60 T_h e thorax

Anatomy of the lungs

Anatomy of the lungs

The left lung is divided by the oblique fissure, which lies nearer to the vertical than horizontal, so the upper and lower lobes could also be called anterior and posterior. On the right, the equivalent of the left upper lobe is further divided to give the middle lobe. Each lobe is composed of segments, with anatom ically defined and named bronchial, pulmonary arterial and venous connections (Figure 60.1). The right main bronchus (RMB) is shorter, wider and nearly vertical compared with the left main bronchus (LMB). As a consequence, inhaled foreign bodies are mor e likely to enter the RMB than the left (Figure 60.2). The trachea and bronc hi have a systemic arterial blood supply delivered by the bronchial arteries, which arise directly from the nearby tho racic aorta. Lymphatic drainage tends to follow the bronchi. Lymph nodes are both named and identified by numbered ‘stations’ and more recently into zones, which are of importance in stag ing of lung cancer (Figure 60.3). -

The assessment of patients requiring lung surgery • Surgical oncology as applied to chest surgery • Chest wall disorders • Posterio r A nterior Right upper lobe Posterior Apical Anterior Right lower lobe Horizontal /f_i ssu re Apical Middle lobe Medial Posterior Basal Lateral Lateral Oblique /f_i ssure Anterior Posterio r A nterior Left upper lobe Oblique /f_i ssure Posterior Apical Left lower lobe Anterior Apical Superior lingular Anterior Basa l Inferior lingular Lateral Posterior Figure 60.1 The lobar and segmental divisions of the lungs, right lung above and left lung below as if viewed from the side.

BENIGN LUNG TUMOURS

BENIGN LUNG TUMOURS

Benign tumours of the lung are uncommon and account for fewer than 15% of solitary lesions seen on chest radiographs. A peripheral tumour usually causes no symptoms until it is large; a central tumour may present with haemoptysis and signs of bronchial obstruction while still small. A tumour is likely to be benign if it has not increased in size on chest radiographs for more than 2 years or it has some degree of calcification; however, a tissue diagnosis is usually pursued. Most benign nodules are granulomas (tuberculosis or his - toplasmosis). The most common benign tumour is a hamar - toma, a developmental abnormality containing mesothelial and endothelial elements. Diagnosis (and definitive treatment) is achieved by excision of the lesion. Any of the mesodermal elements of the lung may for m a mesodermal tumour (chon - droma, lipoma, leiomyoma). Deposits of amyloid may have a similar radiographic appearance to a nodule (pseudotumour).

CHEST TRAUMA

CHEST TRAUMA

The approach to trauma must be methodical and exact because the signs, particularly in the presence of other injury , - . -

(a) (b) Figure 60.27 (a) A large solitary bulla seen on videothoracoscopy. (b) The bulla de /f_l ated and rolled in preparation for staple resection. /uni00A0

and ATLS (Advanced Trauma Life Support) must be followed. Thoracic trauma is responsible for over 70% of all deaths following road tra ffi c accidents. Blunt trauma to the chest in isolation is fatal in 10% of cases, rising to 30% if other injuries are present. The indications for emergency room thoracot omy in blunt chest trauma include massive haemothorax, sus pected cardiac tamponade and witnessed cardiac arrest in the resuscitation area. Success rates are low . Penetrating thoracic wounds vary according to the prevalence of civil violence a mortality rate of 3% for simple stabbing to 15% for gunshot wounds. The indications for emergency room thoracotomy are similar to those for blunt chest trauma. The standard approach is a left anterior thoracotomy , unless the penetrating injury is in the right chest; however, it may be necessary to extend the incision to bilateral thoracotomies or a clam-shell incision.

DISORDERS OF THE CHEST WALL Tumours of the chest w

DISORDERS OF THE CHEST WALL Tumours of the chest wall

These can be tumours of any component of the chest wall, i.e. bone, cartilage and soft tissue. They are treated similarly to those that occur at other sites and require specialist surgical - input only if major resection and chest wall reconstruction are contemplated.

DISORDERS OF THE PLEURA

Pneumothorax

DISORDERS OF THE PLEURA Pneumothorax

Pneumothorax is the presence of air outside the lung, within the pleural space. It must be distinguished from bullae or air cysts within the lung. Bullae can be the cause of an air leak from the lung and can therefore coexist with pneumothorax. Spontaneous pneumothorax occurs when the visceral pleura ruptures without an external traumatic or iatrogenic cause. Cases are divided into primary spontaneous pneumo thorax (PSP) and secondary spontaneous pneumothorax (SSP). Pneumothorax can also occur following trauma or iatrogenic injury such as insertion of a central line. Tension pneumo thorax is when (independent of aetiology) there is a build-up of positiv e pressure within the hemithorax, to the extent that the lung is completely collapsed, the diaphragm is flattened, the mediastinum is distorted and, eventually , the venous return to the heart is compromised. Surgical emphysema is the pr esence of air in the tissues. It requires a breach of an air-containing viscus in communica tion with soft tissues, and the generation of positive pressure to push the air along tissue planes. The most serious cause is Sven Ivar Seldinger , 1921–1998, Swedish radiologist, introduced the Seldinger technique to obtain safe access to blood vessels and other hollow organs. also occur with asthma or barotrauma from positive-pressure ventilation. A poorly managed chest drain, with intermittent build-up of pressure, allows air to track into the chest wall thr ough the point where the drain breaches the parietal pleura. Primary spontaneous pneumothorax This is a common condition characteristically seen in young people from their mid-teens to late twenties. About 75% of cases are in young men, who tend to be tall and have a family history of the condition. It is due to leaks from small blebs, vesicles or bullae, which may become pedunculated, typically at the apex of the upper lobe or on the upper border of the lower or middle lobes. Secondary spontaneous pneumothorax This occurs when the visceral pleura leaks as part of an underlying lung disease; any disease that involves the pleura may cause pneumothorax, including tuberculosis, any cavitat - ing lung disease and necrosing tumours. As such it tends to occur in older patients, often with a history of underlying lung disease such as emphysema. The pneumothorax may be less well tolerated. The risk of recurr ent pneumothorax is increased after the first episode. The best estimates of recurrence rates are: /uni25CF of patients who experience a first event, only about one- third experience recurrence; /uni25CF of those who have a second episode, about one-half go on to experience a third episode; /uni25CF those who have had three episodes will probably go on to have repeated recurrences. Current recommendations from the BTS are that, in cases of persistent air leak following drain insertion or failure of the lung to re-expand, an early (3–5 days) thoracic surgical opinion should be sought. Summary box 60.1 Indications for surgical intervention for pneumothorax include: /uni25CF - /uni25CF /uni25CF /uni25CF - /uni25CF /uni25CF Current recommendations (Figure 60.7) focus on the use of small bore (10–14 /uni00A0 Fr) chest drains, usually of a Seldinger - type, inserted ideally under ultrasound guidance. However, knowledge of the role of the ‘surgical’ chest drain and how to insert it safely is still required.

Normal Second ipsilateral pneumothorax First contralateral pneumothorax Bilateral spontaneous pneumothorax Pneumothorax fails to settle despite chest drainage Spontaneous haemothorax: professions at risk (e.g. pilots, divers) Pregnancy

Spontaneous pneumothorax If bilateral/haemodynamically unstable proceed to chest drain signi /f_i cant smoking history NO Primary Evidence of underlying pneumothorax lung disease on exam Aspirate Size >2 cm YES* 16–18 G cannula and/or Aspirate <2.5 L breathless NO Success (<2 cm and breathing improved) YES Consider discharge review in OPD in 2–4 weeks *In some patients with a large pneumothorax but minimal symptoms conservative mangement may be appropriate Figure 60.7 British Thoracic Society guidelines on the management of spontaneous pneumothorax (2010) (adapted from www.bts.org.uk). OPD, /uni00A0 outpatient department.

Disorders of the diaphragm

Disorders of the diaphragm

Disorders of the diaphragm can be broadly classified as disor ders of innervation, leading to paralysis of the diaphragm, with elevation and reduction of thoracic volume leading to breathlessness, and disorders of anatomy , which ar e further categorised into congenital diaphragmatic hernias or acquired hernias, usually secondary to trauma. There are two well recognised congenital sites where abdominal viscera can herniate into the chest (Figure 60.28). /uni25CF The foramen of Morgagni: a hernia in the anterior part of the diaphragm with a defect between the sternal and Giovanni Battista Morgagni , 1682–1771, Professor of Anatomy , Padua, Italy , for 59 years, regarded as ‘the founder of morbid anatomy’. Victor Alexander Bochdalek , 1801–1883, Professor of Anatomy , Prague, Czech Republic. Mark M Ravitch , 1910–1989, paediatric surgeon, University of Pittsburgh, PA, USA. Donald Nuss , contemporary , paediatric surgeon, Norfolk, V A, USA, described this technique in 1987. the transverse colon. /uni25CF The foramen of Bochdalek: through the dome of the dia - phragm posteriorly . Traumatic rupture of the diaphragm may occur with blunt - trauma. Unless there is severe bleeding or strangulation of the - viscera it is best managed after an interval. In a severely injured patient being ventilated it can wait until other injuries are dealt with and weaning fr om the ventilator is being considered. , with When the diaphragm is breached, as in anatomical dis - orders, repair either with primary closure or with a mesh is usually possible via a thoracotomy . Diaphragmatic paralysis, particularly idiopathic unilateral paralysis, can be treated by plication, returning the diaphragm to a lower position and impr oving thoracic volume.

1 4 2 3 Figure 60.28 Diagram of sites of hernias. The usual sites of congenital diaphragmatic hernia: 1, foramen of Morgagni; 2, oesophageal hiatus; 3, foramen of Bochdalek (pleuroperitoneal hernia); 4, dome.

FURTHER READING

FURTHER READING

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Haemoptysis

Haemoptysis

Diseases causing repeated haemoptysis include carcinoma, bronchiectasis, carcinoid tumours and some infections. Severe - mitral stenosis is now a rare cause. Patients with repeated - haemoptysis should be investigated, at the very least by chest radiography and bronchoscopy . Haemoptysis following trauma may be from a lung contusion or injury to a major airway . Treatment depends on the underlying cause. Common associated chest symptoms include cough with or without sputum, pain, breathlessness, hoarseness and more general symptoms of systemic upset, including fatigue and loss of weight. Occasionally , chest disease may cause palpitations - owing to a trial fibrillation. Any of these symptoms in associa - tion with haemoptysis requires urgent investigation. Investigation Bronchoscopy Flexible bronchoscopy (Table 60.4) may be performed with the patient awake and the oropharynx anaesthetised with topical lignocaine (Figure 60.11). The bronchoscope is passed - into the nose or mouth and through the vocal folds under direct vision. As the scope is flexible, its tip can be directed into the segmental bronchi with ease. Tissue and sputum samples may be obtained for diagnostic purposes. There is a greater range of movement with this instrument, but the biopsies are relatively small and suction limited. Rigid bronchoscopy requires general anaesthesia in most instances. It is ideal for therapeutic manoeuvres, such as removal of foreign bodies, aspiration of blood and thick secre - tions, and intraluminal surgery (laser resection or stent place - ment). The surgeon and the anaesthetist share control of the airway . The bronchoscope is passed under direct vision into the oropharynx, behind the epiglottis, until the vocal folds are seen and introduced into the trachea. The trac heal rings and the carina should be easily seen. Advancing the bronchoscope into the RMB or LMB reveals the orifices of the more peripheral bronc hi. Operability of an endobronchial tumour may be assessed in terms of its location (e.g. the proximity of a lesion to the carina). Complications are rare but include bleeding, pneumothorax, laryngospasm and arrhythmia.

TABLE 60.4 Uses of bronchoscopy. Diagnostic Con /f_i rmation of disease: carcinoma of the bronchus; in /f_l ammatory or infective processes Investigative

Tissue biopsy Preoperative Before lung resection assessment Before oesophageal resection Persistent haemoptysis Therapeutic Removal of secretions Removal of foreign bodies Stent placement, endobronchial resection, etc.

Rigid bronchoscopy can be combined with endobron chial interventions to tackle airway tumours; these techniques include use of laser or cryotherapy , with heat or cold respec tively , to excise potentially obstructing endobronchial tumours y patency and breathing. and improve airwa Other techniques of biopsy of intrathoracic lesions are often necessary to confirm diagnosis, stage disease and plan treatment. T he options range from percutaneous needle biopsy under radiological control (typically CT scan) to open (V ATS) lung biopsy . Endobronchial ultrasound (EBUS) and naviga tional bronchoscopy are alternative airway techniques used to obtain intrathoracic biopsies. Summary box 60.4 Biopsy hazards /uni25CF /uni25CF /uni25CF Tracheal obstruction may present acutely as a life-threatening emergency or insidiously with little in the way of symptoms until critical narrowing and stridor occur. The more common causes of airway narrowing are outlined in Table 60.5 . Treatment depends on the underlying cause. Tracheostomy may be required to overcome the obstruction, but there are few indications to do this as an emergency . Tracheal replacement resection of up to 6 /uni00A0 cm of trachea is possible. Sleeve resections of the major bronchi are also possible.

(b) Figure 60.11 (a) Rigid and /f_l exible bronchoscopes. (b) View past the carina into the left main bronchus with a tumour seen in the bronchial lumen. Bleeding disorders Systemic anticoagulation Pulmonary hypertension TABLE 60.5 Causes of airway narrowing. Intraluminal Inhaled foreign body Neoplasm Intramural Congenital stenosis Fibrous stricture (post intubation or tuberculosis) Extramural Neoplasm (thyroid cancer, secondary deposits) Aortic arch aneurysm

INTRODUCTION Anatomical development of the lungs

INTRODUCTION Anatomical development of the lungs

The lungs are derived from an outpouching of the primitive foregut during the fourth week of intrauterine life. This bud becomes a two-lobed structure, the ends of which ultimately become the lungs. The lobar arrangement is defined early and is fairly constant but anomalies of fissures and segments leading to anatomical variation in the adult are common. The primitive lungs drain into the cardinal veins, which ultimately become the pulmonary veins draining into the left atrium. Variability in venous drainage is very common and is usually of little functional significance. At the most severe end of the spectrum is total anomalous drainage, which pr esents in early infant life because oxygenated blood is all directed back to the right heart.

Inhaled foreign bodies

Inhaled foreign bodies

This is a fairly common occurrence in small children and is often marked by a choking incident that then apparently passes. Surprisingly large objects can be inhaled and become lodged in the wider calibre and more vertically placed RMB. There are three possible presentations: 1 asymptomatic; 2 wheezing (from airway narrowing) with a persistent cough and signs of obstructive emphysema; 3 pyrexia with a productive cough from pulmonary suppu - ration. Either flexible or more often rigid bronchoscopy is required to remove the foreign body .

Inserting and managing a chest drain

Inserting and managing a chest drain

An intercostal tube connected to an underwater seal is central to the management of chest disease; however, the management of the pleura and of chest drains can be troublesome, even in experienced hands. The safest site for insertion of a drain (Figure 60.8 the triangle that lies: /uni25CF anterior to the mid-axillary line; /uni25CF above the level of the nipple; /uni25CF below and lateral to the pectoralis major muscle. This will ideally find the fifth space. The technique includes the following. /uni25CF Meticulous attention to sterility throughout. /uni25CF Adequate local anaesthesia to include the pleura. /uni25CF Sharp dissection to cut only the skin. /uni25CF Blunt dissection with artery forceps down through the muscle layers; these should only be the serratus anterior and the intercostals. /uni25CF An oblique tract, so that the skin incision and the hole in the parietal pleura do not overlie each other and the drain is in a short tunnel, which reduces the chance of entraining air. /uni25CF A drain for pneumothorax and haemothorax should aim towards the apex of the lung. A drain for pleural e ff usion or empyema should be nearer the base. The drain should pass over the upper edge of the rib to avoid the neurovas - cular bundle that lies beneath the rib.) is in /uni25CF The retaining stitch should be secure but should not oblit - erate the drain. /uni25CF A vertical mattress suture is inserted for later wound clo - sure. This is vital for pneumothorax management but should be omitted if the drain is for empyema (provided there is adherence of the pleura) because that tract should lie open. /uni25CF Connect the drain to an underwater seal device which functions as a one-way valve. /uni25CF After completion, check that the drain has achieved its objective by taking a chest radiograph. It is preferable not to apply suction to the drain or clamp it. The danger is that the clamp may be applied for trans - port and forgotten. Dangers of disconnection and siphoning are small or best averted in other ways apart from clamping.

Age >50 and YES Secondary pneumothorax or x-ray? YES

> 2 cm or breathless NO Aspirate YES Size 16–18 G cannula 1–2 cm NO Aspirate <2.5 L NO Success YES NO (size now <1 cm) Admit Chest drain High- /f_l ow oxygen size 8–14 Fr (unless suspected oxygen sensitive) Admit Observe for 24 hours

(a)) (c) (d) (b A bubbling drain should (almost) never be clamped. Remove the drain when it no longer has a function. Summary box 60.2 Suction on a pleural tube /uni25CF /uni25CF /uni25CF

Triangle of ‘safety’ Mid-axillary line Figure 60.8 Insertion of chest drain: (a) triangle of safety; (b) pleura; (d) suture placement; (e) gauging the distance of insertion; central trochar and positioning of drain; (h) underwater seal chest drain bottle. Be aware! Inserting the drain, and not the suction, is the life- saving manoeuvre If the lung is reluctant to expand, the suction deviates the mediastinum If the lung is fragile, it may worsen an air leak

Introduction

Introduction

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Investigation of the respiratory system

Investigation of the respiratory system

Pulmonary function tests (PFTs) are useful in determining the functional capacity of the patient and the severity of pulmonary disease, and in predicting the response to various treatments. The tests range from simple clinic or bedside measurements to those only available in specialist centres. Spirometry is the most commonly performed PFT and measures specifically the amount (volume) and/or speed (flow rate) of air that can be inhaled or exhaled. It is reported in both absolute values and as a predicted percentage of normal. Normal values vary , depending on gender, race, age and height. The most common parameters measured in spirometry are defined below and illustrated in Figure 60.5 . Basil Martin Wright , 1912–2001, member of the scientific sta ff of the Medical Research Council Research Centre, Northwick Park Hospital, Harrow , UK. Peak expiratory flow rate Peak expiratory flow rate (PEFR) is measured by a Wright peak flow meter or a peak flow gauge. This is the maximum airflow velocity achieved during an expiration delivered with maximal force from the total lung capacity . It is a reliable and reproduc - ible test but has the disadvantage of being e ff ort dependent, and it may therefore be a ff ected by abdominal or thoracic wound pain. PEFR measurements are often used in managing asthma, but there are many other causes of low PEFR such as a pr oblem with large airway patency . Forced expiratory volume in 1 second The forced expiratory volume in 1 second (FEV) is the amount 1 of air forcibly expired in 1 second. It is low in obstructive lung disease and may be normal in patients with poor gas exchange. Forced vital capacity The forced vital capacity (FVC) is the volume of air forcibly displaced following maximal inspiration to maximal expiration. The FEV and the FVC can be measured using a Vitalograph, 1

Postoperative Perioperative dyspnoea death Dynamic lung volumes, Thoracoscore transfer factor +/– split function testing Yes Offer surgery as part of multimodality management

(b) and a ratio (FEV /FVC) can be calculated (Figure 60.5 1 low ratio indicates obstruction and the test should be repeated after bronchodilators. A normal ratio (FVC and FEV reduced 1 to the same extent) indicates a restrictive pathology . There are two physiological categories of lung disease: obstructive and restrictive (Table 60.1). In obstructive condi tions such as asthma or emphysema, the flo w of air in and out of the lungs is impaired. In restrictive disease, such as lung fibrosis, the lungs have lost size or elasticity , becoming ‘sti ff ’ so that they do not fill or expand properly . Diffusion capacity The di ff usion capacity (DLCO) is a measurement of the lung’s ability to transfer gases and is often referred to as the ‘trans fer factor’. It cannot be performed at the bedside, requires the patient’s current haemoglobin level and is a test of the integrity of the lung’s alveolar–capillary surface area for gas ex change. In lung diseases that damage the alveolar walls, such). A ↓↓ ↓ - ↓↓ ↓ ↓ ↓↓ as emphysema, or that thicken the alveolar membrane, such as lung fibrosis, it may be reduced. In patients who require - surgery to remove part of their lung, for example for lung cancer, measurement of DLCO is an important determinant of ‘fitness’ for surgery and it should be measured formally as part of a lung function test.

4 4 3 3 q 2 2 Volume (litres) 1 1 1 0 2 3 4 5 6 0 Normal Obstructive Tidal volume Total lung capacity (TLC) Normal Figure 60.5 Spirometry. (a) Spirogram tracings obtained from a Vitalograph: vital capacity (FVC) 3.8 litres, FEV /FVC 82%; (ii) obstructive defect, reversible asthma, 1 FEV /FVC 40%; q after a bronchodilator, FEV 2.5 litres, FVC 3.5 litres, FEV 1 1 2.0 litres, FEV /FVC 90%. No change with bronchodilators. (b) 1 from Gray HH. Pulmonary embolism. Medicine International 1993; 4 3 2 p 1 1 2 3 4 5 6 1 0 2 3 4 5 6 Time (seconds) Restrictive VC TLC Vital capacity (VC) VC TLC Obstructive Restrictive (i) normal forced expiratory volume in 1 s (FEV) 3.1 litres, forced 1 p before a bronchodilator, FEV 1.4 litres, FVC 3.5 litres, 1 /FVC 71%; (iii) restrictive defect, /f_i brosing alveolitis, FEV 1.8 litres, FVC 1 1 Changes in lung volume in obstructive and restrictive lung disease. (Reproduced 21 : 477, by kind permission of the Medicine Group (Journals) /uni00A0 Ltd.) TABLE 60.1 Spirometry values in obstructive and restrictive lung diseases. Obstructive pattern Restrictive pattern PEFR Normal or FEV Normal or 1 FVC Normal or FEV /FVC <70

> 80 1 FEV , forced expiratory volume in 1 second; FVC, forced vital 1 capacity; PEFR, peak expiratory /f_l ow rate.

Oxygen saturation (S O) refers to the degree of oxygen p 2 molecules (O) carried in the blood attached to haemoglobin 2 molecules (Hb). It is a measure of how much oxygen the blood is carrying as a percentage of the maximum it could carry . The common method of monitoring the oxygenation of a patient’s haemoglobin is through a pulse oximeter. Blood gases The S O measured non-invasively with a pulse oximeter p 2 measures only oxygenation, not ventilation, and provides no information regarding a patient’s carbon dioxide or bicarbon ate levels, blood pH or base deficit. This requires arterial blood sampling or ‘blood gases’ (Table 60.2). The FEV and DLCO are often used to predict the risk 1 of postoperative dyspnoea after lung resection. The predicted postoperative values can be calculated by considering the vol ume of lung, more specifically the number of bronchopulmo nary segments, expected to be removed at surgery . For example if five segments of the left upper lobe are to be removed, the postoperative predicted FEV in a patient with a preoperative 1 FEV of 2.5 litres (85% predicted) is ((19 /uni00A0 – /uni00A0 5)/19) /uni00A0 ×/uni00A0 2.5 = 1 1.84 litres and ((19 /uni00A0 – /uni00A0 5)/19) /uni00A0×/uni00A0 85% = 62.6% predicted. This assumes that all bronchopulmonary segments are function ing (e.g. not collapsed) and contribute equally to lung func tion. Although an optimum cut-o ff of postoperative predicted FEV of 40% is widely cited, there are currently limited data 1 to provide guidance on this figure to help predict an acceptable degree of postoperative dyspnoea and quality of life. Patients should still be o ff ered surgical resection if the predicted risk of postoperative dyspnoea is moderate or high, as long as they are aware of and accept the risks of dyspnoea and associated complications. Exercise testing Other functional assessments, including the shuttle walk test, 6-minute walk test, stair climbing coupled with other tests such as oxygen saturations, as well as cardiopulmonary exercise testing (CPET), could be considered for patients at moderate or high risk of postoperative dyspnoea and may help predict surgical outcome after lung resection. In patients with moder ate to high risk of postoperative dyspnoea, using a shuttle walk test distance of >400 /uni00A0 m and CPET of >15 /uni00A0 mL/kg/min are cut-o ff values for good function. Ernest Henry Starling , 1866–1927, Professor of Physiology , University College, London, UK. The key to many aspects of practical chest surgery is an under - standing of the pleura and of the mechanics of breathing. Management of the essentially healthy pleural space is logical and simple and needs minimal technology . On the other hand, when pleural disease is advanced, for example when there is gross pleural sepsis surrounding a leaking and trapped lung, management is di ffi cult and the patient ma y require prolonged care with repeated interventions. The physiology of pleural fluid - The turnover of fluid in the human pleural space is about 1–2 /uni00A0 litres in 24 hours, with only 5–10 /uni00A0 mL of fluid present at any one time as a film, about 20 /uni00A0 /uni03BC m thick, between the visceral and parietal pleura. The mechanisms and equations given are simplifications but serve to explain the clinical conditions encountered. The fluid is produced from the capillaries of the parietal pleura as a transudate, according to the Starling capillary loop pressures. Howe ver, there is a further negative force in the pleura. The elastic content of the lung causes it to recoil and collapse if not held open by the negative pressure in the pleura. This elastic recoil exerts about 4 /uni00A0 mmHg of negative pressure and favours accumulation of fluid. The secreting forces add up to about 11 /uni00A0 mmHg in health. Pleural fluid is mainly reabsorbed (about 90%) by the visceral pleura, whose capillaries are part of the pulmonary circulation. The principal force in absorption of pleural fluid is oncotic pressure (approximately 25 /uni00A0 mmHg) - minus the di ff erence in mean capillary hydrostatic pressure of - the pulmonary capillary (8 /uni00A0 mmHg). Thus, the overall absorb - ing pressure is 25 /uni00A0 – /uni00A0 8 = 17 /uni00A0 mmHg, producing a net drying e ff ect (17 /uni00A0 – /uni00A0 11) of about 6 /uni00A0 mmHg (Figure 60.6). Gas in the pleural space There is normally no free gas in the pleural space because - the same physiological mechanism that absorbs air from a - pneumothorax prevents any gas accumulating. The partial pressures (water as saturated vapour pressure) of the gases in venous/end-capillary blood are: /uni25CF P O 40 /uni00A0 mmHg 5.3 /uni00A0 kPa 2 /uni25CF P CO 46 /uni00A0 mmHg 6.1 /uni00A0 kPa 2 /uni25CF P N 573 /uni00A0 mmHg 76.4 /uni00A0 kPa 2 /uni25CF P H O 47 /uni00A0 mmHg 6.3 /uni00A0 kPa 2 These partial pressures add up to less than atmospheric pressure (760 /uni00A0 mmHg). Free gas is therefore absorbed into the blood and lost to the atmosphere thr ough the lungs, with the gases moving in relation to their solubility (carbon dioxide quickest and nitrogen slowest) and relative concentrations in the pleural space and the blood. This does not favour nitrogen, which constitutes about 80% of atmospheric air. Breathing oxygen accelerates nitrogen removal by reducing the content - of nitrogen in the blood and increasing the gradient for its absorption. Nitrous oxide anaesthesia is dangerous in the pres - ence of a pneumothorax; nitrous oxide is very soluble and, although not normally present in the pleural space, it will be

TABLE 60.2 Arterial blood gases: ‘normal values’. pH 7.35–7.45 PaCO 4.5–6 /uni00A0 kPa (35–50 /uni00A0 mmHg) 2 PaO 11–14 /uni00A0 kPa (83–105 /uni00A0 mmHg) 2 Standard bicarbonate 22–28 mmol/L Anion gap 10–16 mmol/L Chloride 98–107 mmol/L

(b) rapidly transported into the space if the patient is given nitrous oxide to breathe.

Produced at a rate of: and reabsorbed: 0.6 mL/kg per hour or 1000 mL 80–90% into per day pulmonary capillaries 10–20% (plus protein) into lymphatics Capillary hydrostatic +32 +8 pressure Colloid –25 –5 –25 pressure 4 Elastic recoil Net drying effect 6 mmHg Figure 60.6 (a) Production and absorption of pleural /f_l uid. (b) pleural physiology. (See the text for an explanation of this simplistic physiological model.)

LUNG TRANSPLANTATION (see Chapter 92)

LUNG TRANSPLANTATION (see Chapter 92)

Lung transplantation is an established therapy for those with end-stage parenchymal or pulmonary vascular disease; it is limited by the number of donor lungs available.

Learning objectives

Learning objectives

To understand: The anatomy and physiology of the thorax • Investigation of chest pathology • The role of surgery in pleural disease •

Lung abscess

Lung abscess

The causes of lung abscess are shown in Table 60.8 . The chest radiograph shows a cavity with a fluid level or in mycetoma a fungal ball. Most acute abscesses resolve with appropriate antibiotic therapy and postural drainage. Surgery is avoided. Small radiologically sited drains are used sometimes in the intensive care unit.

Speci /f_i c pneumonia Streptococcal Staphylococcal Pneumococcal Klebsiella spp. Anaerobic Bronchial obstruction Carcinoma Carcinoid Foreign body Postoperative atelectasis Chronic respiratory sepsis Sinusitis Tonsillitis Dental infection Septicaemia Penetrating lung injury

MAJOR THORACIC SURGERY

MAJOR THORACIC SURGERY

The British Thoracic Society (BTS) recommends a tripartite risk assessment model for patients undergoing lung resection, considering the risk of operative mortality , risk of perioperative myocardial events and risk of postoperative dyspnoea (Figure 60.4).

MEDICAL CONDITIONS FOR WHICH SURGERY MA Y BE REQUI

MEDICAL CONDITIONS FOR WHICH SURGERY MA Y BE REQUIRED Bronchiectasis

Bronchiectasis is chronic irreversible dilatation of the medium- sized bronchi, which may occur following a suppurative pneumonia or bronchial obstruction. It is the pathological end stage of a range of conditions. If generalised it is almost never considered for surgical resection. Cases caused by whooping - cough and measles are decreasing in frequency in resource- rich countries.

Mechanics of breathing

Mechanics of breathing

The intercostal muscles contract, causing the ribs to move upwards and outwards, thereby increasing the transverse and anteroposterior dimensions of the chest wall. Along with - the diaphragm, which contracts simultaneously and flattens, increasing the vertical dimension of the chest cavity , these muscles are the muscles of respiration. In addition, the acces - sory muscles of respiration – the neck and spinal muscles such - as sternocleidomastoid – may be used particularly during heavy breathing, such as when exercising or during periods of illness such as a pneumonia (lung infection). As the volume increases, the intrathoracic pressure falls and air flows in until the alveolar pressure is the same as the atmospheric pressure. The only force used in normal expiration is the elastic recoil of the lung. Ability to cough comfortably to clear retained secretions is an essential part of recovery from surgery . In a vigorous cough, probably the only muscle in the body that is r elaxed is the dia phragm; as the abdomen and chest wall and accessory muscles contract, the limbs are braced and the sphincters are tightened. When the intrathoracic and abdominal pressure is built up, the glottis is opened and the diaphragm is forced up as a piston, or like the plunger of a syringe, to expel air at high velocity .

Lingula Apical lower Apical Middle lower lobe Basal Basal lower lower Figure 60.2 Surgical anatomy of the bronchial tree. To surgically remove the right lower lobe and conserve the middle lobe, the sur geon must be prepared to dissect and separately divide the apical bronchial segment (red line). 1 Supraclavicular zone Station 1: low cervical, supraclavicular sternal notch 4 Upper zone Station 2: upper paratracheal Station 3: prevascular/retrotracheal 10 Station 4: lower paratracheal Subcarinal zone 11 Station 7: subcarinal 8 Hilar/interlobular zone Station 10: hilar Station 11: interlobar Lower zone Station 8: paraoesophageal Station 9: pulmonary ligament Figure 60.3 Lymph node stations related to the bronchial tree are particularly important in the staging of lung cancer, with N1 nodes (10–14) and N2 nodes (2–9) shown. AP , anteroposterior.

NEOPLASMS OF THE LUNG

NEOPLASMS OF THE LUNG

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Other conditions of the mediastinum

Other conditions of the mediastinum

Many of the primary tumours such as neurogenic tumours and germ cell tumours can present as cysts or have a cystic quality . In addition, the mediastinum can contain other cysts, often with an embryological aetiology . Thymic, pericardial, bronchogenic and foregut cysts can all present asymptom - atically or with local compression (Figure 60.26). Surgical excision is recommended if the diagnosis is unclear or the patient has symptoms.

Other diseases of the chest wall

Other diseases of the chest wall

- Congenital abnormalities are often incidental findings on chest radiography (e.g. bifid rib), but there are some important exceptions. Cervical rib and thoracic outlet syndrome This rib is usually represented by a fibrous band originating from the seventh cervical vertebra and inserting onto the first thoracic rib. It may be asymptomatic, but because the subclavian artery and brachial plexus course over it a variety of symptoms may occur. The lower trunk of the plexus (mainly T1) is compressed, leading to wasting of the interossei and altered sensation in the T1 distribution. Compression of the subclavian artery may result in a poststenotic dilatation with thrombus and embolus formation. The diagnosis, assessment and surgery are fraught with uncertainties and are best left to those with a well-developed interest in this problem. Pectus excavatum The sternum is depressed, with a dish-shaped deformity of the anterior portions of the ribs on one or both sides. Whether it causes cardiopulmonary issues through compression remains unclear but certainly the disfigurement can lead to significant psychological concerns. It can be repaired either as an open procedure (modified Ravitch procedure), which involves resect - ing the a ff ected costal cartilages and mobilising the sternum, or as a minimally invasive technique, the Nuss procedure. A metal bar is placed behind the sternum to hold this central panel in its new position; the bar has to be removed after a period of time (Figure 60.29). Pectus carinatum (pigeon chest) In this condition the sternum is elevated above the level of the ribs and treatment is o ff ered for aesthetic reasons. It often comes to light during the growth spurt at adolescence when, of course, the teenager is particularly sensitive about appearance. Most patients are asymptomatic and the only justification for treatment is on cosmetic grounds. Some surgeons make a very good case for this but the risk of morbidity and of a less than perfect result must be clearly spelt out to the patient and his/ her parents. Surgery (modified Ravitch) involves mobilising the sternum with the costal cartilages so that the sternum can be flattened to a more anatomical position. Surgery is best left until the late teens, when further growth of the chest wall is unlikely . Alternatively , an external orthotic brace can be worn in young patients with a pliable chest wall to remodel the chest shape over time.

Figure 60.29 (a) Insertion of a preformed bar placed

thoracoscopically beneath the pectus excavatum. (b) Chest radiograph following inser tion of a metal bar bracing the sternum forward (the Nuss procedur

e).

Pleural effusion

Pleural effusion

Pleural e ff usion can be readily understood with reference to the physiological mechanisms governing the flux of pleural fluid given above. Pleural e ff usions are divided into exudates and transudates, depending on protein content (more [exudates] or less [transudates] than 30 /uni00A0 g/L), and characterised further according to glucose content, pH and lactate dehydrogenase content. The following are the most common ways in which the pleural fluid balance is disturbed. Malignant pleural effusion Pleural e ff usion is a common complication of cancer. This may be due to: /uni25CF lung cancer; /uni25CF pleural involvement with primary or secondary malignancy; /uni25CF mediastinal lymphatic involvement. Lung cancer There may be direct involvement of the parietal and/or - visceral pleura, collapse of the lung parenchyma and spread to the mediastinal lymphatics, or a combination of these, causing pleural fluid accumulation. It is usually regarded as a feature that puts lung cancer beyond surgical cure. Pleural malignancy The only primary malignancy of the pleura seen with any regularity is malignant mesothelioma. This is a consequence of asbestos exposure, with few exceptions. The peak of asbestos importation into the UK was from 1960 to 1975, with the inci - dence initially rising but more recently stabilising (2015–2017), with a fall in incidence projected in the future. Mesothelioma commonly presents with breathlessness because of pleural e ff usions, pain and systemic features of malignancy . Di ff use - seeding of the parietal and visceral pleura is a common pattern any origin. Mediastinal lymphatic involvement In many instances, particularly in breast cancer, there is no evident disease in the pleura. The disease is in the mediastinal lymphatics, which are obstructed, and this upsets the balance of physiological forces that control pleural fluid. Surgery for patients with malignant pleural effusion The surgeon has two roles: to make the diagnosis and to achieve e ff ective palliation by draining the fluid and pleurodesis. Diagnosis Pleural biopsy can be obtained by a range of techniques, with V ATS being the most common. An unequivocally positive biopsy is useful, but a negative biopsy may be a sampling error. Summary box 60.3 Biopsy of the pleura /uni25CF /uni25CF /uni25CF /uni25CF /uni25CF Pleural infection and empyema Empyema is the end stage of pleural infection from any cause. It most commonly results from infection of the underlying lung, involving pneumonia or a lung abscess, but can occur as a complication of any thoracic operation. It is seen if a traumatic haemothorax becomes infected or in the course of management of pneumothorax or pleural e ff usions. It may be associated with pus under the diaphragm (Table 60.3 pathological diagnosis requires the presence of thick pus with a thick cortex of fibrin and coagulum over the lung. When empyema presents de novo it usually follows pneumo nia, and three phases are described: 1 In the exudative phase, there is a protein-rich (>30 /uni00A0 g/L) e ff usion. If this becomes infected with the organisms from the lung (typically Streptococcus milleri and Haemophilus influ enzae in children), the scene is set for empyema. At this stage antibiotics may be all that is required. Aspiration or drainage to dryness in addition is preferred. 2 Over subsequent days, the fluid thickens to what is known as the fibrinopurulent phase. Drainage at this stage is prudent as antibiotics on their own are unlikely to be curative. 3 The organising phase causes the lung to be trapped by a thick peel or ‘cortex’ for which surgical management may be required. Leon David Abrams , 1923–2012, cardiothoracic surgeon, the United Birmingham Hospitals, Birmingham, UK.

Cytological examination of the pleural /f_l uid (low yield) Abrams’ needle (low yield in malignancy) Computed tomography (CT)-guided needle biopsy of a suspicious area VATS biopsy Open surgical biopsy formation. Pulmonary infection Unresolved pneumonia, bronchiectasis, tuberculosis, fungal infections, lung abscess Aspiration of pleural effusion Any aetiology Trauma Penetrating injury, surgery, oesophageal perforation Extrapulmonary sources Subphrenic abscess Bone infections Osteomyelitis of ribs or vertebrae

Primary lung cancer

Primary lung cancer

- Lung cancer is one of the most common cancers throughout the world. In the UK, there are approximately 45 /uni00A0 000 new cases a year. From the time of diagnosis, 60% of patients are dead within 1 year and only 15% survive 5 years, making lung cancer the most common cause of cancer death. Survival is dependent on the stage that the patient presents with lung cancer. The number of lung cancer operations performed in the - UK has significantly increased over the last 10 years. The pro - portion of lung cancers in which resection is attempted varies ut, in most resource-rich countries, is over 30%. Most patients b o ff ered lung cancer surgery are in the early stages. The tho - king in a cancer team has a role in diagno - racic surgeon wor sis, staging and palliation, in addition to curative resection in appropriate cases. Cigarette smoking is undoubtedly the major risk factor for developing bronchial carcinoma and accounts for 85–95% of all cases. To a lesser extent, atmospheric pol - lution and certain occupations (mining of radioactive ore and chromium) contribute. For practical purposes, lung cancers are divided into small cell lung cancer and non-small cell lung cancer (NSCLC), which are seen in a ratio of about 1:4. /uni25CF The pattern of disease, the prognosis and the results of treatment for small cell (also known as oat cell) carcinoma di ff er from all other types su ffi ciently for these to be man aged di ff erently from the outset on the basis of the histo logical classification. /uni25CF Subdivisions of NSCLC according to histological charac teristics are much less important, but pathological staging is critical to treatment and outcome. Histological classification of lung cancer Small cell lung cancers were known as oat cell cancers because of the packed nature of small dense cells. They are a type of neuroendocrine tumour (NET) and represent about 20% of all lung cancers. They tend to metastasise early to lymph nodes and by blood-borne spread. The median survival is measured in months. The tumours are very responsive to chemotherapy such that median survival may be doubled (although it is still short) but they are rarely , if ever, cured. Surgery is rarely o ff ered unless in very limited stage disease. Non-small cell lung cancers : adenocarcinoma is now the most common of the NSCLC types, having overtaken squamous cancer. The increasing incidence is partly due to an increasing incidence in women and may be the result, in part, of a move towards lower tar cigarettes that are inhaled more deeply to get the same e ff ect. Squamous carcinoma typically appears as a cavitating tumour. Large cell undi ff erentiated is a discrete histological type of NSCLC and is included within NETs. NETs of the lung are a group of lung cancers that include small cell cancer and large cell undi ff erentiated lung cancer, but also include other less aggressive tumour types, including typical carcinoid and atypical carcinoid tumours. These occur in the major (cen tral) bronchi and 20% are found peripherally . They are char acteristically slow growing and highly vascular. Most behave in a benign way; however, approximately 15% metastasise. The patient often presents with a history of recur rent pneumonia or haemoptysis, but carcinoid syndrome is rare unless there are extensive pulmonary or hepatic metastases. Surgical excision is preferred because the prognosis following complete resection is excellent (>90% 10-year survival). Accurate diagnosis and staging of the tumour are vital if surgery is to be considered. Clinical features Clinical features of lung carcinoma depend on: /uni25CF the site of the lesion; /uni25CF the invasion of neighbouring structures; /uni25CF the extent of metastases. Henry Khunrath Pancoast , 1875–1939, Professor of Radiology , University of Pennsylvania, Philadelphia, PA, USA, described this condition in 1932. Lee M Eaton , 1905–1958, neurologist who was a professor at the Mayo Clinic, Rochester, MN, USA. Edward H Lambert , 1915–2003, Professor of Physiology , University of Minnesota, MN, USA. Eaton and Lambert described this condition in a joint paper in 1956. loss, dyspnoea and non-specific chest pain. /uni25CF Haemoptysis occurs in fewer than 50% of patients pre - senting for the first time. /uni25CF Cough, or a changed cough, is a common presentation but non-specific in this population. /uni25CF Severe localised pain suggests chest wall invasion with the - infiltration of an intercostal nerve. Invasion of the apical - area may involve the brachial plexus, leading to Pancoast’s syndrome. - /uni25CF Dyspnoea or breathlessness may come from loss of func - tioning lung tissue, lymphatic invasion or the development of a large pleural e ff usion. /uni25CF Pleural fluid is an ominous feature and the presence of blood in a pleural e ff usion suggests that the pleura has been directly invaded. /uni25CF Clubbing and hypertrophic pulmonary osteoarthropathy occasionally accompany some lung cancers and may re - solve with excision of the primary lesion. /uni25CF Invasion of the mediastinum may result in hoarseness (because of recurrent laryngeal nerve involvement), dys - phagia (because of the involvement of, or extrinsic pres - sure on, the oesophagus) and superior vena caval obstruc - tion. /uni25CF Small cell carcinoma is associated with the development of myopathies, including the Eaton–Lambert syndrome, which is similar to myasthenia gravis. Treatment of lung cancer Careful investigation is required to determine which tumours are operable and will benefit from a major thoracic resection. The internationally agreed tumour–node–metastasis (TNM) staging system gives prognostic information on the natural history of the disease. Tumours graded up to T3, N1, M0 can be encompassed within an anatomical surgical resection and have a much improved prognosis when treated surgically so the - tumour must be staged accurately before resection. Increas - - ingly , for higher stage tumours a multi- or trimodality approach is being o ff ered where patients have chemotherapy , with or followed by radiotherapy follow ed by surgery . A number of non-tumour-related factors, including the general fitness of the patient and the results of lung function tests, help to determine the appropriate treatment. In patients with incurable disease, treatment is palliative to maximise quality of life. Survival Carcinoma of the bronchus generally has a low survival rate after diagnosis. Important factors in determining prognosis are the size of the tumour (T status), the spread or stage of the cancer as determined by the TNM classification, the histological type of the tumour and the general condition of the patient. Early detection and surgical resection o ff er the best hope for cure. Increasing emphasis in recent years has been on the early detection of lung cancer, with guidance on symptoms and signs of potential lung cancer that require urgent chest radiograph and referral to a lung cancer team. Non-invasive investigations Chest radiography A chest radiograph will detect most lung cancers but some, particularly early curable tumours, are hidden by other struc tures. Secondary e ff ects such as pleural e ff usion, distal collapse and raised hemidiaphragm may be evident (Figure 60.12 Computed tomography CT is the first investigation in suspected lung cancer. The surgeon needs to know whether the primary is resectable (T /uni00A0 stage) and which, if any , lymph nodes are involved (N stage). Lymph nodes more than 2 /uni00A0 cm in diameter are likely to be involved in the disease (70%) (Figure 60.13) and those less than 10 /uni00A0 mm in the shorter axis are unlikely to be involved. Remote metastases to the liver, adrenal glands or elsewhere may be detected. Positron emission tomography The patient is given radiolabelled fluorodeoxyglucose (FDG), which is taken up by all metabolising cells but more avidly by cancer cells. The FDG enters the Krebs cycle but cannot complete it and accumulates in proportion to the glucose avidity of the cells. High accumulation is associated with lung cancers and secondaries. Infection or other inflammation, and lymphadenopathy secondary to it, are also FDG avid. Sputum cytology Sputum cytology may reveal malignant cells but the false- negative rate is high. Invasive investigations Once lung cancer is suspected, diagnosis and further staging are sought. The choice of investigation depends on the position of the primary tumour in the lung (peripheral or central) and the clinical stage of the cancer (presence of enlarged lymph nodes or metastasis). Bronchoscopy Flexible bronchoscopy is usually performed under sedation, particularly in patients with more centrally placed lung cancers. It allows assessment of the segmental airway , cytological testing through brushing and washing of the concerned segmental bronchi and transbronchial needle aspiration (TBNA). Endobronchial ultrasound EBUS allows bronchoscopic assessment of suspicious medi astinal lymph nodes with an ultrasound probe incorporated into the tip of the bronchoscope to aid TBNA (Figure 60.14 Johann Friedrich Horner , 1831–1886, Professor of Ophthalmology , Zurich, Switzerland, described this syndrome in 1869. Sir Hans Adolf Krebs , 1900–1981, Professor of Biochemistry , University of Oxford, Oxford, UK. -). Endoscopic ultrasound (EUS) is a similar technique that, by passing the probe down the oesophagus, allows fine-needle aspiration (FNA) of less approachable mediastinal lymph nodes. Navigational bronchoscopy Navigational bronchoscopy provides a virtual three- dimensional map of the lung using radiological guidance during a flexible bronchoscopy , which can guide the physician to target, locate and perform an anatomically precise lung biopsy , place markers for radiation therapy and/or facilitate - surgical removal of a small peripheral lung lesion or use thermal ablative techniques for peripheral lung lesions.).

Figure 60.12 Chest radiograph of carcinoma of the lung. This patient has a large mass in the right upper lobe, causing Horner’s syndrome, a Pancoast tumour. Figure 60.13 Paratracheal lymphadenopathy shown on a computed tomography scan.

Computed tomography-guided biopsy Percutaneous CT-guided FNA may give a good yield of cells for cytological examination. Alternatively , a core of tissue can be obtained for formal histology . These techniques are best for larger and more peripheral lesions. Pneumothorax is common (10%) but rarely requires intercostal tube drainage. The contraindications include poor respiratory reserve, when even a small pneumothorax would be hazardous. Surgical diagnosis and staging Mediastinoscopy , mediastinotomy , V ATS or thoracotomy lymph node/lung biopsy are aimed at establishing a tissue diagnosis and assessing the degree of spread (staging), which determines resectability . Histological proof of the status of mediastinal nodes may be important to avoid unnecessary thoracotomy for incurable cancers and, conversely , to avoid denying surgery to patients whose lymph nodes are enlarged but benign. Mediastinoscopy Following an incision in the neck and careful blunt dissection in front of the trachea, access to the paratracheal and subcarinal nodes via mediastinoscopy is achieved and biopsies taken (Figure 60.15). These techniques may also be used in the diagnosis of other mediastinal conditions, including: /uni25CF lymphoma; /uni25CF anterior mediastinal tumours; /uni25CF thymoma; /uni25CF sarcoid, tuberculosis or any other cause of lymphadenop athy . VATS mediastinal lymph node and lung biopsy For inaccessible mediastinal lymph nodes, or when diagnosis of the lung tumour has not been possible through radiological or bronchoscopic techniques, V ATS allows diagnosis of the tumour and staging of the mediastinum and gives the oppor tunity to assess the likely operability of the lung cancer.

Figure 60.14 Endobronchial ultrasound allows accurate detection of enlarged mediastinal lymph nodes for diagnosis and staging of lung cancer. Figure 60.15 Mediastinoscopy. The mediastinoscope slides down immediately in front of the trachea, behind the aortic arch, and behind and between the great vessels of the head and neck.

Primary tumours of the mediastinum

Primary tumours of the mediastinum

Thymoma, neurogenic tumours, germ cell tumours and lymphoma are the usual primary tumours of the mediastinum. /uni25CF Thymoma . This is the most common mediastinal tumour, accounting for 25% of the total, and is derived from the thymus gland (Figure 60.23). Thymomas vary in behaviour from benign to aggressively invasive, as reflected in the Masoaka classification system used to stage thymo mas and more recently the TNM classification. They are often related to myasthenia gravis, a neuromuscular condi tion that can have a high associated incidence of thymomas, and inter estingly may respond to excision of the thymus gland even when the gland has no associated thymoma present. T he only reliable indicator of malignancy is cap sular invasion. Diagnosis and treatment are best achieved by complete thymectomy , which for large tumours (>5 /uni00A0 cm) Akira Masoaka , 1930–2014, Professor of Surgery , Nagoya, Japan. or if tumour invasion is suspected a median sternotomy is performed. If the thymoma is small or when the patient has myasthenia gravis and the thymus is being excised as a treatment, various less invasive approaches can be con - sidered, including a V ATS approach or a transcervical approach with or without an additional V ATS procedure. /uni25CF Germ cell tumour . The anterior mediastinum is the most common site of extragonadal germ cell tumours. They account for 13% of all mediastinal masses and cysts and contain elements from all three cell types (mesoderm, endoderm and ectoderm). They tend to present in young) adults and 75% are benign and cystic, although they may cause compression of neighbouring structures; hence, dermoid cysts are best excised. Malignancy is suspected if elevated levels of serum alpha-fetoprotein, human chorionic gonadotropin and carcinoembryonic antigen are detected. After initial treatment with chemotherapy , a patient with tumour marker normalisation and a persistent mass on CT may be considered for surgical resection. If tumour markers fail to normalise, further chemotherapy is usually o ff ered. /uni25CF Lymphoma . Lymphoma is a common cause of a mediast - inal mass lesion, particularly in the anterior mediastinum, and can lead to superior vena cava obstruction or other symptoms of local compression. The main treatment is ely required apart from chemotherapy , and surgery is rar obtaining tissue for diagnosis. /uni25CF Mesenchymal tumours . Lipomas are common in the - anterior mediastinum. Other mesenchymal tumours are very rare. - /uni25CF Thyroid . Ectopic thyroid (and parathyroid) tissue may be found in the anterior mediastinum but usually the mass is an extension of a thyroid lesion (retrosternal goitre). Exci - sion of retrosternal thyroids may be required if there is lo - - cal airway compression and stridor and can be performed via a transcervical incision, but occasionally median ster - notomy may be required.

Figure 60.23 Computed tomography scan showing a thymoma pre

senting as a mediastinal mass.

/uni25CF Neurogenic tumours . These may derive from the sympathetic nervous system or the peripheral nerves and are more prevalent in the posterior mediastinum. They may be painful but are more often discovered acciden tally on routine chest radiography and can be quite large (Figure 60.24). They include neuroblastoma in childhood, and Schwannomas and neurofibromas in adults, which are usually benign. Phaeochromocytoma arises fr om the sym pathetic chain and produces the characteristic endocrine syndrome. Excision of neurogenic tumours is generally recommended, particularly if the patient is developing symptoms. This can be performed through a thoracotom though for smaller tumours a V ATS approach can be used (Figure 60.25). /uni25CF Enlarged mediastinal lymph nodes are commonly involved by metastatic tumour, mimicking a primary mediastinal lesion. Symptoms are generally secondary to compression or invasion of a structure within the mediastinum. Surgery such as mediastinoscopy is reserved for diagnosis only . Theodor Schwann , 1810–1882, Professor of Anatomy and Physiology , successively at Louvain (1839–1848) and Liège, Belgium (1849–1888).

Figure 60.24 Computed tomography scan showing a right-sided paravertebral neurogenic tumour. Figure 60.25 Video-assisted thoracoscopic surgery (VATS) image of a neurogenic tumour attached to the posterolateral chest wall prior to excision. Figure 60.26 Computed tomography scan of the chest showing a bronchogenic cyst splaying the carina.

Pulmonary sequestration

Pulmonary sequestration

This describes a section of non-functional lung separated from the normal bronchial connection with other abnormalities of development, which often include a direct systemic arterial supply from the aorta. V enous return is to the pulmonary veins in the majority of cases. The segment becomes cystic and infected, resulting in the common appearance of a solid lung mass that may be homogeneous or heterogeneous, occasion ally with cystic changes on CT scan. Interlobar sequestration occurs within the lung substance. It may present with recurrent chest infections and/or haemoptysis. Patients with extralobar sequestration are usually asymptomatic because air spaces are not present, and therefore it usually presents as an incidental finding. Theodor Albrecht Edwin Klebs , 1834–1913, Professor of Bacteriology , successively at Prague, Czech Republic; Zurich, Switzerland; and The Rush Medical College, Chicago, IL, USA. Developmental lung cysts have a tendency to become infected. Acquired lung cysts may contain air or fluid and may be single or multiple. Pulmonary hydatid disease is a cause in endemic areas. Air cysts (bullae) may be spontaneous but may be secondary to emphysematous degeneration (Figure 60.27).

Risk of operative mortality

Risk of operative mortality

The Thoracic Surgery Scoring System (Thoracoscore) is the most widely used model to assess the risk of operative mortality in thoracic patients. Risk is calculated based on nine variables – age, sex, American Society of Anesthesiologists score, perfor - mance status, dyspnoea score, priority of surgery , extent of surgery , malignant diagnosis and composite comorbidity score. It is currently the most robust model available to estimate the risk of death when considering patients f or thoracic surgery .

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Risk of perioperative myocardial event

Risk of perioperative myocardial event

History , physical examination and resting electrocardiogram (ECG) form the basics of assessing perioperative cardiovas - - cular risk. Patients who are found to have an active cardiac condition should be evaluated by a cardiologist and optimised (medical, revascularisation or cardiac surgery) before thoracic surgery . Sur gery should be avoided within 30 days of myocar - dial infarction.

2 14 3 Peripheral zone Station 12: lobar 12 13 Station 13: segmental 7 Station 14: subsegmental 11 Oesophagus 9 AP zone Station 5: subaortic 6 Station 6: para-aortic 5 Left pulmonary artery

Risk assessment for surgery Postoperative cardiac event ACC/AHA risk strati /f_i cation +/– cardiology review Address potentially modi /f_i able risk factors and reassess Does the patient accept the risk in each category +/– potential impact on lifestyle? No Exclude surgery from multimodality management Figure 60.4 Tripartite risk assessment. ACC, American College of Cardiology; AHA, American Heart Association.

Risk of postoperative dyspnoea

Risk of postoperative dyspnoea

Any patient undergoing general anaesthesia requires some assessment of respiratory function. This may be a clinical appraisal of fitness, but more detail is necessary for patients who are undergoing lung resection.

Surgical approach to lung cancer resection

Surgical approach to lung cancer resection

Thoracotomy Although the most frequent indication for thoracotomy is lung cancer, all surgeons dealing with trauma should be able to perform a thoracotomy if required. The standard route into the thoracic cavity is through a posterolateral thoracotomy . The incision is used for access to the: /uni25CF lung and major bronchi; /uni25CF pleura; /uni25CF thoracic aorta; /uni25CF oesophagus; /uni25CF posterior mediastinum. A double-lumen endotracheal tube is used to allow ven - tilation of one lung while the other is collapsed, to facilitate surgery and to protect the non-operated lung and retain con - trol of ventilation (Figure 60.16). The patient is turned to the - -

Tracheal in /f_l atable cuff Bronchial in /f_l atable cuff Figure 60.16 The double-lumen tube permits separate ventilation of the right and left lungs.

lateral position with the a ff ected side up (Figure 60.17 incision passes 1–2 /uni00A0 cm below the tip of the scapula and extends posteriorly and superiorly between the medial border of the scapula and the spine. /uni25CF The incision is deepened through the subcutaneous tissues to the latissimus dorsi. This muscle is divided with coagu lating diathermy , taking care over haemostasis. /uni25CF A plane of dissection is developed manually , deep to the scapula and serratus anterior. The ribs can be counted down from the highest palpable rib (which is usually the second) and the sixth rib periosteum is scored with the dia thermy near its upper border. A periosteal elevator is used to lift the periosteum o ff the superior border of the rib or, alternatively , the intercostal muscle is cut with diathermy just above the rib (Figure 60.18). /uni25CF This reveals the pleura, which may be entered by blunt dissection. A rib spreader is inserted between the ribs and opened gently to prevent fracture. In an emergency thoracotomy for penetrating wounds of the heart, a more anterior approach is used and no specialised supporting equipment is required (Figure 60.19). The incision is taken down to the fourth or fifth rib with a scalpel, and the pleural cavity is opened using scissors. This gives rapid access to the left pleural cavity in cases of massive left haemothorax and the pericardium if cardiac tamponade is suspected. A left anterior thoracotomy can be quickly converted to a clamshell or bilateral thoracotomy if necessary . Analgesia is an important aspect of postoperative care, and the process may be started prior to thoracotomy with an epi dural catheter placed by the anaesthetist or intraoperatively by infiltrating the intercostal nerves in the region of the incision with a long-acting local anaesthetic or increasingly via a surgi-). The cally sited paravertebral catheter. Various strategies have been developed to deliver analgesics postoperatively to facilitate a normal breathing pattern. Video-assisted thoracoscopic surgery (VATS) Various approaches utilising thoracoscopic techniques can - be used to gain access to the chest cavity and facilitate lung - -

Double-lumen tube to protect the underlying lung Elbows are placed at 90° to upper arms Incision curves below angle of scapula Underlying leg bent for stability Upper leg cushioned Figure 60.17 Correct positioning for thoracotomy. B 5 C 6 A 7 Latissimus dorsi 8 9 muscle Serratus anterior muscle Figure 60.18 Incision and layers encountered during posterolateral thoracotomy. A, The latissimus dorsi is divided in line with the skin incision. B, If the serratus anterior is divided, it should be close to its attachment to ribs 6, 7 and 8. It can be left intact and mobilised along its inferior border. C, The intercostal muscles are stripped off the upper border of the rib. A sandbag or dense pillow to roll the patient 30º Arm for anaesthetist' s Incision in 5th access intercostal space Arm back Figure 60.19 Emergency left anterior thoracotomy for access to the heart. This requires no special supports or devices.

lung resections with dissection of the hilar structures and full lymph node staging commonly performed through one- (uniportal), two- or three-port V ATS incisions. The technique avoids rib-spreading and appears to reduce postoperative pain and length of stay and aids a speedier recovery , particularly in frail patients. Robotically assisted thoracic surgery (RATS) In this approach, the thoracoscopy is done using a robotic system with three-dimensional vision. The surgeon sits at a control panel in the operating room and moves robotic arms to operate through several small incisions in the patient's chest. RATS is similar to V ATS in terms of less pain, less blood loss and a shorter recovery time (Figure 60.20). For the surgeon, the robotic system may provide more manoeuvrability and more precision when moving the instru ments than standard V ATS. It may have advantages when performing more comple x lung resections such as segmentec tomies or mediastinal tumours (thymectomy). Surgical management of lung cancer The principle of surgery is to remove all cancer (the primary and the regional lymph nodes) but to conserve as much lung as possible. The selection of patients in terms of the stage of the lung cancer and fitness to undergo such surgery is paramount. Surgery with curative intent is o ff ered to patients with early stage lung cancer (T1–3, N0–1) (Table 60.6). Assessment of a patient's fitness to undergo lung cancer resection involves considering premorbid conditions, which can be aided using risk scores such as Thoracoscore, cardiovascular function and lung function; see BTS guidelines in Assessment of fitness for major thoracic surgery and UK National Institute for Health and Care Excellence (NICE) guidelines in Table 60.7 Lung function, in particular, will aid the surgeon in selecting the type of procedure o ff ered and the likelihood of breathless ness or dyspnoea following lung resection. - Choice of lung resection Segmentectomy and wedge resection - Segmentectomy and wedge resections are performed in patients with small tumours (1–2 /uni00A0 cm) that are predominantly ground glass, not solid (lepidic) and with borderline fitness, through thoracotomy or increasingly by V ATS or RATS. Each lobe of the lung has segments, which allows anatomical dissection and ligation of the segmental pulmonary artery , vein and bronchus (segmentectomy) (Figure 60.2) or non-anatomical excision can be performed (wedge resection) combined with removal of regional lymph nodes. Lobectomy Lobectomy remains the treatment of choice for patients with early-stage lung cancer. The surgery can be performed via thoracotomy or V ATS. Following dissection of the fissure and hilar structures, the branches of the pulmonary artery and . veins to the lobe are isolated and ligated. The bronchus is usually stapled but can be sewn. - The patient does not routinely need intensive care and postoperative ventilation is best avoided. The 30-day mortal - ity rate is 1–2%, with morbidity such as chest infection or car - diac arrhythmia at around 10%. The average length of stay is around 5–7 days. Pneumonectomy Pneumonectomy is removal of a whole lung and has a higher mortality rate (5–8%). As such the number of pneumonec - tomies performed in the UK has fallen and now makes up less than 5% of lung cancer surgery . The surgeon must be satisfied that the patient is fit to tolerate this procedure from the preoperative work-up. This procedure is reserved for either centrally placed tumours involving the main bronchus or those that straddle the fissure. Bronchoplastic lung resections Increasingly , owing to the associated complications and higher mortality of a pneumonectomy , preservation of lung tissue is being considered but without compromise of the surgical resection margins. Sleeve lung resections involve removing a central tumour that is invading a major bronchus, such as the LMB or RMB, together with the lobe of the lung involved,

TABLE 60.6 UK National Institute for Health and Care Excellence (NICE) recommendations for surgery for non- small cell lung cancer (NSCLC). Surgery with curative intent for NSCLC Offer patients with NSCLC who are /f_i t for surgery open or thoracoscopic lobectomy as the treatment of /f_i rst choice. If complete resection is possible, consider segmentectomy or wedge resection for patients with smaller tumours (T1a–b, N0, M0) and borderline /f_i tness Offer more extensive surgery (bronchoangioplastic surgery, bilobectomy, pneumonectomy) only when needed to obtain clear margins Perform hilar and mediastinal lymph node sampling or en bloc resection for all patients undergoing surgery with curative intent For T3 NSCLC with chest wall involvement, aim for complete resection by extrapleural or en bloc chest wall resection For people with operable stage IIIA–N2 NSCLC who can have surgery and are well enough for multimodality therapy, consider chemoradiotherapy with surgery Figure 60.20 A thoracic surgeon performing robotically assisted thoracic (RATS) lung resection remotely from an operating console.

with reanastomosis of the cut major bronchus to the remaining lobar bronchus. Complications of lung resection /uni25CF Bleeding . Bleeding should be avoidable by the use of a careful surgical technique but may be severe in the pres ence of dense adhesions. /uni25CF Respiratory infection . Many of these patients are ex-smokers and therefore basal collapse and hypoxaemia are common postoperatively . /uni25CF Persistent air leak . Chest drains are placed at the time of surgery to deal with the air leak. Rarely , the air leak persists and the remaining lung does not expand. Re-thoracotomy may then be necessary to seal the leak. /uni25CF Bronchopleural fistula . This is a serious complica tion. Following pneumonectomy , the space left behind is initially filled with air. This is slowly reabsorbed and the space fills with tissue fluid. The fluid level rises until the air is finally reabsorbed (Figure 60.21). Dehiscence of the bronchial stump leads to the development of a br oncho pleural fistula and the fluid in the space (which is almost inevitably infected) is expectorated in large quantities. This complication has a high morbidity and mortality rate. The patient is nursed sitting up and turned so that the a ff ected space is dependent; this is to pr event infected fluid from entering the remaining lung while arrangements are made to site a pleural drain. This should be connected to an underwater seal but not suction. Bronchopleural fistulae are unlikely to resolve spontaneously and management is highly specialised. Postoperative care Enhanced recovery after surgery (ERAS) is a strategy that seeks to reduce patients’ perioperative stress response, thereby reducing potential complications, decreasing hospital length of stay and enabling patients to return more quickly - to their baseline functional status. These principles have been applied to patients having lung cancer surgery . Postoperatively , patients have limited respiratory reserve following lung resec - tion, so infection and fluid overload are to be avoided. Once air leaks have settled, the drains are removed. Mobilisation, breathing exercises and regular physiotherapy are begun as soon as the patient’ s condition permits. Postoperative pain - It is important to deal with postsurgical pain e ff ectively so that a normal breathing pattern and gas exchange are achieved in the early postoperative period. Four strategies are routinely used in combination: - 1 paravertebral/extrapleural or epidural catheter-delivered local anaesthetic; 2 intercostal nerve blocks; 3 PCA with intravenous boluses of opiates; 4 background oral analgesia with paracetamol and/or non-steroidal anti-inflammatory drugs. Long-term postsurgical pain can be reduced by careful attention to detail during the operation. Sources of avoidable chronic pain include rib fracture and the entrapment of inter - costal nerves during wound closure .

treatment with curative intent (including surgery). Perioperative mortality Consider global risk score, such as Thoracoscore Ensure patient is aware of risk before consenting Cardiovascular function Assess risk factors and cardiac functional capacity Avoid surgery within 30 days of MI Lung function Perform spirometry, measure TLCO if disproportionate breathlessness or other lung pathology, perform segment count and assess exercise tolerance Consider shuttle walk testing (cut-off 400 /uni00A0 m) and cardiopulmonary exercise testing (cut-off 15 /uni00A0 mL/kg/minute) if moderate to high risk of postoperative dyspnoea FEV , forced expiratory volume in 1 s; MI, myocardial infarction; TLCO, transfer factor for carbon monoxide. 1 From NICE Clinical Guideline 122, available from: www.nice.org.uk/guidance/ng122. Optimise primary cardiac treatment and begin secondary cardiac prophylaxis as soon as possible Offer surgery if two or fewer risk factors and good cardiac functional capacity Seek cardiology review if active cardiac condition, three or more risk factors or poor cardiac functional capacity Consider revascularisation before surgery in stable angina Continue anti-ischaemic treatment in perioperative period. Discuss perioperative platelet treatment if patient has a coronary stent Offer surgery if normal FEV and good exercise tolerance 1 or FEV or TLCO below 30% and patient accepts the 1 risks of dyspnoea Offer radiotherapy with curative intent if lung function poor but patient is otherwise suitable for radiotherapy with curative intent and volume of irradiated lung is small

For all malignancies, the lung is the most common site of metastases that often develop through haematogenous spread. The presence of metastases is regarded as a sign of advanced disease and few curative treatment options exist; however, surgical resection of lung metastases may result in a survival advantage, particularly with metastases from solid tumours such as colorectal cancer, though the evidence still remains uncertain. The selection criteria often used when considering lung metastasectomy include control of primary tumour; no evidence of metastases outside the lung; possibility of complete resection utilising lung-sparing techniques; and acceptable operative risks with adequate pulmonary function. Various approaches can be considered, though V ATS is increasingly favoured over thoracotomy owing to reduced postoperative pain and length of stay , and therefor e speedier recovery . The disadvantage of V ATS is the inability to palpate and evaluate the lung in its entirety to locate other nodules deeper within the lung parenchyma, particularly those not identified on prior CT imaging. The main principle when resecting lung metastases is to utilise lung-sparing techniques as much as possible, e.g. wedge resections rather than lobec - tomy , because it is likely that later reoperations to resect new metastases may be necessary . Long-term outcome depends on the primary tumour type, with germ cell tumours having the best outcome. Patients with epithelial tumours (carcinomas) generally hav e a 30–40% 5-year survival, as reported in several r etrospective series.

(b) (c) Figure 60.21 Chest radiographs (a) pre- and (b) post-pneumonec tomy, with rising /f_l uid level (c) in the left haemothorax.

Surgical management of pleural effusions and infec

Surgical management of pleural effusions and infections

Thoracoscopy or video-assisted thoracoscopic surgery (VATS) The direct-vision thoracoscope has been used for many years, but its use was limited mainly to performing biopsies. Since the advent of video-assisted thoracoscopy (Figure 60.9) the surgeon's hands are now free because the camera is attached to the thoracoscope, which can be operated by an assistant with the image displayed on a screen. The surgeon is able to manipulate instruments with both hands to perform a variety of procedures. The number of ports required depends on the type and complexity of the surgery . The patient is usually positioned with the diseased side uppermost, having had a double-lumen endotracheobronchial tube (ETT) placed by the anaesthetist to allow for single-lung ventilation. The principal). The - -

Figure 60.9 V i d e o - a s s i s t e d t h o r a c o s c o p i c s u r g e r y (V A T S) u t i l i s e s modern thoracoscopic instruments and digital technology and avoids large incisions.

postoperative pain and a more rapid recovery . VATS drainage, pleural biopsy and talc pleurodesis V ATS drainage, pleural biopsy and talc pleurodesis is increas ingly performed for the management of patients with an undi agnosed or malignant pleural e ff usion. It can be performed using a single port and allows direct visualisation of the pleural cavity for complete drainage, multiple pleural biopsies and excellent talc insu ffl ation to achieve pleurodesis. VATS debridement of empyema Pleural infection, particularly early in its evolution, requires drainage, but once the fluid component becomes fibrinopu rulent and loculated it requires surgical debridement, which can often be achieved through a V ATS approach. The lung is isolated through the use of a double-lumen tube, the patient is positioned disease side up and the pleural cavity is entered. T he fluid and debris are vigorously debrided, freeing the lung and allowing for re-expansion. At the end of the case, carefully positioned chest drains are placed to allow for dependent drainage. Following the procedure, the patient requires good analge sic control, typically using patient-controlled analgesia (PCA), and physiotherapy to help fully re-expand the lung prior to final removal of chest drains. Decortication If the lung fails to re-expand after drainage of the empyema, the more radical operation of decortication may be required (Figure 60.10). The fibrous cortex or peel from the entrapped underlying lung is removed so that the lung can expand to obliterate the pleural space. This is usually performed through a posterolateral thoracotomy , though in selected cases it can be performed as a V ATS procedure. It requires careful dissection to remove the parietal and visceral cortex, taking care not to damage the visceral pleura, so allowing the lung to re-expand fully .

Figure 60.10 Chest computed tomography scan showing an empy ema with a grossly thickened pleura (arrow).

Surgical management of pneumothorax

Surgical management of pneumothorax

Pleurectomy and pleurodesis Surgery for pneumothorax can be performed by video-assisted thoracoscopic surgery (V ATS) or as an open procedure (thora cotomy). The object of the exercise is threefold: /uni25CF to deal with any leaks from the lung; /uni25CF to search for and obliterate any blebs and bullae; /uni25CF to make the visceral pleura adherent to the parietal pleura so that any subsequent leaks are contained and the lung cannot completely collapse. Pleural adhesion is achieved in one of three ways: 1 pleurectomy : systematically stripping the parietal pleura from the chest wall; 2 pleural abrasion : a scourer is used to scrape o ff the slick surface of the parietal pleura; 3 chemical pleurodesis : usually talc is used and is insuf flated into the chest cavity .) (f) (g) (e (h)

penetration of the skin, muscle and pleura; (c) blunt dissection of the parietal (f) digital examination along the tract into the pleural space; (g) withdrawal of

THE DIAPHRAGM

THE DIAPHRAGM

The diaphragm is the fibromuscular structure separating the thorax from the abdomen.

THE MEDIASTINUM

THE MEDIASTINUM

The mediastinum refers to the central area in the chest between the thoracic inlet and the diaphragm, between the right and left pleural surfaces, and which extends from the inner aspect of the sternum to the vertebral column. It contains the heart, great /uni00A0 vessels, trachea and oesophagus and is arbitrarily subdivided into compartments (superior, inferior, anterior, middle and posterior). Many of the regional lymph node chains draining the chest and its organs are also found

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in the mediastinum. Various surgical procedures to approach structures, and particularly lymph nodes, in the mediastinum are performed, usually as diagnostic procedures. The surgical approach when mediastinal tumours require resection depends on the anatomical location of the tumour (Figure 60.22 and includes median sternotomy for anterior mediastinal pathology , thoracotomy or V ATS for posterior mediastinal pathology and transcervical (neck incisions) for superior mediastinal pathology . The middle mediastinum can usually be approached through thoracotomy or V ATS. Increasingly , a robotic or RATS approach is used, particularly for anterior mediastinal tumours such as thymomas.

mediastinum mediastinum Thymoma Lymphoma Lymphoma Thyroid Germ cell tumour Parathyroid Middle mediastinum Cystic lesions Lymphoma Mesenchymal tumours Posterior mediastinum Neurogenic tumours Cystic lesions Mesenchymal tumours Figure 60.22 Mediastinal pathology. Subdivisions of the mediastinum with the most common mediastinal masses.

Treatment

Treatment

- Removal of the bronchiectatic part of the lung for bleeding, recurrent infection or copious symptoms can be very e ff ective when the disease is localised. y ,

Tuberculosis

Tuberculosis

Surgery is rarely indicated for tuberculosis in resource-rich countries but, when it is, it must be combined with adequate antitubercular chemotherapy or the benefit of surgery will be lost. Summary box 60.5 Tuberculosis: indications for surgery /uni25CF /uni25CF /uni25CF /uni25CF Diagnosis Surgical procedures may be necessary to establish the diag nosis if suspected clinically but sputum or pus cultures are persistently negative. Complications such as an aspergilloma in a chronic cavity causing life-threatening haemoptysis may require lobectomy

Suspicious lesion on chest radiograph in which neoplasia cannot be excluded Chronic tuberculous abscess, resistant to chemotherapy Aspergilloma within a tuberculous cavity Life-threatening haemoptysis