**Федеральное ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ ОБРАЗОВАТЕЛЬНОЕ УЧРЕЖДЕНИЕ
ВЫСШЕГО ОБРАЗОВАНИЯ «СЕВЕРО-ОСЕТИНСКАЯ ГОСУДАРСТВЕННАЯ МЕДИЦИНСКАЯ АКАДЕМИЯ» МИНИСТЕРСТВА ЗДРАВООХРАНЕНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
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Основы рентгенологического исследования

Учебно-методическое пособие

The bases of X-ray examination

Manual

Владикавказ

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Основы рентгенологического исследования.

The bases of X-ray examination. Manual

В пособии представлены основные принципы рентгенологического исследования, базовые принципы интерпретации рентгенологических изображений в диагностике заболеваний легких, сердечно-сосудистой системы, органов брюшной полости и костно-суставной системы. Учебно-методическое пособие предназначено для студентов, изучающих курс «Радиология» на английском языке, а также для преподавателей у англоязычных студентов по практическому курсу.

The manual presents the basic principles of radiological examination, basic principles of interpretation of radiological images in the diagnosis of lung diseases, cardiovascular system, abdominal organs, bones and joints. The manual is intended for students studying the course "Radiology" in English, as well as for teachers in English-speaking students in the practical course.

CONTENTS

1. AN INTRODUCTION

Regular x-rays (plain x-rays) account for about 80% of imaging examinations. X-ray examinations, or plain x-rays, are made by an x-ray beam passing through the patient. The x-rays are absorbed in different amounts by the various tissues or materials in the body. Most of the beam is absorbed or scattered. This represents deposition of energy in the tissue but does not cause the patient to become radioactive or to emit radiation. A small percentage of the incident radiation beam exits the patient and strikes a detector.

The classic imaging receptor is a film/screen combination. If it is on screen it is called fluoroscopy; if it is on the film-it is called radiography. The x-ray beam strikes a fluorescent screen, which produces light that exposes the film, and then the film is developed. Newer systems are called computed radiography or digital radiography. In computed radiography, the x-rays strike a plate that absorbs the x-rays and stores the energy at a specific location. The plate is then scanned by a laser, which releases a point of light from the plate. The location is detected and stored in a computer. In digital radiography detector systems, the x-ray hits a detector and then is converted to light immediately. Once either type of image is stored in the computer, it can be displayed on a monitor for interpretation or transmitted to remote locations for viewing.

Ionizing radiation in large doses, substantially higher than any medical radiographic procedure, is known to produce cell mutations that can lead to many forms of cancer or anomalies. Public health data on lower levels of radiation vary as to their assessment of risk, but it is generally held that only medically necessary diagnostic examinations should be performed and that studies using x-rays should be avoided during potentially teratogenic times, such as pregnancy.

2. CHEST X-RAY

Goal: To get a notion about the most important radiological syndromes of chest pathology, how to use them in reaching diagnosis of most frequently performed diseases.

Knowledge objectives: to know normal x-ray anatomy of the chest, lungs and mediastinum, main |X-ray syndromes of lung deseases, the ability of interpretation of chest X-ray.

Skill objectives: The ability of interpretation of chest X-ray, make an X-ray report.

Subject- matter:

- Modalities and technique of chest X-ray
- Normal chest anatomy
- Main pathology

EDUCATION MATERIAL

Images (x-rays) are produced using ionizing radiation. Plain films are produced without the add contrast material like barium and iodine.

These images are relatively inexpensive to produce, they can be obtained almost anywhere using portable or mobile machines, and are still the most widely obtained imaging studies.

Densities

Conventional radiography is limited to demonstrating five basic densities.

Table 1. *– Basic densities seen on conventional radiography*

Density	Appearance
Air (least dense)	Absorbs the least x-ray and Appears "blackest" on conventional radiographs
Fat	Gray
Fluid and soft tissue	Both fluid (e.g., blood) and soft tissue (e.g., muscle) have the same densities on conventional radiographs
Calcium	The most dense, naturally occurring material (e.g., bones) absorbs most x-rays
Metal (most dense)	Usually absorbs all x-rays and appears the "whitest" (e.g., bullets, barium)

Quality of the film

When looking at the radiograph, first pay attention to two radiographic parameters prior to checking for pathology -the quality of the film and patient-dependent factors.

Patient –dependent factors:

1.Patient's rotation

On a high-quality frontal view of the chest X-ray, the medial ends of both clavicles should be equidistant from the spinous process of the vertebral body projected between the clavicles. If this is not the case then the patient is rotated, either to the left or to the right.

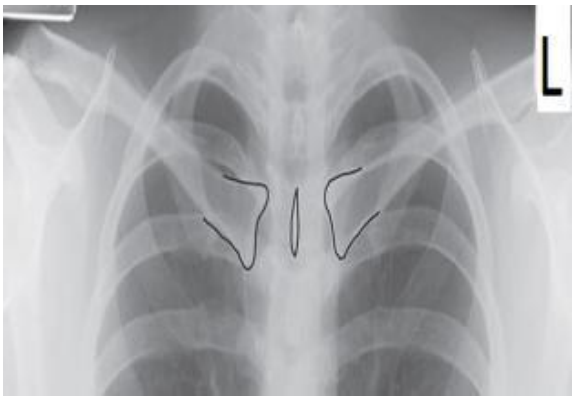

Figure 1. - *The normal position of the patient*

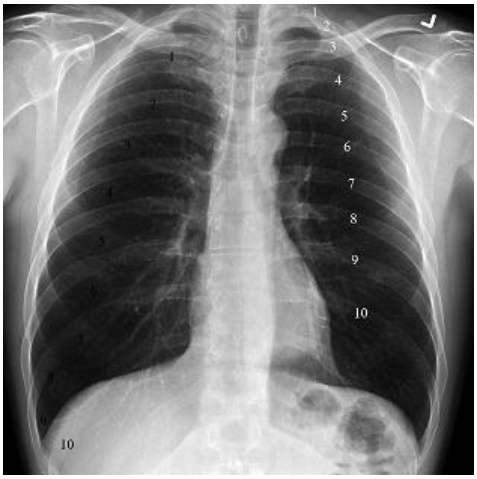

Figure 2. - *The posterior parts of the ribs are numbered white*

1. The inspiration

The patient has to make adequate inspiratory effort. If six anterior or ten posterior ribs are visible then the patient has taken a good breath in.

2. Exposure quality and satisfactory penetration

On a high quality radiograph, the vertebral bodies should be just visible through the heart. If the vertebral bodies are not visible, then an insufficient number of x-ray photons have passed through the patient to reach the x-ray film.

As a result, the film will look ‘whiter’. Similarly, if the film appears too ‘black’, then too many photons have resulted in overexposure of the x-ray film. The film is too dark.

Chest x-rays can be taken from different views, projections:

1. posterior to anterior (PA), anterior to posterior (AP) projections. The PA view is most commonly used because it will give the most accurate assessment of the cardiac size and the scapulae can be rotated out of the way;
2. frontal, lateral and oblique views. Frontal and lateral views are used to diagnose lung diseases; oblique views are used to diagnose changes of the heart configuration.

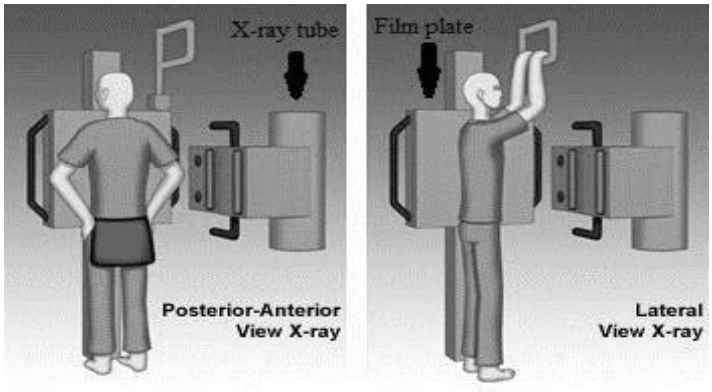

Figure 3. - *The scheme of PA and lateral views*

The normal chest radiograph

In frontal view, chest X-ray lung form right and left lung field, which are crossed by the ribs.

The lung fields look black because of the aeration. In the medial parts of the 2nd and the 4th ribs there are hila regions. Most of the hilar densities are made up of the pulmonary arteries.

Between two lung fields there is a large opacity of the mediastinum, including heart and large blood vessels.

At the background of the lung fields the lung markings are seen as blurred white lines.

Lung markings are mostly represented by blood vessels. Blood vessels branch and taper gradually from the hila centrally to the peripheral margins of the lung. You cannot accurately differentiate between pulmonary arteries and pulmonary veins on a conventional radiograph.

It is possible to visualize trachea and main bronchi. Segmental and subsegmental bronchi are almost invisible on a normal chest radiograph as they are normally very thin-walled, they contain air, and they are surrounded by air.

The bone structures are visible; it is possible to assess the rib cage **(Figure 2)**, clavicles, scapulars and a thoracic part of vertebra column.

Neither the parietal pleura nor the visceral pleura are normally visible on a conventional chest radiograph. In the pleural space there are several milliliters of fluid, but no air.. The pleura will be thickened if a fissure contains fluid or develops fibrosis from a chronic process.

The diaphragms are typically dome-shaped, although many people have polyarcuate diaphragms that look like several domes rather than one. The right hemidiaphragm is usually higher than the left. The edges of both hemidiaphragms form sharp costophrenic angles with the chest wall and blunting of these angles should raise the suspicion of pleural fluid.

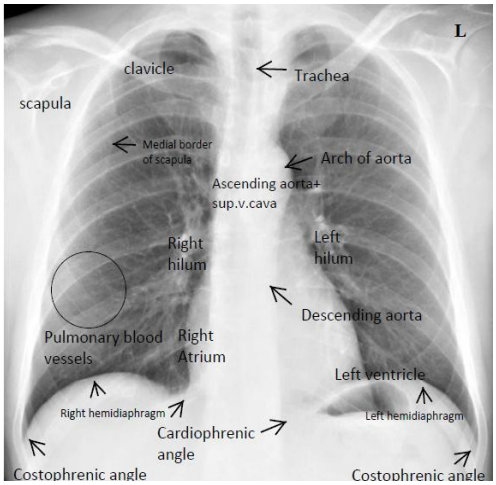

Figure 4. *- Frontal view of normal chest. Good inspiratory effort. There is no evidence of active pleural or pulmonary parenchymal abnormality. The hila and pulmonary vasculature are normal. The heart size is within normal limits. The costophrenic angles are clear*

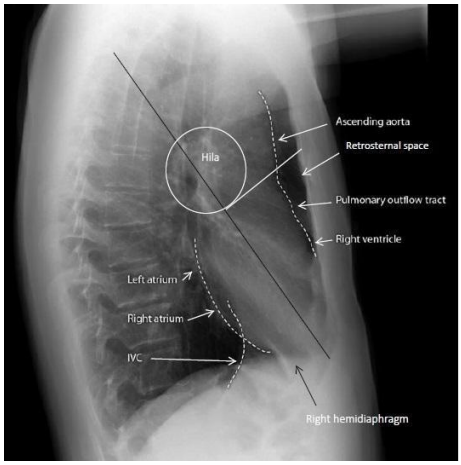

Figure 5. - *Normal lateral chest X-ray. Black line represents the approximate location of the oblique fissure. White line is the approximate location of the horizontal fissure*

The main X-ray syndromes of lung diseases

Syndrome consists of symptoms. There are three main X-ray symptoms of lung abnormalities:

1. Non-airated part of the lung absorbs more X-rays than the surrounding aerated tissue. That's why this part is determined as opacification.

There are characteristics of the opacification whish has to mentioned in the X-ray report.

1) Localization (superior, middle, inferior lobe; apex, upper, middle, lower lung area; the number of the segment);
2) The number of opacities (single or multiple);
3) Form (round, polycyclic, triangular, line, etc.);
4) Size (in mm- less 1 mm –focus; 1-3 mm –node; >3 mm- mass);
5) Structure of opacity (homogeneous, heterogeneous);
6) Intensity of opacity (low intensive-lung markings are visible behind the opacity; mildly intensive-the density is equal to the density of a rib);
7) Outlines (well defined, not clear, smooth, rough, etc.).

2. The increased aeration of the lung or the parts of lung absorb less X-rays than the surrounding tissues and look like lucent part.
3. Changes of lung markings. This is caused by opacification of interstitial tissue.

Main radiology syndromes of pulmonary diseases:

1. Opacified hemithorax

2. Confined opacity

3. Round shaped opacity

4. Solitary nodules and group of nodules.

5. Diffuse multiple nodules

6. Hyperinflation of the lung tissue

7. Ring shadow opacity

8. Changes of lung markings

9. Hila pathology

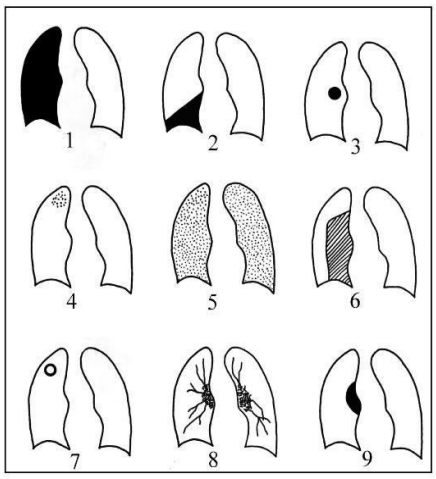

Figure 6. *Main radiology syndromes of pulmonary diseases*

Opacified Hemithorax.

The term Opacified Hemithorax means the total or subtotal decreasing of inflation of the lung field.

The main causes of an opacified hemithorax:

1. Atelectasis of entire lung (Collapse of the entire lung);
2. A very large pleural effusion;
3. Pnemonia of the entire lung;
4. Pneumofibrosis of the entire lung;
5. Pneuomonectomy- removal of the entire lung.

To differentiate these pathologies you have to determinate two main symptoms:

a) a shift (dislocation) of mediastinum;
b) structure of the opacity.

To identify the shift of the mediastinum you have to imagine three lines on the frontal chest X-ray and use as a mark:

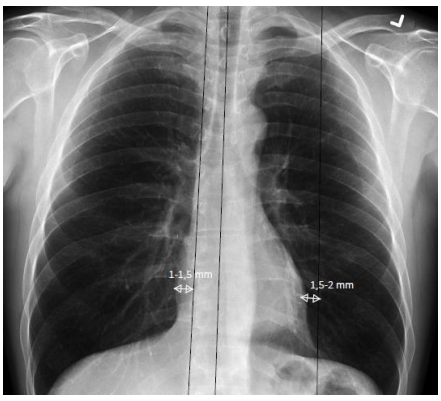

Figure 7. - *Normal position of the mediastinum. Trachea is located in the middle*

1st line - Line of right lateral border of the vertebra column;

2md line – line through the spinous processes;

3rd mid-clavicle line.

Atelectasis of the entire lung usually results from a complete obstruction of the right or left main bronchus. With bronchial obstruction, no air can enter the lung. The remaining air in the lung is absorbed into the bloodstream through the pulmonary capillary system. This leads to loss of volume of the affected lung and shift of the mediastinum organs *towards the side* of the *homogeneous* opacity.

Massive pleural effusion. If fluid, whether blood, an exudate, or a transudate, fills the pleural space to opacify almost the entire hemithorax, then the fluid acts like a mass compressing the underlying lung tissue. As the volume of the pleural cavity increases it dislocates the mediastinum to the *opposite side*. The liquid looks like *homogeneous* opacity.

In case of pneumonia, inflammatory exudate fills the air spaces causing consolidation and opacification of the lung. The hemithorax becomes opaque because the lung no longer contains air and looks like *heterogeneous* opacity without *no shift*.

Pneumofibrosis of the entire lung is a scarring of the lung tissue. It can be caused by a chronic inflammation, especially tuberculosis, sarcoidosis, environmental agents like asbestos and silica. The structure is heterogeneous because of a lineal fibrous tissue, the decrease of the lung volume leads to dislocation of the mediastinum to the effected side.

Table 2. – *Differential diagnosis of opacified hemithorax*

Pathology	Shift	Structure of opacity
Atelectasis	The side of the opacity	Homogeneous
Pneumonectomy	The side of the opacity	Homogeneous
Fibrosis	The side of the opacity	Heterogeneous
Pleural effusion	To the opposite side	Homogeneous
Pneumonia	No shift	Heterogeneous

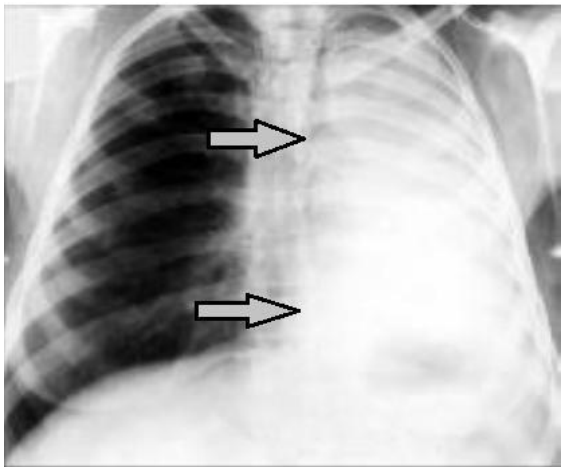

Figure 8. - *Total homogeneous opacity of left hemithorax with a shift of the mediastinum to the side of the effect. Atelectasis of entire lung*

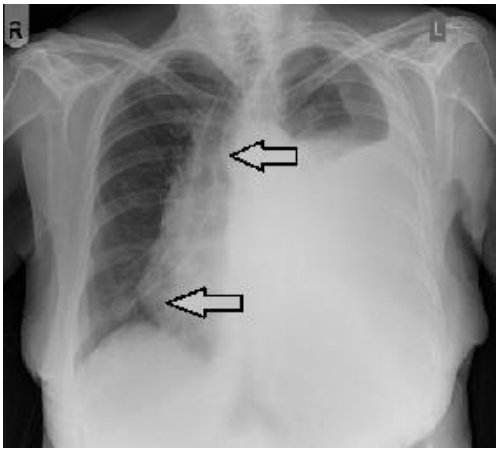

Figure 9. - *Subtotal homogeneous opacity of left hemitorax with a shift of the mediastinum to the opposite side. Subtotal pleural effusion of left hemithorax*

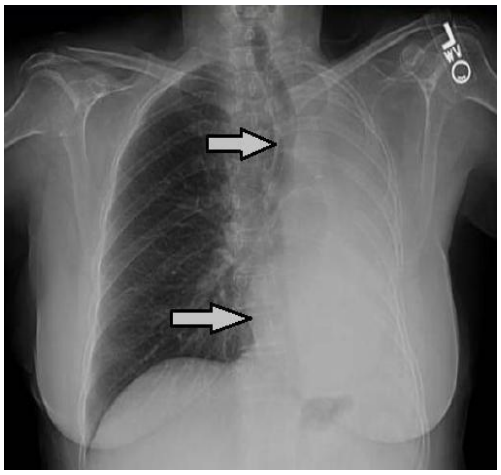

Figure 10. - *Total homogeneous opacity of left hemithorax with a shift of the mediastinum to the side of the effect. To differentiate it from atelectasis pay attention to bone structures- to perform pneumonectomy, either the 5th or 6th rib on the affected side is removed.*

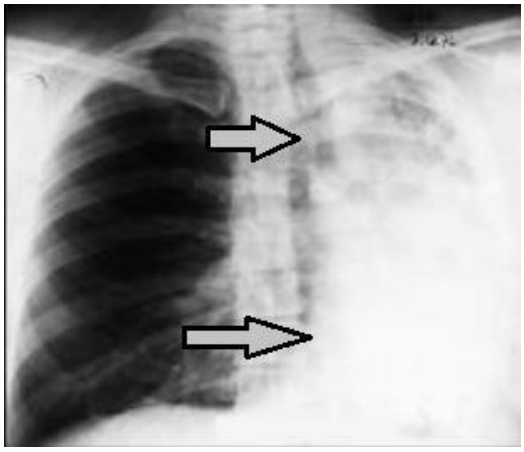

Figure 11. - *Total heterogeneous opacity of left hemithorax with a shift of the mediastinum to the side of the effected part. Fibrosis*

Confined opacity.

The causes of confined opacity syndrome are:

1. Lobe/segmental/subsegmental atelectasis;
2. Lobe/segmental pneumonia;
3. Small pleural effusion.

To differentiate these pathologies you have to determinate three main symptoms:

a) Localization- to localize a confined opacity you need to know segmental structure of the lungs (Pic.11).As on frontal view X-ray the projection of most of the segments are stratify to each other it is very important to make lateral view of the chest.

b) Structure of the opacity

c) The size of the opacity. If the opacity repeats the form of the anatomical structure (lobe or segment), pay attention the size. If the size of the opacity is less the size of the normal anatomical structure that means the volume has decreased. This point is useful for differentiation between pneumonia and atelectasis.

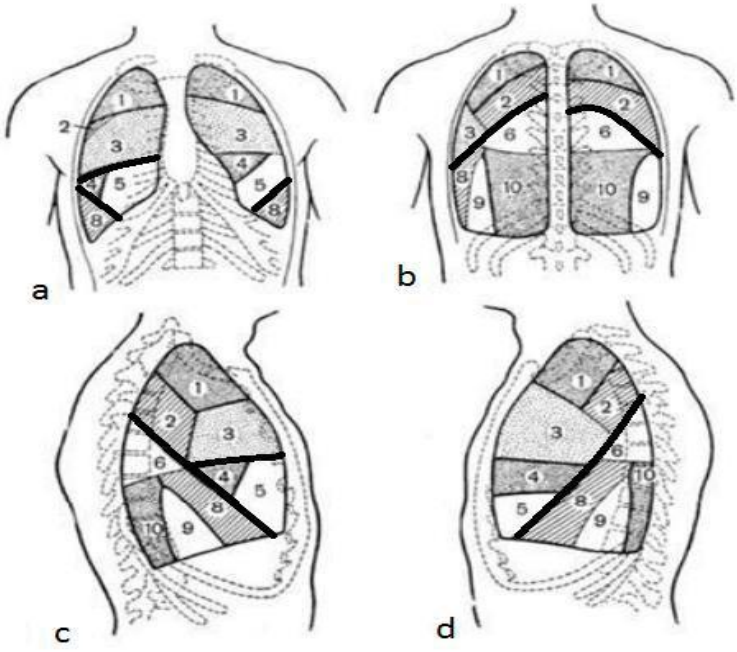

Figure 12. - *The scheme of segmental structure of the lungs:* ***a****- anterior view;* ***b****-posterior view;* ***c****-right lung;* ***d****-left lung, thin black line shows a projection of the fissures*

The sign of the atelectasis.

The form the opacity usually represents the form of the anatomical structure (lobe or segment). The lower volume of the affected lobe or segment is due to a collapse. The structure of the opacity is usually homogenious.

The sign of the lobar/segmental pneumonia.

Pneumonia can be defined as consolidation of a lung produced by inflammatory exudate, usually as a result of an infectious agent. The structure of the opacity is more often homogeneous, but sometimes it can be heterogeneous. The outlines may by fluffy and indistinct.

The sign of the pleural effusion.

As the effusion under the lung grows in size, it first fills the posterior costophrenic angle, visible on the lateral view of the chest. This occurs with approximately 75 ml of fluid. When the effusion reaches about 300 ml in size it fills lateral costophrenic angle, visible on the frontal chest x-ray.

The outline of the effusion is usually oblique meniscus-like and well defined. The structure of the opacity is homogeneous.

Sometimes the pleural effusion accumulates between the layers of an interlobar pulmonary fissure. They are lenticular in shape; most often occur in the minor fissure.

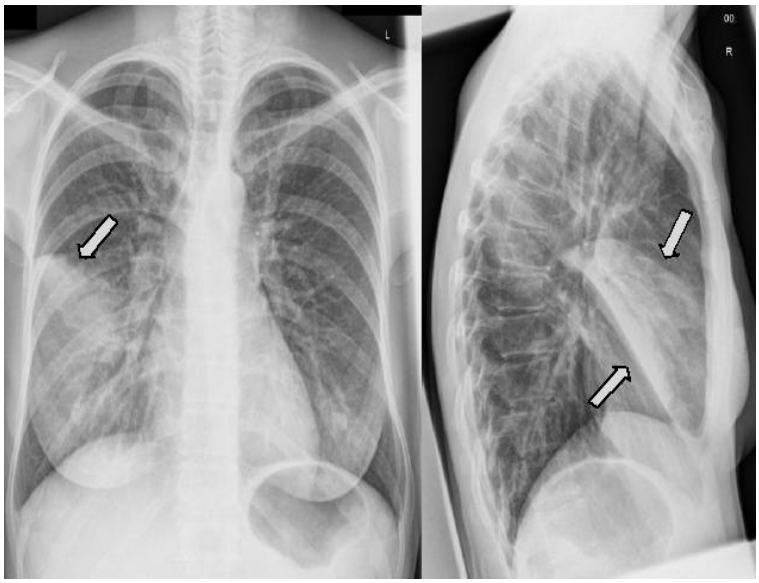

Figure 13. - *Homogeneous opacity of the middle lobe of the right lung with well-defined outlines. Lobar pneumonia*

Figure 14. - *Homogeneous pacification of lower Notice its volume decrease and well defined outlines. Atelectasis of the right upper lobe*

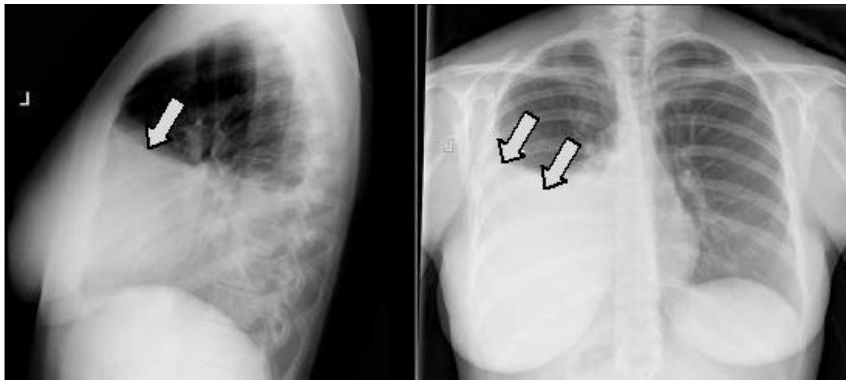

Figure 15. - *Homogeneous opacification of the lower lobe of the left lung with well-defined oblique outline. Left-sided pleural effusion*

Round shaped opacity.

Round shaped opacity is the symptom of all pathological processes which have got round, semicircular, oval form and a size of more than 30 mm.

The localization of the round opacity can be intrapulmonary or extrapulmonary. If the center of the opacity is located in the lung field, it means it is located in the lung. If the center of the opacity is located out of the lung field, it means it is located extrapulmonary (mediastinum, chest wall, subphrenic space).

The main causes of round shaped opacity:

1. Round pneumonia
2. Tumor
3. Filled cyst
4. Tuberculoma

To differentiate these pathologies you have to determinate three main symptoms:

a) Localization
b) Outlines
c) Structure

Round pneumonia is usually heterogeneous with fluffy indistinct outlines. It is normally surrounded with an aerated tissue from all sides.

Tumor has rough contours, homogeneous or heterogeneous structure, especially if the decay or petrification has happened.

Filled cyst has clear well-defined outlines and homogeneous structure.

Tuberculoma is a benign non-neoplastic mass caused by a localized tuberculosis infection. On the chest X-ray, it can look like homogeneous or heterogeneous in a case of petrification or decay, well-defined opacity, usually localized in lower areas of the lung.

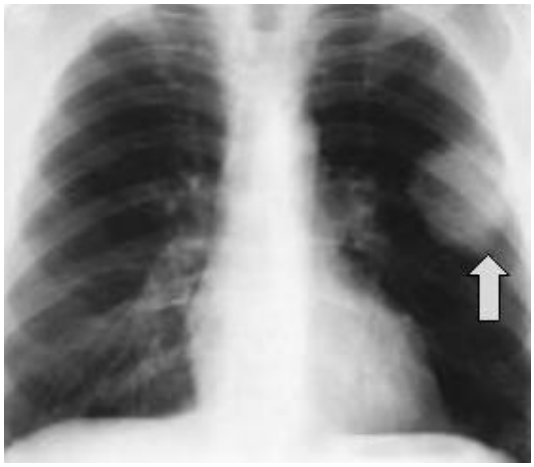

Figure 16.- *Peripheral round-shaped opacity of the left middle pulmonary lobe with homogeneous structure and rough contours. Peripheral tumor*

Solitary nodules and group of nodules.

Nodules are multiform opacities with a size 1-30 mm. If you can see several nodes located near, each in the area of two intercostal spaces – that means it is a group of nodules.

The main causes of solitary and group nodules

1. Non –specific inflammation
2. Tuberculosis
3. Tumor, including metastases

To differentiate these pathologies you have to determinate three main symptoms:

1) Localization and prevalence
2) Outlines of the nodules
3) Intensity of the opacity

The localization of the nodules at the top (apex) of the lung indicates **tuberculosis**. In case of the tuberculosis it can be a tuberculoma or focal tuberculosis.

Solitary nodule localized in other areas of the lung can be due to **a tumor or metastasis.**

If the outlines of a nodule are blurry it can be an inflammation –a **focal pneumonia**.If the outlines of a nodule are well defined it can indicate a focal tuberculosis or tumor depending on a localization.High intensive nodules are normally calcified and it usually happens in case of tuberculoma.

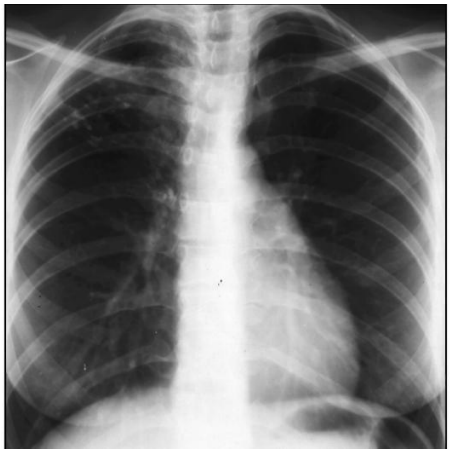

Figure 17. - *Group of nodes of right lung apex. The opacity of these nodes have well defined outlines and high intensity. Focal tuberculosis*

Diffuse multiple nodules.

More than 150 diseases can cause diffuse multiple nodules syndrome. The main cause of their appearance is the spread of the pathologic cells or bacterial agents by blood, lymph or bronci.

The main differential signs:

1) The size: miliar (1-2 mm), small (3-4 mm), medium (5- mm), large (9-12(30) mm).
2) Localization: one or both of sided, upper, medial or lower areas of the lung field.
3) The dynamic of the nodes: stability, consolidating or destructing.
4) Clinical manifestation: without clinical features, acute or gradient process of the lung desease.

In case of miliar nodules without clinical features you can think about **pneumoconiosis.** Pneumoconiosis is a lung disease caused by an inhalation of

different organic or inorganic dusts or chemical irritants, usually over a prolonged period of time.

If the patient with miliar nodes has got an acute clinical features it is necessary to make series of chest X-rays: if the nodes have got the tendency for consolidation that is more likely to be pneumonia; if there are no changes- it can be military tuberculosis.

Small nodes without clinical manifestation, mainly localized in upper areas of the lung can be a feature of chronic **hematogenous tuberculosis**. Metastases or focal pneumonia produce medium and large nodules.

Metastases are usually sharply outlined with clear demarcation between the node and surrounding lung tissue. Pneumonia has a blurry outlines, it disappears after the treatment.

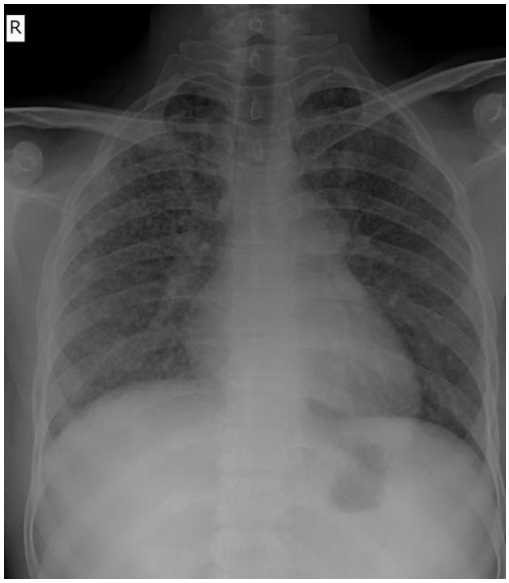

Figure 18. - Diffuse miliary nodules demonstrated throughout both lung fields. Miliary tuberculosis

Figure 19. - *Multiple well defined nodules localized in both lung fields. Metastases*

Hyperinflation of the lung tissue.

Hyperinflation can be cause by extra- or intrapulmonary processes.

Extrapulmonary process – **pneumothorax -** the presence of an air or gas in the cavity between the lungs and the chest wall, causing a collapse of the lung.

The negative pressure in the pleural space rises higher than the intralveolar pressure and the lung collapses.

The parietal pleura remains in contact with the inner surface of the chest wall, but the visceral pleura retracts toward the hilum with the collapsing lung.

The visceral pleura becomes visible as a thin, white line outlined by the air on both sides, marking the outer border of the lung and indicating the presence of the pneumothorax.

There is usually, but not always, an absence of lung markings in a space between collapsed lung and a chest wall.

The simple absence of the lung markings is not sufficient to warrant the diagnosis of a pneumothorax as other diseases can also produce such findings. Bullous disease of the lung and large cysts in the lung can have appearances of the pneumothorax.

In case of a large pneumothorax the mediastinum can be displaced to the opposite side.

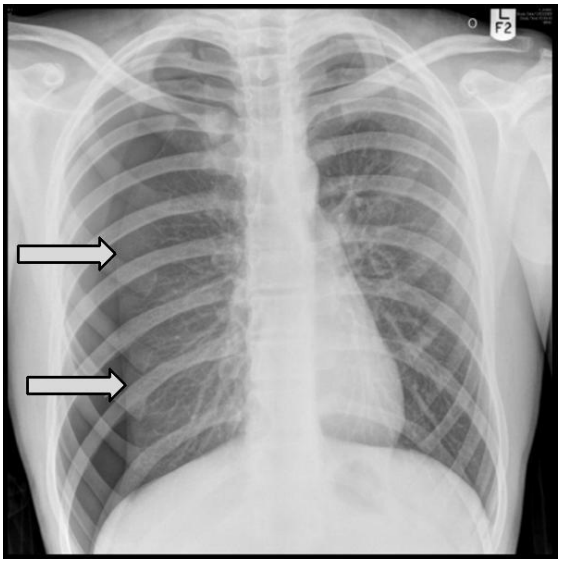

Figure 20. - *White arrows show the border of collapsed lung*

Intrapulmonary cause of lung hyperinflation is **emphysema.**

Emphysema is a chronic obstructive pulmonary disease (COPD). Emphysema is defined pathologically as an abnormal permanent enlargement of air spaces distal to the terminal bronchioles, accompanied by the destruction of alveolar walls.

Emphysema is commonly seen on CXR as a diffuse hyperinflation with flattening of diaphragms, increased retrosternal space, bullae (lucent, air-containing spaces that have no vessels that are not perfused).

Ring shadow opacity.

The cause of a ring shadow opacity is a cavity in the lung. A pulmonary cavity is a gas-filled area of the lung in the center of a nodule or area of consolidation.

Pulmonary cavities may be the result of:

1. Malignancy
2. Inflammation
3. Congenital.

To differentiate these pathologies you have to determinate three main characteristics:

a) The thickness of the wall
b) Amount of the cavities
c) Presence of liquid

The cavitating malignancy usually has got thick irregular walls without liquid inside. There can be few of such cavities in the case of destruction of the metastases.

The inflammation can be specific (tuberculosis) and non-specific.

In case of **tuberculosis**, cavities are characteristically thick with smooth walls without liquid inside. As for the amount, they can be solitary and multiple.

Non-specific cavity is called an **abscess**. Abscess occur as a result of the inflammatory process of the lung. The walls are thick and smooth, but there is a liquid inside, visible like a horizontal line.

The causes of congenital cavities are polycystic lung disease and solitary cysts. They have got thin smooth walls and no liquid inside.

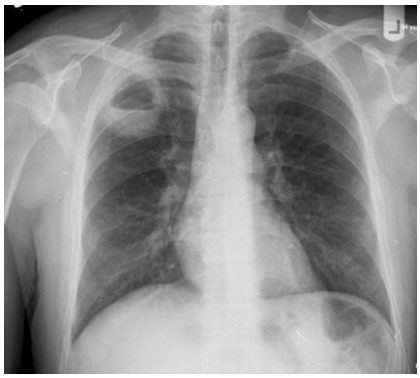

Figure 21. - *Thick walled cavity with an air-fluid level in the right upper area. An abscess*

Changes of lung markings.

The lung markings are a reflection of other structures within the lungs that show-up as white on the X-ray. These other structures are made up primarily of blood vessels, but also bronchial walls, lymphatics and some fibrotic tissue that accompanies vessels and bronchi (interstitial tissue).

Normal pulmonary vessels can be followed from the hilum toward the lung periphery in all directions. They branch at acute angles, taper and diverge toward the periphery.

Abnormal pulmonary markings are any shadows in the area of lungs that are in addition to the normal markings

Vessels in the lungs may appear as small nodules. Vessels on-end should be the same size as similarly distributed vessels in profile: i.e., expected size/compared size.

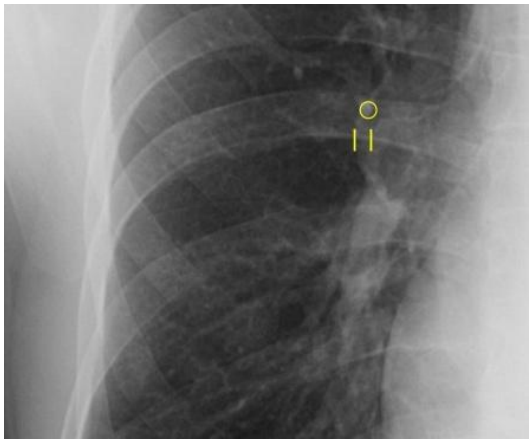

Figure 22. - *Vessel on-end (circled) is about the same size as the vessel seen leading to it (between lines, below the circled vessel)*

The pathological changes of lung markings are called interstitial disease.

Mainly it is reticular interstitial disease and it appears as a network of lines.

The main causes are: pulmonary **interstitial edema and idiopathic pulmonary fibrosis**.

Pulmonary interstitial edema can occur because of increased capillary pressure (congestive heart failure), increased capillary permeability (allergic reactions) or decreased fluid absorption (lymphatic blockage from metastatic disease).

On CXR it is possible to find the accentuation of the pulmonary interstitial markings, expansion of the interstitial space by fluid.

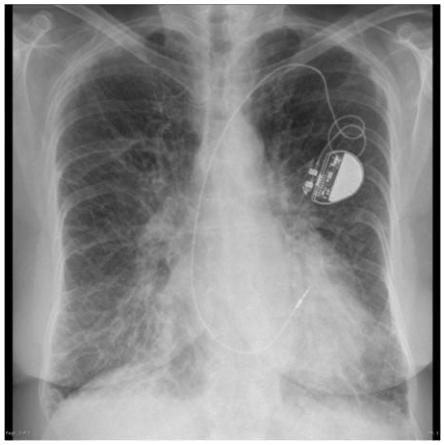

Figure 23. - *The heart is enlarged and there is marked prominence of the interstitial lines. Pulmonary interstitial edema*

Hilar pathology.

The hila (lung roots) are complicated structures mainly consisting of the major bronchi and the pulmonary veins and arteries. Although the hilar lymph nodes are not visible on a normal chest x-ray, they are of particular clinical importance. The hila may be at the same level, but commonly the left hilum is higher than the right. Both hila should be of similar size and density. If either hilum is bigger and denser, this is a good indication that there is an abnormality.

Hilar enlargement may be unilateral or bilateral, symmetrical or asymmetrical. In combination with clinical information, each of these patterns is often helpful in reaching a diagnosis.

A differential of possible etiologies can be broken up into three different categories:

1. Inflammation (sarcoidosis, silicosis)
2. Neoplasm (lymphoma, metastases, bronchogenic carcinoma)

3. Infection (tuberculosis, histoplasmosis, infectious mononucleosis)

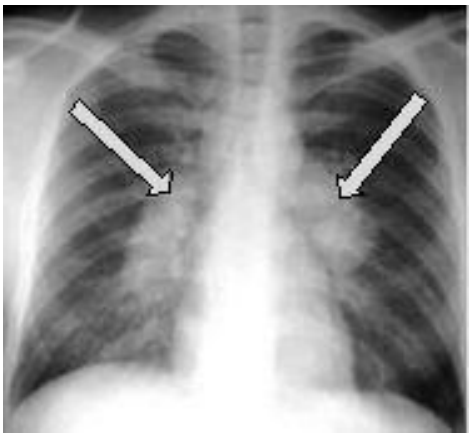

Figure 24. - *Bilateral hila adenopathy. Sarcoidosis*

3. HEART AND CARDIOVASCULAR SYSTEM

Goal: To get a notion about the most important radiological syndromes of heart pathology, how to use them in reaching diagnosis of most frequently performed diseases.

Knowledge objectives: to know normal x-ray anatomy of the heart and mediastinum, main |X-ray syndromes of hert diseases, the ability of interpretation X-ray film with heart lesions.

Skill objectives: The ability of interpretation X-ray film with heart lesions, make an X-ray report.

Subject- matter:

- Modalities and technique of chest X-ray, particular quality in heart pathology
- Normal anatomy
- Main pathology

EDUCATION MATERAL

Conventional radiology of the heart helps to suspect some of the heart pathologies at the early stages of diagnostic search. Chest x-ray is not the most informative method of heart visualization. Ultrasound, CT, MRI are the methods to consider if you wish to focus on the heart.

The heart can be examined in different views.

Frontal view radiograph:

1. Left lateral view radiograph
2. Right oblique view radiograph (with or without contrasted esophagus)
3. Left oblique view radiograph(with or without contrasted esophagus)

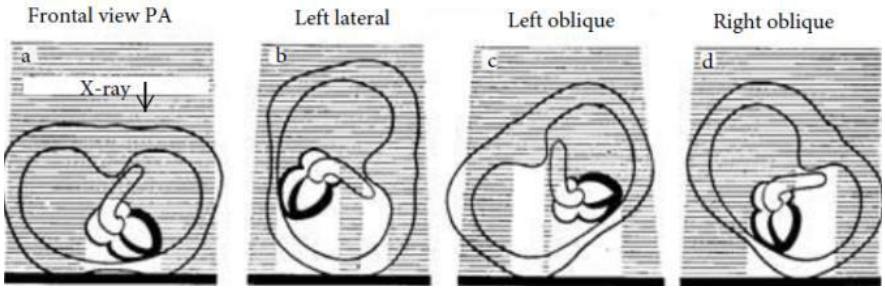

Figure 25. - *The position of the patient to the X-ray beam*

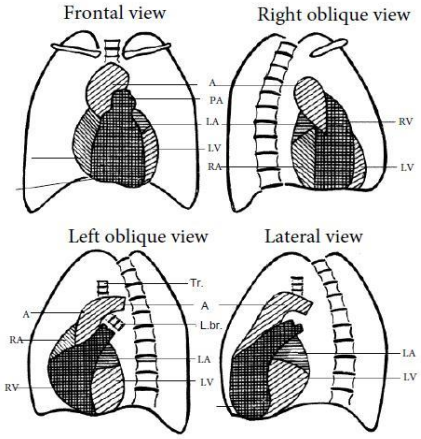

Figure 26. - *The main basic views for heart X-ray imaging. A-Aorta, RA- right atrium; RV- right ventricle; LA- left atrium; LV- left ventricle; Tr.- trachea; L.br.- left bronchus*

On frontal posterior-anterior (PA) Chest X-ray you have to pay attention to the size and position of the heart.

There are three main normal positions. The position is the ratio of heart axis to the horizontal surface of diaphragm. The position depends on the shape of patient's thorax.

1. Vertical (asthenic type of the body)
2. Oblique (normosthenic type of the body)
3. Horizontal (hypersthenic type of the body)

The cardiac silhouette can appear enlarged due to these main reasons:

1. The heart is enlarged (cardiomegaly).
2. A pericardial effusion mimics the appearance of cardiomegaly

To find out the enlargement of cardiac silhouette on the frontal chest radiograph the cardiothoracic ratio is used, which is measurement of the widest transverse diameter of the heart compared to the widest internal diameter of the rib cage. In most normal adults at full inspiration, the cardiothoracic ratio is less than 50%. That is, the size of the heart is usually less than half of the internal diameter of the thoracic rib cage.

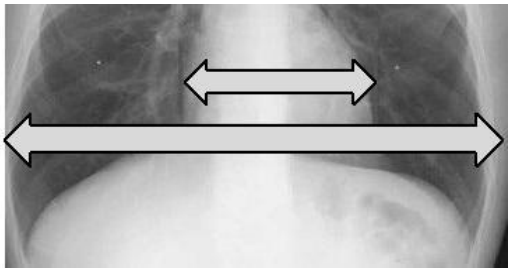

Figure 27. - *Cardiothoracic ratio*

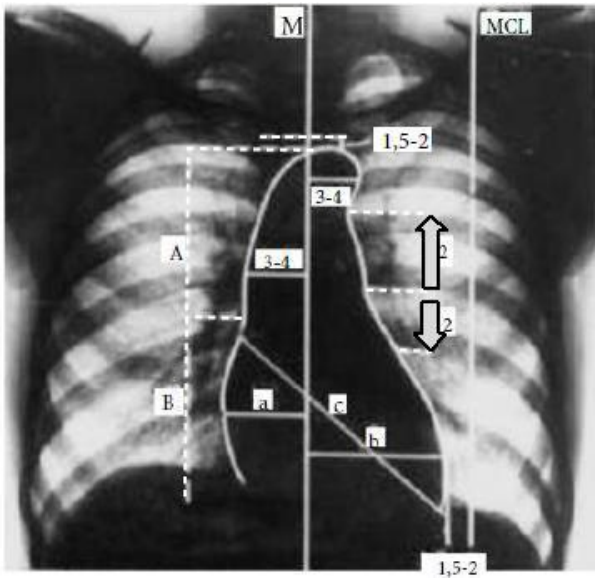

Figure 28. - *The main sizes of heart silhouette on frontal CXR; M-medial line of the thorax; MCL- middle clavicle line; c-heart axis; A/B=1:1;a/b=1/3:2/3*

To evaluate for the presence of enlargement of the cardiac silhouette in the lateral projection, look at the space posterior to the heart and anterior to the spine at the level of the diaphragm.

In a normal person, the cardiac silhouette will usually not extend posteriorly and project over the spine.

As the heart enlarges, whether that enlargement is due to cardiomegaly or pericardial effusion, the posterior border of the heart may extend to, or overlap, the anterior border of the thoracic spine. This can be useful as a confirmatory sign of cardiac enlargement first suspected on the frontal projection.

To find out the isolated enlargement of chambers oblique views are used. Otherwise, sometimes it is useful to make esophagus contrasted to find out the shift as a result of chamber enlargement.

The main forms (configurations) of enlarged heart silhouette:

1) Mitral form

2) Aortic form

3) Trapezoid/triangular form

The mitral form is characterized by enlargement of left atrium and main pulmonary artery. The causes are:

- overload of right chambers of the heart as a result of chronic pulmonary diseases. In that case the right borders are enlarged too;
- dilatation/hypertrophy of the left atrium as a result of mitral stenosis or insufficiency with retrograde pulmonary hypertension.

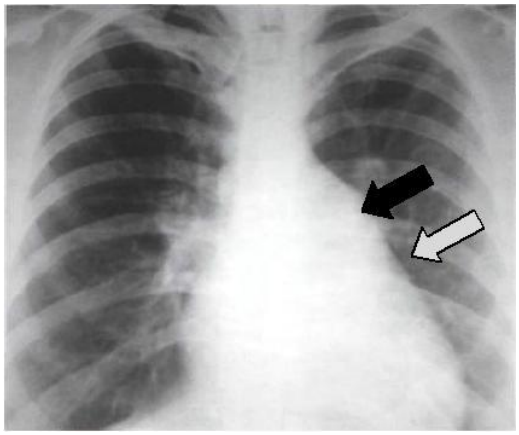

Figure 29. - *Mitral form of the heart. Enlargement of pulmonary artery outline (black arrow); Enlargement of left atrium outline (grey arrow)*

The aortic form is characterized by enlargement of left ventricle as a result of dilatation or hypertrophy.

The main causes are:

- Aortic valve stenosis or insufficiency
- Arterial hypertension

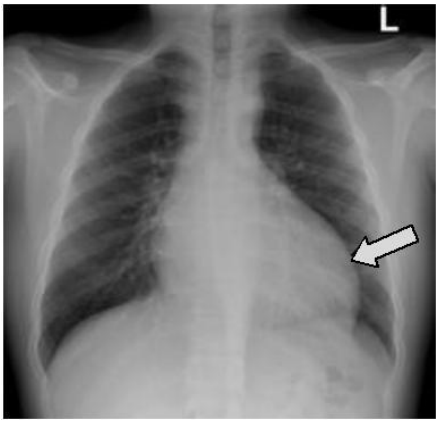

Figure 30. - *Aortic form of the heart. Hypertrophy of left ventricle as a result of aortic stenosis*

The trapezoid form or triangular form is typical for cardiomyopathy and pericardial effusion. Cardiomyopathy is a diffuse disease of heart muscle when all chambers are enlarged by dilatation or by hypertrophy.

Pericardial effusion is an accumulation of the fluid (serous, pus, blood) in pericardial cavity. The causes are inflammation of pericardium or myocardium, heart failure or wound of the heart with heart tamponade.

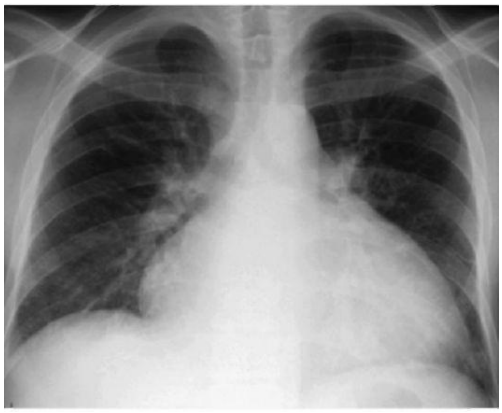

Figure 31.- *Trapezoid form. Cardiomyopathy; both contours of the heard are enlarged*

Figure 32. - *The form of the heart silhouette is nearly globe-shaped. Tense pericardial effusion*

Pulmonary edema can occur as a result of heart failure. When the pulmonary venous pressure is sufficiently elevated, fluid moves out of the lung interstitial tissue into its airspace.

The radiographic findings are:

- Fluffy, indistinct, patchy airspace densities that are usually centrally located.
- Pleural effusion

Figure 33. - *Fluffy, indistinct airspace opacities, centrally localized. Pulmonary edema*

4. ABDOMEN AND GASTROINTESTINAL TRACT

Goal: To get a notion about the most important radiological syndromes of abdominal pathology, how to use them in reaching diagnosis of most frequently performed diseases.

Knowledge objectives: to know main |X-ray signs of gastrointestinal and abdominal diseases.

Skill objectives: The ability of interpretation conventional and barium X-ray film,make an X-ray report.

Subject- matter:

- Modalities and technique of conventional and barium X-ray
- Conventional abdominal X-ray
- Barium X-ray of gastrointestinal tract

EDUCATION MATERIAL

While imaging of the abdomen is now largely performed using CT, ultrasound, MRI, or endoscopic methods, many patients still have "plain films" of the abdomen as a first step of diagnostic search.

There are two different types of investigations:

1) Without contrast matter (Conventional abdominal X-ray);

2) Barium study of gastrointestinal tract (barium swallow or enema).

Plain film of the abdomen is performed in patients with acute abdominal pain in a standing or lying position.

Conventional abdominal X-ray

What to look for:

1) Look at gas pattern
2) Check for extraluminal air
3) Look for abnormal abdominal calcifications

Gas pattern

Relatively large amounts of gas are normally present in the stomach and colon but only a small amount is usually seen in the small bowel. The presence of fluid and gas in the lumen called **fluid level**. Three to five fluid levels less than 2.5 cm in length may be seen, particularly in the right lower quadrant, without any evidence of intestinal obstruction or paralytic ileus. More fluids levels has to direct the physician to the intestinal obstruction.

Otherwise, gas in the intestinal tract can exist in lumen without any fluid. Such condition is called **dilatation**. This is a sign of an intestinal obstruction.

The causes of obstruction can be mechanical (tumor, foreign body, stricture) or dynamic- paralysis of gastrointestinal motility.

It is possible to find out the level of the obstruction determining dilated part of gastrointestinal tract.

Gastric dilatation

Mechanical gastric obstruction caused by carcinoma or pyloric stenosis in children, which often leads to a huge fluid-filled stomach that occupies most of the abdomen and is demonstrated as a soft-tissue mass with little or no bowel gas beyond. Usually a little gas is present in the stomach, which allows the organ to be identified. If oral contrast medium is given, it may not pass beyond the obstructed pylorus.

Figure 34. - *Dilated stomach in an infant with a pyloric stenosis*

Distinction between small- and large-bowel dilatation

When a radiograph shows dilated bowel it is important to try to determine whether it is small or large bowel, or both. Useful differentiating features include the size and distribution of the loops. Dilated small-bowel loops are usually more numerous and arranged centrally in the abdomen. The loops show a small radius of curvature and rarely exceed 5 cm in diameter. The presence of solid faeces is the only reliable sign that the loop is large bowel. In the small bowel the valvulae are much closer together than colonic haustra and become thinner when stretched, but still remain relatively close together as the diameter of the small bowel increases.

Figure 35. - *Dilated loops of a small bowel with level of fluid (black arrow). Small bowel obstruction*

Figure 36. - *Few air-fluid levels. Small bowel obstruction*

Figure 37. - *A dilation of the large intestine, indicated by the larger diameter of the air-filled segments and haustras. Large bowel obstruction*

Another method to diagnose the intestinal obstruction, especially to differentiate it with dynamic obstruction (decreasing of the motility) is a barium follow trough. The patient has to be given 200 ml of barium (contras matter) to drink and X-rays should be taken every two hours until the entire large bowel is opacified. Normally, contrast reaches the caecum in 3-3,5 hours; right colon-5-6 hours; left colon-10-12 hours;rectum-17-24 hours.

Extraluminal air

Air is normally not present in the peritoneal cavity. The cause of extraluminal air (free air) is a rapture of an air-containing organ- loop of a bowel (perforated ulcer, diverticulus appendix, carcinoma or trauma)Air can also stay on for several days after abdominal surgery.

There are three major signs of free intraperitoneal air:

1) Air beneath the diaphragm

2) Visualization of both sides of the bowel wall
3) Visualization of the falciform ligament

Air beneath the diaphragm

Air will rise to the highest part of the abdomen. Therefore, in the upright position free air will usually reveal itself under the diaphragm as a crescentic lucency that is parallel to the surface of the diaphragm. If the patient is unable to stand or sit upright, then a view of the abdomen with the patient lying on her/his left side has to be taken.

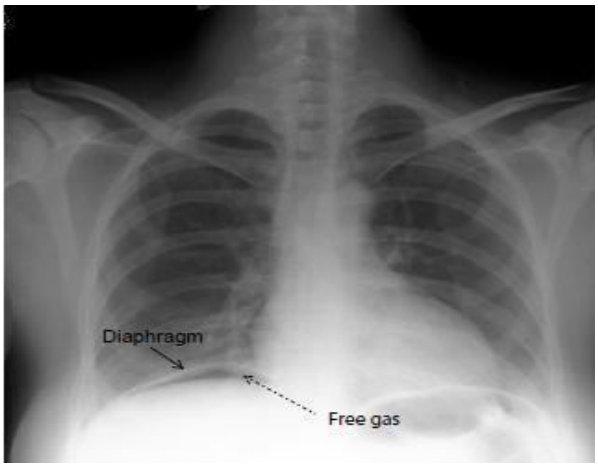

Figure 38. - *Crescentic lucency under right hemidiaphragm. A sign of free abdominal gas*

Visualization of both sides of the bowel wall

In the normal abdomen we can visualize only the air inside the lumen of the bowel, but not the wall of the bowel itself. The ability to see both sides of the bowel wall is sign of free intraperitoneal air. It is also called a Righler sighn. This sign usually requires large amounts of free air in the abdominal cavity.

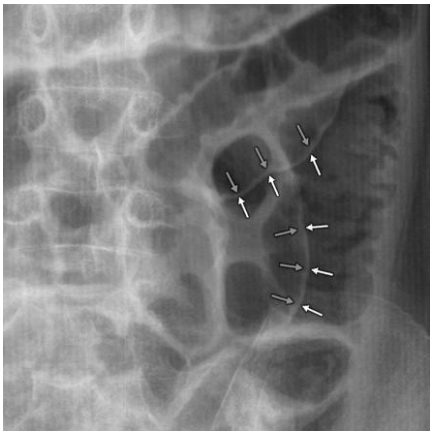

Figure 39. - X-ray Rigler's sign: grey arrows-luminal surface; white arrows-peritoneal surface

Visualization of the falciform ligament

Falciform ligament is normally invisible. When a large amount of free air is present and the patient is in supine position, free air may rise over the anterior surface of the liver, surround the falciform ligament, and render it visible.

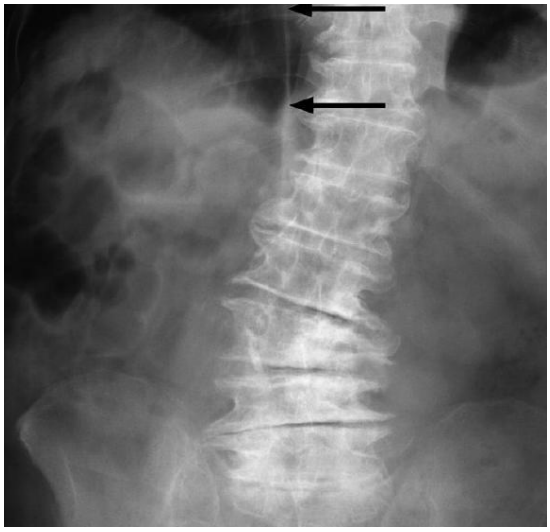

Figure 40. - *Falciform ligament sign*

Abnormal abdominal calcifications

Types of calcifications:

1. Rimlike (round,ring)
2. Linear
3. Lamellar (laminar,flaked)
4. Cloudlike, amorphous

Rimlike calcifications

Rimlike calcifications - calcifications that has occurred in the wall of a hollow organ.

– Renal, splenic, liver cysts
– Aneurisms
– Saccular organs as gallbladder and urinarybladder

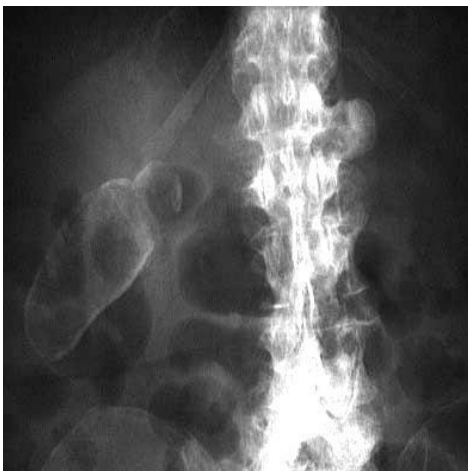

Figure 41. - *Calcified gallbladder wall*

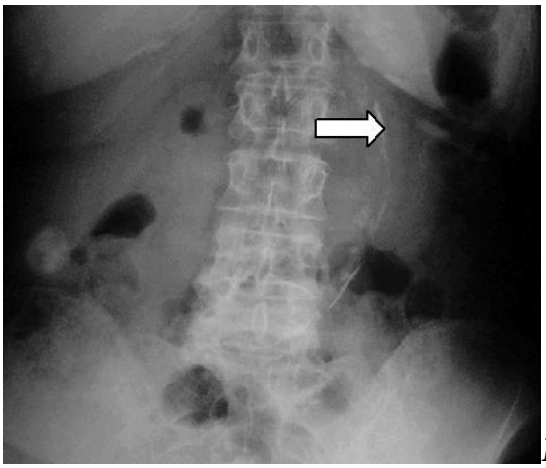

Figure 42. - Calcified aortic aneurism

Linear calcification

Linear calcification occur in the walls of tubular structures such as arteries. Walls of veins do not calcify. calcified thrombi in veins are called phlebolitis.

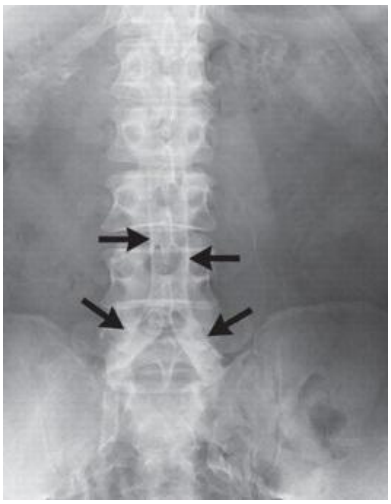

Figure 43. - *Calcification of the wall of the abdominal and the common iliac arteries*

Lamellar calcifications

Lamellar calcifications form around a nidus inside a hollow lumen- gallbladder and urinary bladder. Such calcifications are usually called stones or calculi and include renal and ureteral calculi.

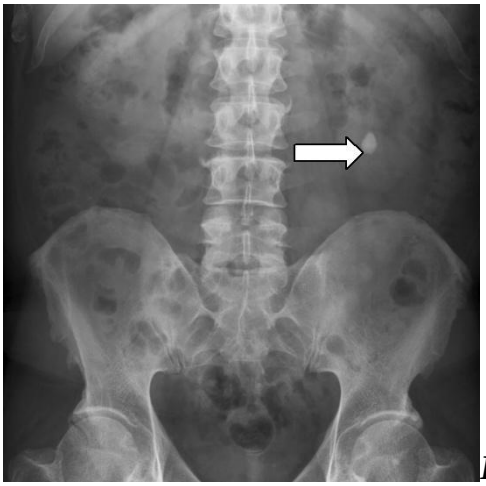

Figure 44. - Kidney stone

Cloudlike calcifications

Cloudlike calcifications are formed inside of a solid organ or tumor. It can be a body of the pancreas, leiomyoma of uterus, lymph nodes and soft tissues.

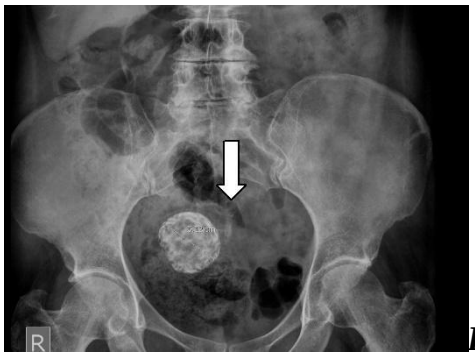

Figure 45. - Calcified uterine leiomyoma

Barium study of gastrointestinal tract

During the performance of barium studies, fluoroscopy spot films and films are usually obtained by the radiologist in several projections.

Barium is a dry, white, metallic powder that is mixed with water to make a barium liquid. Barium is an X-ray absorber and appears white on the X-ray film. In addition to drinking barium, some patients may be given baking soda crystals to further improve the images. This type of procedure is called a double-contrast examination.

Main X-ray syndromes of gastrointestinal diseases.

1) Diffuse extension of the lumen
2) Local extension or local *collection of barium*
3) Diffuse constriction of the lumen
4) Local constriction or *filling defect*-a lesion usually of soft tissue density, that protrudes into the lumen and displaces the intraluminal contrast.

Esophagous.

Diffuse extension

Diffuse extension of the esophagus lumen can occur as a result of esophageal achalasia. Achalasia is a primary esophageal motility disorder characterized by the absence of esophageal peristalsis and impaired relaxation of the lower esophageal sphincter (LES) in response to swallowing.

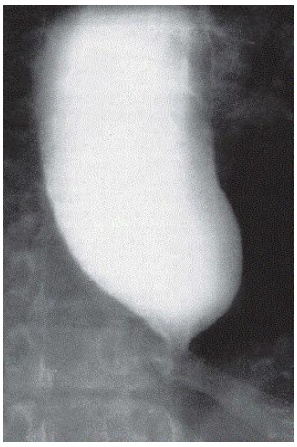

Figure 46. - *The esophagus is extended. Abdominal part of*

Local collection of barium

Local collection of barium as an X-ray symptom usually occur as a result of esophageal diverticula. Diverticula are usually produced when the mucosal and submucosal layers herniate through a defect in the muscular layer.

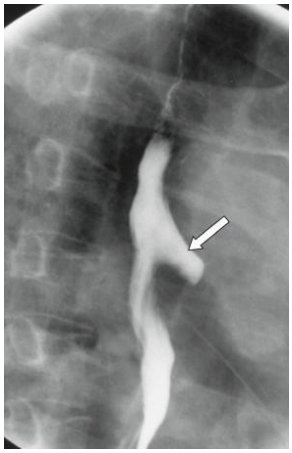

Figure 47. - *Esophageal diverticula*

Diffuse constriction

Diffuse constriction of the esophagus lumen mainly occur as a result of chemical burn (acid, alkali) with later scaring scarring.

Figure 48. - *A long, narrow stricture from the carina to the distal esophag*

Filling defect

Filling defect as an X-ray symptom occurs as a result of a tumor. It can look like annular constricting or mass.

Figure 49. - *Annular constriction lesion-the tumor encircles the normal lumen of esophagus*

Stomach and duodenum

Local collection of the contrast. Main reasons for this symptom are gastric and duodenal *ulcers*. Most gastric ulcers occur on the lesser curvature or posterior wall in the region of the body or antrum of the stomach. Almost all duodenal ulcers occur in the duodenal bulb, the majority are on the anterior wall of the bulb.

Figure 50. - *A large collection of barium, located on the lesser curvature. Gastric ulcer*

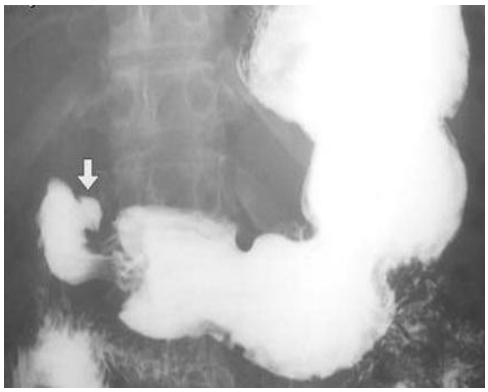

Figure 51. - *A collection of barium of the duodenal bulb. Duodenal ulcer*

Filling defects

Filling defects mainly occur in stomach as a result of a gastric carcinoma. Gastic carcinomas may be polypoid, infiltrating or ulcerative in form.

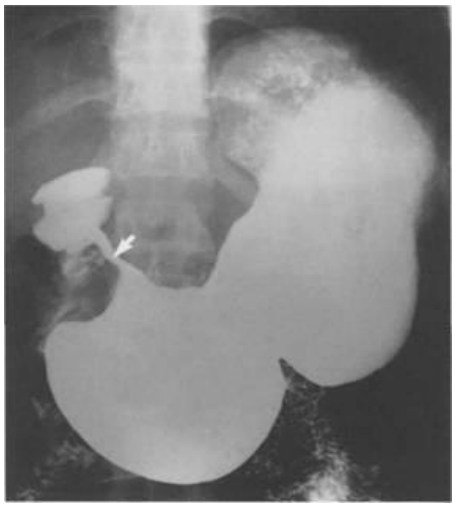

Figure 52. -*A large filling defect in the pyloric part that displaces the barium around it. Gastric carcinoma*

Small and large bowel

The barium study of the small bowel is not widely used. Some of the diseases are possible to find on the conventional x-ray without the use of contrastin (see above). To insert the barium into the colon the barium enema is used. To perform a barium enema, the patient has to prepare for it take a laxative or purifying enema before the study.

Local collection of the contrast for large colon can occur as a result of diverticula. Sometimes diverticula can become inflamed (diverticulitis) and perforate. When there are lots of deverticula it is called diverticulosis.

Figure 53. - *Diverticulosis*

Filling defect

The main reason for filling defects is a colonic carcinoma. The imaging findings of carcinoma of the colon include the presence of a persistent, large, polypoid filling defect; annular constriction of the colonic lumen producing an apple core sign.

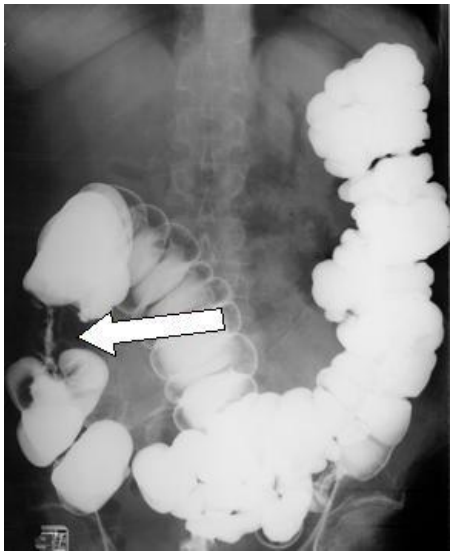

Figure 54. - *An apple core sign in ascending colon*

5. BONES AND JOINTS

Goal: To get a notion about the most important radiological syndromes of bone and joint pathology, how to use them in reaching diagnosis of most frequently performed diseases.

Knowledge objectives: to know main |X-ray signs of bone deseases, and traumas ,the ability of interpretation X-ray film with bone lesions.

Skill objectives: The ability of interpretation X-ray film with bone lesions, make an X-ray report.

Subject- matter:

- Modalities and technique of chest X-ray, particular quality in heart pathology
- Normal anatomy
- Main pathology

EDUCATION MATERIAL

On conventional radiographs bones consist of a dense cortex of compact bone, which completely envelopes a less dense medullary cavity containing cancellous bone arranged as trabeculae, separated primarily by blood vessels, hematopoetic cells and fat. On conventional radiographs, the cortex produces a smooth white shell of varying thickness that appears as a dense white band along the outer margins of the bone. The medullary cavity on conventional radiographs appears as a core of less dense, grayish material inside the cortical shell, interlaced with a fine network of bony trabecular markings.

Almost all examinations of bone start with conventional radiographs obtained with at least two views exposed at a 90° angle to each other (called orthogonal views) so as to localize abnormalities better and to visualize as much of the circumference of the bone as possible.

The main bone pathology:

1) Skeletal trauma
2) Infection diseases
3) Bone tumors (malignant, benign, tumor-like disorders)
4) Joint disease

The main X-ray symptoms of bone pathology.

Changes of bone density.

Increased density is called *osteosclerosis*. It can be diffuse and focal.

The opposite state- diffuse decreased density is called *osteoporosis*.

Table 3 - *Changes in bone density*

Density	Prevalence	Pathology
Increased density ↑	Diffuse	Diffuse osteoblastic metastases Osteopetrosis
	Focal	Localazed osteoblastic metastases Degenerative and postinflamatory process Osteoblastic sarcoma
Decreased density ↓	Diffuse	Osteoporosis Rickets
	Focal	Localized osteolytic metastases Multiple myeloma Osteomyelitis Tumors

On conventional radiographs, there will be an overall or local whiteness (sclerosis) of the bone due to compacting of bone trabeculae.

The features of osteoporosis on conventional radiographs are decreasing of the bone density that starts to look like surrounding tissue density, enlargement of the bone trabecula, thickening of the cortex.

Figure 55. - *Diffuse metastatic disease from prostate carcinoma. The bones are diffusely sclerotic. You can no longer see the normal trabeculae*

Figure 56. - *A focal sclerotic metastasis of the vertebra body*

Figure 57. *- Lateral radiograph of an osteoporotic spine, showing compression fractures (wedge fractures) of the L1 and L3 vertebral bodies*

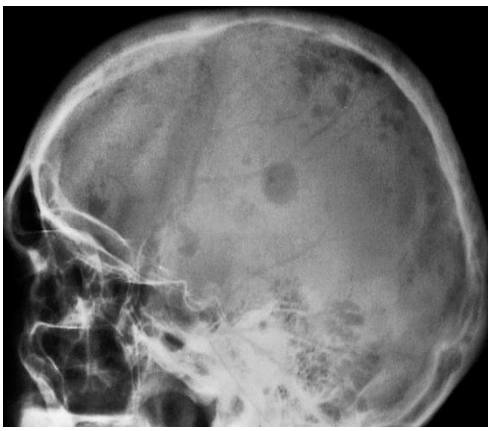

Figure 58. - *Multiple focal areas of decreased density of the scull. Multiple myeloma*

Changes of the bone structure. Destruction.

Destruction- the substitution of the bone tissue by another pathologic tissue. It can occur as a result of tumor or inflammation.

Flatus (Soap bubble)-increasing of the bone volume with decreasing of the bone tissue as a result of substitution by soft masses (tumor).

Figure 59. - *A focal increase of a bone, a "soap bubble" lesion without the defect of the cortex. Nonossifying fibroma*

Periosteal reaction.

Periosteal reaction, also known as a periostitis, is a non specific radiographic finding that occurs with periosteal irritation. Normally, periost is invisible on X-ray, it starts to be prominent when it is calcified. Practically anything that breaks, stretches, inflames, or even touches the periosteum leads to periostal reaction.

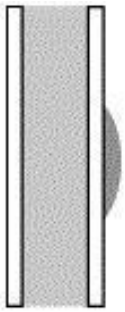

Figure 60. - *Solid periosteal reaction along the cortex of a bone. Causes: infection, benign neoplasms, hypoxia of the tissue*

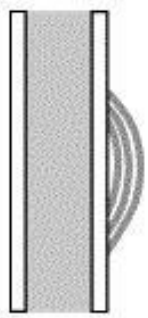

Figure 61. - *Lamellated (onion-skin) periosteal reaction. The cause is chronic but progressive process-chronic osteomyelitis, Ewing sarcoma*

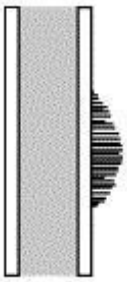

Figure 62. - *"Hair-on-end" or "sunburst" periosteal reaction. The perpendicular lines are calcification of perivascular soft tissues. Causes are: chronic osteomyelitis and osteogenic sarcoma*

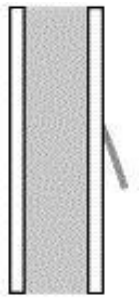

Figure 63. - *a Codman's triangle. The usual cause is malignant tumor which destructs the cortex*

Skeletal trauma

Fracture

A fracture is identified on a radiograph as a linear lucency within bone and a disruption or break in the nearby cortex accompanied by varying degrees of displacement of the fracture fragments. Soft tissue swelling is usually present adjacent to an acute fracture.

If the cortex is broken through and through, the fracture is called complete. If only a part of the cortex is fractured, it is called incomplete.

Fractures are usually described using four major parameters:

- The number of fragments
- The direction of the fracture line
- The relationship of the fragments to each other
- By communication of the fracture with the outside atmosphere

Dislocation

In a dislocation, the bones that originally formed the two components of a joint are no longer in apposition to each other. Dislocations occur only at joints

In a subluxation, the bones that originally formed the two components of a joint are in partial contact with each other. Subluxations also occur only at joints.

Figure 64. - *Posterior elbow dislocation*

The non-specific inflammation of the bone is osteomyelitis. It can be posttraumatic and haematogenious, acute and chronic. The X-ray features are focal cortical bone destruction, releasing of bone tissue fragments (sequestrum),

periosteal reaction. Inflammatory changes accompanying the infection may produce soft tissue swelling and focal osteoporosis from hyperemia.

Figure 65. - *The deformation of the femoral bone with multiple focuses of osteosclerosis and osteoporosis, narrowing of medullary canal. Chronic osteomyelitis*

Specific agents of bone inflammation can be tuberculosis,

syphilis. **Bone tumors**

Main X-ray features of benign tumors are: solid mass, absence of cortex destruction; the structure of the bone is changed, but safe; there are no calcifications of surrounding soft tissue; slow time of growing. Benign tumors - osteoma, osteochondroma, chondroma.

Main X-ray features of malignant tumors are: destruction of all bone structures with spreading to surrounding soft tissue; calcifications of surrounding tissue; the bone structure is chaotic; a Codman’s triangle and "hair-on-end" or sunburst periosteal reaction; rapid growth.

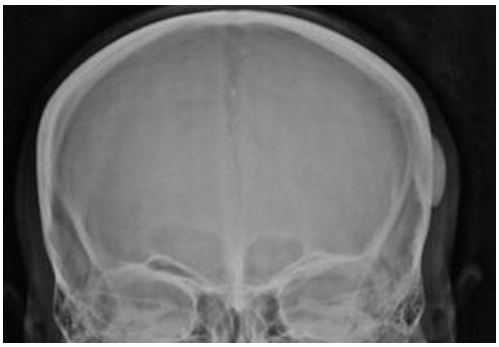

Figure 66. - *A compact osteoma of left temporal bone*

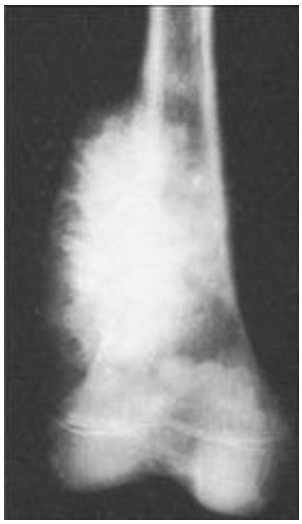

Figure 67. - *A high-density destructing bone mass with sunburst periostitis. Osteosarcoma*

Joint disease

The inflammation of join is called arthritis. It can be non-specific, specific or degenerative (osteoarthritis)

The X-ray features of degenerative arthritis are:joint space narrowing, subchondral sclerosis, marginal osteophyte formation, subchondral cysts.

Figure 68. - *Degenerative arthrosis of a knee joint. (Osteoarthritis)*

Specific and non-specific arthritis is accompanied with bone structure lesions such as destruction, deformation and soft tissue swelling.

Ankylosis is an immobility and consolidation of a joint due to disease, injury, or surgical procedure. The X-ray features are: absence of joint space; transition of bone trabeculae; absence of subchondral bone-cortex.

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