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UNIVERSITATEA DE STAT DE MEDICINĂ ŞI FARMACIE „NICOLAE TESTEMIŢANU"

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MEDICAL IMAGING IN TABLES AND ALGORITHMS

Guidelines

CHIŞINĂU

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The Guidelines touch upon a very important problem of healthcare of patients in absolutely all areas of medicine, because not a single area of modern medicine can be imagined to be successful without the use of data obtained through medical imaging methods.

Methodical materials contain tables, figures and algorithms that highlight key moments in medical imaging and facilitate their understanding.

The new Guidelines are recommended for the 3rd-year students of Faculty of Medicine, which only start studying clinical disciplines, but it will be also useful for the 6th-year students, who resume studying the subject "medical imaging" on the basis of clinical knowledge to master the art of using imaging methods in order to obtain maximal information in each case.

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CONTENTS

INTRODUCTION

Medical imaging is the branch of medicine that deals with exploration of the organs and the systems of the human body for diagnostic purposes, evaluation the treatment effectiveness and prevention of pathologic processes using electromagnetic waves and ultrasound.

On the other hand and on the basis of the name, medical imaging can be defined as diagnostic imaging, visualization of normal and pathological structures of the human body.

For years, doctors could only dream of being able to view pathological changes in the patient's body. The first opportunity to realize this dream occurred in 1895, with the discovery of X-rays by W.C.Roentgen. Radiology had remain the only method of viewing up to the 50s, when the clinical use of methods of ultrasound and nuclear medicine started. The term "medical imaging" itself arose when digital image processing became possible.

At present it is impossible to imagine everyday medical practice without the use of imaging methods in order to make a diagnosis and to check the effectiveness of treatment. Knowledge of these methods is essential for a successive and effective activity of each physician, aside from his specialty.

This guideline does not pretend to replace manuals and intends to facilitate the introduction in the subject and further mastering medical imaging by students.

I. MEDICAL IMAGING. COMPONENT PARTS. METHODS OF EXAMINATION

Table 1.1

KEY DATES IN RADIOLOGY HISTORY

Year	**Event**
1895	Discovery of X-rays (W.C.Roentgen)
1896	Discovery of radioactivity (H.Becquerel)
1901	Rontgen receives the Nobel Prize in Physics for the discovery of x-rays
1905	The first book on Chest Radiography is published
1918	G. Eastman introduces radiographic film
1920	The Society of Radiographers is founded
1934	Joliot and Curie discover artificial radionuclides
1937	The first clinical use of artificial radioactivity is done at the University of California- Berkeley
1946	Nuclear medicine is founded
1950	The first clinical use of ultrasonography (W.D. Keidel)
1950′	Development of the image intensifier and X-ray television Wide-spread clinical use of nuclear medicine starts
1962	Introduction of SPECT and PET methods
1967	The first clinical use of MRI takes place in England
1972	CT is invented by British engineer Godfrey Hounsfield
1977	The first human MRI images are produced
1979	Comack and Hounsfield receive the Nobel Prize in Medicine for computed axial tomography
1975-1985	Advancement of clinical use of two-dimensional ultrasonography
1985	Clinical use of Color Doppler begins

Table 1.2.

COMPONENT PARTS OF MEDICAL IMAGING

Method / Characteristics	Radiology	Ultrasonography	Magnetic resonance imaging	Nuclear medicine	Thermography
Energy	X-rays	Acoustic waves	Magnetic field and radio waves	Gamma rays	Infrared rays
Source of energy	X-ray tube	Piezoelectric crystal	Permanent magnet, antennas	Radionuclide	Human body
Morphological investigation	+++	+++	+++	+ - ++	++
Dynamic investigation	+	++	+	+++	-
Terminology	Opacity Lucency (hyperdensity, hypodensity in computed tomography)	Hyperechoic Hypoechoic	Hyper-intensive, Hypo-intensive	Hot area Cold area (node, spot)	
Ionizing action	+	-	-	+	-
Contraindications	Pregnancy	-	Implanted metallic dispositives	Pregnancy	-
Contrast media	Substances with higher or lower density	Substances with micro bubbles	Paramagnetic substances		

Table 1.3.

X-RAY PROPERTIES

<table>
<tr><td rowspan="3">Common for all kinds of electromagnetic waves</td><td colspan="2">Travel straight ahead, along the straight line</td></tr>
<tr><td colspan="2">Travel with the velocity of light (300 000 km/sec)</td></tr>
<tr><td colspan="2">Travel in all directions</td></tr>
<tr><td rowspan="5">Passing through the human body</td><td colspan="2">Penetration</td></tr>
<tr><td rowspan="3">Absorption, which depends on:</td><td>Density</td></tr>
<tr><td>Thickness</td></tr>
<tr><td>Frequency (wavelength)</td></tr>
<tr><td colspan="2">Dispersion</td></tr>
<tr><td colspan="3">Chemical photographic action</td></tr>
<tr><td colspan="3">Effect of fluorescence</td></tr>
<tr><td rowspan="3">Ionizing effects</td><td colspan="2">In the air</td></tr>
<tr><td rowspan="2">In the human body</td><td>Somatic</td></tr>
<tr><td>Genetic</td></tr>
<tr><td colspan="3">Cannot be detected by sense organs</td></tr>
</table>

Figure 1.1.

X-ray tube

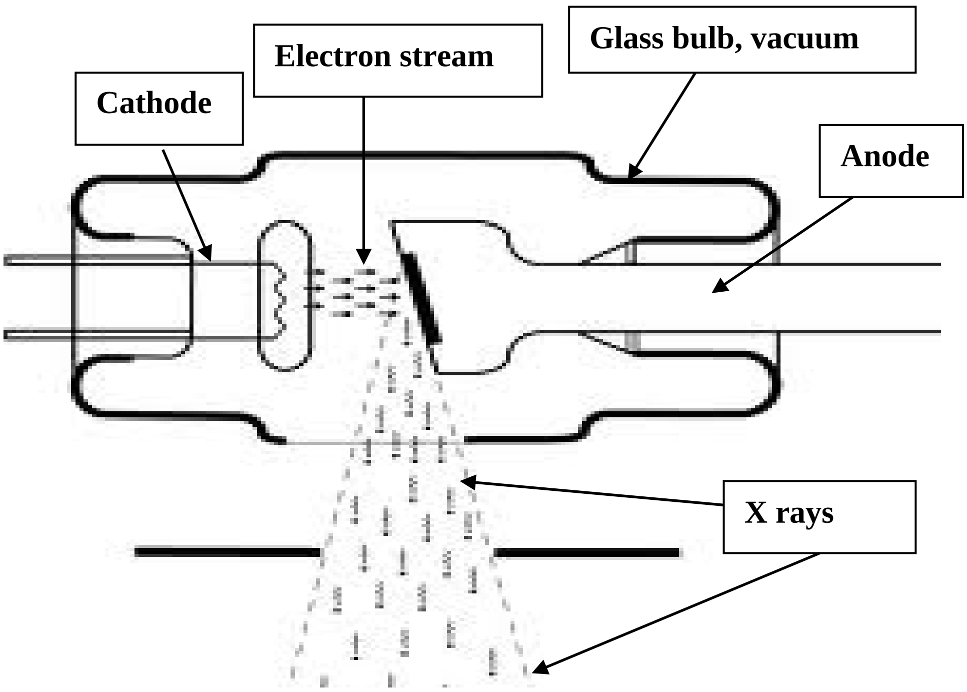


Table 1.4.

NATURAL CONTRAST LEVELS

(from minimal to maximal density)

Level	**Substance with appropriate density**
1	Air
2	Fat tissue
3	Liquids / soft tissues / parenchymatous organs
4	Bones
5	Metal

Table 1.5.

UNITS OF MEASURE FOR IONIZING RADIATION

Characteristics. Level of detection of radioactivity.	**Old unit**	**SI unit**	**Correlation old unit/ SI unit**
Radioactivity of the source of ionizing radiation	Curie (**Cu**)	Becquerel (**Bq**)	1Bq=0,027mCu
Air	Roentgen (**R**)	Coulomb/kilogram (**C/kg**)	500R=129mC/kg
Absorbed dose (for X-rays)	**Rad** (Radiation Absorbed Dose)	Grey (**Gy**)	
Equivalent dose (independent of the nature of ionizing radiation)	**Rem** (Rad Equivalent Man)	Sievert (**Sv**)	1Sv=100rem

Table 1.6.

CHARACTERISTICS OF RADIOGRAPHIC IMAGE

Characteristics	**Meaning**
Contrast	Correlation between white and black. Variation of shading set between the most dark and the most white point of the image
Definition	Clearness of the contour lines of the image. The contour lines should be: well-defined clear precise, an unclear contour may mean a sign of pathology
Resolution	Minimal distance between 2 well distinguishable objects (when these may be appreciated like 2 different objects)

Table 1.7.

LAWS OF FORMING OF RADIOGRAPHIC IMAGE

Law	**Cause**	**Conclusions**
Conic projection	X-ray beam has a conical shape with its top at the X-ray tube and its base on the radiographic plate	Radiographic image is always larger than the object
		Closer the object is to the screen (x-ray film), the image is less increased
Summation of plans	A radiographic image is a two-dimensional image of a three-dimensional object	2 items, located in the same plane (in the way of x-ray) but at different distances from the X-ray tube and film overlap and project simultaneously
		When tilting the X-ray tube, the image of the object located closer to the tube, will be shifted more towards the periphery of the screen (parallax effect) and so two objects will be projected separately
Tangential projections	X-rays travel straight ahead, along the straight line	The image of a plane object located parallel to the screen is always increased but not deformed
	X-rays are neither reflected nor refracted by structures that meet	The image of a plane object located oblique to the screen is increased and deformed
		The image of a plane object located perpendicularly to the screen is linear

Table 1.8.

RULES OF IMAGE POSITIONING (ORIENTATION)

Method	**Conceivable position of the patient, for the radiographic image orientation**
Radiography	Vertical (cranial upward, caudal downward), face to face (left of the patient is on right of the examiner, right of the patient is on left of the examiner) or profile for lateral projection
CT, MRI	The patient is positioned in dorsal decubitus, the examiner looks at the patient being at his feet (for axial images anterior-upward, posterior-downward, left-on right, right-on left)

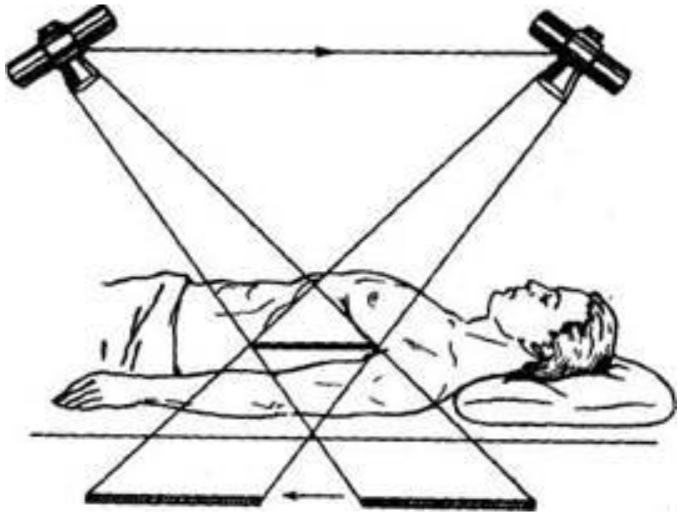
Table 1.9.

CLASSIFICATION OF RADIOLOGICAL CONTRAST MEDIA

<table>
<tr><td colspan="4">Radionegative (lucent, nonopaque), low density: gases</td></tr>
<tr><td rowspan="5">Radiopositive (opaque): high density</td><td colspan="3">Insoluble (barium sulfate)</td></tr>
<tr><td colspan="3">Liposoluble (iodinated CM)</td></tr>
<tr><td rowspan="3">Water-soluble (iodinated CM)</td><td colspan="2">The elimination mainly through biliary ways</td></tr>
<tr><td rowspan="2">The elimination mainly through urinary ways</td><td>Ionic</td></tr>
<tr><td>Non-ionic</td></tr>
<tr><td colspan="4">Double contrastation (using both radiopositive and radionegative media)</td></tr>
</table>

Figure 1.2

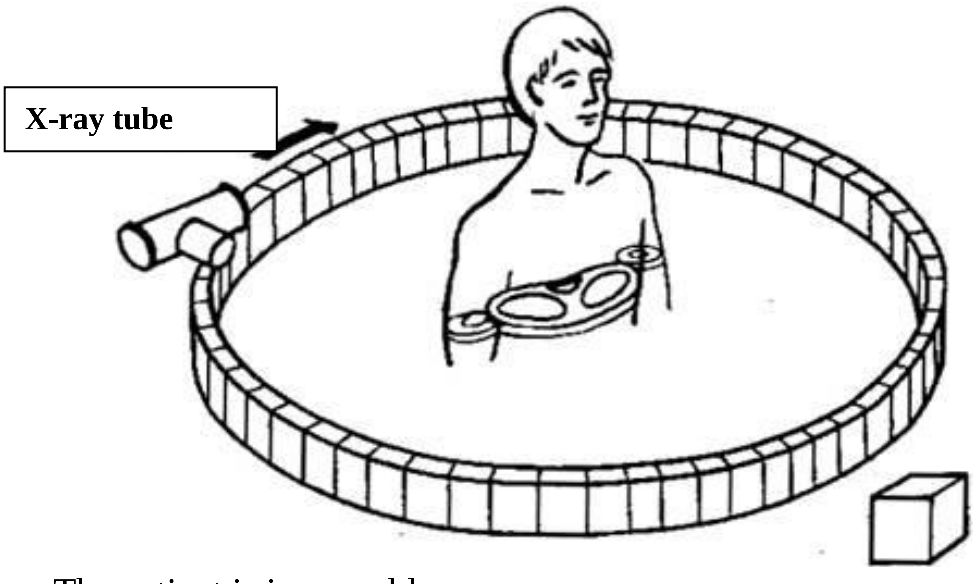
Plane (conventional, linear) tomography.



- The patient is immovable.
- X-ray tube and screen are moving synchronously in opposite directions, pivoting around an axis fixed to the depth chosen for investigation.

Figure 1.3.

Computed tomography



- The patient is immovable.
- X-ray tube and detectors move around the patient
- X-ray beam is fan-shaped collimated

Table 1.10.

COMPARATIVE ANALYSIS OF PLANE TOMOGRAPHY AND COMPUTED TOMOGRAPNY

Characteristics	**Plane tomography**	**Computed tomography**
The presence of the image of the structures located above and below the plane of section	Indistinct, but present	Not present
Grades (levels) of contrast	5 (those of natural contrast)	≥2000 (Hounsfield scale)
Real plan of section	Frontal, most often	Axial
Possibility of 3D reconstruction	-	+
Cost of investigation	Relatively low	High

Figure 1.4.

Piezoelectric crystal and piezoelectric effect

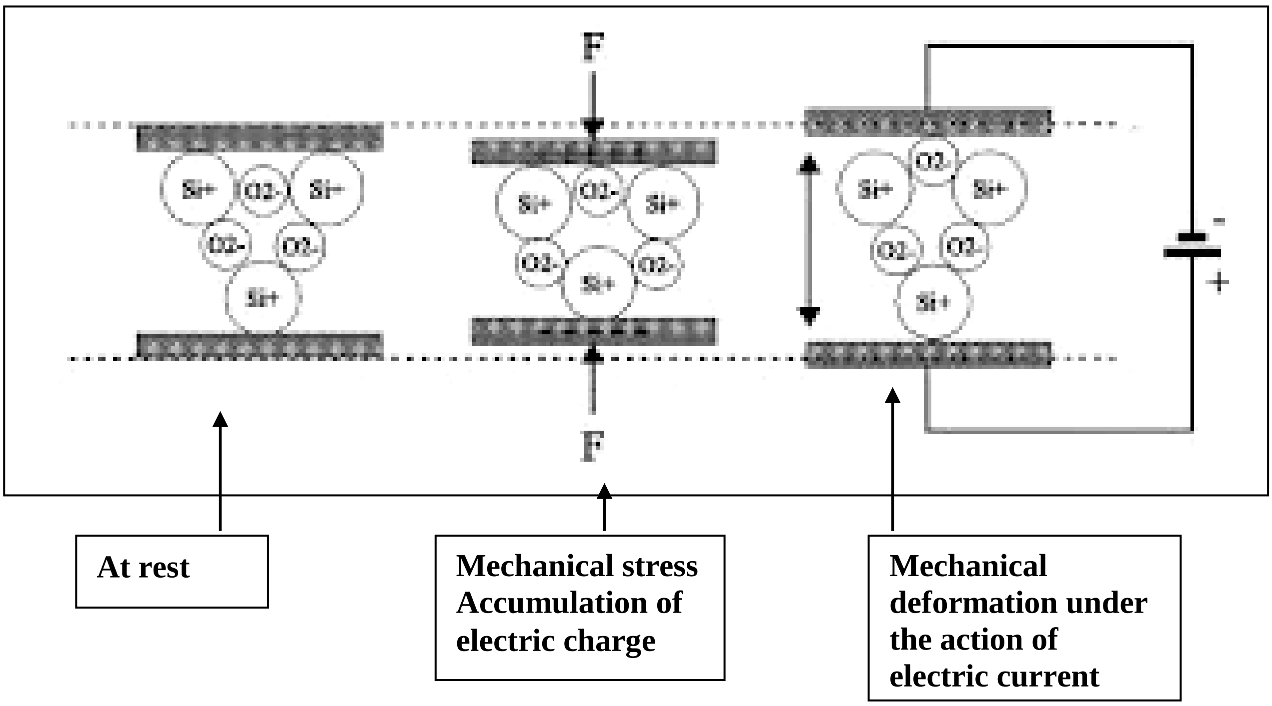


Table 1.11.

PROPERTIES OF ULTRASOUND

<table>
<tr><td rowspan="3">Propagation</td><td colspan="3">Rectilinear</td></tr>
<tr><td colspan="3">The velocity of propagation of ultrasound in a homogeneous medium at a given temperature is constant</td></tr>
<tr><td colspan="3">The mean velocity of propagation of ultrasound in biological media is 1540 m/s</td></tr>
<tr><td rowspan="6">When going through the human body</td><td rowspan="3"><u>Reflection</u></td><td colspan="2">It occurs when the object size exceeds ultrasonic wavelength</td></tr>
<tr><td rowspan="2">Occurs at a transition zone between two media with different acoustic impedance</td><td>The greater the difference in acoustic impedance between two media, the more ultrasound is reflected</td></tr>
<tr><td>In regions where acoustic waves meet air or bone (large difference in acoustic impedance) investigation becomes practically impossible</td></tr>
<tr><td colspan="3">Absorption</td></tr>
<tr><td colspan="3">Refraction</td></tr>
<tr><td colspan="3">Dispersion</td></tr>
</table>

Table 1.12.

Methods of ultrasonography

Echography (based on the reflection of ultrasound from immoveable structures): mode	**Doppler-echography (based on the reflection of ultrasound from moving structures): Doppler methods**
• A (amplitude) • M (motion) • B (brightness, two-dimensional echography) • 3D • 4D	• Pulsative • Continual • Color Doppler • Tissular Doppler (tissue in motion) • Power Doppler (analyzes very low flows)

Table 1.13.

CHARACTERISTICS OF IONIZING RADIATION

Characteristics / **Ionizing radiation**	**Nature**	**Electric charge**	**Mass**	**Penetration in substances**
α particles	Identical with nucleus of helium	+2	4 atomic mass	Very low – 0,5 mm
β particles	Electron or positron	-1 or +1	of electron	More than **α** – 0,5 cm
γ-rays	Electromagnetic waves	-	0	High
X-rays	Electromagnetic waves	-	0	High

Table 1.14

MAIN ADVANTAGES AND DISADVANTAGES OF DIFFERENT IMAGING METHODS

Method	**Advantages**	**Disadvantages**
Radiography	• easily accessible • visualizes fine details • can serve as forensic document, allows creating archive • lower radiation dose	• does not allow functional investigation • does not allow guiding invasive manipulations
Fluoroscopy	• Allows functional investigation • Allows guiding invasive manipulations	• High radiation dose • Visualizes less details • Relatively subjective • Cannot serve as forensic document
Computed tomography	• The possibility of studying small anatomical structures including several mm in diameter • Elimination of summation • Possibility of reconstruction in different sections and 3D • Objective densitometric analysis of structures • Differentiating density variation of 0.4-0.5% • Allows guiding invasive manipulations	• Ionizing effect • High cost • Only transversal (axial) sections are primary images

USG	• Non-invazive • Does not use ionizing radiation • Painless, harmless to the patient • Easily accessible • Relatively low cost • Portable, can be performed under any circumstances (to bedside, in the operating room, etc.). • Can be performed in any patient and probe position • Can be repeated as often as necessary	• Operator-depending • Impossibility to investigate the structures covered by air, bone, fat
MRI	• Does not use ionizing radiation • Allows different plans of scanning • Excellent soft tissue visualization • Excellent view of the brain and spinal cord • Does not require contrast agents to visualize blood vessels, biliary ducts, heart	• Very high cost • Relatively less accessible • Duration of scanning is very long • Impossibility of investigation of the patients having metallic implants • Insufficient view of calcified structures

II. CHEST IMAGING

Scheme 2.1.

EXAMINATION OF A CHEST RADIOGRAPH

1. **Identification**	Name of the patient Date of examination
2. Estimation of the quality of the film	Position of the patient Exposition
3. **Examination of bony structures and soft tissues**	
4. **Examination of the mediastinum**	Cardiac silhouette; Pulmonary hilum Identification of the trachea and the main bronchi
5. **Examination of pleura**	Parietal, Diaphragmal, Visceral pleura. Fissures
6. **Examination of lung fields**	From cranial to caudal Comparison right-left Pulmonary vasculature.
7. **Semiological analysis. Additional structures**	

Table 2.1.

SIMPLE CHEST X-RAY. PULMONAY FIELDS AND ZONES

<table>
<tr><th colspan="3">Pulmonary fields</th><th colspan="3">Pulmonary zones</th></tr>
<tr><th rowspan="2">Pulmonary field</th><th colspan="2">Limits</th><th rowspan="2">Pulmonary zone</th><th colspan="2">Limits</th></tr>
<tr><th>Superior</th><th>Inferior</th><th>Medial</th><th>Lateral</th></tr>
<tr><td>Apical</td><td>The upper thoracic contour</td><td>Clavicle</td><td>Perihilar (intern, medial)</td><td>Mediastinal shadow board</td><td>The line drawn through the middle of the clavicle shadow that projects over the lung field</td></tr>
<tr><td>Superior</td><td>Clavicle</td><td>The anterior arch of the 2nd rib</td><td>Central (medial)</td><td>The line drawn through the middle of the clavicle shadow that projects over the lung field</td><td>Medioclavicular line (drawn from the intersection of the shadow of the clavicle with the chest wall to the diaphragm)</td></tr>
<tr><td>Medial</td><td>The anterior arch of the 2nd rib</td><td>The anterior arch of the 4th rib</td><td rowspan="2">Peripheral (lateral)</td><td rowspan="2">Medioclavicular line (drawn from the intersection of the shadow of the clavicle with the chest wall to the diaphragm)</td><td rowspan="2">Lateral chest wall</td></tr>
<tr><td>Inferior</td><td>The anterior arch of the 4th rib</td><td>Diaphragm</td></tr>
</table>

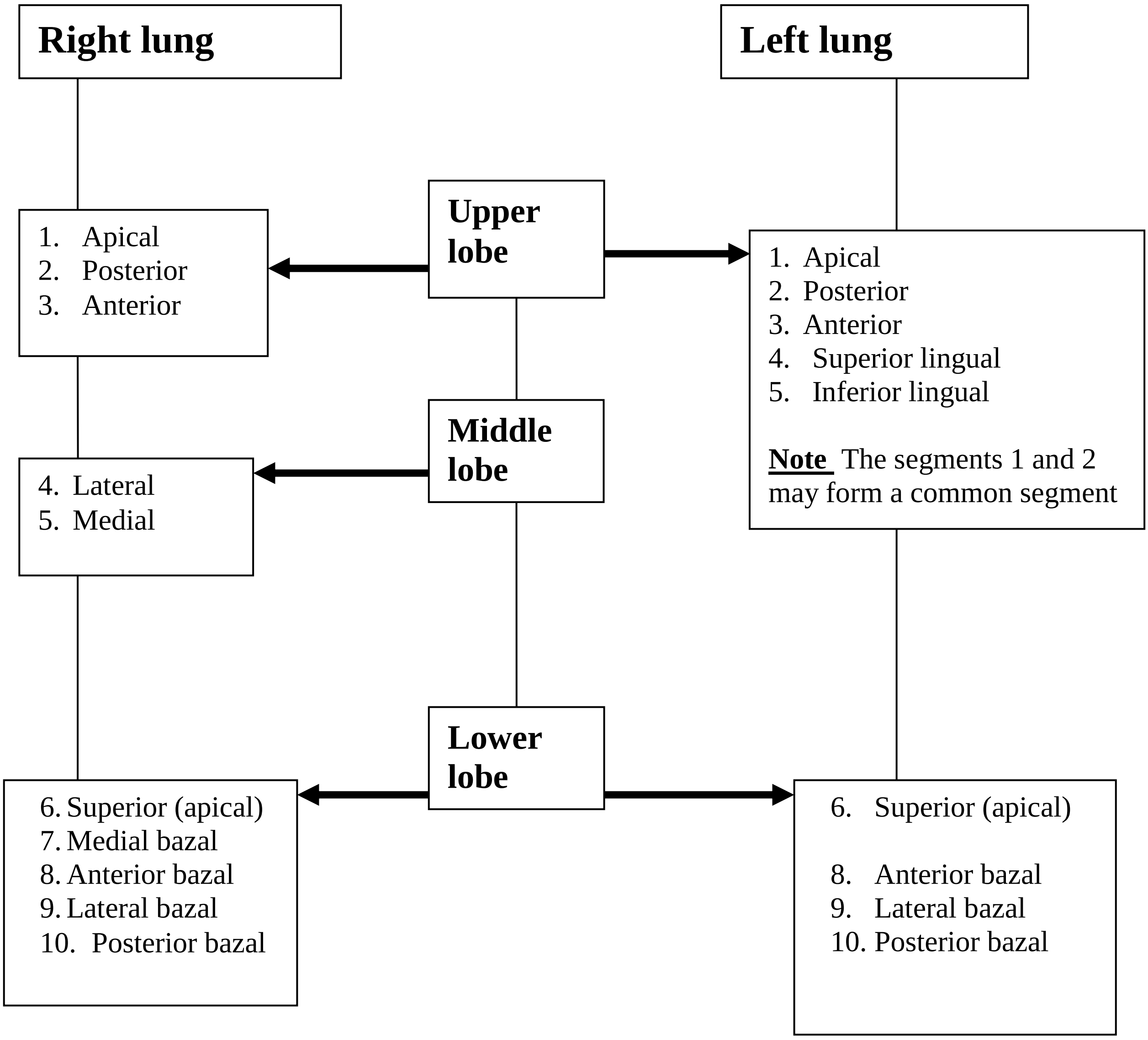
Table 2.2.

SIMPLE CHEST X-RAY.
BASIC ANATOMICAL LANDMARKS

	Anatomical structure	Landmark on standard chest radiograph
Frontal view	The most left point of the cardiac shadow	About ≈ 1 -1.5 cm medial from the left medioclavicular line
	The most right point of the cardiac shadow	About ≈ 1 – 1.5 cm lateral from the right lateral contour of spinal cord
	The upper point of the right hemidiaphragm	Anterior arch of the 5^{th} – 6^{th} rib, inspiration
	Left hemidiaphragm	1-2 cm lower than the right one
	Bifurcation of trachea	T5 Angle 45-70° Right bronchus is more vertical than the left one
	Aortic arch (upper level of the cardiac shadow)	T3
	Right pulmonary hilum	Medial zone Between the anterior arches of the 2^{nd} and the 4^{th} rib
	left pulmonary hilum	About ≈ 2 cm (or width of a rib) upper than the right one
Lateral view	Oblique fissure (right lung)	From T4 via right pulmonary hilum to the upper point of the right hemidiaphragm
	Horizontal fissure (right lung)	Level of the anterior arch of the 4^{th} rib
	Oblique fissure (left lung)	From the intervertebral disk T3-T4 via the left pulmonary hilum to the upper point of the left hemidiaphragm

Scheme 2.2.

PULMONARY SEGMENTS



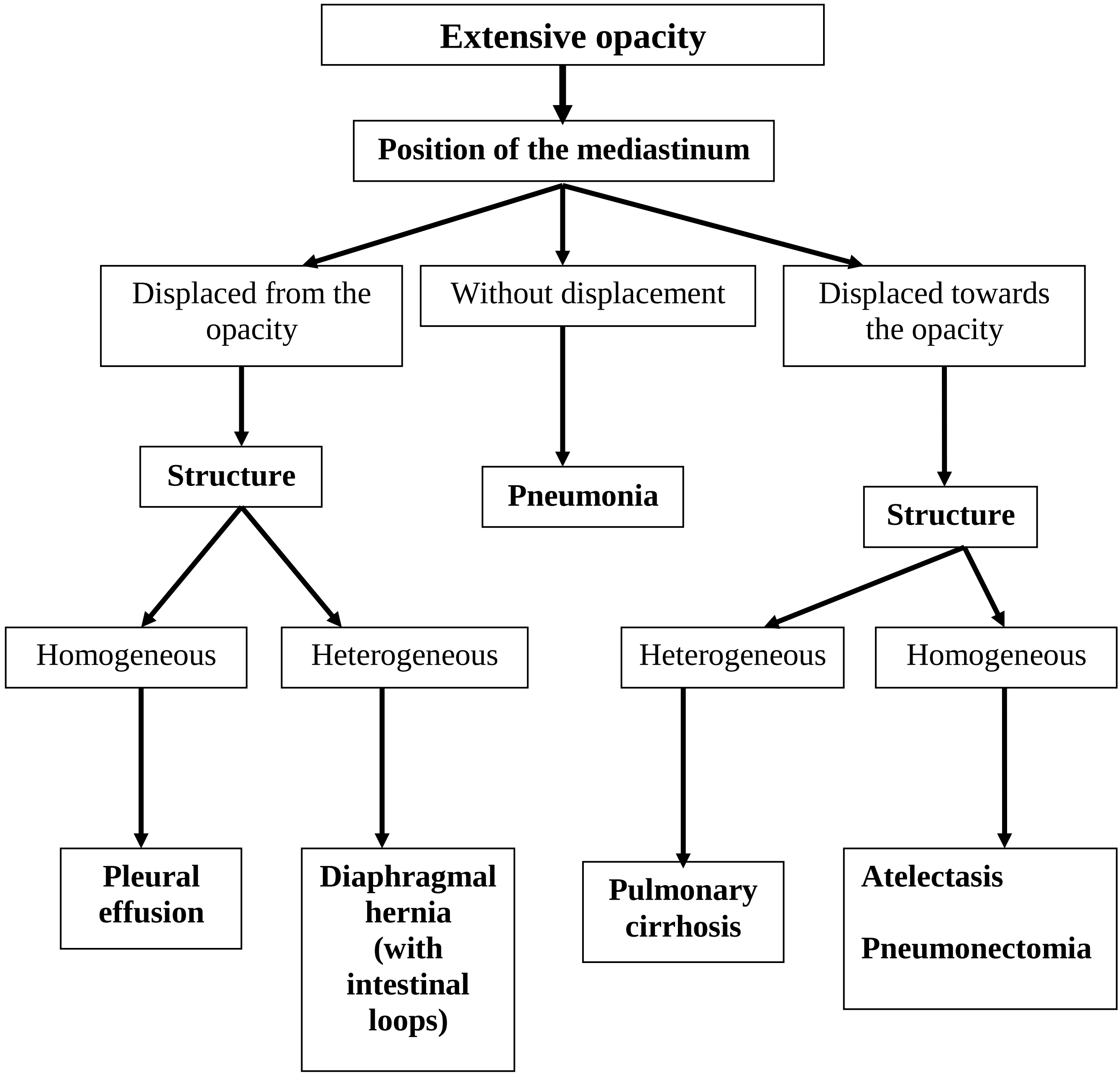
Scheme 2.3.

EXAMINATION OF PULMONARY OPACITY

1. Localization	segment, lobe, lung
2. Number	single, multiple disseminated
3. Form	Corresponding to anatomical structures (lob, segment); Rounded Ring-shaped Linear Triangle Irregular
4. Dimensions	Extensive: total (al the hemithorax) subtotal: 2/3 of hemithorax Limited: up to 1/3 of hemithorax Nodular: less then 2.5 cm
5. Borders	ill-defined well-defined regular, irregular
6. Structure	homogeneous, heterogeneous
7. Mediastinum	Without displacement Displaced towards the opacity Displaced from the opacity
8. Mobility (for fluoroscopy**)**	Immobile Mobile by itself Mobile secondary to the movements of other structures

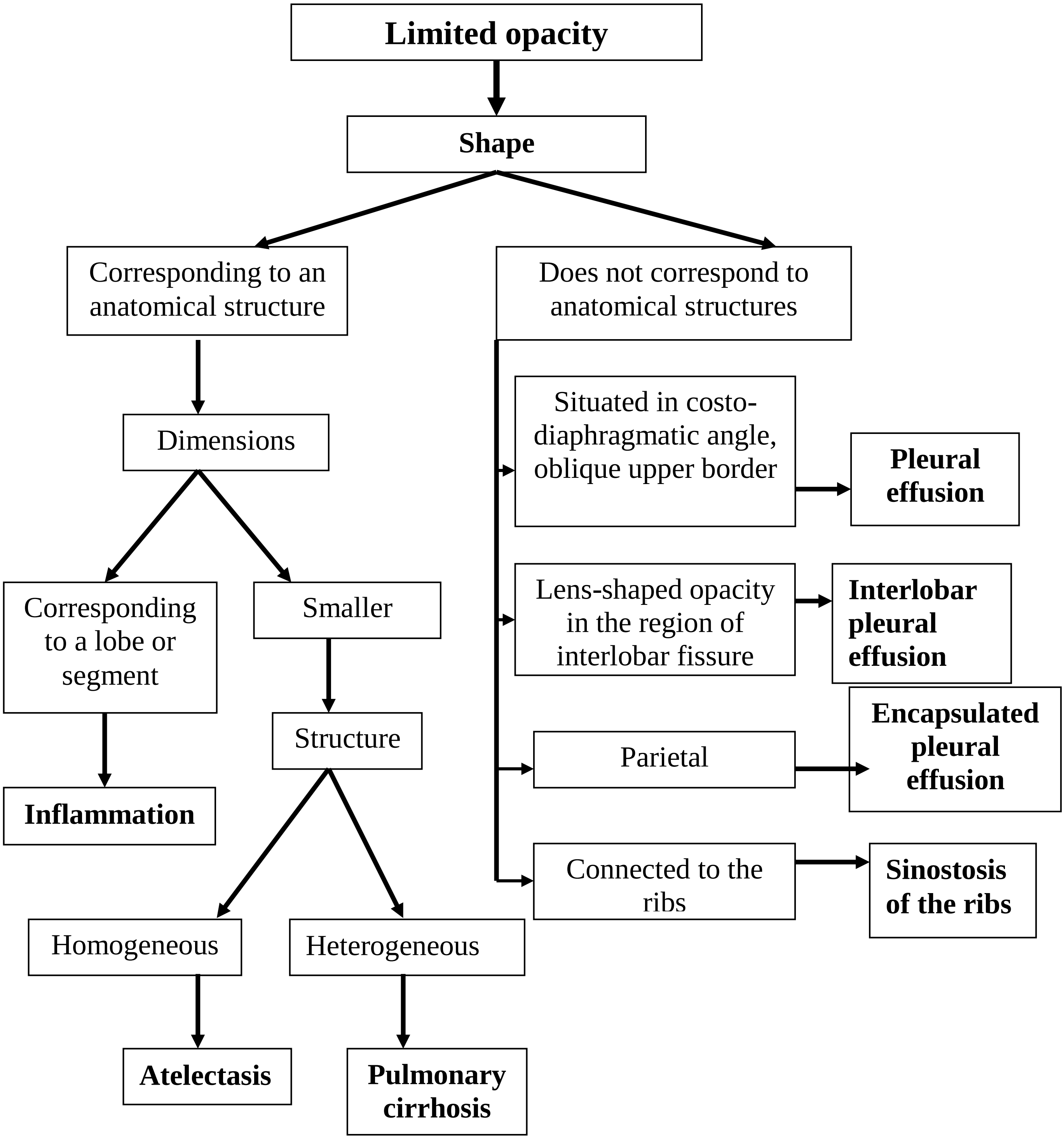
Algorithm 2.1.

Total or subtotal opacity



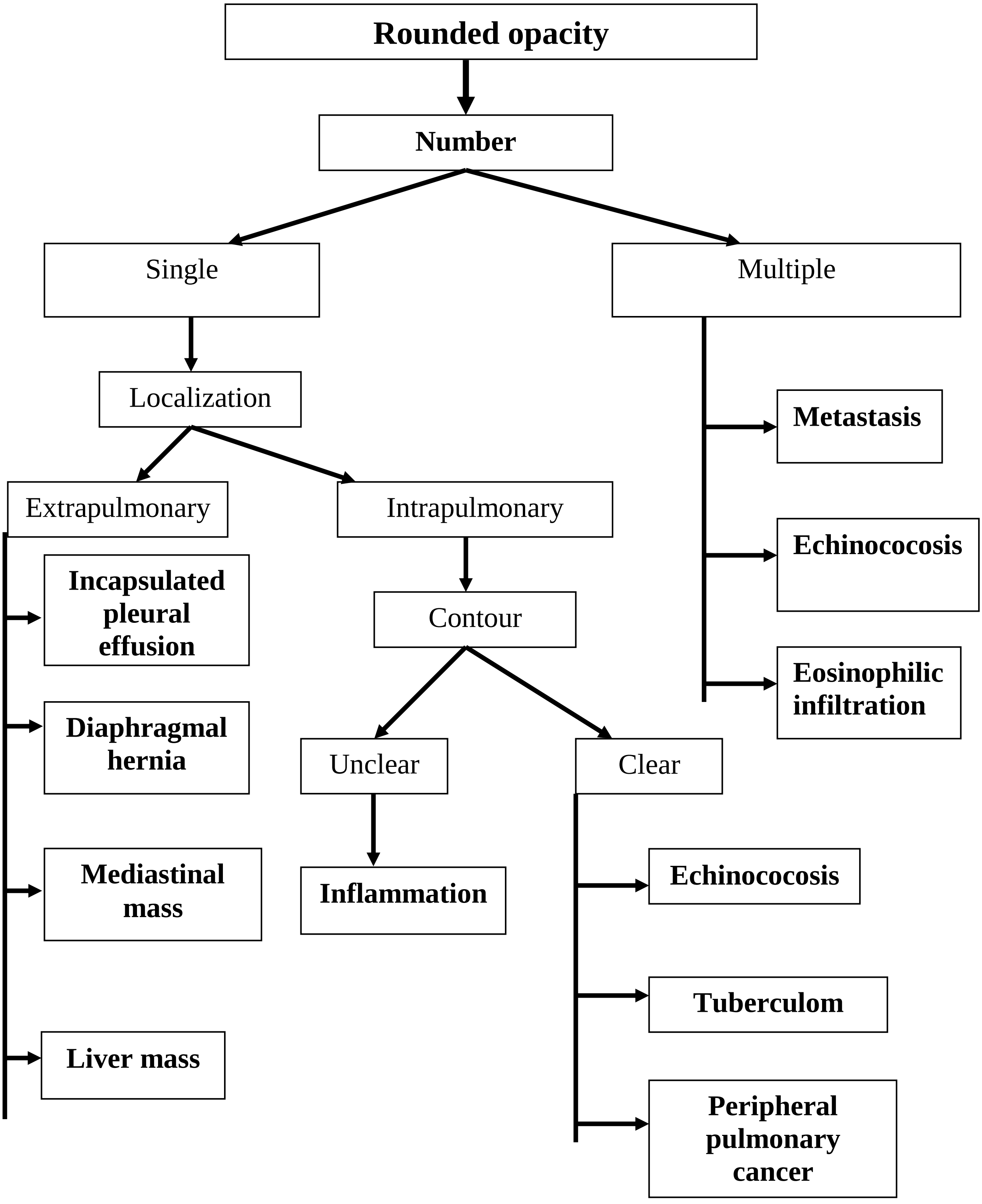
Algorithm 2.2.

Limited opacity



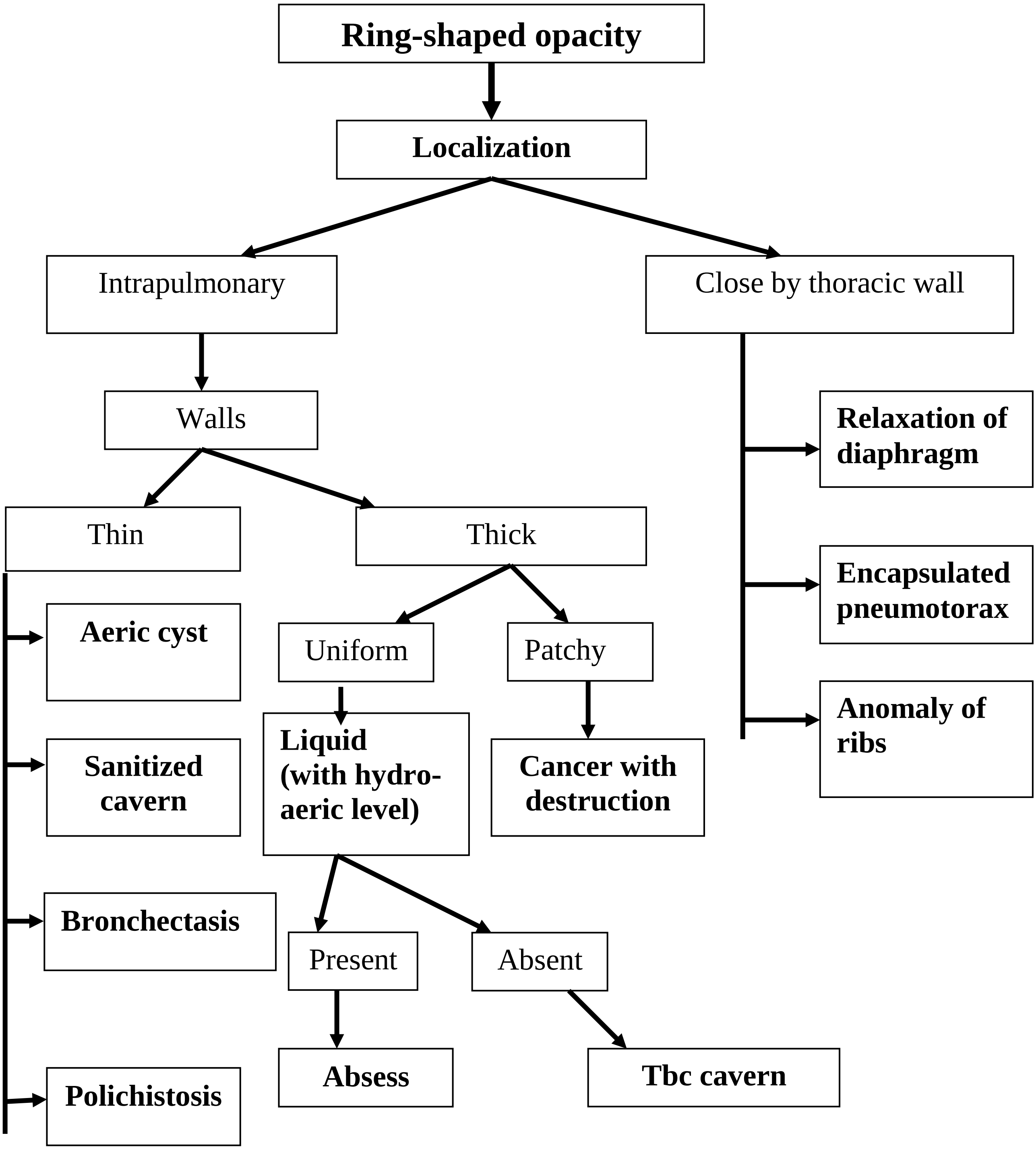
Algorithm 2.3.

Rounded opacity



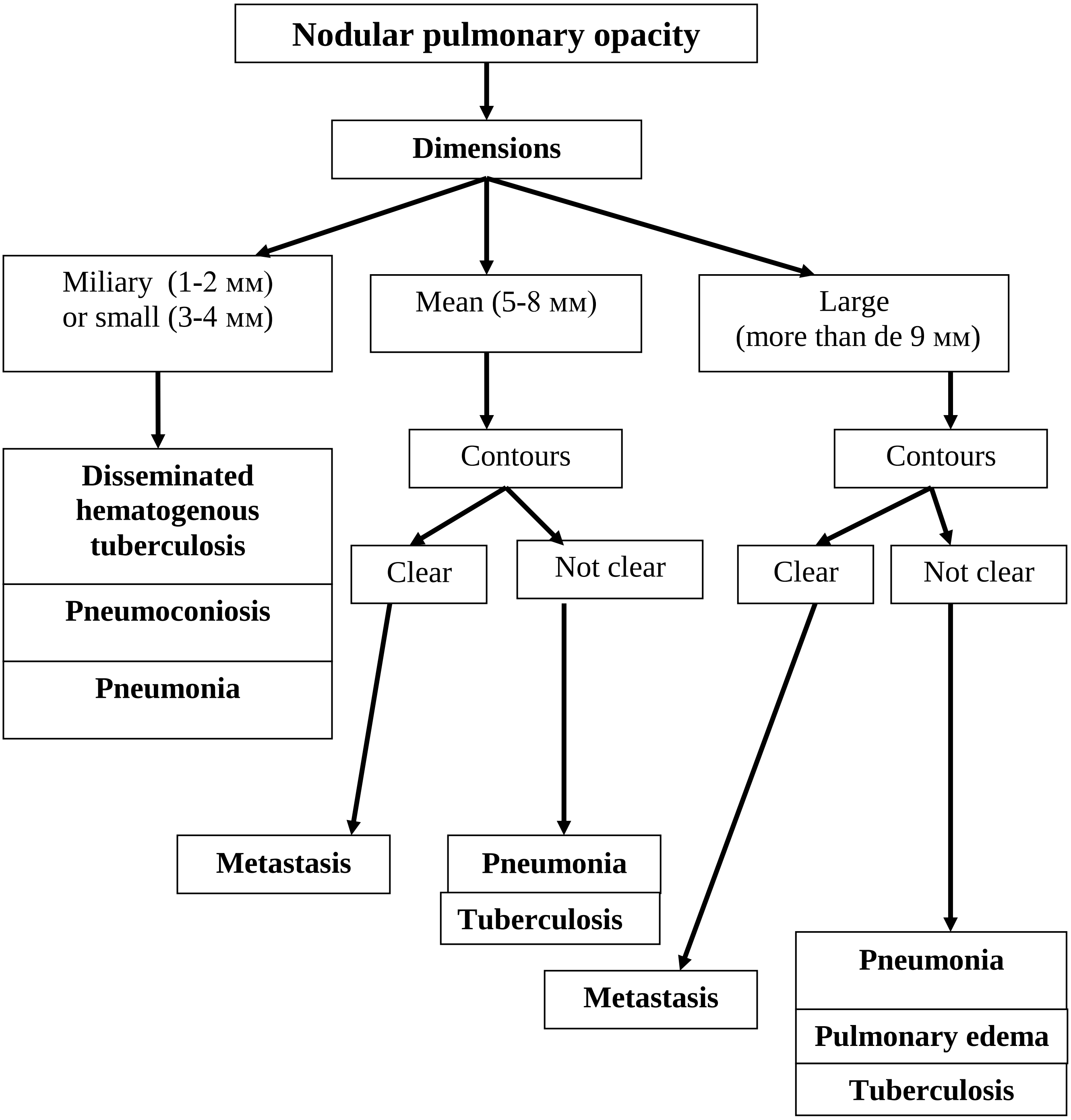
Algorithm 2.4.

Ring-shaped opacity



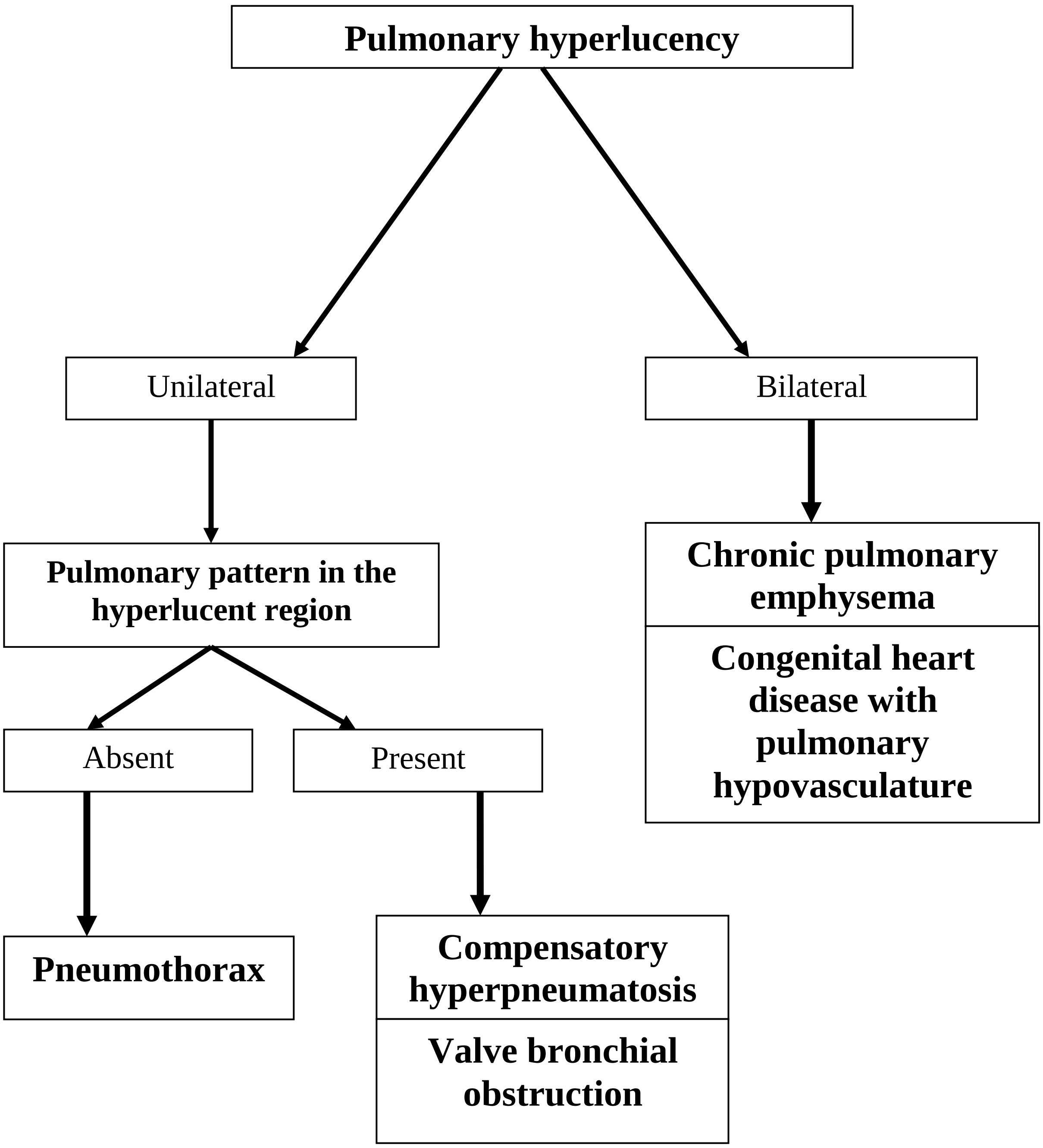
Algorithm 2.5.

Nodular opacity



Algorithm 2.6.

Pulmonary hyperlucency



Algorithm 2.7.

Examination of changers in pulmonary hilum

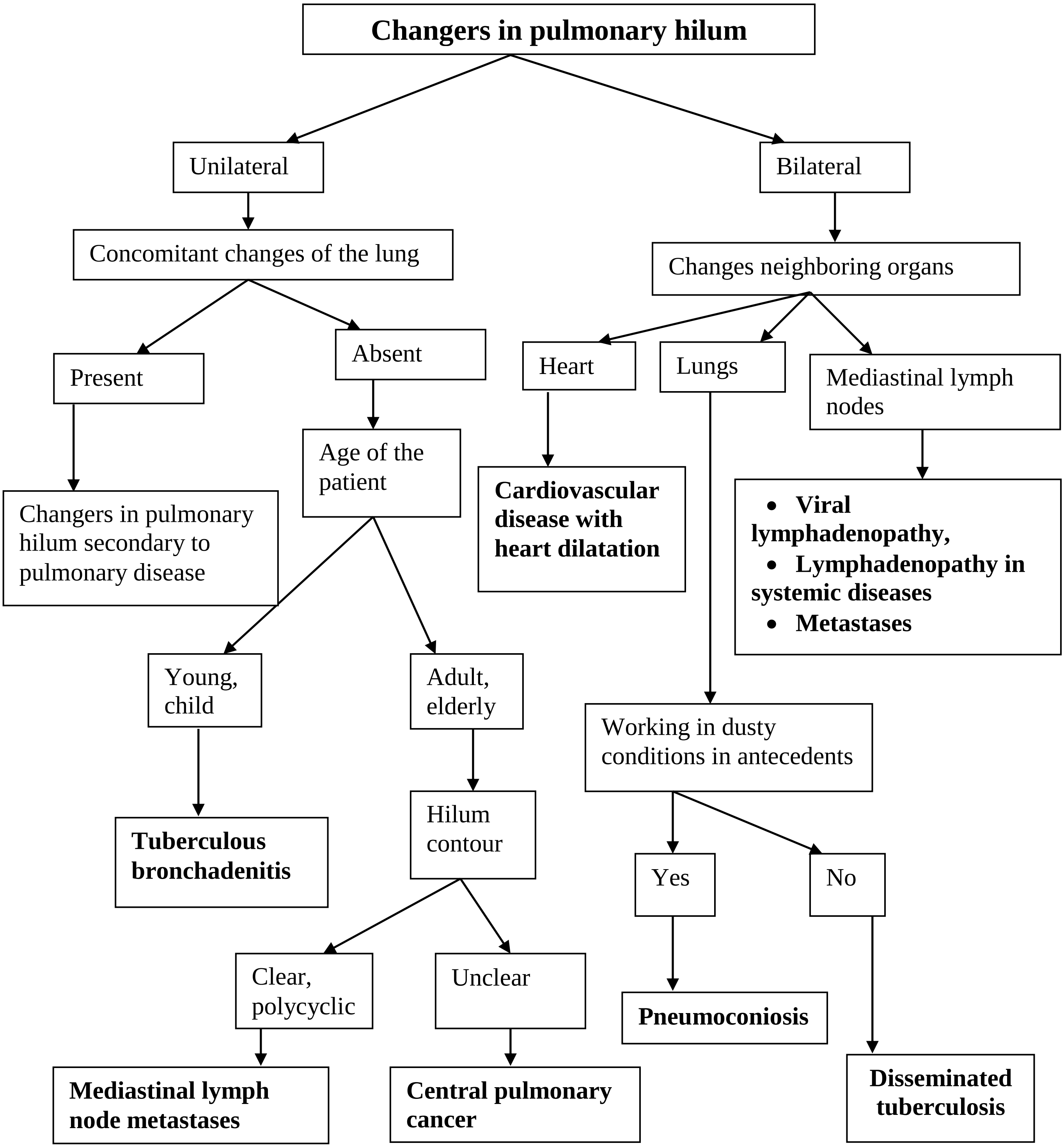


Table 2.3.

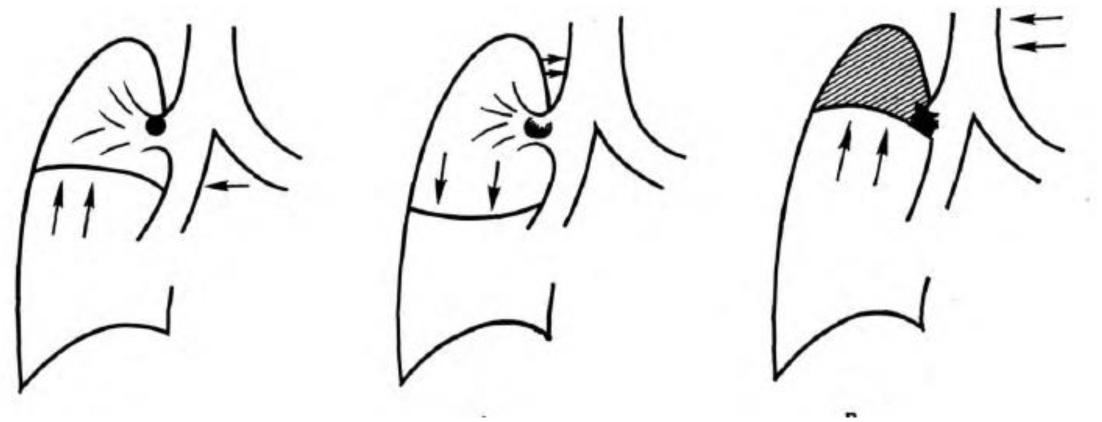
Disturbance of bronchial patency

The degree of bronchial obstruction	**Changes in ventilation**	**Radiological symptom**
Partial obstruction	The amount of the air inhaled through the affected bronchus and exhaled is the same, but less than normal, reducing the volume of the lung	Diminution of lung transparence
Valve obstruction	The air is inhaled through the affected bronchus, but cannot be exhaled being accumulated in the lung	Hyperlucency
Complete obstruction	Bronchus is closed, no air is inhaled through it	Opacity

Figure 2.1.

The degree of bronchial obstruction

a) **b)** **c)**



a) Partial obstruction
b) Valve obstruction
c) Complete obstruction

Table 2.4.

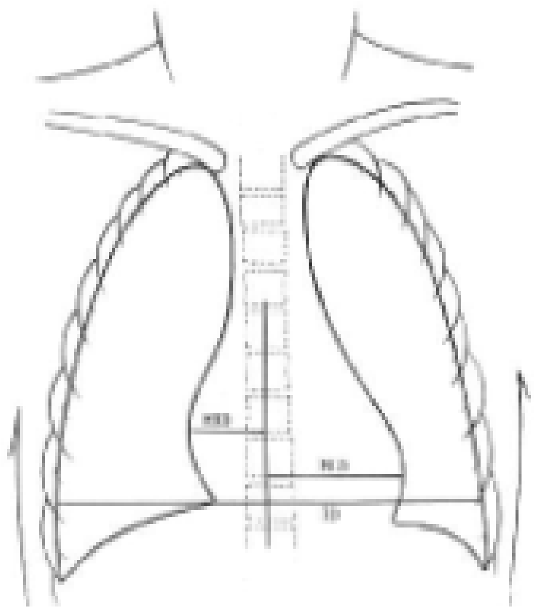
RADIOLOGICAL SEMIOLOGY OF PULMONARY PATHOLOGY SYNDROMES

Radiological changers:	**Opacity**	Total/subtotal	
		Limited	
		Rounded	
		Ring-shaped	
		Nodular	
	Hyperlucency		
	Changers of pulmonary hilum		
	Changers of pulmonary pattern	Decreasing	
		Accentuation	
		Deformation	
Localization of pathological changers:	**Parietal syndrome**	Soft tissue pathology	
		Bone pathology	
	Pleural syndrome	Pleural effusion	
		Pneumothorax	
		Hydropneumothorax	
		Pleural calcification	
	Mediastinal syndrome	Presence of air in mediastinum	
		Presence of liquid in mediastinum	
		Presence of anomalous tissue in mediastinum	
	Pulmonary syndrome	Alveolar	
		Interstitial	
		Bronchial	
		Vascular	
		Parenchymatous:	Nodular
			Cavitary

III. CARDIOVASCULAR IMAGING

Figure 3.1.

Evaluation of cardio-thoracic ratio (CTR)



- Cardio-thoracic ratio (CTR) is the ratio between the maximal transverse diameters of cardiac shadow and of the chest, measured on a chest X-ray in posterior-anterior projection.

Table 3.1.

Normal CTR

Age	**Normal CTR**
New-born	up to 0,58
Adolescents and adults	0,44-0,48
Elderly	0,50-0,55

Table 3.2.

Normal pulmonary circulation

Pulmonary circulation particularities	**Normal pulmonary pattern (pulmonary vasculature)**
• Low blood pressure in pulmonary vessels (25/10 mm Hg) • Low vascular resistance, Blood depositing function • Blood vessels of both systemic and pulmonary circulation are present • Arterio-venous and veno-arterial anastomoses are present (normally, blood circulation via anastomoses is ≤ 1% of minute-volume of pulmonary circulation) • Dependent on respiratory motions	• Consists of pulmonary arteries and veins (in young and adult persons; in elderly persons (after 50-55 years old) it includes interstitial connecting tissue as well • Dichotomic division of vessels (each divides in 2) • Diameter of each following vessel is 2 times less than this of the previous • In orthostatic radiograph pulmonary pattern is more apparent in inferior regions • 1,5-2 cm to the thoracic wall, pulmonary vasculature is no more seen (capillary segment) • Radial direction of the pulmonary arteries in basal regions • Horizontal direction of the pulmonary veins in basal regions, more apparent in middle and inferior regions • **Normal pulmonary hilum** in adult person: width of right hilum is ≤ 14 - 15 mm and is the same or 1-2 mm less than the width of the space between the right hilum and the cardiac shadow

Table 3.3

Pulmonary pattern disturbances in cardiovascular pathology

Syndrome	**Cause**	**Pulmonary pattern disturbances**	**In which pathology it may occur**
Hypovolemia	Decrease of the amount of blood that comes in pulmonary circuit in systole	• Pulmonary hyperlucency • Narrowing of peripheral pulmonary arteries • Narrowing of pulmonary hilum, its structure is unchanged (sometimes it is difficult to visualize) • Pulmonary artery convexity may be extruded, concave or normal	Congenital heart diseases with pulmonary hypovasculature
Hypervolemia	Increase of the amount of blood that comes in pulmonary circuit in systole	• Dilation of pulmonary vessels • Transparent lung fields • Dilation of pulmonary hilum, its structure is unchanged • Nodular opacities in the region close to hilum (transversal section of dilated vessels) • The waist of the heart is diminished, pulmonary artery convexity is extruded	Congenital heart diseases with pulmonary hypervasculature

Venous congestion	Disturbances of pulmonary venous return	• Homogenization of pulmonary hilum • Diminution of transparence of lung fields • Unclear contour of blood vessels and bronchi • Kerley lines	• Congenital or acquired mitral stenosis • Mitral insufficiency • Left ventricle insufficiency • Total cardiac failure
Pulmonary hypertension	Increase of pulmonary vascular resistance	• Dilation of pulmonary hilum, its structure is unchanged • Nodular opacities in the region close to hilum (transversal section of dilated vessels) • Decrease of pulmonary vasculature in peripheral regions • Pulmonary artery convexity is extruded • Narrowing of pulmonary veins	Diseases which lead to hypervolemia and venous congestion in the absence of the opportune treatment

Figure 3.2.

Cardiac convexities. Simple chest X-ray

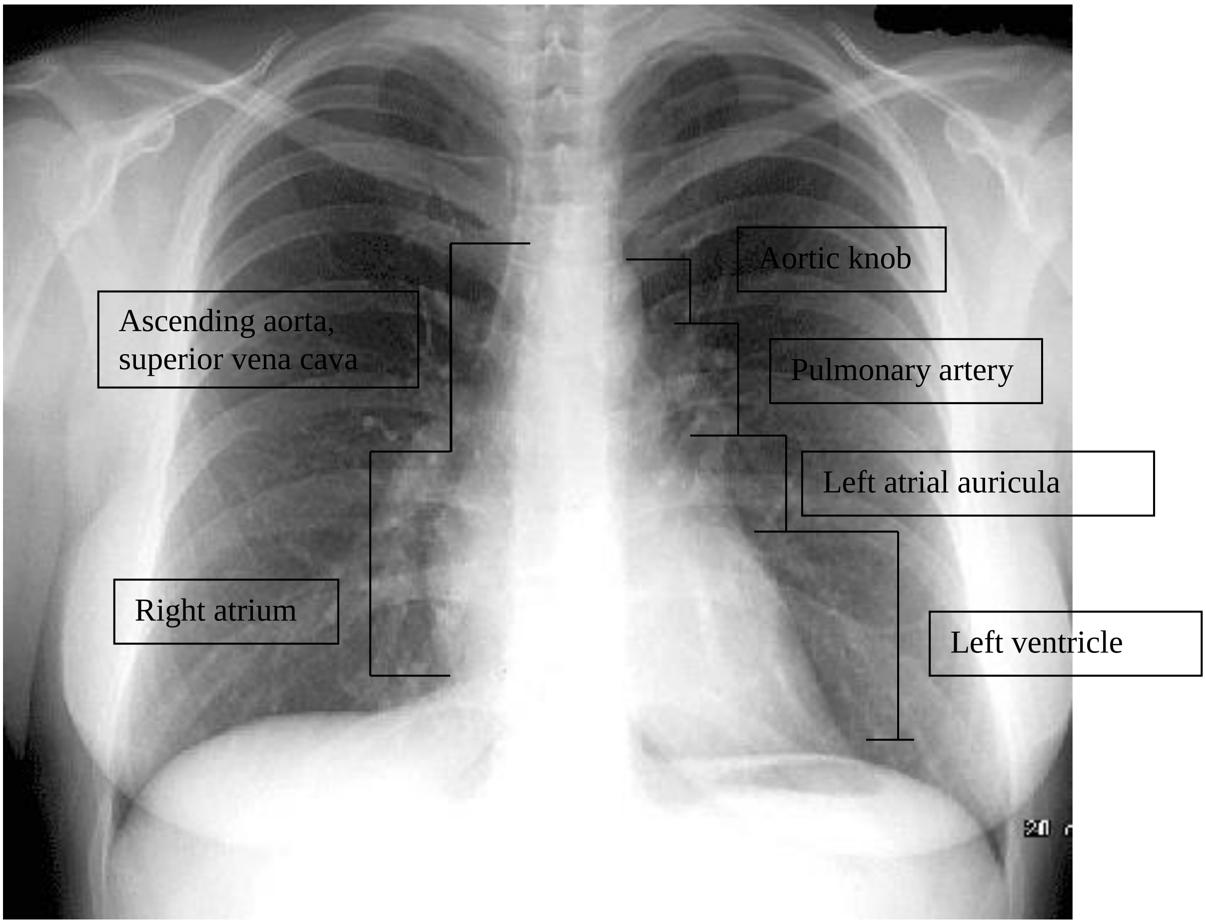


Table 3.4.

Pathological cardiac configurations

Cardiac configuration / **Structures involved**	**Mitral**	**Aortic**	**Tricuspid (triangular, trapezoid, cardiomyopathic)**
Right atrio-vasal angle	Displaced cranially	Displaced caudally	Displaced cranially
Waist of the heart	Smoothed, Pulmonary artery convexity is extruded	Extruded	Smoothing of all cardiac convexities
Aortic knob	Diminished or not seen	Extruded	
Dilation of the heart shadow	May be LV dilation. May be dilation of RA convexity and double contour because of LA dilation	LV dilation May be dilation of the ascending aorta	The heart shadow is dilated bilaterally, „lies” on the diaphragm
Pathologies	• Mitral valvulopathy • Atrial septal defect • Persistent ductus arteriosus	• Aortic valvulopathy • Coarctation of aorta • Arterial hypertension • Tetralogy of Fallot	• Important pericardial effusion • Polyvalvulopathy including that of the tricuspid valve • Dilative cardiomyopathy

Table 3.5.

Possibilities and value of imaging modalities in assessing cardiac pathology

Signs	Imaging modality					Priority method
	Radiological contrast methods	CT	ECHO	MRI	Nuclear medicine	
Morphological changes	++	+++	+++	+++	+	ECHOCG
Functional status	++	++	+++	+++	++	ECHOCG
Function of the valves	+	+	+++	+++	-	ECHOCG
Coronary arteries	+++	++	-	++	-	Coronary angiography
Myocardial perfusion and metabolism	-	+	-	+++	+++	Nuclear medicine
Thoracic aorta	++	+++	++	+++	+	CT, MRI

Scheme 3.1.

Sequence of primary investigation of a patient with cardiovascular pathology

1.
- Anamnesis
- Clinical examination

2. Electrocardiogram

3. Simple chest X-ray

4. Echocardiography

5. Diagnostic conclusion.

6. If diagnosis is not clear, functional investigation and/or additional imaging methods using:

- Angiography
- CT
- MRI
- Myocardial scintingraphy

IV. IMAGING OF DIGESTIVE TUBE AND HEPATOBILIARY SYSTEM

Table 4.1.

BASIC METHODS OF THE DIGESTIVE TUBE CONTRASTATON (BARIUM MEAL TECHNIQUES)

Method	**Contrast agents**	**Object to be visualized**
In thin layer (small amount of contrast media)	Radiopositive (barium sulphate)	Relief of mucosa, folds.
Double contrast	Radiopositive (barium sulphate) + radionegative (air)	Thin relief of mucosa (area gastrica). Visualization of vegetations.
In tight filling	Radiopositive (barium sulphate)	Shape, position, dimensions, peristalsis of the digestive tube segment.

Figure 4.1.

Topography of digestive tube organs

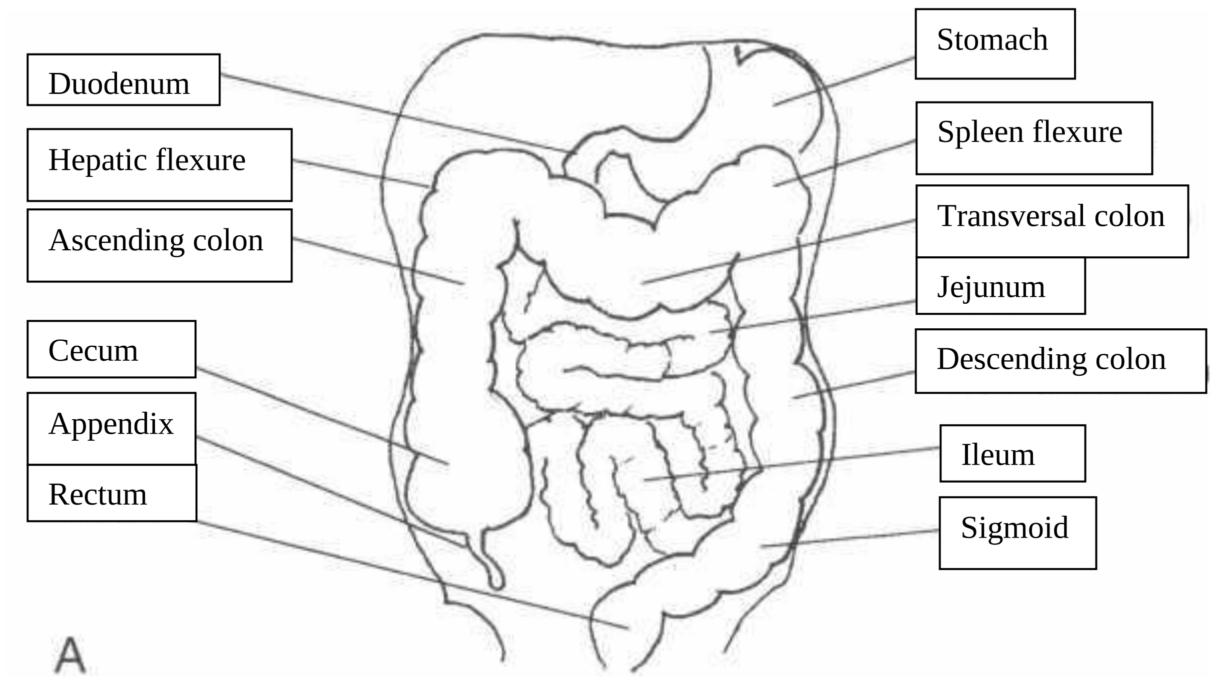


Figure 4.2.

Projection of the abdominal parenchymatous organs
Simple abdominal X-ray

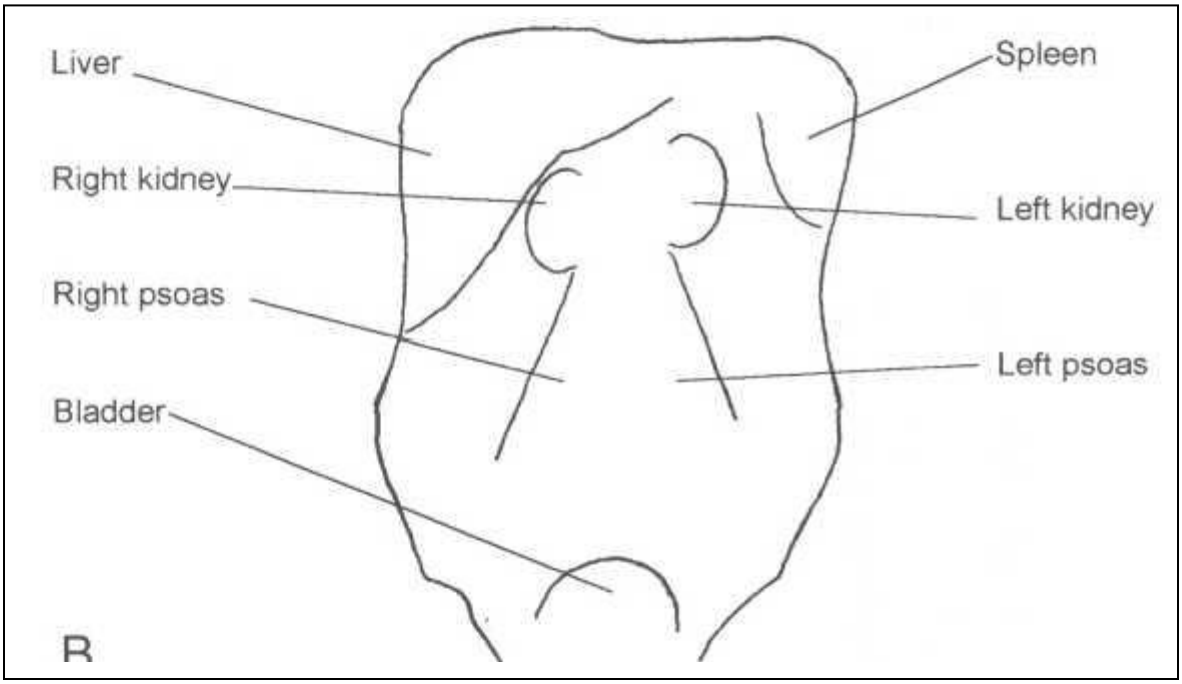


Table 4.2.

Simple abdominal X-ray in acute abdominal syndrome
(Orthostatic position)

Cause of acute abdominal syndrome	**Radiological findings**
Perforation of a cavity organ	Pneumoperitoneum (subdiaphragmal free air in peritoneal cavity)
Intestinal occlusion	Hydro-aeric levels

Table 4.3.

RADIOLOGICAL ANATOMY OF DIGESTIVE TUBE ORGANS

Organ	Localization	Folds	Dimensions	Particularities
Oesophagus	The posterior mediastinum	Longitudinal	Maximal width up to 2-3 cm Length usually about 25cm	Basic physiological narrowings: • Pharyngoesophageal (level of the VI-th cervical vertebra) • At the level of the aortic arch • At the level of the tracheal bifurcation • Diaphragmal
Stomach	The left upper part of the abdominal cavity	Longitudinal in the region of lesser curvature, in the region of greater curvature the folds are oblique and may form an irregular contour		
Duodenum	Behind the stomach, caudally from the pyloric region	Longitudinal in duodenal bulb, transversal in the rest of the segments	Length - 24 cm	A fixed segment (excepting the bulb). Forms Treitz angle with jejunum
Jejunum	Predominantly in the left part of the abdominal cavity	Transversal („like bird's feather"), evident	Total length is 2-3 m in a living person; about 6 m in dead body	
Ileum	Predominantly in the small pelvis	Transversal („like bird's feather"), less evident, not clearly viewed in the distal regions		
Colon	Peripheral regions of the abdominal cavity			It is possible to see haustra coli, sometimes - taenia coli

Table 4.4.

PASSAGE OF CONTRAST MEDIA VIA DIGESTIVE TUBE

Segment of digestive tube	**Beginning of appearance of contrast media in the organ after oral use**	**Complete evacuation of contrast media**
Oesophagus	Immediately	5-7 seconds
Stomach	Several seconds	From 1.5-2 to 4 hours; most often about 1.5 hours
Duodenum	30 seconds	
Jejunum	40 seconds	3-5 hours
Ileum	About 1.5 hours	8-9 hours
Colon	3-4 hours (ileocecal passage and cecum)	Complete contrast enhancement of all parts of the colon within 18-24 ore

Scheme 4.1.

PATHOLOGICAL CHANGES OF DIGESTIVE TUBE

FUNCTIONAL

Changes of tonus	Hypertonia Hypotonia Atonia Spasm
Changes of peristalsis	Hyperkinesia Hypokinesia Akinesia
Changes of secretion	Hypersecretion
Changes of transit	Acceleration Slowing

MORPHOLOGIC

Changes of position	Ptosis Ascension (hernias including) Displacement Torsion Traction	
Changes of mobility	Pathological mobility of normally fixed segments	
	Decreased mobility of normally mobile organs	
Changes of dimension	Length	Dolichosegments Brachisegments
	Width	Megasegments Stenosis
Changes of contour	Minus-filling	Lacuna Recess Incisure Amputation Impression Rigidity
	Plus-filling	Niche Diverticulum Spicules
Changes of shape		
Changes of relief	Fold dimensions	Hypertrophy Atrophy
	Anomalous fold orientation	Deviation Convergence Interruption Disorganization

Table 4.5.

DIFFERENCIAL DIAGNOSIS OF DIGESTIVE TUBE STENOSES

Characteristics	**Benign stenosis**	**Malignant stenosis**
Length	Long	Short
Number	Single or multiple	Single
Transverse	Axial	Asymmetric
Change of size increase:	Progressive	Sharp
Folds	Not interrupted	Interrupted, disorganized
Other possible signs		Rigidity

Table 4.6.

Radiological investigation of the biliary tract

Contrast method	The way of introduction of contrast agent	Visualized structures
Without contrast (simple abdominal X-ray)		Radiopositive concrements in gallbladder and bile ducts
Peroral cholecystography	Per os	Gallbladder
Intravenous cholecystocholangiography	Intravenous	Gallbladder and bile ducts
Endoscopic retrograde cholagniopancreatography	By catheter introduced in the ductus choledochus through Oddi sphincter, introduced in the duodenum endoscopically	Biliary tree, pancreatic duct
Percutaneous transhepatic cholangiography	In bile ducts by percutaneous puncture of the liver	Bile ducts, sometimes gallbladder
Perioperative and postoperative cholangiography	By the catheter (tub t Kehr) placed in ductus cysticus, perioperatively (usually during cholecystectomy). The investigation is performed during surgery or in the postoperative period	Bile ducts

Scheme 4.2.

IMAGING SIGNS OF LIVER PATHOLOGY

Normal liver (Ultrasonography)	**Homogenous Micronodular structure**	
	Tubular formations with narrow walls in the region of the hilum	Portal vein Artery Hepatic duct
Diffuse liver diseases	**Liver dimensions**	Enlarged Diminished
	Structure	Heterogeneous
	Echogenity (if USG performed)	Hyperechoic Hypoechoic Calcification
	Vascularization	Unchanged Portal hypertension
Focal liver diseases	**Dimensions**	
	Localization	Lobe Segment
	Number	Single Multiple
	Structure	Homogenous Heterogeneous
	Density	Solid Fluid
	Contour	Well-defined (regular or iregular) Ill-defined

Indirect signs	Deformation of contours Impression/amputation of vascular and/or biliary structures
Associated changes	Cirrhosis Steatosis Portal hypertension

V. IMAGING OF OSTEO-ARTICULAR SYSTEM

Scheme 5.1.

Types of fracture

Mechanism of fracture	Mechanical power		
	Stress ("tired")		
	By firearm		
	Pathologic fractures		
Relation between the place of application of force and the place of fracture	Direct		
	Indirect		
Number	Single		
	Multiple		
	Comminuted		
	Simultaneous		
Line of fracture	Complete	Direction of line of fracture	Transversal
			Oblique
			Spiral
			Longitudinal
			In shape of T, V, Y
	Incomplete	„Green steak”	
		Subperiosteal	
		Depressed	
		Fissure	

Table 5.1.

Radiological changes of bones and joints

Bone changes	**Changes of shape**	Hyperostosis	
		Exostosis	
		Oedostosis („bone swelling”)	
		Scoliostosis	
	Changes of dimension	Atrophy	
		Hypoplasia	
		Hyperplasia	
		Dysplasia	
	Changes of structure	Destructive	**Osteoporosis**
			Osteolysis
			Osteodestruction
			Osteonecrosis
		Constructive	**Osteosclerosis**
	Changes of periosteum: Periostitis /periostosis	Linear	
		Lamellar	
		Dentate	
		Spicular	
		Spur periosteum ("cap")	
	Heterogeneous ossification		
	Changes of axis and position	Traumatic	Fracture
			Luxation
		Scoliostosis	

<table>
<tr><td rowspan="6"><u>Articular changes</u></td><td rowspan="5">Changes of intraarticular space</td><td rowspan="3">Thickness</td><td>Widening</td></tr>
<tr><td>Narrowing</td></tr>
<tr><td>Disappearance</td></tr>
<tr><td colspan="2">Shape</td></tr>
<tr><td colspan="2">Transparence</td></tr>
<tr><td colspan="3">Changes of articular surfaces</td></tr>
<tr><td rowspan="9"><u>Changes of soft tissues</u></td><td rowspan="3">Volume</td><td colspan="2">Thickening</td></tr>
<tr><td colspan="2">Reduction in size</td></tr>
<tr><td colspan="2">Dislocation</td></tr>
<tr><td rowspan="2">Structure</td><td colspan="2">Induration</td></tr>
<tr><td colspan="2">Calcification</td></tr>
<tr><td rowspan="4">Aetiology</td><td rowspan="3">Primitive (of tissue itself)</td><td>Inflammation</td></tr>
<tr><td>Trauma</td></tr>
<tr><td>Tumour</td></tr>
<tr><td colspan="2">Secondary to bone pathology</td></tr>
</table>

Table 5.2.

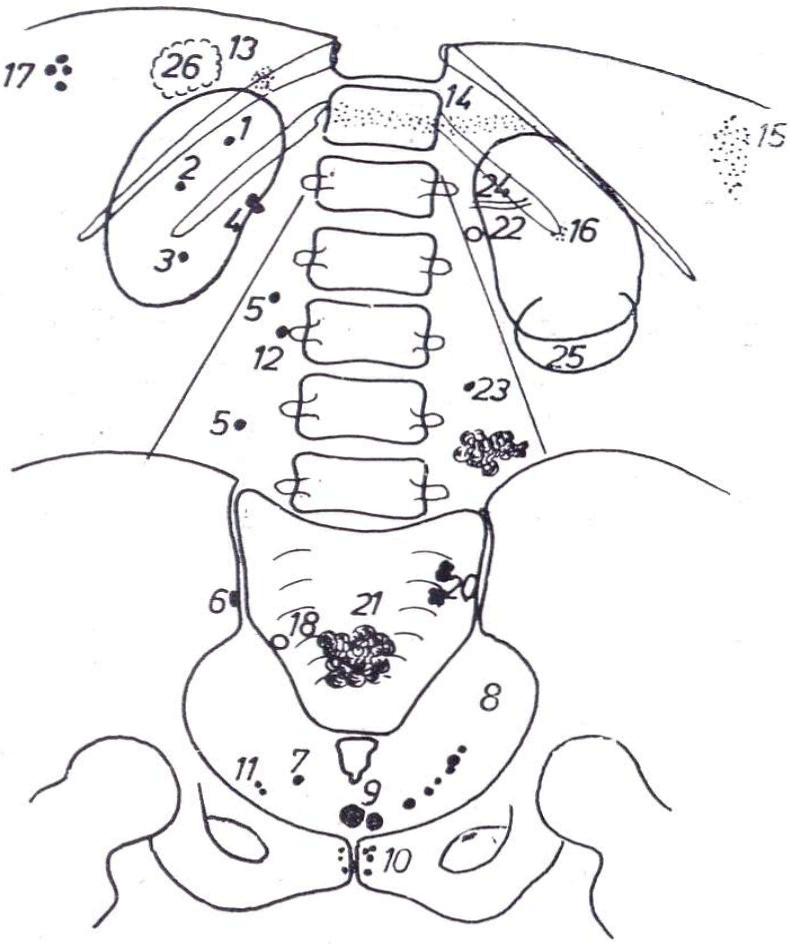
The most frequent bone tumours

Benign tumours		Malignant tumours	
Name	**Tissue**	**Name**	**Tissue**
Osteoblastoclastoma Osteoid osteoma Osteoma	Bone	Osteosarcoma	Bone
Chondroma Chondroblastoma Chondromyxoid fibroma	Cartilage	Chondrosarcoma	Cartilage
Osteochondroma	Bone and cartilages	Sarcoma Ewing	Reticuloendothelial
Myxoma Lipoma Fibroma	Connective tissue	Reticular sarcoma	Reticuloendothelial
Angioma	Vascular structures	Angiosarcoma	Vascular structures
Eosinophilic granuloma	Reticuloidal, eosinophils	Periosteal fibrosarcoma	Periosteum

VI. IMAGING OF KIDNEYS AND URINARY SISTEM

Figure 6.1.

Simple abdominal X-ray. Variants of concrements (stones) localization

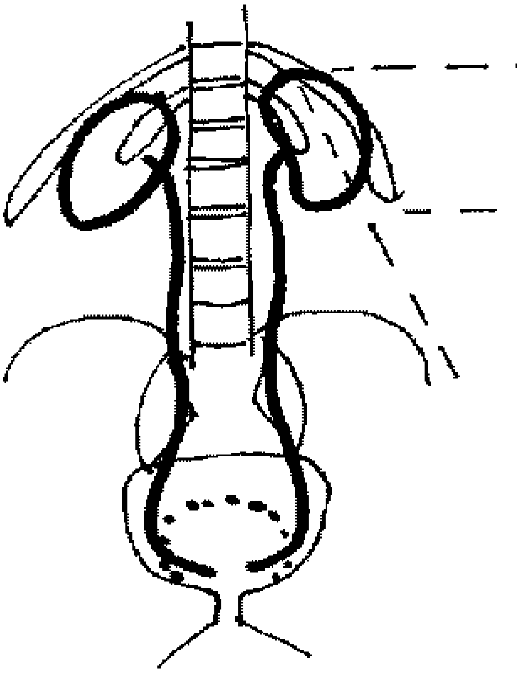


1. Renal stone in the superior calyx
2. Renal stone in the middle calyx
3. Renal stone in the inferior calyx
4. Concrement in the renal pelvis
5. Concrements in the ureter
6. Triangular concrement in the ureter
7. Calculus in the bladder-urethral orifice

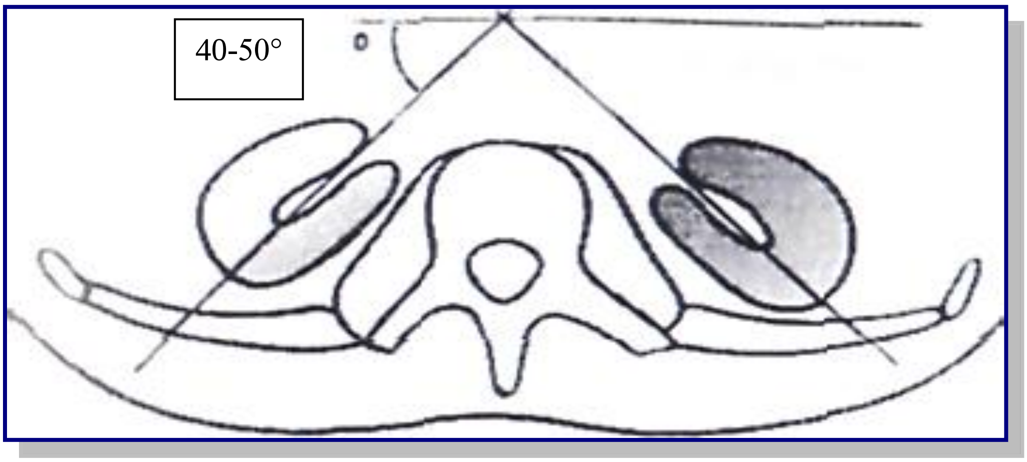
8. Multiple small stones in the inferior part of ureter
9. Calculi in the urinary bladder
10. Calculi in the prostate
11. Phleboliths
12. Transverse apophysis ossification of the 3rd lumbar vertebra
13. Calcification in the right adrenal gland
14. Pancreatic calcifications
15. Splenic calcification
16. Calcified costal cartilage
17. Biliary concrements
18. Appendicular concrement
19. Calcified retroperitoneal lymph node
20. Calcified lymph nodes
21. Calcified fibroma
22. Calcified renal vessel
23. Calcified mesenteric lymph node
24. Calcified splenic artery
25. Calcified wall of a cyst (in the left kidney)
26. Calcified hydatic cyst (in the liver)

Figure 6.2. (a, b)

Renal topography



a)



b)

Figure 6.3.

Renal structure

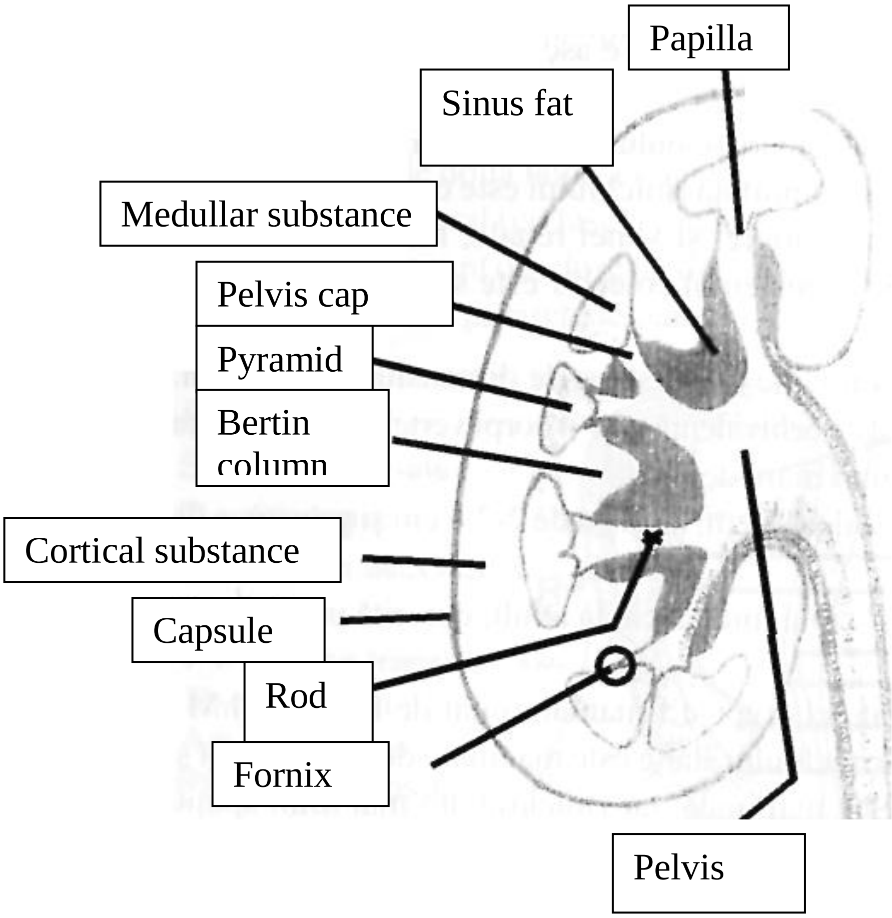


Table 6.1.

POSITION OF KIDNEYS

Age	Position of kidney	Orientation of renal pelvis
During intrauterine period	In the pelvis	Lateral
< 4 years	Gradually rising to lumbo-diaphragmatic bed	Undergoes rotation around the longitudinal axis
> 4 years	Situated in lumbo-diaphragmatic bed on the sides of the spine, retroperitoneal, between the XI-th thoracic vertebra and the II-nd-III-rd lumbar vertebrae	Medial

Scheme 6.1.

Developmental abnormalities of urinary system

Anomalous number

Renal agenesis

- Absence of kidney (more often, on the left)
- Absence of renal artery
- Compensatory hypertrophy of contralateral kidney

Renal aplasia

- Embryonal bud is present
- The kidney is rudimentary, frequently with cystic degeneration and calcifications
- Hypoplasia of the renal artery
- Absence of pelvis and ureter - blind ureter

Supernumerary kidney

- an independent kidney with its separate excretory system and vascularization
- ectopic kidney, most often inferior lumbar
- ectopic inflow of ureter

	Duplication of kidney	• common parenchymal mass, with two unequal systems of calyx-pelvis • complete reno-ureteral duplicity • incomplete reno-ureteral duplicity
Anomalous dimension	**Renal hypoplasia**	• partial • total • uni- or bilateral
	Renal hypertrophia	• usually bilateral enlarged kidneys • thickened renal parenchyma • increased diameter of excretory cavities • increased diameter of vessels • Harmonious renal proportions • Not often unilateral - compensatory hypertrophia (in case of agenesia, hypoplasia)
Anomalous shape	**Persistent fetal lobulation**	• normal – disappears at the age over 4 years • irregular kidney contour, normal vasculature, normal excretory cavities
	Renal fusion	▪ bilateral symmetric ▪ bilateral asymmetric ▪ unilateral asymmetric • Horseshoe kidney • S-shaped („sigmoid”) kidney • L-shaped kidney • Boulder-shaped kidney
Anomalous position	**Ectopia**	• cranial ectopia – intrathoracic kidney • caudal ectopia – inferior lumbar, pelvic, presacral kidney • cross ectopia
	Malrotaţion	• anterior, posterior, external orientation of the hilum • multiple renal arteries, atypical emergence

Anomalous structure of parenchyma	**<u>Cystic dysplastic kidney diseases</u>**	• multicystic kidney • segmental cystic dysplasia • renal hypoplasia with polycystic dysplasia • multiple cysts associated with urinary way obstruction
	<u>Hereditary cystic kidney disease</u>	• hepatorenal polycystic disease • cystic disease of the medulla • microcystic renal disease with congenital nephrotic syndrome
	<u>Renal cysts in hereditary malformation syndromes</u>	• tuberous sclerosis or Bourneville's disease • Lindaun disease • hepatocerebrorenal syndrome

Anomalous renal vessels

- Multiple renal arteries - (accessory arteries) polar (aberrant) 43,5% (Hellstrőm)
- Absence of renal arteries, hypoplasia of renal arteries

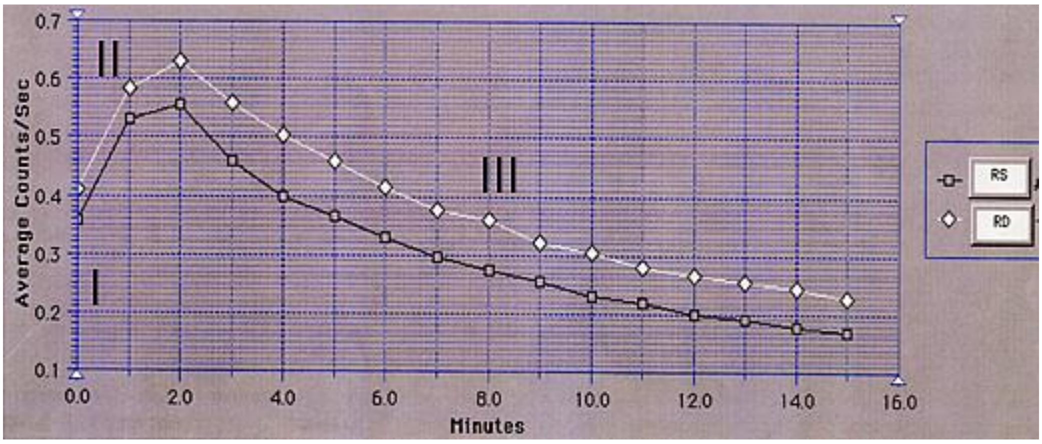
Excretory tract malformations

- Duplicity of calyx, pelvis
- Microcalyx
- Megacalyx (hypoplasia of pyramids with intact cortical substance) – wide pelvic rods
- Blind ureter
- Diverticulum of calyx
- Ureterocele - sacciform dilatation of the terminal ureter 0.5-4cm (snakehead)
- Ectopia of ureteral ostia
- Retrocaval ureter
- Congenital hydronephrosis - parietal neuromuscular dysplasia
- Congenital ureteral stricture at the pyelocaliceal junction, ureterovesical junction
- Other malformations - stenosis, endoluminal membranes, torsions

Figure 6.4.

Nuclear medicine. Renography.

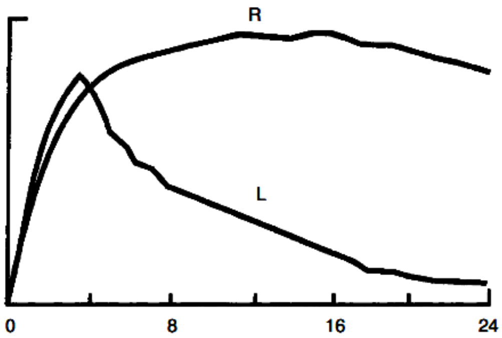
Segments of renal curve.



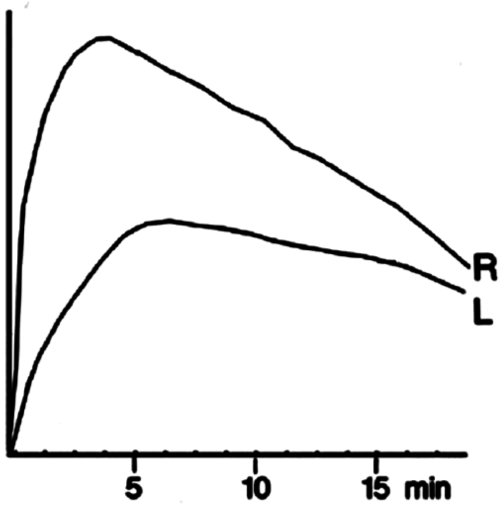
I. Vascular segment
II. Accumulation segment (filtration/secretion)
III. Segment of elimination (excretion)

Figure 6.5.

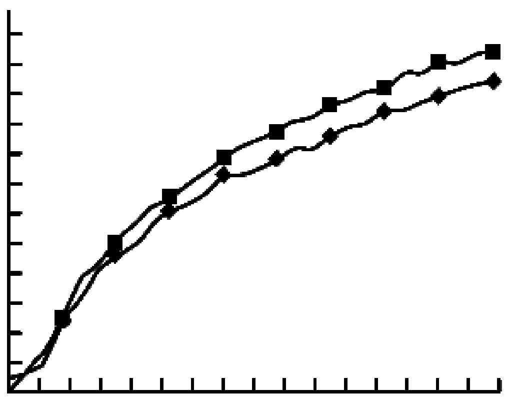
Pathological changes of renal curve



a) Obstructive changes at the level of the right kidney



b) Reduced renal function of the left kidney



c) Bilateral chronic renal failure

Bibliography

1. Grancea V. Bazele radiologiei şi imagisticii medicale. Bucureşti, 1996, 329 p.
2. Misra R., Planner A., Uthappa M. A-Z of Chest Radiology. Cambridge Univercity Press, 2007, 211 p.
3. Monnier J.P., Tubiana J.M. Radiodiagnostic. Paris, Masson, 1999, 473 p
4. Ouellette H., Tetrault P. Clinical radiology made ridiculously simple. USA, Miami, 2003
5. Sutton D. Textbook of Radiology and Imaging. Volume I. Elseiver Science, 2003, 930 p.
6. Sutton D. Textbook of Radiology and Imaging. Volume II. Elseiver Science, 2003, 1022 p.
7. Şerban A.G.. et al. Radiologie şi imagistica medicală. Editura a II. Bucureşti, 2009, 416 p.
8. Volneanschi V., Matcovschi S., Dionidis I., Gîtlan I. Radiodiagnostic. Radioterapie. Chişinău, 2000, 382 p.
9. Зегенидзе Г.А. – ред. Клиническая рентгенорадиология. Руководство в 5 томах. Том 1. Москва, 1983. 433 стр.
10. Илясова Е.Б., Чехонацкая М.Л., Приезжева В.Н. Лучевая диагностика. Москва, 2009, 275 стр.
11. Линдендратен Л,Д., Королюк И.П. Медицинская радиология. Москва, 671 стр.