these fistulas.

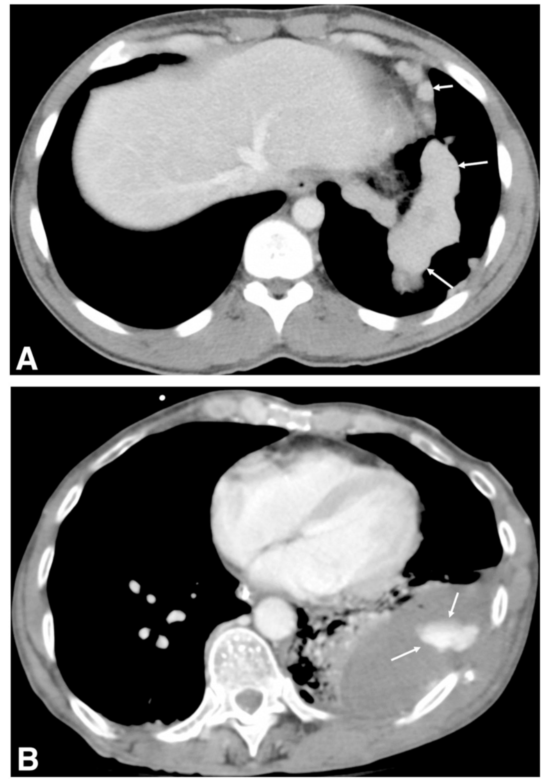

Fig. 18. Thoracic splenosis. Axial contrast-enhanced CT (A) in a patient with prior history of splenectomy for blunt abdominal trauma identifies slowly growing left pleural nodules. This finding is consistent with intrapleural splenosis (white arrows). Patient returns to the emergency department 12 months later after a motor vehicle accident. CT (B) in the emergency department identifies a large left hemothorax with active contrast extravasation (white arrow) likely hemorrhage from the ruptured thoracic splenosis.

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Conflict of interest

The authors declare that they have no conflict of interest.

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