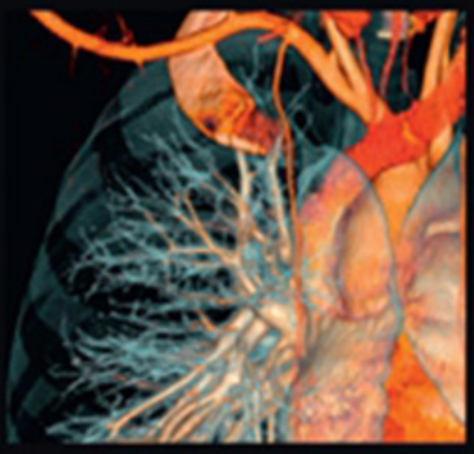
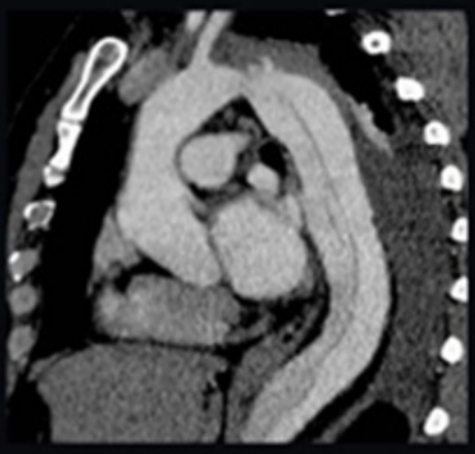
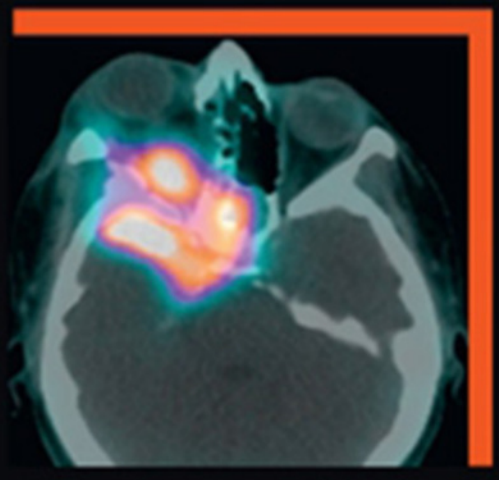

Second Edition

Grainger & Allison's Diagnostic Radiology Essentials

Lee Alexander Grant • Nyree Griffin

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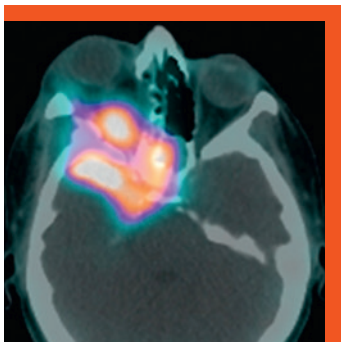

Second Edition

Grainger & Allison's Diagnostic Radiology Essentials

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First edition 2013
Second edition 2019

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ISBN: 978-0-7020-7311-3
E-ISBN: 978-0-323-56884-5

Printed in China
Last digit is the print number: 9 8 7 6 5 4 3 2 1

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PREFACE

This second edition of *Grainger & Allison's Diagnostic Radiology Essentials* is the culmination of one year's hard work on the part of the editors to update and extensively revise the original first edition. There are now new sections on functional imaging and interventional radiology as well as the latest 8th edition of TNM staging for cancers.

This book is based on the current sixth edition of *Grainger & Allison's Diagnostic Radiology*. Again, the overriding vision is to provide a unique single volume general radiology textbook, which attempts to encapsulate all the core information provided in its parent book, but presents it in an easy to read format. With this in mind, we have again made use of standardized headings throughout the book and have again directly linked images with the relevant text by placing them on the facing page. We have again made use of colour formatting throughout the book, to make it more accessible to the reader and facilitate quicker referencing. Inevitably due to limitations of space not every detail or as many figures could be included as we would have liked. However, we hope we have achieved, within space limitations, what we set out to do.

As with the first edition, the aim of this textbook is to provide as close as is possible a 'one-stop reference guide' for both trainees and practising consultants. Since the first edition was published we have continually received enthusiastic feedback from radiology trainees as to how this book has become an essential study aid in helping them successfully pass their FRCR part 2A examinations.

We are extremely grateful to Michael Houston for giving us the opportunity to build on the success of our first edition and the continuing support given to us by the editors of the *Grainger & Alison's Diagnostic Radiology* series. We would like to acknowledge the important groundwork that Joannah Duncan put in to creating the first edition, and single out Joanne Scott for special praise in working tirelessly with us in helping create this second updated and improved edition.

Lee Grant BA FRCR
Nyree Griffin MD FRCR
2018

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ACKNOWLEDGEMENTS

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SECTION 1

CHEST

1.1 CHEST WALL AND PLEURA

RIB LESIONS

Benign

Congenital abnormalities The upper ribs are commonly bifid, splayed, fused, or hypoplastic ▶ they are occasionally associated with syndromes (e.g. basal cell naevus syndrome) or other anomalies (e.g. Sprengel's deformity)

- ***Cervical rib:*** this arises from C7 (affecting 1–2% of the population) and consists of an initially downward sloping rib just lateral to the spine (cf. an initially upward sloping normal rib) ▶ it can cause a thoracic outlet syndrome and is often bilateral and asymmetrical

Callus Post fracture this can mimic an intrapulmonary opacity

Rib notching This is due to external pressure on a rib (e.g. coarctation of the aorta, neurofibromatosis type I (NF2))

Benign primary tumours These are infrequent ▶ they are most commonly cartilaginous tumours (e.g. a chondroma or osteochondroma) ▶ they are predominantly found in an anterior location and may show characteristic cartilaginous calcification

Other benign rib lesions Fibrous dysplasia ▶ histiocytosis X ▶ haemangioma ▶ aneurysmal bone cyst

Aggressive

Destructive rib lesions These are most commonly an osteomyelitis or a neoplastic disease

- ***Malignant rib tumours:*** these are commonly metastatic deposits or myeloma ▶ primary malignant tumours are rare (but usually a chondrosarcoma)
- ***Osteomyelitis:*** this is uncommon ▶ it may be due to haematogenous spread (e.g. staphylococcal or tuberculous), or it may be caused by direct spread from the lung or pleural space (e.g. actinomycosis)

Bronchial carcinoma (including pancoast's tumours) These can spread from the lung to a rib ▶ MRI can determine the extent of a Pancoast's tumour (and assess the relationship between the tumour and the plexus brachialis)

DIFFERENTIAL OF RIB NOTCHING

Inferior rib notching	**Arterial:** Coarctation of the aorta, aortic thrombosis, subclavian obstruction, any cause of pulmonary oligaemia **Venous:** Superior vena cava obstruction **Arteriovenous:** Pulmonary arteriovenous malformation, chest wall arterial malformation **Neurogenic:** Neurofibromatosis (ribbon ribs)
Superior rib notching	**Connective tissue diseases:** Rheumatoid arthritis, SLE, Sjögren's, scleroderma **Metabolic:** Hyperparathyroidism **Miscellaneous:** Neurofibromatosis, restrictive lung disease, poliomyelitis, Marfan's syndrome, osteogenesis imperfecta, progeria
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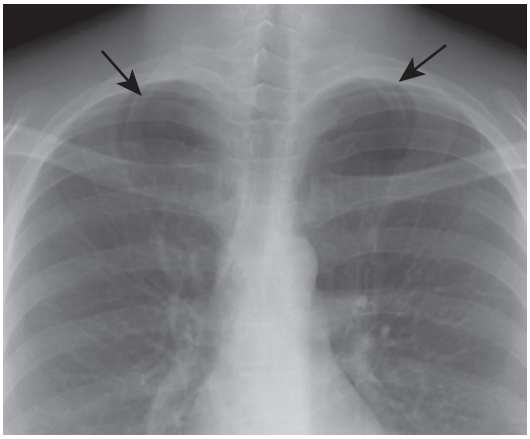
CLAVICLES

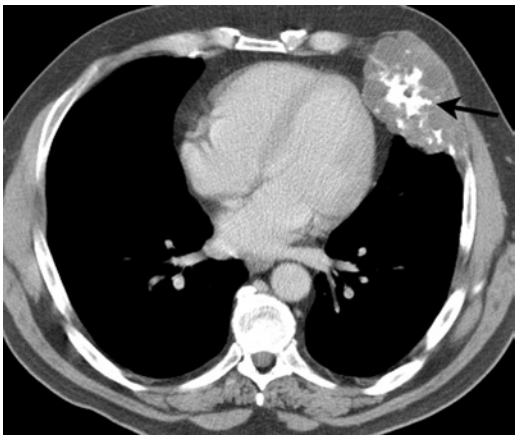
Definition Together with the spine the medial clavicular heads can assess rotation ▶ the joints at both ends are synovial and may be eroded in any synovitis appearing more ill defined (e.g. rheumatoid arthritis, hyperparathyroidism)

Pearl Neoplasms of the clavicle are usually malignant (myeloma or metastatic)

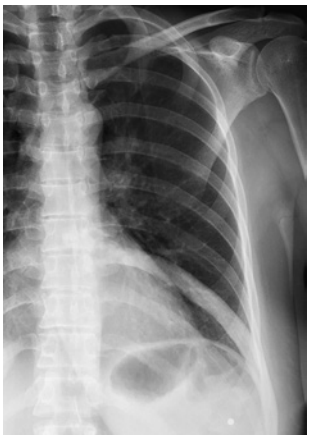
- Other primary tumours/tumour-like conditions:
  - Osteosarcoma ▶ Ewing's sarcoma ▶ post radiation sarcoma ▶ aneurysmal bone cyst ▶ histiocytosis X ▶ intersternocostoclavicular hyperostosis



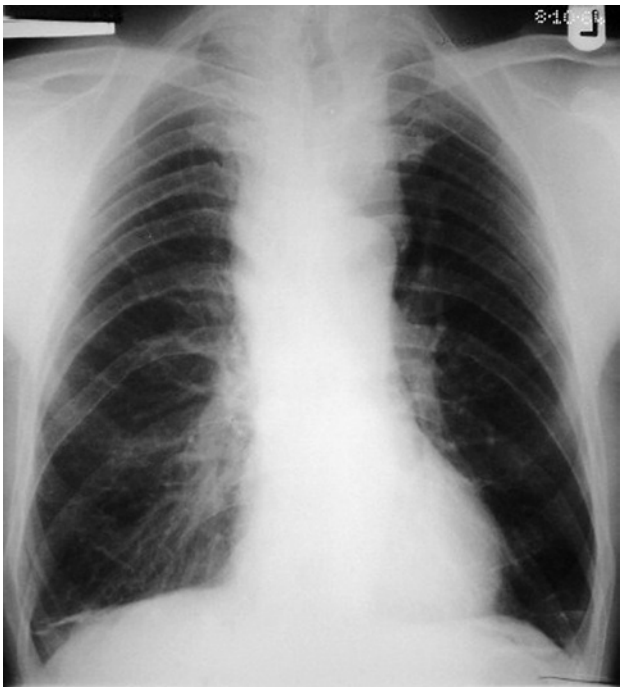
Cervical ribs. Bilateral downsloping cervical ribs (arrows).



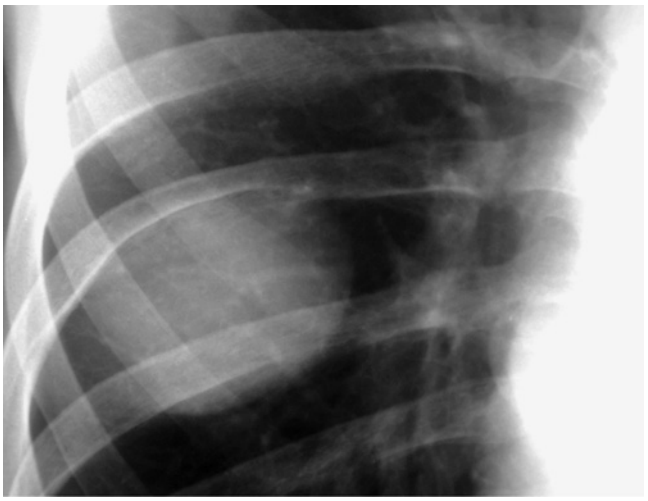
Axial CT. Chondrosarcoma of an anterior left rib demonstrating a large soft tissue component with internal punctuate calcification (arrow).



Fibrous dysplasia in a rib. CXR detail of the left lung. Compared with the other ribs the 9th rib shows an increase in density and is slightly broadened.*



Chest radiograph in a patient with coarctation. There is rib notching and enlargement of the left subclavian artery, causing a '3' sign.



Neurofibromatosis type 1 (NF-1): skeletal findings. Pressure erosion of a rib due to a neurofibroma. (Most rib deformities in NF-1 are due to the skeletal dysplasia, not pressure erosion.)

SOFT TISSUE LESIONS

POLAND'S SYNDROME

Definition An autosomal condition where there is unilateral absence or hypoplasia of the pectoralis major muscle ▶ it is accompanied by ipsilateral hand and arm anomalies (particularly syndactyly), rib anomalies and hypoplasia of the breast and nipple

CXR Unilateral lung transradiancy and an abnormal anterior axillary fold

SOFT TISSUE TUMOURS

Benign (rib separation or notch-like remodelling from pressure erosion)

Lipoma The most common benign chest wall tumour

CT A low-density well-demarcated homogeneous mass (–90 to –150HU) ▶ soft tissue components suggest a liposarcoma

MRI T1WI: high SI ▶ T2WI: intermediate SI (and low SI with fat suppression)

Neurofibroma Rib splaying and pressure erosion ▶ widened intervertebral foramina

CT Lower density than muscle before and after IV contrast medium

MRI T1WI: low to intermediate SI ▶ T2WI: high SI ▶ T1WI + Gad: marked contrast enhancement

Haemangiomas An uncommon anterior mediastinal lesion (± phleboliths)

CT A smooth, sharp, lobulated mass with central heterogeneous enhancement ▶ there may be bone remodelling and hypertrophy

MRI The best investigation for delineating its extent ▶ there are signal inhomogeneities generated by vessels, soft tissue and haemorrhage

- T1WI: intermediate SI ▶ T2WI: high SI

Lymphangiomas

CT Fluid-filled cyst ± septation

MRI Features of a cyst with a low protein content

Malignant (bony destruction)

- Malignant primary chest wall tumours are rare ▶ the most common are lipo- or fibrosarcomas
- Secondary tumours of the chest wall are common, particularly if there is local tumour spread (e.g. carcinoma of the breast and lung)

STERNAL LESIONS

PECTUS EXCAVATUM

Definition A depressed sternum resulting in the anterior ribs projecting more anteriorly than the sternum (funnel chest) ▶ it may be an isolated abnormality or associated with other disorders such as Marfan's syndrome or congenital heart disease (particularly an ASD)

CXR The condition is best assessed on a lateral CXR ▶ PA CXR: leftward shift of the heart ▶ straightening of the left heart border with prominence of the main pulmonary artery segment ▶ an indistinct right heart border simulating middle lobe disease (the sternum replaces aerated lung at the right heart border) ▶ a steep inferior slope of the anterior ribs ▶ undue clarity of the lower dorsal spine seen through the heart

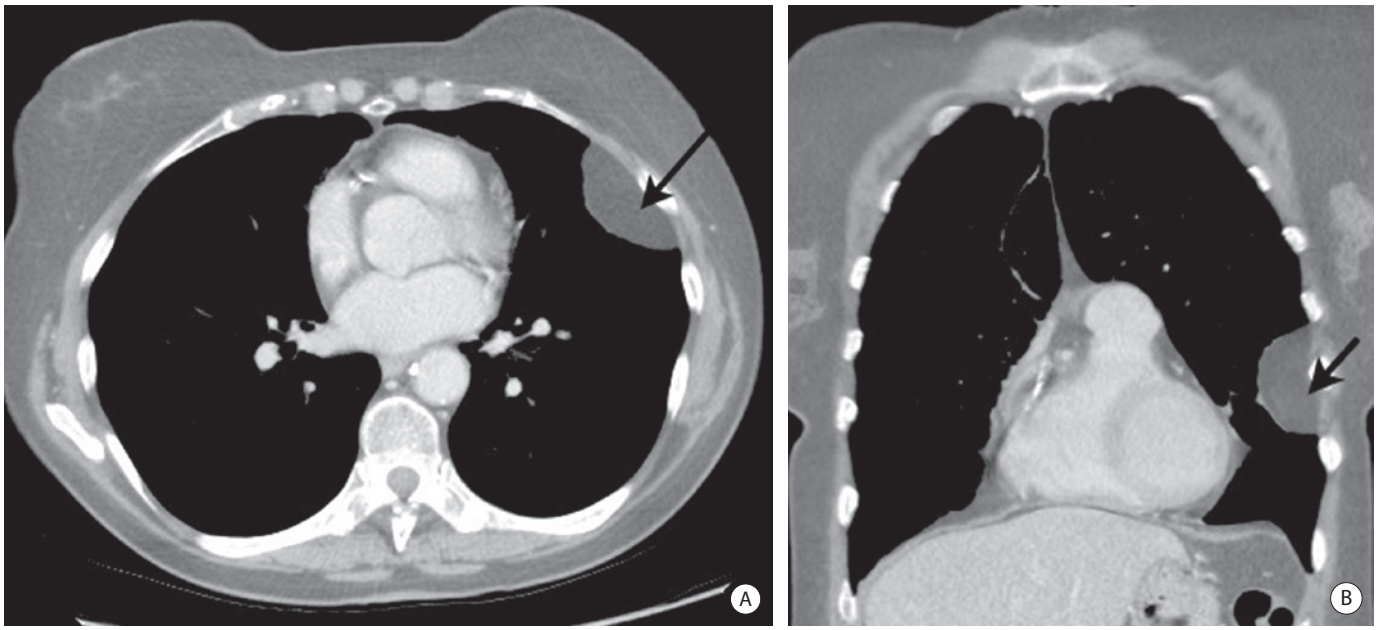
Pearl *Pigeon chest (pectus carinatum):* the reverse deformity, which may be congenital or acquired

STERNAL NEOPLASMS

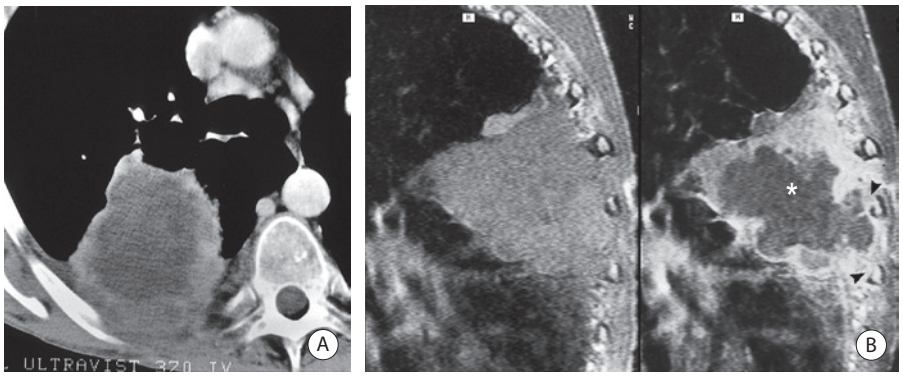
Definition These are usually malignant: myeloma ▶ chondrosarcoma ▶ lymphoma ▶ metastatic carcinoma

- The most common benign tumour is a chondroma
- Relevant non-neoplastic processes: osteomyelitis ▶ histiocytosis X ▶ Paget's disease ▶ fibrous dysplasia

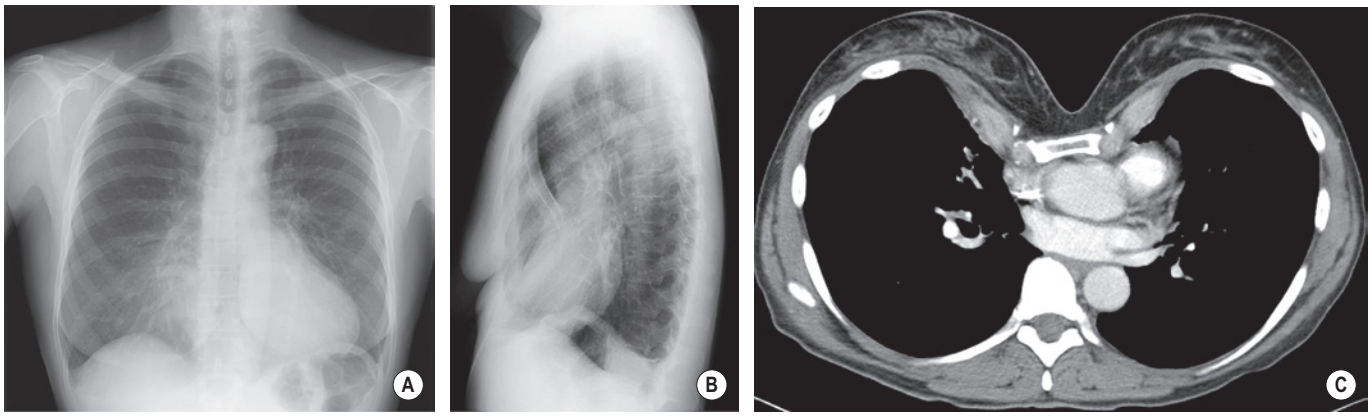
CT This is the recommended investigation: it eliminates any overlapping structures, detects bony destruction and allows imaging of the adjacent soft tissues



Axial (A) and coronal (B) CT images of a chest wall lipoma.



Invasive malignant T-cell lymphoma. (A) CECT. Enhancing peripheral tumour tissue is widely invading the posterior chest wall. (B) Sagittal T1WI (left) and T1WI + Gad (right) demonstrating the widespread invasion of the posterior chest wall by enhancing tumour tissue. There is invasion of 2 ribs, including cortical rib destruction (arrowheads). The central non-enhancement of the tumour is due to necrosis (asterisk).*



Depressed sternum. (A) PA CXR. The depressed sternum displaces the heart to the left and rotates it so that the left heart border adopts a straight configuration. The ill-defined right heart border simulates middle lobe collapse. Horizontal (posterior) and steeply oblique (anterior) ribs. (B) Lateral CXR demonstrates posterior sternal displacement. (C) Axial CT.*

PLEURAL THICKENING AND FIBROTHORAX

DEFINITION

- Pleural thickening usually represents an organized end stage of infective or non-infective inflammation
- If generalized and gross it is termed a fibrothorax and may cause significant ventilatory impairment
  - *Common causes:* empyema ▶ tuberculosis ▶ haemorrhagic effusions
  - Extensive calcification favours TB or empyema

RADIOLOGICAL FEATURES

XR Fixed shadowing (water density) located within the dependent parts of the pleural cavity ▶ costophrenic angle blunting is common

- *In profile:* it appears as band of soft tissue density (up to 10 mm thick) parallel to the chest wall and with a sharp lung interface
- *En face:* it appears as an ill-defined veil-like shadowing
- *Fibrothorax:* a smooth uninterrupted pleural density extending over at least ¼ of the chest wall

US A homogeneous echogenic layer just inside the chest wall ▶ US is only reliable if this is > 1 cm thick

CT The most sensitive modality ▶ pleural thickening is seen particularly on the medial rib aspect

- *Fibrothorax:* pleural thickening (> 3 mm) extending > 8 cm (craniocaudal) or > 5 cm (laterally)

MRI Low SI is a reliable indicator of benign pleural disease

PEARLS

- Extensive pleural calcification favours previous tuberculosis or empyema ▶ an asbestos-related fibrothorax is usually bilateral and rarely calcified

Apical pleural CAP Unilateral or bilateral fibrous pleural thickening is common in the apical pleural cupola (with an unknown aetiology but which may be secondary to TB or because the apices are relatively ischaemic areas of lung) ▶ it should be distinguished from a Pancoast's tumour (if in doubt perform a CT or MRI)

Asbestos exposure This can induce fibrous pleural thickening ▶ it can be diffuse but is more often multifocal and often calcified ▶ it is most commonly found along the lower thorax and diaphragmatic pleura

CXR Calcified plaques may have a 'holly leaf' configuration when viewed *en face*

CT Circumscribed areas of pleural thickening separated from an underlying rib and extrapleural soft tissues by a thin layer of fat ▶ they may be calcified

LOCALIZED FIBROUS TUMOUR (LOCALIZED MESOTHELIOMA)

DEFINITION

- A localized fibrous tumour of the pleura (⅔ are benign) ▶ there is no relation to previous asbestos exposure

CLINICAL PRESENTATION

- It presents in middle age and 50% are asymptomatic
- Hypertrophic osteoarthropathy is a well-recognized complication (10–30%) ▶ it uncommonly produces hypoglycaemia

RADIOLOGICAL FEATURES

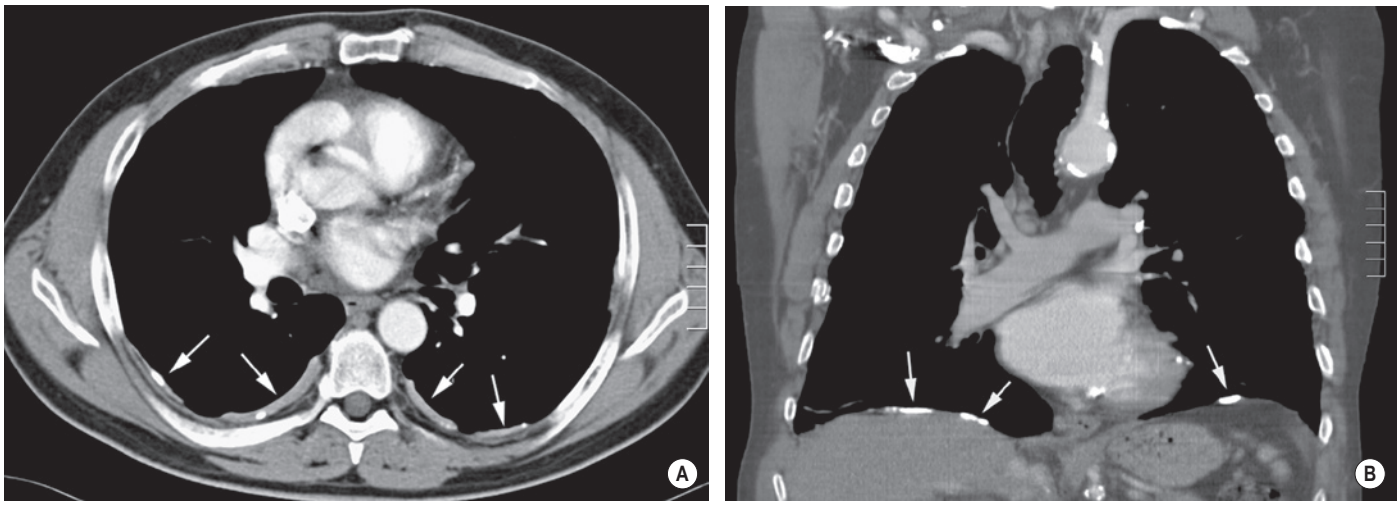
CXR A pleurally based, well-demarcated, slightly lobulated mass ▶ there can be marked positional variation with postural change (as it may be pedunculated) ▶ it can be massive (measuring up to 10-20 cm, with malignant tumours usually > 10 cm)

CT A heterogeneous mass (necrosis or haemorrhage) ▶ it frequently enhances but is rarely calcified

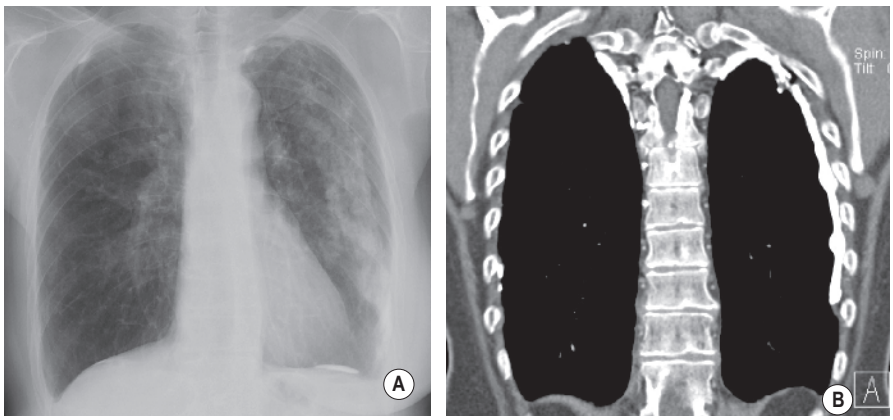
MRI T1WI / T2WI: low SI

PEARLS

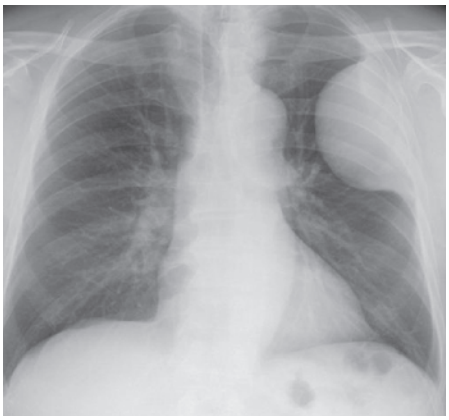
- The visceral pleura is more commonly involved
- The invasive form only grows locally (cf. a malignant mesothelioma)
- Pleural fibromas usually make an obtuse angle with the chest wall (extra pulmonary origin)
- Rarely arise within a fissure



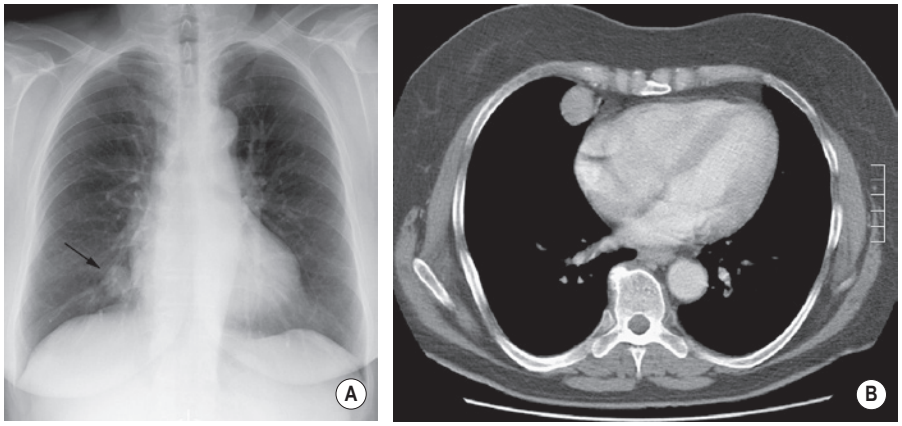
Pleural plaques caused by asbestos exposure. (A) Axial and (B) coronal CT. Pleural plaques are most commonly found along the lower thorax and on the diaphragmatic pleura (arrows). They can partially or completely calcify or ossify.*



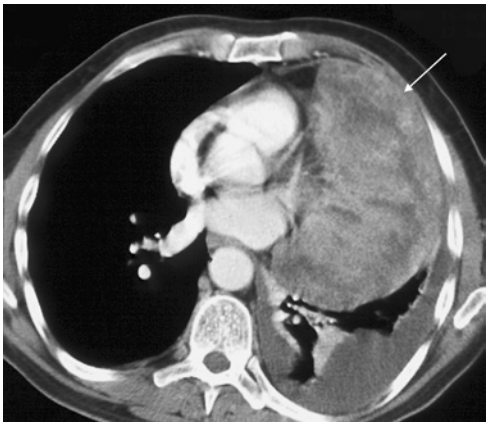
Pleural calcification. (A) On the CXR an extensive sheet-like calcification of the left pleura is seen together with focal calcifications of the diaphragmatic pleura. (B) CT demonstrates the extent and thickness of the pleural calcification.**



Large benign pleural fibroma. Well demarcated and homogeneneous mass making an obtuse angle with the chest wall. **



Benign pleural fibroma. (A) PA CXR demonstrating a small well-demarcated, homogeneous, slightly lobulated mass (arrow). (B) CT shows that the mass is pleurally based, sharply defined and slightly enhancing.*



Malignant fibrous tumour of pleura. Note the pleural effusion and the local invasion of the chest wall (arrow).

MALIGNANT MESOTHELIOMA

DEFINITION

- A rare primary pleural neoplasm strongly related to prior asbestos exposure (particularly crocidolite and amosite fibres)
- It predominantly involves the parietal pleura ▶ it can also involve the abdominal peritoneal lining

CLINICAL PRESENTATION

- Chest wall pain, dyspnoea and weight loss ▶ 4M:1F
- There is a latency period of 20-40 years post exposure ▶ it is associated with a poor prognosis

RADIOLOGICAL FEATURES

- It is radiographically indistinguishable from pleural metastases

XR Irregular nodular pleural thickening that is almost always associated with a pleural effusion (which is often haemorrhagic) ▶ it is usually confined to one hemithorax

CT Circumferential nodular pleural thickening (>1 cm) extending into the fissures or over the mediastinal surface, it can invade the chest wall ▶ there may be low attenuation necrotic areas present ▶ Metastatic mediastinal nodes in up to 50%

- *Lung encasement and volume loss:* there is a relative absence of any mediastinal shift even if there is a large effusion due to fixation of the mediastinum by tumour
- Previous evidence of asbestos exposure (e.g. calcified pleural plaques) is usually *absent*

MRI This is superior in assessing any mediastinal and chest wall involvement

- T1WI/T2WI: slightly greater SI than muscle

FDG PET Increased uptake (not tumour specific)

PEARLS

- **Diagnosis:** percutaneous needle biopsy (US or CT guidance)

PERICARDIAL MALIGNANT MESOTHELIOMA

- The most common primary pericardial malignancy (with a possible asbestos link) ▶ it presents with a haemorrhagic effusion (+/– cardiac tamponade)

  CT/MRI A well-defined single mass, multiple nodules or diffuse plaques wrapping around the heart and great vessels

PLEURAL METASTASES

DEFINITION

- Malignant pleural disease due to haematogenous spread from primary tumour elsewhere ▶ occasionally it is from direct seeding (e.g. malignant thymoma)
- This is the most common pleural neoplasm (and is more common than a mesothelioma)
- It is usually an adenocarcinoma
- Primary tumour is often lung, breast, lymphoma, ovary, stomach

CLINICAL PRESENTATION

- Chest wall pain, dyspnoea

RADIOLOGICAL FEATURES

CT There are usually multiple foci but there can be diffuse tumoural pleural thickening extending into the fissures (mimicking a mesothelioma) ▶ it is often accompanied by a pleural effusion ▶ pleural thickening is often lobulated

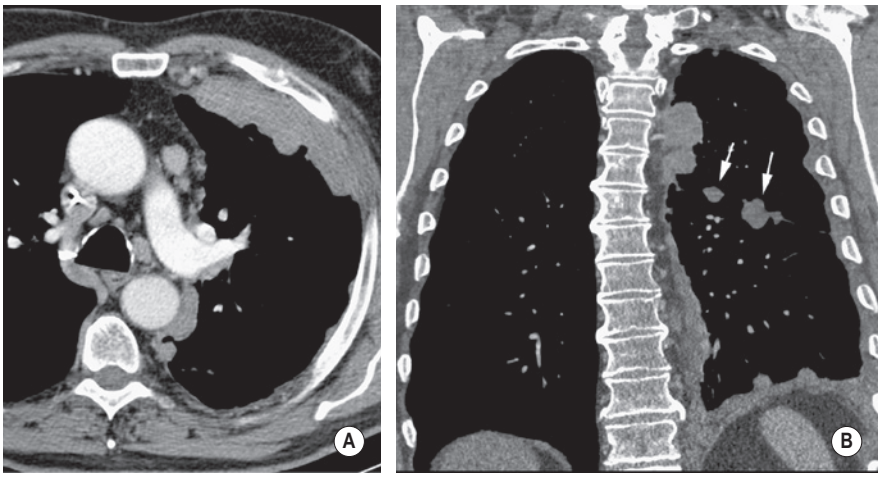
- Signs suggesting malignancy: circumferential thickening, nodularity, parietal thickening >1 cm, mediastinal pleural involvement

MRI DWI and DCE MRI may aid differentiation

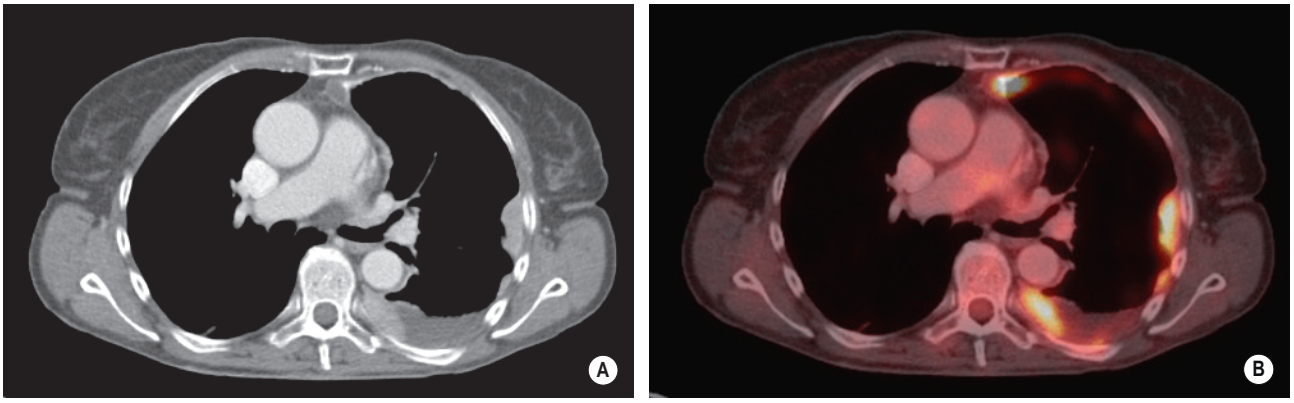
FDG PET Increased uptake in malignant disease, but it is not completely tumor specific with uptake in some benign inflammatory lesions.

PEARLS

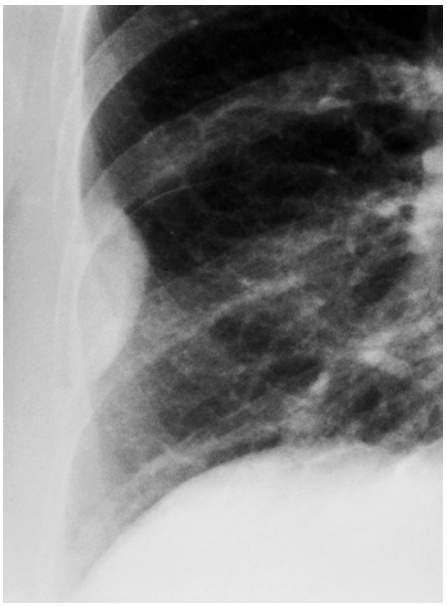
- Metastatic disease to the pleura is the second most common cause of a pleural effusion in patients >50 years (after congestive heart failure)
- It is the commonest cause of a pleural exudate



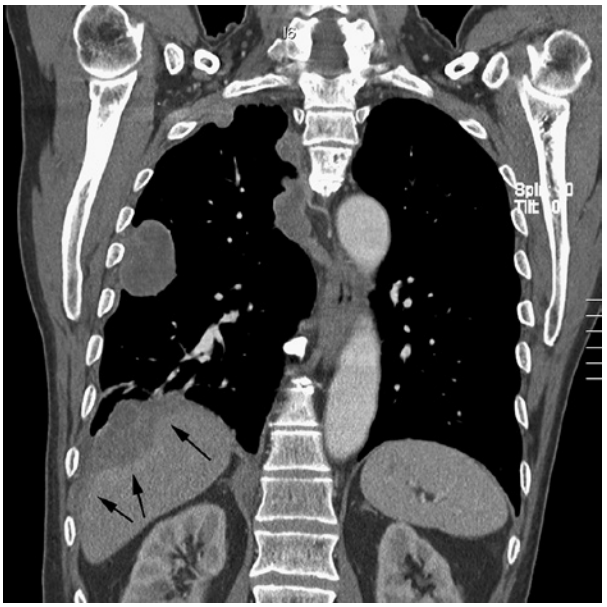
Malignant mesothelioma. (A, B: axial and coronal CT). Diffuse lobulated and nodular thickening of the pleura with tumour extension into the lobar fissure (arrows). Note the metastatic hilar and mediastinal adenopathy.*



Malignant mesothelioma. CT and PET-CT fusion image showing tumour extent.**



Pleural metastasis from carcinoma of uterus. This case is unusual in that the lesion is solitary and no pleural effusion is present.



Malignant pleural thickening caused by metastatic pleural disease. Note the compression on the right hemidiaphragm and the extension of the tumour into the liver (arrows).*

PLEURAL EFFUSION

Definition

- Accumulation of fluid within the pleural space
  - **Transudate:** the rate of pleural fluid accumulation exceeds resorption, leading to a plasma ultrafiltrate (with a low protein content)
  - – ***Causes:*** cardiac failure ▶ lymphatic obstruction
  - **Exudate:** increased pleural permeability leads to the accumulation of proteinaceous pleural fluid
  - – ***Causes:*** neoplasia (including metastases and mesothelioma) ▶ pleural inflammation ▶ infection (parapneumonic effusions) ▶ collagen vascular disease ▶ pulmonary embolism
  - **Additional causes of a pleural effusion:** cytotoxic drugs ▶ cirrhosis (with transdiaphragmatic passage of ascites + hypoalbuminaemia) ▶ renal disease (uraemia) ▶ immunocompromise ▶ a subphrenic abscess (which is often accompanied by basal atelectasis, consolidation and a subdiaphragmatic air-fluid level)

Radiological features

XR All types of simple pleural effusion are radiographically identical

- *Small effusions:*
  - Lateral decubitus CXR: this can detect as little as 10 ml of fluid
  - Lateral CXR: blunting of the posterior angles (approximately 50 ml)
  - PA CXR: blunting of the lateral costophrenic angles (200–500 ml)
- *Larger effusions:* homogeneous opacification of the lower chest with obliteration of the costophrenic angle and hemidiaphragm ▶ a superior meniscus (concave to the lung and higher laterally)
- *Massive effusions:* dense opacification of the hemithorax with contralateral mediastinal shift (unless there is associated obstructive collapse of the ipsilateral lung or extensive pleural malignancy) ▶ it may cause diaphragmatic inversion (particularly on the left as there is no liver support)
- *Localized subpulmonary effusion:* a 'high hemidiaphragm' with a contour that peaks more laterally than usual – the straight medial segment falls rapidly away to the costophrenic angle laterally ▶ separation of the gastric bubble from the diaphragm
- *Supine position:* generalized 'veil-like' haze with no meniscus present ▶ preserved lung vascular markings
- *Loculated effusion:* Fluid collecting between pleural layers ▶ a lenticular configuration with smooth margins ▶ usually there are additional clues indicating additional pleural disease

US Pleural fluid is usually echo-free with a highly echogenic line at the fluid–lung interface ▶ exudative and haemorrhagic effusions may be echogenic (homogeneous, complex or septated) and are often accompanied by pleural thickening

- Fluid bronchograms and vessels on Doppler examination will identify consolidation

CT A pleural effusion appears as a dependent sickle-shaped opacity of low attenuation ▶ CT characterizes the morphology of any pleural thickening that may accompany an effusion (nodular malignant or uniform benign) ▶ it identifies any causative underlying disease ▶ it can distinguish between free and loculated fluid (but cannot distinguish between a transudate or exudate)

- *Pleural lesions:* these make an obtuse angle with the chest wall (cf. intrapulmonary lesions which make an acute angle with the chest wall)
- *Parietal pleural thickening:* this usually indicates a pleural exudate
- *Liver interface:* this is indistinct with pleural fluid, but sharp with ascites

Pearls

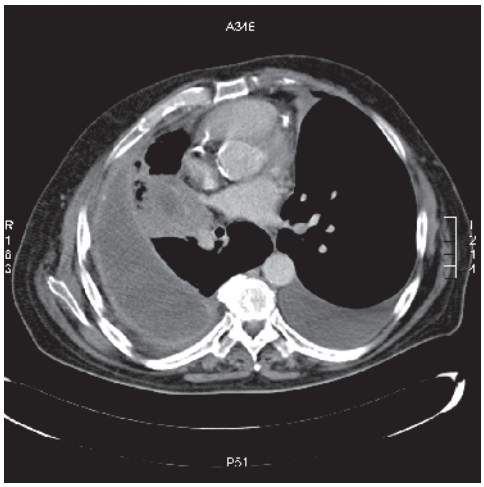
- **Right-sided effusion:** this is associated with ascites, heart failure and liver abscesses
- **Left-sided effusion:** this is associated with pancreatitis (with a high pleural fluid amylase level), pericardial disease, oesophageal rupture and aortic dissection
- **Bilateral pleural effusions:** these tend to be transudates and are secondary to generalized changes affecting both pleural cavities (e.g. uraemia or the nephrotic syndrome)
- **Massive effusions:** these are often due to malignant disease (particularly lung or breast metastases) but can also occur with heart failure, cirrhosis, TB and trauma
- **Empyema:** a collection of pus within a naturally existing anatomical cavity such as the pleural space (cf. an abscess, which is a collection of pus in a newly formed cavity) ▶ this commonly follows a pneumonia and associated parapneumonic effusion
- **Bronchopleural fistula:** a communication with the pleural space via the proximal airways (cf. distal air spaces with a pneumothorax) ▶ this occurs following lung resection or a necrotizing infection
- **Chylothorax:** milky chylous effusions (containing triglycerides) following thoracic duct rupture or seepage from any collaterals ▶ high protein content prevents expected reduction in attenuation

  MRI T1WI: this may demonstrate high SI (due to a high protein content)
- **Haemothorax:** this demonstrates a tendency for loculation if the blood clots with pleural thickening and calcification as recognized sequelae

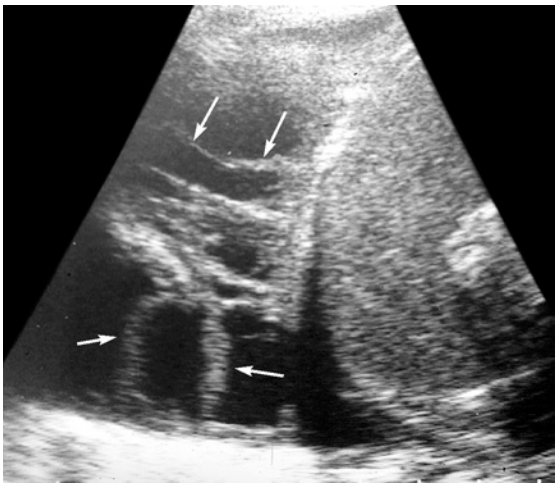
  CXR Indistinguishable from other pleural effusions

  CT It may be hyperdense

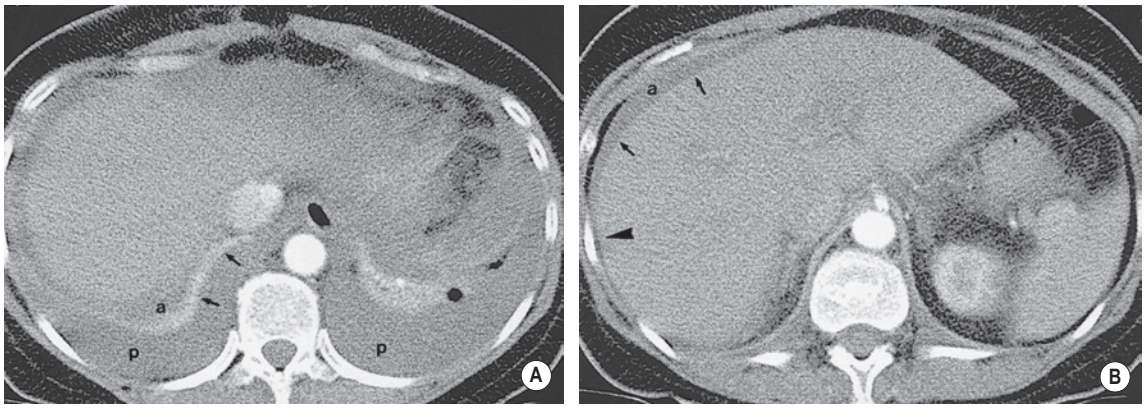
  MRI T1WI / T2WI: high SI (if subacute or chronic with a possible haemosiderin low SI rim)



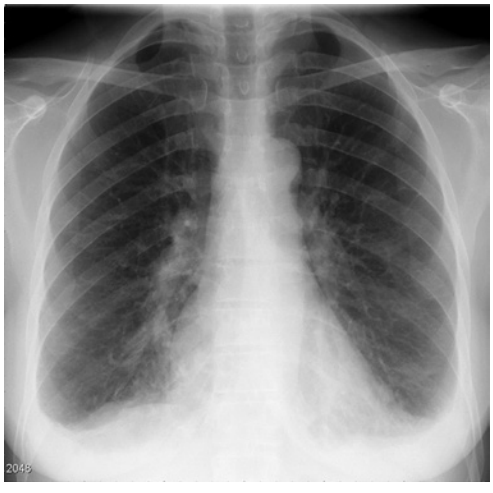
Empyema. CECT shows a thickened and enhanced smooth pleura in keeping with an empyema. Contrast this with the simple left pleural effusion.**



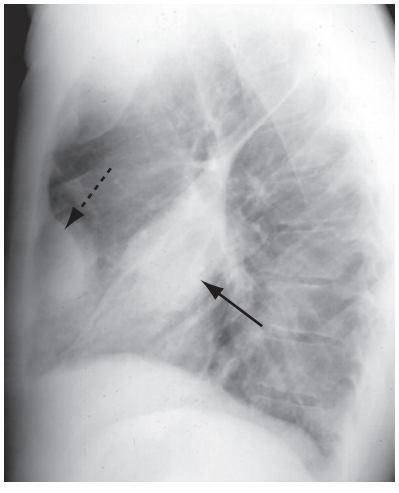
US of an empyema. The pleural fluid is separated by septa (arrows). Although the pleural fluid is echo-free in part, some areas return echoes owing to the turbid nature of the empyema fluid.*



CT signs which may differentiate pleural effusion and ascites. Scans through lower thorax/upper abdomen in patient with bilateral pleural effusions and ascites. (A) *Displaced crus sign*: The right pleural effusion collects posterior to the right crus of the diaphragm (arrows) and displaces it anteriorly. *Diaphragm sign:* The pleural fluid (p) is over the outer surface of the dome of the diaphragm, whereas the ascitic fluid (a) is within the dome. (B) *Interface sign:* The interface (arrows) between the liver and ascites is usually sharper than between liver and pleural fluid. *Bare area sign:* Peritoneal reflections prevent ascitic fluid from extending over the entire posterior surface of the liver (arrowhead), in contrast to pleural fluid in the posterior costophrenic recess.†



Bilateral pleural effusions. Erect CXR. The pleural effusion obscures the diaphragm and both costophrenic angles. It has a curvilinear upper margin concave to lung and is higher laterally than medially.*



Encapsulated fluid on a lateral CXR. Pleural fluid is encapsulated in the major fissure (arrows) and against the anterior chest wall (dotted arrow). These encysted fluid collections can mimic a lung tumour.*

PNEUMOTHORAX

DEFINITION

- Air within the pleural space – if liquid is present the nomenclature depends on the relative volumes and liquid type: (hydro-, haemo-, pyo-, chylo-) pneumothorax

CLINICAL PRESENTATION

- Sudden dyspnoea ▶ chest pain
- Adhesions can limit collapse but may also account for continued air leakage from the lung surface, and can bleed if teared ▶ appear as straight band shadows extending from the lung to chest wall

Causes of a secondary adult pneumothorax*	
Airflow obstruction	Asthma Chronic obstructive pulmonary disease (COPD) Cystic fibrosis
Pulmonary infection	Cavitary pneumonia Tuberculosis Fungal disease AIDS Pneumatocele
Pulmonary infarction	
Neoplasm	Metastatic osteosarcoma
Diffuse lung disease	Histiocytosis X Lymphangioleiomyomatosis Fibrosing alveolitis Other diffuse fibroses
Hereditable disorders of fibrous connective tissue	Marfan's syndrome
Endometriosis	
Catamenial pneumothorax: pleural endometrial deposits leading to recurrent pneumothoraces associated with the menses	
Traumatic, noniatrogenic	
Ruptured oesophagus/trachea	
Closed chest trauma (± rib fractures)	
Penetrating chest trauma	
Traumatic, iatrogenic	
Thoracotomy/thoracocentesis	
Percutaneous biopsy	
Tracheostomy	
Central venous catheterization	

RADIOLOGICAL FEATURES

Typical CXR signs A separate visceral pleural line from the chest wall commonly seen at the lung apex (erect CXR) ▶ a transradiant zone devoid of vessels lateral to the pleural line ▶ it may be more evident on expiratory films (due to an increased relative size of the pleural space)

- Skin folds can cause diagnostic problems (particularly in neonates and the elderly)

Supine pneumothorax Pleural air rises and collects anteriorly (particularly medially and basally) with no obvious lung edge visible

CXR Ipsilateral lung transradiancy ▶ a deep lateral finger-like costophrenic sulcus ▶ a transradiant band parallel to the diaphragm or mediastinum ▶ undue clarity of the mediastinal border ▶ diaphragmatic depression

- *'Double diaphragm' sign:* visualization of the undersurface of the heart (visible anterior costophrenic recess)

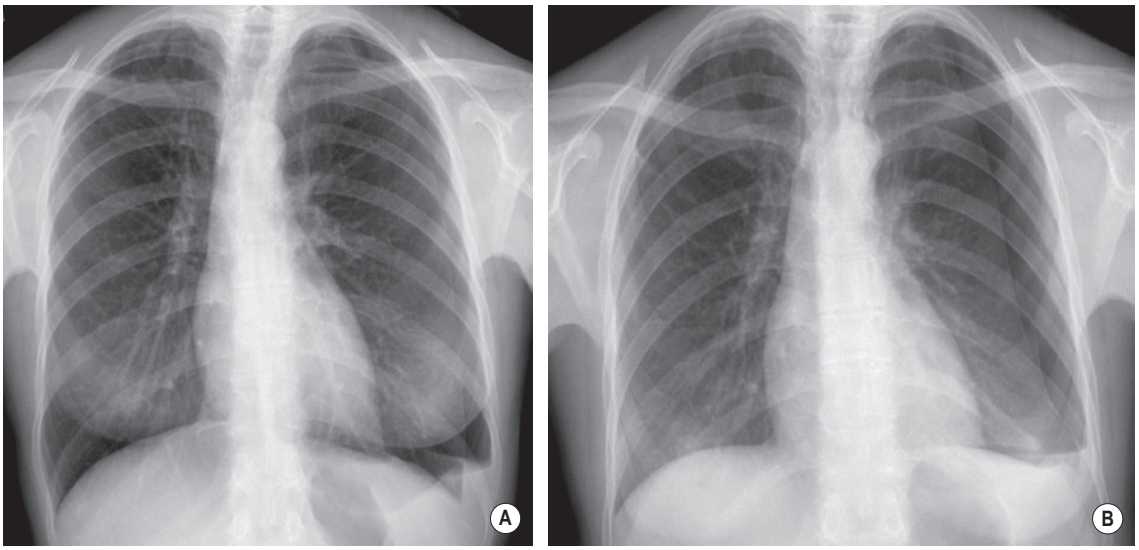
Tension pneumothorax A life-threatening complication present when the intrapleural pressure is positive relative to the atmospheric pressure (air can enter but not leave the pleural space) ▶ the mediastinal displacement can have an adverse effect on gas exchange and cardiovascular performance with a rapid clinical deterioration

CXR Absent lung markings on the affected side ▶ moderate or gross mediastinal displacement away from the side of the pneumothorax ▶ eversion of the diaphragm

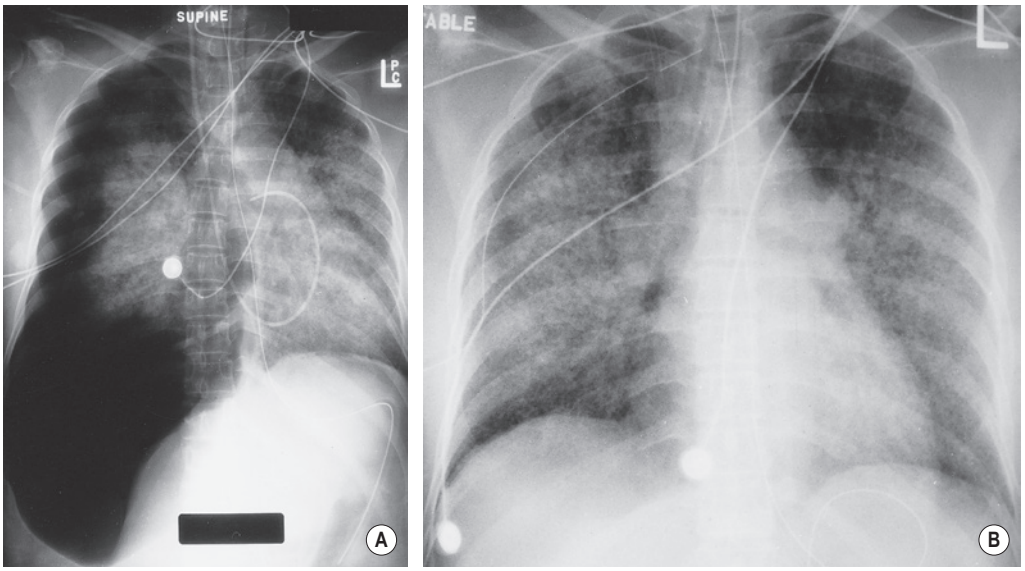
- The diagnosis is made clinically and a CXR should not usually be performed

PEARLS

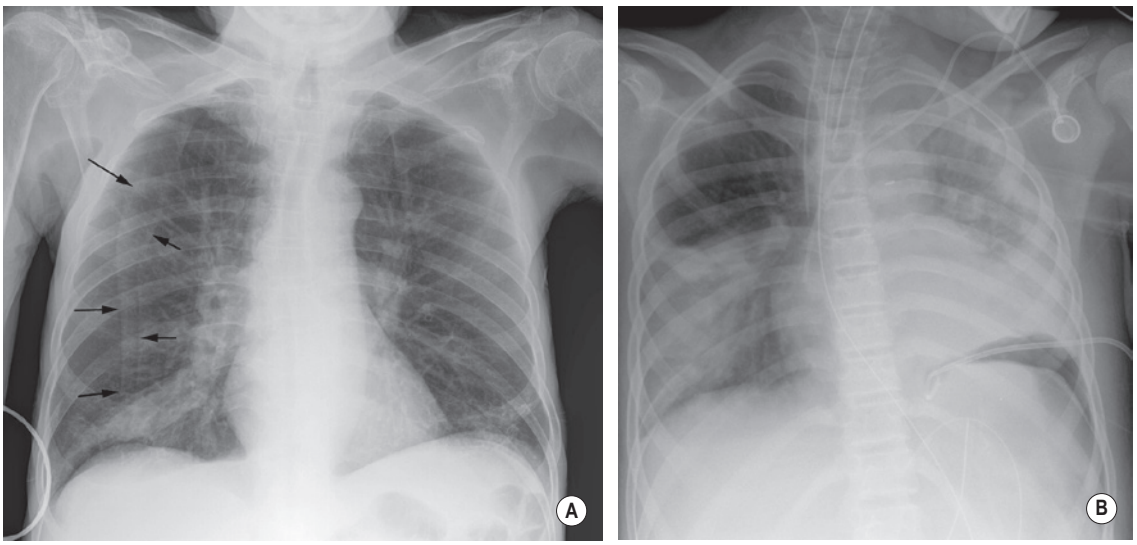
- A pneumothorax can be confirmed with a lateral decubitus view or a supine decubitus projection (immobile patients)
  - *Indeterminate circumstances:* a repeat expiratory CXR or CT
- A haemopneumothorax is a common complication of a traumatic pneumothorax
- Re-expansion oedema can follow rapid therapeutic lung expansion
- **Features that help identify artefacts and skin folds:**
  - Extension of the 'pneumothorax' line beyond the margin of the chest cavity ▶ laterally located vessels ▶ an orientation of a line that is inconsistent with the edge of a slightly collapsed lung ▶ a skin fold margin tends to be much wider than the normally thin visceral pleural line
- **Primary spontaneous pneumothorax (PSP):** the most common adult pneumothorax (commonly seen in young males with otherwise normal lungs) ▶ it is caused by rupture of an apical pleural bleb ▶ if untreated it commonly recurs on the same side



Left primary spontaneous pneumothorax. CXR (A) at deep inspiration and (B) deep expiration. The pneumothorax is accentuated on the CXR at suspended deep expiration (B).*



(A) Tension pneumothorax following a transbronchial lung biopsy. There is inversion of the right hemidiaphragm, and deviation of the mediastinum to the opposite side. (B) Following insertion of a right-sided chest drain the diaphragm and mediastinum have returned to a normal position. The diffuse bilateral infiltrate is due to pre-existing pulmonary haemorrhage.†



(A) Skin fold mimicking a right pneumothorax: laterally located blood vessels, margin of the lines, inconsistent orientation of the lines with the edge of a collapsed lung. (B) Supine pneumothorax. Increased transradiation at the left base and the costophrenic sulcus laterally is more pronounced ('sulcus' sign).**

DIAPHRAGMATIC HERNIA/EVENTRATION

DEFINITION

- **Hernia:** intrathoracic movement of the abdominal contents through a diaphragmatic defect
  - The diaphragm initially develops as an incomplete septum – the septum is derived from several separate elements which fuse between the 6th and 7th weeks of gestation to close the posterolateral diaphragmatic defects that are initially present
  - *Bochdalek hernia:* the most common type (70%) ▶ this occupies a posterolateral location through the pleuroperitoneal foramen
  - *Morgagni hernia:* anterior herniation through the formamen of Morgagni ▶ this usually presents later in childhood or adult life
- **Eventration:** part of the normal diaphragm is replaced by a thin layer of connective tissue and a few muscle fibres (the unbroken continuity differentiates this from a hernia) ▶ it also includes elevation as a result of acquired paralysis and associated muscular atrophy

CLINICAL PRESENTATION

- Asymptomatic in an adult ▶ respiratory distress in the newborn

RADIOLOGICAL FEATURES

Adults

Bochdalek (posterior) hernia A defect through the pleuroperitoneal foramen, the majority are left sided ▶ it usually contains retroperitoneal fat, kidney or spleen

CXR A well-defined, dome-shaped, soft tissue opacity midway between the spine and lateral chest wall (PA) ▶ a focal bulge 4–5 cm anterior to the posterior diaphragmatic insertion (lateral CXR)

CT/MRI A soft tissue mass protruding through the posteromedial aspect of either hemidiaphragm

Morgagni (anterior) hernia

CXR/CT An opacity at the right cardiophrenic angle frequently containing omentum or gut ▶ it demonstrates a smooth, well-defined margin and its soft tissue radiodensity allows differentiation from a fat pad collection (although it is more difficult to differentiate from a pericardial cyst)

Paediatric

Antenatal US This allows a diagnosis to be made

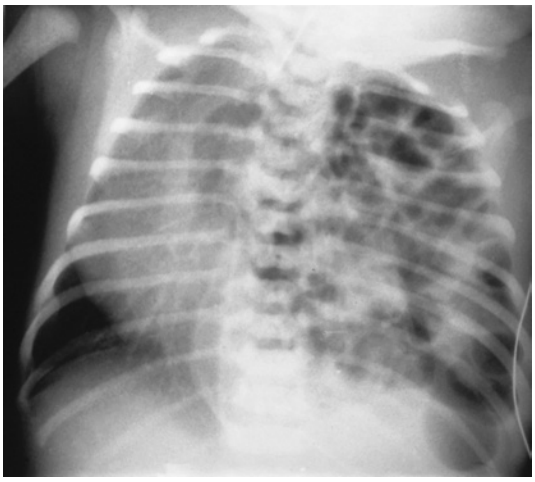
CXR An opaque hemithorax with mediastinal deviation away from the lesion ▶ once the GI tract begins to fill with air, radiolucencies will be seen within the affected hemithorax with progressive mediastinal deviation ▶ a NGT can determine the position of the stomach (an intrathoracic stomach is associated with earlier herniation and more severe pulmonary hypoplasia)

PEARLS

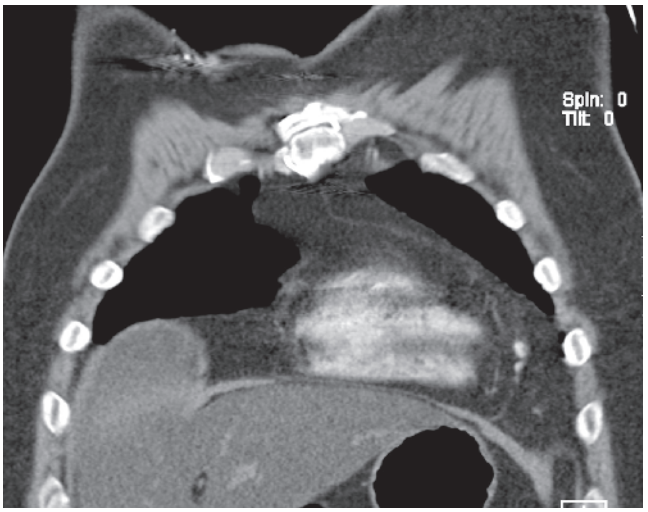
- **Total eventration:** this demonstrates a left-sided predominance
- **Localized eventration:** this predominantly affects the anteromedial right hemidiaphragm
- **Neonatal diaphragmatic hernia:** this can be compounded by severe respiratory difficulties secondary to any associated pulmonary hypoplasia, persistent fetal circulation and a degree of surfactant deficiency ▶ malrotation and small bowel malfixation are also associated problems
  - *Treatment:* surgical repair

Causes of bilateral symmetrical elevation of the diaphragm
Supine position
Poor inspiration
Obesity
Pregnancy
Abdominal distension (ascites, intestinal obstruction, abdominal mass)
Diffuse pulmonary fibrosis
Lymphangitis carcinomatosa
Disseminated lupus erythematosus
Bilateral basal pulmonary emboli
Painful conditions (after abdominal surgery)
Bilateral diaphragmatic paralysis

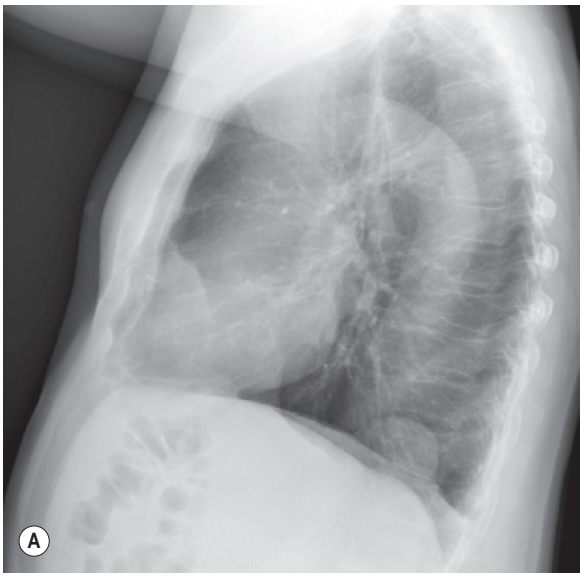
Causes of unilateral elevation of the diaphragm
Posture – lateral decubitus position (dependent side)
Gaseous distension of stomach or colon
Dorsal scoliosis
Pulmonary hypoplasia
Pulmonary collapse
Phrenic nerve palsy
Eventration
Pneumonia or pleurisy
Pulmonary thromboembolism
Rib fracture and other painful conditions
Subphrenic infection
Subphrenic mass

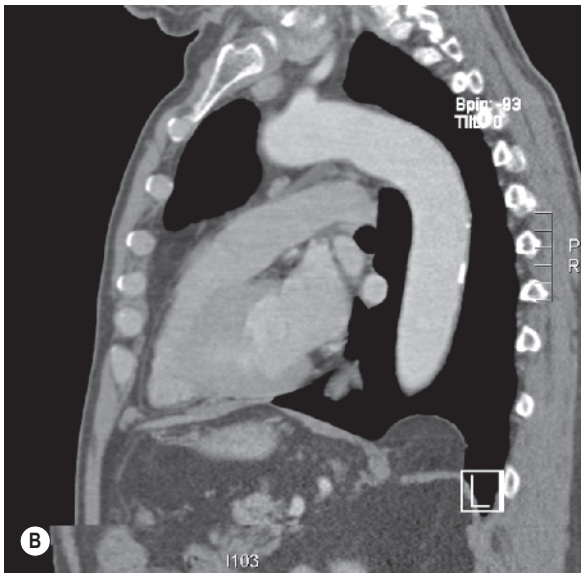


Congenital diaphragmatic hernia showing bowel extending from the abdomen in the left hemithorax and shift of the mediastinum to the right side.*

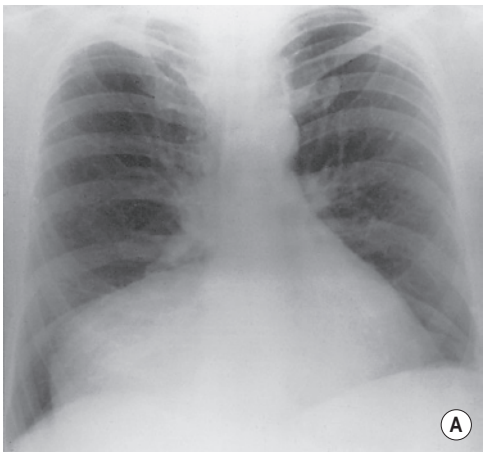


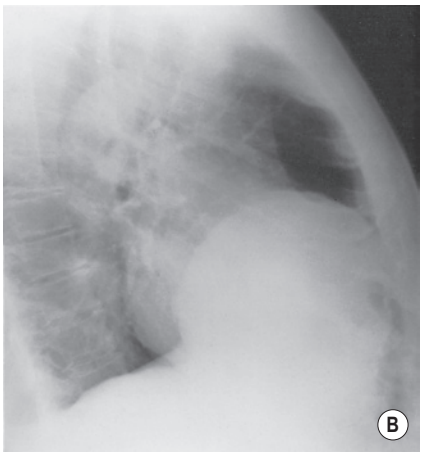
Focal eventration. CT shows the presence of liver under the elevated part of the diaphram.**

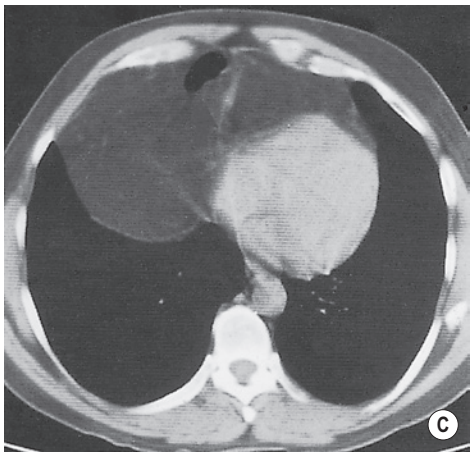




Bochdalek hernia. (A) Lateral CXR shows a focal bulge on the diaphragmatic contour just above the posterior costophrenic recess. (B) CT shows a fatty mass abutting the defect in the posteromedial aspect of the left hemidiaphragm.**







Morgagni's hernia. (A) PA and (B) lateral CXRs show a large mass in the right cardiophrenic angle. CT (C) confirms the presence of a Morgagni hernia.†

1.2 MEDIASTINUM

ACUTE MEDIASTINITIS

DEFINITION

- Acute infection of the mediastinum ▶ this is rare
- It is most commonly due to an oesophageal perforation (e.g. following endoscopy or from a swallowed object) – the alimentary contents serve as an infective source

Other causes

- Boerhaave's syndrome (forceful vomiting that tears the oesophagus) with the tear almost invariably just above the gastro-oesophageal junction ▶ leakage through a necrotic neoplasm ▶ post sternotomy ▶ infective extension from the neck, retroperitoneum or adjacent intrathoracic or chest wall structures

CLINICAL PRESENTATION

- Patients are often very ill with a high fever, tachycardia and chest pain
- 5–30% associated mortality with acute mediastinitis from oesophageal perforation even with treatment

RADIOLOGICAL FEATURES

CXR Widening and lack of clarity of the mediastinal outline ▶ streaks or round collections of air within the mediastinum ▶ mediastinal air-fluid levels ▶ pleural effusions are frequent (more commonly on the left) ▶ lower lobe pneumonia or atelectasis ▶ air within neck soft tissues

Barium swallow This may show the perforation site (a non-ionic contrast medium must be used)

CT Obliteration of the normal mediastinal fat planes ▶ gas bubbles within the mediastinum ▶ a walled-off discrete fluid or air-fluid collection (abscess) ▶ empyema, subphrenic or pericardial collection formation

- *Post sternotomy:* distinguishing a retrosternal haematoma from reactive granulation tissue or cellulitis is difficult, as is distinguishing osteomyelitis from the direct effects of the surgical incision
  - Substernal fluid collections and small amounts of air are normal in the first 20 postoperative days ▶ de novo postoperative or worsening gas collections should raise concern

FIBROSING MEDIASTINITIS (SCLEROSING MEDIASTINITIS/MEDIASTINAL FIBROSIS)

DEFINITION

- Proliferation of fibrous tissue and collagen within the mediastinum
- This is usually due to previous histoplasmosis or tuberculosis infection ▶ it is usually maximal within the upper mediastinum, but may extend to the lung roots
- *Other causes:* idiopathic (similar to retroperitoneal fibrosis or peri-aortitis) ▶ autoimmune disease ▶ radiation therapy ▶ drugs (particularly methysergide)

CLINICAL PRESENTATION

- SVC obstruction ▶ occasionally central pulmonary artery or venous obstruction

RADIOLOGICAL FEATURES

CXR Non-specific features ▶ CXR often underestimates the disease extent, but may show calcification of the mediastinal or hilar lymph nodes (if it is due to previous tuberculous or fungal infection)

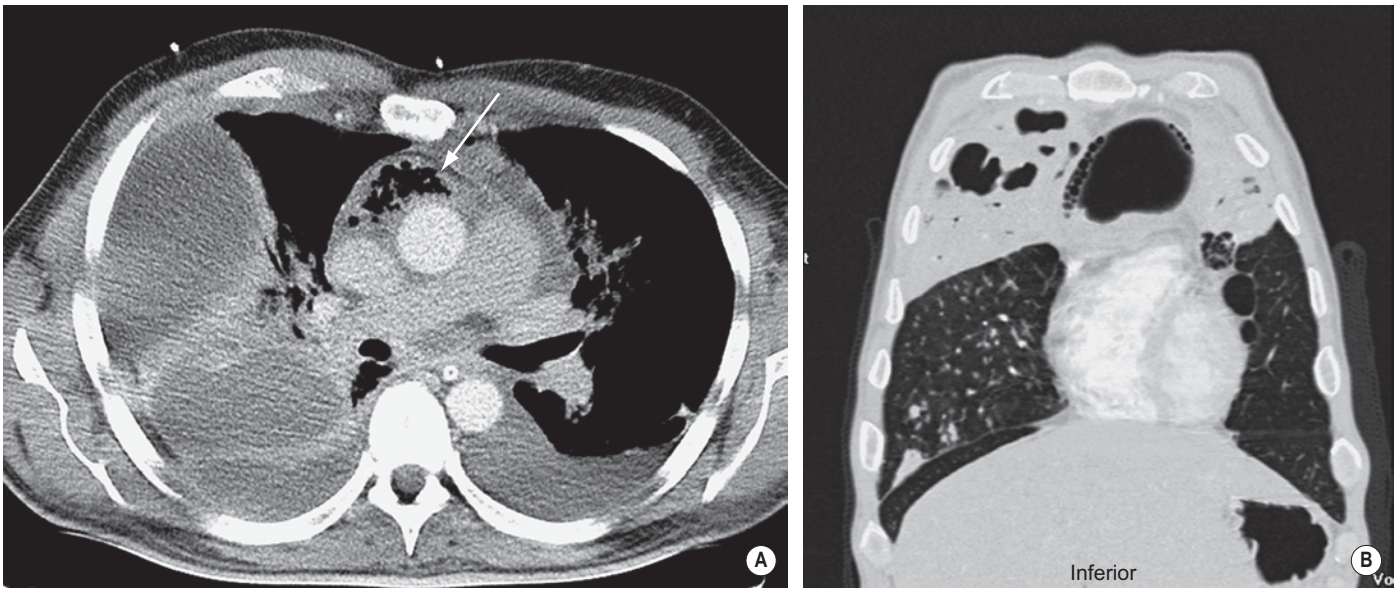
CT An infiltrative (often extensively calcified) hilar and mediastinal process ▶ it is relatively focal if it is secondary to previous histoplasmosis or tuberculosis infection (a more diffuse appearance is seen with the idiopathic form) ▶ airway narrowing ▶ vascular encasement ± obstruction

MRI This provides similar information to CT ▶ however, MRI lacks sensitivity for detecting calcification (which is an important feature differentiating fibrosing mediastinitis from other infiltrative disorders of the mediastinum such as lymphoma or metastatic carcinoma) ▶ extensive regions of decreased signal intensity help differentiate fibrosing mediastinitis from other infiltrative mediastinal lesions

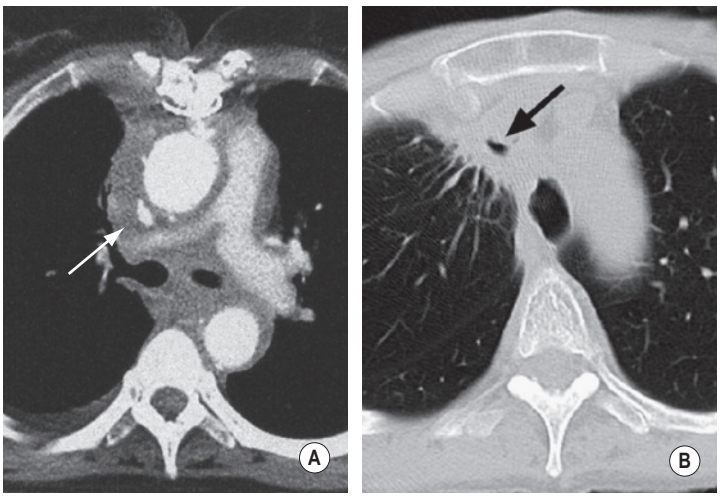
- T1WI: heterogeneous infiltrative mass of intermediate SI
- T2WI: more variable ▶ reduced SI = calcification or fibrous tissue, increased SI = active inflammation
- T1WI + Gad: heterogeneous enhancement

PEARL

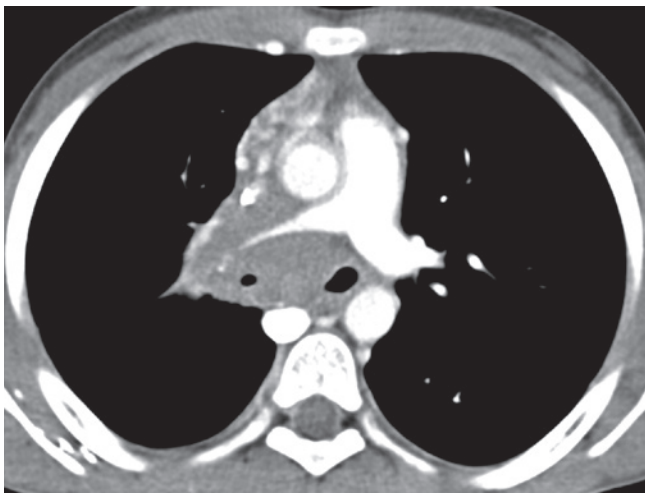
- Two patterns of fibrosing mediastinitis:
  - Focal (80%): caused by histoplasmosis ▶ mass of soft tissue attenuation that is often calcified ▶ usually located in the right paratracheal, subcarinal or hilar regions
  - Diffuse (20%): not related to histoplasmosis ▶ often occurs in the setting of retroperitoneal fibrosis ▶ manifests as a diffusely infiltrating non-calcified mass affecting multiple mediastinal compartments



Abscess formation. (A) CT of an anterior mediastinal abscess (arrow). (B) Coronal CT (different patient) demonstrating a tuberculous mediastinal abscess and associated lung changes.*



Mediastinitis. (A) Fibrosing mediastinitis. There is confluent soft tissue infiltration throughout the mediastinum without evidence of a discrete mass. Note the marked narrowing of the SVC (white arrow). (B) Tracheal narrowing from mediastinal fibrosis of unknown cause (different patient). The trachea (black arrow) is markedly narrowed and distorted and lies within the fibrotic scarring. The more posterior oesophagus is relatively dilated and gas filled.*



Fibrosing mediastinitis. CECT shows a partly calcified hilar mass secondary to histoplasmosis causing stenosis of the right pulmonary artery.**

THYROID MASSES

DEFINITION

- Most mediastinal thyroid masses are downward extensions of a multinodular colloid goitre (occasionally an adenoma or carcinoma)

CLINICAL PRESENTATION

- Usually an incidental CXR finding

RADIOLOGICAL FEATURES

XR A well-defined mass (spherical or lobular) within the superior aspect of the anterior or middle mediastinum ▶ tracheal displacement (± narrowing)

Scintigraphy ^{123}I or ^{131}I will demonstrate a thyroid mediastinal mass

CT This is almost as specific as scintigraphy but it will also demonstrate the shape and position of the mass ▶ the mass is invariably continuous with the thyroid gland in the neck ▶ it will demonstrate higher attenuation values than muscle pre and post IV contrast medium administration (due to its inherent iodine content) ▶ intense and prolonged enhancement ▶ areas of low attenuation are due to cystic degeneration ▶ retrotracheal masses will separate the trachea and oesophagus – this is virtually diagnostic of a thyroid mass

- *Benign disease:* this may demonstrate rounded or irregular well-defined areas of calcification
- *Carcinoma:* this occasionally demonstrates amorphous cloud-like calcification

MRI This identifies any cystic and solid components together with any haemorrhage (but not calcification)

PEARL

- It is not possible to determine any malignant potential on CT unless the tumour has clearly spread beyond the thyroid gland

PARATHYROID MASSES

DEFINITION

- Parathyroid tumours causing hyperparathyroidism are commonly located near the thyroid thymus
- *Causes of primary hyperparathyroidism:* single adenoma (80%) ▶ hyperplasia (15%) ▶ carcinoma (4%) ▶ multiple adenomas (1%)
  - Occasionally it can be due to hormone excretion from an ectopic bronchial carcinoma

RADIOLOGICAL FEATURES

- Small tumours are almost never visible on plain radiographs ▶ they are best detected using either US or ^{99m}Tc-MIBI

US An oval, well-defined anechoic or hypoechoic mass posterior to the thyroid gland (approximately 10 mm in size but can grow to 4–5 cm) ▶ larger tumours are more likely to be multilobulated and to contain echogenic areas, cysts and calcification ▶ retropharyngeal and mediastinal nodes are not very accessible ▶ a parathyroid gland can be mistaken for an ectopic thyroid nodule or a hyperplastic lymph node

CT This is useful for assessing sites inaccessible by US

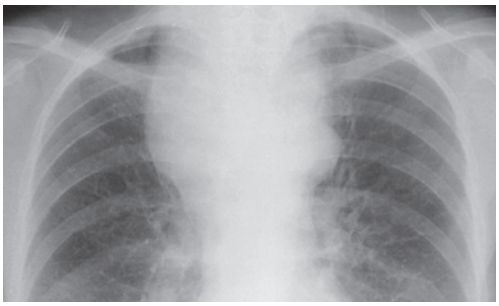
MRI T1WI: isointense to muscle ▶ T2WI: high SI

Scintigraphy

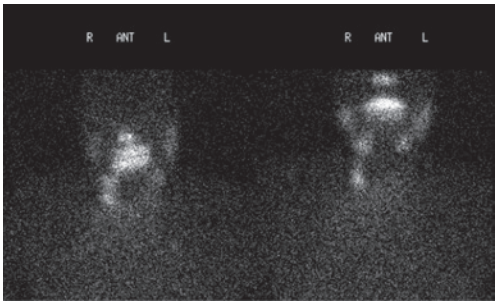
- ***Subtraction imaging:*** a ^{99m}Tc or ^{123}I image (thyroid uptake only) is subtracted from a ^{201}Tl or ^{99m}Tc-MIBI image (uptake within both the thyroid and parathyroid glands)
- ***Timed imaging:*** ^{99m}Tc-MIBI (sestamibi)
  - *Early (15 min post injection):* thyroid and parathyroid uptake
  - *Delayed (90 min post injection):* there is significantly longer parathyroid tracer retention with thyroid 'washout'

PEARLS

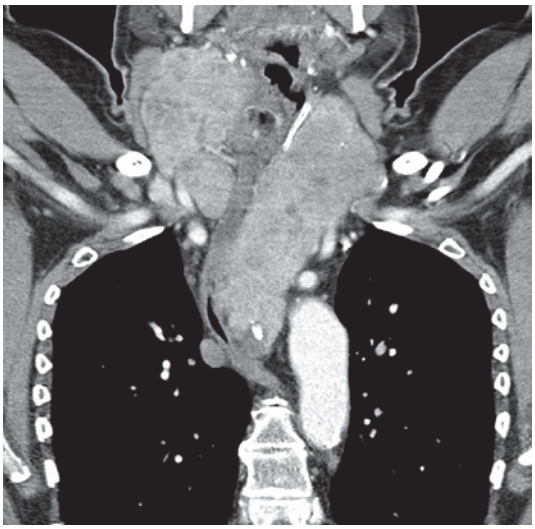
- *Normal arrangement:* usually 4 glands are found adjacent to the thyroid lobes, thoracic inlet or mediastinum (up to 5 mm in long axis)
  - Ectopic glands can be found anywhere from behind the angle of the mandible down to the aortic root
- Selective arteriography, venous sampling and venography can be used for further assessment
- It is associated with the MEN I syndrome



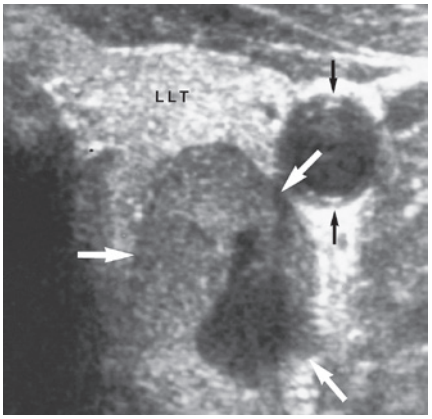
PA CXR of an intrathoracic thyroid mass.*



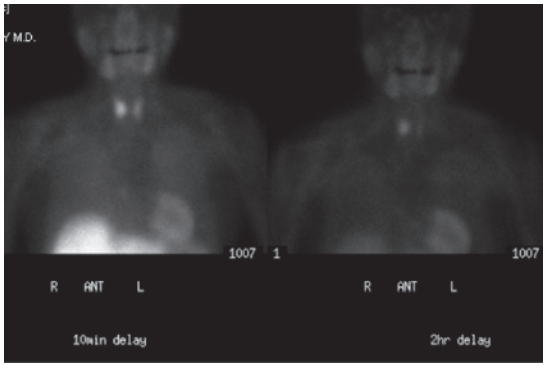
^{123}I radionuclide imaging of the face and neck demonstrates iodine uptake of the goitre.**



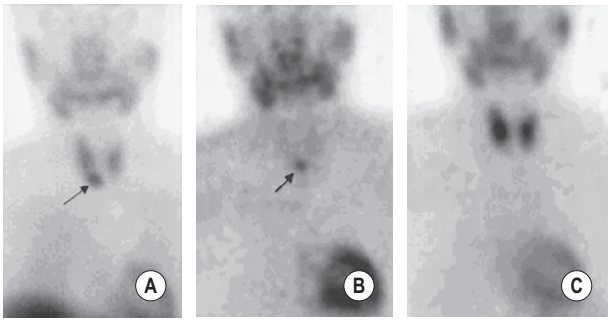
Coronal CT demonstrating thyroid intrathoracic extension. The thyroid demonstrates heterogeneous contrast medium enhancement and there are flecks of calcification in the gland.*



High-resolution US of the left lobe of the thyroid (LLT) anterior to a parathyroid adenoma (white arrows). There is a small area of cystic degeneration within the posterior aspect of the adenoma. Carotid artery (black arrows).*



Role of scintigraphy in detecting parathyroid adenomas. A 66-year-old woman with hypercalcaemia. CT (not shown) did not reveal a parathyroid adenoma. ^{99m}Tc-sestamibi radionuclide imaging demonstrates uptake in both thyroid and parathyroid parenchyma in the 10-minute delayed image (left); however, at 2-hour delay, imaging (right) demonstrates persistent uptake in the right lobe of the thyroid gland, representing the parathyroid adenoma.**



Parathyroid adenoma. ^{99m}Tc-MIBI images at 10 min (A) and 3 h (B) showing a persistent focus of activity inferior to the right lobe of the thyroid; $^{99m}TcO_4$ image (C) shows normal thyroid uptake but the adenoma is not visualized.

THYMOMA

Definition

- A thymic epithelial neoplasm (usually low grade), which is the most common primary adult tumour of the anterior mediastinum
- An invasive thymoma (25%) demonstrates contiguous spread and is histologically indistinguishable from a benign tumour ▶ it is only identified by any extra-capsular spread

Clinical presentation

- It is rare under the age of 20 years – the average age at diagnosis is 50 years (but earlier in those with myasthenia gravis) ▶ M = F
- It is asymptomatic in up to 50% of patients – any symptoms are caused by compression or invasion of nearby mediastinal structures
- Up to 50% of patients have myasthenia gravis ▶ approximately 10–20% of patients with myasthenia gravis have a thymoma

Radiological features

CT This is the best imaging modality ▶ 90% arise within the upper anterior mediastinum (usually anterior to the ascending aorta and lying above the right ventricular outflow tract and pulmonary artery)

- A thymoma is spherical or oval in shape with lobulated borders (± cystic areas) ▶ there may be punctate or curvilinear calcification ▶ there is homogeneous density and uniform enhancement post IV contrast medium
  - Asymmetrical focal swelling (cf. generalized hyperplasia with myasthenia gravis)
- **Invasive thymoma:** a poorly marginated mass (which does not respect tissue planes) ▶ invasion of the mediastinal fat and pleura ▶ vascular encasement
  - *Pleural metastases:* via drop metastases once the pleural space has been breached
  - *Trans-diaphragmatic spread:* via the retrocrural space (30%) to involve the peritoneal surfaces and para-aortic regions

MRI T1WI: similar SI to that of muscle and adjacent normal thymic tissue ▶ T2WI: increased SI relative to adjacent mediastinal fat ▶ heterogeneity of SI can be caused by cystic change and haemorrhage

Pearls

- Thymoma can be difficult to diagnose in young patients as the normal gland is variable in size
- *Other syndromes associated with a thymoma:* hypogammaglobulinaemia ▶ red cell aplasia
- *Thymic cysts:* uncommon ▶ if congenital tend to be simple/unilocular ▶ acquired tend to be multilocular and are seen in association with thymic tumours, Langerhans cell histiocytosis or following irradiation

OTHER THYMIC TUMOURS

THYMIC CARCINOMA

Definition An aggressive and locally invasive malignancy (particularly invading the mediastinum, pericardium and pleura) with a poor prognosis

- It presents with chest pain and weight loss, usually in adults

CT A large heterogeneous mass with areas of necrosis and calcification ▶ it frequently metastasizes to the regional lymph nodes with distant sites involved at presentation

THYMOLIPOMA

Definition A rare benign encapsulated tumour composed of mature fat and normal thymic tissue ▶ it is associated with myasthenia gravis, aplastic anaemia, Graves' disease and hypogammaglobulinaemia

- Age range: 3–60 years ▶ it is usually asymptomatic although it can be large at presentation

CT/MRI It can grow to a large size before discovery and, being soft, moulds itself to the adjacent mediastinum ▶ the mass is fatty in nature ▶ occurs low in the anterior mediastinum (often the cardiophrenic angle)

THYMIC HYPERPLASIA

Definition This is most commonly associated with myasthenia gravis, but can also be seen with thyrotoxicosis and collagen vascular diseases

CT/MRI It rarely causes visible thymic enlargement ▶ if it is visible both the lobes are usually uniformly enlarged

Pearl The thymus may atrophy with stress or as a consequence of steroid or anti-neoplastic drug therapy – it usually returns to its original size on recovery but it may undergo rebound thymic hyperplasia making it difficult to distinguish from neoplastic involvement

THYMIC LYMPHOMA

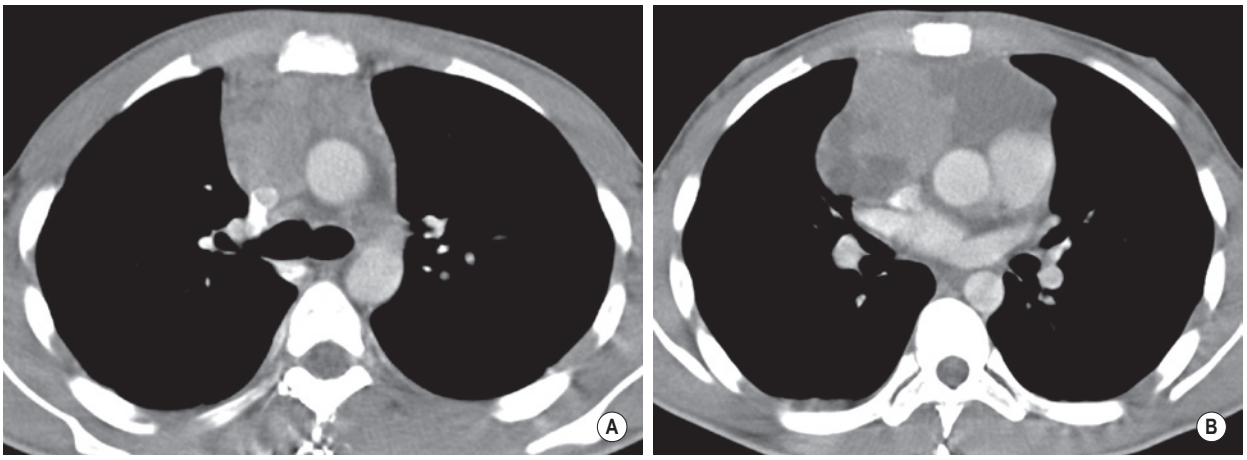
Definition This is usually part of a generalized disease (most commonly Hodgkin's disease)

CT/MRI Imaging features are similar to thymoma

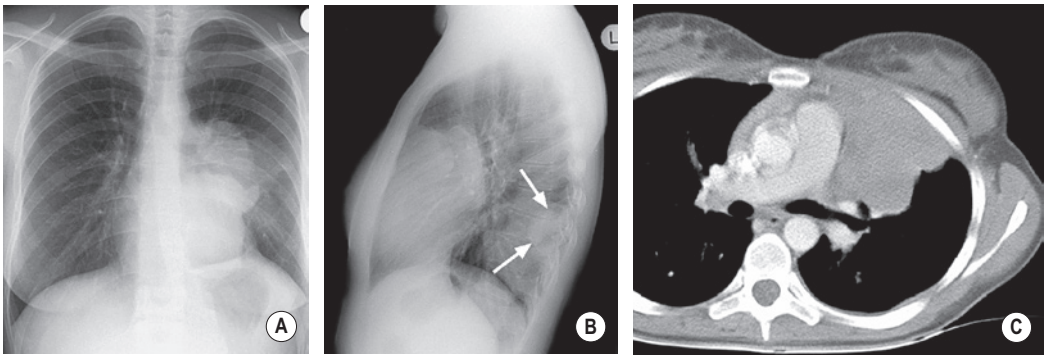
THYMIC CARCINOID

Definition An APUDoma which is histologically distinct from a thymoma (but with identical imaging features) ▶ it forms part of the MEN I syndrome ▶ aggressive tumour

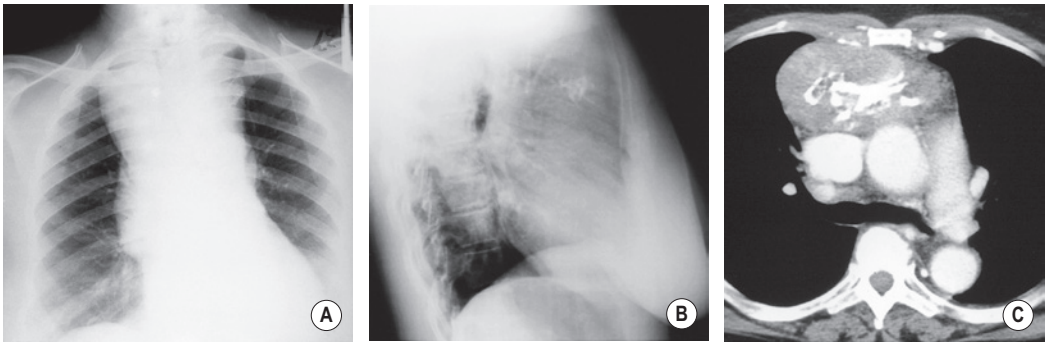
Pearl It may secrete adrenocorticotrophic hormone in sufficient quantities to cause Cushing's syndrome (40%)



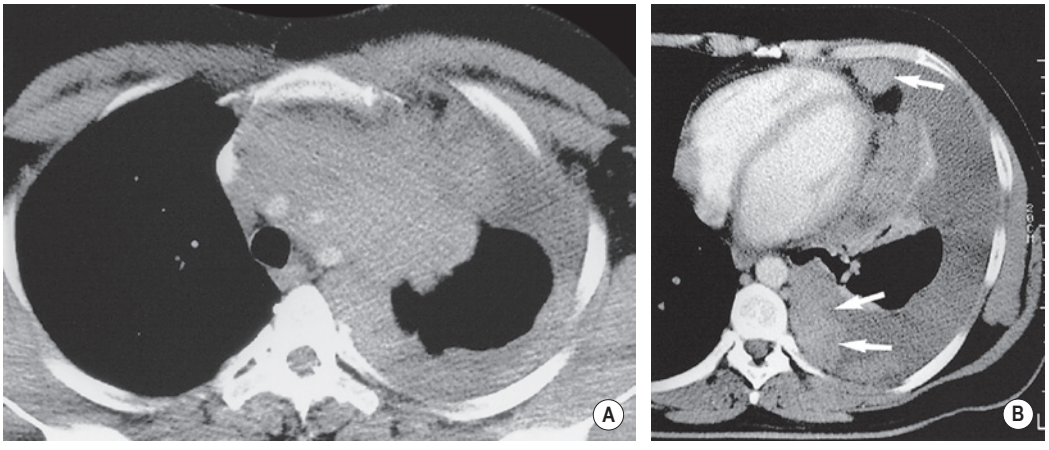
Thymic carcinoma. A 16-year-old man with history of weight loss and night sweats. Contrast medium-enhanced CT images show a heterogeneously enhancing anterior mediastinal mass arising from the right lobe of the thymus (A), with cystic (or necrotic) components. It extends inferiorly in the retrosternal space (B) and has no clear fat plane between it and the mediastinal structures (B). It was surgically excised and pathological examination revealed thymic carcinoma.**



Malignant thymic mass. (A) PA and (B) lateral CXRs – the lateral view demonstrates pleural metastases posteriorly (arrows). (C) CT confirms the anterior position of the primary tumour suspected from the filling of the retrosternal window apparent on the lateral CXR.*



Thymoma. (A) CXR demonstrating a large anterior mediastinal mass (A) with coarse calcification visible on (B) the lateral view and (C) CECT.*



Invasive thymoma in a young man. (A) A lobular anterior mediastinal mass associated with a pleural effusion. (B) Image obtained through the lower chest demonstrates mixed soft tissue (arrows) and fluid attenuation owing to transpleural spread of tumour.*

MEDIASTINAL GERM CELL TUMOURS

DEFINITION

- Germ cell tumours of the mediastinum are derived from primitive germ cell elements left behind after embryonal cell migration ▶ the anterior mediastinum is the commonest extragonadal site (60%) ▶ malignant tumours are almost always seen in male patients ▶ almost all are in intimate contact with the thymus
- Anterior mediastinal masses: 10-15% (adults) ▶ 25% (children)
- **BENIGN** (70%)
  - MATURE (usually cystic) TERATOMAS
  - Contain elements of all 3 germinal layers: ectoderm (skin, teeth, hair) ▶ mesoderm (bone, cartilage, muscle) ▶ endoderm (bronchial / GI epithelium)
  - Usually benign but malignant tumours have a poor prognosis
- **MALIGNANT** (30%)
  - SEMINOMAS (majority)
    - Most common malignant mediastinal germ cell tumour
  - NON- SEMINOMATOUS GERM CELL TUMOURS (NSGCTs)
    - Include malignant teratoma, embryonal carcinoma, choriocarcinoma, endoderm sinus tumour and mixed cell types ▶ they are generally more aggressive and have an association with Klinefelter's syndrome and haematological malignancies (e.g. the acute leukaemias)

CLINICAL PRESENTATION

- Usually present during the 2nd to 4th decades
- TERATOMAS
  - They are usually asymptomatic and are diagnosed incidentally on CXR or CT ▶ can give symptoms if compress the bronchial tree or SVC ▶ haemorrhage or infection can lead to a rapid size increase ▶ they predominantly affect young adolescents ▶ women slightly outnumber men
- SEMINOMAS
  - Occur almost exclusively in men (2nd to 4th decade)
- NSGCTs
  - 90% are seen in young adult male patients ▶ more commonly symptomatic due to mass effect or invasion

RADIOLOGICAL FEATURES

Mature teratoma

A well defined, rounded or lobulated anterior mediastinal mass localized to the anterior mediastinum ▶ it can frequently be of a large size (and can occupy the entire haemothorax) ▶ haemorrhage or infection can lead to a rapid size increase ▶ it can occasionally rupture into the mediastinum or lung (mimicking the appearance of a malignant lesion)

CT A combination of fat, fluid and soft tissue components (± calcification which can occasionally represent a tooth) favour a mature teratoma over other causes

MRI This provides similar information but may not detect any calcification ▶ fat is virtually diagnostic of a teratoma

Seminoma

CT/MRI Well-defined solid masses ▶ possibly small areas of haemorrhage and necrosis ▶ homogenous attenuation and signal intensity

NSGCTs

These are often more lobular in outline ▶ they grow rapidly and metastasize readily to the liver, lungs, bones or pleura ▶ adjacent mediastinal fat planes may be obliterated

CT Lobular asymmetrical mass ▶ homogenous soft tissue density or multiple areas of contrast enhancement ▶ decreased attenuation can be due to necrosis and haemorrhage

- NSGCTs tend to be more heterogenous and demonstrate more contrast enhancement than seminomas

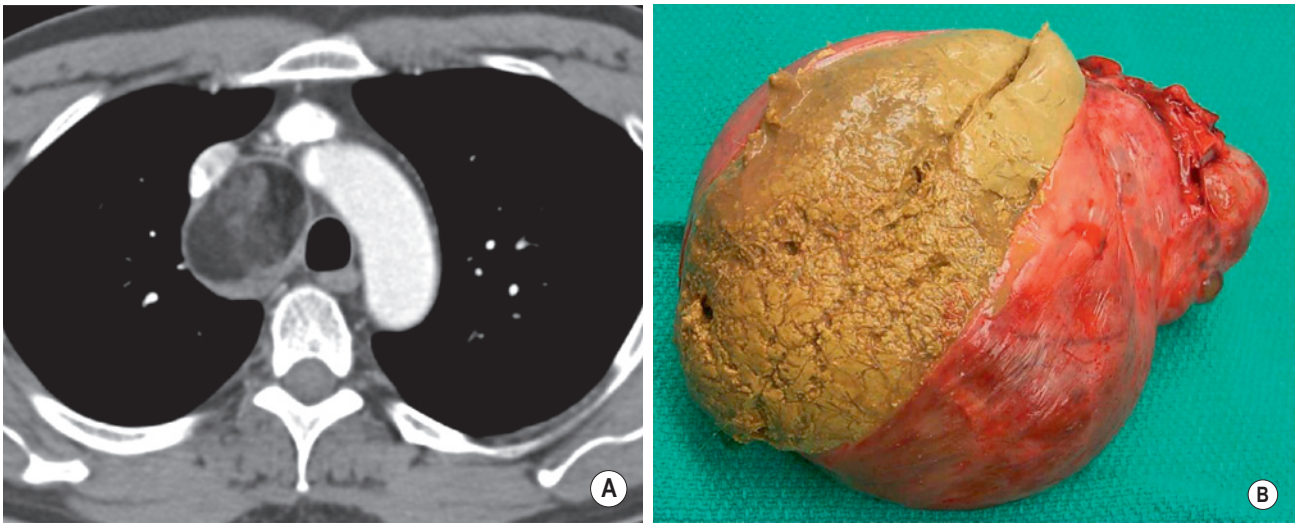
PEARLS

- Malignant tumours secrete human chorionic gonatotrophin and α-fetoprotein ▶ these can be used as tumour markers

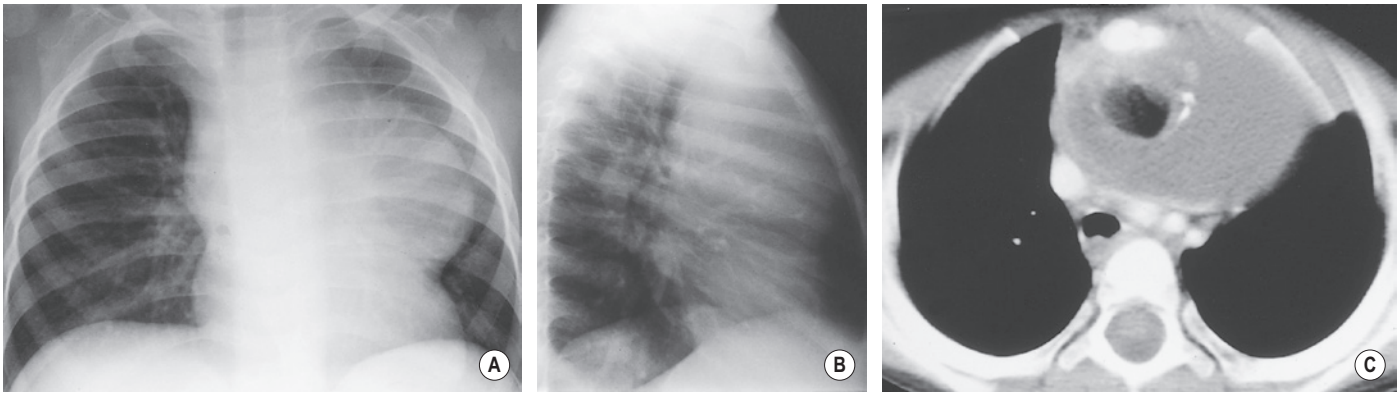
Treatment

- *Teratomas:* benign course ▶ surgical resection treatment of choice due to low malignant potential
- *Seminomas:* radiotherapy (it is very radiosensitive) ± chemotherapy ± surgery
- *NSGCTs:* chemotherapy ± surgical resection of any residual tissue

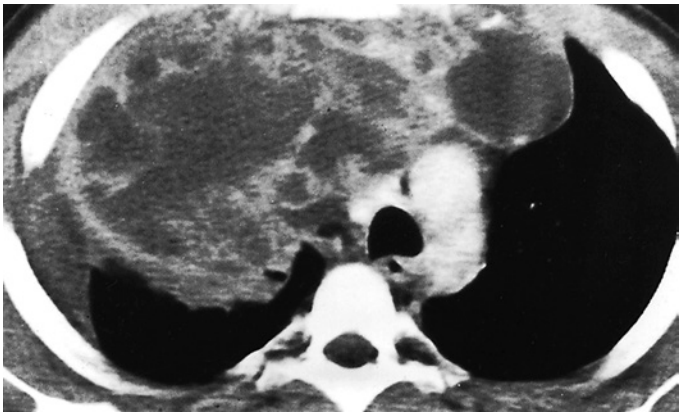
Prognosis Teratomas and seminomas have a good prognosis (however, teratomas should be removed as 20% are malignant)



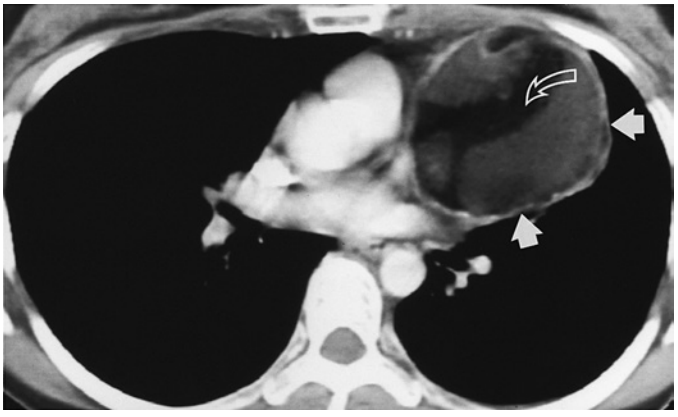
Cystic teratoma. (A) CT shows a heterogeneous mass with areas of fat attenuation. (B) Gross pathological specimen demonstrated sebaceous material and pieces of hair (not shown).**



Benign teratoma. AP (A) and lateral (B) chest films demonstrate an oval anterior mediastinal mass overlying the left hilum. (C) CT demonstrates an oval mass of soft tissue density containing fat and calcification.†



Malignant germ-cell tumour. CT shows a lobular asymmetrical mass with low attenuation areas corresponding to necrotic tumour intersected by neoplastic septation.*



Teratoma. Contrast-enhanced CT reveals a heterogeneous anterior mediastinal mass with a calcified rim (short white arrows). There is also fat attenuation within the mass (curved open arrow).‡

BRONCHOGENIC CYST

DEFINITION

- A cyst derived from the embryological foregut
- Following abnormal budding of the developing tracheobronchial tree with separation of the buds from the normal airways
- It has a *thin*-walled fibrous capsule which is lined with respiratory epithelium, and usually contains thick mucoid material

CLINICAL PRESENTATION

- A solitary asymptomatic mediastinal mass presenting at any age
- Can grow very large without causing symptoms but can compress surrounding structures causing symptoms (particularly airways)

RADIOLOGICAL FEATURES

- Most are located adjacent to the trachea or main bronchi (commonly a subcarinal location)

CXR A spherical or oval mass with a smooth outline ▶ most are unilocular ▶ calcification of the cyst wall is rare ▶ a subcarinal cyst may resemble a large left atrium

CT A thin-walled mass demonstrating no contrast enhancement ▶ it is often in contact with the carina or main bronchus ▶ it can push the carina forward and the oesophagus backward (such displacement is almost never seen with other masses except for a thyroid mass or an aberrant left pulmonary artery) ▶ it frequently projects into the middle (± posterior) mediastinum

- *Cyst contents:* these are of usually uniform attenuation (close to water) ▶ they can have attenuation values similar to soft tissue and therefore tumour ▶ it may also show uniform high density due to high protein or calcium within the fluid, or as a liquid/calcium level due to milk of calcium (rare)

MRI T1WI: variable SI (protein, blood or mucous contents) ▶ T2WI: hyperintense (paralleling CSF)

PEARLS

- 25% are located within the pulmonary parenchyma (usually the medial lower lobe) ▶ rarely it may become infected or there may be haemorrhage into the cyst (which can be life-threatening)

OESOPHAGEAL DUPLICATION (ENTERIC) CYST

DEFINITION

- A cyst derived from the embryological foregut
- It has a *thick* wall (due to smooth muscle within its walls) ▶ it is lined with gastrointestinal epithelium (which is commonly gastric) ▶ it may become infected or the ectopic gastric mucosa may cause haemorrhage or perforation

	Bronchogenic cyst	Enteric cyst
Common location	Subcarinal	Intimately related to the oesophagus
Cyst wall	Thin	Thick
Symptoms	Asymptomatic (unless large)	Symptomatic (peptic ulceration)

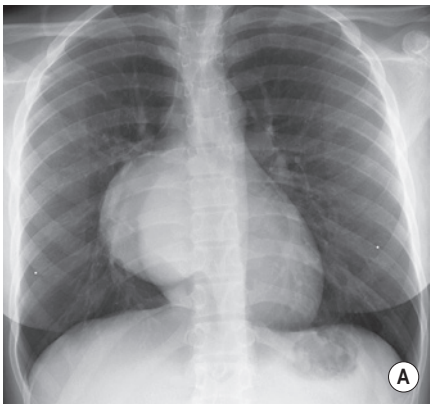
CLINICAL PRESENTATION

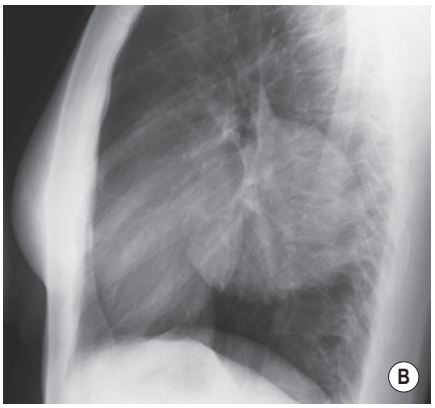
- These are uncommon ▶ many are clinically silent (but usually present first in childhood) ▶ they may cause dysphagia, pain or symptoms due to the compression of adjacent structures

RADIOLOGICAL FEATURES

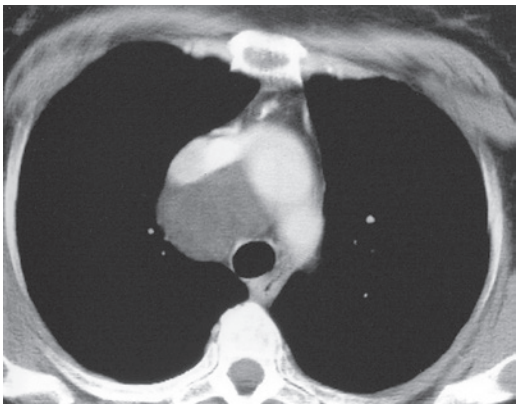
Barium swallow Extrinsic or intramural oesophageal compression

CT/MRI Imaging features are identical to those of a bronchogenic cyst (except that an oesophageal duplication cyst will have thicker walls, a more tubular shape and be in more intimate contact with the oesophagus)

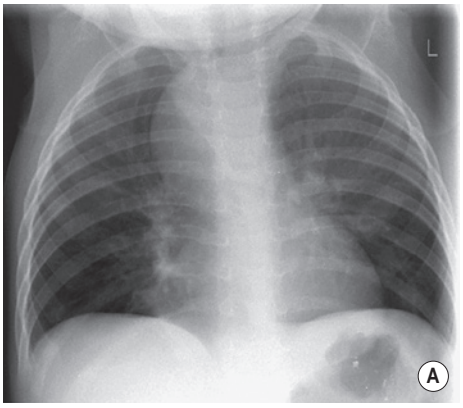


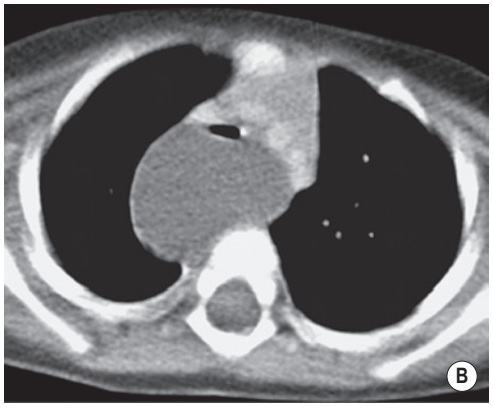


Bronchogenic cyst in a young woman with cough. (A) Frontal and (B) lateral chest radiographs show a large, smooth, well-marginated mass in the middle mediastinum – the most common location for a bronchogenic cyst.

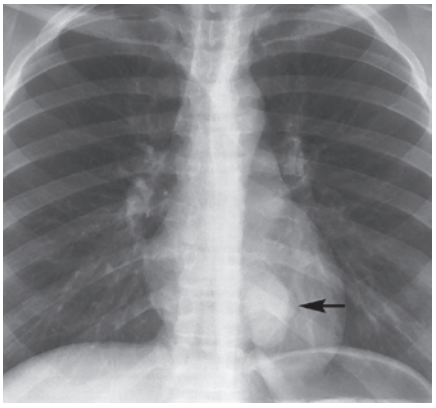


Bronchogenic cyst. The CT attenuation was almost the same as that of the other soft tissue structures and it was not possible to predict the cystic nature of the mass. The cyst was surgically removed.*

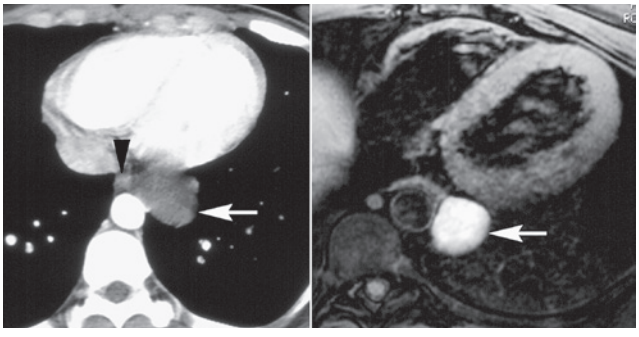




Oesophageal duplication cyst on (A) CXR and (B) CT. This case shows the typical features of a well-defined spherical mass projecting from the mediastinum.*



Oesophageal duplication cyst. Frontal chest radiograph shows a lobulated left retrocardiac mass (arrow).



Oesophageal duplication cyst. Contrast-enhanced CT (left panel) shows a well-marginated water attenuation mass (arrow) that is closely associated with the distal oesophagus (arrowhead). Note that the lesion is homogeneous and of high signal intensity on T2WI MRI (right panel).

NEURENTERIC CYSTS (SEE ALSO CONGENITAL SPINAL ANOMALIES)

DEFINITION

- This results from incomplete separation of the foregut from the notochord during early embryonic life ▶ the cyst wall contains both gastrointestinal and neural elements with an enteric epithelial lining
- There is usually a fibrous connection to the spine or an intraspinal component ▶ communication with the gastrointestinal tract may be present (but communication with the oesophageal lumen is rare)

CLINICAL PRESENTATION

- These frequently produce pain and are therefore seen early in life

RADIOLOGICAL FEATURES

- A well-defined, round, oval or lobulated mass within the middle and posterior mediastinum ▶ it is located between the oesophagus (which is usually displaced) and the spine

CT/MRI Appearances are similar to other foregut duplication cysts ▶ MRI is the investigation of choice for demonstrating the extent of any intraspinal involvement

PEARL

- Typically there are associated vertebral body anomalies (e.g. a butterfly or hemivertebra)

PERICARDIAL CYSTS

DEFINITION

- An outpouching of the parietal pericardium, representing the most common pericardial mass ▶ if it communicates with the pericardial cavity it is known as a pericardial diverticulum
- It is lined by mesothelial cells and usually contains clear fluid

CLINICAL PRESENTATION

- Asymptomatic

RADIOLOGICAL FEATURES

XR A well-defined oval mass within the cardiophrenic angle

CT/MRI A well-defined, oval fluid-filled cyst attached to the pericardium (and surrounded by normal pericardium)

PEARLS

- It is usually located at the anterior right cardiophrenic angle
- It can occur within the left cardiophrenic angle in up to ⅓ of cases
- Differential diagnoses of a cardiophrenic angle mass: lipoma ▶ pericardial fat pad ▶ foramen of Morgangi hernia ▶ enlarged epicardial lymph nodes ▶ pleural tumour

PNEUMOMEDIASTINUM

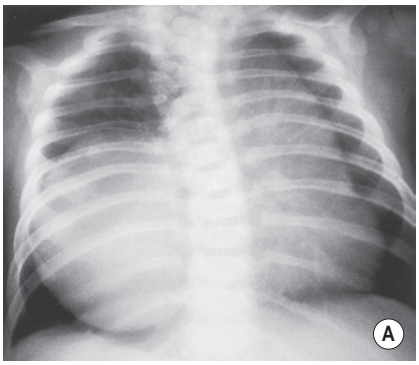
DEFINITION

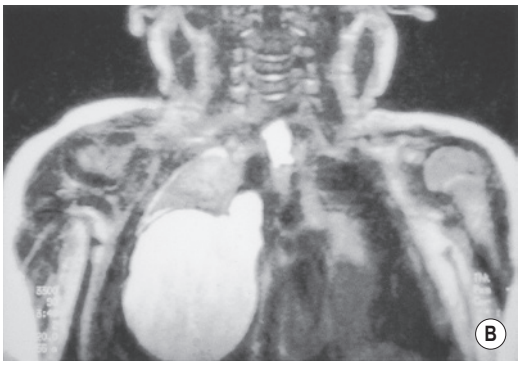
- A pneumomediastinum, in itself, is of little consequence ▶ however, the underlying cause may be of great significance
- **Intrathoracic causes:** asthma ▶ blunt trauma ▶ vomiting ▶ straining against a closed glottis
- **Extrathoracic causes:** dissection of air from the neck or retroperitoneum

RADIOLOGICAL FEATURES

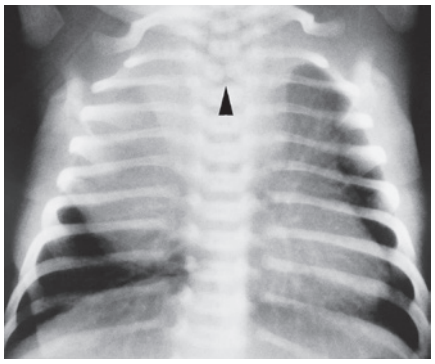
Signs:

- *'Ring around the artery':* air around the pulmonary artery
- *'Sail sign':* elevation of the thymus
- 'Continuous diaphragm sign': air trapped posterior to the pericardium
- *'Extrapleural sign':* air extending laterally between the parietal pleura and diaphragm
- *'Tubular artery sign':* air adjacent to the major branches of the aorta
- *'Double bronchial wall sign':* air adjacent to the bronchus

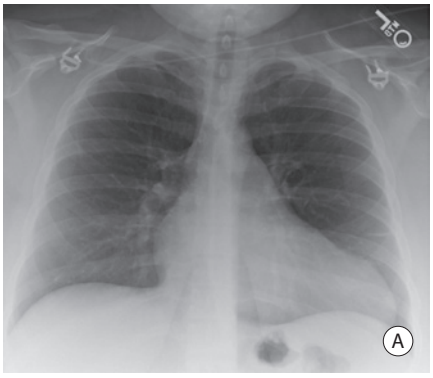


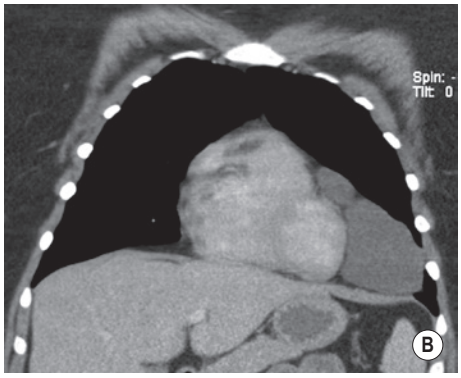


Neurenteric cyst. (A) CXR showing multiple segmentation anomalies affecting the cervicothoracic spine with a large soft tissue mass occupying the right hemithorax. (B) Coronal T2WI showing the high SI cystic mass originating from the cervicothoracic spine and causing compressive atelectasis of the right upper lobe.[†]

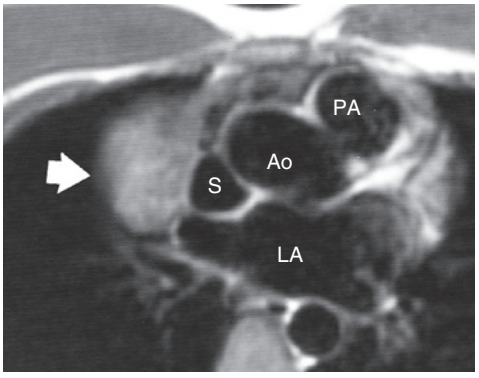


Neurenteric cyst in an infant. Frontal chest radiograph shows a large right-sided mediastinal mass. Note the butterfly vertebral body (arrowhead). (Courtesy of Helen Carty, Liverpool, UK.)

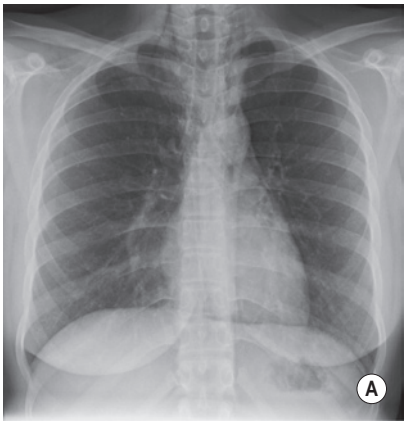


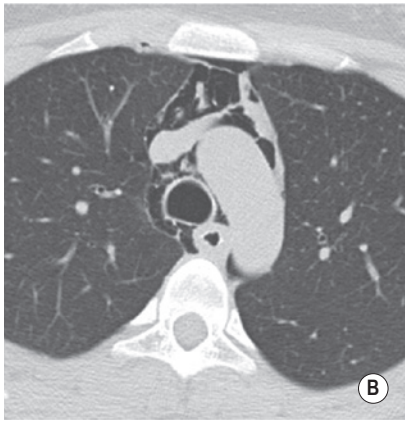


Pericardial cyst. (A) Frontal chest radiograph of a 33-year-old woman shows an abnormal mass-like contour of the left ventricle. (B) Coronal contrast medium-enhanced CT image demonstrates a mass of fluid attenuation without internal enhancement and no perceptible wall, located anterior and to the left of the heart.**

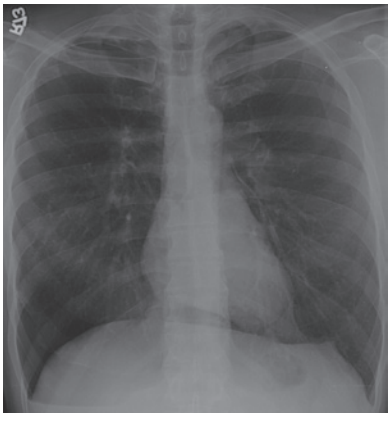


Pericardial cyst. Axial spin-echo MRI at the base of the heart. An intermediate signal intensity smooth mass extrinsic to the heart is identified (arrow). Ao = ascending aorta, LA = left atrium, PA = main pulmonary artery, S = superior vena cava.*





Pneumomediastinum. (A) CXR shows vertical lucent lines in the neck extending into the mediastinum. (B) CT demonstrating air tracking around the mediastinal structures.**



Continuous diaphragm sign in pneumomediastinum. Frontal chest radiograph shows an uninterrupted outline of the diaphragm indicative of a pneumomediastinum.**

MEDIASTINAL ADENOPATHY

DEFINITION

- Mediastinal nodes > 2 cm (short-axis diameter) are likely to represent metastatic carcinoma, malignant lymphoma, sarcoidosis, tuberculosis or fungal infection
  - *Smaller mediastinal nodes:* the differential also includes lymph node hyperplasia and pneumoconiosis
  - *Widespread moderate enlargement:* this is seen with chronic diffuse lung disease and bronchiectasis

RADIOLOGICAL FEATURES

CXR Right paratracheal nodes widen the right paratracheal stripe ▶ azygos nodes displace the azygos vein laterally ▶ nodes beneath the aortic arch obliterate the aortopulmonary window ▶ hilar lymph nodes enlarge the hilar shadows ▶ subcarinal nodes widen the carinal angle ▶ posterior mediastinal nodes displace the paraspinal or para-oesophageal lines

CECT This is a sensitive imaging modality ▶ short-axis lymph node measurements are the most representative (the long axis can vary according to the nodal orientation within a CT slice)

- Moderate nodal contrast enhancement is non-specific (it can be seen with inflammatory disorders) ▶ when striking it suggests a metastatic neoplasm from a hypervascular primary (e.g. melanoma, renal or thyroid carcinoma, carcinoid)
- Low-density centre with rim enhancement of an enlarged node is a useful pointer towards TB

Lymph node calcification This is seen with tuberculosis, fungal infections, sarcoidosis, silicosis and amyloidosis

- It is rare with metastatic neoplasms (although it may be seen with an osteosarcoma, chondrosarcoma or mucinous colorectal and ovarian tumours)
- It is virtually unknown with an untreated lymphoma ▶ it is occasionally seen with treated Hodgkin's disease
- The common patterns: course irregularly distributed clumps within the node ▶ homogeneous calcification of the whole node
- *'Eggshell' calcification:* a ring of calcification at the periphery of a node ▶ this is seen particularly with sarcoidosis and silicosis
- Pneumocystis jiroveci *infection (AIDS patients):* this leads to a strikingly foamy appearance

Low attenuation nodes (necrosis) Tuberculosis ▶ metastatic neoplasms (notably testicular) ▶ lymphoma ▶ attenuation values below that of water have been seen in Whipple's disease

PEARLS

Sarcoidosis *Symmetrical* hilar lymphadenopathy (in almost all cases) ▶ this is the most common cause of intrathoracic lymphadenopathy ▶ the anterior nodes occasionally increase in size (posterior nodal enlargement is very unusual) ▶ stippled or eggshell calcification

- *Garland's triad ('1-2-3' sign):* symmetrical hilar adenopathy + right paratracheal adenopathy

Malignant lymphoma *Asymmetrical* hilar lymphadenopathy involving multiple nodal groups ▶ nodal enlargement is seen in a higher proportion of Hodgkin's than non-Hodgkin's disease

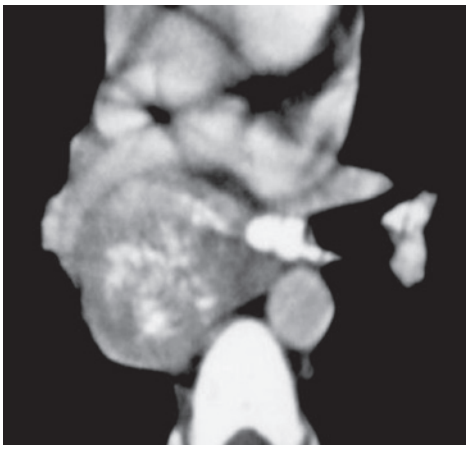
- Anterior mediastinal and paratracheal nodes are the most frequently involved (subcarinal nodes are also often involved) ▶ contiguous retroperitoneal disease is likely
- The posterior mediastinal and paracardiac nodes are infrequently involved (the latter are important sites of recurrent disease as they may not be included in the initial radiotherapy field)
- Hilar nodal enlargement is rare without mediastinal nodal enlargement ▶ usually seen with mediastinal enlargement
- Hodgkin's disease (particularly the nodular sclerosing form) has a propensity to involve the anterior mediastinal and paratracheal nodes
- Nodal enlargement in lymphoma and leukaemia has the same pattern
- Can have rapid response with therapy

Tuberculosis and histoplasmosis These may affect any nodal group ▶ associated pulmonary consolidation may or may not be present ▶ involved nodes often return to a normal size with healing ▶ dense calcification is frequent ▶ rim enhancement with a low-density centre may be seen

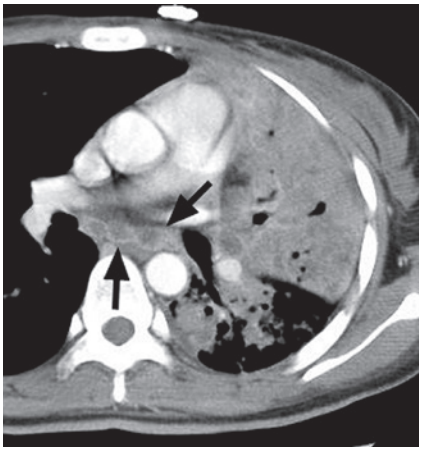
Castleman's disease A benign lymph node hyperplasia of uncertain aetiology with substantial lymph node enlargement seen throughout the body (but is often localized to one area) ▶ it appears as a smooth lobulated hilar mass ▶ any involved nodes may calcify ▶ the nodal enlargement is very vascular (with strikingly uniform enhancement)

- *Thorax:* it is usually situated within the middle or posterior mediastinum ▶ affected in 70% of cases
- *Abdomen, pelvis or retroperitoneum:* affected in 10–15% of cases

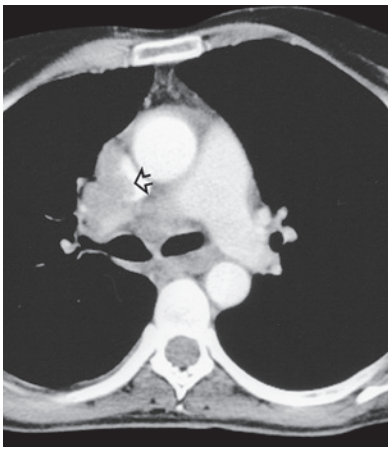
Metastatic carcinoma As well as from bronchial carcinoma, metastases can also occur from any extrathoracic primary carcinoma (e.g. the GI tract, kidney, testis, head and neck tumours, breast)



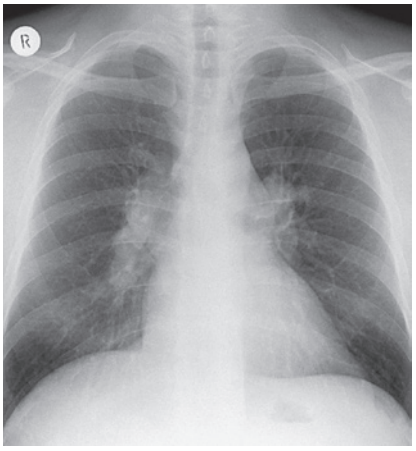
High-attenuation lymph nodes. Transaxial image of chest CT shows a calcified mediastinal lymphadenopathy. Such dystrophic calcification is common as a sequela of *Histoplasma capsulatum* infection ▶ however, it can also be seen with metastatic lymphadenopathy of mucinous adenocarcinomas.**



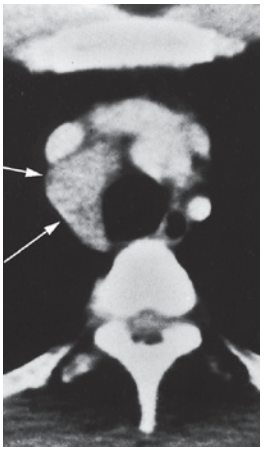
Tuberculous lymphadenopathy. Following contrast enhancement there is rim enhancement and central low attenuation due to caseation (arrows).*



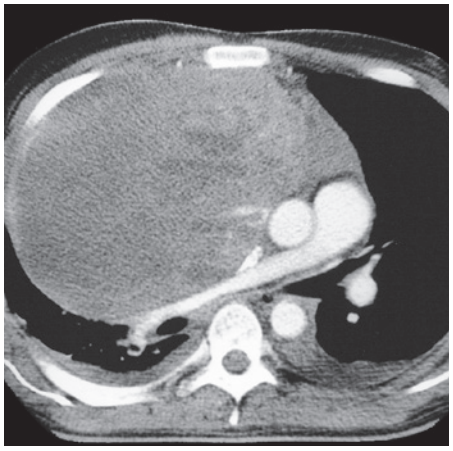
Metastatic malignant teratoma involving mediastinal nodes and directly invading the lumen of the SVC (arrow), where it is outlined by IV contrast medium.*



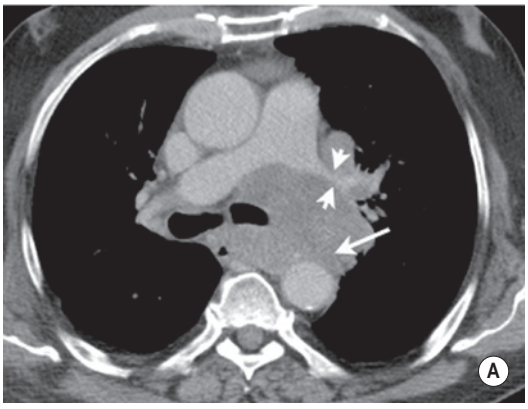
Sarcoidosis producing symmetrical bilateral hilar lymph node enlargement.*

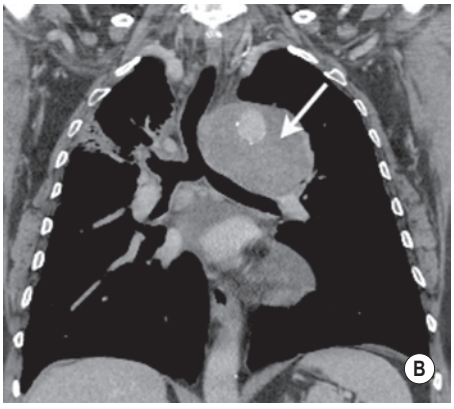


Right paratracheal lymph node enlargement (arrows) due to sarcoidosis.*



Massively enlarged lymph nodes. Massive anterior mediastinal nodal enlargement secondary to Hodgkin's disease. There is marked compression and distortion of the mediastinal structures and bilateral small pleural fluid reactions.*





Non-small cell lung carcinoma. (A) Axial and (B) coronal CT demonstrating massive mediastinal adenopathy partially encasing the thoracic aorta (arrows) as well as compressing and nearly occluding the left main pulmonary artery (arrowheads). The trachea and left main bronchus are also displaced by the mass. The patient presented with a hoarse voice due to involvement of the recurrent laryngeal nerve by this mass.

PERIPHERAL NERVE SHEATH TUMOURS

Definition

- Most common posterior mediastinal tumour ▶ adults > children
- These originate from a paravertebral intercostal nerve within the posterior mediastinum
- **Benign:**
  - *Neurofibroma:* a non-encapsulated tumour with a central position within a nerve (containing all the nerve elements) ▶ it affects patients during the 2nd–4th decade
  - *Schwannoma (neurilemmoma):* an encapsulated tumour that is eccentrically placed within a nerve (arising from the nerve sheath) ▶ it affects patients during the 5th decade
- **Malignant:**
  - *Nerve sheath tumours (neurogenic sarcomas):* these are rare ▶ they affect patients during the 3rd–5th decades (with an earlier presentation in NF-1)

Clinical presentation

- Often asymptomatic (and an incidental CXR finding) ▶ mass effect or nerve entrapment ▶ pain should raise the possibility of a malignant lesion

Radiological features

Benign tumours

CXR A well-defined round or oval posterior mediastinal mass ▶ any pressure deformity causes a smooth, scalloped indentation on the adjacent ribs, vertebral bodies (dural ectasia causes posterior vertebral body scalloping), pedicles or transverse processes ▶ there is preservation of the scalloped cortex (which is often thickened) ▶ the adjacent rib spaces are widened

NECT A widened intervertebral foramina in 10% (with an associated dumb-bell-shaped mass extending through the foramina) ▶ homogeneous or heterogeneous appearance (± punctate foci of calcification) ▶ generally < 2 vertebral bodies long

CECT Heterogeneous enhancement

MRI T1WI: variable SI (similar to the spinal cord) ▶ T2WI: the 'target' sign: a characteristic high SI peripherally with low SI centrally ▶ T1WI + Gad: uniform enhancement

Malignant tumours

CT These are usually larger masses (>5 cm)

MRI This cannot reliably differentiate a malignant from a benign tumour ▶ heterogeneous SI (haemorrhage or necrosis) or infiltration of any adjacent structures are concerning as is a sudden size change ▶ haematogenous lung metastases have been reported

SYMPATHETIC GANGLION TUMOURS

Definition Rare ▶ originate from nerve cells rather than nerve sheaths within sympathetic ganglia/adrenal glands

- **Ganglioneuroma:** a *benign* form ▶ this occurs in children or young adults
- **Ganglioneuroblastoma:** an *intermediate* form (with variable degrees of malignancy) ▶ this occurs in children
- **Neuroblastoma:** a *highly malignant* form ▶ this occurs in children younger than 5 years of age ▶ the posterior mediastinum is the most common extra-abdominal location

Radiological features

- A well-defined elliptical mass ▶ a vertical orientation along the course of the sympathetic chain and extends over 3 to 5 vertebral bodies (cf. a peripheral nerve tumour which is generally < 2 vertebral bodies long) ▶ calcification in 25% of cases

CT Variable appearances

MRI T1WI/T2WI: ganglioneuromas and ganglioneuroblastomas demonstrate homogeneous intermediate SI ▶ neuroblastomas are more heterogeneous (due to haemorrhage, necrosis and cystic degeneration) and may be locally invasive, crossing the midline

MEDIASTINAL PARAGANGLIOMAS

Definition

- Tumours arising from the paraganglion cells of the sympathetic system (benign or malignant)
  - *Chemodectoma:* almost all are close to the aortic arch (aortic body tumours) with other mediastinal chemodectomas rarely seen ▶ they are usually single tumours
  - *Phaeochromocytoma:* < 2% occur within the chest ▶ most are found within the posterior mediastinum or closely related to the heart (particularly the left atrial wall or interatrial septum)

Clinical presentation

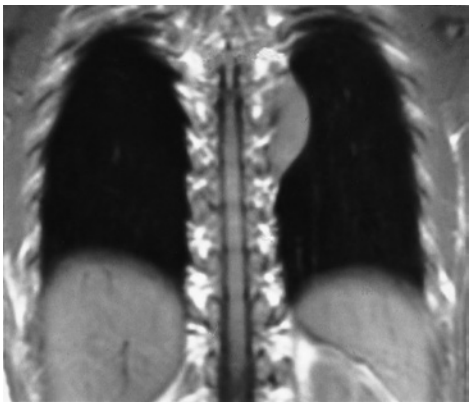
- A third of mediastinal phaeochromocytomas are asymptomatic (non-functioning) ▶ the remainder present clinically with catecholamine overproduction

Radiological features

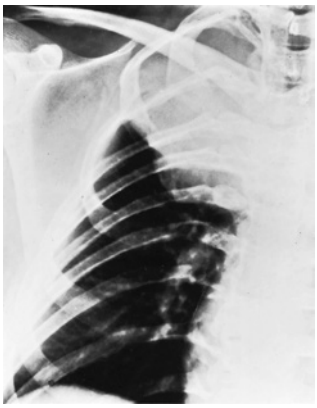
CXR/CT Rounded soft tissue masses which are very vascular and therefore enhance intensely

MRI T1WI: SI similar to muscle ▶ T2WI: high SI

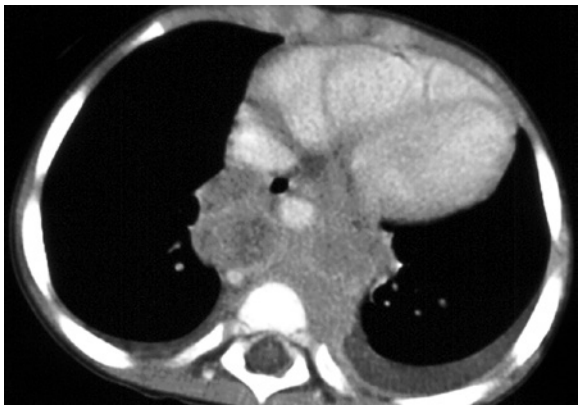
Scintigraphy Radio-iodine MIBG or somatostatin receptor scintigraphy demonstrates increased activity ▶ this is useful for identifying extra-adrenal phaeochromocytomas



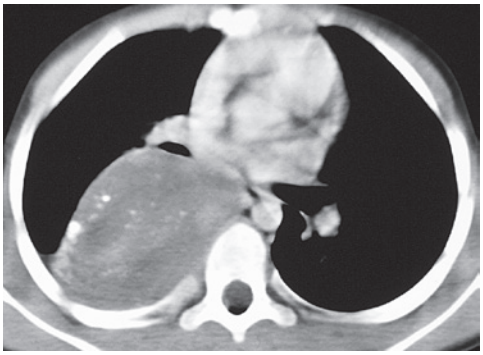
Neurofibroma in the left paravertebral region. Coronal T1WI demonstrates the tumour well and shows that it does not enter the spinal canal or encroach significantly on the adjacent foramina.*



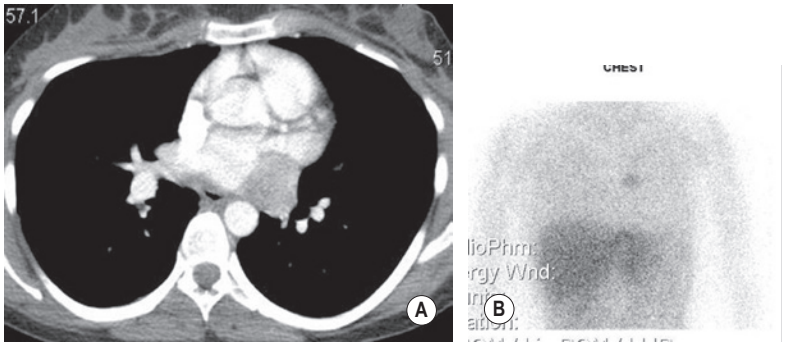
Neurofibrosarcoma showing widening and pressure deformity of adjacent ribs. A benign neurofibroma would have had identical features.*



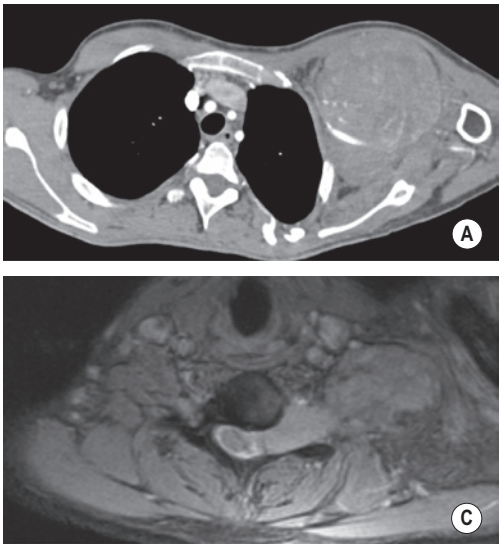
Neuroblastoma. Contrast-enhanced CT shows an infiltrative posterior mediastinal mass that encases the descending thoracic aorta. (Courtesy of Donald Frush, Durham, NC.)

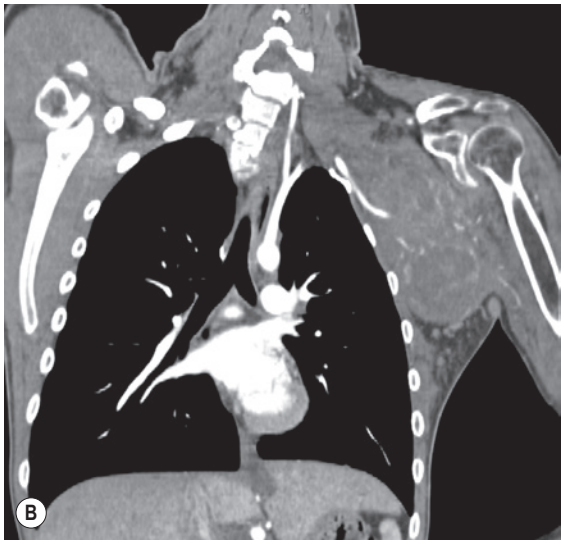


Ganglioneuroma in a 7-year-old girl with cough. Contrast-enhanced CT shows that the mass is heterogeneous and contains punctuate and chunk-like calcification.



Paraganglioma. CT of the chest demonstrates an enhancing mediastinal mass arising in the middle mediastinum adjacent to the left atrium, and protruding into it (A). I-131 *meta*-iodobenzylguanidine (MIBG) scintigraphy shows increased uptake, revealing that it is a paraganglioma (B).**





Malignant nerve sheath tumour. A 23-year-old patient with left axillary mass and left shoulder pain. (A) Axial and (B) coronal contrast medium-enhanced CT images show a large heterogeneously enhancing mass in the left axilla, which encases the left subclavian artery. Axial contrast medium-enhanced MRI demonstrates that this enhancing mass expands the neural foramen of the spine, with no erosion of the vertebral body, suggesting that this is a neurogenic tumour (C).**

LYMPHANGIOMAS (CYSTIC HYGROMAS)

Definition

- Focal mass-like congenital malformations of the lymphatic system composed of complex lymph channels or cystic spaces (containing clear or straw-coloured fluid)
- Classified as simple (capillary), cavernous or cystic (hygroma) depending on the size of the lymphatic channels ▶ cystic are the most common
- It is usually as part of an extension from a lymphangioma within the axilla or neck (but occasionally wholly confined to the mediastinum) ▶ it is most commonly seen within the anterior or superior mediastinum ▶ complete resection may be difficult due to their insinuating nature

Clinical presentation

- A neck mass presenting in early life ▶ purely mediastinal lymphangiomas present in older children and adults as an asymptomatic mediastinal mass

Radiological features

CT A cystic mass whose contents mirror the attenuation values of water ▶ envelops rather than displaces structures

MRI T1WI/T2WI: signal characteristics compatible with fluid contents ▶ septations can be seen

Pearl Complete resection may be difficult due to their insinuating nature

FATTY TUMOURS OF THE MEDIASTINUM

Definition

- *Lipoma:* a benign fatty tumour
- *Liposarcoma:* a malignant fat-containing tumour
- *Lipoblastoma:* a benign tumour of childhood
- *Angiolipoma and myelolipoma*: benign tumours

Radiological features

CT Regardless of whether they are benign or malignant, fatty tumours are well-defined round or oval mediastinal masses ▶ they are usually located within the anterior or middle mediastinum

- *Lipoma:* uniform fat attenuation (a few strands of soft tissue may be present) ▶ there is usually no mass effect (as it is a soft tumour that does not compress surrounding structures unless it is very large)
- *Liposarcoma:* heterogeneous fat attenuation ▶ large areas of soft tissue attenuation ▶ local invasion/infiltration
- *Lipoblastoma/angiolipoma/myelolipoma:* fat and soft tissue attenuation ▶ it can be indistinguishable from a liposarcoma

Pearls

Mediastinal lipomatosis Massive (usually symmetrical) collections of fat throughout the mediastinum (most prominent in upper mediastinum) ▶ it is seen especially in Cushing's disease, steroid therapy and in obese subjects

- Relatively large fat collections are often 'normally' present within the cardiophrenic angles of obese patients

Abdominal fat herniation Herniation of omental and peri-gastric fat commonly herniates via the oesophagel hiatus or formamen (Morgagni / Bochdalek)

LATERAL THORACIC MENINGOCELE

Definition

- A rare lesion due to protrusion of redundant spinal meninges through an intervertebral foramen ▶ filled with CSF
- Asymptomatic
- It is commonly associated with neurofibromatosis (as are neurofibromas)

Radiological features

CXR A posterior mediastinal mass (often with pressure deformity on the adjacent bone) ▶ it is indistinguishable from a neurofibroma

CT/MRI A fluid-filled mass (rather than solid) ▶ intrathecal contrast medium (CT) demonstrates flow into the lesion

EXTRAMEDULLARY HAEMATOPOIESIS

Definition

- Compensatory expansion of the bone marrow seen with thalassaemia, hereditary spherocytosis and sickle cell anaemia ▶ this leads to extrusion of bone marrow through the cortex, with creation of a paravertebral mass
- Asymptomatic

Radiological features

CT/MRI One or more smooth, lobular or spherical masses within the paravertebral gutters (usually located within the lower thorax) ▶ these are usually bilateral and symmetrical and of homogeneous soft tissue attenuation (occasionally a fatty component is visible)

- The bones may appear normal or demonstrate an altered lace-like trabecular pattern (due to the associated marrow expansion)

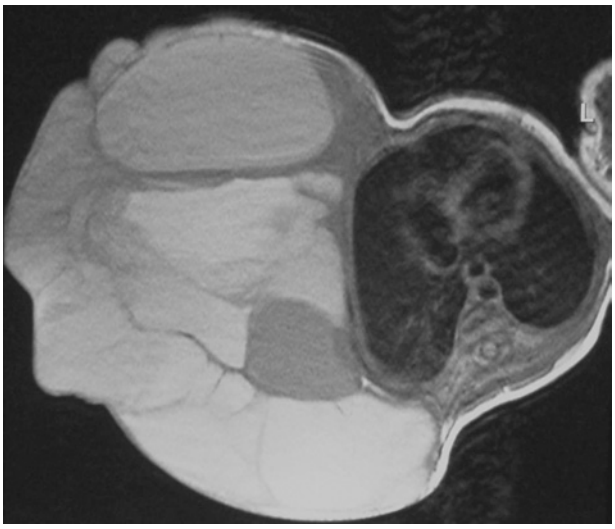
MEDIASTINAL PANCREATIC PSEUDOCYST

Definition

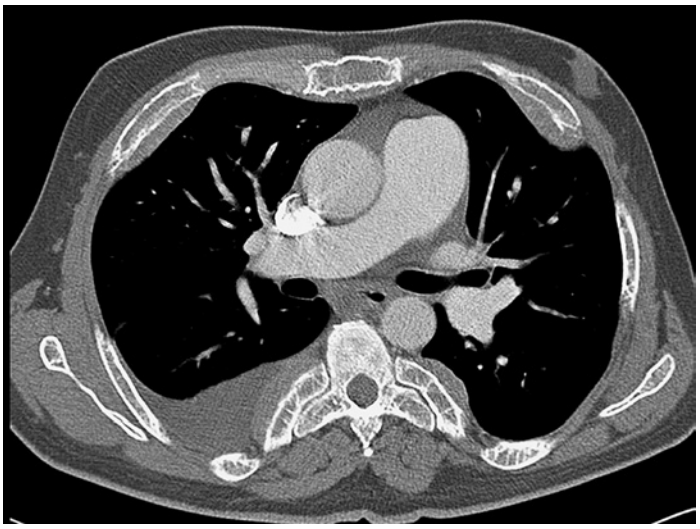
- This follows extension of a pancreatic pseudocyst into the posterior mediastinum ▶ this occurs via the oesophageal or aortic hiatus and therefore lies adjacent to the oesophagus ▶ usually middle or posterior mediastinum
- Most cases are seen in adults with clinical features of a chronic pancreatitis (it can also occur in children following trauma)

Radiological features

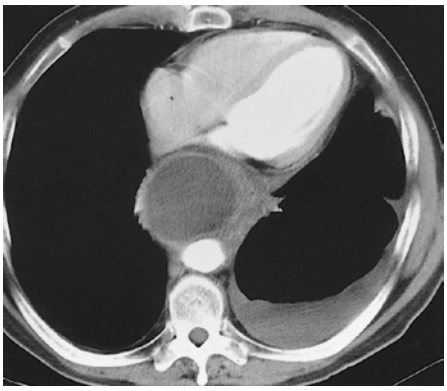
CT A thin-walled cyst continuous with the pancreas ▶ left-sided or bilateral pleural effusions



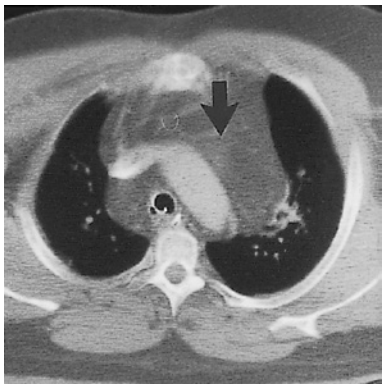
T2WI. Extrathoracic cystic hygroma (lymphangioma) in a neonate showing high SI due to the dilated lymphatic spaces.†



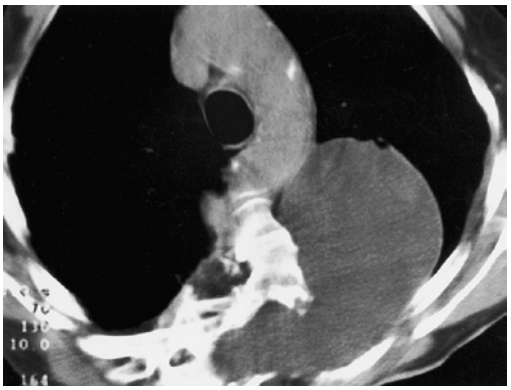
Extramedullary haematopoiesis showing smooth pleurally based masses and altered bone texture in this patient with thalassaemia. There is also a small right pleural effusion.*



Pancreatic pseudocyst. CECT shows a round posterior mediastinal cystic mass located behind the heart and demonstrating enhancing walls. Note the associated left pleural effusion.†



Mediastinal lipomatosis. CECT shows excess mediastinal fat deposition, particularly anteriorly (arrow).†



Lateral thoracic meningocele. Non-contrast CT shows a well-marginated water attenuation mass arising from the spinal canal. Note the marked widening of the neural foramen.

Summary of mediastinal masses

Anterior mediastinum	Middle mediastinum	Posterior mediastinum
Hernia (Morgagni)	Hernia (hiatus/aortic)	Hernia (Bochdalek)
Aortic aneurysm	Aortic aneurysm	Aortic aneurysm
Cystic hygroma	Lymph nodes (sarcoidosis/TB/lymphoma/metastases)	Myeloma/metastases
Diaphragmatic eventration	Foregut duplication cysts	Diaphragmatic eventration
Thymic tumours*	Neurenteric cyst	Sympathetic ganglion cell tumours
Retrosternal thyroid mass*	Mediastinal paragangliomas	Peripheral nerve tumours
Germ cell tumour*	Carcinoma of the bronchus	Lateral thoracic meningocoele
Lymph nodes (lymphoma)*	Fatty mediastinal tumours/mediastinal lipomatosis	Extramedullary haematopoiesis
Pericardial cyst		Paravertebral abscess
Pericardial fat pad		Pancreatic pseudocyst
Sternal masses		Neurenteric cyst

*Anterior mediastinal masses: '4 Ts' – **T**hymic, **T**hyroid, **T**eratoma or **T**errible lymphoma

CONGENITAL ABSENCE OF THE PERICARDIUM

Definition

- A congenital pericardial defect caused by vascular compromise to the pleuropericardial membrane during development
- This varies from a small defect to complete (bilateral) absence of the pericardium ▶ complete absence commonly affects the left pericardium (bilateral and isolated right-sided lesions are very rare)

Clinical presentation

- Complete absence is usually asymptomatic ▶ partial absence may be complicated by herniation or cardiac chamber entrapment (particularly affecting the left atrial appendage)

Radiological features

CXR/CT/MRI

- *Complete absence of the left pericardium:* cardiac displacement into the left chest ▶ interposition of lung between the aorta and pulmonary artery (also between the left hemidiaphragm and cardiac silhouette) ▶ an ill-defined right cardiac border (due to leftward cardiac displacement and rotation) ▶ medial/lateral borders of the main pulmonary artery may be more visible due to absence of anterior pericardial reflection
- *Partial pericardial defect:* varying degrees of pulmonary artery or left atrial appendage prominence ▶ the heart retains its normal position

Pearls

- This is associated with congenital heart and lung anomalies: ASD ▶ TOF ▶ PDA ▶ bronchogenic cysts ▶ pulmonary sequestration
- It is associated with large pleural defects (the lung can herniate and surround the intrapericardial vascular structures)

PERICARDITIS

Definition

- Pericardial inflammation caused by: myocardial infarction (Dressler syndrome) ▶ mediastinal irradiation ▶ infection (viral or bacterial) ▶ connective tissue diseases (rheumatoid arthritis or SLE) ▶ metabolic disorders (uraemia or hypothyroidism) ▶ neoplasia ▶ AIDS ▶ TB (immunocompromised) ▶ trauma

Clinical presentation

- Chest pain ▶ dyspnoea ▶ pericardial friction rub ▶ pulsus paradoxus

Radiological features

CXR Acute pericarditis commonly manifests as a pericardial effusion (which is usually diagnosed with echocardiography) ▶ >50 ml fluid ▶ CXR positive if >200 ml

- *Pericardial effusion:* a sudden increase in the cardiac silhouette without specific chamber enlargement ▶ filling in of the retrosternal space ▶ effacement of the normal cardiac borders ▶ a 'water bottle' cardiac configuration ▶ the bilateral 'hilar overlay' sign ▶ the 'epicardial fat pad' sign (with an anterior pericardial stripe > 2 mm on a lateral CXR)

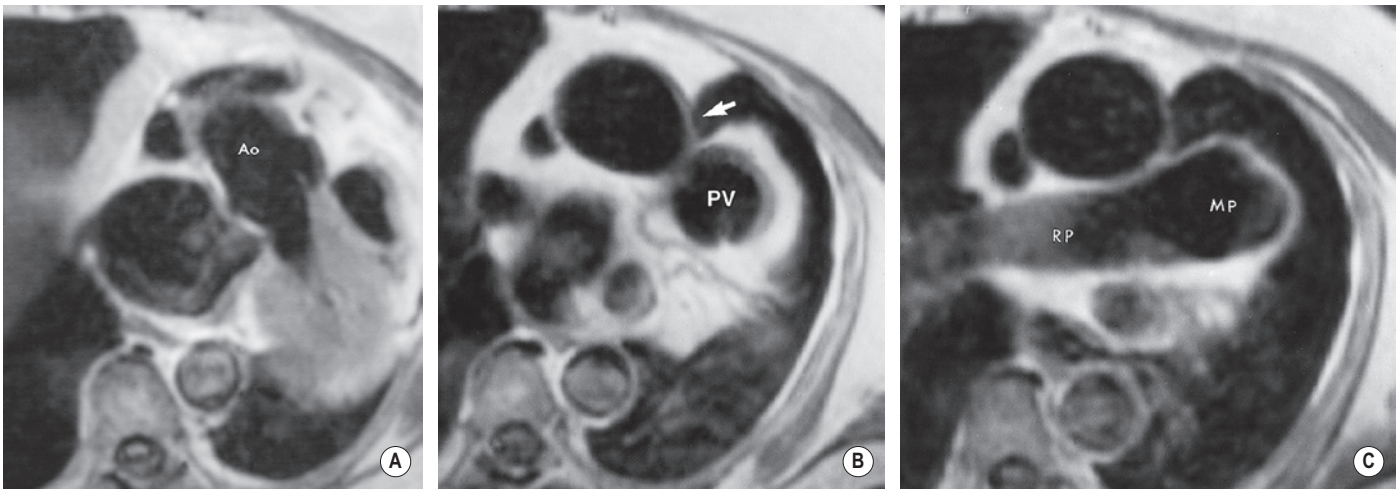
CT Pericardial enhancement (increased attenuation suggests haemorrhage) ▶ increased pericardial thickness

MRI In the absence of haemorrhage, effusions are predominantly low SI ▶ haemorrhagic effusions are of variable SI (depending upon the blood product age)

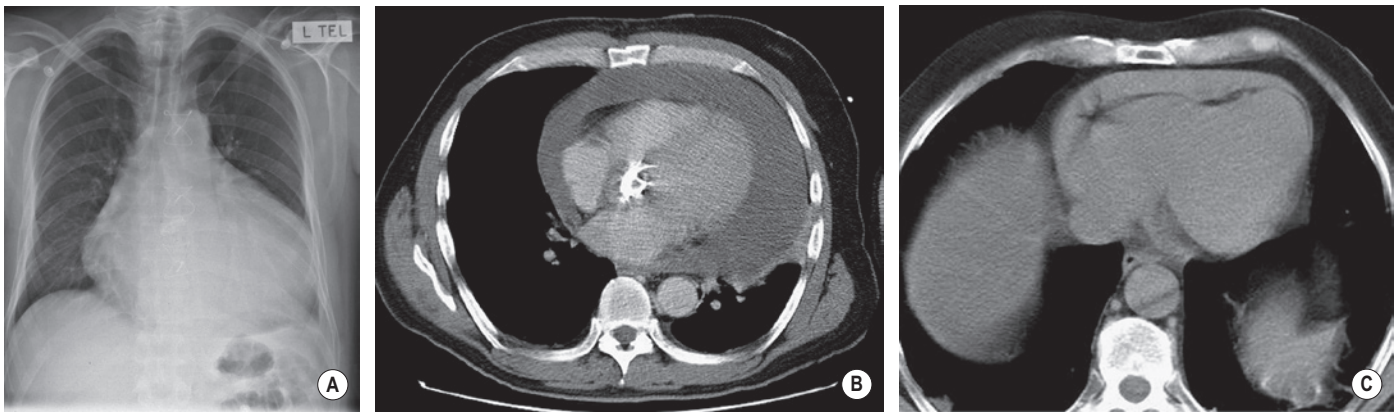
- *Inflammatory conditions*: T2WI: thickened inflamed pericardium returns moderate to high SI ▶ T1WI + Gad: enhancement

Pearls

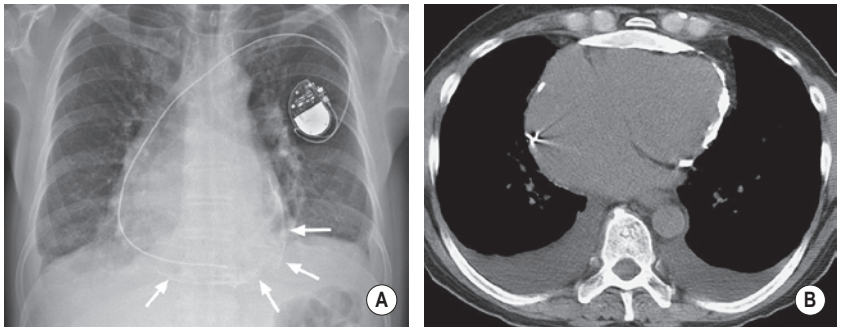
- **Causes of a transudative pericardial effusion:** cardiac surgery ▶ CCF ▶ uraemia ▶ myxoedema ▶ collagen vascular diseases
- **Causes of a haemopericardium:** trauma ▶ aortic dissection or rupture ▶ neoplasm
- **Constrictive pericarditis:** this represents a chronic phase of fibrous scarring, pericardial thickening and obliteration of the pericardial cavity ▶ it can result in restriction of diastolic cardiac filling
  - The aetiology is usually unknown (but is presumed secondary to an occult viral pericarditis) ▶ it can follow mediastinal irradiation or following cardiac surgery ▶ neoplastic infiltration can follow carcinoma of the lung or breast, lymphoproliferative malignancies and melanoma
  - **CT/MRI** Pericardial thickening ≥ 4 mm ▶ there is commonly pericardial calcification ▶ a reduced right ventricular volume ▶ a dilated right atrium, SVC and IVC ▶ hepatomegaly and ascites ▶ little enhancement
- **Pericardial neoplasms:** metastases are much more common than rare primary pericardial tumours ▶ metastases to consider: lung/lymphoma/breast/melanoma/colon ▶ most common primary malignancy is malignant mesothelioma (haemorrhagic effusion) ▶ pericardial effusion is the most common finding ± a mass



Partial absence of the pericardium. T1WI. (A) Image through the aortic valve and proximal ascending aorta (Ao). The heart is displaced into the left chest and rotated in a clockwise manner. (B) Image through the pulmonary valve (PV). A sliver of lung (arrow) invaginates to come into contact with the ascending aorta. (C) Image through the main (MP) and transverse right (RP) pulmonary arteries. The MP protrudes to the left and is in contact with the lung.*



Pericardial effusion. (A) The heart had become rapidly enlarged in this patient who had previously undergone aortic valve replacement. (B) NECT through the level of the valve replacement demonstrates the large pericardial effusion. (C) A large haemopericardium complicating a type A aortic dissection (different patient). The haemopericardium is the same attenuation as soft tissue on this unenhanced image.*



Dense pericardial calcification demonstrated on (A) CXR (arrows) and (B) CT. There are bilateral pleural effusions in this patient with constrictive calcific pericarditis (previous TB).*

1.3 PULMONARY INFECTION

LOBAR PNEUMONIA

Definition

- An infection developing within the distal airspaces (and adjacent to the visceral pleura) ▶ it spreads via collateral air drift (pores of Kohn), producing homogeneous opacification of partial or complete lung segments (and occasionally an entire lobe) ▶ any lung opacification is limited by the fissures and is usually unifocal
- As the airways are not primarily involved and remain patent there is little or no volume loss ▶ there is also associated air bronchogram formation
- On CT appears as lobar/sublobar sharply demarcated consolidation

***Streptococcus pneumoniae* (pneumococcal pneumonia)**

- *The most common community-acquired adult bacterial pneumonia*
  - ***Predisposing factors:*** *chronic illness ▶ alcoholism ▶ sickle-cell disease ▶ splenectomy*

CXR/CT Homogeneous consolidation that crosses segmental boundaries but only involves one lobe (± air bronchograms or a parapneumonic effusion) ▶ it is commonly basal and solitary (but may be multifocal) ▶ the lobar volume is usually unchanged (and rarely increases) ▶ there is a fairly rapid XR resolution (total resolution usually occurs within 2–6 weeks)

- Empyema and cavitation formation are infrequent ▶ effusions are common
- **Round pneumonia:** a spherical pneumonia (with ill-defined margins) that is usually seen in children (due to the lack of collateral air drift) ▶ it can demonstrate a rapid change in size and shape ▶ it may simulate a lung mass
  - *Organisms: Haemophilus influenzae ▶ Streptococcus* ▶ pneumococcus
  - *Location:* it is always within the posterior (usually lower) lobes

Klebsiella

CXR/CT A homogeneous opacity similar to that seen with *S. pneumoniae* (or it may produce a bronchopneumonia pattern) ▶ there is rapid cavitation of any lobar consolidation ▶ early abscess formation ▶ ground-glass attenuation on CT

- It is often accompanied by bulging fissures (signifying a very exudative response)

***Legionella* (Legionnaires' disease)**

- *This is acquired in a community, nosocomial, or an epidemic fashion and is associated with a contaminated water source ▶ there is rapid progression (with up to a 30% mortality rate)*
  - *Predisposing factors: post-transplantation (immuno-suppression) ▶ COPD ▶ heart failure ▶ renal disease*

CXR Solitary or multifocal, lobar pneumonia-like, homogeneous opacities simulating *S. pneumoniae* infection (with a tendency to a round and mass-like appearance) ▶ there is rapid spread of the initial consolidation to the other lobes ▶ cavitation can be seen in immunocompromised and post renal transplant patients ▶ pleural effusions are present in 10–35% of cases ▶ can mimic round pneumonia

Actinomycosis

- *An anaerobic, Gram-positive bacterium (*Actinomyces israelii*): this is a mouth commensal, causing infection when it accesses devitalized tissues (particularly within the cervicofacial region and abdomen) ▶ it generates a chronic inflammatory reaction, causing abscess and fistula formation (which contain tiny sulphur granules)*
  - *Lung involvement is seen in <25% of cases (due to aspiration or spread from other foci)*

CXR Homogeneous opacification (as a lobar-type pneumonia or as a mass) ▶ cavitation is common and can mimic the appearance of a bronchogenic carcinoma ▶ focal fibrosis (± contraction) may be severe ▶ there are associated pleural effusions, pleural thickening, empyema formation and disease extension into the contiguous soft tissues or bones (the resultant periostitis sets this apart from other infections)

CT Scattered peripheral areas of homogeneous consolidation with central low attenuation and adjacent pleural thickening

Nocardiosis

- *An aerobic, Gram-positive bacillus (*Nocardia asteroides*): most cases arise within North America in immunocompromised patients ▶ the initial pulmonary focus may disseminate to other organs (notably the brain)*

CXR There is usually unifocal or multifocal pulmonary consolidation ▶ there can be single or multiple pulmonary nodules (which can mimic a primary lung cancer or metastatic disease) ▶ there may be lymphadenopathy and chest wall involvement ▶ cavitation and pleural effusions are frequent

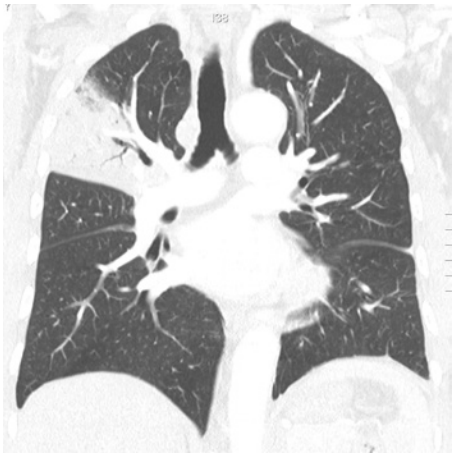
Chlamydial pneumonia

- **Chlamydia psittaci:** *this causes psittacosis (ornithosis) and is usually seen following direct bird contact*

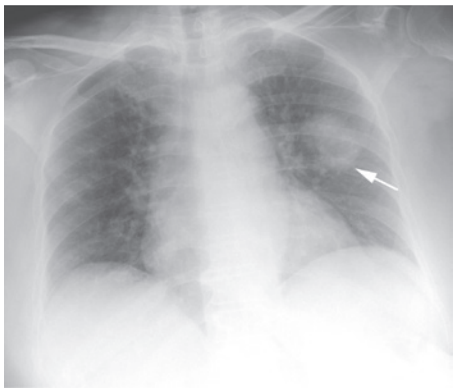
CXR Small to large homogeneous opacities (± perihilar or basal reticular opacities) ▶ there are occasionally enlarged hilar nodes and small effusions ▶ any radiographic opacities clear slowly

- **Chlamydia pneumoniae:** *this causes an asymptomatic or mild adult respiratory infection – it is one of the commonest causes of a community-acquired pneumonia*

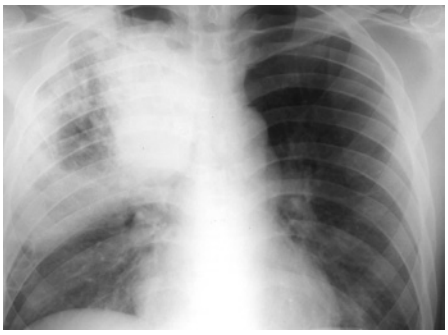
  CXR/CT
  - *Primary disease:* a unifocal homogeneous opacity (occasionally multifocal) ▶ bronchovascular thickening ▶ lymphadenopathy ▶ reticular or linear opacities ▶ airway dilatation
  - *Recurrent disease:* bilateral and more heterogenous changes ▶ small or moderate pleural effusions (up to 50%)



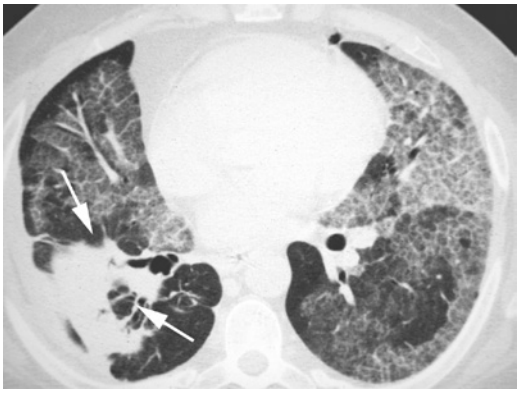
Lobar pneumonia. A 36-year-old man with *S. pneumoniae* pneumonia. Coronal reformatted CT image shows a homogeneous focal area of consolidation in the right upper lobe. Patent bronchi (air bronchograms) are seen within the area of consolidation.**



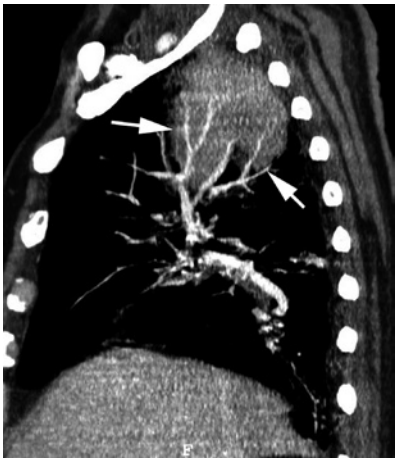
Round pneumonia. A previously healthy 64-year-old man with fever and productive cough. Chest radiograph shows a mass-like area of consolidation in the left upper lobe (arrow).**



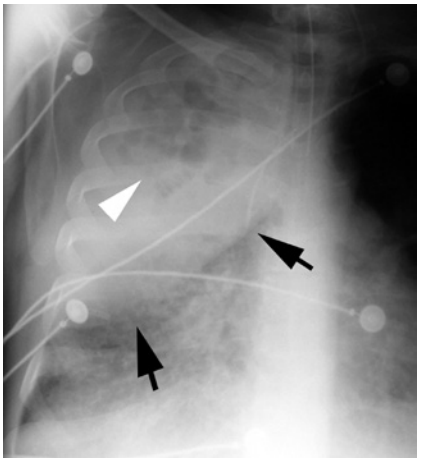
Legionnaires' disease. The PA CXR demonstrates homogeneous opacities in the right upper lobe. The medial one resembles a mass.*



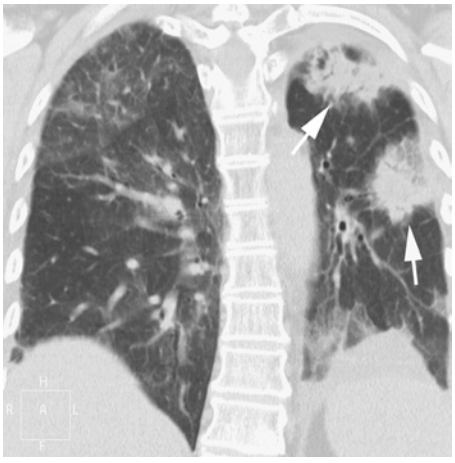
Alveolar proteinosis and *Nocardia* pneumonia. A 42-year-old man with alveolar proteinosis who presented with fever. CT at the level of the lower lobes shows bilateral areas of extensive ground-glass opacities with superimposed smooth septal lines and intralobular lines, resulting in a pattern known as 'crazy-paving'. Note a localised area of consolidation (arrows) and a right pleural effusion.**



Segmental *Pneumoccocal pneumonia* pneumonia. 48-year-old man with fever and a right upper lobe pneumonia. Sagittal reformatted minimum intensity projection (MIP) image from dynamic contrast-enhanced MDCT shows a normal pattern of pulmonary vasculature within a homogeneous right upper lobe consolidation (CT angiogram sign) (arrows).**



Klebsiella pneumonia. A 50-year-old man with fever and a severe right pneumonia. Posteroanterior chest radiograph shows dense consolidation of the right upper lobe with visible areas of abscessification (arrowhead). Note an inferior convexity of the major fissure ('bulging fissure' sign) (arrows) characteristic of lobar expansion.**



Chlamydia pneumoniae pneumonia. A 67-year-old woman with chest pain, fever and non-productive cough. Coronal reformatted CT shows multiple ill-defined, rounded areas of consolidation in the left upper lobe with visible air bronchogram and poorly defined margins (arrows).**

BRONCHOPNEUMONIA

Definition

- A multifocal infection centred within and along the course of the distal airways ▶ predominantly peribronchiolar inflammation
- Bronchial spread results initially in large heterogeneous scattered opacities
- Air bronchograms are usually absent as the disease primarily affects the bronchi (filling them with inflammatory fluid)

CT Centrilobular ill-defined nodules ('tree-in-bud')/branching linear opacities/airspace nodules/multifocal lobular consolidation

SPECIFIC INFECTIONS

Staphylococcus aureus

- This usually affects debilitated hospitalized or institutionalized patients (following aspiration from the upper respiratory tract) ▶ pneumatoceles may form (particularly in children)
- Pleural effusions, empyemas and cavitation are common ▶ spontaneous pneumothoraces can also occur
- *Septicaemic infections* (e.g. drug addicts, infective endocarditis): can cause disseminated, poorly marginated and peripheral multifocal nodules which can cavitate

Gram-negative pneumonias

- These are usually caused by hospital-acquired enterobacteria in debilitated patients (e.g. *Proteus*, *E. coli*, *Pseudomonas* and *Haemophilus*) ▶ the bacteria are aspirated from a colonized upper respiratory tract
- *E. coli*: multilobar bronchopneumonia (usually lower lobes)
- *Pseudomonas:* extensive confluent bronchopneumonia ▶ frequently cavitates ▶ predominantly upper lobe
- *Haemophilus influenzae:* multilobar, lobar or segmental consolidation ± effusions

ANAEROBIC PNEUMONIA

Definition

- This usually results following the aspiration of anaerobic bacteria ▶ it is associated with altered consciousness and mechanical ventilation

Radiological features

CXR Changes are usually delayed by 24–72 hours ▶ heterogeneous opacities are seen in the dependent lung segments (uni- or bilaterally) ▶ multiple cavities (reflecting severe lung necrosis) may be seen 1–3 weeks following aspiration

- Delayed presentation is associated with discrete thick irregular-walled lung abscesses (⅔ are within the upper lobe apico-posterior segments or lower lobe superior segments)

Pearls

Empyema A suppurative infection of the pleural space ▶ this is a common complication of anaerobic infections (and may occur without any XR evidence of pneumonia)

US Septations ± echogenic internal material (representing pus)

CT A 'split' enhancing thickened pleura ▶ displaced lung and vessels (± gas within the empyema collection)

- *Long-term sequelae:* fibrothorax ▶ sheet-like pleural calcification (especially following TB)

ATYPICAL PNEUMONIA

***Mycoplasma* pneumonia**

Definition The major non-bacterial cause of a community-acquired pneumonias (20 and 40 years) ▶ it resembles a viral infection with spread from the upper to lower respiratory tract ▶ it is usually self-limiting

CXR There is most commonly a unilateral lower lobe process beginning as a heterogeneous, reticular, segmental or peribronchial region of opacification that may become lobar or homogeneous ▶ pleural effusions and nodal enlargement are uncommon

HRCT Ground-glass and homogeneous opacities ▶ bronchiolitis with centrilobular nodules ▶ bronchovascular thickening (80%)

Viral pneumonias

Definition These are common in children (and unusual in adults) ▶ they predispose to secondary bacterial infection

Influenza A and B

- A common cause of an adult pneumonia (particularly affecting the elderly) and immunocompromised

  CXR Scattered homogeneous opacities that rapidly become bilateral, extensive and confluent ▶ pleural effusions are rare ▶ clinical relapse may be due to a secondary bacterial pneumonia

  HRCT Ground-glass opacities ▶ nodules ▶ a 'tree-in-bud' appearance

Varicella

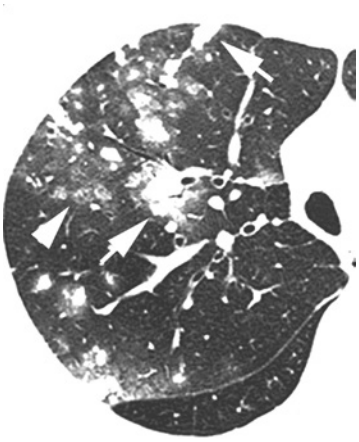
- This affects young adults more frequently than children ▶ there is an increased risk with lymphoma, pregnancy and steroid therapy ▶ pulmonary involvement follows a skin rash by 1–6 days

  CXR/CT Widespread 5–10 mm poorly marginated nodules or acinar opacities (which may become confluent) ▶ the nodules usually resolve in 1–2 weeks but can persist for months ▶ numerous residual small irregular calcified nodules may remain

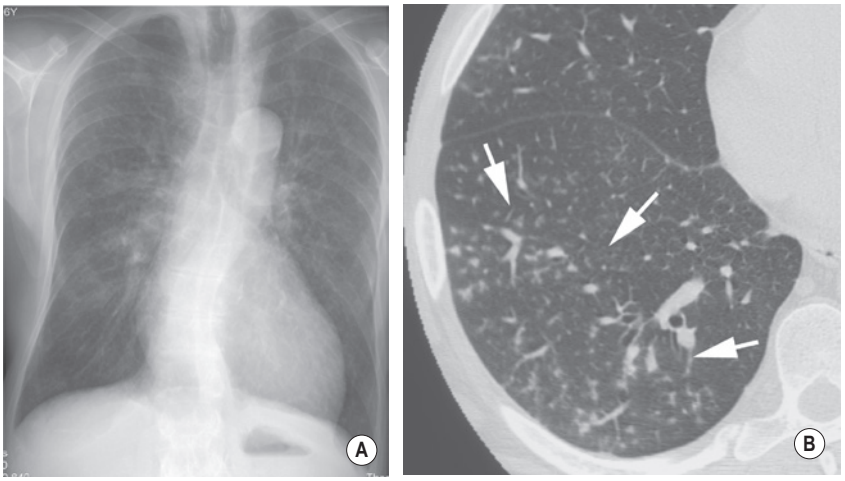
Herpes simplex virus type I (HSV-1)

- Immunocompromised or ventilated patients

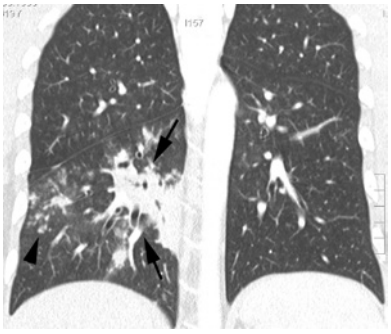
  CT Patchy consolidation ▶ ground-glass opacities ▶ 'tree-in-bud' appearance



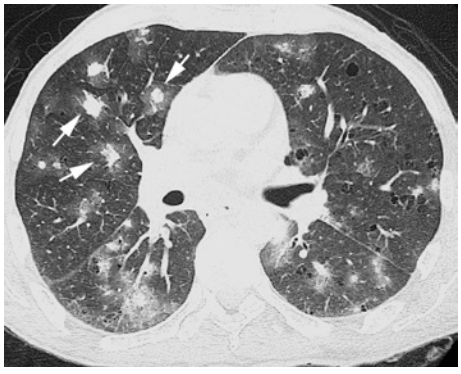
Mycoplasma pneumonia. A 35-year-old man presents with non-productive cough and fever. CT shows airspace nodules, focal areas of lobular consolidation (arrows) and patchy ground-glass opacities (arrowhead).**



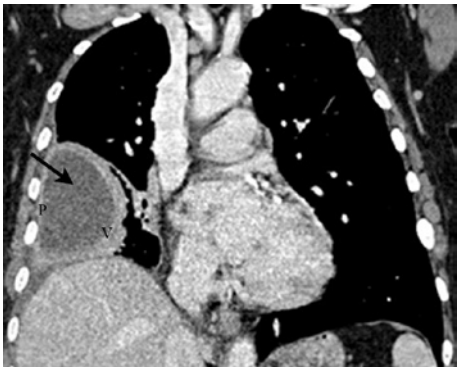
Cellular bronchiolitis. A 71-year-old man with fever of 48-h duration. (A) Posteroanterior chest radiograph is normal. (B) Complementary CT shows centrilobular branching nodular and linear opacities resulting in a 'tree-in-bud' appearance (arrows). *Mycoplasma* bronchiolitis was diagnosed.**



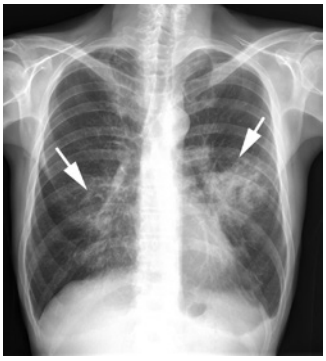
Bronchopneumonia caused by *H. influenzae*. A 48-year-old man with productive cough and fever. Coronal reformatted CT shows a focal area of consolidation in the right lower lobe with visible air bronchogram and poorly defined margins (arrows). Also evident are small nodular opacities and a few 'tree-in-bud' opacities (arrowhead).**



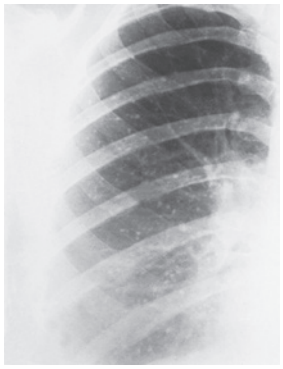
Herpesvirus pneumonia. A 34-year-old severely immunocompromised patient with fever. CT at the level of the bronchus intermedius in a patient with herpesvirus infection shows multiple, bilateral and randomly distributed pulmonary nodules surrounded by a 'halo' of ground-glass opacity (arrows).**



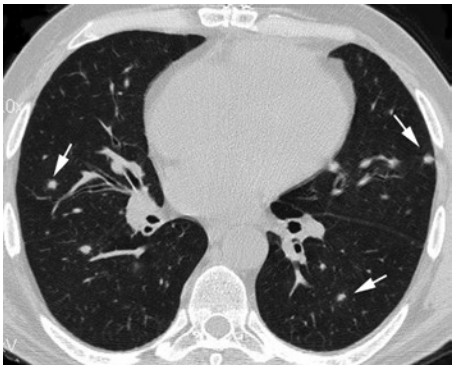
Coronal CT demonstrating a right lower lobe empyema (arrow). The central low attenuation collection of pus is surrounded by enhancing pleura. This demonstrates the 'split pleura' sign with separation of the visceral (v) from the parietal (p) pleural surfaces.



Haemophilus influenzae pneumonia. A 49-year-old man with fever. Posteroanterior chest radiograph shows bilateral areas of consolidation with ill-defined margins. A community-acquired *H. influenzae* pneumonia was diagnosed.**



Multiple calcified varicella scars.†



Varicella pneumonia. A 30-year-old man with lymphoma and new development of fever and skin rash. CT of the lower lobes shows multiple, bilateral and randomly distributed well-defined small pulmonary nodules (arrows).**