CHAPTER 6. PULMONARY IMAGING

6.1 X-ray methods of respiratory system examination

Chest radiograph is the primary and the most frequent method of lung examination. In addition, it is the examination that you most likely will review by yourself. Chest radiographs number more than half of all the examinations performed in any radiology practice. Chest radiograph certainly is used to diagnose pulmonary diseases, traumas of thorax and polytraumas, in patients with not clear reasons of fever, in patients with oncological diseases.

Chest radiograph can be of 2 types: survey and targeted. Survey chest radiograph (fig.6.1, 6.2), as a rule, are carried out in two projections – direct and lateral (how the body is oriented to the x-ray source).

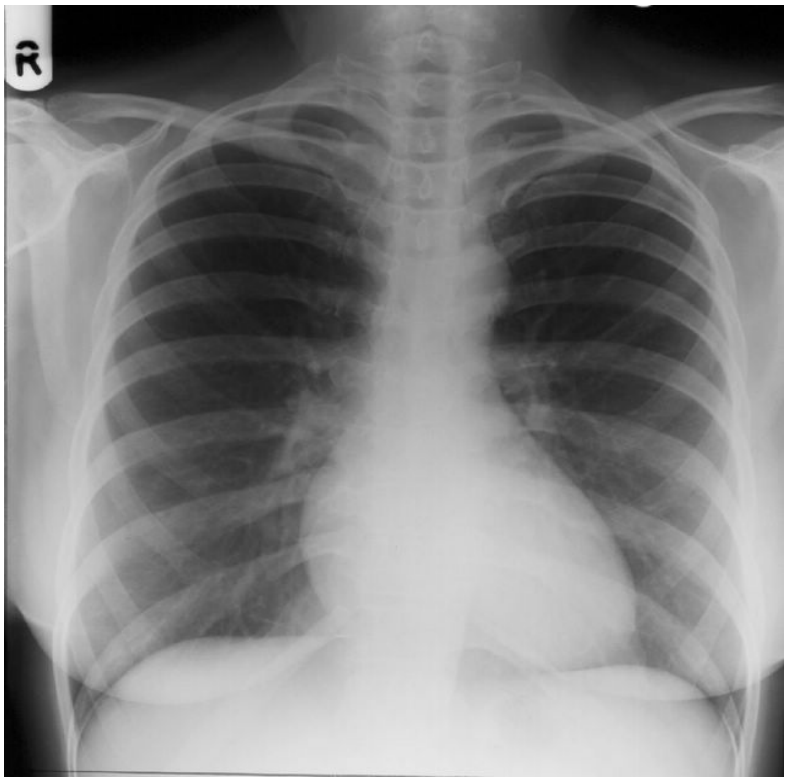

Fig. 6.1. Chest radiograph. Posterior-anterior projection.
Norm.
See text.

Linear tomography. The technique is the following stage in radiological examination. The linear (conventional) direct tomography is carried out more often. The median cut is made at the level of half of thorax's width; the middle of anteroposterior diameter (from the back to the sternum) in the adult is 9-12 cm. The anterior cut is 2 cm is closer from the median one anteriad; the posterior cut is 2 cm retrad from the median one. Shadows of neither anterior nor posterior parts of ribs are not detected on the median tomogram. Anterior parts of ribs can be seen on the

anterior tomogram, posterior parts, vice versa, can be visualized on the posterior tomogram (fig. 6.3).

Fig 6.2. Chest radiograph, right lateral projection
Normal view

Usually according to these basic attributes topographical lung cuts can be easily identified. The linear tomography is applied for:

- estimations of major airways;
- specifications of structure of pathological formation (disintegration, calcification);
- tumour detection against the background of obstructive changes;
- visualization of the increased lymph nodes in lungs and mediastinum.

CT. The computed tomography provides the diagnostic information unattainable by other methods (fig. 6.4). CT it is applied for:

- . detection of the pathological changes hidden by pleural pleural exudate;
- assessment of interstitial patterns;
- differentiation of solid and liquid formations in lungs;
- detection of nodules up to 15 mm;
- detection of larger foci of lesion located inconveniently for diagnostics or with insignificant increase in density;
- visualization of pathological formations in mediastinum;
- by means of CT carry out virtual bronchoscopy;
- in case of probable surgical or radiotherapy treatment.

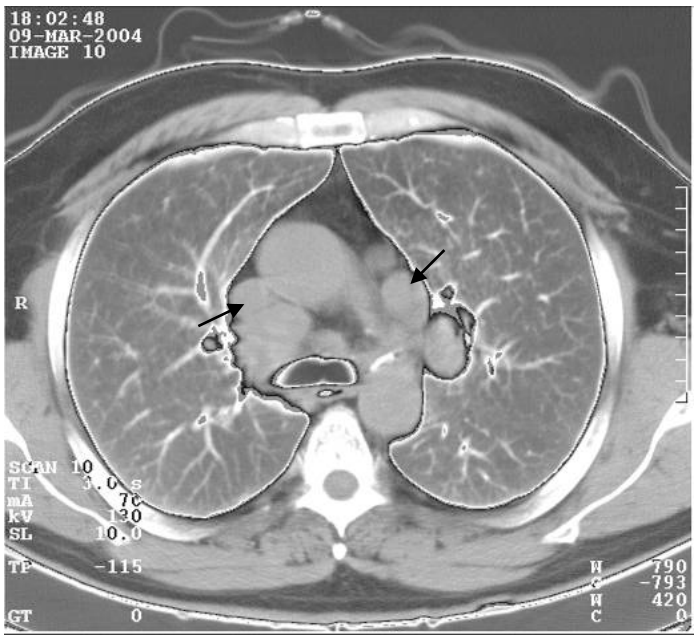

Fig. 6.4. CT-scan at a level of a bifurcation of a trachea. Enlarged lymph nodes without a calcification in a mediastinum (arrows). Hodgkin's lymphoma

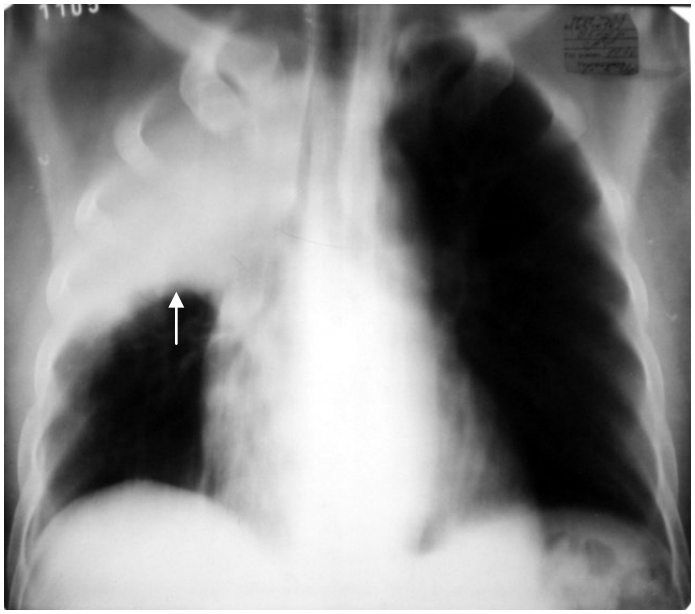

Fig. 6.3. Convencional tomography of a chest in a direct projection at a level of a bifurcation of a trachea. The right upper lobe gives an intensive shadow and diminished in sizes (arrow). Obstructive atelectasis upper lobe of right lung

- estimations of intrachest lymph nodes. At CT lymph nodes of mediastinum and hila can be seen since they are 10 mm (at linear tomography – not less than 20 mm). Being smaller than 1 cm they are regarded as normal; from 1 up to 1,5 cm – as suspicious; the bigger ones are considered to be definitely pathological;
- solutions of the same questions as at a linear tomography as well as when the lattest is non-informative;

Fluoroscopy. Its advantage is in reception of the image in real-time mode, in estimation of movement of thoracic structures, in multiaxial examination which provides with adequate spatial orientation and with the choice of optimal views for target images. Besides punctures and other manipulations on thoracic organs are carried out under the control of fluoroscopy.

Fluorography. Fluorography used as a screening method of lung visualization. Now fluorograhy is superseded by digital radiography.

Bronchography. The method of contrast examination of bronchial tree is called bronchography. Often lipiodol serves as a contrast medium for bronchography.

Introduction of contrast medium into tracheobronchial tree can be performed in different ways. The most wide-spread methods are those with the use of catheters: transnasal catheterization of bronchi under local an esthesia and bronchography under narcosis. After introduction of contrast medium into tracheobronchial tree serial images are made regarding the sequence of bronchial system contrasting.

As a result of the development of bronchoscopy, which is based on fiber optic, diagnostic value of bronchography has decreased. It is used now mostly when bronchoscopy does not give satisfactory results.

Angiopneumography is a technique of contrast examination of vessels of lesser circulation. Selective angiopneumography is used more often. It involves introduction of radiopaque catheter into the cubital vein with its subsequent conducting through the right cardial cavities either to the left or to the right trunk of pulmonary artery. The following step of examination is to introduce 15-20 ml of 70% water solution of contrast medium under pressure and making serial imaes. The following diseases of pulmonary vessels can be indications for this method: embolism, arteriovenous aneurysms, pulmonary varices, etc.

6.2. Radionuclide examinations of respiratory apparatus

Radionuclide diagnostics methods are directed at investigation of three main physiological processes which are the basis for external breath: alveolar ventilation, alveolar-capillary diffusion and capillary blood flow (perfusion) of the pulmonary arterial system. Nowadays applied medicine does not have more informative methods of registration of regional blood flow and pulmonary ventilation.

Two kinds of radiopharmaceuticals are usually used for such investigations: radioactive gases and radioactive particles.

Regional ventilation. Radioactive gas ^{133}Xe (T½ biol. - 1 min., T½ phys. – 5,27 days. γ-, β- rays). Investigation of alveolar ventilation and a capillary blood flow with ^{133}Xe is carried out on the multidetector scintillation devices or the gamma camera.

Radiopulmonography (radionuclide ventilation study)

Introducted intratracheally ^{133}Xe (xenon) is distributed to various lung parts according to the level of ventilation of these zones (fig.6.5). Pathological processes in lungs, resulting in local or diffusive disorders of ventilation, reduce gas amount getting into affected parts. It is registered with the help of the radiodiagnostic

facilities. External registration of xenon γ-radiation enables to obtain graphic record of ventilation and blood-flow levels in any part of the lung.

Intrapulmonary dynamics of ^{133}Xe depend on the extent of alveolar participation in external respiration and on permeability of alveolar-capillary membrane.

Perfusion scintigraphy of lungs. It is applied for examination of pulmonary blood flow, mainly for diagnostics of pulmonary thromboembolism. Radiopharmaceutical ^{99m}Tc (technetium) is used which is the macroaggregate of human serum albumin. The principle of a method is in time blockade of an insignificant part of pulmonary capillaries. In some hours after an injection albuminous particles are destroyed by blood enzymes and macrophages. Disturbance of a capillary blood flow are accompanied by change of normal accumulation of radiopharmaceuticals in lungs (fig.6.6).

PET (positron emission tomography) is the best way to detect lung cancer expansion (fig.6.7). Examination is carried out with the radiopharmaceutical 18-fluorineglucose. Application of a method is limited by its high cost.

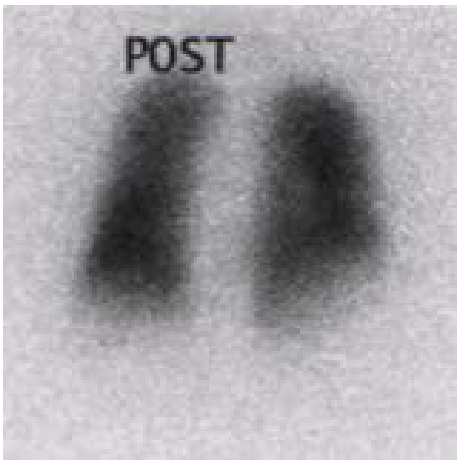

Fig. 6.5. Normal distribution of radiopharmaceutical (radioactive gas ^{133}Xe) in lungs [101]

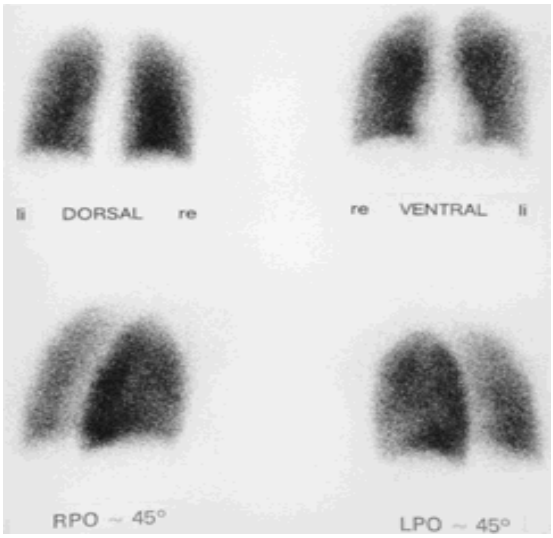

Fig. 6.6. Perfusion scintigraphy lung. Radionuclide lung imaging. Normal perfusion scan in the four projections A-P (dorsal), P-A (ventral), LPO 45° and RPO 45° [101]

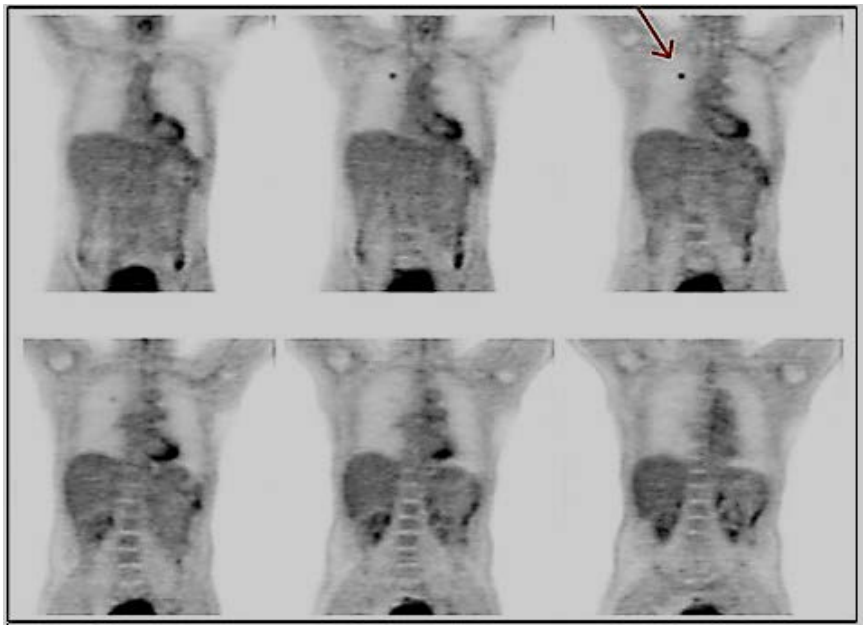

Fig. 6.7. PET: small cancer of lung (arrow) [106]

6.3. Role MRI in diagnostics of lung diseases

Application of MRI is limited, mainly, to visualization of pathological formations mediastinum and hila, defeats of a chest wall, soft tissues revealing and the characteristic of diseases of large vessels of a chest cavity, especially aortas. Clinical value MPT pulmonary parenchyma is insignificant (fig.6.8). Nevertheless unlike a chest film, CT, the MRI is capable to find out a tumour against obstructive atelectasis (fig. 6.9). It is important for planning of beam therapy.

Fig. 6.8. Coronal T2-weighted MRI a thorax. A tumor (cancer) of a top of the right lung, sprouting in soft tissues and a backbone (arrows)

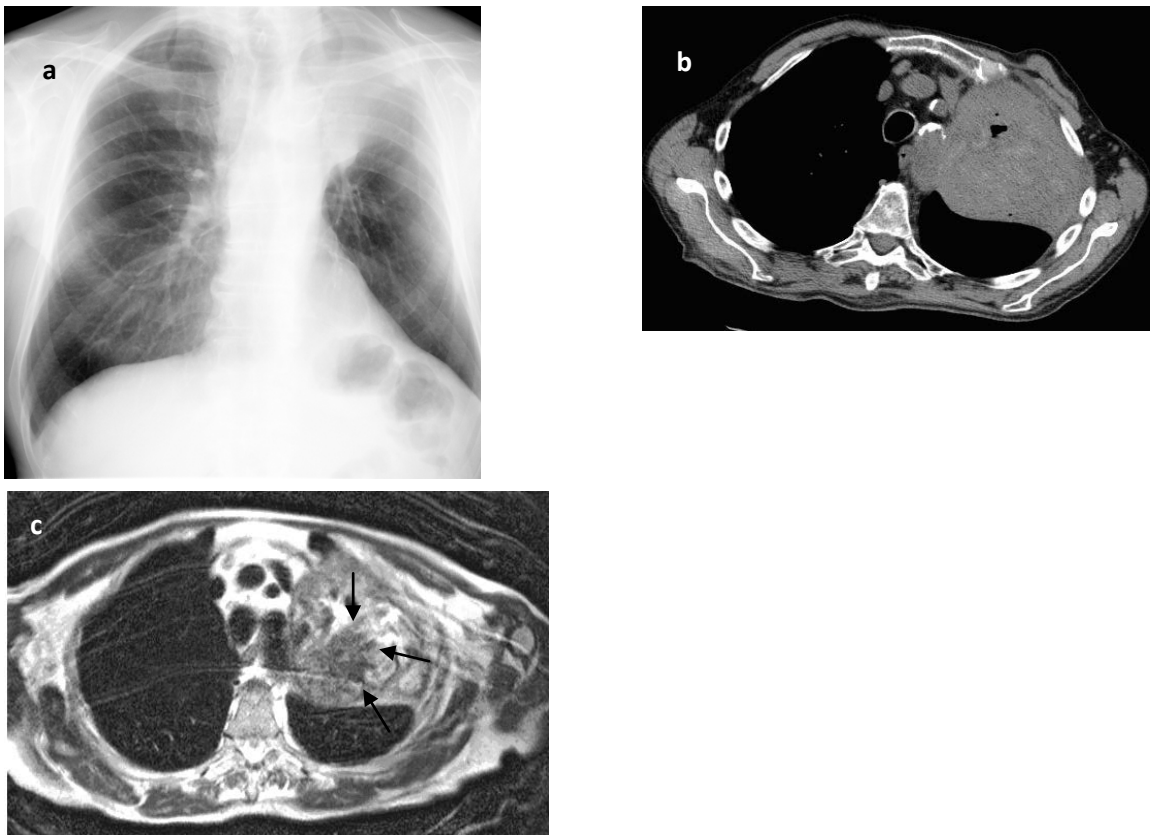

Fig. 6.9: a) chest radiograph. Frontal view. Homogeneous shadow in the upper right lung field with oblique bottom border. Dome of the diaphragm on the left is raised (located above the right); b) computed tomography of the thorax at the level of IV thoracic vertebra. There is a zone of increased density corresponding segments basale apicoposterior, anterius with small area of destruction; c) magnetic resonance imaging of the chest at the level of thoracic vertebra IV: axial scan. T2 WI. Hypo-intense zone is defined on the background of the hyper-intense of the magnetic signal corresponding to the image of the primary tumor (arrows) on the background of obstructive atelectasis due to filling of the bronchi with secretions. Hilar bronchogenic carcinoma causing obstruction of the left upper lobe bronchus with atelectasis.

6.4. Role of ultrasonic in diagnostics of respiratory system diseases

This method has the limited value in diagnostics of the majority of diseases of thoracic organs (except for diseases of cardiovascular system). It enables to receive the information concerning the formations adjoining the thorax, pleural cavity (liquid and dense formations) and a diaphragm (about movement and the form); also information about the formations which are developing in certain departments of mediastinum (for example, thymus gland).

6.5. The analysis of the chest radiograph

For a systematic evaluation, a chest radiograph should first be looked at from a technical view point.

The analysis of direct chest radiograph should start with an estimation of technical qualities of a picture. The radiograph should capture a thorax completely from apex to diaphragm and costodiaphragmatic recesses. Symmetric position of sternal ends of the clavicle towards the edges of the thoracic vetebral bodies (spinous processes) indicates that the position of a patient's body during the radiography is correct.

If specifications are set correctly (current, voltage, exposure), three or four bodies of top vertebras can be seen on the radiograph; other chest vertebras are outlined only slightly as a continuous shadow on mediastinum.

The radiograph should be contrast enough: a median shadow and liver region should be white; and lung fields should be dark, with the distinct image of lung pattern.

Outlines of a diaphragm, top edges of ribs, heart should be distinct.

After an estimation of technical qualities of a picture, one should proceed with the radioanatomical estimation of a thorax.

First of all, the right side of a thorax should be differentiated from the left one. You should pay attention to a heart's shadow: in a healthy person 1/3 of this shadow is situated to the right of the midline; and 2/3 to the left.

The diaphragm limits lung fields by dome-shaped shadow from below. In the central part it is situated in the highest position, and closer to the bottom it forms external costodiaphragmatic recesses. The diaphragm is mostly situated in the sixth rib (front department). The rib "crosses" a diaphragm in the center. The right slope of a diaphragm is 1-1,5 cm above than left one.

Some muscles and soft tissues of chest wall are projected onto lung fields. It should be taken it no account that decrease in transparency of pulmonary fields can be caused by stratification of sternocleidomastoid, big and small pectoral muscles, wide muscles of a back, mammary gland and mammilla.

On the direct radiograph such bone elements as ribs and clavicle are visible. Ribs are projected against the background of transparent pulmonary fields as 9-10 pairs from both sides. Posterior and anterior fragments of ribs should be differentiated. Posterior fragments form more intensive shadows and have a short curve upwards near vertebras, and then they are directed downwards and ectad. Anterior fragments are lower than the posterior ones corresponding to them, and are directed from and above to the inside and downwards; the forward ends of ribs pass into costal cartilages which do not produce a shadow on radiographs of children and young people. Shadows of hilum (plural: hila) are also various. On chest radiographs, the term hilum represents the composite shadow of the bronchi, pulmonary arteries and veins, and lymph nodes on the medial aspect of each lung.

The hilum of left lung is hidden behind the image of heart, but its top border is always distinctly marked by a wide shadow of the left branch of pulmonary artery. The hilum of right lung, as a rule, has no such distinct top border. Lymph nodes and walls of large bronchial tubes are not part of the shadow image of a lung hilum. Hilum form the oblique shadows on each side of mediastinum which remind of a configuration of a comma or a half moon. On the right the shadow of a hilum is separated from a median shadow by a transparent strip (≈ 1 cm), representing a projection of the basic and right lower-lobe bronchial tube; on the left the hilum is usually hidden by shadow from heart. The location of the top border of hila is defined by a level of the largest vascular trunks (intercostal level II). The top border of the left hilum is located above. The width of a hilum in the adult varies from 1,5 up to 2,5 cm, and the left hilum is always wider than the right one.

The external contour of a shadow of a righ thilum is rectilinear or slightly concave. Camber or polycyclicity of a contour of a hilum testifies its pathology. Right hilum is subdivided into head, body and tail. The head is situated on the level of cartilaginous parts of the 2nd rib; the body is between the 2nd and the 3rd ribs, and a tail part extends from the 3rd rib downwards to the 4th rib. Hila should be studied with the help of the shadow picture obtained at height of a deep breath and preferably in the vertical position of the patient. The hilum is normally structured, i.e. its shadow is non-homogeneous because of its projective stratification of vascular branches on the pulmonary artery, as well as of bronchial cross-section.

In small children hila regions are hidden by heart shadow more than in older children and adults. Hila are shaded by cross-sectioned heart and wide thymus. The median shadow represents mediastinum, backbone and sternum. However, during examination of the patient in a direct projection the median shadow, first of all, is a cardiovascular shadow since other formations are not represented outside cardiovascular bunch. Lymph nodes can be found in mediastinum. Because of small size they cannot be seen on images. But at the same time the radiological method is the leading one in detection of pathologically changed intrachest lymph nodes.

Against the background of transparent pulmonary fields shadows can be seen that are images of pulmonary blood vessels – arteries and veins (pulmonary vascular pattern). Bronchi and connective tissue interlayers normally are not visible. Elements of pulmonary vascular pattern (pulmonary drawing) are extended through 3/4 pulmonary fields, in external departments they are not visible. Shadows of vessels are bigger and more intensive in medial areas. Along certain linear shadows and at their ends small roundish or oval dense shadows are visible. Their diameter usually corresponds to the width of those linear shadows of pulmonary vascular pattern which are stratified or which they end with. Closer to the hilum they are the biggest.

Roundish or oval shadows are image of axial or oblique blood vessel section, unlike longitudinal projection at linear imaging.

In the upper part of a thorax the right outline of a median shadow goes along a right edge of spine shadow, but the arched bottom protrudes in the right pulmonary field up to 1-2,5 cm from border of vertebras bodies.

As to the left outline of a median shadow, it protrudes considerably further to the left of edge of spine shadow. Its the most left point is 1,5-2 cm inward from left median-clavicular line.

Lobes of the right lung are projected on the anterior chest wall as follows: the upper lobe occupies space from the apex to the anterior part of the 4th rib, the middle lobe – from the 4th rib to the 6th one, the lower lobe – from posterior part of the 4th-5th ribs to the diaphragm. On the left the upper lobe is extended from the apex to the anterior part of the 6th rib, the lower part – from posterior part of the 3rd-4th ribs to the diaphragm.

Lateral viewing can simplify the localization of pathological processes in lungs. First, on the lateral image the peak of the diaphragmatic cupula should be found. A straight line is drawn from it through the shadow of the middle of the hilum till its crossing with the spine. This line corresponds to an oblique fissure and separates the lower lobe from the upper one in left lung, and from the upper and the middle in right lung (fig. 6.10).

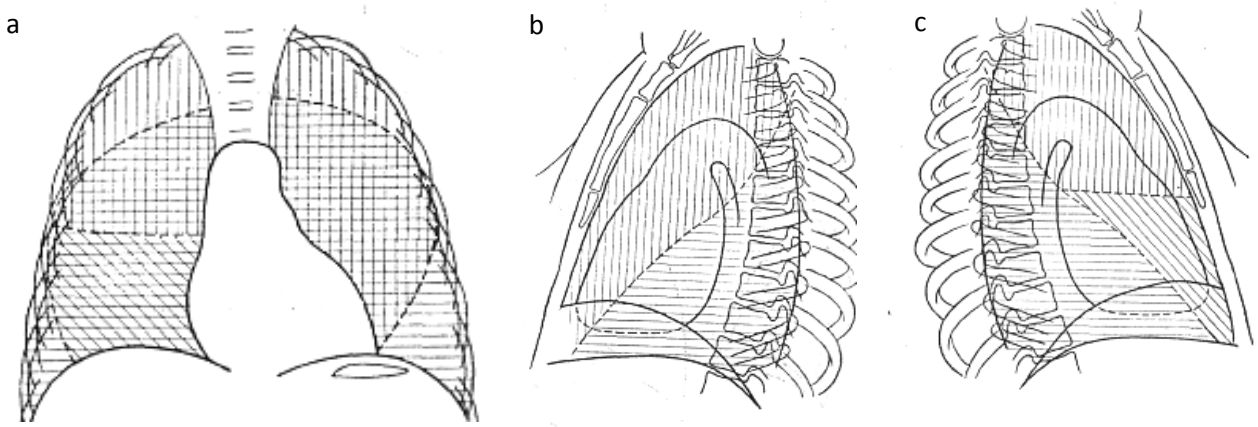

Fig. 6.10. Projection of lung lobes in a posterior-anterior (a), left lateral (b) and right lateral views(c). Vertical shading marks the upper lobe, the oblique shading − middle lobe, the horizontal shading − the lower lobe [32]

Additionally drawing a horizontal line from the middle of the hila towards thorax will mark location of the interlobe fissure dividing the upper and middle lobe. Trachea divides into two main bronchi: the right and the left. They are considered to be main stem bronchi. The main bronchi divide into lobar bronchi, i.e. bronchi of the

second order (there is also an intermediate bronchus on the right). Lobar bronchi divide into tertial bronchi also known as segmental bronchi. Each segment also has an independent segmentary artery besides bronchus. The artery enters the segment with the bronchus. The upper lung lobe consists of three segments: 1 apical, 2 posterior, 3 anterior.

6.6. The main radiological syndromes at lung injuries and diseases

There are nine basic syndromes of radiological symptoms of lung pathology:

1. Total or subtotal shadowing of pulmonary fields.
2. Limited shadowing of pulmonary fields.
3. A round shadow in pulmonary field.
4. Local radiolucency.
5. Nodular patterns and limited dissemination.
6. Diffusive disseminations.
7. Interstitial lung patterns.
8. Changes in hila.
9. Extensive radiolucency of pulmonary field.

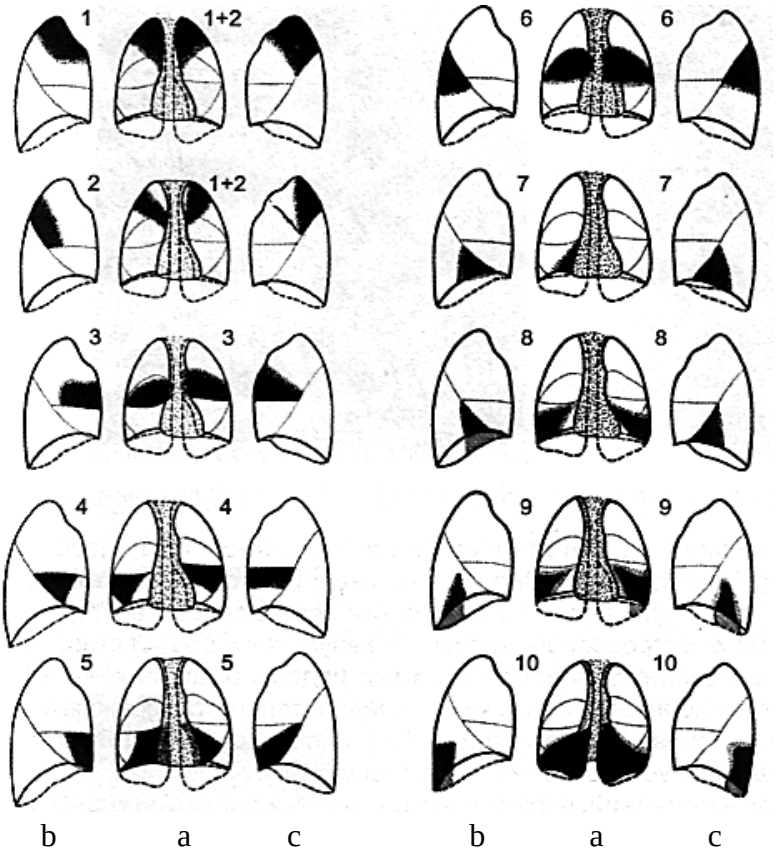

Fig. 6.11. Schemes of pulmonary segments in a posterior-anterior (a), right (b), and left (c) lateral views [35]

The middle lobe consists of two segments (4-5). Right lung: 4 - external, 5 - internal segments. Left lung: 4 segment - upper uvular and 5 segment - lower uvular. The lowest lobe lung on the right will consist of 5 segments: 6 - superior, 7 – medial basal**,** 8 **–** anterior basal, 9 – lateral basal**,** 10 – posterial basal. In left lung only 9 segments allocate quite often, 7 is absent (fig. 6.10).

To characterize each shadow on the image completely, it is necessary to know the following eight attributes of a shadow:

1. Location of a shadow.
2. Number of shadows.
3. Form of a shadow.
4. Sizes of a shadow.
5. Intensity of a shadow.
6. Figure of a shadow (structure).
7. Contours of a shadow.
8. Ability of a shadow to shift.

First seven attributes are estimated according to radiographs, and the eighth one (ability to shift) mainly at fluoroscopy.

Numerous pathological processes in lungs cause changes in their transparency.

Total or subtotal shadowing of pulmonary fields (the opaque hemithorax). X-ray imaging reveals the symptom of shadowing in case of infiltration of pulmonary tissues, increasing of a tumour node fluid accumulation, airless parts of lung. A total or subtotal shadow is formed due to atelectasis, pneumonia of all lung, total exudative pleurisy, cirrhosis of lung, diaphragmatic hernia. If mediastinum is shifted opposite to shadow, it indicates a pathological process in a pleural cavity or diaphragmatic a hernia (fig.6.12.).

Fig. 6.12. The anteroposterior chest radiograph reveals a large right pleural effusion extending around the lung laterally towards the apex. Notice, the mediastinum is shifted to the left

If the shadow is homogeneous, then the patient has accumulation of fluid in lungs. Fluid accumulation can be easily identified with the help of US, CT. If it is non-homogeneous, then the patient has diaphragmatic a hernia (fig. 6.13).

When mediastinum shifts aside, atelectasis, pneumosclerosis, condition after pneumonectomy are possible.

Atelectasis is defined as a less of volume of the lung or a part of the lung and is commonly referred to as «collapse». Atelectasis can classified by the mechanism which causes the volume loss:

1) resorption (obstructive) atelectasis: resorption is the most common mechanism for atelectasis and typically occurs in the setting of airway obstruction. Once the airway is obstructed the gas in the alveoli is resorbed leading to volume loss (fig. 6.14);

2) passive (relaxation) atelectasis: relaxation denotes atelectasis that occurs when an in thoracic abnormality such as pneumothorax or pleural effusion impairs the expansion of the lung and leads to volume loss. This type of atelectasis can also be seen in the immediate area near a space-occupyng lesion with the lung such as a mass;

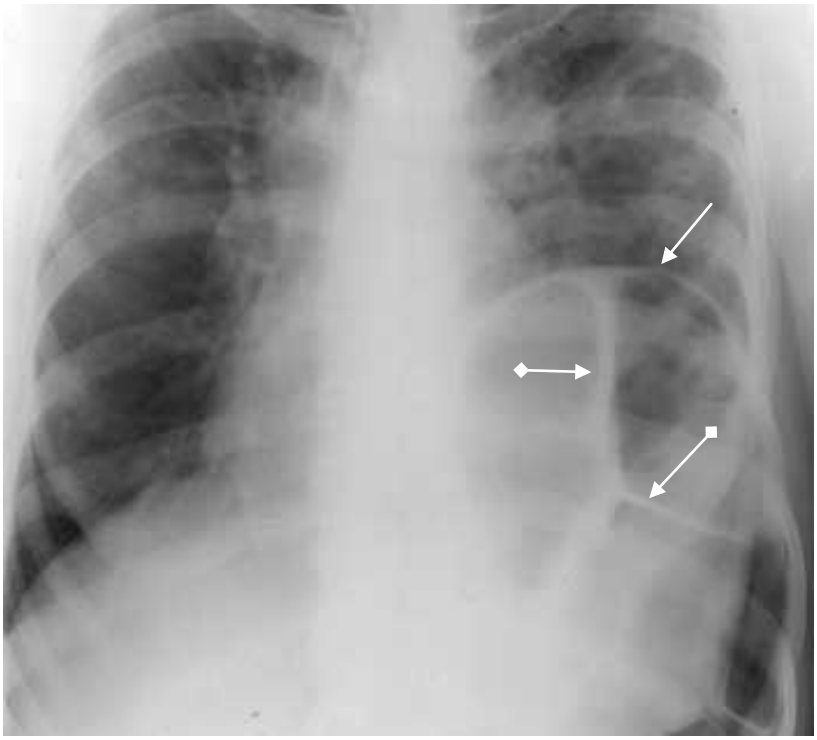

Fig. 6.13. The anteroposterior chest radiograph. In the left pulmonary field a subtotal non-homogenious shadow with the radiolucent zone (white arrow) divided by linear shadows (arrows with rhombs). Pulmonary vasculature in the left lung is prominent. Mediastinum is shifted to the right. The cupula of diaphragm on the left is not differentiated clearly. Diaphragmatic hernia at the left

3) cicatrization atelectasis is produced by organizing scar tissue. This occurs most often in healing tuberculosis and other granulomatosis diseases, as well as entities such as pulmonary infarct and pulmonary trauma (fig 6.15).

At pneumonia mediastinum is not shifted. For a pneumonia the syndrome of consolidation which arises at air space disease is characteristic. The air space disease pattern or alveolar pattern is characterized by a homogenous density.Ill defined borders are often observed. There is usually no volume loss noted and distribution may by diffuse or focal.

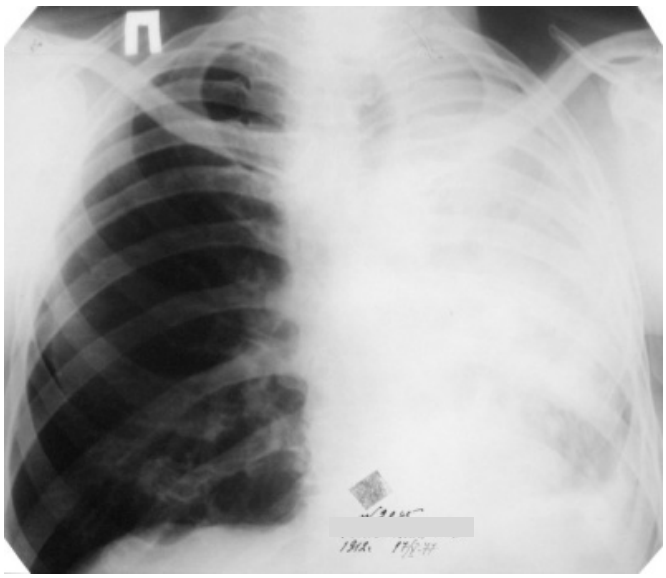

Fig. 6.14. Total shadow in the left pulmonary field. Posterior-anterior chest radiograph of a patient with obstructive atelectasis of the left lung due to central bronchogenic carcinoma

If present air bronchogram sign is virtually diagnostic of air space disease. This is the result of air in the bronchus being surrounded by airless lung (fig. 6.16).

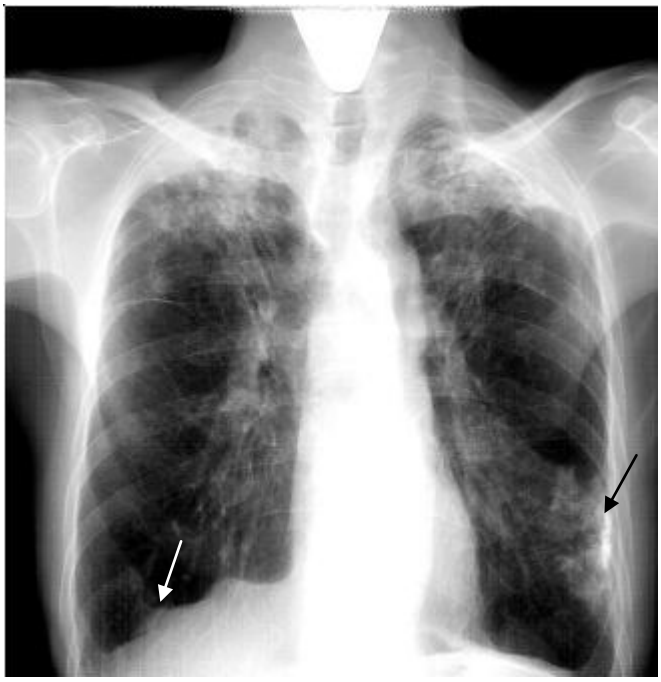

Fig. 6.15. The frontal chest radiograph. Extensive non-homogeneous intensive shadow in both pulmonary fields, mainly in the upper parts, due to numerous nodules, fibrosis and pleural layers. Hila are shifted up. On the left at the level of the anterior departments of the VI-VIII there is intensive, non-uniform calcined shadowing (black arrow). The the right the diaphragmatic cupula is deformed by pleuro-diaphragmatic commissures (white arrow). Right dome of the diaphragm is deformed by pleura-diaphragm adhesions (white arrow). Cicatrization atelectasis upper lobes due cirrhotic tuberculosis of both lungs. Calcification of the pleura on the left

The limited shadowing in lung detects involvement of a lung lobe, of one or several segments, pleurisy, diaphragmatic hernia, mediastinal tumours (fig. 6.17, 6.18). In spite of the fact that pathological changes in lung are commonly characterized by shadow with irregular form, sometimes regular-shaped shadows can be observed (round, ring-shaped, triangular, and linear). Linear shadows in lungs can form at chronic inflammatory diseases following growth of connective tissues, at pleura thickening (fig. 6.15), at some kinds of pulmonary congestion. Segmentary

atelectasis, pneumonias, mediastinal pleurisies, pulmonary infarction are characterized by triangular shadows (fig. 6.19).

A round shadow in pulmonary field. During research spherical formations in lungs in direct and lateral projections are characterized by round shadows. Also uses the terms nodule and mass. A nodule is a discrete, more or less rounded opacity < 3 cm in diameter. A solitary pulmonary nodule is a well circumscribed rounded opacity, less than 3 cm in diameter within the lung parenchyma unassociated with

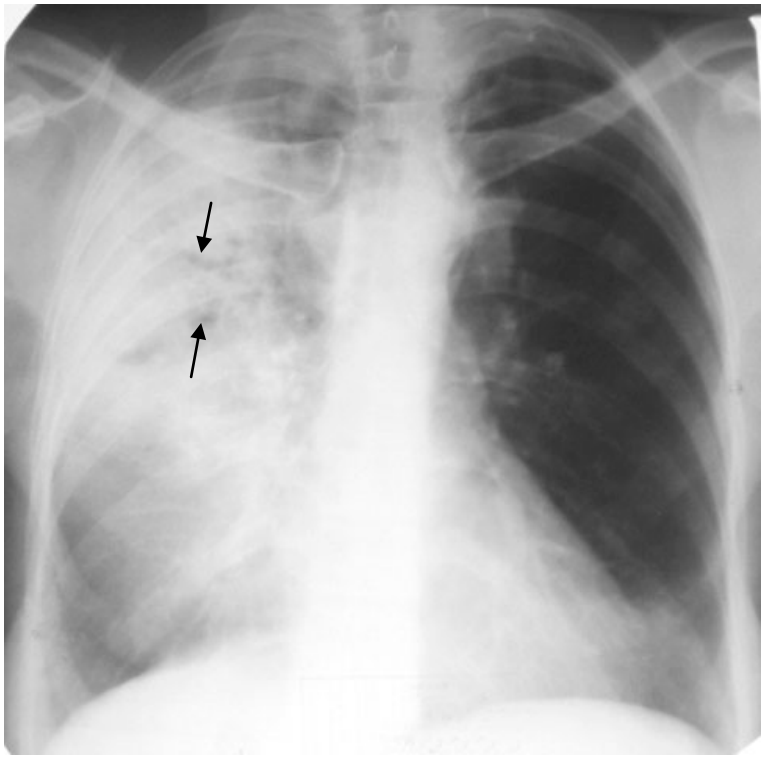

Fig. 6.16. Total shadowing of right pulmonary field, air bronchogram (arrows). Acute pneumonia of the lower lobe of the right lung

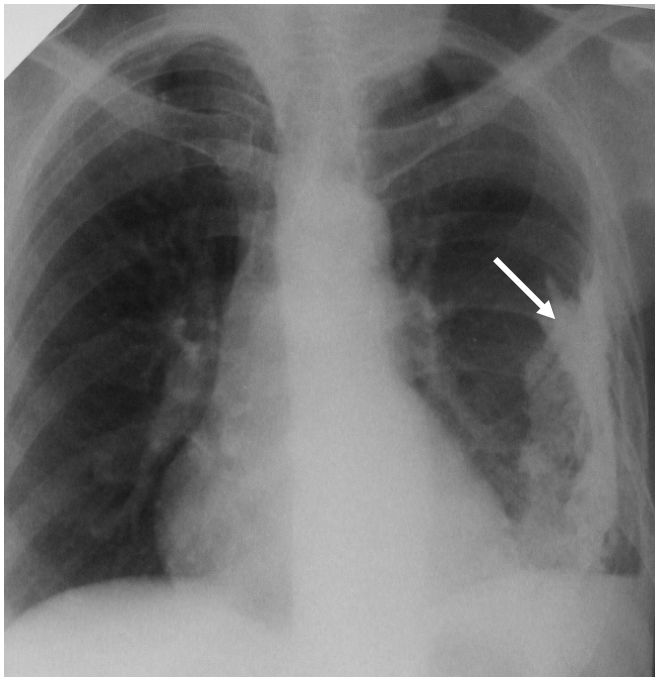

Fig. 6.17. The frontal chest radiograph. There is an intensive limited shadow with accurate rough contours in the left pulmonary field. The shadow is more intensive in the lateral department (arrow). Calcification pleurae on the left

adenopathy, atelectasis or pneumonia. A mass is a disrete, more or less rounded opacity > 3 cm in diameter.

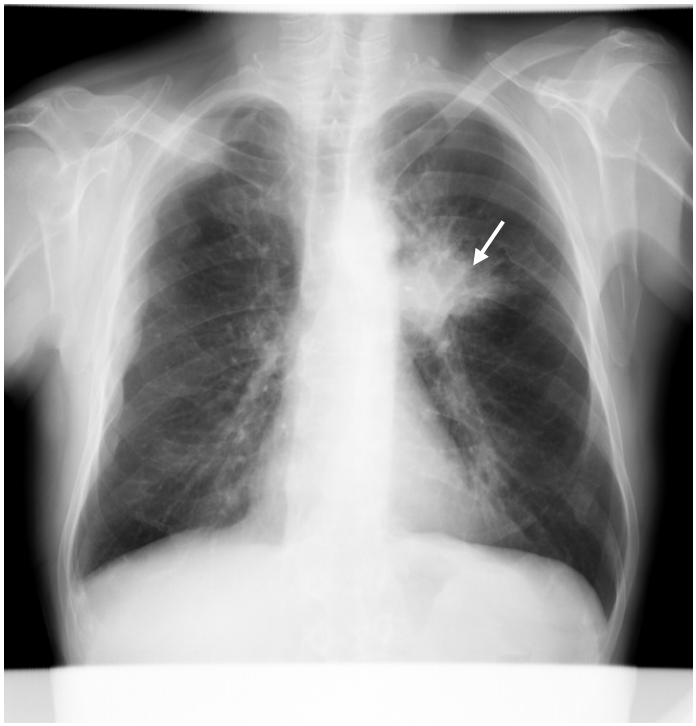

Fig. 6.18. Chest radiograph. In the middle zone of the left lung there is a limited shadow of average intensity with not distinct contours (arrow). Acute pneumonia in the third segment of left upper lobe

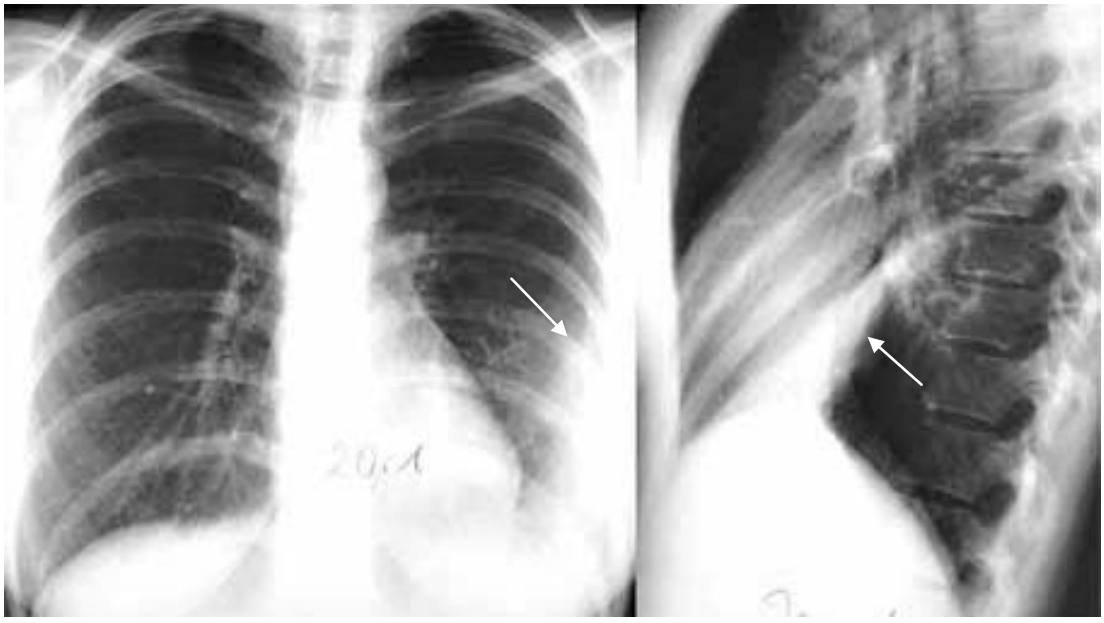

Fig. 6.19. Survey radiographs of a thorax in direct and lateral projections. There is a limited shadow of homogeneous structure, the triangular form (arrows) in projection VIII segment of the lower lobe of the left lung. Pulmonary embolism in segment VIII of the lower lobe of the left lung

Among the diseases producing round shadows, the following ones should be mentioned: peripheral cancer, tubercular infiltration, tuberculoma, metastasises of malignant tumours, echinococcus, mediastinal tumour, benign tumours, etc (fig. 6.20).

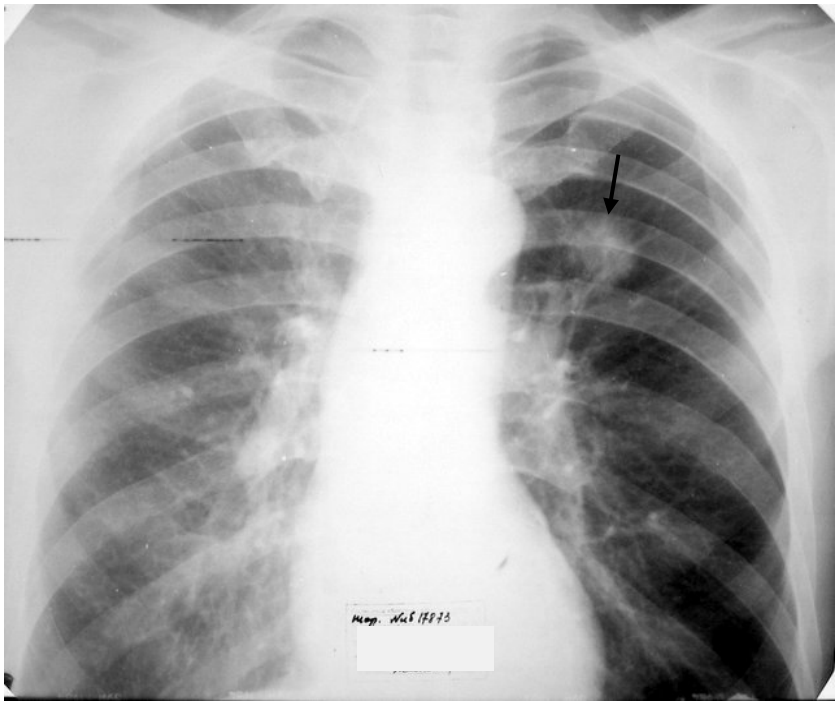

Fig. 6.20. The frontal chest radiograph.
At intercostal II level, in a medial zone of the left lung there is a round small not intensive shadow (nodule) with indistinct contours (arrow) and "path" to a hilum of the left lung. Peripheral cancer of the left lung

Nodular patterns. A nodular pattern is characterized by a collection of innumerable small, discrete opacities that measure 2-10 mm in diameter and is subcategory of the interstitial pattern. This radiographic pattern is typical of certain interstitial lung diseases. Can be observed at acute pneumonia, hematogenic disseminated tuberculosis, pneumoconiosis, tumor deposits, etc. (fig. 6. 21).

Miliary pattern: a collection of tiny (1 to 2 mm in diameter) discrete opacities in the lungs, generally uniform in size and widespread in distribution.

If nodular pattern are in limits of two segments of lungs that it is limited dissemination, if it is more – diffusive.

According to the structure shadows are divided into: homogeneous (unstructured) and inhomogeneous. Atelectasis, exudative pleurisy, echinococcus cyst, lobar pneumonia in stages of hepatization produces a homogeneous shadow. Lung tumours, bronchopneumonia, abscessing pneumonias are characterized by inhomogenous shadows.

Shadow intensity depends on extent of pathological process in lungs and on pathomorphological substratum. The shadow is considered intensive when neither lung pattern, nor ribs shadows can be differentiated against its background. Shadows of small intensity are characterized by the presence of lung pattern against their

background. The shadow of average intensity has no lung pattern. However ribs shadows are differentiated against its background.

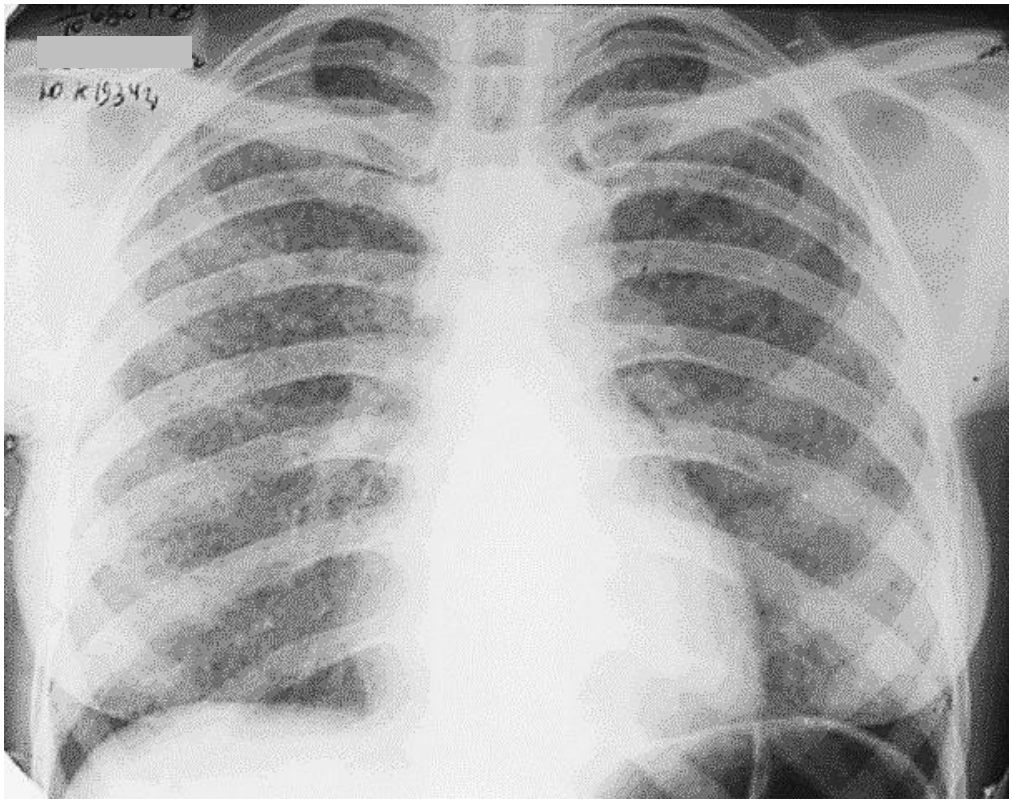

Fig. 6.21. The frontal chest radiograph. There is microfocal diffusive dissemination (miliary patterns) on the both sides along all pulmonary fields. Hematogenic disseminated (miliary) tuberculosis

Contours of a shadow in lung are often blurred, gradually turning into normal pulmonary tissue. It can be observed at acute inflammatory processes. Clear smooth contour is typical for echinococcus cyst, suppurated aerocele, inflammatory process within one lobe, whose shadow is distinctly limited by interlobar fissura. Clear smooth contour is developed by tuberculoma, peripheral lung cancer.

Local and extensive radiolucency of pulmonary field. Increased lung transparency can be observed at various diseases. It can be diffusive, bilateral, unilateral or local. The normal density of the lung is attributable to about 90% air and 10% tissue and blood. When the lungs appear hyperlucent (darker than usual) on a chest radiograph is amplies one of the following:

1) there is less lung tissue present;
2) there is more air present;
3) there is less perfusion;
4) a combination of the above.

More extensive radiolucency in both pulmonary fields is caused by the decrease of pulmonary tissue in patients with emphysema, bronchial asthma, chronic bronchitis (fig. 6.22).

Increase of transparency of lung, and its lobes is caused by their ventilation

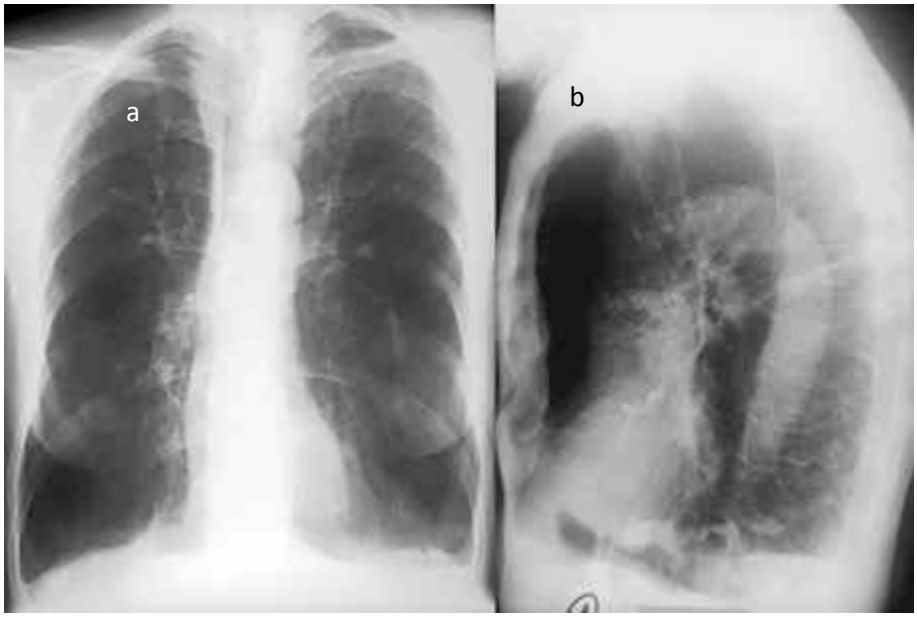

Fig. 6.22. Radiographs of lungs in frontal (a) and lateral (b) projections. Deformation of a thorax similar a barrel, expansion of intercostal intervals, low standing of domes of a diaphragma decrease of the heart width on the frontal chest film. Increase of pulmonary fields in sizes. Extensive radiolucency in both pulmonary fields. Emphysema of lungs

disorders (valve corking of bronchi) or pneumothorax; at the lattest there are no elements on pulmonary image in general (fig. 6.23).

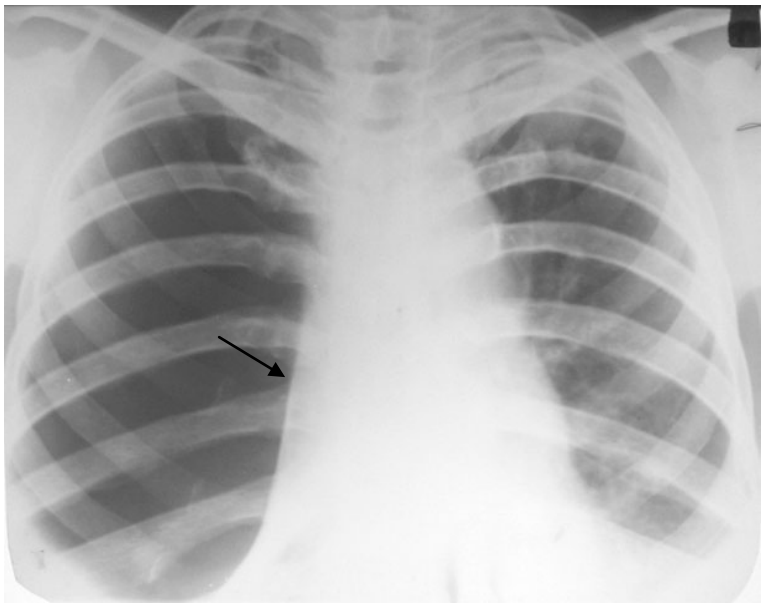

Fig. 6.23. Anteroposterior radiograph shows asymmetrical hyperlucency in the right pulmonary field. Compression atelectasis of right lung (arrow). Pneumothorax

The local radiolucency symptom is provided by gas-filled cyst. Cavity: a gas-containing space within the lung surrounded by a wall whose thickness is greater than 1 mm and often irregular in contour. Ring-shaped shadow in lung corresponds to the lung cavity with air. On x-ray film the closed ring is detected in direct and lateral

projections at fluoroscopy. Cavity can be caused by the tubercular cavern, decaying cancer, emptying abscesses, gas-filled cyst, cystic bronchiectasis (fig. 6.24).

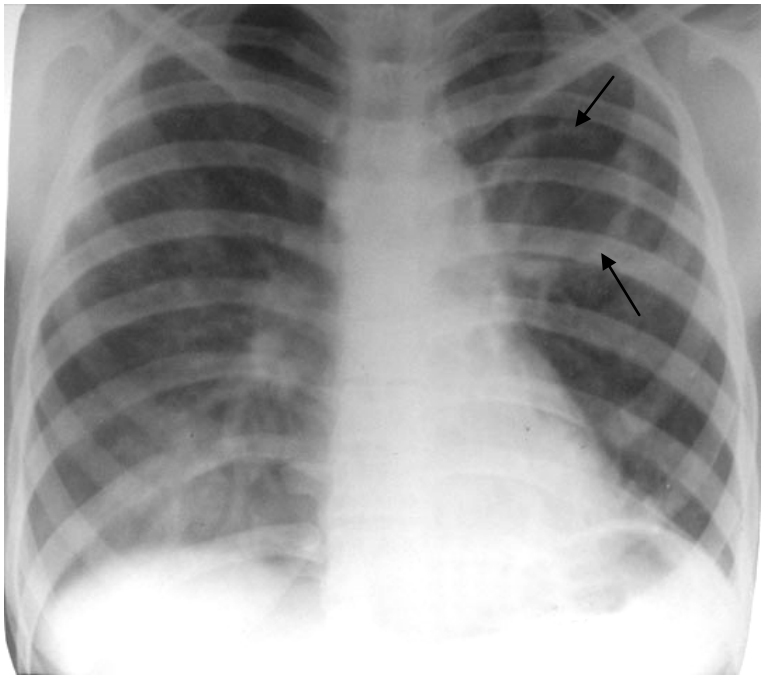

Fig. 6.24. Chest film. Cavity in pulmonary field (arrows). Walls in regular intervals thick. There is no liquid in the cavity. The cavernous form of pulmonary tuberculosis

The characteristic of lucent is carried out under the same circuit and sequence, as shadow.

The characteristic on position of a cavity matters for topical diagnostics – the cavity is outside of or inside lung and for differential diagnostics.

The characteristic on number of cavities. Single cavities are characteristic for a chronic abscess lung, a breaking up cancer. Plural cavities are at bronchictasia, at cavernous a tuberculosis.

In the form of a cavity can be correct, ring forms at the generated tubercular cavity and wrong – at abscesses, bronchictasia.

The sizes of cavities. It is accepted to divide cavities on fine (diameter of 1,5 cm), average (1,5-5 cm), large (up to 8 cm) and huge (from above 8cm).

Figure (structure) of a cavity. It is necessary to understand a condition of walls, contents of a cavity and surrounding tissue as this definition. Air cavities can be without liquid contents and with a liquid. The horizontal level of a liquid above which air settles down will be defined, happens at the generated abscess lung in later stage. Very seldom at a tuberculosis, an abscess and a breaking up cancer in a cavity, except for a liquid, there can be a slice necrotizing and come off from a bulk pulmonary tissue – the sequestration. Air cavities without a liquid, as a rule, happen at cysts a lung; at a tuberculosis also there is not enough liquid in cavities (fig. 6.24 and 6.25).

Condition of walls of a cavity. Walls cavernous formations can be as thin-walled capsules, the fibrous, precisely outlined rings or as the expressed inflammatory process with not well defined borders. Lung cancer with destruction has non-uniform thickness of a wall, tuberculosis cavity, as rule, has uniform thickness of a wall. The syndrome of the limited radiolucent represents local increase of a transparency of a pulmonary field. Its form can be ring shaped or wrong. The intrapulmonary processes causing this syndrome are, abscesses, bullous emphysema (fig. 6.26), destructive cavity of a peripheral cancer, destructive forms of a tuberculosis of lungs, empty abscess, bronchiectasis. External lung the diseases shown by this syndrome: pneumothorax, diafragm hernias. The local symptom of a lucent gives air cyst.

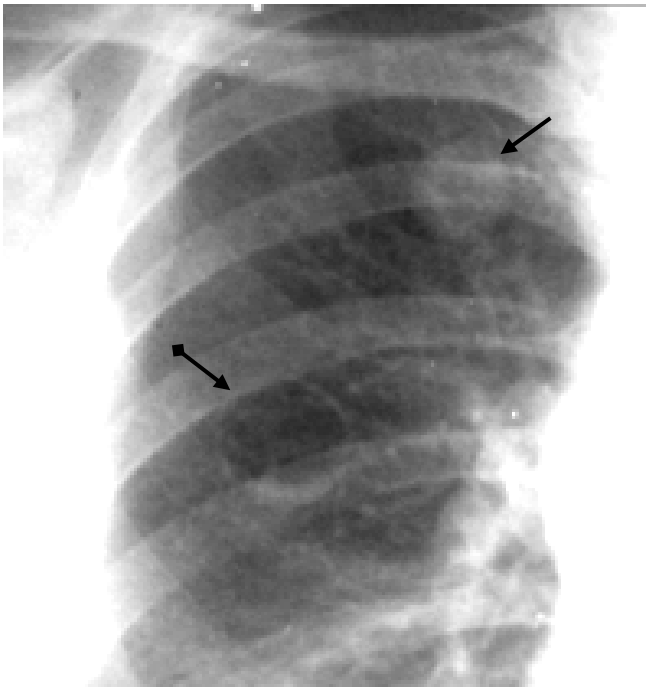

Fig. 6.25. Enlargement radiograph of a thorax in direct projection. Under clavicle to a zone of the right pulmonary field a round shadow with the accurate smooth contours, homogeneous, average intensity (arrow). In the right pulmonary field ring-shaped a shadow with accurate, thin, equal walls, at the bottom pole of this shadow a small congestion of a liquid with horizontal level (an arrow with a rhombus). Filled and emptied cysts the right lung

Sometimes the so-called huge cyst occupies almost entire lung and increases its transparency (fig. 6.26).

Interstitial lung patterns. The interstitium of the lung consists of the supporting structures such as pulmonary vessels, bronchi, and connective tissue. Most lung diseases cause an increase in the radiodensity of the lung, and if this is due to a relative thickening of the interstitium – this will be manifest as increased prominance of the interstitial markings on the chest film. If generalized or diffuse, this will likely appear as a linear or reticular pattern (fig. 6.27), whereas if localized, it may appear as multiple tiny nodules. Common causes of this pattern include pulmonary edema, inflammation, fibrosis, and tumour. Many of these diseases produce some degree of air space or acinar pattern as they progress.

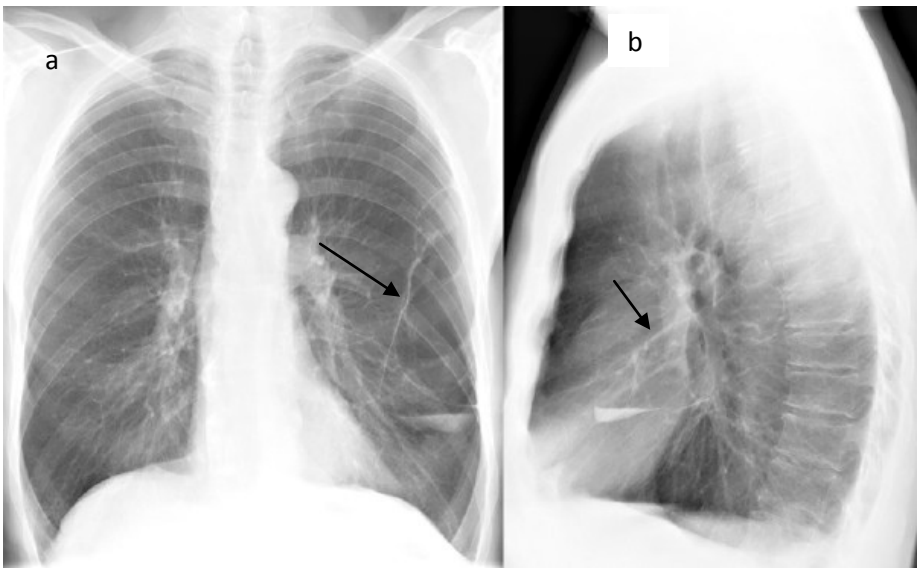

Fig. 6.26. Survey radiographs of lungs in a posterior-anterior (a) and left lateral projections (b). The limited radiolucent zone with horizontal level of a liquid (arrow) in lateral part of the left pulmonary field of incorrectly oval form with thin accurate walls, lateral wall merges with a chest wall. Huge bullous emphysema the left lung

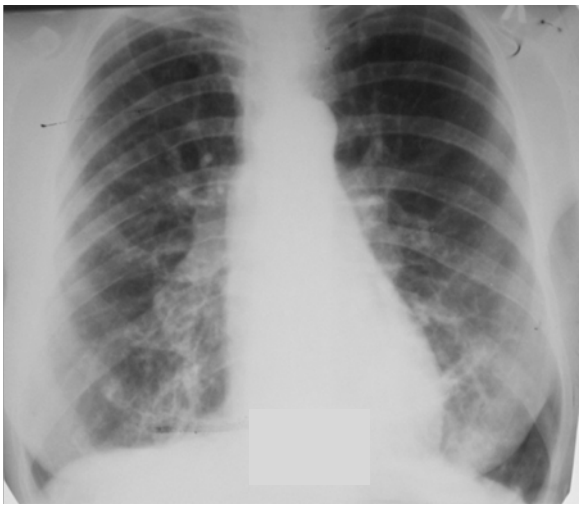

Fig 6.27. Chest radiograph. Frontal view. Diffuse bilaterial reticular – mesh like appearance, more in basal parts of pulmonary fields. Chronic bronchitis

Changes in hila. Many pulmonary diseases are accompanied by change of hila and, first of all, their enlargement. Enlargement of hila can be unilateral, e.g., at sharp inflammations, and bilateral. Bilateral enlargement of hila without change of their structure and position is observed at the increased blood flow in lesser circulation at some acquired and congenital malformations. Enlargement of hila in these cases is accompanied by intensification of pulmonary vessels and change of a configuration of heart (fig. 6. 28). Enlargement of hilum is promoted by increase in lymph nodes (fig. 6.29). Polycyclicity of contour of the enlarged hilum in the adult person indicates tumoral lesion of lymph nodes. Fibrous changes of hilum correspond to fibrous changes in lung (fig. 6.15).

Relocation and mobility disorders of diaphragm.

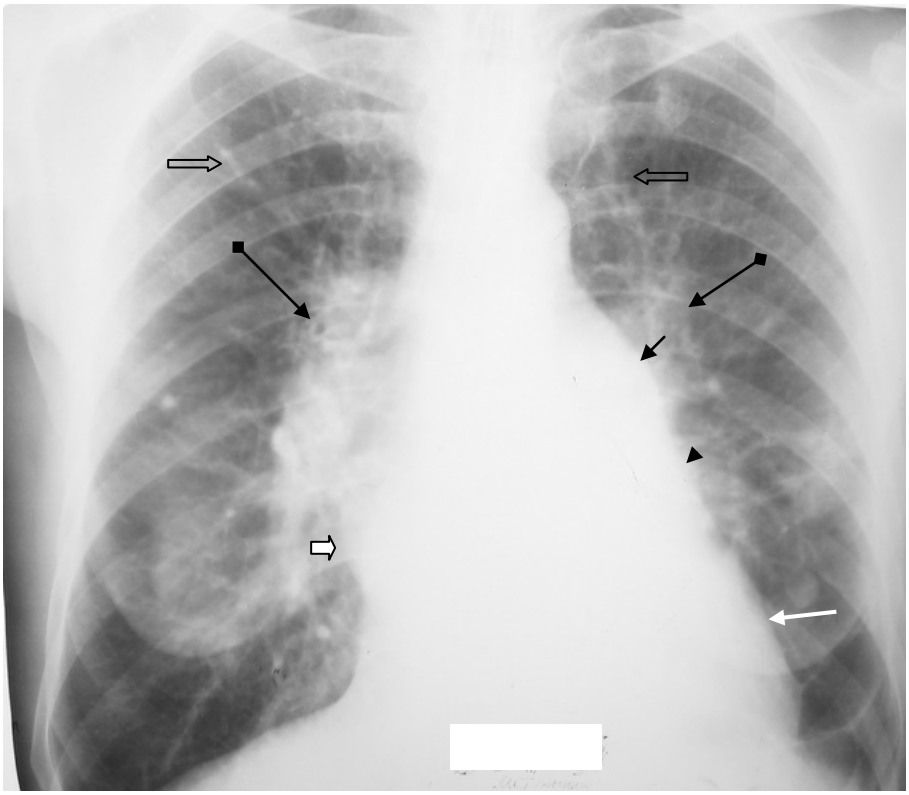

Fig. 6.28. The frontal chest radiograph. Shades of hila of lungs are increased at the expense of expansion of vascular trunks forming them (an arrow with a rhombus). Enlargement of the upper zone vessels from both sides (thick arrows). The heart shadow is expanded (mitral configuration). Increase in arches on the left contour: pulmonary artery (black arrow), the left atrium (small black arrow), left ventricle (white arrow). The increased left atrium forms an additional arch on the right contour of heart (figured arrow). Mitral insufficiency. Signs of venous stagnation in lesser circulation

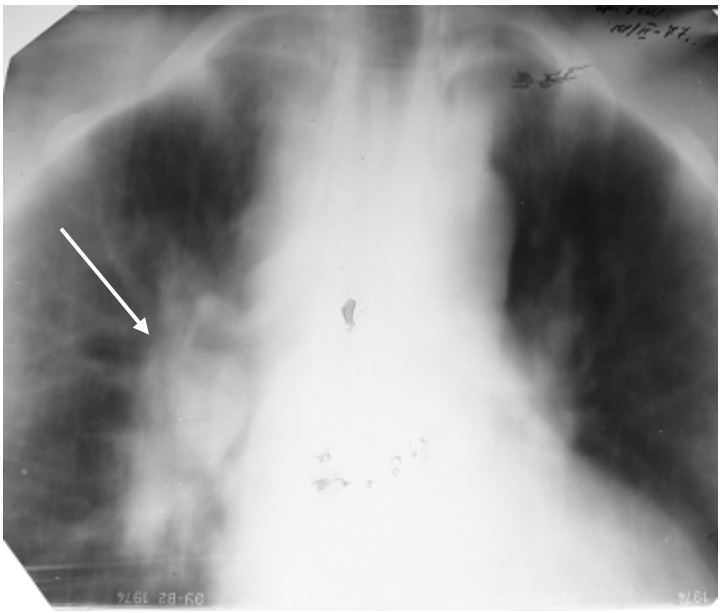

Fig. 6.29. Fragment of the conventional tomogram of a thorax in direct projection at the level of bifurcacatio tracheas. The hilum of the right lung is expanded, its external contour polycyclic (arrow). A tuberculosis of lymph nodes of a hilum of the right lung

Pulmonary diseases which are accompanied by reduction of lung or its lobes following development of cirrhosis, fibrothorax of different origin, atelectasis, as well as absence of a lobe or the entire lung following surgery, are characterized by high position of diaphragm. It can also be observed at relaxation, paresis and paralysis of diaphragm. Sometimes high position of a diaphragm is caused by tumour growth in subdiaphragmatic organs. Low position of diaphragm is observed when the entire lung or its part is increased (emphysema, bronchial asthma).

6.7. Radiological signs of acute inflammatory processes in lungs

Currently there is no uniform classification of types of acute pneumonia. Many researchers prefer to divide acute pneumonic processes according to the etiological basis.

Pneumococcal pneumonia. Lobar pneumonia is the most well-known. Lobar pneumonia is the result of alveolar wall injury with severe haemorrhagic edema induced by inhaled infectious organisms that reach the subpleural zone of the lung. The process leads to consolidation of an entire lobe or segment. It is characterized by the acute onset, severe course, sequence of pathologicoanatomic changes. Infection that gets into the body aerogenically at presence of some predisposing factors (cooling, overfatigue, etc.) affects the entire lobe lung or part of it. In clinical and pathologicoanatomical terms pneumonia is characterized by interchange of four stages of development.

The stage of inflow or hyperemia involves overflow of a lung lobe with blood, capillary dilatation, accumulation of serous fluid with erythrocytes and leukocytes in alveoli. Duration of this stage is about one day. Typical features of this stage of pneumonia are: lung pattern of the lobe enhances, insignificant reduction in transparency in 2-3 days, enlargement of a hilum, sometimes the linear shadow of interlobe pleura, restraint of movement of diaphragmatic cupula. In 2-3 days hyperemia stage turns into red hepatization (or consolidation) stage. Cavities of alveoli are filled with fibrin with erythrocytes, leukocytes, alveolar epithelium, that results in lobe increasing in size and density.

Red and grey hepatization stages are charctarized by the intensive almost homogenous shadow of affected lung lobe. Its intensity increases towards the periphery. The lobe usualy has common sizes, often with enlarged hilum, whose structure is lost. The lobe decreases at atelectasis. Besides, shadowing at lobar pneumonia differs in two more features: first, intensity of shadow increases towards the periphery; second, that on its background in medial departments are visible radiolucent a strip of bronchial tubes of large and average sizes (this sign is air bronchogram, visualization of air within normal intrapulmonary bronchi caused by

consolidation in adjacent alveoli providing tissue contrast between lucent airways and opaque lung (fig. 6.30).

Adjacent pleura is condensed, sometimes pleural effusion can be observed (fig. 6.31 and 6.32). There are no radiological distinctions between red and grey stages of hepatization.

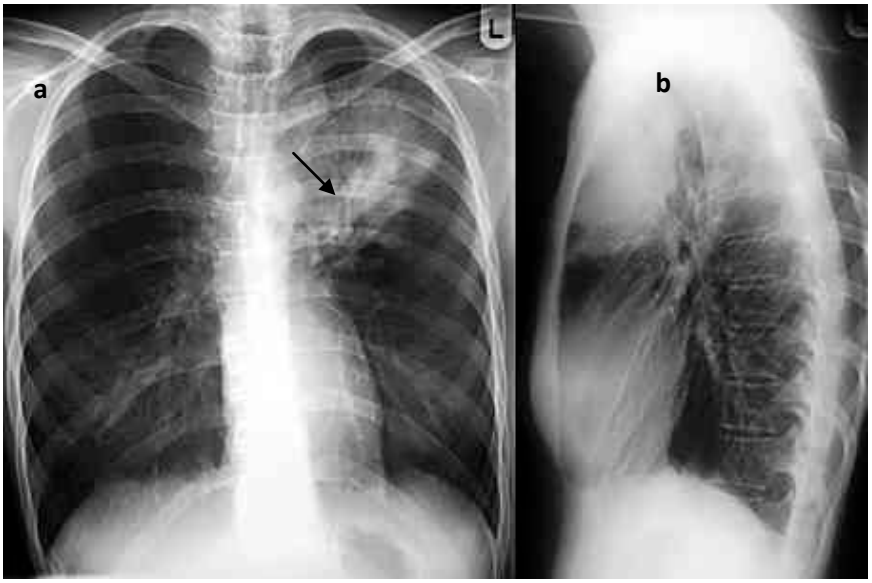

Fig. 6.30. Survey radiograph in frontal and lateral projections. Extensive shadowing of left pulmonary field, air bronchogram (arrows). Acute pneumonia of the upper lobe of left lung

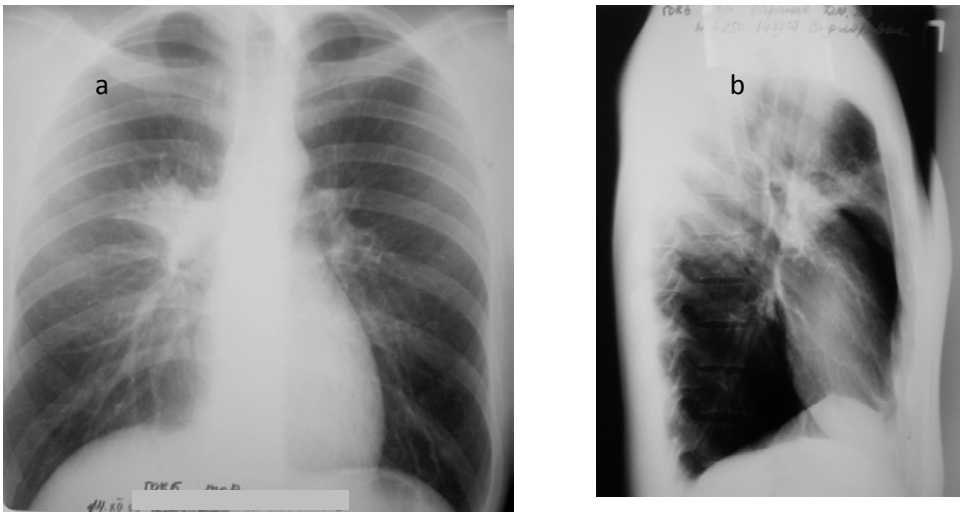

Fig. 6.31. Survey radiographs of the 23-year-old patient's thorax in frontal (a) and right lateral (b) projections. The limited shadow in the forward (III) segment of the upper lobe of the right lung. Shadow has average intensity in the medial part and small intensity on the peripheries, its contours are indistinct, except for the bottom border adjoining the interlobe fissura. The hilum on the right is expanded. Acute right pneumonia with affection of the anterior segment of the upper lobe of the right lung by analogy with periscissuritis

Fig. 6.32. The same examination as in the previos images, but in 10 days after the treatment. Positive dynamics. Infiltrative shadow in the anterior segment of the right lung disappeared. Induration of interlobar pleura on the right still remains (between the upper and medial lobes) (arrow). Acute pneumonia of the right lung on the convalescent stage

The convalescent stage is characterized by gradual decrease in intensity of a shadow, its fragmentation and reduction in sizes. The shadow of a hilum remains enlarged and non-structured. The same concerns lung pattern on the place of former hepatization: it remains enhanced during 2 - 3 weeks after clinical recovery. Complications, unfavorable outcome (incl. abscessing pneumonia with bronchiectasis, cirrhosis) are possible.

Bronchopneumonia. Its causative agent is pneumococcus. Lobules are involved in inflammatory process at bronchopneumonia. Unlike lobar pneumonia, the clinical course is less severe, the onset is gradual, temperature is usually not high. Bilateral lung affection with nodular shadows corresponding to the lobules sizes (1,0 cm), with indinstinct contours of small or average intensity is typical at radiological research. The highest number of nodular shadows is located in the inferior lung departments. Through the entire lung lung patterns intensification is observed, hila are increased. Pleural reaction is possible, as well as development of exudative pleurisy. At bronchopneumonia nodular shadows can fuse followed by the development of large inflammation loci. Bronchopneumonia can be characterized by small nodular shadows. One of the typical features of bronchopneumonia is fast dynamics of nodular shadows during the first week and disappearance of nodular shadows is observed in 10-14 days (fig. 6.33 and 6.34). It is the main difference from tuberculosis.

Streptococcal and staphylococcal pneumonias. Make up about 10 % of all

types of acute pneumonia. These types of pneumonia are more prone to occur in children, including those of younger age and infants.

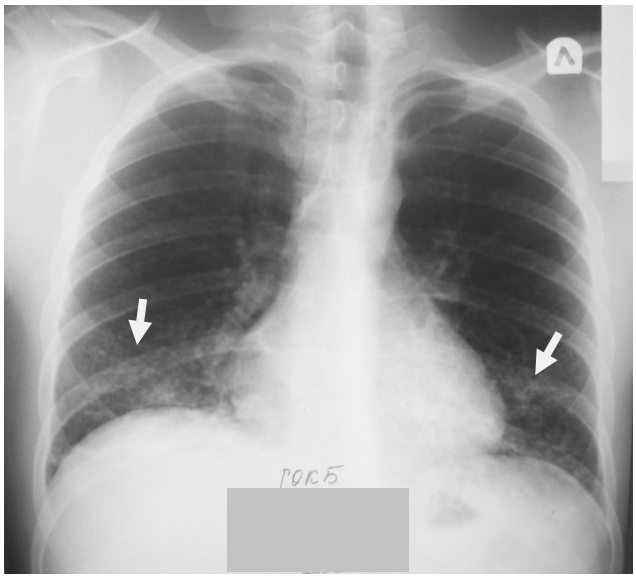

Fig. 6.33. Chest radiograph. Frontal view. The highest number of nodular shadows (nodular patterns) is located in the inferior lung departments (arrows). Bronchopneumonia

Fig. 6.34. The same case as the previous radiograph.Disappearance of nodular patterns in the lower lobes in 10 days of treatmen

Primary staphylococcal and streptococcal pneumonias in adults can clinically proceed in two ways.

The only way to distinguish staphylococcal type of pneumonia from the streptococcal one is the bacteriological analysis.

The radiological image of strepto- and staphylococcal pneumonias is characterized by presence of numerous inflammatory foci of large and average sizes, usually in both lungs. Outlines of pneumonic consolidations are indistinct, intensity of shadows depends on their sizes; the tendency towards their fusion and following disappearance can be observed. In such cases radiolucency appears against the background of shadows of inflammatory masses. These radiolucencies are delimited

below by horizontal fluid level. Often may be present air-fluid level. Relatively fast change of radiological image is typical. Within 1-2 weeks (or longer) occurrence of infiltrations can be observed, their decay, transformation of decaying cavities into thin-walled cysts with their subsequent reduction. One x-ray film can reveal all stages of development pneumonic infiltrates, what makes radiological image look peculiar (fig. 6.35).

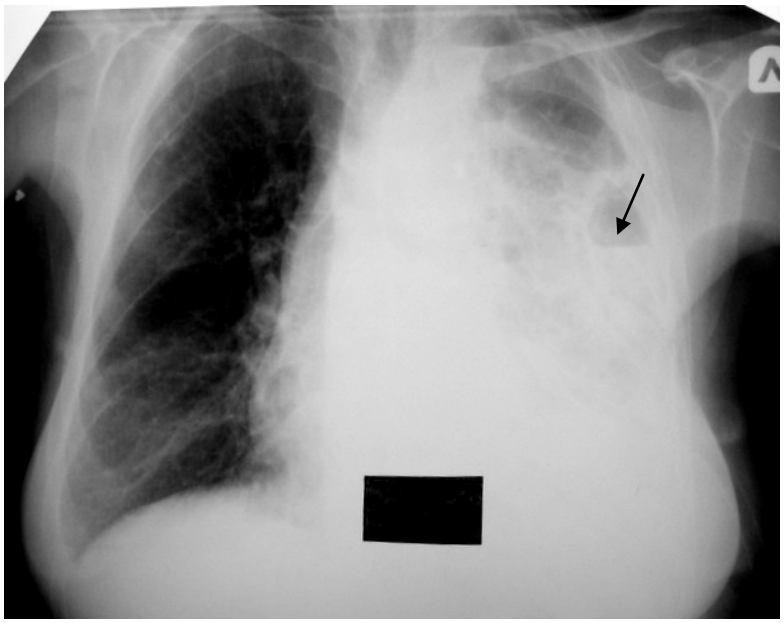

Fig. 6.35. The frontal chest radiograph. The total non-uniform shadow in the left pulmonary field, in the top department of average intensity with an indistinct contour, in the bottom department with high intensity, on this background is available a hyperlucency (arrow) with horizontal level (a disintegration cavity). The dome of a diaphragm and sine at the left are not differentiated. Mediastinum it is displaced to the right. A staphylococcal pneumonia of left lung. Pleural effusion in the left side

Viral pneumonia. The most common cause of it is influenza virus. The main clinical presentations are: pains in a thorax, moist cough, general weakness. Low-grade fever is common, though sometimes the temperature can rise up. Blood count is characterized by leukopenia, sometimes by lymphocytosis. Clinical peculiarity of acute interstitial pneumonia is its resistance to sulfanilamide and to most of antibiotics. There are 3 stages of radiological image of acute interstitial pneumonias: 1) initial, tracheobronchitis characterized by interstitial patterns. Substratum of these changes is inflammatory infiltration of interstitial tissue located around bronchi, vessels, acinus, lobules, segments. There is a significant amount of shadows, and their usual radial orientation disappears; 2) peribronchitis, when on radiologic studies, these findings appear as 4- to 10-mm, poorly defined nodules, especially in hilum and supradiaphragmatic departments; 3) pneumonic, when multifocal more large nodules are a basic element of a radiological image; airspace consolidation can develop; there is no pleural effusion (fig.6.36).

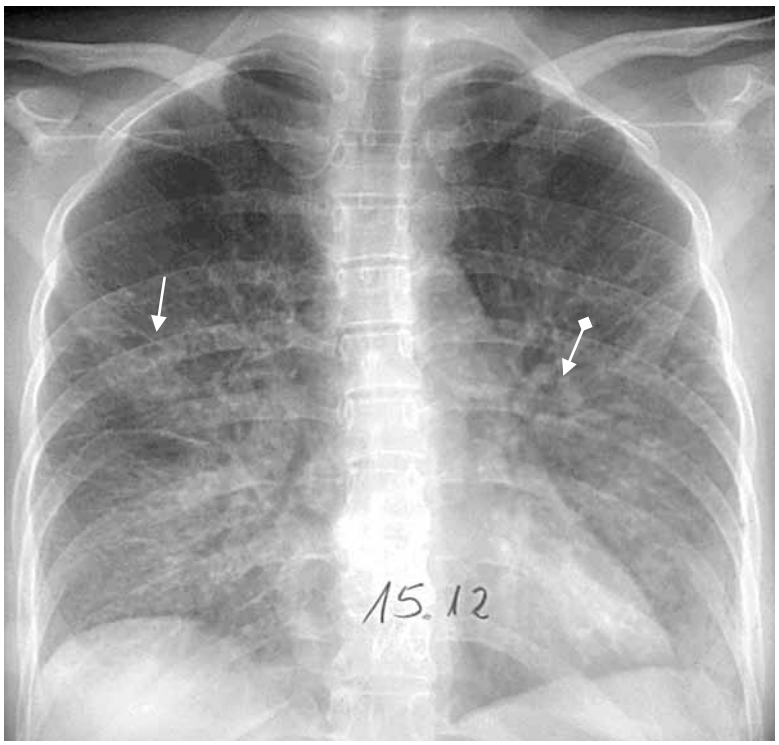

Fig. 6.36. The survey radiograph of a thorax in direct projection. Structure of hilum of both lungs is indistinct. Interstitial lung patterns (as a linear and reticular pattern) of both lungs is intensified and deformed in the middle and inferior departments (arrow). In the hilum region of left lung nodules of small intensity (arrow with rombus).
Viral pneumonia [119]

Clinical course of interstitial pneumonias is long: radiological changes are observed within 3-6-8 weeks and more. When progressing favourably, acute viral pneumonia resolves completely and normal radiological picture is restored. When the disease progression is prolonged, hardening of the pleura and of the pneumosclerosis areas can be observed as residual effects. Quite often chronic bronchitis, diffusive pneumosclerosis, bronchiectasis develop.

Dynamics of roentgenological picture, sputum analysis, immunological examinations enable to diagnose correctly.

Septic pneumonias are acute inflammatory processes in lungs following hematogenic bringing of infection from single purulent foci (osteomyelitis, liver abscess, furuncle). Staphylococci, or more seldom streptococci and colon bacillus, are causative agents. Groups of microbes first get into the blood flow, in lesser circulation circle, settle in small pulmonary vessels, bringing on their thrombosis with the subsequent transition of inflammatory process to a pulmonary tissue. In a lung there is an inflammatory focus from which the further distribution of process goes on lymphatic ways. There are no typical clinical presentations of septic pneumonia. X-ray examination detects extensive bilateral defeat of lungs, numerous nodular and infiltrative shadows. The latest tend to disintegrate and develop abscess-like cavities, without horizontal levels (fig. 6. 37).

CT. By means of CT it is possible at earlier stages at a sharp pneumonia to detect changes in pulmonary tissues, and also to establish localisation and prevalence of process more precisely.

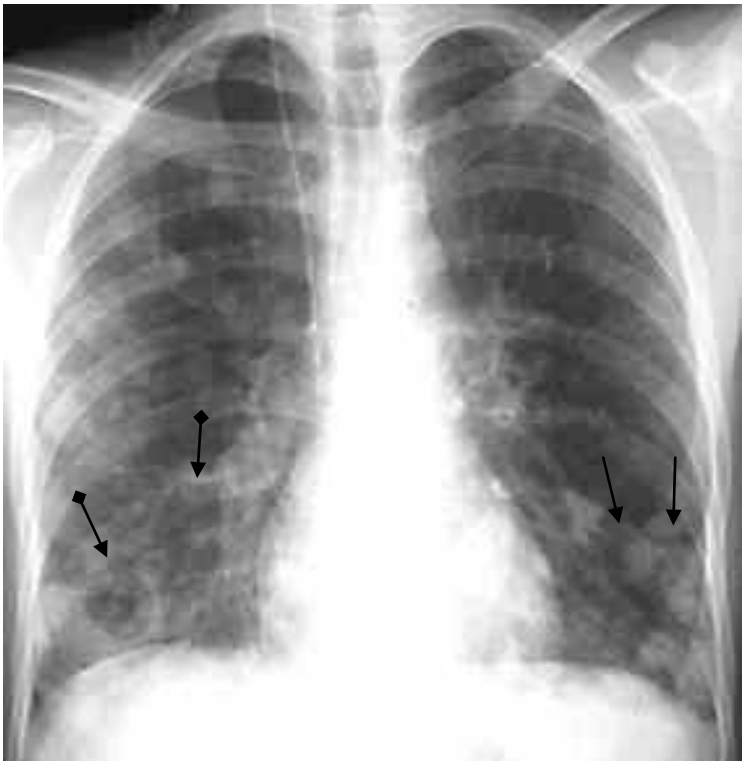

Fig. 6.37. The frontal chest radiograph. Plural roundish shadows with indistinct contours in the inferior department of a pulmonary field on the left (arrows). On the right in the inferior department of a pulmonary field the limited shadow, non-uniform with indistinct contours in which there is roundish radiolucency (arrow with a rhombus).
Septic pneumonia with disintegration cavities

By means of CT the symptom of air bronchogram can be detected, which is typical for inflammatory indurations in pulmonary tissue. Absence of this symptom may indicate obstructive character of changes in lungs or destructive necrotic process.

6.8. Radiological signs of chronic nonspecific inflammatory processes in lungs

Chronic bronchitis. At acute inflammation of bronchi, radiological research is carried out not only to detect bronchitis, but also to eliminate the possibility of other pulmonary diseases, mainly pneumonia and bronchitis. In mild cases of acute bronchitis the pattern does not differ from the norm. In severe cases of bronchitis intensification of lung and hila patterns can be identified. At chronic bronchitis the following pathological changes can be detected: 1) thickening of bronchial walls and increase of connecting tissue in lungs (pneumosclerosis); 2) lungs hyperinflation with symptoms of pulmonary hypertensia.

The second group of factores is typical only for diffusive obstructive bronchitis. Unchanged lung patterns does not necessarily indicate the absence of chronic bronchitis.

The thickening of bronchial walls is indicated as ring-shaped shadows of axial sections of bronchi. Thickness of the ring usually makes up less than 1 mm. When bronchus is located parallel to the x-ray film or at an angle to it, thickened walls can be seen as parallel lines (“tram rails”), each with width of less than 1 mm (fig. 6.38).

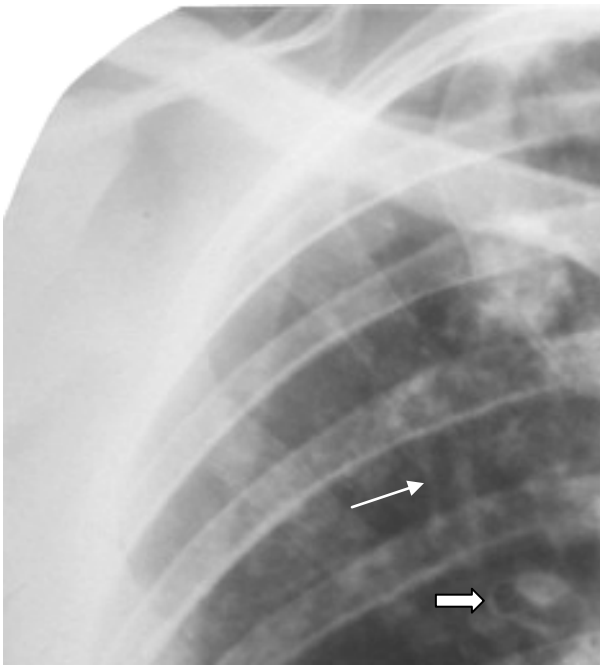

Fig. 6.38. Fragment radiograph of chest in direct projection. Parallel linear shadows (arrow) and ring-shaped shadow (thick arrow) caused by peribronchial development of connective tissue. A chronic bronchitis

The thickening of bronchial walls is combined with other changes of lung patterns, first of all, with symtoms of diffusive interstitial fibrosis. On the images it is developed as reticulate trabecular meshwork by figure and is caused by thickening of alveolar and interlobular septum (fig. 6.39).

Fig. 6.39. The frontal chest radiograph. Diffuse bilaterial reticular – mesh like appearance. Chronic bronchitis

Symptoms of pulmonary emphysema and pulmonary hypertension are detected on the radiographs more seldom, e.g. thorax enlargement, thorax protrusion, enlargement of pulmonary cone, attenuation of peripheral lung patterns, thickening and low position of diaphragm, small cardiac shadow.

6.9. Radiological signs of respiratory tuberculosis

It can produce any radiological syndrome. In general there are 12 clinical forms of tuberculosis. We will consider the most common of them. There are two stages of tuberculosis: 1) infiltrration, dissemination, disintegration; 2) resorption, induration, cicatrization.

Primary tuberculosis. Primary tuberculosis begins as initial inoculation in the lung. Patients with primary tuberculosis usually have radiographic abnormalities. This includes consolidation, cavitary nodules and masses, miliary nodules, adenopathy, pleural effusions.

Secondary tuberculosis. The secondary form of tuberculosis involves reactivation of dormant foci of infection. The infection thrives in areas of high oxygen concentration, particularly the apper lobes. Fibronodular consolidation may occur with or without cavitation and adenopathy. In end stage of reactivation tuberculosis, there is fibrosis and scarring with volume loss, calcification.

Tuberculous primary complex (Ranke complex). It is a combination of specific pulmonary tissue injury (usually of limited character) and injury of intrachest lymph nodes involvement, mainly regional ones. The triad is typical for tuberculous primary complex: 1) primary focus (infiltrate) in pulmonary tissues; 2) regional lymphangitis is a thickened shadow (vascular path), proceeding towards the hilum and connecting with the shadow of hyperplastic lymph node; 3) regional lymphadenitis. Thus bipolarity, "dumbbell" forms (fig. 6.40).

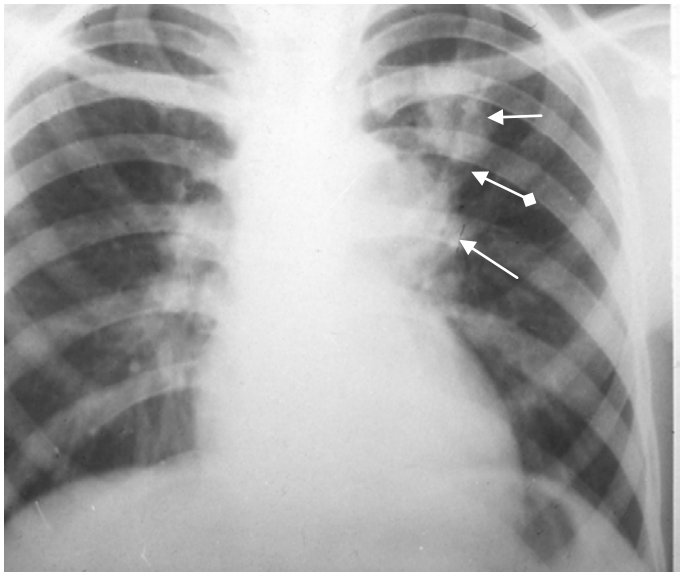

Fig. 6.40. The frontal chest radiograph. In the upper department of the left lung a roundish shadow with not absolutely distinct contours, non-gomogenious, and highly intensive (black arrow). The left hilum is enlarged; its external contour is convex (arrow with a rhombus). Between a shadow and a hilum there is linear pattern (white arrow). Tuberculous primary complex in the left lung in a phase of consolidation and calcification

Tuberculosis of intrachest lymph nodes. In this case tomograms should be made. Types of tuberculosis of intrachest lymph nodes include: infiltrative, tumour-like, indurative bronchadenitis.

Infiltrative bronchadenitis. It is characterized by development of inflammatory processes outside a capsule of lymph nodes, i.e. in pulmonary tissues. Enlargement and deformation of hilum can be observed, the contour is indistinct, the structure is disturbed (fig. 6.41).

Tumor-like bronchoadenitis. Condensation, deformation, enlargement of as hadow of a hilum arises with typical changes of the external contour acquiring polycyclic wavy character (fig. 6.42).

Indurative form of lymphadenitis is characterized by development of a fibrous connecting tissue in lymph nodes and by remains of specific inflammatory infiltration and of caseous mass.

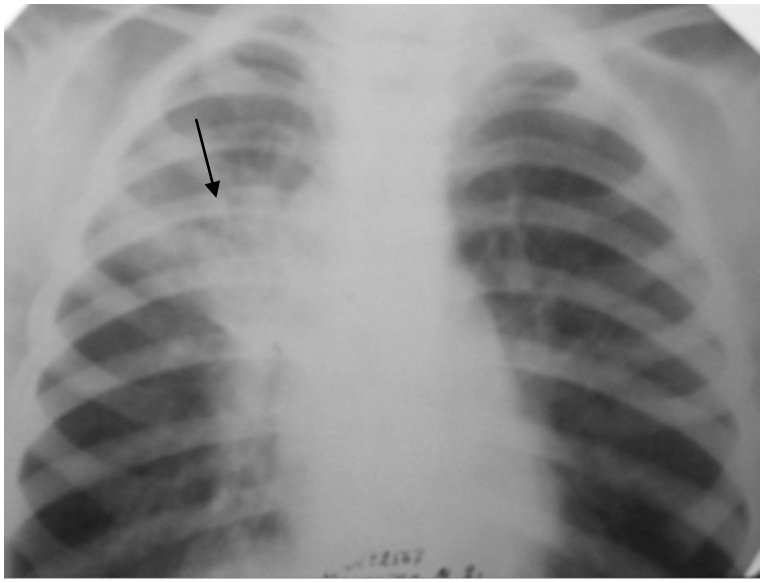

Fig. 6.41. The frontal chest radiograph. The frontal chest radiograph (the patient of 16 years). In the field of a hilum of the right lung the limited shadow with indistinct contours (arrow). The hypoinflation in projection of the right upper lobe. Primary tuberculosis of intrachest lymph nodes on the right (infiltrative form)

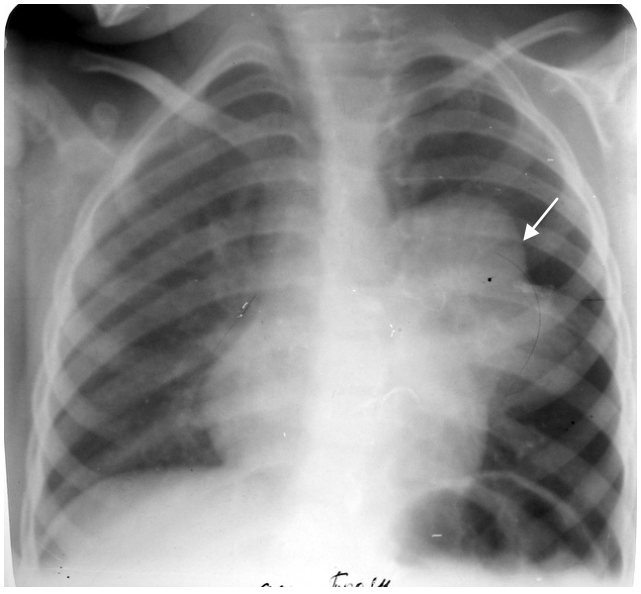

Fig. 6.42. The frontal chest radiograph. At the left in the hilum a polycyclic shadow with accurate contours (arrow). Tuberculosis of intrachest lymph nodes of the left lung (tumoral form)

Nodular tuberculosis. The radiographs reveal numerous multifocal shadows of different density, locating in groups in the upper departments of lung – in apex and subclavian areas (fig. 6.43).

Hematogenously disseminated tuberculosis. Is dynamic for a long time − 7-9 months. Acute hematogenously disseminated tuberculosis (miliary tuberculosis). On the radiograph is identified as symmetric dissemination in all fields of small identical (1-2 mm) miliary pattern of equal density and sizes (fig. 6.44).

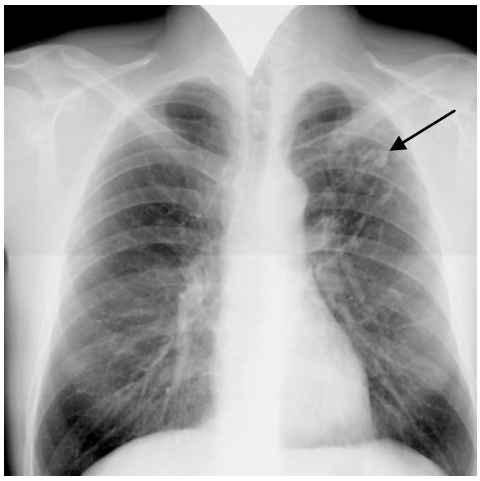

Fig. 6.43. The frontal chest radiograph. In the first intercostal space on the left lung nodular shadowing with mottled character (arrow). Nodular tuberculosis of the left lung

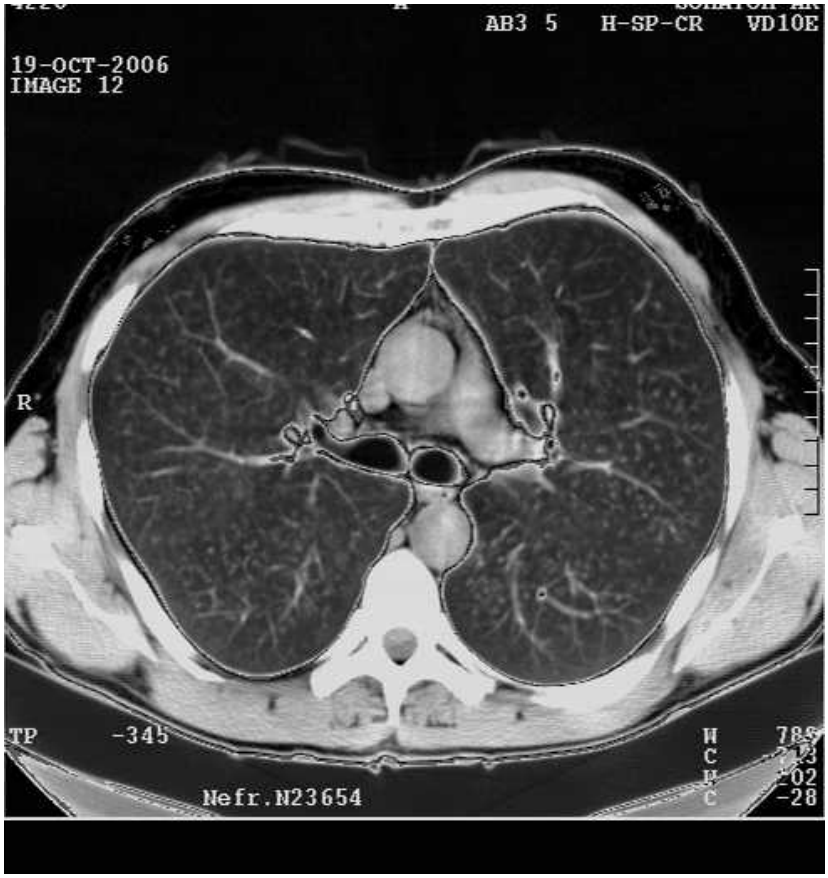

Fig. 6.44. CT-scan of thorax at the level of tracheal bifurcation. Microfocal diffusive dissemination is revealed in both lungs. Hematogenously disseminated (miliary) tuberculosis

Subacute hematogenously disseminated tuberculosisis displayed as nodules of different sizes and forms, of identical intensity, symmetrically located from both sides.

Chronic hematogenously disseminated tuberculosis can be distinguished by dissemination of polytypic nodules (with different sizes, forms, density) distributed through different parts of lungs; by marked pleural thickening and moving hila upwards (fig. 6.45).

Infiltrative pulmonary tuberculosis. Infiltrative tuberculosis can proceed acutely, clinically it can be similar to flu or pneumonia, however onset of tuberculous process is delayed, mycobacterium tuberculosis may appear in sputum. Low-intensity, indistinct consolidation (oval or roundish), located in the upper departments of lungs and connected by linear shadows: a path with a hilum (fig. 6.46 and 6.47).

Fig. 6.45. The frontal chest radiograph. Against the background of lung interstitial lung patterns in both pulmonary fields diffusive dissemination of nodules of different sizes and intensity can be observed (arrows indicate separate nodule shadows). Chronic hematogenously disseminated tuberculosis

Tuberculoma are spherical formations (nodule) with the diameter of more than 1 cm. It usually presents as a solitary well-defined nodule, up to 5 cm in diameter. Calcification is common but cavitation is unusual. Morphologically tuberculoma are foci of caseous pneumonia of various prescription surrounded by connective tissue fibrous capsule. Tuberculoma frequently arises against the background of other

tuberculous changes: nodules, calcification of pleural commissures, apical stratifications (fig. 6.48).

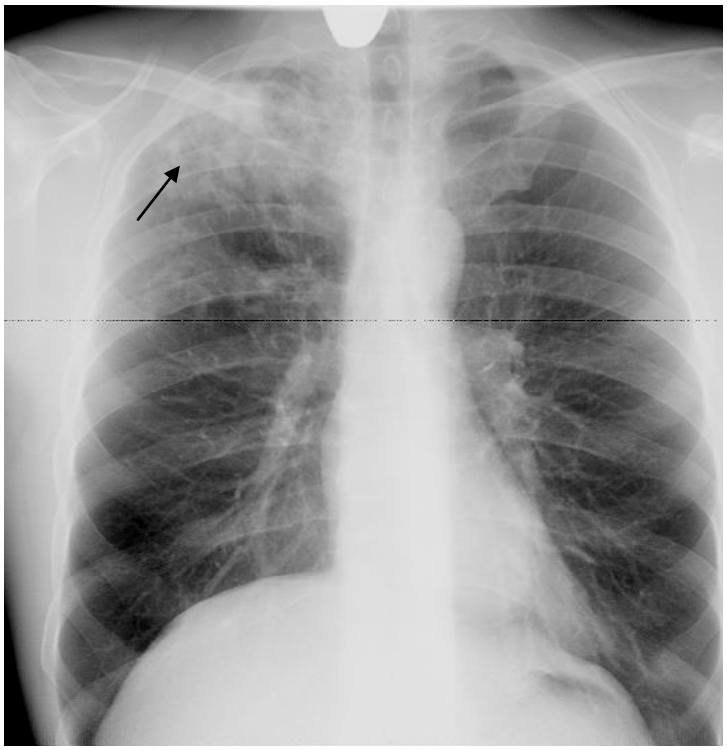

Fig. 6.46. In the upper department of the right lung the limited shadow of average intensity with indistinct contours (arrow). Infiltrative tuberculosis of the right lung

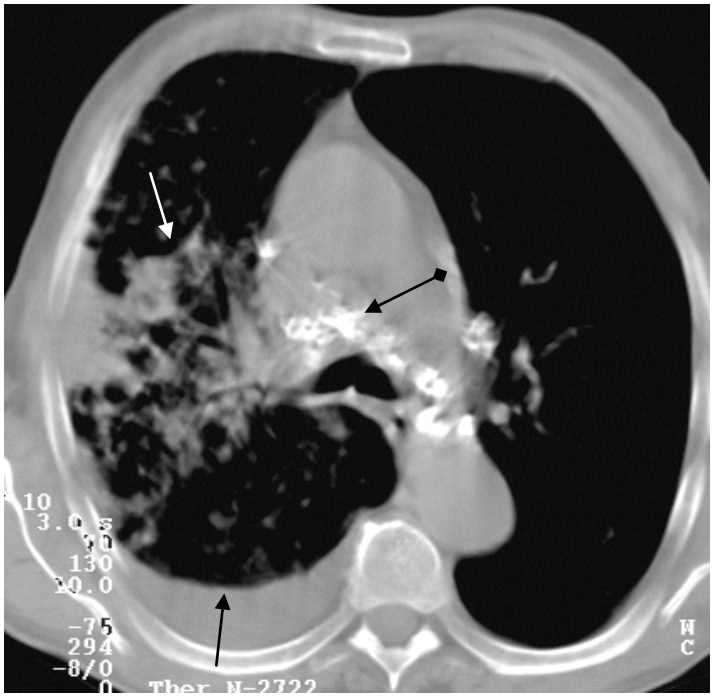

Fig. 6.47. CT-scan of thorax at the level of tracheal bifurcation. Nonhomogeneous increase of density of pulmonary tissue with indistinct contours within the upper lobe on the right (white arrow). Pleural effusion on the right (black arrow). Calcified lymphnodes of mediastinum (arrows with rhombus). Infiltrative tuberculosis of the upper lobe of right lung. Exudative pleurisy on the right

Cavernous tuberculosis. It is characterized by presence in lungs of isolated caverns without marked perifocal infiltration and fibrous changes in pulmonary tissue. Infiltrative, focal, disseminated forms can serve as the initial form. (fig. 6.49).

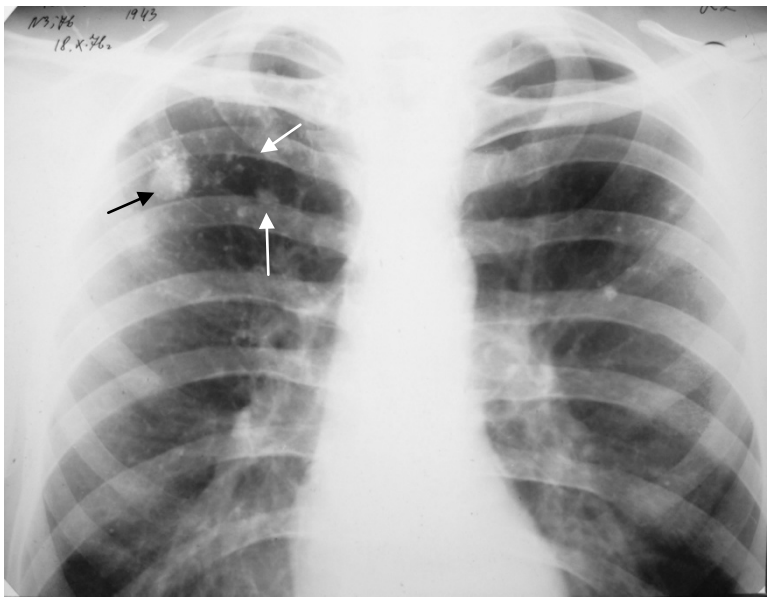

Fig. 6.48. On the right a nodule of average intensity sized of 2 sm in diameter with distinct contours and intensive inclusions (black arrow). In surrounding pulmonary tissue nodules of average and high intensity (white arrows). Tuberculoma of the right lung

The main symptom of cavern is a cavity of lucency without horizontal level of fluid with clear closed ring-shaped shadow, clearly outlined internal and external

Fig. 6.49. On the left roundish shadow (cavity) with uniform thickness of the wall (black arrow). Cavernous tuberculosis of the left lung

borders and with a shadow of drainage bronchus connected with a hillum, without marked signs of pneumosclerosis and fibrosis in surrounding pulmonary parenchyma.

Fibrotic cavernous pulmonary tuberculosis. It is the most dangerous form of tuberculosis since patients in most cases are eliminators of bacilli. Clinically this form of tuberculosis takes long and quite, often wavy course with change of the period of tuberculosis onset for the period of clinical well-being. Radiographic

image: the caverns against the background of marked fibrosis of pulmonary and surrounding tissue, with intestitial lung patterns, thorax, narrowing of pulmonary fields, shift of mediastinal organs and pleural commissures. As a result of frequent exacerbations pulmonary changes are polymorphous (fig. 6.50).

Fig. 6.50. Chest film. In the upper part of right and left lung ring shaped shadows (cavities) without presence of fluid (black arrows) and non-homogeneous shadows with average intensity and distinct contours (white arrows). Fibrotic cavernous tuberculosis of both lungs

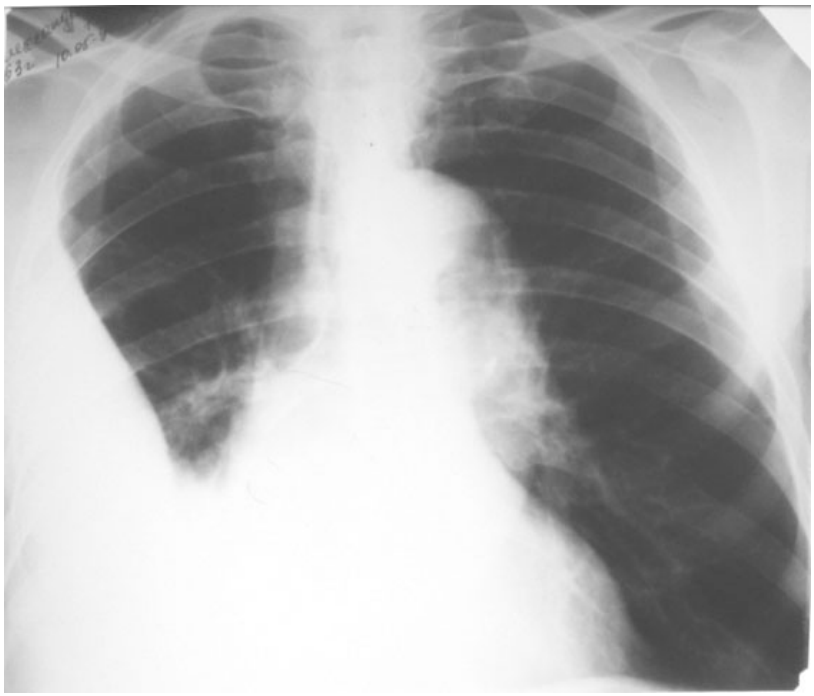

Fig. 6.51. Chest film. Pleural fluid. The hemidiaphragm outline is obscured and there is homogeneous opacification of the lower hemithorax associated with a triangle shape of the fluid at its upper, lateral margin. May be the only manifestation of primary tuderculosis

Tuberculosis with fibrosis of lungs. Tuberculosis with fibrosis of lungs is characterised by the reduction of the injured lung at the expense of development of sclerous changes in it (cicatrization atelectasis), at preservation of activity of

tubercular process. More often fibrosis changes arise in the upper lobes of lungs. The basic radiological sign is reduction of the injured sites and their non-homogeneous shadow. It is caused by the development of cicatricial changes in pulmonary tissue, presence of nodules of the various sizes and intensity, residual cavities. The hilum is deformed, condensed, displaced towards the injured department of a lung (fig. 6.52).

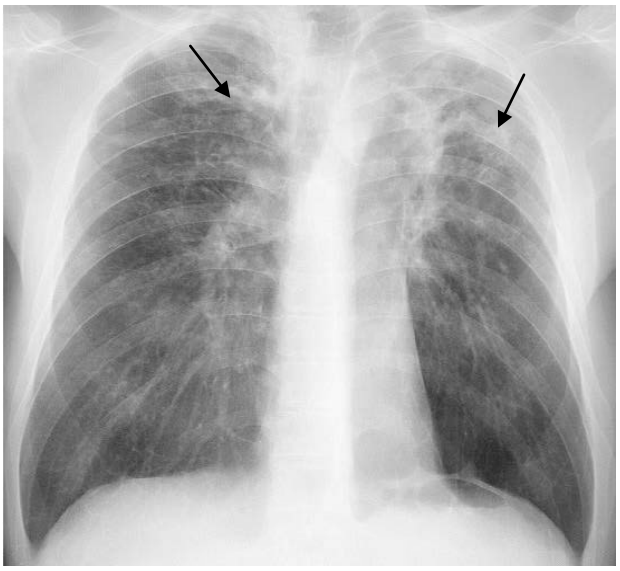

Fig. 6.52. The frontal chest radiograph. In the upper departments of both lungs the limited non-homogeneous shadows with distinct contours (arrow). Hila of lungs shift upwards. The tuberculosis of both lungs with fibrosis

The computer tomography supplements data radiography and a linear tomography at the expense of higher sensitivity to nodules and cavities of destruction. CT helps to distinguish the tubercular defeats of lungs hidden pleural effusion or massive pleural imposition.

The pneumoconioses (black-lung disease). Black-lung disease refers to professional dust fibrosis of lung, developing at inhalation and accumulation in pulmonary parenchyma of an inorganic mineral, metal or organic dust. These include silica, asbestos, talc, berilium. Depending on character of development of pathological process and its distribution, distinguish interstitial, nodular and central forms pneumofibrosis . Alongside with development of a connecting tissue gradually there are emphysema sites (fig. 6.53).

6.10. Radiological signs of traumatic lung injuries

At some patients they can be revealed already at first radiological examination, however traumatic changes in lungs can be detected at increasing hypoxia in 6-12-24 hours after a trauma. The most common type of injury is parenchyma rupture with haemorrhage around the affected part. Pneumothorax can develop at thoracic trauma. The congestion of gas in the pleural cavity leads to partial collapse of the lung (passive atelectasis). Increased transparency of external departments of pulmonary fields and absence of lung patterns is typical; thus the density of the shadow of the

Fig. 6.53. The frontal chest radiograph. Intensification of the interstitial marking. Maltiple pulmonary nodules mainly in the middle departments of lungs (arrows). Pneumoconiosis (silicosis)

collapsed lung increases. When both air and liquid are present in the pleural cavity simultaneously, fluoroscopy or radiography should be performed (if the patient's condition is satisfactory for it) in the standing position or in the lateroposition. The established horizontal level of fluid enables to diagnose. At massive pneumothorax shift of the median shadow towards the healthy side can be detected on the radiograph (fig. 6.54).

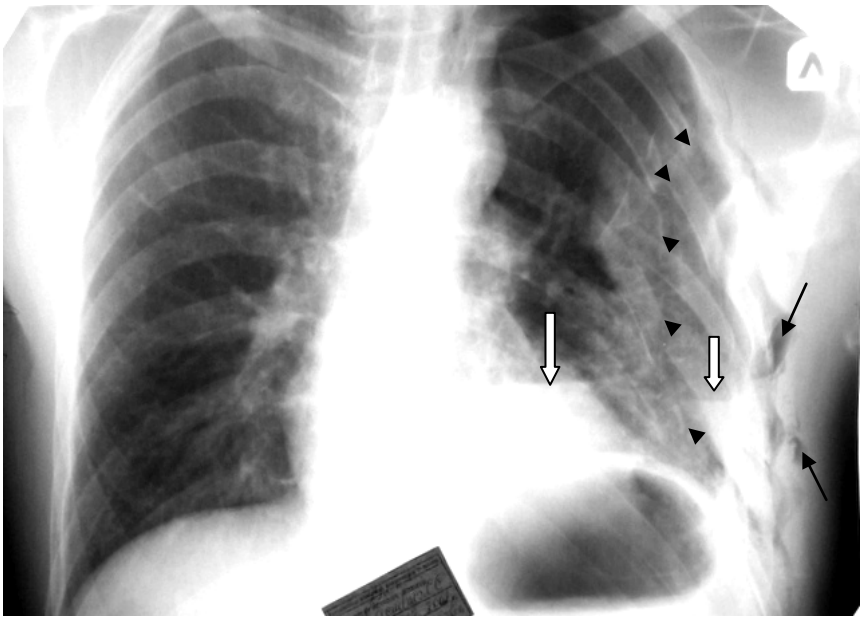

Fig. 6.54. Lines of fractures in back departments IV−VIII of ribs at the left (small black arrows). A non-homogeneous shadow in the left pulmonary with horizontal level (figured arrows). Radiolucent zones in a projection of soft tissue at the left (black arrows). The cupula of diaphragm at the left is raised. A bruise and rupture of the left lung, pneumothorax and hydrothorax at the left. Multiple fractures of ribs at the left (IV−VIII). Hypodermic emphysema

The CT plays an important role in detecting traumatic damages of chest wall, pleura and lungs. CT is more sensitive in detecting small traumatic damages of the lungs that are difficult to reveal on roentgenograms.

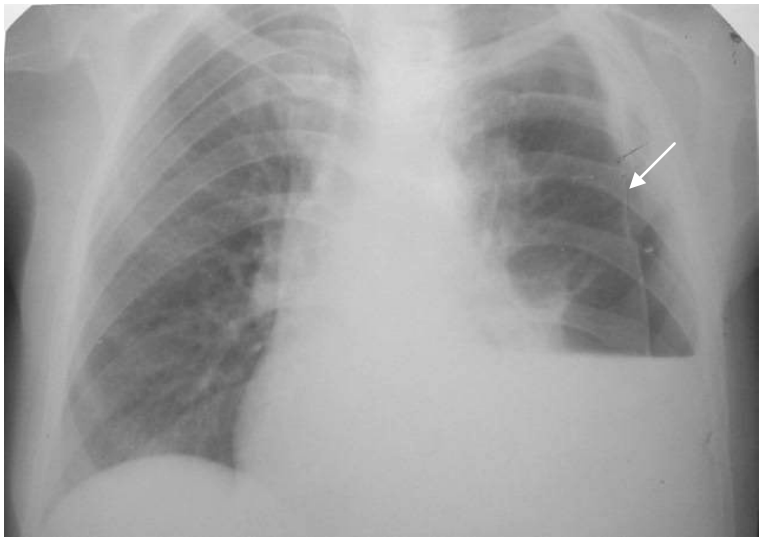

Fig. 6.55. The frontal chest radiograph. In the lower department of the right pulmonary field intensive homogeneous shadow with distinct horizontal top level. In lateral part of the left pulmonary field a radiolucent zone without elements of pulmonary vessels. The left lung in passive atelectasis (arrow). Mediastinum is displaced to the right. Pneumothorax and hydrothorax on the left

By means of CT even small congestions of fluid and air in pleural cavity can be detected. The liquid and gas can move on pleural space, and their revealing at radiography in position of the patient on the back is not always possible. Imaging on CT does not depend greatly on the patient's position, thus detectability of injuries increases.

6.11. Radiological signs of lung tumours

Lung cancer (also called bronchogenic carcinoma) is the most common fatal malignant neoplasm. The radiological manifestation of lung cancer depends on the location of the tumour, its spread in the thorax and its histological type. Lung cancer invades locally by endobronchial and transbronchial growth, spreads within the lymphatic system to hila and mediastinal nodes, and also spreads through the bloodstream to secondary sites, including other thoracic structures. When the tumour is peripheral, it presents radiographically as a solitary pulmonary nodule or mass. The cardinal signs of central tumours are lung collapse or obstructive pneumonitis of the lung beyond the tumour and the presence of a hilum or parahilum mass, signs which may be seen in isolation or in conjunction with one another. CT, because of its better contrast resolution, will detect smaller lesions and virtually eliminate the problem of the tumour being hidden by normal overlying structures. Both CT and MRI play a major role in lung cancer staging. Signs of intrathoracic spread include bone

destruction, pleural effusion, hila and mediastinal lymphadenopathy, metastasis in the contralateral lung.

The central lung cancer. Clinical symptoms of the disease are: bronchial passableness disorders, change of drainage function of the bronchial tube. Basically, complaints of the patient are reduced to cough, often attack-like one, discharge of phlegm with blood, short wind, general weakness, rise of body temperature up to subfebrile figures, loss of body weight.

Central cancer develops from epithelium of the mucous membrane of large bronchial tubes: main, lobe or segmentary. Growth of a tumour can be directed to a lumen of the bronchial tube (mainly endobronchial cancer), peribronchial growth of a tumour outside from a wall of the bronchial tube (mainly exobronchial a cancer) is rather seldom observed.

In endobronchial of cancer tumour growth in an initial phase of development when the sizes of a tumour are very small, it is impossible to establish the diagnosis clinically and radiologically. In case of increase of its sizes ventilation of the lung segment or lobe is damaged, what gives the basis to suspect a tumour. There comes the second phase of tumour development and the first stage of bronchostenosis development – hypoventilation. At the second bronchostenosis stage valvular emphysema can develop which is characterized by the increased transparency of a segment or a lobe, expansion of intercostal intervals, displacement mediastinum at the forced breath in the healthy side (fig. 6.56).

Fig. 6.56. Chest film. Frontal view. Increasing radiolucenty of the left pulmonary area. Second stage of bronchostenosis of the left main bronchial tube. Endobronchial lung cancer of the left main bronchial tube

In process of tumour growth obturation of bronchus (bronchial passableness disorder of the third stage) occurs which causes development of bronchostenosis. At

radiography find the atelectasis of a segment, lobe or lung look like a homogeneous intensive shadow, with reduced sizes, concave interlobar borders, high located diaphragm and mediastinum displaced to the side of the lesion (fig. 6.57).

Bronchography detects pulmonary filling defect; in initial stages – rough, wavy contour, amputation of the bronchial tube in total obturation.

Tomograms help to detect narrowing of the bronchial tube lumen, a tumour shadow or bronchus air column rupture in its obstruction by the tumor.

Cancer growth outside the bronchial tube. Changes occur in the hilar zone, its expansion is detected due to primary tumour and MTS in lymph nodes, the shadow of the hilum loses its structure, merging with a median shadow. The contour is inverted to the pulmonary field, it is radiant and laminate, which testifies germination of the tumour in surrounding pulmonary tissue. The increase in tumour sizes up to several centimeters in diameter results in narrowing of the bronchial tube lumen, and ventilation disorders. Peribronchial growth of a tumour is difficult to define.

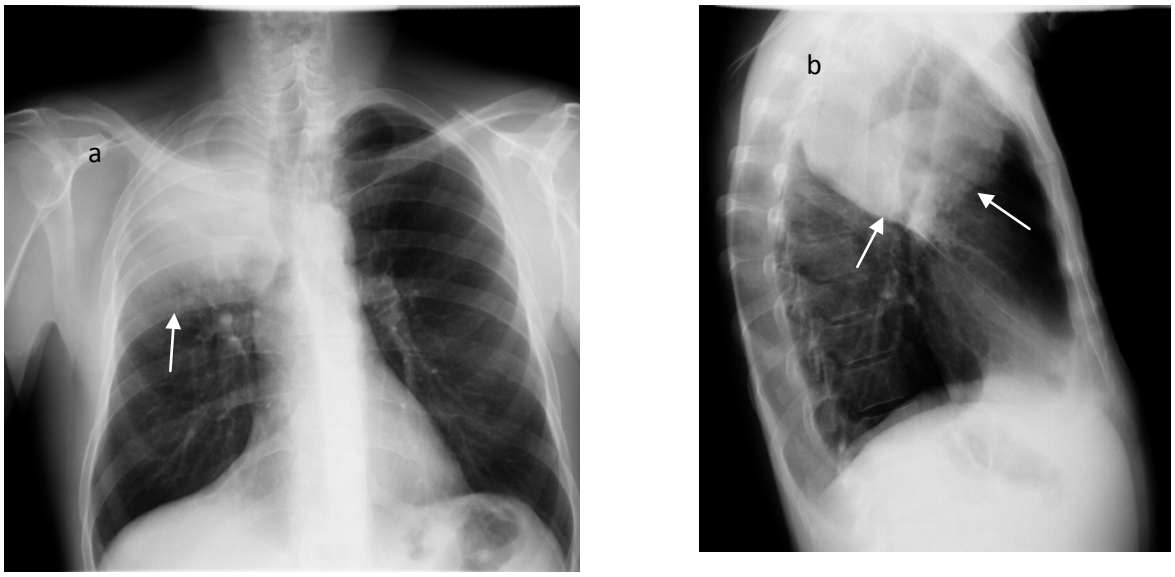

Fig. 6.57. Frontal (a) and lateral (b) chest radiographs. In upper department of right pulmonary field homogeneous shadow with lower concave contour and without air bronchogram (arrows). Right upper lobe atelectasis caused by endobronchial lung cancer

If formed thickening around of bronchial tube on chest radiograph have arisen the fan-shaped shadows in a hilum and in lung.

On tomograms the homogenous thickening of walls of bronchial tubes is defined. At the further growth of the tumour and germination of the wall bronchial lumens are narrowed, hypoventilation occurs. Bronchography detects extended concentric narrowing of the bronchial tubes and their walls thickening (fig. 6.58 and 6.59).

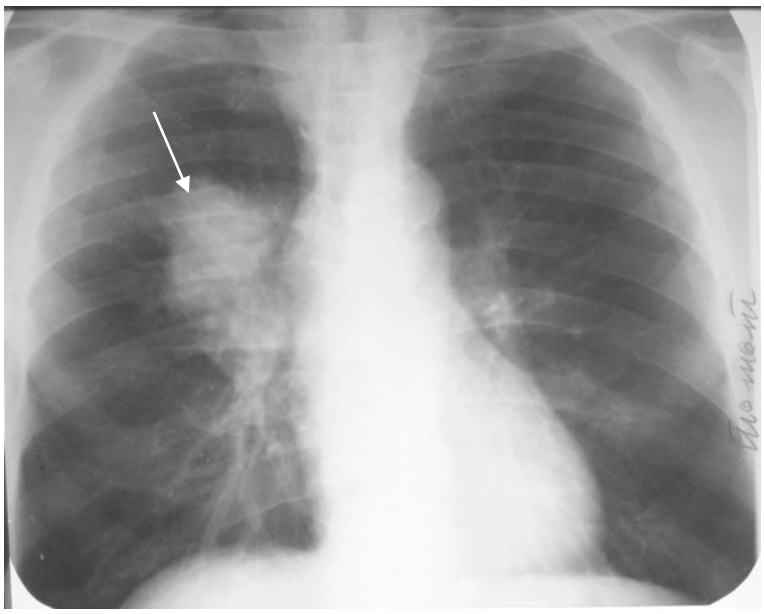

Fig. 6.58. Chest film. Limited shadow in the field in hilar zone of right lung with indistinct contours (arrow). Central cancer of the upper lobe of right lung when the tumor grows to outside from a bronchial tube

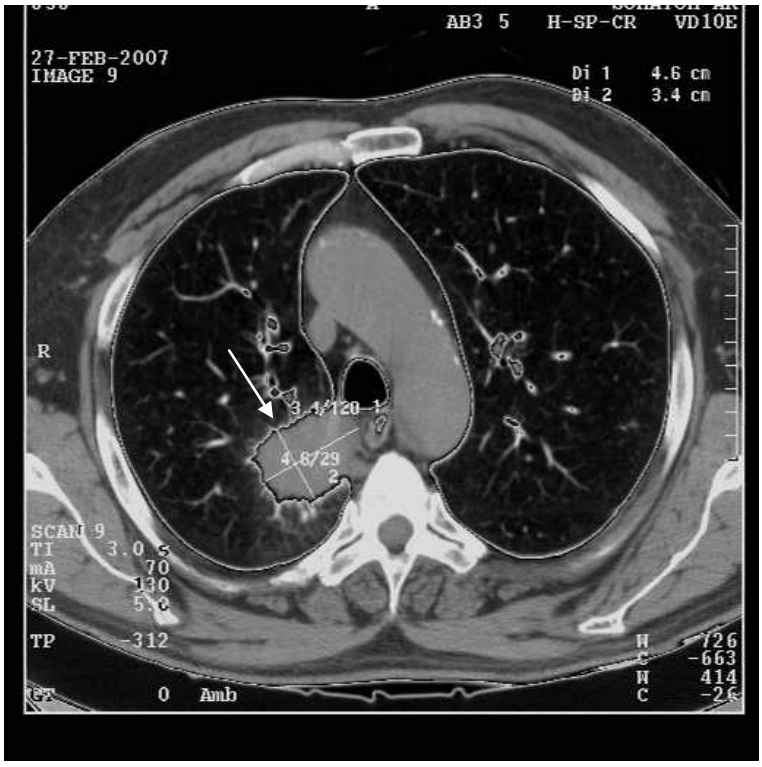

Fig. 6.59. CT-scan on the level of arch of the aorta. In the area of right hilum there is a shadow with irregular contour (arrow). Central cancer of the upper lobe of the left lung when the tumor grows outside the bronchial tube

Peripheral lung cancer develops from the small bronchial tube wall and more often grows as a noddule, locating under the pleura, or at significant distance from the pleura. The most often peripheral cancer localization is detected in the right lung and the upper lobes of both lungs.

Clinically, peripheral cancer does not manifest itself or a long time as it is located far from major bronchi. In this connection, it is more often detected radiographically. Clinical manifestations arise later and are characterized by occurrence of chest pain what is caused by germination of tumour in the pleura, in its germination in the bronchial tube cough with phlegm and hemoptysis occur.

Peripheral cancer at the beginning of its development forms small nodules of the polygonal form with diameter of 3-4 mm; it acquires the spherical form. Growth of the tumour can be slow or fast. Shadow intensity can be various depending on the nodule size. The shadow is more often non-homogenous, contour is irregular (hilly, bumpy).

Patterns close to the tumour noduleis usually reticular, which is likely caused by previous chronic inflammatory process. In some cases it is possible to see the path going from a round shadow of the tumour to the hilum, caused by lymphangitis or peribronchial and perivascularis tumour growth (fig. 6.60).

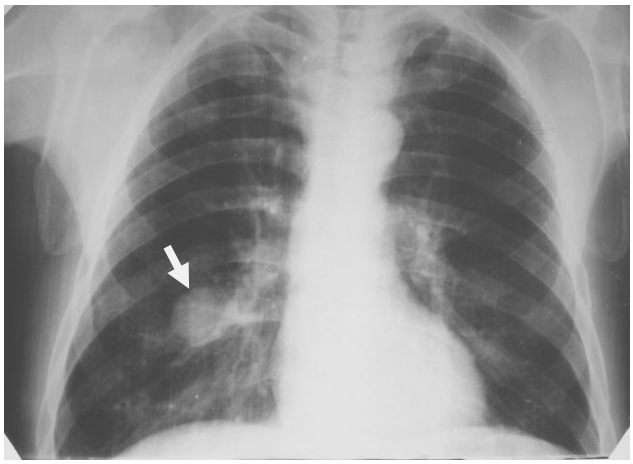

Fig. 60. Chest film. The round shadow in pulmonary field (arrow). Peripheral lung cancer

The tomography performed in peripheral cancer detects knottiness of the tumour shadow, the cavity of disintegration; it helps to reveal drainage of the bronchial tube, a condition of hilum and mediastinum lymph nodes (fig. 6.61).

Fig. 6.61. Ct-scan on the level of the aorta arch. Round shadow with a radiant contour in the second segment of the right lung (arrow) is detected. Peripheral lung cancer

Lung apex cancer (Pancoast′s neoplasm). Clinical manifestation is late. Pains are typical. Radiographically this cancer is characterized by a shadow which occupies the area of the whole lung apex. The bottom border of the shadow is distinct and is inverted by camber downwards while other borders are not differentiated. On the shadow background usually it is possible to see the destruction of posterior rib parts and several vertebras (fig. 6.62).

Fig. 6.62. CT sclice on the level of Th_{III} vertebra. Mass in upper lobe of left lung, which involves Th_{III} vertebra, soft tissue and back part of the IV rib (arrows). Pancoast′s neoplasm of the left lung

Mediastinal form of cancer. In the clinical picture the most important is compression syndrome (vena cava superior, large nervous trunks). Such symptoms as neck and face edema, feeling of compression in the neck and chest area are observed. Primary localization of a tumour in most cases appears not clear, the minimal sizes of a tumour do not allow to define it at radiological research, the early tendency to metastasis in lymph nodes mediastinum however is characteristic.

Nowadays the leading way of mediastinum masses diagnostics is CT and MRI which allow to establish exact localization of a mass, its relations with surrounding anatomic structures, and in some cases to give enough exact tissue characteristic of a mass (lipoma, cyst).

Radiographically the picture, characteristic for a mediastinum tumour is: presence of the extensive tissue overlapping a shadow of the lung hilum from the one side (increase lymph nodes unilateral), merging with a median shadow. Sometimes it is difficult to define the nature of the increased lymph nodes because Hodgkin′s disease or lymphosarcoma can give a similar picture (fig. 6.63).

MTS in lung. As a rule, MTS give a round shadows (multiple pulmonary nodules) in the x-ray image. They are usually multiple, but sometimes solitary MTS can be observed. CT is the most sensitive method of detection of MTS in lungs. It provides confident identification of small nodules with the size up to 3 mm (radiographycally > 6 mm); in the area of hila a threshold of revealing for CT is 5-6 mm (fig. 6.64 and 6.65).

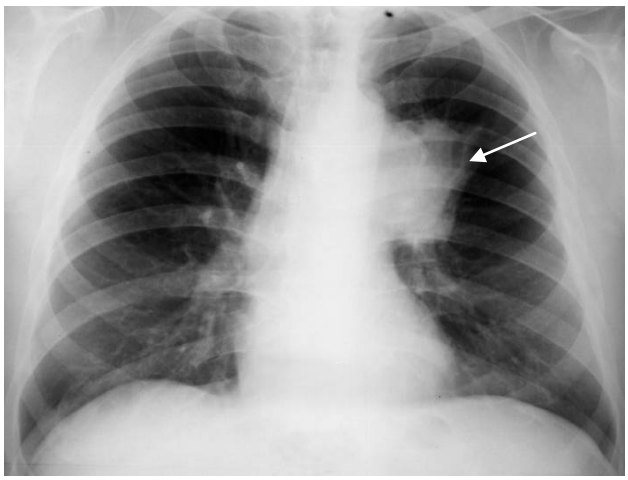

Fig. 6.63. The frontal chest radiograph. Conglomerate of the increased lymph nodes in the hilum of the left lung (arrow). Mediastinal form of lung cancer in the left side

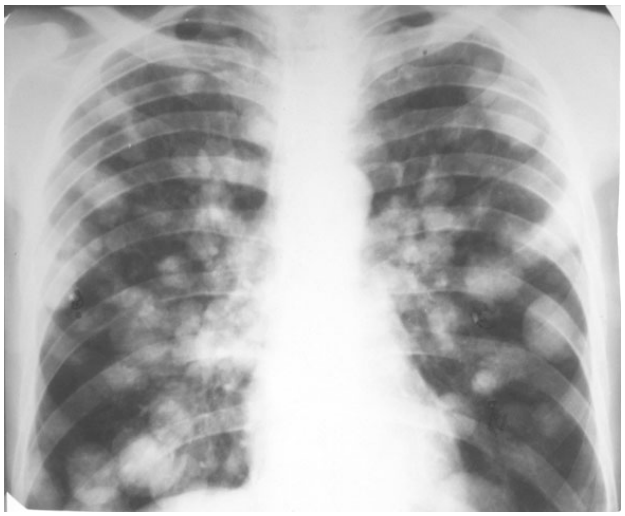

Fig. 6.64. Chest film. Multiple pulmonary nodules in both lungs. Cancer metastases in lungs

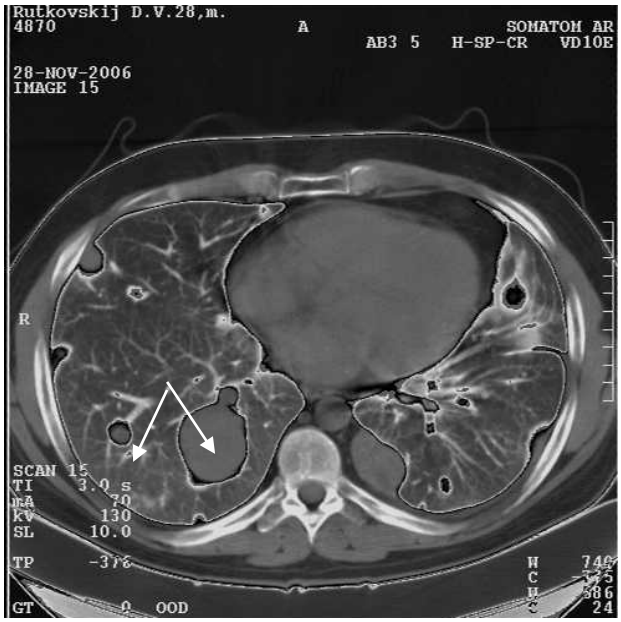

Fig. 6.65. The computer tomogram of the thorax at level $T_{IX.}$ Multiple cancer metastases in both lungs (some metastases are specified by arrows)

Miliary carcinomatosis. Miliary carcinomatosis manifests itself as small-nodular simmetric dissemination, especially dense in the inferior parts of lungs.

The differential diagnosis is difficult. It is necessary to carry out careful phlegm analysis and puncture biopsy.