Fig. 6.10 Consolidation: (a) and (b) right upper lobe; (c) and (d) right middle lobe.
Fig. 6.11 Posteroanterior chest X-ray showing bronchopneumonia. There is patchy consolidation in the mid and lower zones of the left lung. In this patient this was due to tuberculosis. Note that the left lung is less well expanded than the right, as shown by the more acute angulation of the rib cage on the left side.

**Linear tomography**

The routine chest X-ray consists of shadows at all depths in the chest superimposed on one another. It has the disadvantage that not more than some 40% of the lung tissue is shown unobscured by shadows of the bony thorax or mediastinum. The tomograph is a device whereby a picture is obtained of a section of the thorax at any chosen depth. The X-ray tube above the patient and an X-ray film below the patient are linked by an arm and rotated around a pivot whilst the picture is being taken. The centre of the pivot is aligned with the level of interest in the chest and the result is that only this section is in focus, while everything else is blurred. Multiple sections can be taken and often quite confusing complex shadows can be distinguished into specific anatomical and pathological features (see Figs 6.10 and 6.12).
Fig. 6.12  (a) Chest X-ray showing a mass overlying the heart. (b) Tomography showing the mass to be intrapulmonary and close to the main bronchi (arrow).
Computerized tomography

This technique produces serial tomographic images in an axial plane. Its particular value in chest disease is in revealing the presence of small malignant deposits within the lung which are not visible on the chest X-ray, showing pleural shadows in much greater detail, and in enabling mediastinal shadows to be more accurately demonstrated and delineated (Fig. 6.13).

Fig. 6.13 (a) Mediastinal mass shown on computerized tomography reconstruction; posteroanterior view. (b) Dense anterior mediastinal mass shown on computerized tomography scan.
Radioisotope imaging

Within the lung, the most widely used technique is of perfusion scanning or combined ventilation and perfusion scanning. The particular value of this technique is in aiding the diagnosis of pulmonary embolism although the results must be interpreted in conjunction with the clinical situation. The typical symptoms of pulmonary embolism are breathlessness, pleuritic chest pain and haemoptysis, but these are not always all present. There may be no abnormal physical signs and, especially in the early stages, the chest X-ray may be normal. It is in this situation that lung perfusion scanning may be most useful.

Fig. 6.14 Ventilation (V)/perfusion (Q) isotope scan of the lungs. Segmental and sub-segmental loss of perfusion (left) can be seen with relatively normal ventilation (right). The clear punched-out areas in the perfusion (Q) scans indicate areas of reduced isotope concentration during the perfusion scan. Thus these are areas of reduced blood flow. The ventilation scans show normal aeration of the lungs as depicted by the isotope distribution in the pulmonary airways. These sequences of scans are suggestive of pulmonary embolism because they show impaired perfusion with normal ventilation.
A lung perfusion scan is performed by injecting a small dose of $^{99m}$technetium-labelled macroaggregated human albumin particles intravenously and subsequently taking a gamma-camera picture of the impacted particles in the lung (Fig. 6.14). When the distribution of perfusion is abnormal, additional information can be obtained by studying the distribution of ventilation; this can be shown using an inhalation of a radioactive gas such as $^{81m}$krypton. Comparison of the pictures enables matching or mismatching of ventilation and perfusion defects to be observed.

It is generally agreed that if a patient has a normal chest X-ray and a normal lung perfusion scan within 24 hours of the suspected event, it is unlikely that a pulmonary embolism has occurred. The difficulty comes in interpreting abnormal scans, since perfusion defects may arise not only from emboli but also may be due to regional abnormalities in ventilation, as is found in patients with asthma or chronic airflow obstruction. In these cases the defect in ventilation and perfusion is often matched although this may also occur when pulmonary embolism is present. The best which can be obtained from lung perfusion and ventilation scanning is a percentage probability of pulmonary embolism having occurred, taking into account the clinical likelihood of the diagnosis being correct.

**Ultrasound**

Ultrasound is a valuable non-invasive method of assessing pleural fluid and tumours. Sometimes it is not clear from a chest X-ray whether basal shadowing consists of pleural fluid, pleural thickening or tumour, consolidation of the lung, or a combination of all three. A lateral decubitus X-ray may resolve the problem by demonstrating the presence of free fluid but if this is insufficient then ultrasound examination in a number of positions can show the extent of fluid, whether or not it is loculated, and the locations of associated pleural and pulmonary changes.

**Magnetic resonance imaging (MRI)**

MRI may be of use in demonstrating mediastinal abnormalities but its role in comparison with computerized tomographic scanning is, as yet, incompletely understood.

**PLEURAL ASPIRATION AND BIOPSY**

A pleural effusion can give rise to diagnostic problems and sometimes management problems when the amount of fluid causes respiratory embarrassment.

When a pleural effusion is seen as a presenting feature in a middle-aged or older patient in the UK, the most likely cause is carcinoma. Less commonly,
particularly in younger patients, it may be due to tuberculosis. In either case
the diagnosis is best obtained by aspiration and pleural biopsy. Aspiration
alone has a lower incidence of accuracy.

A useful technique of pleural biopsy is to use an Abram’s pleural biopsy
needle. This can be inserted under local anaesthesia posteriorly or laterally
whilst the patient is in a comfortable sitting position resting his arms and head
on an overbed tray. The needle should be inserted a little below the upper edge
of maximum dullness using local anaesthesia and a small sharp pointed scalpel
incision to aid passage of the needle through the skin and muscle. This needle
can be used to aspirate up to 1 litre of fluid in order to obtain samples and
relieve symptoms, but before all the fluid present has been aspirated samples
of the pleura can be taken and sent for histological examination.

The pleural fluid should be examined for protein content. A transudate as
occurs in cardiac and renal failure can be distinguished from an exudate,
usually resulting from pleural inflammation, by its lower protein content (less
than 30 g/l). Frankly blood-stained effusions occur with carcinoma, pulmo-
nary infarction, trauma, and sometimes tuberculosis. More commonly, however,
in tuberculous effusions the fluid is straw-coloured and has a high protein
content. The fluid should also be examined for cell content. Many polymorphs
may be seen if fluid is secondary to an underlying pneumonic infection. With
tuberculosis the fluid usually contains many lymphocytes. Tubercle bacilli are
rarely seen and, even in biopsy-proven cases of tuberculous pleural effusion,
may only be cultured in less than 20%. Cytological examination of pleural
fluid may demonstrate the presence of malignant cells.

In empyema pus is present in the pleural cavity; this pus has characteristic
appearances and will be full of white cells and organisms.

**Thoracoscopy**

This technique enables the pleural cavity to be directly examined and biopsies
to be taken under direct vision. The procedure is commonly performed under
a general anaesthetic by a surgeon who uses a rigid thoracoscope after the lung
has been deflated. More recently flexible thoracoscopes have been developed
which can sometimes be used under local anaesthetic but this technique is only
available in specialized centres.

**Pleurodesis**

Where pleural fluid is troublesome and causing breathlessness, as is often the
case in patients with large malignant pleural effusions, it may be useful to
perform pleurodesis. In some patients with extensive carcinoma the pleural
effusion may be a terminal event but in patients with breast carcinoma there is
commonly prolonged survival after treatment of malignant pleural effusion
and effective pleurodesis is very worthwhile.
The best technique is to insert a size 16 plastic catheter into the chest under local anaesthetic and either slowly or intermittently drain the pleural fluid over 24 hours or longer. When the pleural cavity is dry, an agent such as tetracycline (500 mg) can be instilled through the tube and after a period of clamping the pleural cavity can again be drained and sucked completely dry using a suitable vacuum pump. The tube can subsequently be removed; this technique usually produces an 85% success rate in preventing recurrence of the pleural fluid.

**Pneumothorax**

When air leaks into the pleural space either spontaneously, as commonly occurs in otherwise fit young people, or as a result of an injury with puncture of the lung, a pneumothorax develops (Fig. 6.9). This may require treatment and it is often worthwhile in the first instance aspirating up to 1 litre of air from the pneumothorax using a small plastic cannula and a 50 ml syringe with the three-way tap connected to an underwater seal. The best position for aspiration of an uncomplicated pneumothorax is with the patient sitting at an angle of about 45°; the needle is inserted in the second intercostal space in the mid-clavicular line. This technique is successful in many patients and avoids the need for an intercostal drain. If it does not work, however, an intercostal drain must be inserted in the same position and connected to an underwater seal until there has been complete re-expansion.

**Bronchoscopy**

When an abnormal shadow is detected on the chest X-ray or if the patient has haemoptysis with a normal X-ray, bronchoscopy may be indicated. Normally this is done by the technique of fiberoptic bronchoscopy. The flexible bronchoscope can be passed transnasally in the conscious patient with the help of local anaesthesia. Any endobronchial abnormality can be visualized and biopsies taken using small flexible forceps. In addition, cytological brushing techniques can be performed and specimens of bronchial secretions obtained for microbiological and cytological examination.

The forceps can also be used for obtaining small samples of lung by the technique of transbronchial biopsy. This is particularly useful in diagnosing patients with sarcoidosis.

Useful information about the nature of lung infiltrates can be obtained by broncho-alveolar lavage. For this procedure the bronchoscope is wedged in a bronchus supplying one segment of the lung and a quantity of saline instilled and then removed via the bronchoscope suction channel. The subsequent handling and interpretation of these specimens requires histological examination by a cytopathologist.
Lung biopsy

In addition to obtaining small samples of lung, the technique of transbronchial biopsy can, in conjunction with X-ray screening, be used to biopsy small lesions not in direct vision through the bronchoscope. Solid lesions or cavitating lesions of this type may more usefully be biopsied using a fine aspiration needle. This is inserted percutaneously under X-ray or computerized tomography control.

Rarely it may be necessary to perform a thoracotomy in order to elicit the exact nature of an abnormality but this decision should only be taken after weighing up all the relative risks and benefits.

IMMUNOLOGICAL TESTS

Sometimes asthma is related to the development of type I hypersensitivity to certain allergens and part of the assessment of such patients may include skin prick tests. Bronchial provocation tests are used in certain circumstances by specialized laboratories.

The delayed type of hypersensitivity (type IV) is shown by the Mantoux and Tine tests used to detect the presence of sensitivity to tubercular protein.

Precipitating antibodies are present in patients with some fungal diseases such as bronchopulmonary aspergillosis or aspergilloma. In patients suspected of having an allergic alveolitis antibodies may be demonstrated to the relevant antigens. Immunoglobulin E levels are often raised in patients with asthma.
Clinical assessment of the cardiovascular system requires a rational approach in order to analyse the available information in a coherent manner. In each patient the clinician must integrate the facts available from the history, the examination and the investigations in such a way as to reach a conclusion about the structure and function of the heart, and of the pulmonary and systemic vascular trees. In this respect, the clinical approach to the cardiovascular system has many similarities with the approach to the nervous system.

GENERAL CONSIDERATIONS

Careful assessment of the arterial and venous pulses and of the praecordial impulse should always precede auscultation of the heart. Many students give