Lung

39

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39.1 Anatomy

The combined weight of both lungs is approximately 850 g in the male, 750 g in the female. The apex of each lung is situated in the root of the neck, the base of the lung on the diaphragm. The mediastinum is medial to the lungs, and ribs are present laterally. The hilum of each lung contains a main bronchus, pulmonary artery, two pulmonary veins, pulmonary nerve plexus, and lymph nodes.

The lungs are separated into lobes by invaginations of pleura along fissures (Fig. 39.1). The right lung is divided into three lobes by the oblique and horizontal fissures, the left into two lobes by the oblique fissure. The inferior part of the left upper lobe (the lingula) is the homologue of the right middle lobe.

The trachea branches at the level of T4 and T5 (thoracic vertebrae 4 and 5) into two main bronchi. The right bronchus enters the lung behind the right pulmonary artery, the left bronchus crosses behind the left pulmonary artery and enters the lung below it. The main bronchi divide to give five lobar bronchi. These then divide into segmental bronchi supplying the 19 bronchopulmonary segments. Segments are roughly wedge shaped with their base at the pleural surface. Each segment is supplied by a segmental artery and bronchus. Veins draining segments often anastomose with those from adjacent segments. Bronchopulmonary segments can be resected with little haemorrhage or leakage of air from adjacent raw surfaces. Further divisions of the bronchi produce bronchioles. Glands and cartilage are present in the walls of bronchi but not in bronchioles.

Bronchioles have a diameter of less than 1 mm. Terminal bronchioles lead to respiratory bronchioles, which branch to produce alveolar ducts, alveolar sacs, and then alveoli. The lung may be divided into lobules, areas that measure 1–2 cm across and are poorly demarcated by incomplete fibrous septa. Each lobule is made up of 3–10 acini. An acinus or terminal respiratory unit is that portion of the lung supplied by one terminal bronchiole. Pulmonary arteries are found at the centres of each acinus alongside bronchioles, whereas pulmonary veins run in the interlobular septa. Flattened type 1 pneumocytes and occasional rounded type two pneumocytes line the alveoli.

Lymphovascular drainage:

Lymphatic drainage is by a superficial subpleural lymph plexus and a deep plexus of vessels accompanying the bronchi. Both groups drain through hilar (bronchopulmonary) lymph nodes into tracheobronchial nodes around the bifurcation of the trachea and from there into mediastinal lymph trunks.

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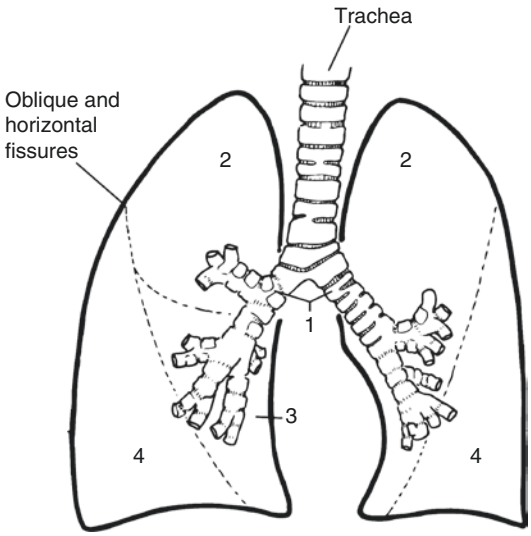

Fig. 39.1 Anatomy of the lungs. *1* Main bronchus, *2* upper lobe, *3* middle lobe, *4* lower lobe (Used with the permission of the Union for International Cancer Control (UICC), Geneva, Switzerland. The original source for this material is from Wittekind et al. (2005))

Blood supply to the lungs is by a dual arterial supply—the pulmonary arteries and the bronchial arteries. Blood returns to the heart via the pulmonary veins or travels in the bronchial veins to the azygos or accessory hemiazygos veins.

39.2 Clinical Presentation

Respiratory symptoms include cough, sputum production, dyspnoea (undue respiratory effort), orthopnoea (breathlessness on lying down), wheeze due to airway obstruction, haemoptysis (coughing up blood), and chest pain. The commonest cause of haemoptysis is acute infection. Other causes include tuberculosis (TB) and pulmonary infarction. Tumour, e.g., carcinoid or bronchial carcinoma, may cause haemoptysis due either to ulceration of the expanding tumour or secondary infection caused by obstruction. Chest pain can be localized and pleuritic, due to infection or infarction or constant, severe, and dull due to chest wall invasion by carcinoma. Lung cancer can produce secondary pneumonia, bronchiectasis, pleural effusions, hoarseness (laryngeal nerve involvement), and paralysis of the diaphragm (phrenic nerve involvement). Tumours in the apical part of the upper lobe (Pancoast's tumours) may result in unilateral Horner's syndrome due to involvement of sympathetic ganglia. Pancoast's tumours may also produce pain and weakness in the shoulder and arm due to invasion of the brachial plexus. Mediastinal disease may lead to superior vena cava syndrome with congestion and oedema of the face, neck, and chest associated with dyspnoea.

Paraneoplastic syndromes are systemic effects of tumours not mediated by tumour spread. They include Cushing's syndrome, inappropriate antidiuretic hormone secretion, and acromegaly. Weight loss may occur in chronic inflammatory diseases such as TB or secondary to tumours.

39.3 Clinical Investigations

- Chest x-ray: primary technique for imaging the thorax.
- CT scan—the only cross sectional imaging technique that adequately evaluates the lung parenchyma and is equivalent to MRI in the evaluation of mediastinum, pleura, and chest wall. CT has a sensitivity of 80–94% compared with results obtained by mediastinoscopy and lymph node sampling. CT scans are used to stage carcinoma of bronchus and may be extended to include liver, adrenal glands, and brain.
- High Resolution (thin section) CT scan (HRCT)—slices are 1–3 mm thick. HRCT is of value for the investigation of sarcoidosis, lymphoma, cryptogenic and extrinsic alveolitis, occupational lung disease, bronchiectasis, and lymphangitis carcinomatosa. It is also used to distinguish emphysema from interstitial lung disease or pulmonary vascular disease.
- Spiral CT scan and Ventilation/Perfusion (V/Q) scan—used in detection of pulmonary emboli.
- MRI—less useful than CT because of poorer imaging of lung parenchyma. MRI may be used in assessing disease near the lung apex, the spine, the thoracoabdominal regions, and

the mediastinum. It can detect invasion into spinal cord, vertebral bodies, brachial plexus and chest.

- PET scan—used to distinguish between benign and malignant conditions. If the lesion does not demonstrate high radiation activity, it is interpreted as having a low metabolic rate and is likely to be benign. Conversely it demonstrates FDG–avid primary cancers and their local and distant metastases.
- Respiratory function tests—include peak expiratory flow rate (PEFR), forced expiratory volume in 1 second (FEV1), vital capacity (VC), forced expiratory ratio (FEV/VC) and carbon monoxide transfer (Tco). These tests are helpful in differentiating between lung disease due to airways obstruction, restrictive conditions, or respiratory muscle weakness.
- Measurement of blood gases—important in the diagnosis of respiratory failure.
- Full blood picture (FBP)—haemoglobin: Anaemia, PCV, secondary polycythaemia.
- Biochemistry—alpha-1-antitrypsin levels, autoantibodies, *Aspergillus* antibodies, IgE to specific allergens. Hypercalcaemia occurs in one in five patients with sarcoidosis, as a paraneoplastic syndrome notably in association with squamous cell carcinoma and secondary to bony metastases. Hyponatraemia is seen in association with small cell carcinoma.
- Sputum—cytological examination of sputum can detect between 60% and 90% of malignancies if multiple specimens are examined. Gram stain and culture are of value in pneumonia, TB, and *Aspergillus*.
- Transthoracic needle aspiration and biopsy (TTNA and TTNB)/percutaneous needle aspiration and biopsy—performed under fluoroscopic or CT guidance. They successfully diagnose lung cancer with at least 85–90% accuracy. The most common indication for aspiration is to evaluate a solitary peripheral lung nodule suspicious of carcinoma. Biopsy is more appropriate when lymphoma or sarcoidosis is suspected. Needle core biopsies may be obtained from lesions close to the chest wall, while more central lesions require fine needle aspiration.
- Bronchial brushings and washings—fibreoptic bronchoscopy (FOB) can reach and sample up to 90% of malignancies.
- Transbronchial fine needle aspiration—at the time of FOB makes submucosal and paratracheal lesions accessible.
- Endobronchial and transbronchial biopsy—lead to a histological diagnosis in 95% of central lung carcinomas, but in only 50–75% of peripheral lesions.
- Transbronchial biopsy is of particular use in the diagnosis of sarcoidosis and lymphangitis carcinomatosa.
- Endobronchial Ultrasound Fine Needle Aspiration or Biopsy (EBUS FNA or Biopsy)-the use of ultrasound with bronchoscopy has increased diagnostic accuracy and yield and decreases the need for mediastinoscopy.
- Bronchoalveolar lavage (BAL)—using a flexible fibreoptic bronchoscope small volume lavages (up to 300 ml) are performed. BAL may be used to monitor progression of interstitial lung disease. It is useful in eosinophilic pneumonia, eosinophilic granuloma, pulmonary alveolar proteinosis, and in the diagnosis of opportunistic infections, e.g., in the immunosuppressed.
- Mediastinoscopy—allows access to, and biopsy of, lymph nodes. Cervical mediastinoscopy accesses paratracheal and subcarinal mediastinal nodes for diagnostic and staging purposes. Anterior mediastinoscopy is used primarily to sample enlarged nodes or tumour in the left aortopulmonary window region.
- Frozen sections—sent intra-operatively to distinguish between inflammatory and neoplastic parenchymal lesions, as a prequel to a cancer resection operation or a lung-sparing wedge resection. These specimens should be handled with care in a microbiological safety cabinet. If there is any suspicion of TB, frozen sections are inappropriate and should not be performed. Such tissue needs thorough formalin fixation.
- Open/closed lung biopsy—used to evaluate pleural/peripheral lesions and interstitial lung disorders.

39.4 Pathological Conditions

39.4.1 Non-neoplastic Conditions

Bacterial pneumonia: Lobar pneumonia can be of rapid onset in otherwise healthy patients, and entire lobes are involved by neutrophilic infiltrates. Bronchopneumonia affects older, debilitated patients and is characterized by more circumscribed infiltrates.

Lung abscess: An area of infection with parenchymal necrosis. Primary lung abscess occurs more often on the right side as the right main bronchus leads more directly off the trachea and aspiration can occur more easily. Secondary abscesses occur when there are predisposing factors such as carcinoma, foreign body, or bronchiectasis.

Viral infection: May occur in the lungs due to respiratory viruses such as influenza or in an immunocompromised patient (cytomegalovirus, respiratory syncytial virus, varicella zoster, or herpes simplex). Histological examination shows alveolar cell injury with a mononuclear cell interstitial infiltrate.

Tuberculosis: The characteristic histological lesion is the caseating granuloma. Primary TB presents with a solitary parenchymal nodule and hilar lymph node involvement. Secondary TB may present as miliary TB, tuberculous pneumonia, or cavitary TB.

Mycotic infections: Tangled masses of fungal hyphae and debris may be found in lung cavities and are known as fungal balls. These are usually non-invasive unless the patient is immunocompromised. *Aspergillus fumigatus* is the most common cause, the fungal balls being called aspergillomas. Surgery may be needed for diagnosis and treatment of disease resistant to medical treatment.

Pneumocystis jiroveci: A fungal organism, which occurs in immunocompromised patients. Classically there is an acellular intra-alveolar exudate. However, *Pneumocystis jiroveci* can produce any pattern of lung injury. Silver stains or antibody techniques demonstrate the organism.

Chronic bronchitis and *emphysema*: Often occur together. Emphysema is characterized by an increase in the size of airspaces distal to the terminal bronchioles. It is classified into three types depending on the part of the lung involved by the process—centrilobular, panlobular (panacinar), and paraseptal. Chronic bronchitis results from hypersecretion from bronchial mucous glands.

Bronchiectasis: Permanent abnormal dilatation of the bronchi with infection of the bronchial wall and obliteration of distal airways. Cystic fibrosis is the most common predisposing factor.

Endogenous lipoid pneumonia: May occur distal to a lung tumour and is secondary to breakdown of lung parenchyma. The alveoli contain lipid-laden macrophages.

Pneumoconiosis: Defined as permanent alteration of lung structure due to inhalation of mineral dusts and tissue reactions, which follow this. Included in this group are *silicosis*, *asbestosis*, *coal worker's pneumoconiosis*, *hard metal disease*, and *berylliosis*. *Asbestosis* is a form of interstitial fibrotic lung disease secondary to asbestos exposure. Fibrosis is characteristically found in the lower lobes, especially in the subpleural areas. Asbestos bodies are present in the lung parenchyma. Asbestosis may be graded depending on the amount of lung substance involved and the severity of the fibrosis. Other asbestos related conditions include benign pleural plaques, diffuse pleural thickening, and malignant mesothelioma. The incidence of carcinoma of the lung is increased in those with a history of asbestos exposure.

Interstitial pneumonia/cryptogenic fibrosing alveolitis/pulmonary fibrosis: Chronic inflammatory disease, which shows thickening of the alveolar walls, initially by lymphocytes and plasma cells, later by fibroblastic proliferation. Eventually "honeycomb lung" is produced with scarring and multiple air-filled spaces. The need to assess both spatial and temporal distribution of the pathology means that open or thoracoscopic lung biopsies from different zones are usually required. Of clinical value is the sub classification of interstitial pneumonia as prognosis and response to treatment varies between subgroups. These include *usual interstitial pneumonia* (*UIP*), *desquamative interstitial pneumonia* (*DIP*), *respiratory bronchiolitis-associated interstitial lung disease* (*RBILD*), and *non-specific*

interstitial pneumonia (*NSIP*). Prognosis and response to treatment are worse for UIP than other subgroups (5-year survival 55%).

Immune-mediated lung diseases: *Extrinsic allergic alveolitis* is a chronic granulomatous disease of the lungs due to inhalation of organic dusts, e.g., farmer's lung, bird—fancier's lung, mushroom worker's lung. Upper lobes are more severely affected than basal portions with fibrotic changes occurring in advanced disease.

Wegener's granulomatosis: In the lungs, it is characterized by vasculitis and granulomas. It may present as isolated pulmonary, upper respiratory or renal disease. Serum c-ANCA positivity is associated with the condition.

Sarcoidosis: Occurs most often in the lungs though lymph nodes, skin, eyes, liver, and spleen may also be affected. Characteristically, sharply circumscribed non-caseating epithelioid granulomas are present, and 25% of cases show marked interstitial fibrosis.

Pulmonary vascular disease: *Emboli* that lodge in peripheral arteries cause pulmonary infarcts in patients, whose pulmonary circulation is already compromised.

Pulmonary hypertension: Primary or secondary. Changes in the arteries may be graded according to the Heath-Edward's classification.

Lung transplantation: The most common indication for lung transplantation is emphysema, e.g., secondary to alpha-1-antitrypsin deficiency. Other indications include chronic obstructive pulmonary disease, septic disease such as cystic fibrosis, fibrotic lung disease, and primary pulmonary hypertension. Surveillance involves transbronchial biopsy to look for rejection, which is graded according to the 2007 working classification.

Rare conditions of variable neoplastic potential include *Langerhans cell histiocytosis* and *pulmonary lymphangioleiomyomatosis*.

39.4.2 Neoplastic Conditions

39.4.2.1 Benign Tumours

Most benign tumours are identified incidentally on chest X-ray as solitary lung nodules. The use of minimally invasive surgery such as video-assisted thoracic surgery has lowered the threshold for early referral and surgical excision.

Chondroid hamartoma: The most common benign lung tumour. It consists of a mass of cartilage with entrapped epithelial structures. Other connective tissue elements such as bone, adipose tissue, and fibrous tissue may be present.

Other benign tumours include *lipoma, sclerosing pneumocytoma, pleomorphic adenoma* and *haemangiopericytoma*.

39.4.2.2 Malignant Tumours

Lung cancer causes approximately 36,000 deaths annually in the UK and has a strong association with cigarette smoking. Two thirds of lung cancers are inoperable at the time of diagnosis. Traditionally lung cancer is classified into either small cell carcinoma (SCLC) or non-small cell carcinoma (NSCLC). The behaviour and treatment of the two groups differs. In general, SCLC is treated by chemotherapy, whereas NSCLC, after appropriate clinical staging, is either resected (stage pT2 N1 disease or less) or treated with radiotherapy or chemotherapy. Few patients with SCLC survive longer than 12–19 months. Patients with NSCLC have an average 5-year survival of 10–15%.

Increasingly, non-small cell lung carcinomas are being further sub-classified by specific cell type, e.g., squamous cell carcinoma, adenocarcinoma, using ancillary techniques such as immunohistochemistry if morphology is unhelpful. If the tumour is an adenocarcinoma, molecular testing is done for mutations which respond to targeted therapies eg epidermal growth factor receptor (EGFR), ROS-1, Anaplastic Lymphoma Kinase (ALK) status.

Squamous cell carcinoma: is a malignant epithelial neoplasm showing at least one of the following: keratinization as single-cell keratinization or keratin pearls, or, intercellular bridges. Squamous cell carcinomas mainly occur centrally in a main or lobar bronchus and can reach a considerable size with central necrosis. Histological variants include *keratinising, non-keratinising* and *basaloid squamous cell carcinoma.*

Adenocarcinoma: The commonest sub-type of lung carcinoma and is a malignant epithelial neoplasm showing glandular differentiation. It is the lung malignancy which occurs most frequently in non-smokers, females, and in the young. It often involves the upper lobes and may present peripherally as a subpleural mass or nodule, with retraction of the pleura. Lung adenocarcinoma is classified into the following subtypes: lepidic, papillary, acinar, micropapillary, solid, invasive mucinous, colloid, fetal and enteric adenocarcinoma. *Minimally Invasive Adenocarcinoma*: a resected lesion ≤30 mm diameter showing an invasive component ≤5 mm and is sub classified into *mucinous* and *non-mucinous* types. *Adenocarcinoma in situ*: a resected lesion ≤30 mm diameter showing a purely lepidic pattern with no evidence of stromal, vascular or pleural invasion and can be mucinous or non-mucinous. *Adenosquamous carcinoma:* shows areas of both squamous cell and adenocarcinomatous differentiation, with the minor component accounting for at least 10%. Prognosis is worse than for pure squamous cell carcinoma or adenocarcinoma.

Secondary adenocarcinomas: may come from pancreas, colon, ovary, or kidney and show various patterns. If there is involvement of the hilar nodes and significant scarring, then the tumour is more likely to be a primary; if multiple tumours are present, it is more likely to be secondary.

Large Cell Carcinoma: is used only in resection specimens for tumours that lack any clear morphologic or immunohistochemical differentiation.

Neuroendocrine tumours: these include *Small Cell Carcinoma, Typical and Atypical Carcinoids and Large Cell Neuroendocrine Carcinoma.*

Typical carcinoid tumours: Account for 90% of bronchial carcinoids. The vast majority are cured by complete excision with more than 90% 10-year survival. They are of low malignant potential—only 10–15% spread to local lymph nodes and distant metastases are rare. Typical carcinoids may occur either centrally or peripherally. Grossly, they are yellowish or pale tan and may be "dumbbell"-like, as they extend into the lumen of the bronchus and the lung parenchyma. They are composed of a uniform cell population arranged in ribbons, cords, or islands. In peripheral carcinoids, the cells are often spindle shaped. They have fewer than two mitoses per ten high power fields and show no necrosis. It is recommended that resection margins should be to within 5 mm of the tumour.

Atypical carcinoids: Metastasize in 50–70% of cases with a 5-year survival of 60%. Necrosis, which is usually focal, and increased mitotic activity (>2–10/10 high power fields) are the most reliable indicators of malignant behaviour.

Small cell carcinoma (*SCLC*): Accounts for 15% of all lung cancers. SCLC is most often located centrally and tends to metastasize early and extensively. It is the lung carcinoma most frequently associated with paraneoplastic syndromes. It is primarily treated with chemotherapy, the role of surgery usually being limited to obtaining a definitive tissue diagnosis and for staging. Histological examination shows small or medium-sized cells with scanty cytoplasm, arranged in nests, ribbons, or strands but often showing a lack of an architectural pattern. A variant of small cell carcinoma is a combined tumour where other tumour elements such as squamous or adenocarcinoma are present.

Large Cell Neuroendocrine Carcinoma (LCNEC): shows a histological pattern of large cells with a high mitotic rate, necrosis and positivity for neuroendocrine immunohistochemical markers.

Salivary gland tumours: *Adenoid cystic carcinoma* is most commonly located in the trachea and major bronchi. The tumour shows a cribriform pattern with tubular and solid areas. Perineural infiltration is common. It is generally slow growing. *Mucoepidermoid carcinoma* arises from minor salivary gland lining the tracheobronchial tree.

Other cancers include the *sarcomatoid carcinomas—pleomorphic carcinoma, spindle cell carcinoma and giant cell carcinoma* containing spindle cells and/or giant cells. Rare cancers: *Carcinosarcomas* contain both malignant epithelial and sarcomatous elements. *Blastomas* have a biphasic pattern consisting of epithelial tubules or cords in an undifferentiated stroma. *NUT carcinoma* is a carcinoma associated with chromosomal rearrangements in the NUT (Nuclear Protein in Testis) gene.

Extranodal marginal zone lymphoma of mucosa-associated lymphoid tissue (Malt lymphoma): is

the commonest primary lung lymphoma. It may be solitary or multifocal. Histological examination shows a monomorphic population of centrocyte-like cells. Most malt lymphomas are low grade but can transform to high grade. Lymphoma may also present in the lung secondary to nodal or systemic disease. Other lymphomas include *diffuse large cell lymphoma*, *lymphomatoid granulomatosis* and *intravascular large B cell lymphoma*.

Tumours of ectopic origin: include *germ cell tumours* such as *mature teratoma* and *immature teratoma, intrapulmonary thymoma, melanoma* and *meningioma.*

Tracheal tumours: Primary tracheal tumours are rare, secondary tumours being more common. In adults, most primary tracheal tumours are malignant and include s*quamous cell carcinoma*, which is usually locally advanced at the time of presentation, and *adenoid cystic carcinoma*.

Chest wall tumours: *Malignant small cell tumour of the thoracopulmonary region* (*Askin tumour)* occurs in the first two decades of life. It is composed of sheets of undifferentiated, small, hyperchromatic cells, which may form rosettes around a central tangle of fibrillary cytoplasmic processes. Other chest wall tumours include *extra-abdominal desmoid tumours*, *elastofibroma dorsi*, and primary tumours of muscle, fat, blood vessels, nerve sheath, or bone.

39.5 Surgical Pathology Specimens: Clinical Aspects

39.5.1 Biopsy Specimens

Percutaneous/transthoracic needle biopsy: Performed under X-ray guidance, an 18-gauge needle is inserted with the aid of a spring-loaded firing device. The biopsy is rinsed directly into the fixative. Occasional cases require fresh tissue to be sent for microbiological culture. Fresh frozen or glutaraldehyde fixed tissue may be needed for special investigations (specialized immunohistochemistry, electron microscopy).

Endobronchial/transbronchial biopsies: Taken by rigid or flexible bronchoscopy. The rigid bronchoscope ranges from 3 to 9 mm in diameter and may be used for straight ahead viewing or at 30° or 90° for visualization of the upper lobe bronchi. It is essential for complete examination of the trachea as a flexible bronchoscopy may miss lesions. It may also be used for brush cytology, biopsy, and to trap sputum for cytology and culture.

However, it allows visualization of major lobar orifices only and is usually performed under general anaesthetic. Flexible bronchoscopes have outer diameters ranging from 3 to 6 mm. Light is transmitted through fibreoptic bundles. The bronchoscope can be attached to a video camera for large screen display. The working channel allows insertion of various diagnostic and therapeutic accessories. Biopsy forceps are inserted to obtain bronchial or transbronchial biopsies. Lesions not accessible to direct biopsy can be approached with a brush to obtain specimens for cytological or microbiologic analysis. Needles may also be used for aspiration and biopsy. Flexible bronchoscopy is the endoscopic procedure of choice as it is simple, quick to use, and is performed under local anaesthetic.

Open lung biopsies: Obtained by thoracotomy for the assessment of peripheral lung disease.

39.5.2 Resection Specimens

Video-assisted thoracoscopic surgery (*VATS*): Direct thoracoscopy is being replaced by video-assisted thoracoscopic surgical (VATS) technique. VATS allows access to peripleural lung nodules, biopsy, and sampling of mediastinal nodes, especially in the aortopulmonary window, examination of the pleural space for tumour, wedge resection of lung for diagnosis of diffuse lung infiltrates, or peripheral nodules, and resection of apical pleural blebs for spontaneous pneumothorax.

Wedge/segmental resections: Obtained via open lung biopsy or video-assisted closed chest biopsy. They are used to sample focal areas that are suspicious, e.g., pleural-based nodules or to resect tumours if a patient cannot tolerate a more extensive procedure. Recurrence rates of tumour are higher than with more radical surgery.

Bullectomies: Used to excise bulla to improve lung function via a median sternotomy approach, posterolateral thoracotomy, or VATS.

Bronchoplastic or sleeve resections: Used as an alternative to pneumonectomy. They are lung sparing and are typically used to resect proximal endobronchial lesions at, or adjacent to, the carina in order to preserve distal, uninvolved lung.

Sleeve lobectomy: Excision of a lobe with the associated lobar bronchus and subsequent anastomosis of the distal bronchial tree to the proximal airway.

Bronchial sleeve resection: Resection of either mainstem bronchus with anastomosis of the distal airway to the carina or lower trachea.

Sleeve pneumonectomy: Resection of the carina with pneumonectomy and anastomosis of the contralateral distal bronchus to the distal trachea.

Lobectomy/bilobectomy: Resection of one or two lobes of lung and includes complete resection of hilar (N1) lymph nodes draining the primary tumour.

Pneumonectomy: Resection of the whole lung and accounts for 20% of all lung resections. It is indicated when tumour invades hilar structures such as the mainstem bronchus or the main pulmonary artery. It is also indicated when tumour crosses the oblique fissure or when there is lymph node involvement along the mainstem bronchus proximal to the upper lobe take-off. In the majority of cases, it is for the purpose of resecting tumours, an exception being recipient pneumonectomy performed prior to lung transplant.

Extended pulmonary resection: Extension of the limits of conventional pulmonary resection with an en bloc excision of contiguous intrathoracic structures involved by tumour.

Extrapleural pneumonectomy: Indications include resection of malignant mesothelioma or rarely carcinoma of the lung, which is restricted to the lung, pleura, and local lymph nodes.

Surgical incisions: The most versatile approach used by the thoracic surgeon is the *posterolateral thoracotomy*. The incision is 8 cm lateral to the 6th thoracic spinous process and curves forward, 2 cm below the tip of the scapula to the mid-axillary line in the line of the ribs. It is used in unilateral lung resection, chest wall tumour resection, unilateral lung volume reduction surgery, bullectomy, and tumours of the posterior mediastinum.

Anterolateral thoracotomy and axillary thoracotomy are used with decreasing frequency. *Median sternotomy* is used in mediastinal tumour resection, bilateral lung volume reduction surgery or bullectomy, resection of multiple pulmonary lesions (e.g., metastases) and transpericardial access to the trachea or bronchus, e.g., carinal tumours.

The thoracoabdominal approach is used in procedures where access is needed to both pleural and peritoneal cavities. Bilateral anterior thoracotomies (also known as the clamshell incision) provide maximum exposure of both hemithoraces and mediastinal structures. This approach is used in bilateral lung resections such as lung transplant and lung reduction surgery.

Lung volume reduction surgery (*LVRS*): A palliative surgical procedure for patients with end-stage emphysema in which 20–30% of each upper lobe is resected.

39.6 Surgical Pathology Specimens: Laboratory Protocols

39.6.1 Biopsy Specimens

Small biopsies are promptly put into 10% formalin fixative.

Endobronchial/transbronchial biopsies:

- Count the number of fragments.
- Record the greatest dimension of the largest fragment (mm).
- Note the colour and consistency of the fragments.
- Place the fragments in cassettes between foam pads or wrapped in filter paper or in molten agar for processing.
- Cut through multiple levels, keeping intervening spares for further stains.

Open lung biopsy:

- Re-inflate the lung using a formalin injection.
- Record the size (mm) and weight (g)/number of fragments.

- Describe the colour and consistency.
- Serially transverse section at 3 mm intervals and sample representative blocks.

Histopathology report:

- Nature of biopsy.
- Size of biopsy (mm), number of fragments.
- Bronchial wall—epithelium, thickness of wall, goblet cell hyperplasia, malignancy.
- Alveoli—count approximate number, type I or II pneumocyte proliferation, inflammation, macrophages in lumen, consolidation.
- Nature of inflammatory cells if present.
- Fibrosis if present: type—interstitial, intra-alveolar (BOOP), grade of fibrosis—mild, moderate, severe.
- Other pathology—vascular, asbestos bodies, doubly refractile material.
- If transplant, grade rejection according to the 1995 working formulation.

39.6.2 Resection Specimens

Larger specimens are put into dry containers and brought promptly to the laboratory.

39.6.2.1 Wedge Resections (Or Cornish pastie)

- Consist of a triangular segment of lung and pleura with two staple lines at the margin (Fig. 39.2).
- Palpate the specimen to locate the lesion.

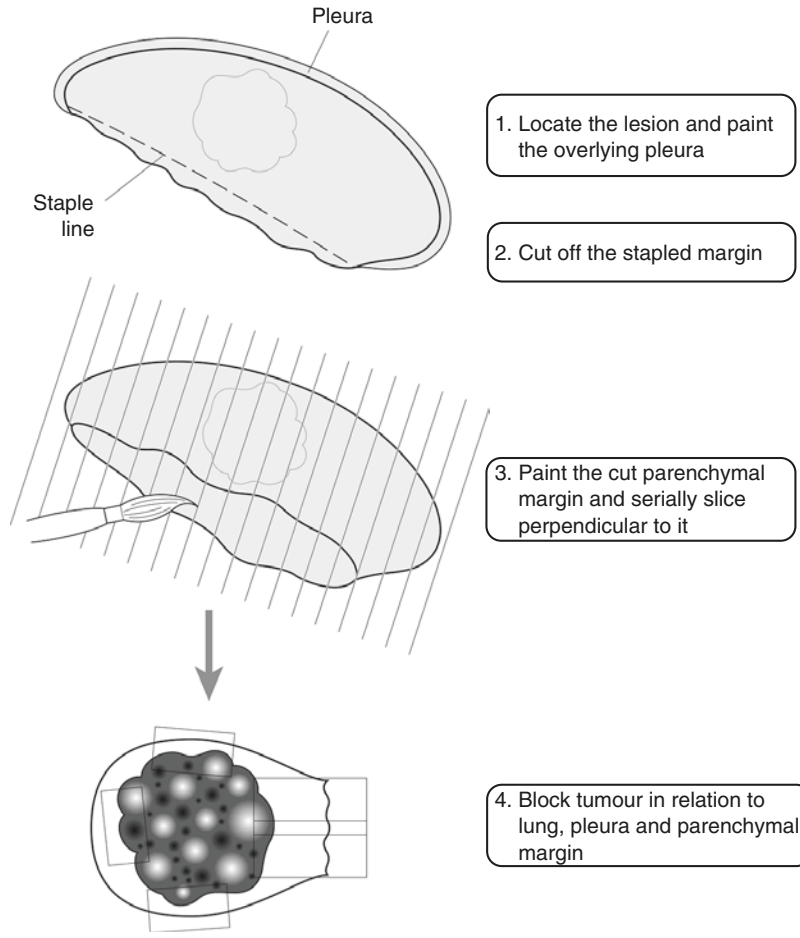

Fig. 39.2 Blocking a wedge resection of lung (Reproduced, with permission, from Allen and Cameron (2013))

- Record the dimensions (cm).
- Describe the pleura.
- Inflate with a syringe of formalin. A disadvantage of inflation fixation is that free cells may be cleared from consolidated alveoli so that diagnoses such as desquamative interstitial pneumonia (DIP) are obscured. Measure the length of the margin. Cut off the staple line as closely as possible. The cut surface of the lung can be taken *en face* or perpendicularly. The open surface is inked.
- Ink the pleural surface over the lesion.
- Serially transverse section at 3 mm intervals.
- Describe the lesion—size, colour, pleural involvement, distance (mm) from margin.
- Describe the remainder of the lung.
- Take representative sections of any lesion, of its relationship to the pleura and uninvolved lung, and the closest margin.
- If the lung disease is diffuse, submit the vast majority of the specimen for histology.

39.6.2.2 Lung Resection for Tumours

Most resections are for tumour: lobectomy, bilobectomy, and pneumonectomy.

Initial procedure:

- Palpate to locate tumour or areas of abnormality.
- Specify which lung or lobe.
- Record the weight (g) and dimensions (cm). Ink the pleura overlying the tumour.
- Remove the bronchial margin by sectioning transversely, before inflation fixation (Fig. 39.3). Sample the hilar nodes.
- Inflation: If the specimen is intact, instill fixative from a height of about 25 cm via tubing that terminates in a nozzle wedged into the

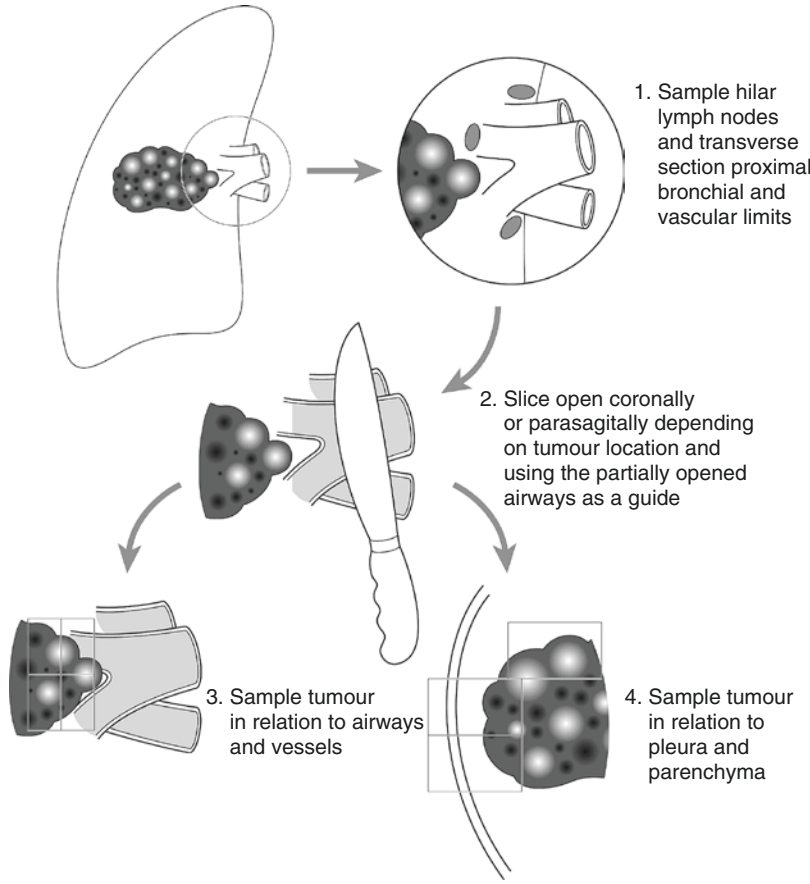

Fig. 39.3 Blocking a pneumonectomy specimen (Reproduced, with permission, from Allen and Cameron (2013))

supply bronchus or bronchi. Continue until the pleural surface is smooth. Immerse in a container of fixative overnight with a covering of lint or filter paper to prevent drying. If the specimen is not intact, inflate with a syringe. Remember to culture, if appropriate, before fixation.
- Allow to fix for 24–36 h.
- To access airways open from the hilum, pass a probe down to the tumour and then cut along it.
- Serially slice the tumour at 3 mm intervals in the plane that best demonstrates its relationship to the anatomical structures. In general, mid-zone and peripheral lesions are sliced parasagittally, hilar lesions coronally.
- With vascular lesions such as pulmonary emboli, approach laterally within fissures cutting towards the hilum until the pulmonary artery is entered.
- Photograph.
- Ribs—decalcify.

Description:

- Lesion site—central/peripheral, main/segmental bronchus.
  - Endobronchial/bronchial/extrabronchial/extrinsic compression.
  - Distances (mm) to the bronchial or parenchymal resection margins/pleura.
- Lesion size—length × width × depth or maximum dimension (cm).
- Lesion appearance—colour/consistency/necrosis/haemorrhage/cavitation.
- Lesion edges—circumscribed/infiltrative.
- Lung—emphysema/fibrosis/bullae/bronchiectasis/mucus plugging/post-obstructive pneumonia.
- Hilar lymph nodes—number/size/colour/consistency.

Blocks for histology (Fig. 39.3):

- Transverse section the proximal resection margin and the pulmonary staple margin if the specimen is a lobectomy.
- Submit all hilar lymph nodes. The surgeon for staging purposes often also submits other separate named lymph node stations, and these are processed separately. The regional lymph nodes are the intrathoracic (mediastinal, hilar, lobar, interlobar, segmental, subsegmental), scalene and supraclavicular nodes. A mediastinal/hilar lymphadenectomy will ordinarily include 6 or more lymph nodes.
- Sample four sections of tumour showing relationships to uninvolved lung, adjacent bronchi, and vessels and the nearest aspect of the pleura.
- Sample uninvolved lung (one or two blocks—more if there is suspected asbestosis).
- Sample the margins of any attached parietal pleura, chest wall soft tissue, or ribs—represent the deepest point of rib invasion.

Histopathology report:

- Type of procedure—wedge resection, lobectomy, bilobectomy, pneumonectomy.
- Tumour type—squamous carcinoma/adenocarcinoma/small cell carcinoma/large cell carcinoma/neuroendocrine tumours/salivary gland type adenocarcinoma/others.
- Tumour differentiation—well/moderate/poor.
- Tumour edge—pushing/infiltrative/lymphoid response.
- Elastin stain may be helpful in recognizing visceral pleural invasion.
- *Extent of local tumour spread: TNM 8 for non-small cell carcinoma, small cell carcinoma and bronchopulmonary carcinoid tumours. Sarcomas are excluded*

pTis	Carcinoma in situ
pT1a	Tumour ≤10 mm diameter
pT1b	Tumour >10–≤20 mm
pT1c	Tumour >20–≤30 mm
pT2	Tumour >30–≤50 mm, or any of: involves main bronchus but not the carina, invades visceral pleura, partial atelectasis/obstructive pneumonitis extending to the hilum
pT2a	>30–≤40 mm
pT2b	>40–≤50 mm

pT3	Tumour >50–≤70 mm; or any of: involvement of parietal pleura, chest wall, phrenic nerve, parietal pericardium or separate tumour nodule(s) in the same lobe as the primary
pT4	Tumour >70 mm, or any of: involvement of great vessels, mediastinum, heart, diaphragm, trachea, recurrent laryngeal nerve, oesophagus, vertebra, or carina. Separate tumour nodule(s) in different ipsilateral lobe to the primary
pN0	No regional node involvement
pN1	Ipsilateral hilar/peribronchial/ intrapulmonary nodes (node stations 10–14)
pN2	Ipsilateral mediastinal/subcarinal nodes (node stations 1–9)
pN3	Contralateral mediastinal, hilar, ipsilateral or contralateral scalene, supraclavicular nodes
pM0	No distant metastasis
pM1	Distant metastasis
pM1a	Separate tumour nodule(s) in a contralateral lobe, pleural or pericardial nodules or malignant pleural or pericardial effusion
pM1b	Single extrathoracic metastasis in a single organ
pM1c	Multiple extrathoracic metastases in a single or multiple organs

- Excision margins—distances (mm) to the proximal bronchial, vascular and mediastinal limits and pleura.
- Other pathology—atelectasis/bronchiectasis/ lipid or suppurative pneumonia.

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