INTERACTIVE AND INNOVATIVE COURSE IN LUNG AND THORACIC ULTRASONOGRAPHY

EDUCATIONAL MATERIAL
PART ONE

PART ONE

THE FIRST PART OF THE COURSE

INTRODUCTION

THE MERE PRESENTATION OF THE COURSE

ULTRASOUND AND CHEST PHYSICIANS – WHY?

THE MAIN TOPICS:

1: LUNG ULTRASOUND

2: OBJECTIVES

3: THE PROJECTS' EXPECTED IMPACT

4: THE ULTRASOUNDS' ROLE IN THE DETECTION OF PLEURAL EFFUSIONS

5: THE DETECTION OF PLEURAL EFFUSIONS

6: THE POSTERIOR-ANTERIOR PROJECTION OF CHEST RADIOGRAPHY

7: OBTAINING AN UPRIGHT LATERAL CHEST RADIOGRAPH

8: ULTRASOUND A CLEAR ↓↓ IN THE OVERALL COMPLICATION

INTRODUCTION: *The mere presentation of the course*

Lectors:

Lavinia Davidescu, Oradea, Romania

- **THIS COURSE** aims *to diminish* the **lack** of *postgraduate medical education* and *informations* using **lung** and **thoracic ultrasonography** for *diagnosis* and *therapy* of **lung** and **pleura diseases**.

- **THE PROBLEM** appeared *as a result* of the **absence** of a **lung** and **thoracic ultrasonography** as part of the Respiratory Medicine *curricula*.

LUNG ULTRASOUND

Lavinia Davidescu

Traditionally, air has been *considered* **the enemy** of *ultrasound* and *the lung* has been *considered* an **organ** not amenable to ***ultra sonographic examination***.

The explanation is *the big attenuation effect* of the **air** on **US**.
In the *last **15** years*, a **new imaging application** of ***sonography*** has *emerged* in **the clinical arena: lung ultrasound** (LUS).
From its' *traditional assessment* of **pleural effusions** and *masses*, **LUS** has *moved* **towards** *the revolutionary approach* of **imaging** the *pulmonary parenchyma*, mainly as a **point-of-care** *technique*.

LUNG ULTRASOUND

Lavinia Davidescu

- *The assessment* of **the lung** has *always* been **considered off-limits** for *ultrasound*, because *ultrasound* **energy** is rapidly *dissipated* by **air**, *ultrasound imaging* is **not** useful for *the evaluation* of **the pulmonary parenchyma**.
- **LUS** has *proved* to be **useful** in *the evaluation* **of many different** *acute* and *chronic* **diseases**: *pneumotorax, cardiogenic pulmonary edema, acute lung injury, pneumonia, interstitial lung disease, pleural patology, pulmonary infarctions, lung contusions* and **s.o**.

Longo D, Fauci A, Kasper D, Hauser S, Jameson J, Loscalzo J: Harrison's Principles of Internal Medicine. 2008

Luna Gargani; Giovanni Volpicelli:How to doit:Lung Ultrasound, Cardiovasc Ultrasound. 2014;12(25).

LUNG ULTRASOUND

Lavinia Davidescu

- **LUS** is *especially* **valuable**;
- **LUS** is *easy to learn* and *to be applied*;
- **LUS** provides *real-time* **imaging**;
- **LUS** is **not** *radiant*;
- **LUS** has *the ability* **to perform** *dynamic imaging*;

The **information** *provided* by **LUS** is *essential*.
In the **next few years**, **LUS** is *likely* to become *increasingly important* in **different** *clinical settings*, from **the emergency department** to the *intensive* care unit, from *cardiology* to **pulmonology** and **nephrology** wards.

OBJECTIVES

Lavinia Davidescu

O1: To ***organize*** a **national** *course* in *order* to *prepare* **participants** with the help of *national* **specialists** in *ultrasonography*, about the *utility* and *how to use* the **lung** and **thoracic ultrasounography.**This course will be *held* in the **higher medical univeristy centers** of *Nord-West* of **Romania: Cluj-Napoca, Timisoara, Oradea.**

O2: To develop an **online e-learning module**, *available* at the **Romanian Society of Pneumology** and for **all specialists** and *residents in pulmonology*, *internal medicine*, *emergency* and **others specialties** interested in the *treatment* of **pleural** and **pulmonary pathology**.

O3: The *novelty* of *this* **project** is given by **a complex** approach for *lung* and *thoracic ultrasonography*, in a *single* **e-learning module**; in essence, this *module* will *be a sum of texts*, *images*, *videos*, *tests* and **other materials** that will be *available*, in *electronic format*.

THE PROJECTS' EXPECTED IMPACT

Lavinia Davidescu

For the participants:

- It will *increase* their **knowledge** in *lung* and *thoracic ultrasonography;*
- It will *help* them **improve** their *skills* in **lung** and **thoracic ultrasonography;**
- It will *increase* their **level** of *motivation* and *commitment*.

THE PROJECTS' EXPECTED IMPACT

Lavinia Davidescu

For the Healthcare System:

- **Increased** and **improved** *knowledge* and *skills* in **lung** and **thoracic ultrasonography** among *physicians*;
- The *implementation* of **mandatory *ultrasound investigation*** in the assessment **protocols** of *lung* and *pleural pathology* in **Romania**;
- The *implementation* of **lung** and **thoracic** *ultrasonography* as a **training course**, as *part* of **the curriculum** for the *speciality* of **pulmonology** in **Romania.**

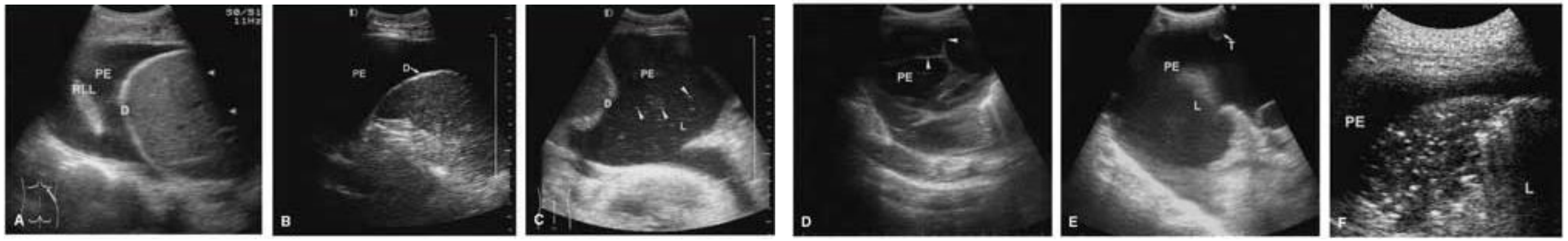
INTRODUCTION: *Ultrasound and Chest Physicians - Why?*

Lectors:

Ruxandra Ulmeanu, Oradea, Romania

THE ULTRASOUNDS' ROLE IN THE DETECTION OF PLEURAL EFFUSIONS

Ruxandra Ulmeanu



Emergency and **critical** care *patients* in *respiratory distress* often **require** *emergent interventions*, including **the immediate treatment** of *pleural effusions*.

THE DETECTION OF PLEURAL EFFUSIONS

Ruxandra Ulmeanu

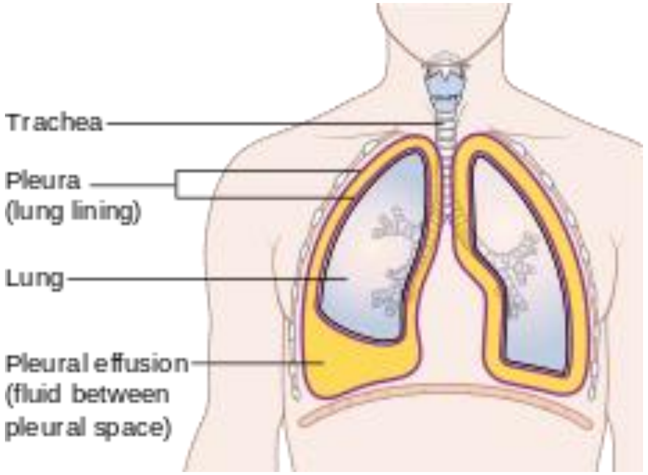
Chest radiographs have been found to be relatively *less sensitive* than **ultrasound.**

Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

Kamila Sikora, Phillips Perera, ThomasMailhot, DikuMandavia, Ultrasound for the Detection of Pleural Effusions and Guidance of the Thoracentesis Procedure, International Scholarly Research Network, ISRN Emergency Medicine Volume 2012, Article ID 676524, 10 pages. doi:10.5402/2012/676524

THE POSTERIOR-ANTERIOR PROJECTION OF CHEST RADIOGRAPHY

Ruxandra Ulmeanu



Pleural effusions are *generally* **recognized** to become **visible** as *blunting* of **the lateral costophrenic angle** at a *volume* of **150–200 cc**.

Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

Kamila Sikora, Phillips Perera, ThomasMailhot, DikuMandavia, Ultrasound for the Detection of Pleural Effusions and Guidance of the Thoracentesis Procedure, International Scholarly Research Network, ISRN Emergency Medicine Volume 2012, Article ID 676524, 10 pages. doi:10.5402/2012/676524

OBTAINING AN UPRIGHT LATERAL CHEST RADIOGRAPH

Ruxandra Ulmeanu

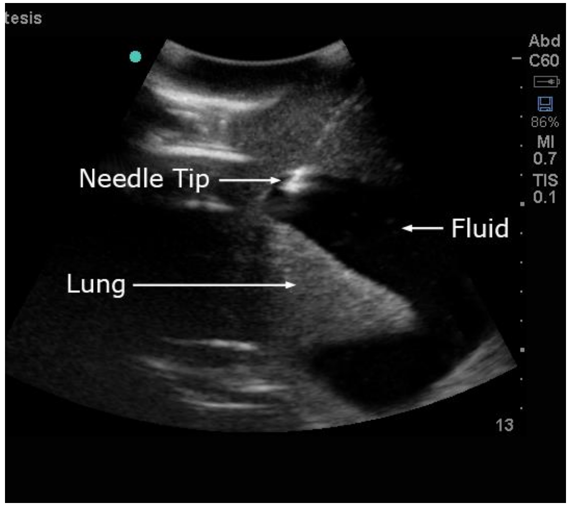
We can *further* **improve** *the detection* of **pleural effusions** with **50 cc** of *fluid, the recognized* **volume** that can be seen as *blunting* **of the posterior costophrenic angle.**

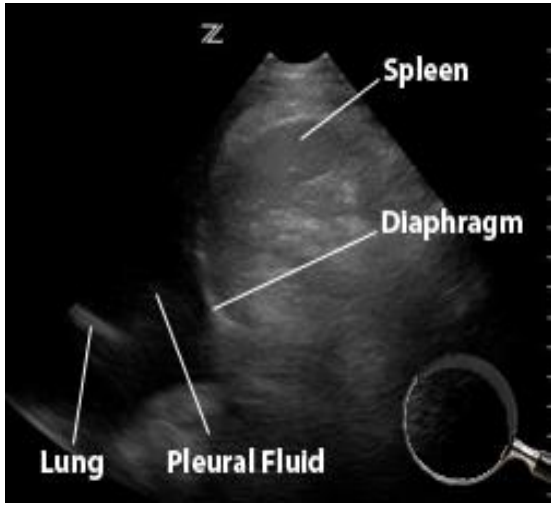
Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

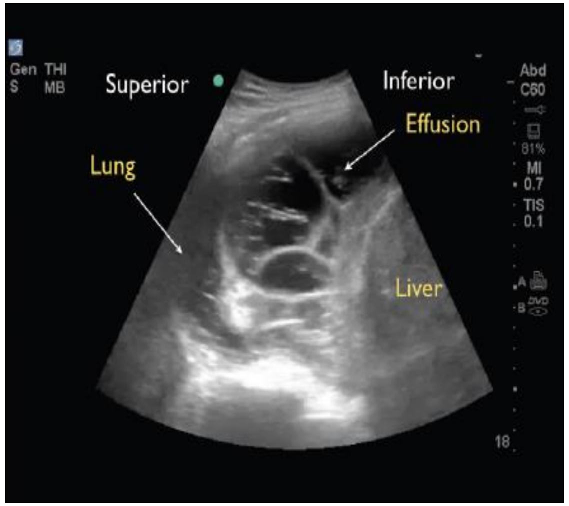
Kamila Sikora, Phillips Perera, ThomasMailhot, DikuMandavia, Ultrasound for the Detection of Pleural Effusions and Guidance of the Thoracentesis Procedure, International Scholarly Research Network, ISRN Emergency Medicine Volume 2012, Article ID 676524, 10 pages. doi:10.5402/2012/676524a

THE DETECTION OF PLEURAL EFFUSIONS

Ruxandra Ulmeanu







In contrast, *ultrasound* has *been demonstrated* to **detect** as *little* as **20 cc** of **pleural fluid.**

Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

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ULTRASOUND A CLEAR ↓↓ IN THE OVERALL COMPLICATION

Ruxandra Ulmeanu

The **most dramatic** *improvement* was *noted* in the rate of **pneumothorax**, which is *the most common* recognized *complication* associated **with the procedure.**

Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

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ULTRASOUND A CLEAR ↓↓ IN THE OVERALL COMPLICATION

Ruxandra Ulmeanu

Physicians in the many specialties that perform the thoracentesis procedure should be urged to learn *ultrasound* and to use this application whenever possible.

Scherpereel A al ; European Respiratory Society/European Society of Thoracic Surgeons Task Force., Guidelines of the European Respiratory Society and the European Society of Thoracic Surgeons for the management of malignant pleural mesothelioma, Eur Respir J. 2010 Mar;35(3):479-95. doi: 10.1183/09031936.00063109. Epub 2009 Aug 28.

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ULTRASOUND A CLEAR ↓↓ IN THE OVERALL COMPLICATION

Ruxandra Ulmeanu

Specialty societies and expert consensus panels now *urge* **integration** of *ultrasound* into the *thoracentesis* **procedure** as the **"best practice"** guideline.

LESSON 1: *The Lungs' Anatomy*

Lectors:

Edith Simona Ianosi, Targul Mures, Romania

Marilena Crisan, Oradea, Romania

Gabriela Jimboreanu, Targul Mures, Romania

LESSON 1

THE LUNGS' ANATOMY

THE MAIN TOPICS:

1: THE RESPIRATORY SYSTEM

2: THE THORAX AND THORACIC CAVITY

3: THE CONTENTS OF THE THORACIC CAVITY

4: THE SUPERIOR AIRWAYS AND THE 'NASAL' CAVITY

5: THE LARYNX AND THE THRACHEA

6: THE BRONCHI AND THE PRIMARY BRONCHI

7: THE STRUCTURE OF THE TRACHEOBRONCHIAL TRUNK

9: THE LUNG AND THE APEX OF THE LUNG

10: THE DIAPHRAGMATIC VIEW

11: THE MARGINS AND THE SEGMENTATION OF THE LUNG

12: THE STRUCTURE OF THE LUNG AND THE MEDIASTINUM

13: THE PLEURA AND THE ROLES OF THE PLEURA

THE RESPIRATORY SYSTEM

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

It **consists** of *the organs* that *participate* in *the exchange* of **the atmospheric air** and **the organism.**
The respiratory organs (majority) in *the thorax/thoracic cavity*:

- **The Respiratory system:**

- ***The superior airways:***
  - The nasal cavity, the oral cavity;
  - The Pharynx;
  - The Larynx;
  - The Trachea;

- ***The inferior airways:***
  - The Bronchi and Bronchioles;
  - The gas exchange zones – ducts and alveolar sacs.

THE THORAX

THE THORACIC CAVITY

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

It contains:

- *The bony skeleton – the dorsal spine, sternal ribs, sup. sternoclavicular joints;*
- *Soft tissues;*
- *The respiratory muscles;*
- *The suspensory muscles;*
- *The diaphragm;*
- *The subcutaneous tissue;*
- *The skin;*
- *The mammary gland;*
- *The chests' organs.*

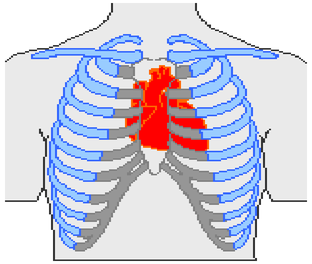
THE CONTENTS OF THE THORACIC CAVITY

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

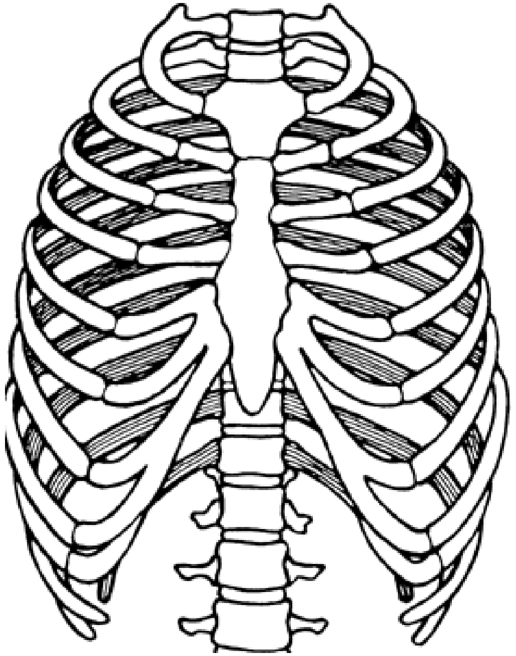
- 2 lungs (each lung embayed/coated by pleura);
- The Mediastinum = the space between the lungs, situated medially, **includes:**
- The intrathoracic trachea, trachea bifurcation + bronchi;
- The esophagus;
- The heart coated by pericardium;
- **Big vessels:**
  - *The aortic artery + the thoracic branches;*
  - *The common pulmonary artery and pulmonary branches – right and left AP;*
  - *4 pulmonary veins;*
  - *The superior and inferior vena cava.*
- The splanchnic – skeletal nerves;
- The vegetative nerves – forming plexes;
- The fat tissue, conjunctive tissue;
- The Lymph nodes + the lymphatic vessels, the thoracic duct (big left lymphatic collector), the right lymphatic duct;
- Timus – well developed in children, rudimental in adults;
- The Diaphragm separates the thorax from the abdomen.

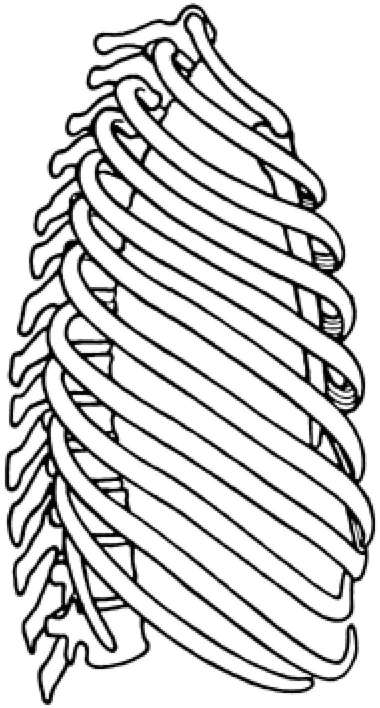
THE THORACIC CAVITY

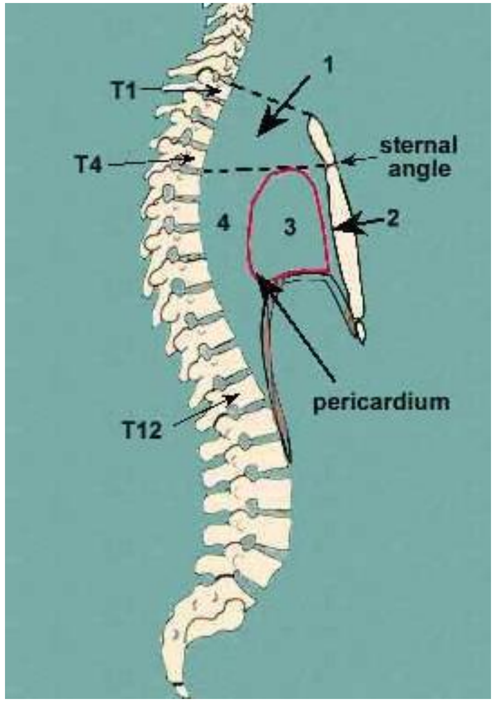
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



- The integrity, form and mobility of the thorax (spine, ribs, sternum) = indispensable for ventilation;
- The modifications of the thorax lead to restrictive DVR type ventilation disturbances.







THE SUPERIOR AIRWAYS

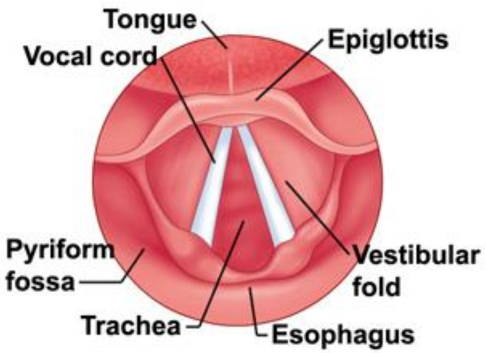
THE 'NASAL' CAVITY

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- The role of air transportation/delivery;
- The olfactive role;
- The role for protection;
- **The role for defense:**
  - The conditions the inspired air;
  - Retains the big particles;
  - The clearance (mucosa with cili) carries the particles deposited on the mucus into the pharynx where they will be swallowed.
- The nasal obstruction through (allergic rhinitis, adenoiditis, severe nasal septum deviation, hypertrophic rhinitis, etc.) favors allergic, inflammatory and infectious diseases of the CRI.

THE LARYNX

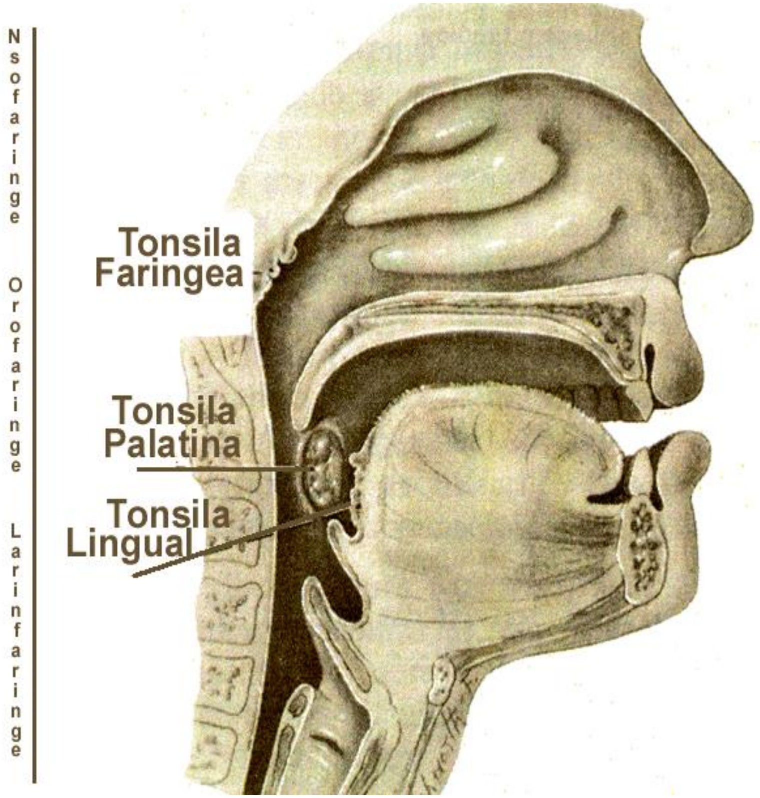
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



- 9 cartilages (thyroid, crycoid, epiglottis);
- +3 pairs: arytenoid, corniculate, cuneiform;
- Ligaments, muscles;
- The vocal cords – Glottis.

Functions:

- Transports/Delivers air into the trachea;
- The mucosis protects and filters the air;
- Role in phonation;
- Impedes foreign bodies that get into the trachea.



THE LARYNX

Edith Simona Ianosi
Marilena Crisan
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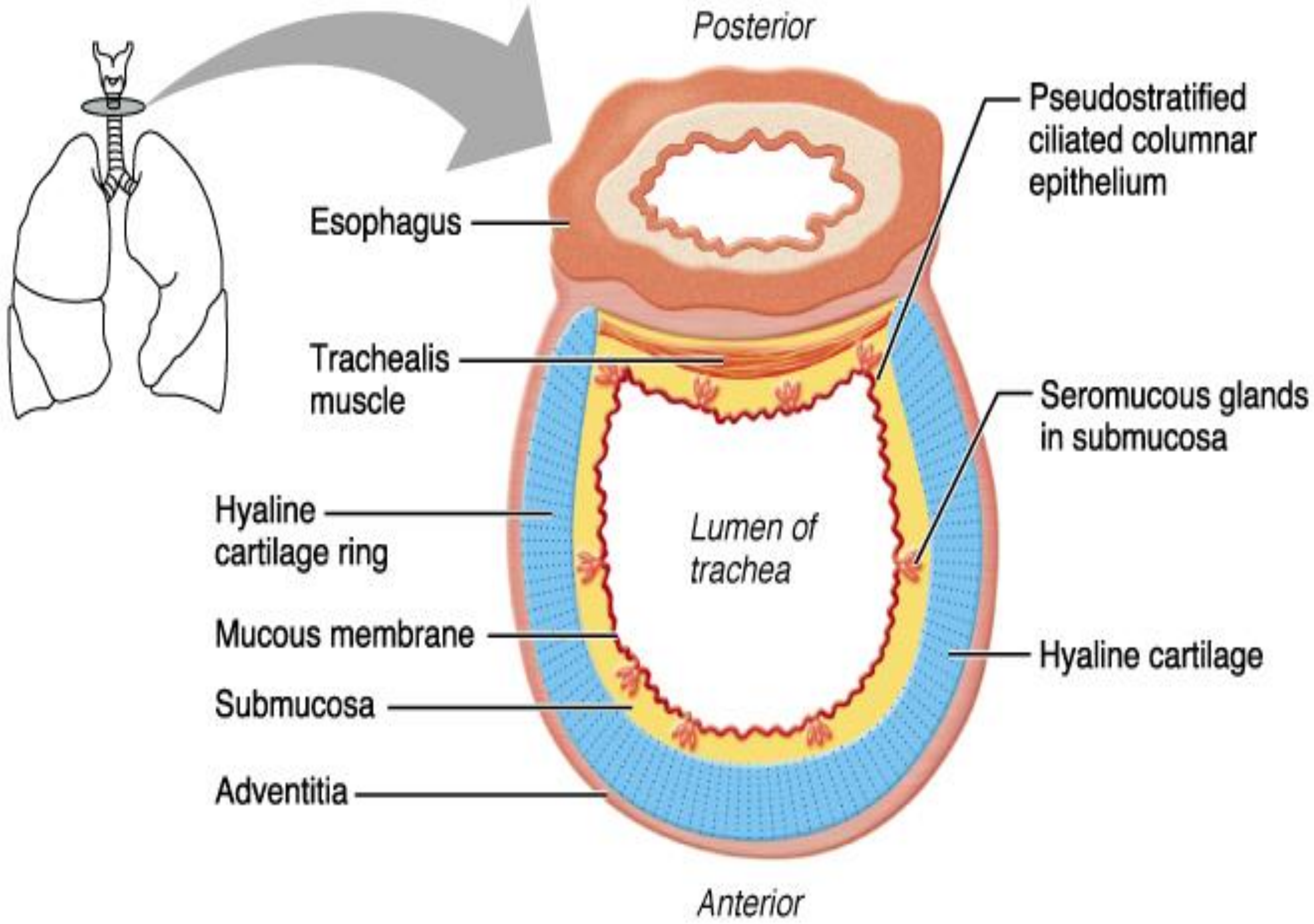


THE LARYNX

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The Tuberculosis of the Larynx

The Mycobacteriosis of the Larynx

THE THRACHEA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- The Cylindrical tube, 13 – 18 cm, median, in front of the esophagus;
- It has 15-20 cartilage rings, of 3-4/1mm; incomplete semilunar (missing post.) + intercartilaginous spaces – maintain permeability of CRI;
- It forks into 2 main branches „tracheal pint, carina" (reper).

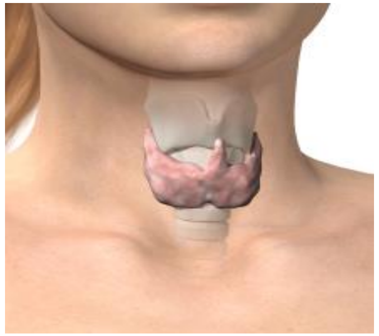
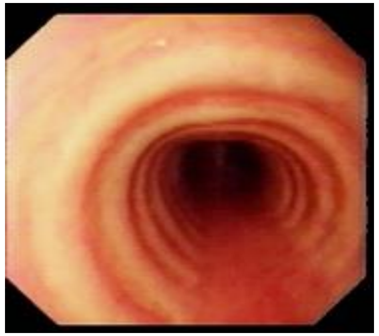
Its' roles:

- It holds the bronchial trunk, ensures the division into the main right and left bronchus;
- It transports air into the bronchi and into the lungs;
- The mucosis protects and filters the air;
- Has a role in the cough reflex;
- It permits deglutition (membraneous posterior wall)

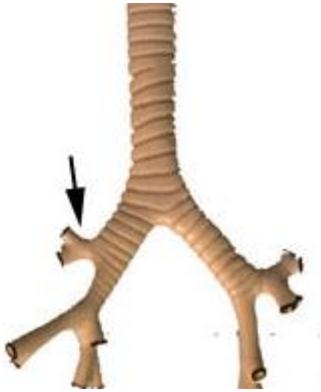
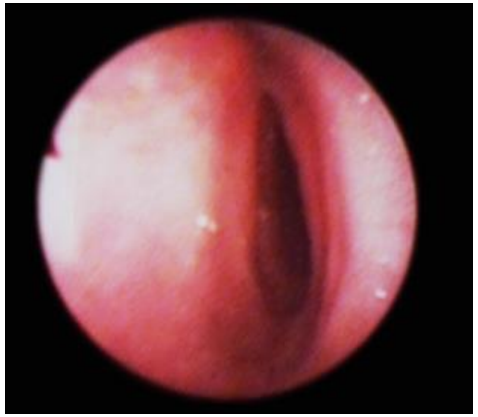
THE THRACHEA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- The Bronchoscopy – The normal aspect of the trachea

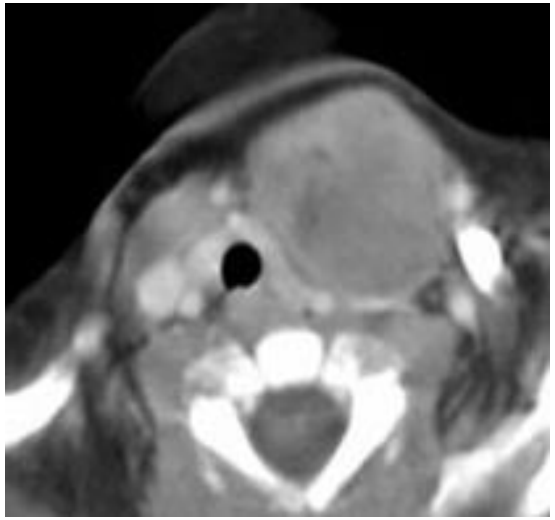

- The compressions of the trachea


THE THRACHEA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

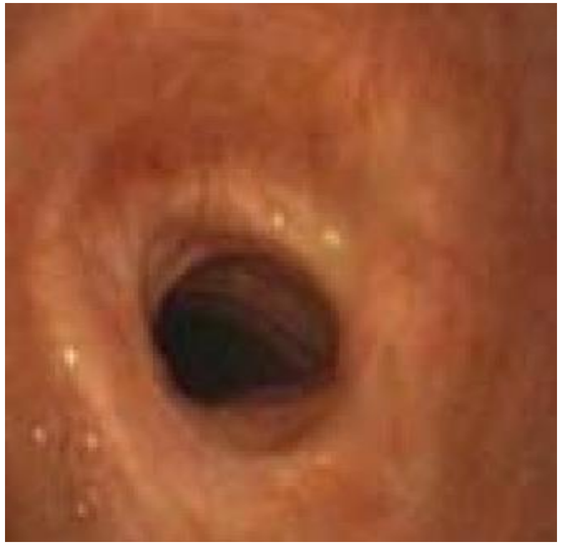
- Tracheal compression by a huge goiter.

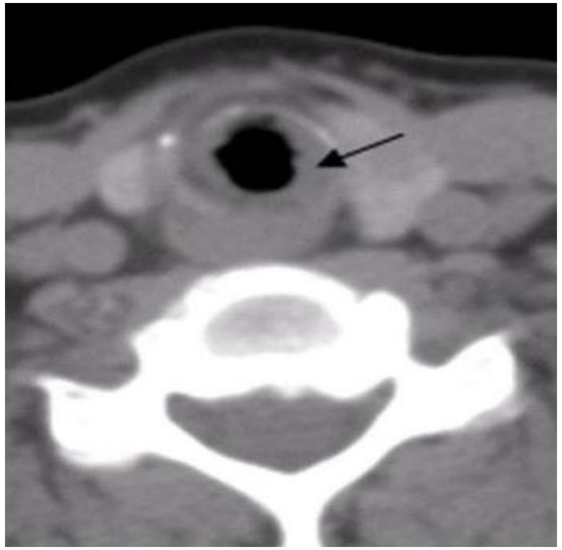


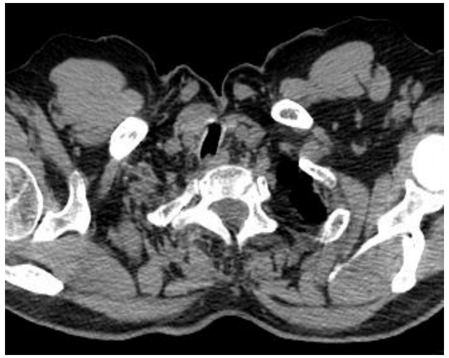
THE THRACHEA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Post intubation tracheal stenosis and post cannulate trachea.



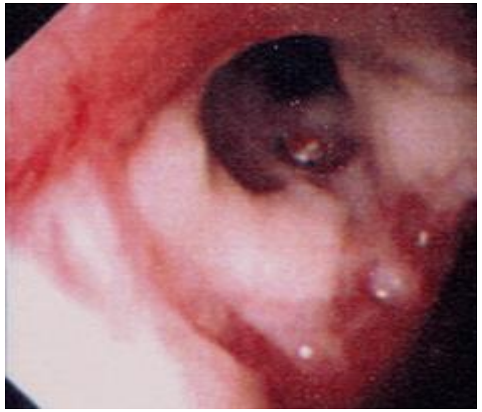


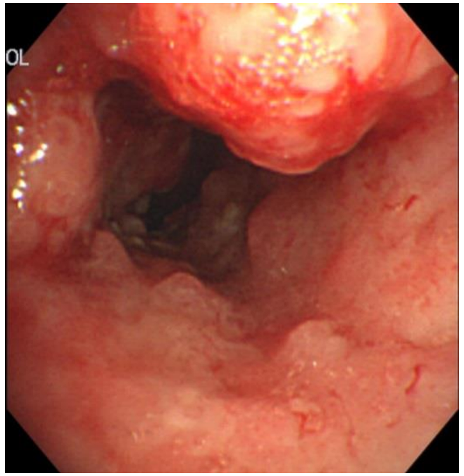


THE THRACHEA

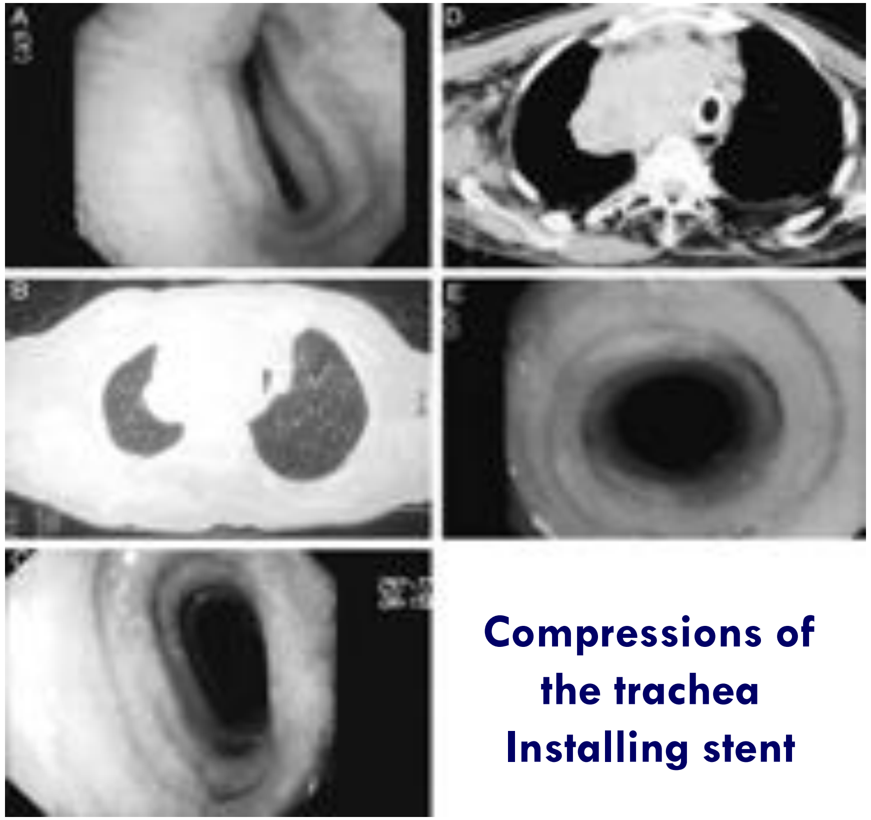
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Granulomas and membranes. TB, over infected tumor, aspergillosis ?





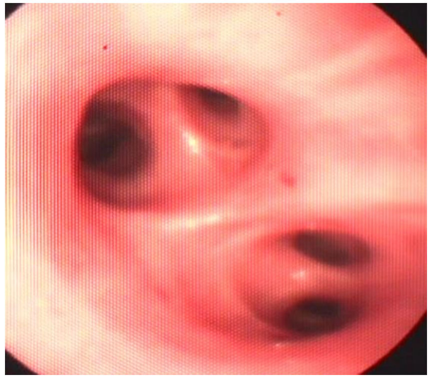
Tracheal proliferative granulomas



Compressions of the trachea
Installing stent

THE PRIMARY BRONCHI

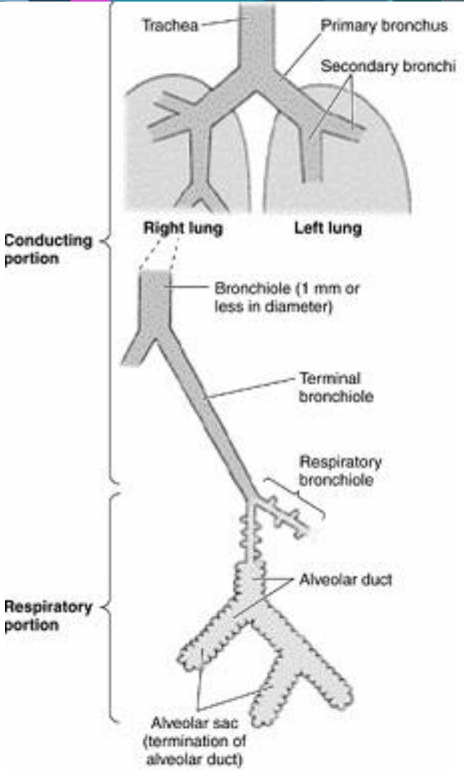
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



- PB – has complete cartilage rings;
- The primary bronchi ramify;

Progressively into:

- The Lobar bronchi;
- The Segmental bronchi;
- The Lobular bronchi;
- The Intra-lobular bronchioles (5mm);
- 5-7 terminal bronchioles;
- The Respiratory bronchioles;
- The Alveolar ducts (their dilatation is sac shaped – alveolar sacs);
- The Pulmonary alveoles (200 μm diameter, 300 million in both lungs).



THE BRONCHI

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

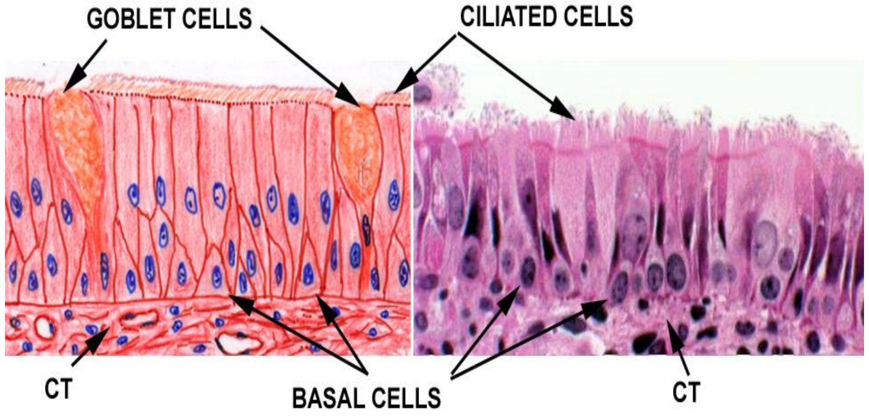
The Tracheo-bronchial mucosis:

- Cylindrical epithelium, ciliated, pseudostratified till the terminal branches –
- Mucocilliary clearance;
- The producer of mucus – "goblet";
- the repartition cells.

The Bronchial glands;

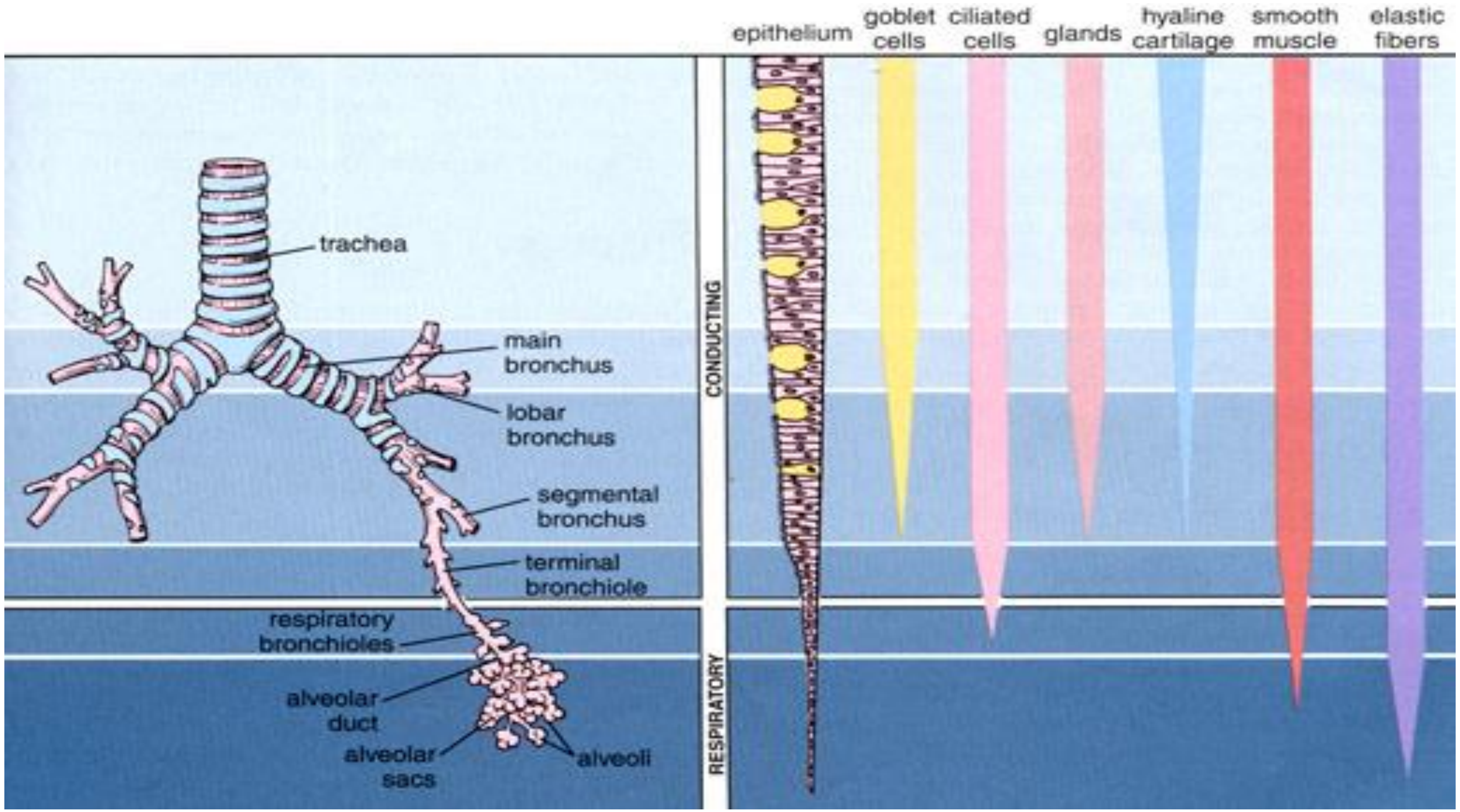
The Suspensory tissue:

- Cartilage;
- Conjunctive tissue - elastic;
- The cartilage maintaining CAI open in pressure variations in inspiration, expiration;
- Bronchioles;
- It has no cartilage structures;
- Muscularly stratum/layer - regulates the air flow in CA.



THE STRUCTURE OF THE TRACHEOBRONCHIAL TRUNK

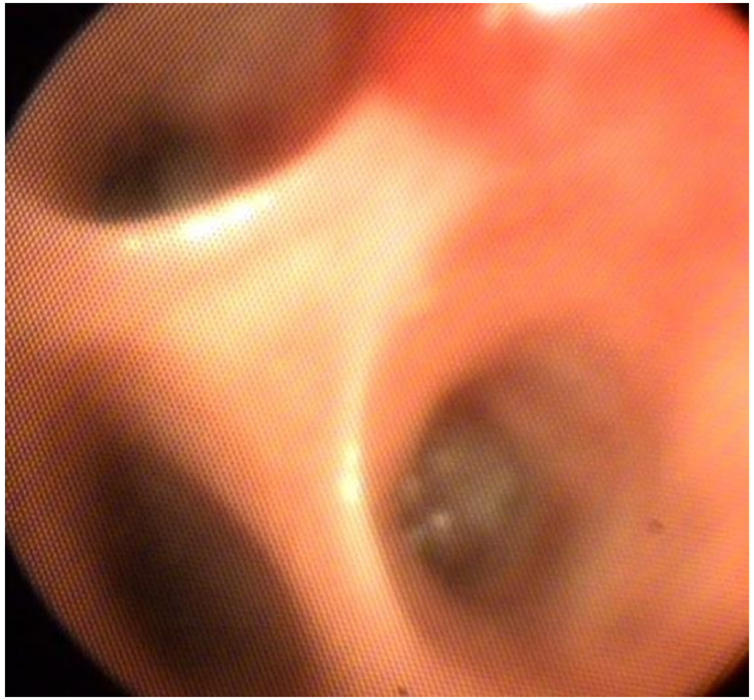
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



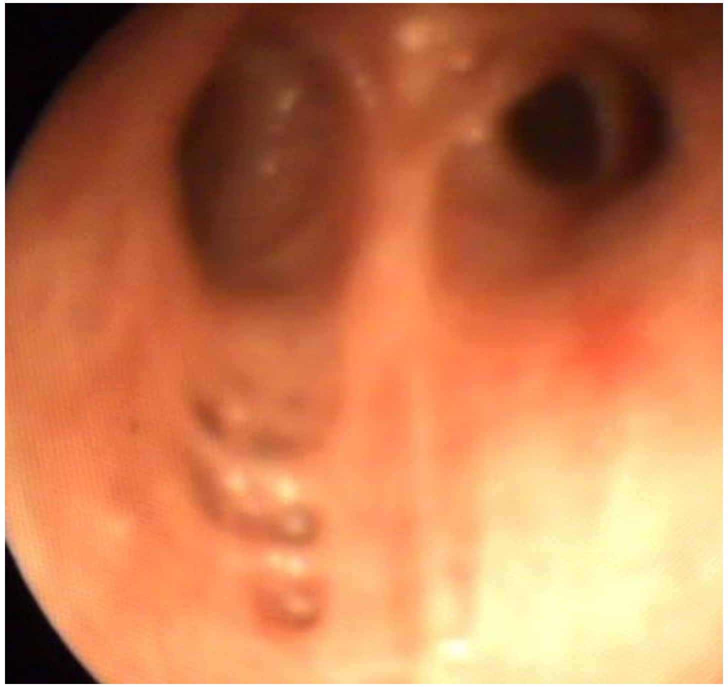
THE BRONCHI

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

Bronchi – normal endoscopic aspect



Chronic bronchial aspect



THE BRONCHI

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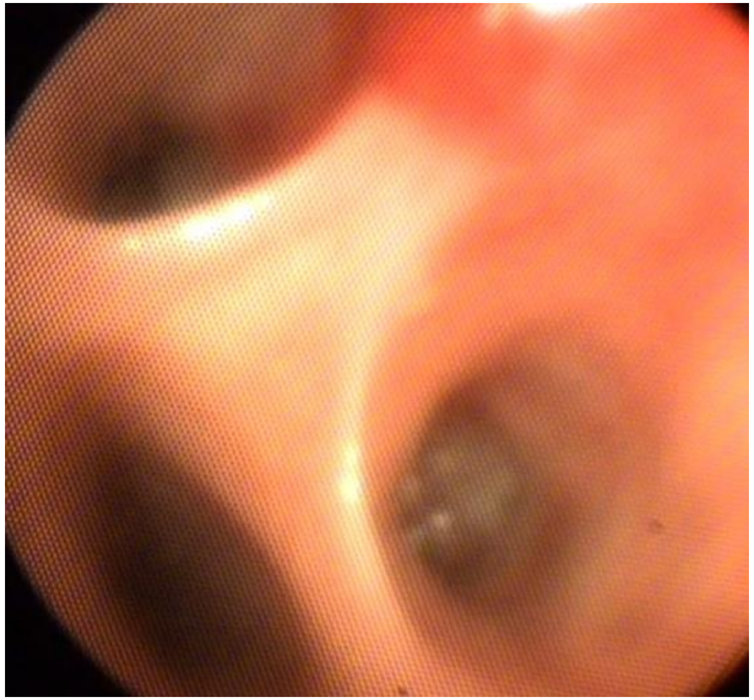
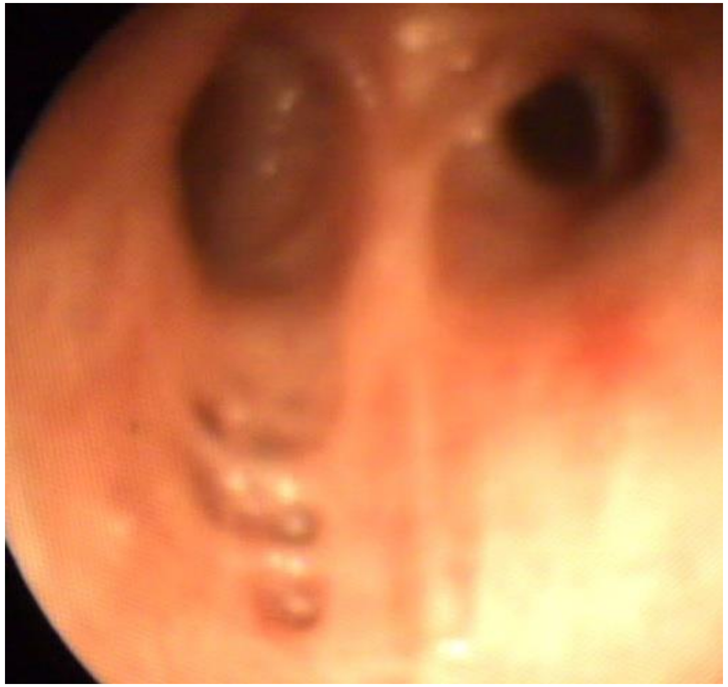
Bronchi – normal endoscopic aspect



Chronic bronchial aspect



THE BRONCHI

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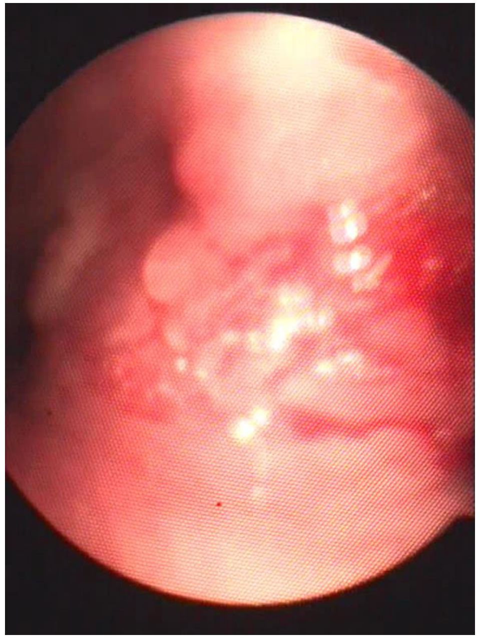
Bronchial neoplasm with the infiltration of the ***tracheal pint***



THE BRONCHI

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Extrinsic bronchial compression

and the infiltration of the spur

THE BRONCHI

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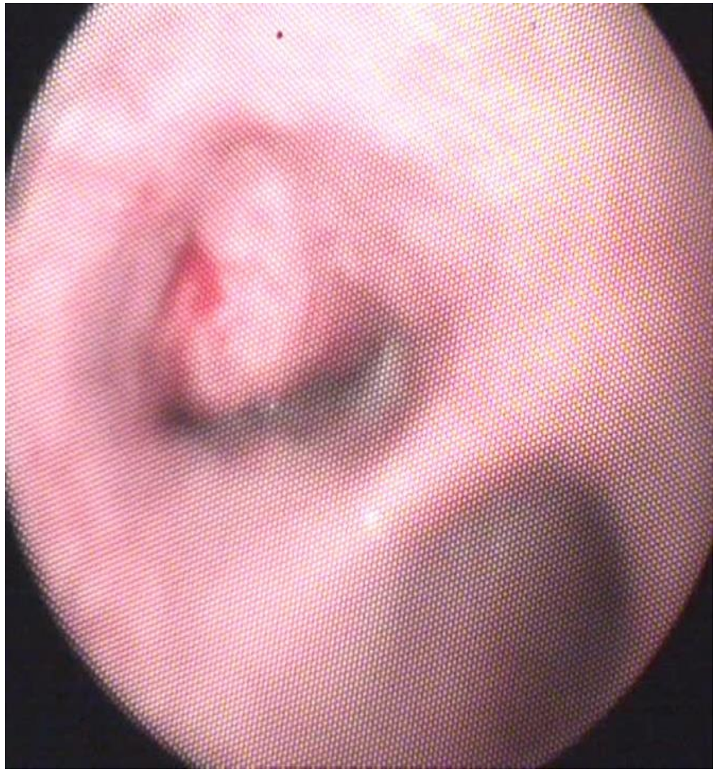
Vegetant bronchial tumor formation



THE BRONCHI

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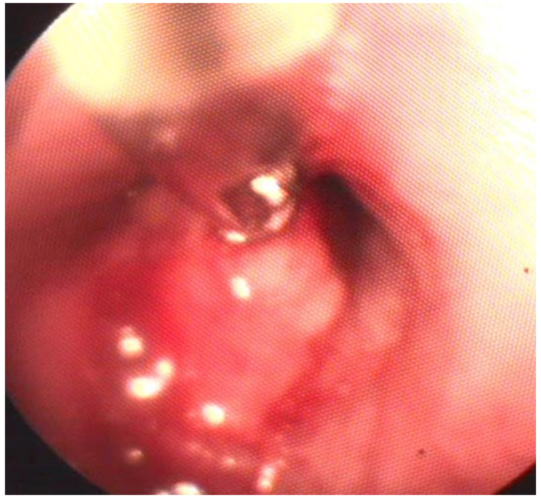
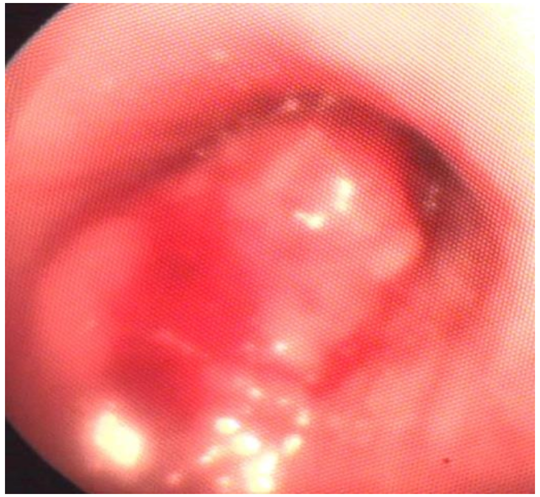
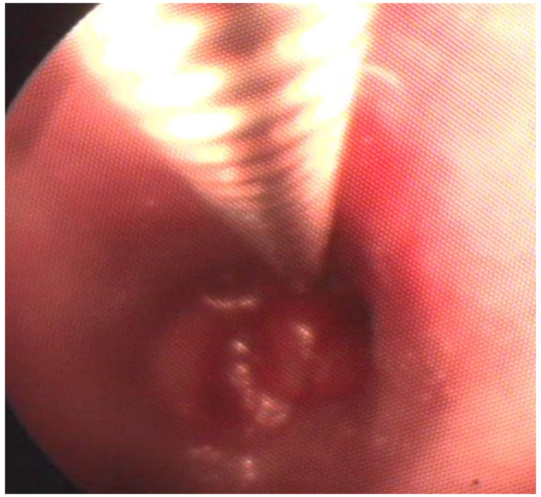
The vegetant bronchial tumor formation, Tumor biopsy





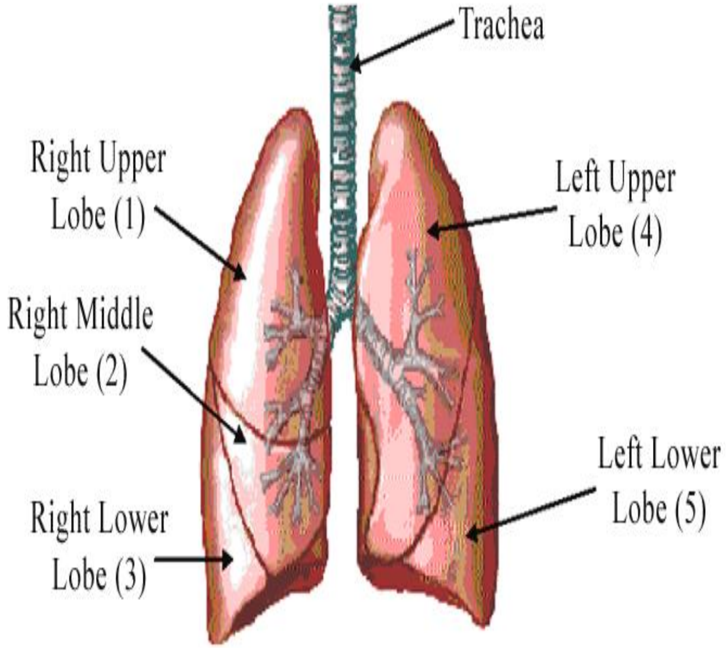


THE LUNG

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The lungs are *paired* organs (right and left) with **an important role** in breathing:

- Two serous pleural, completely separate between themselves – the pulmonary pleura;
- The walls of the thoracic cavity;
- They have a reciprocal relationship, the respiratory mechanism is ensured through it;
- The dimensions + weight varying by: age, gender, individual, in expiration or in inspiration.



THE LUNG

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Marilena Crisan
Gabriela Jimboreanu

The characteristics of the lungs:

Average weight:

- In a child who hasn't breathed yet – 50 g;
- In a child who has already breathed about 150 g;
- In adults - the two lungs weigh approx. 1200 g;
- Total capacity – the maximum quantity of air which the two lungs contain is an average of 4500-5000 cmc;

Consistence: they are soft, sponge-like and very elastic.

THE LUNG

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Marilena Crisan
Gabriela Jimboreanu

The characteristics of the lungs:

Their color:

- At birth they are red;
- After the first breathing – pink;

Adults:

- *Grey + black deposits*, because of the polluted environment, exposition to nicotine, coal particles, silicium, iron, the reticuloendothelial tissue of the lung charges with these particles (pneumoconiosis);
- *Variable deposits of particles* – more abundant in apex and vertebral zone where the respiratory excursions are more reduced.

THE LUNG

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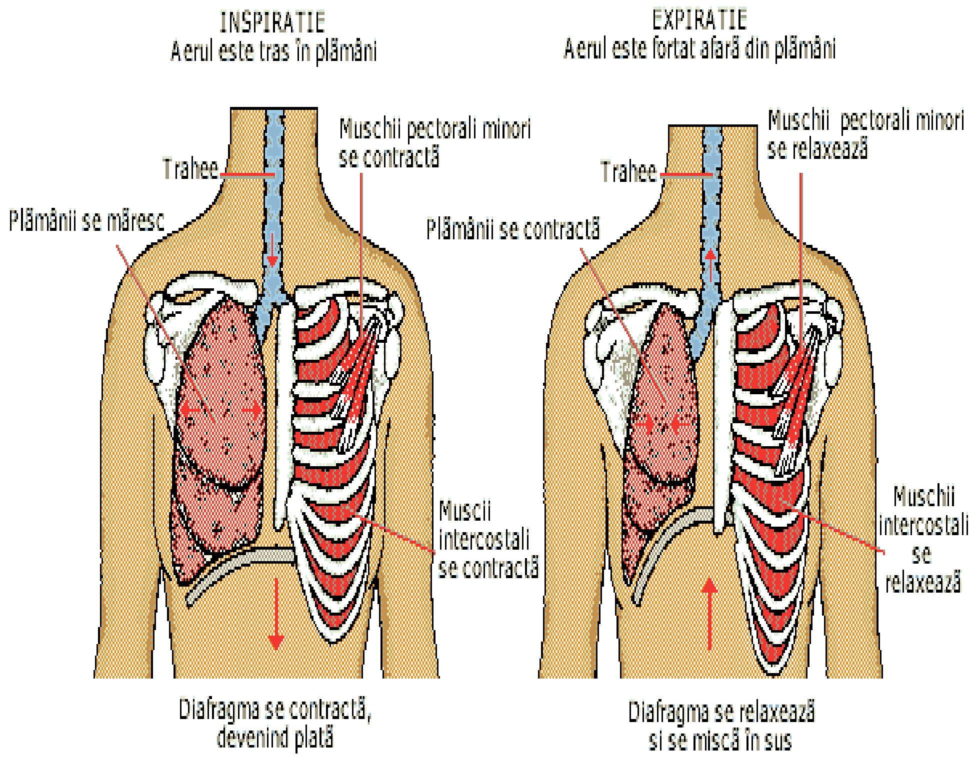
Marilena Crisan
Gabriela Jimboreanu

The external configuration:

The volume of the lungs varies by:

- *The capacity of the thorax;*
- *The respiratory time - inspiration/expiration;*
- *The capacity of the lung – the spirometry permits to determine the respiratory volume.*



THE LUNG

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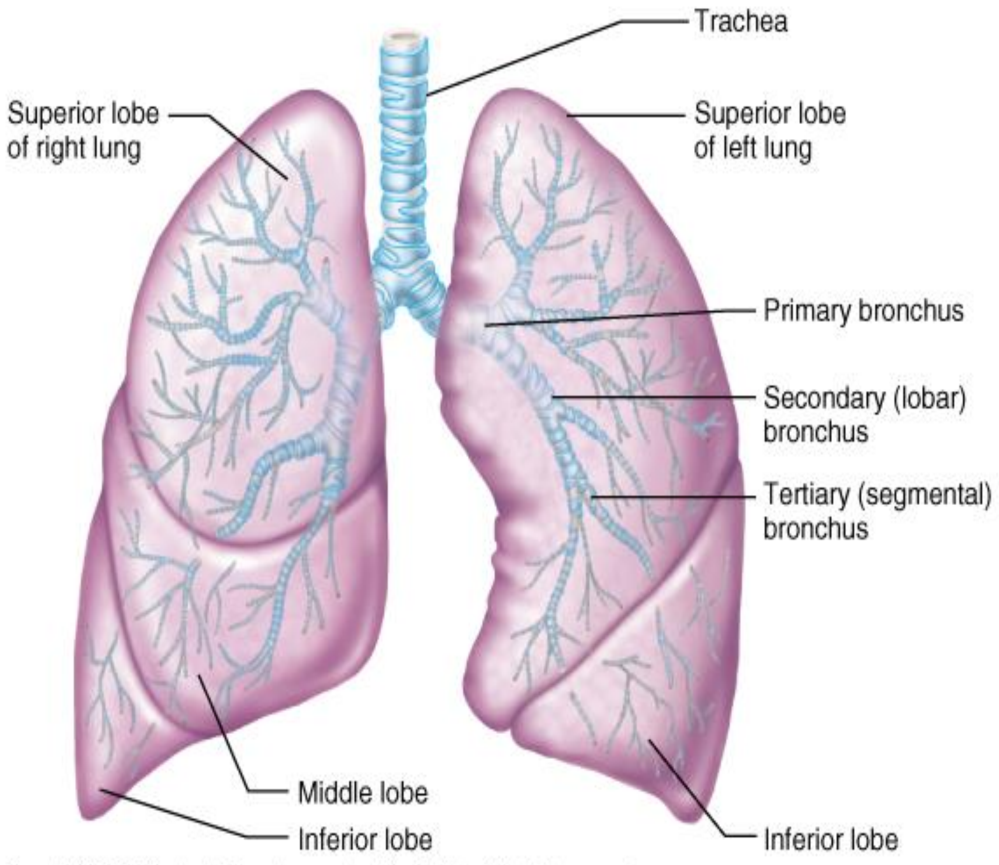
The lungs are:

Conical in shape with:

- *costal, lateral face;*
- *mediastinal-medial face;*
- *diaphragmatic-inferior face;*
- *three margins;*
- *superior peak or apex.*



Costal face/ Facies costalis:

The costal or lateral face:

- *Convex in both parts, vertically and horizontally;*
- *Tight on the internal face of the thoracic wall;*
- *Posterior – it lays in the costovertebral groove (Pars vertebralis), on the vertebral spine flank;*
- *Crossed by the pulmonary fissures.*

THE LUNG

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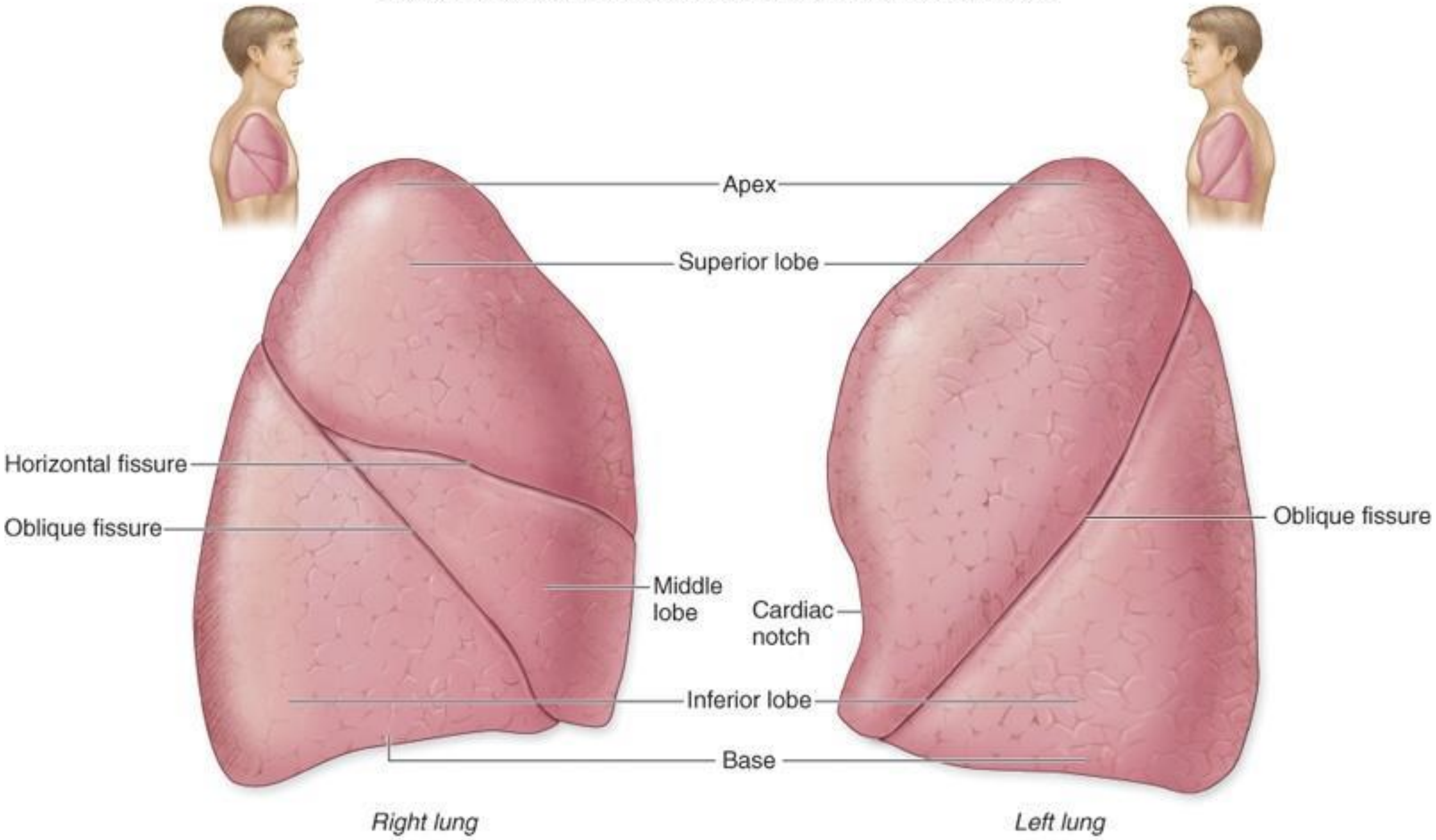

(a) Lateral views

Pulmonary fissures:

The right lung - 2 fissures:

- Oblique fissure, inferior and anterior oblique, which by its cranial segment separates the inferior lobe from the superior one, and by its middle segment it separates the inferior lobe from the middle one;
- Horizontal fissure, horizontal, it orientates anteriorly, from the middle oblique fissure and separates the superior and middle lobes.

The left lung – only one fissure:

- Oblique fissure, very oblique inferiorly and anteriorly, it separates the two lobes of the left lung, the superior and inferior one;
- Corresponding to the fissures, the pulmonary lobes, each one has an interlobular face, sinuous, covered by the visceral pleura.

THE LUNG

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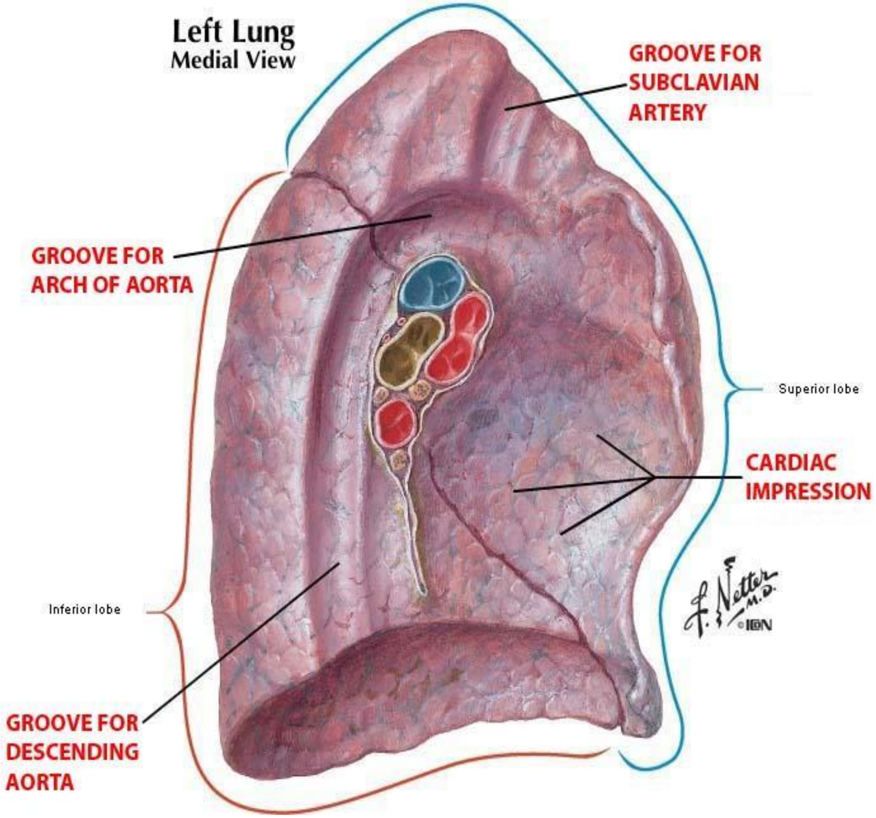
The mediastinal face/ facies mediastinalis:

- Plain vertically, and concave anterior-posteriorly;
- The hilus of the lung (Hilum pulmonis) - in the center;
- The crateriform depression;
- The different constituents of the pulmonary pedicle.



THE LUNG

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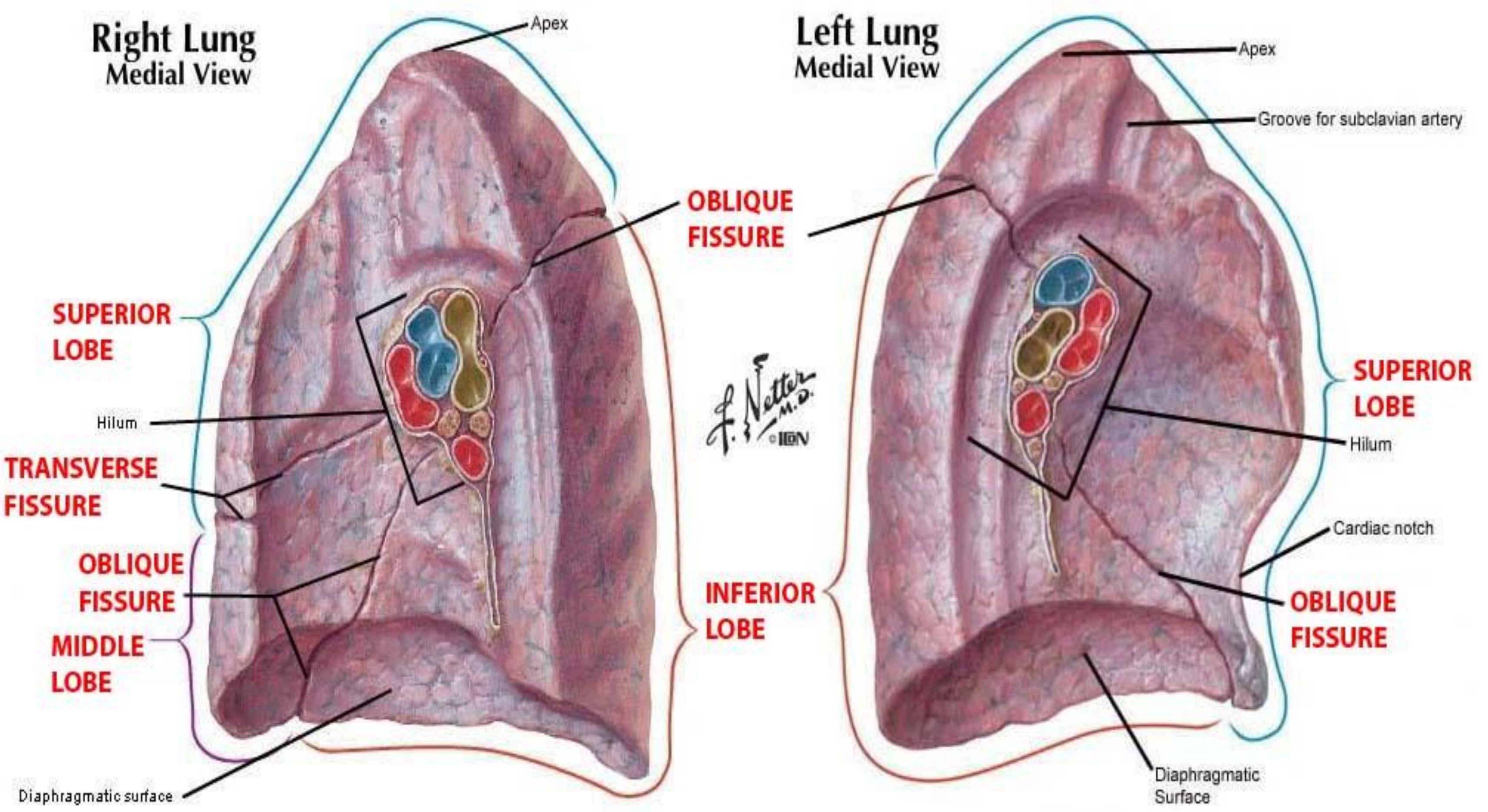
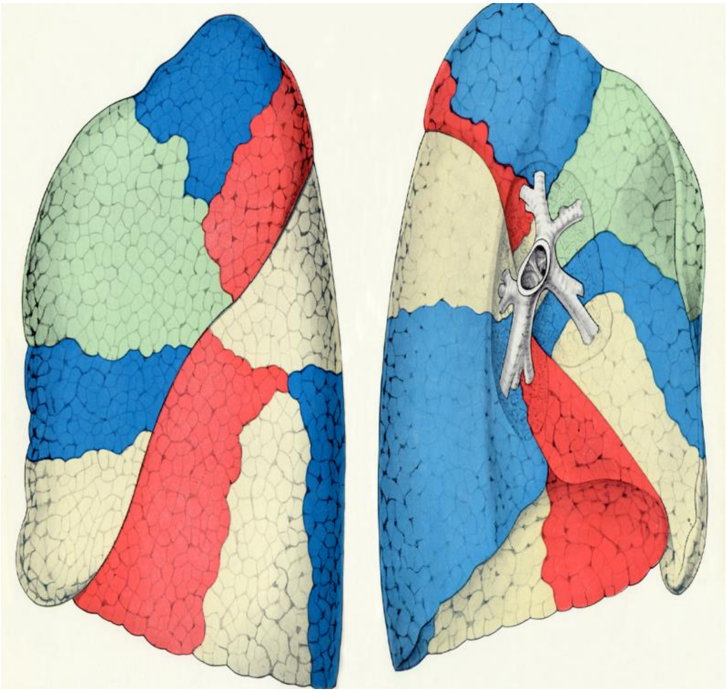


THE LUNG

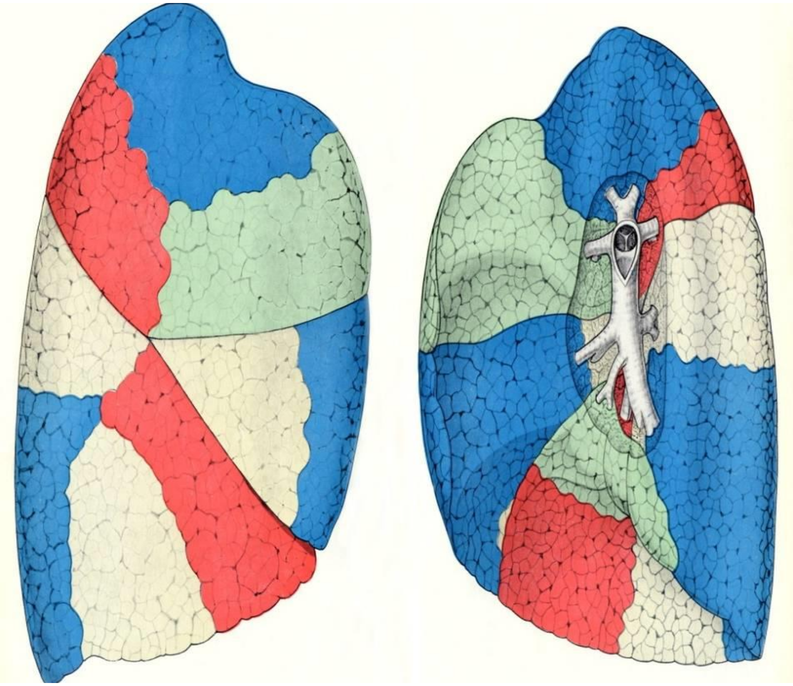
THE LATERAL AND MEDIAL VIEW

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

Left lung: Lateral and medial views in which the individual segments have been injected with colored gelatin. From Brock (1942–1944).



Right lung: Lateral and medial views in which the individual segments have been injected with colored gelatin. From Brock (1942–1944).



THE DIAPHRAGMATIC VIEW FACIES DIAPHRAGMATICA

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Marilena Crisan
Gabriela Jimboreanu

- **Concave** - in all directions, looks inferior + anterior;
- Tight on the convexity of the diaphragmatic cupola - intersected transversally by the oblique fissure, which separates:

The posterior: inferior lobe;
The anterior: middle lobe – right; and the lingual – left.

THE DIAPHRAGMATIC VIEW
FACIES DIAPHRAGMATICA

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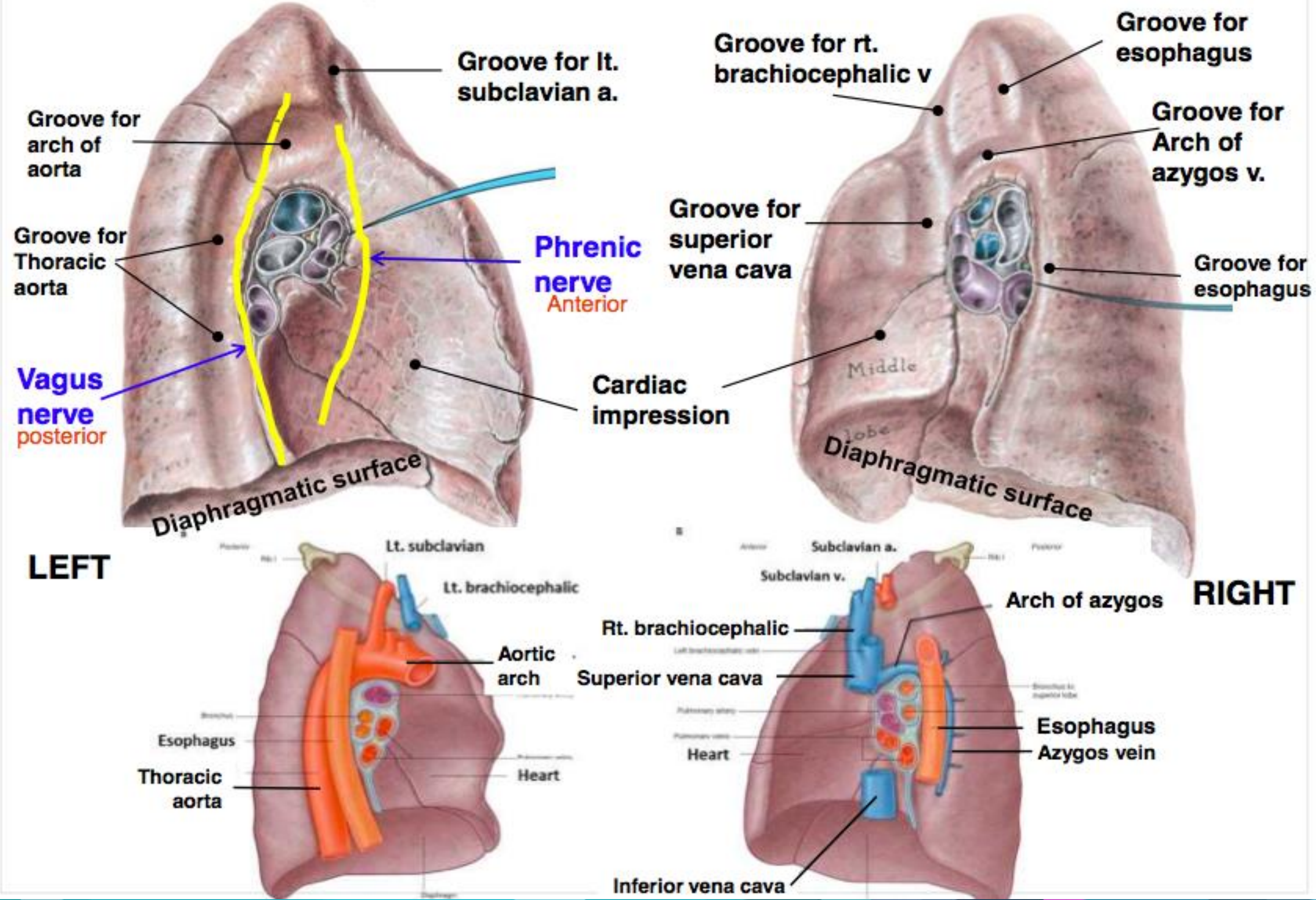

THE MARGINS

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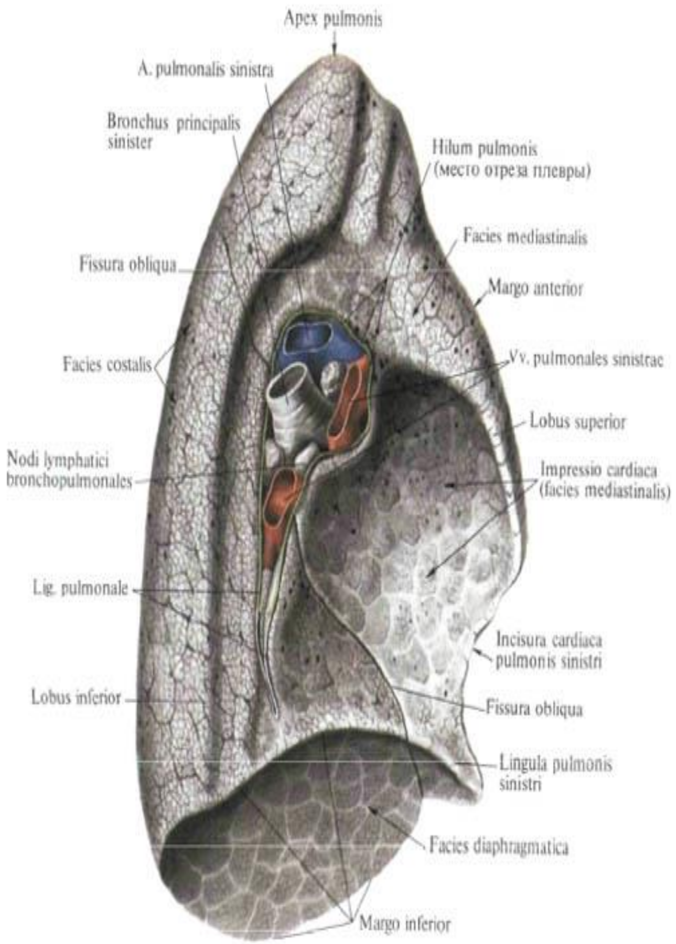
Marilena Crisan
Gabriela Jimboreanu

The inferior margin (Margo inferior):

- The lateral-posterior part;
- It separates the pulmonary base from the costal face;
- Convex on the outside, thin;
- It descends into the costodiaphragmatic pleural recesses;



THE INFERIOR MARGINS

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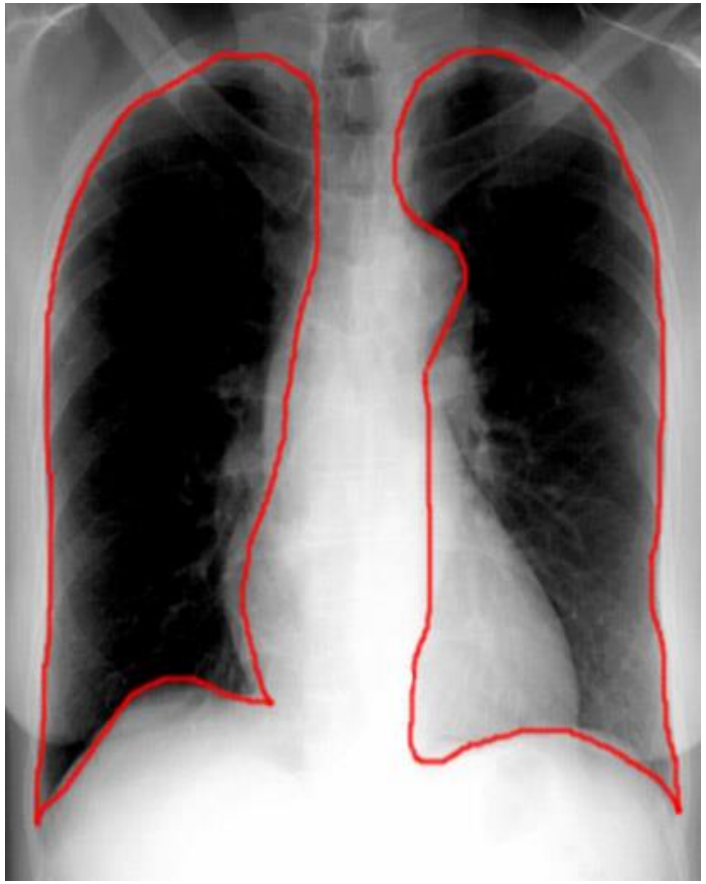
The medial and inferior part:

- It separates the base from the mediastinal face;
- Concave on the inside;
- Situated higher.



THE POSTERIOR MARGINS

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Marilena Crisan
Gabriela Jimboreanu

The posterior margin:

- It separates posteriorly the costal, mediastinal faces;
- Interrupted by the oblique fissure, in1/3 superiorly;
- Rounded, hardly marked, along the spine to the fusion of the anterior face with the lateral face of the thoracic vertebra.

THE APEX OF THE LUNG

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The apex of the lung:

- It overgrows the first rib with 2-3 cm;

Its' two faces:

- anteriorly, convex, inferiorly and anteriorly oblique;
- posteriorly, plain, vertical.

THE SEGMENTATION OF THE LUNG

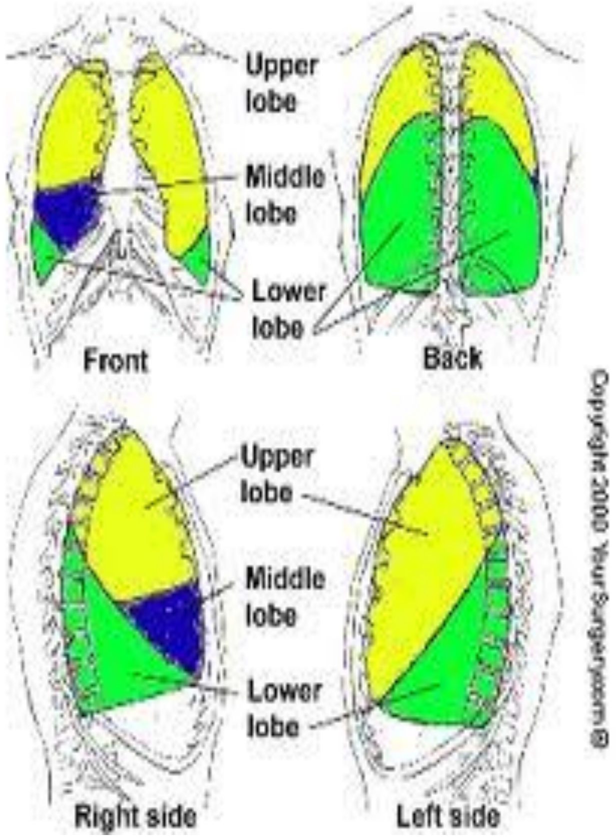
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The segmentation of the lung:

- Lobes of the lung divided into segments;

Each segment:

- Segmentary bronchi;
- One or more pulmonary arterial pedicles;
- Veins – in intersegmentary plan and drainages two adjacent segments.



THE SEGMENTATION OF THE RIGHT LUNG

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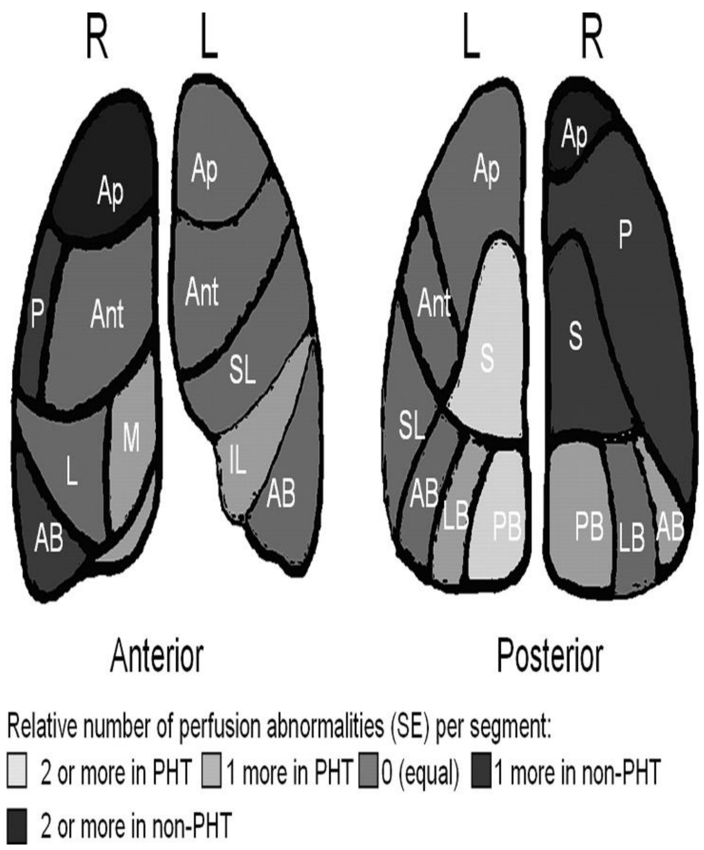
Marilena Crisan
Gabriela Jimboreanu

The segmentation of the right lung:

The superior lobe (Pulmo dexter, lobus superior) - three segments:

- The apical segment (Segmentum apicale/SI)
- The posterior segment (Segmentum posterius/SII)
- The anterior segment(Segmentum anterius/SIII)
- The middle lobe (Pulmo dexter, lobus medius) -two segments:
- The lateral segment (segmentum laterale/SIV)
- The medial segment (Segmentum mediale/SV)



THE SEGMENTATION OF THE RIGHT LUNG

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Marilena Crisan
Gabriela Jimboreanu

The segmentation of the right lung:

The lower lobe (Pulmo dexter, lobus inferior)- five segments:

- The superior group: the fowler segment (Segmentum superior/SVI);

The inferior or basal pyramid - 4 segments:

- The medial basal or paracardiac;
- The anterior basal;
- The lateral basal;
- The posterior basal.

THE SEGMENTATION OF THE RIGHT LUNG

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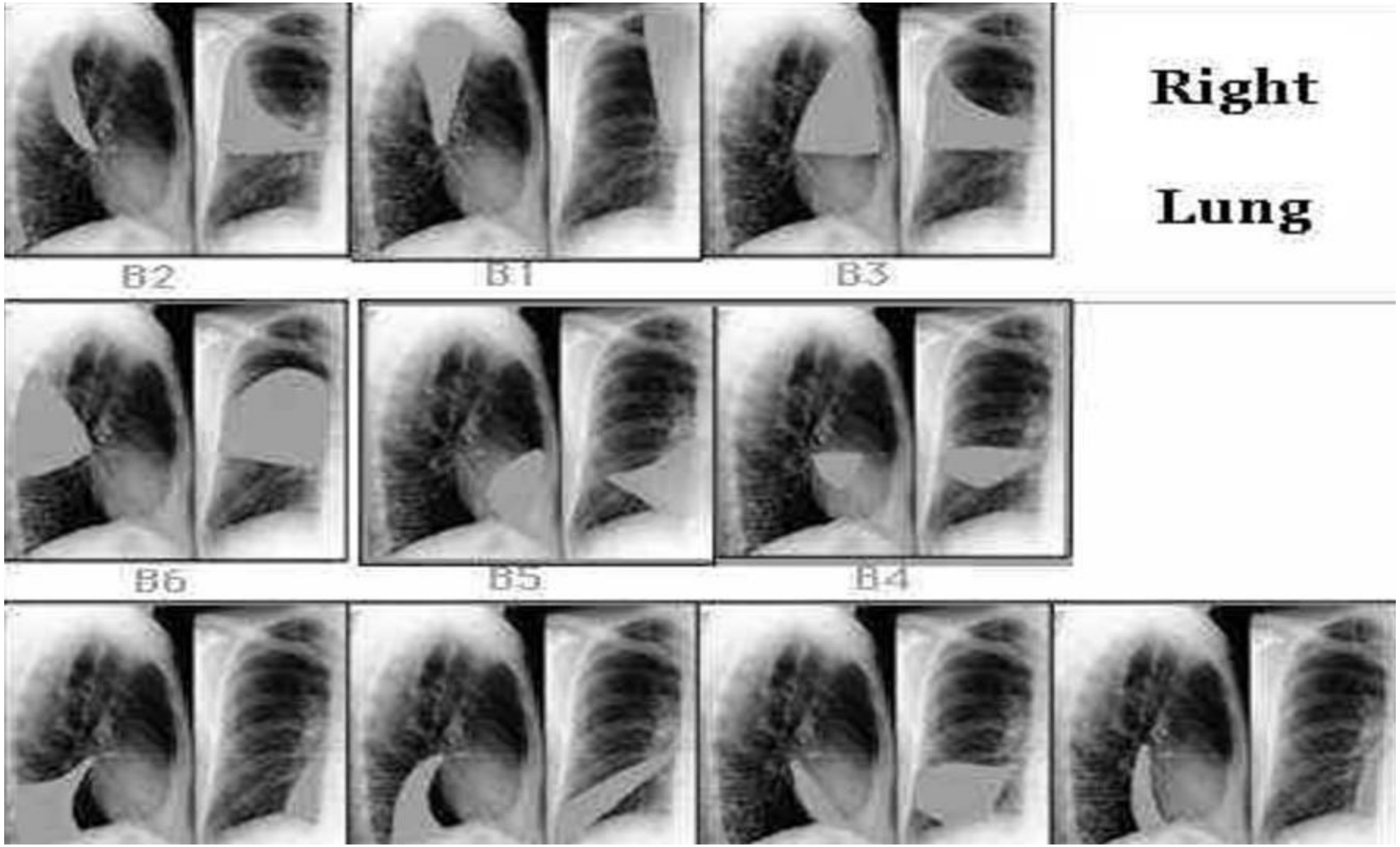
Gabriela Jimboreanu



THE SEGMENTATION OF THE RIGHT LUNG

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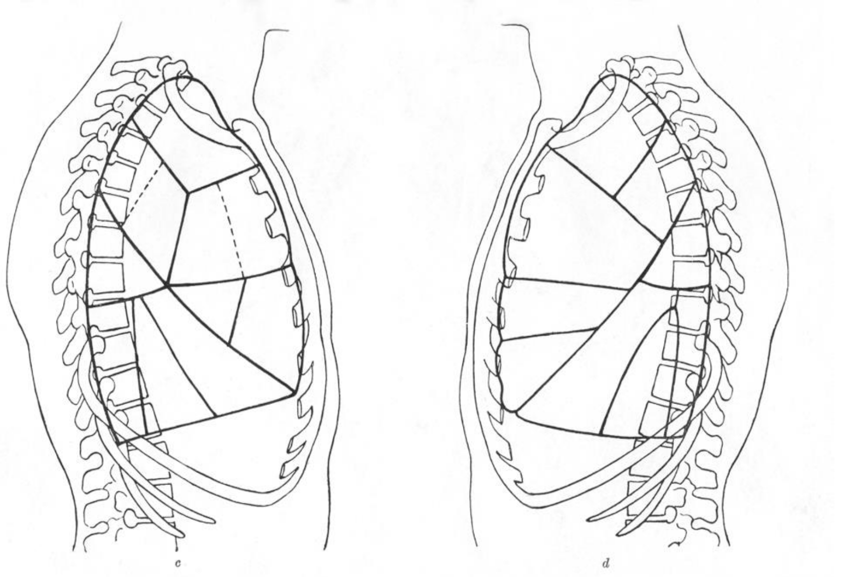
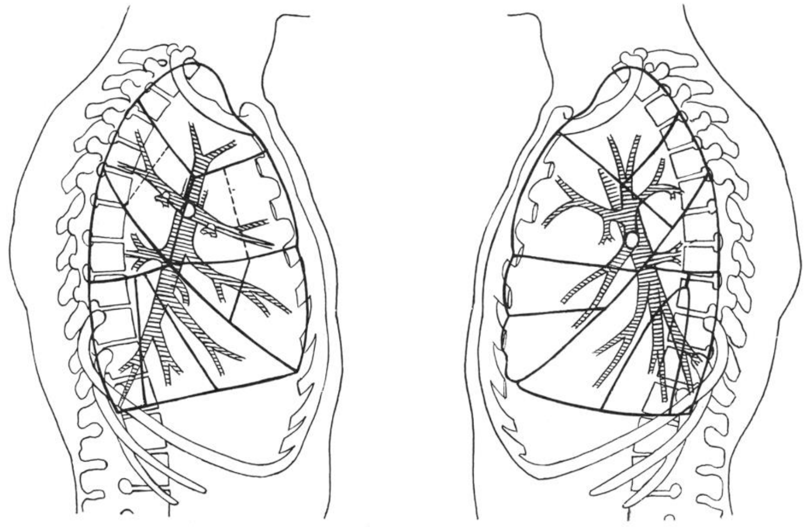
The Bronchopulmonary segments in the lateral view



The division of the tracheobronchial tree



From Brock (1942–1944)

THE SEGMENTATION OF THE LEFT LUNG

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Marilena Crisan
Gabriela Jimboreanu

The segmentation of the left lung:

The upper left lobe (Pulmo sinister, lobus superior):
The superior group (culmen) - three segments:
- The apico-posterior segment;
- The anterior segment;

The inferior group (lingula) - two segments:
- The superior lingular segment;
- The inferior lingular segment

THE SEGMENTATION OF THE LEFT LUNG

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

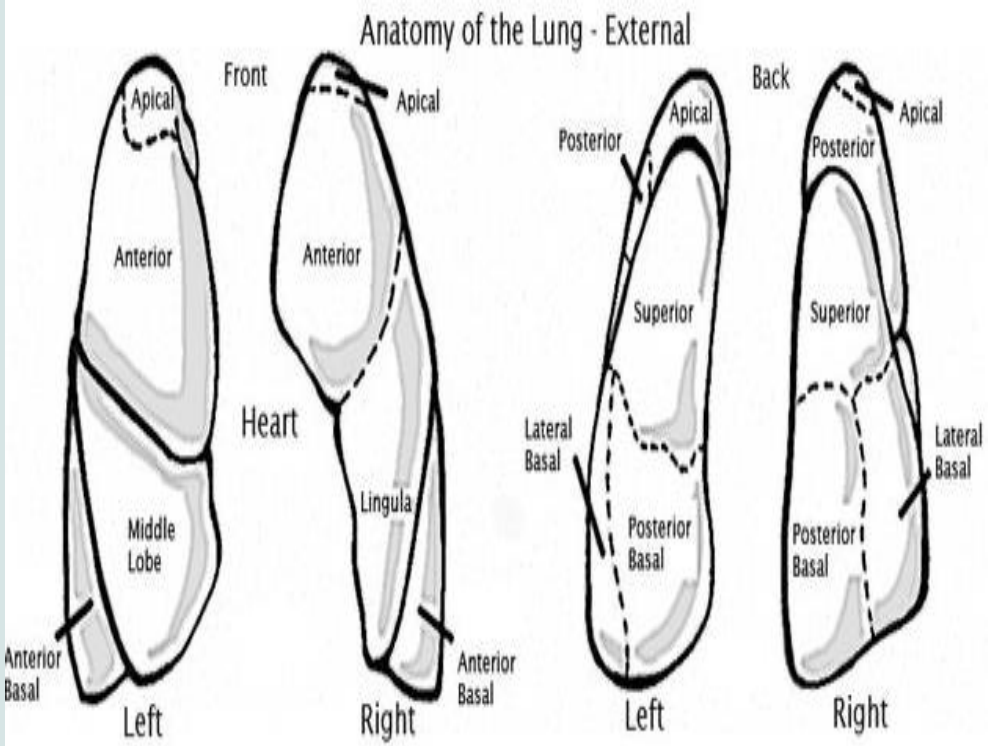
The segmentation of the left lung:

The ***lower left lobe (Pulmo sinister, lobus inferior):***

- The superior group: The fowler segment;

The inferior group (basal pyramid) - 4 segments:

- The medial basal or paracardiac;
- The anterior basal;
- The lateral basal;
- The posterior basal.



THE SEGMENTATION OF THE LEFT LUNG

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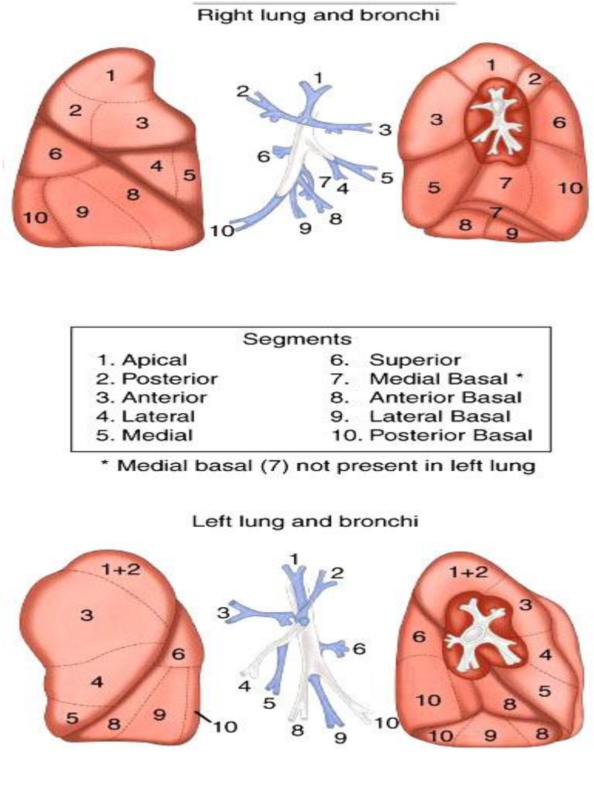

Segmental anatomy of the lungs and bronchi.

THE SEGMENTATION OF THE LEFT LUNG

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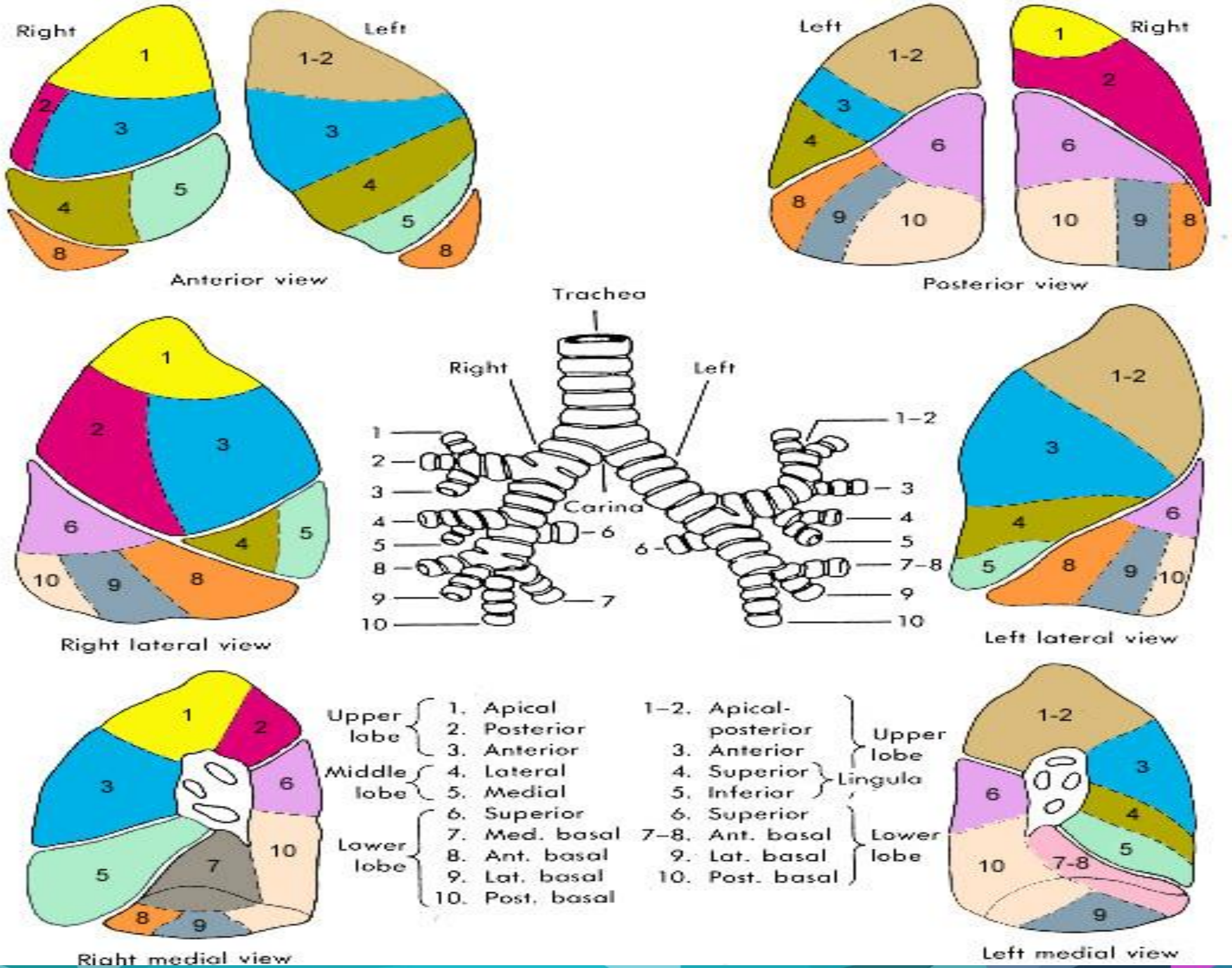

THE SEGMENTATION OF THE LEFT LUNG

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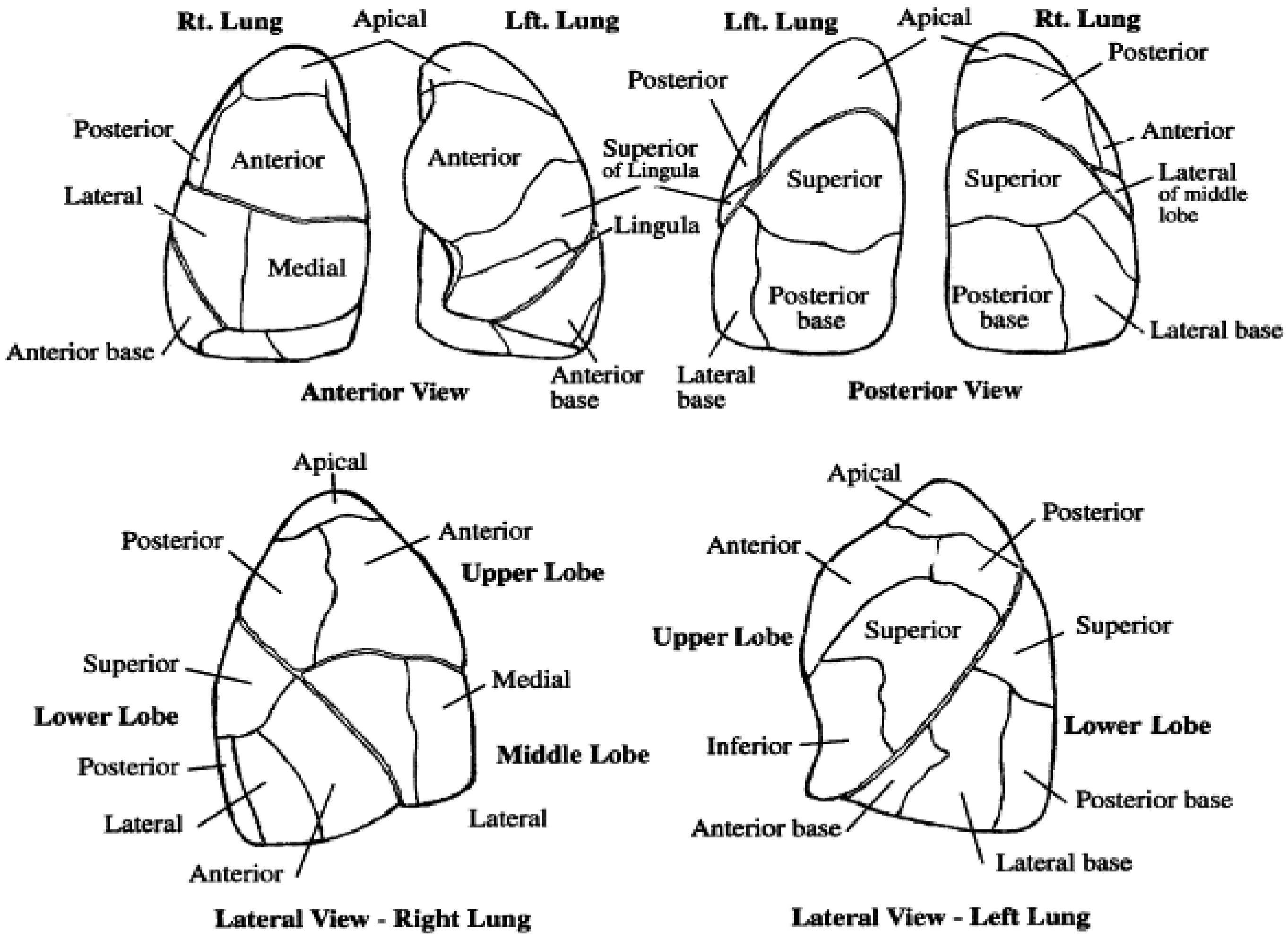


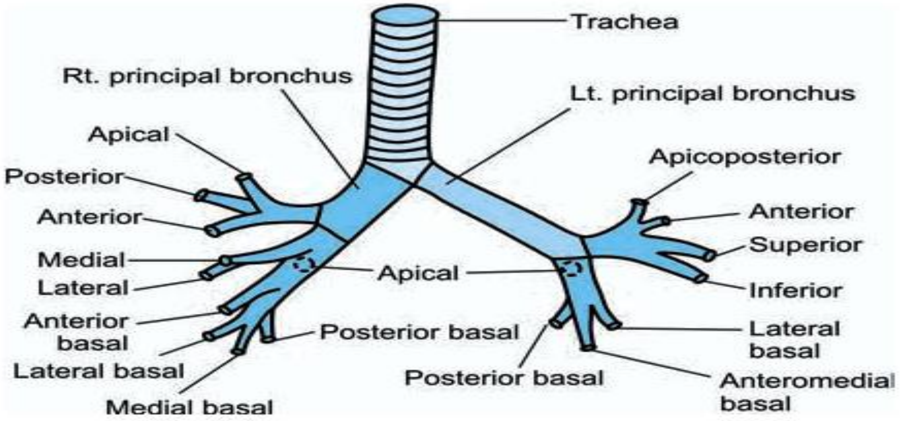
THE SEGMENTATION OF THE LEFT LUNG

LATERAL VIEW

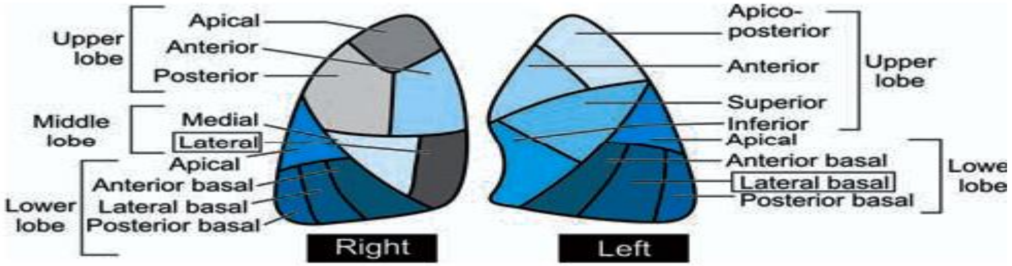
Edith Simona Ianosi

Marilena Crisan

Gabriela Jimboreanu



The bronchial tree



The bronchopulmonary segments
(lateral aspect)

THE STRUCTURE THE LUNG

Edith Simona Ianosi

Marilena Crisan

Gabriela Jimboreanu

A.) The intrapulmonary air spaces:

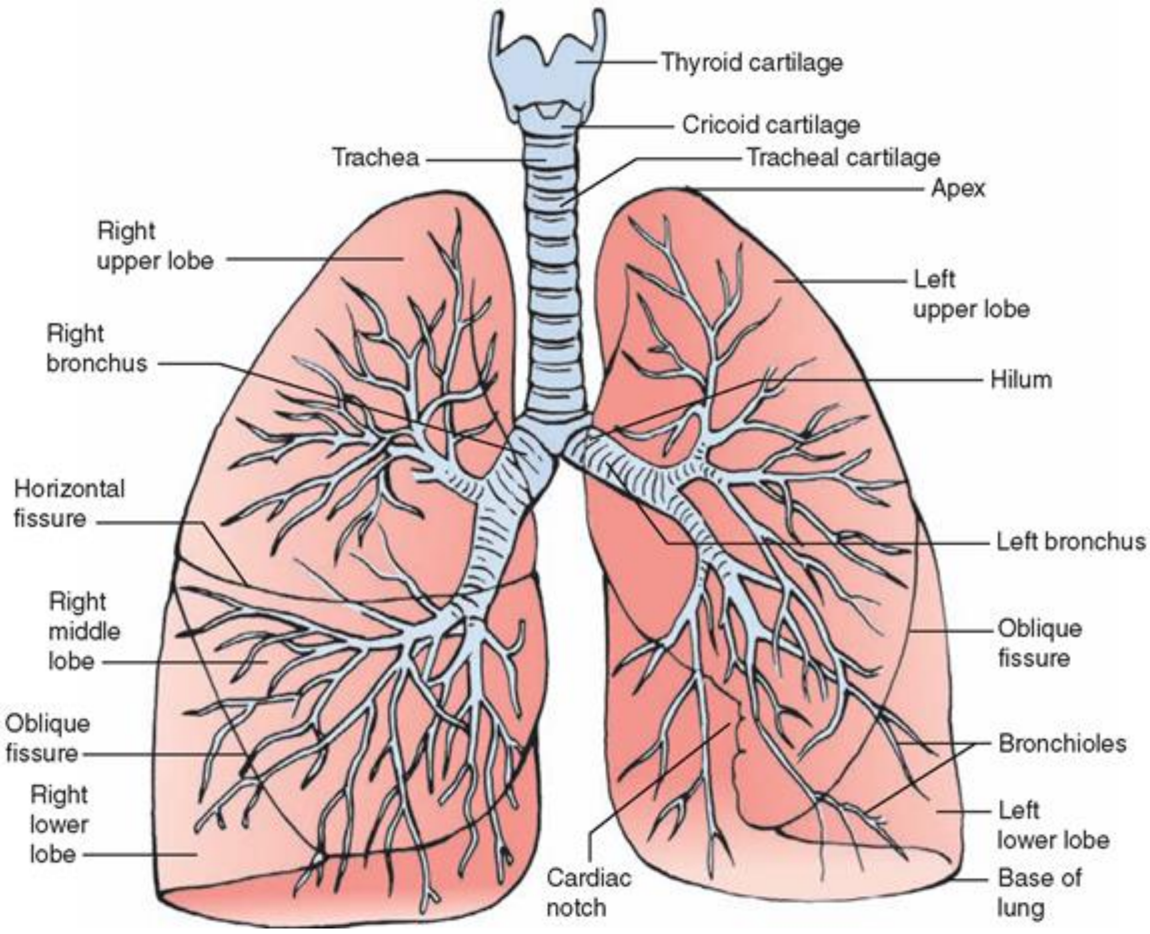
1) The oxygen delivery tract:

- lobal, segmentary, subsegmentary bronchi;
- bronchioles.

2) The gas exchange – canals/grooves and alveolar sacs.

B.) The pulmonary interstitium:

- alveolar walls
- blood vessels



THE STRUCTURE THE LUNG

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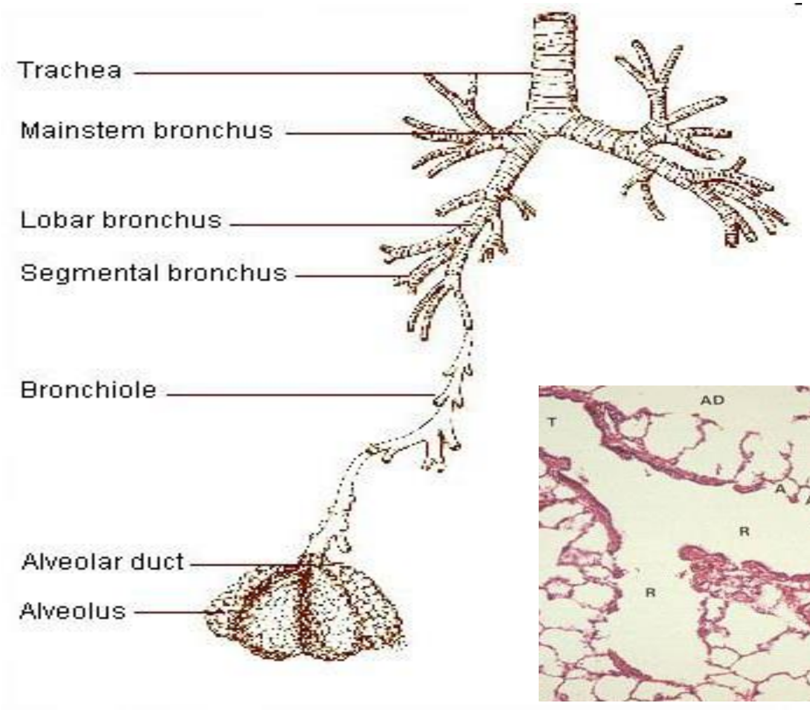
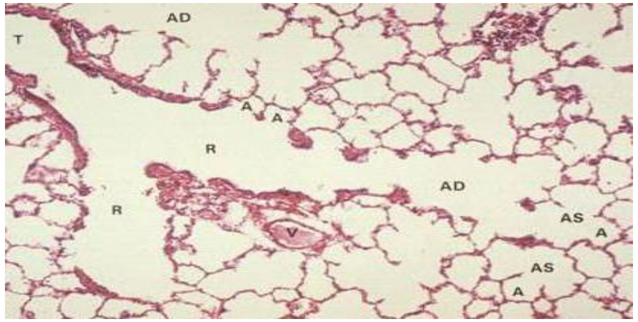
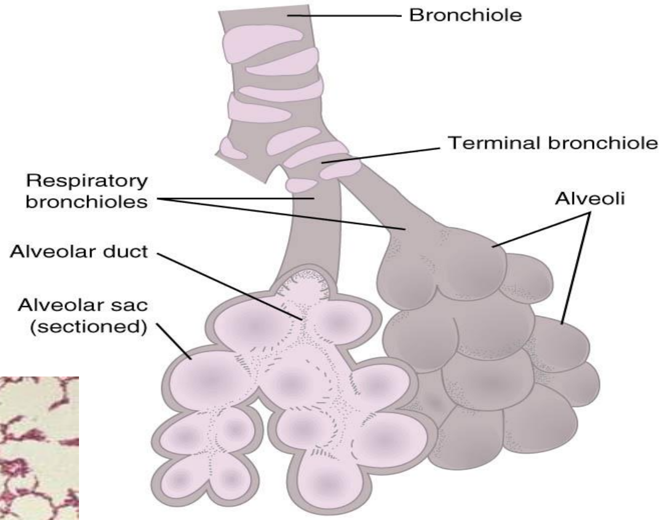
Intrapulmonary conducting airways







THE STRUCTURE
THE LUNG

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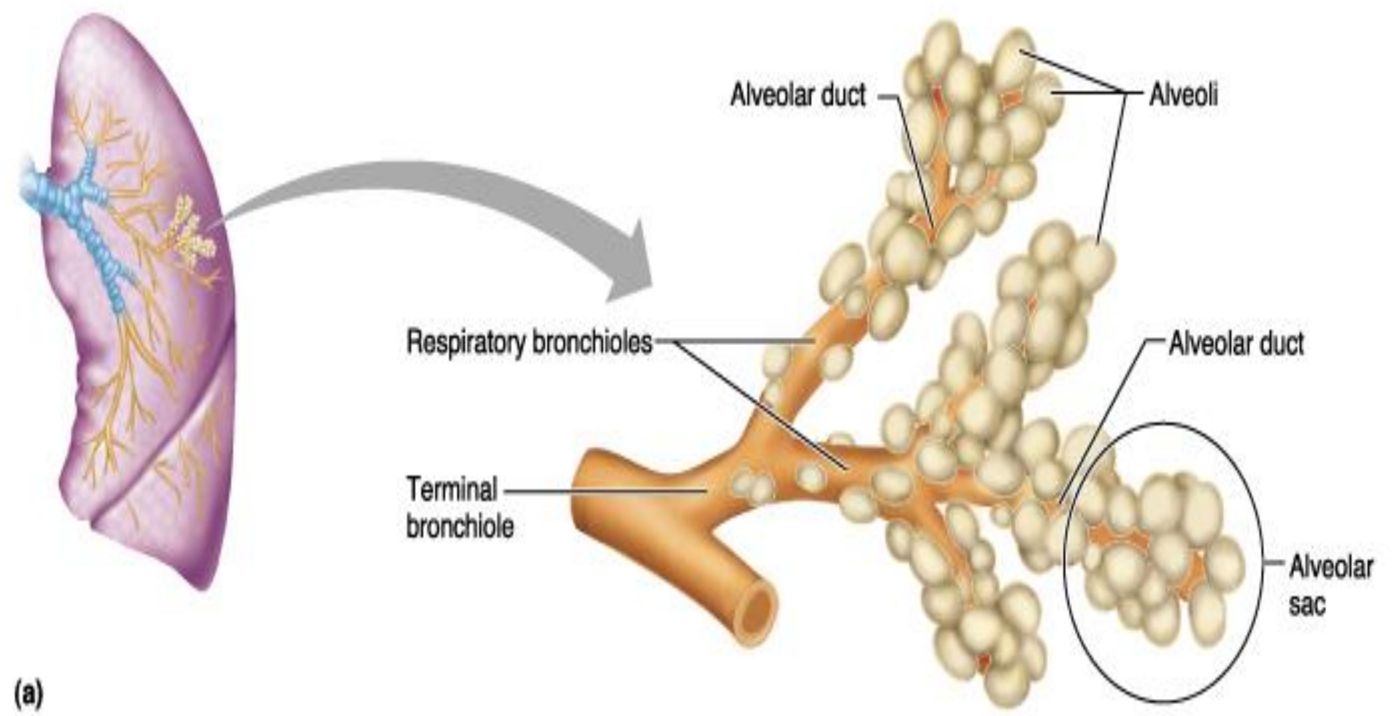
Conducting airways



THE STRUCTURE THE LUNG

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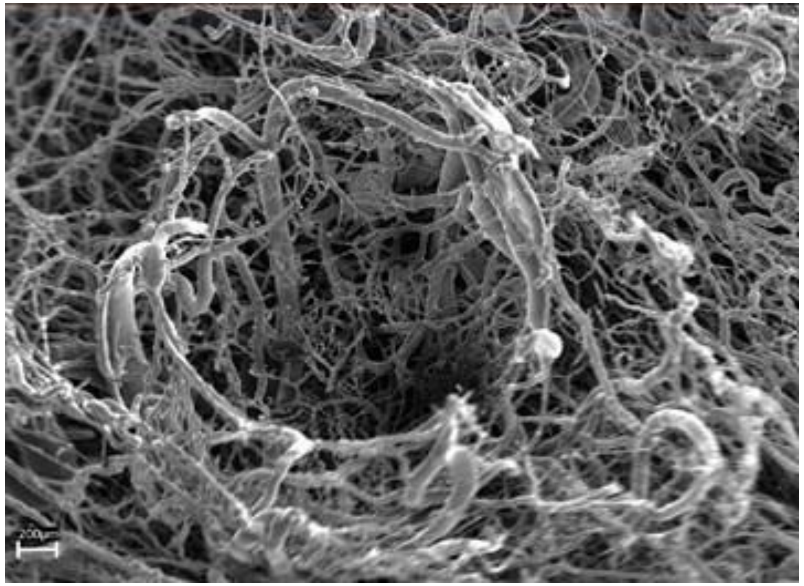
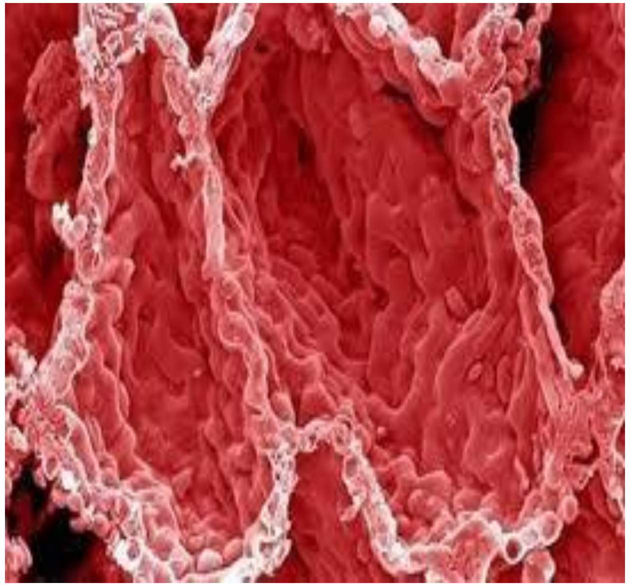
The pulmonary interstitium



Collagen fibers



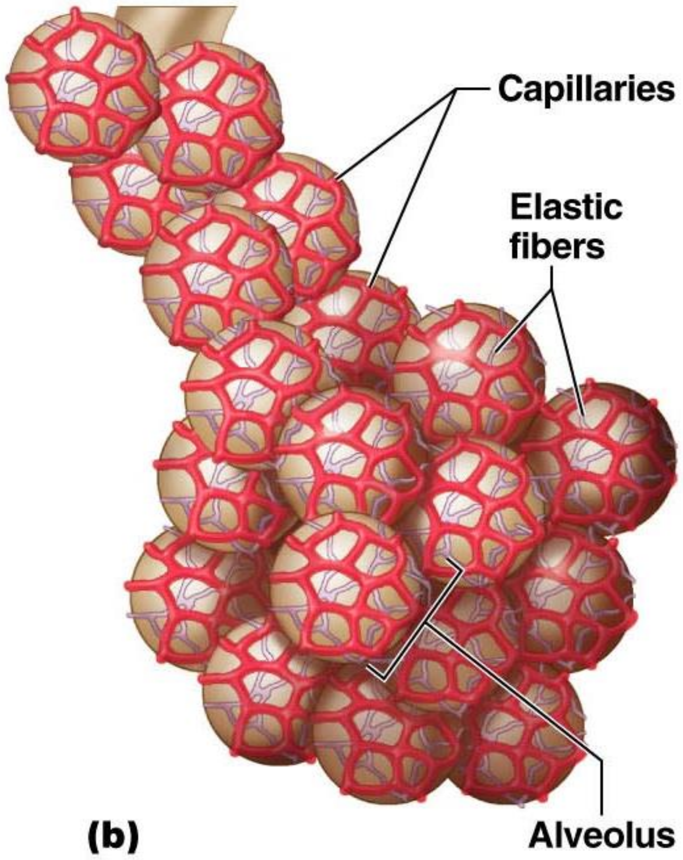
Pulmonary alveolus

THE STRUCTURE THE LUNG

THE ALVEOLUS

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Coated with surfactants;
- ***Epithelium:***
  - Pneumocytes type I - with thin prolongation
  - Pneumocytes II – secrets surfactants
- ***Basal membrane:***
  - Surrounded by elastic fibers and capillaries;
  - Mf can enter into the alveolus.



THE STRUCTURE THE LUNG

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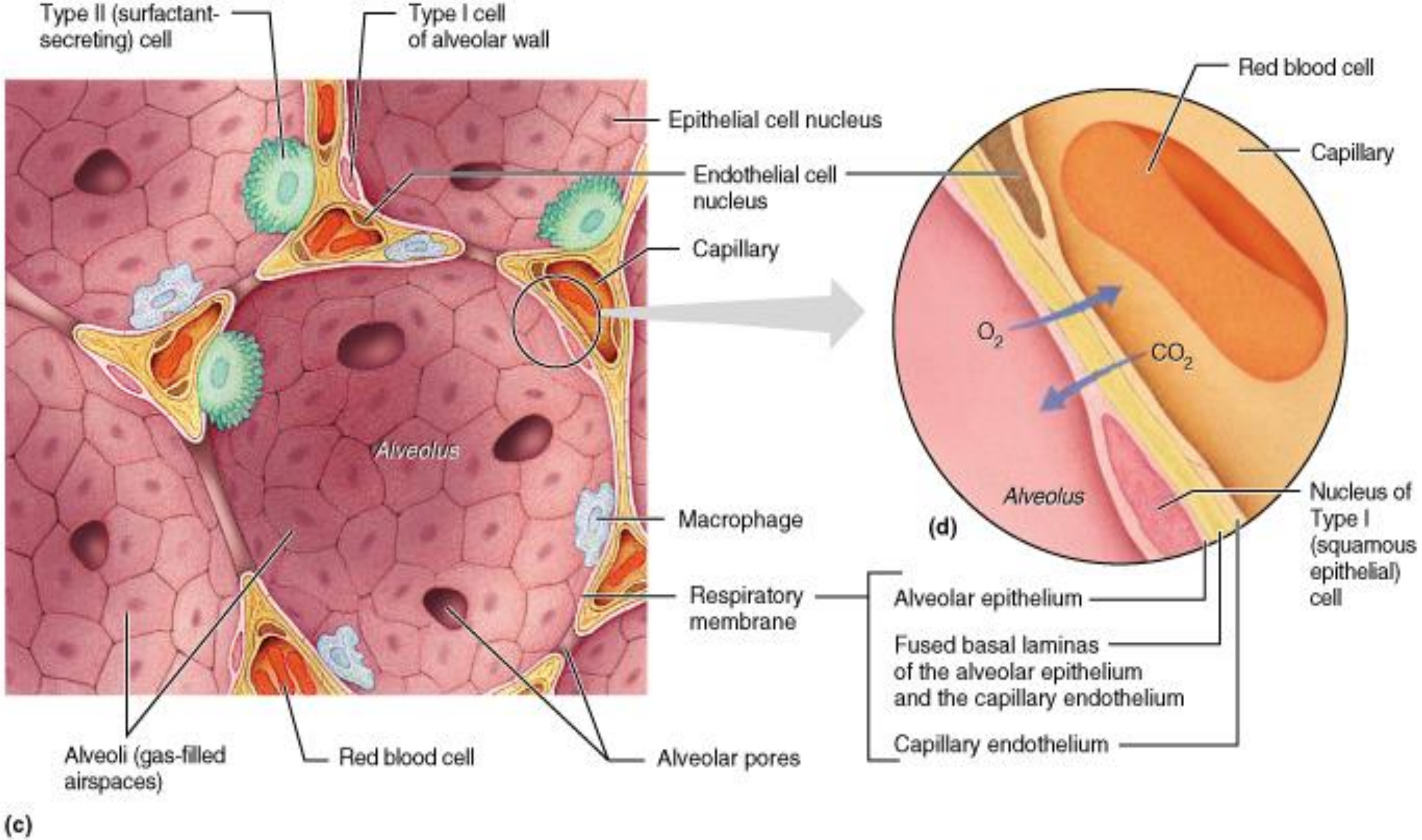
Marilena Crisan
Gabriela Jimboreanu



THE STRUCTURE
THE LUNG

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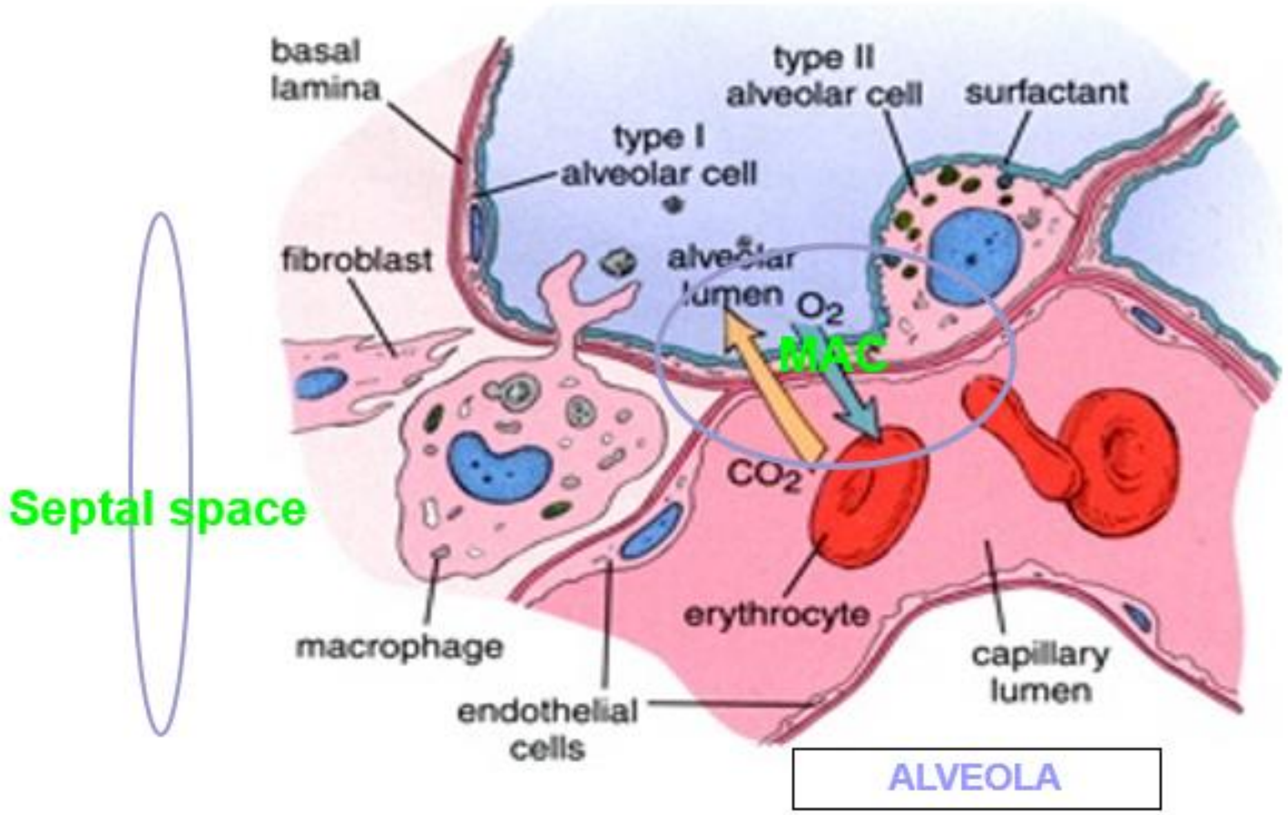
Alveolus MAC. Pulmonary capillary



THE STRUCTURE
THE LUNG

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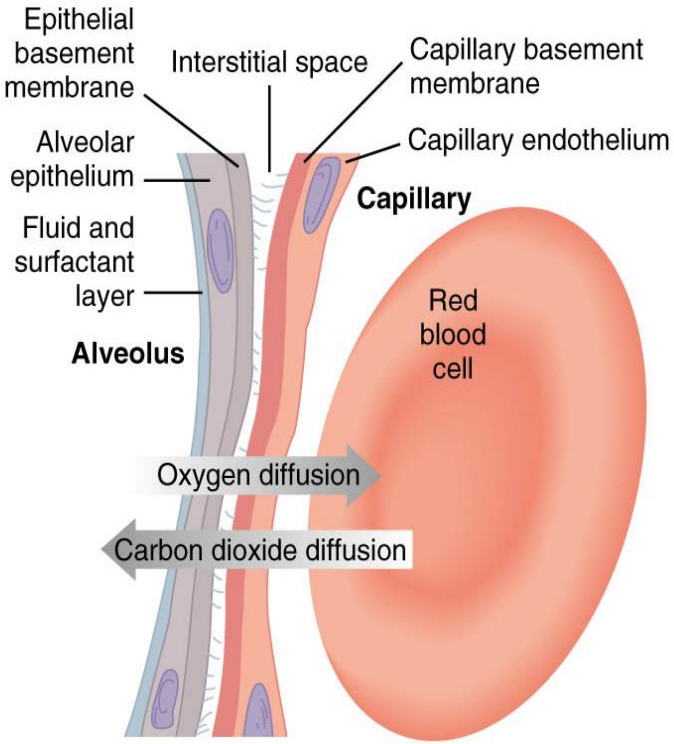
Marilena Crisan
Gabriela Jimboreanu

Air - blood barrier = MAC

1. The surfactant layer;
2. Cytoplasmic extension of type I pneumocystes;
3. Epithelial basement membrane;
4. Capillary basement membrane;
5. Endothelial cells.

THE SURFACTANT – a complex of lipids and proteins; assures the mechanical stability of the lung and maintains beanie alveolar = tensioactive.



THE STRUCTURE
THE LUNG
THE VASCULARISATION

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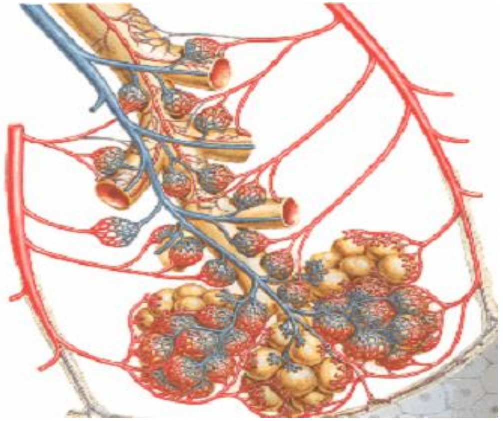
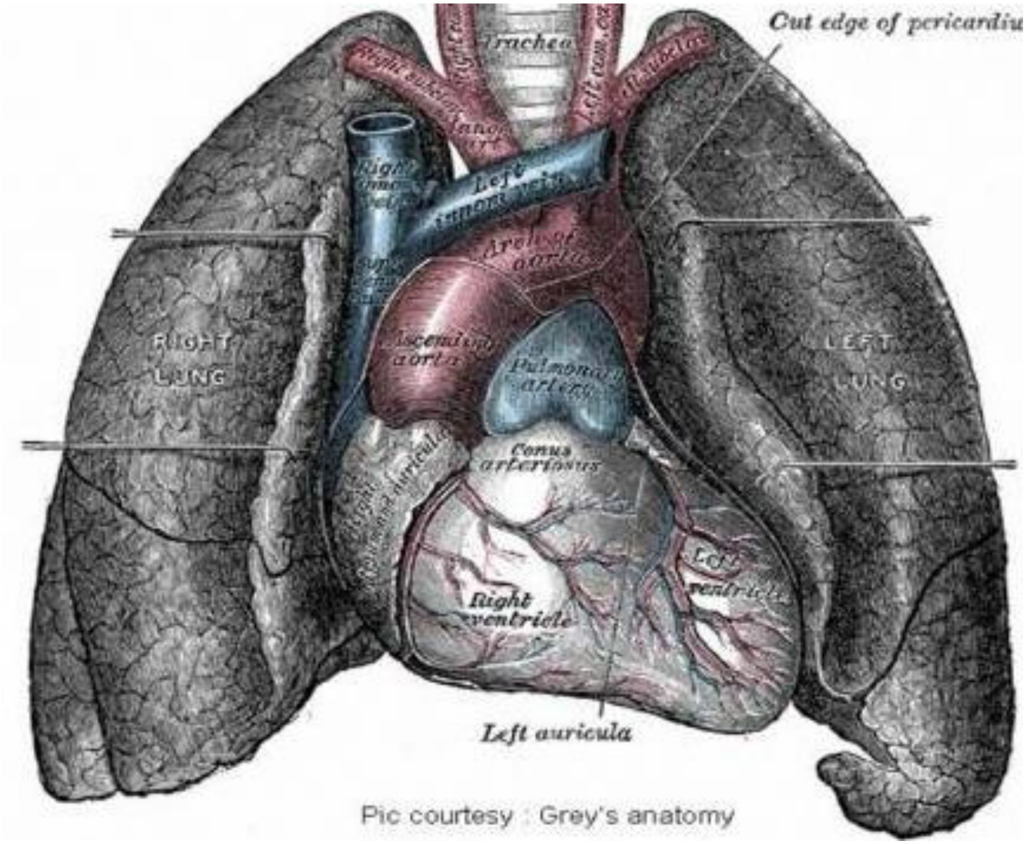
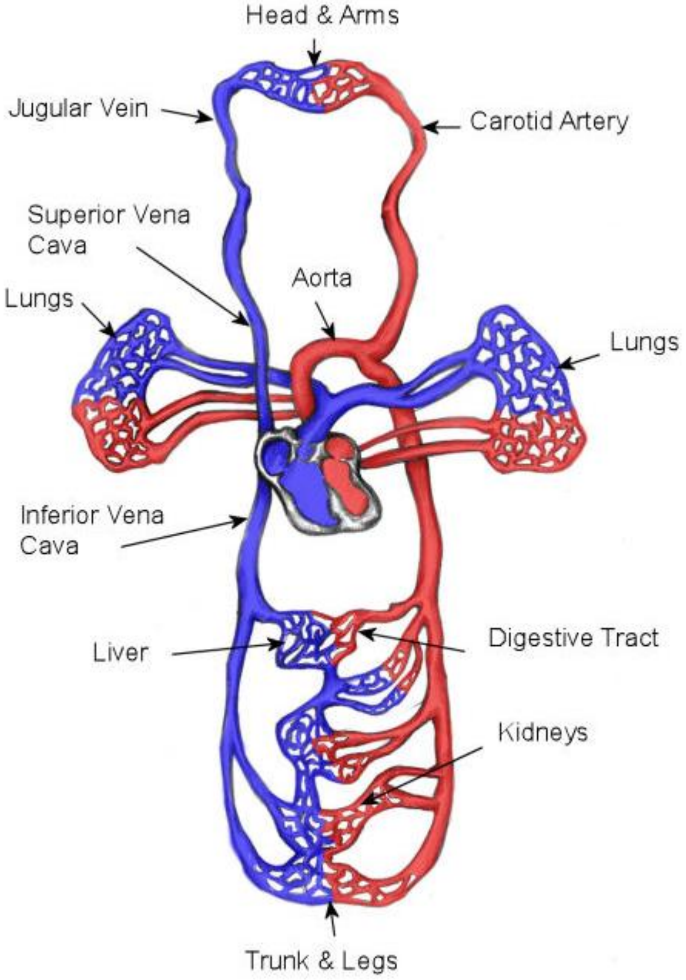
Gabriela Jimboreanu







THE STRUCTURE
THE LUNG

THE VASCULARISATION

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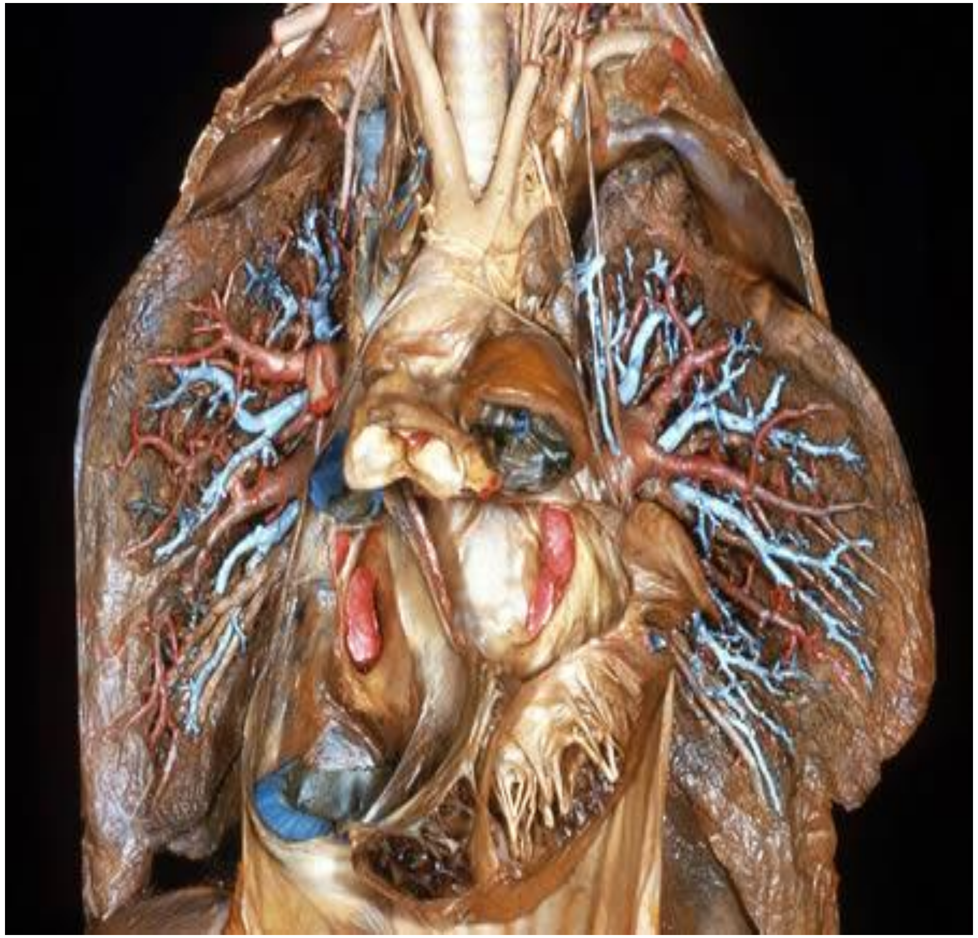
Marilena Crisan
Gabriela Jimboreanu



THE STRUCTURE THE LUNG

THE PULMONARY VESSELS THE FUNCTIONAL CIRCULATION

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The pulmonary artery transports/delivers venous blood CO_2 for the lungs:

- Pressure is 6-10 times less than in the systemic circulation;
- It is divided in branches which accompany the bronchi → reflex vasoconstriction in hypoxia;
- It forms a large capillary network in the alveolar walls.

The pulmonary capillaries – plexes under the alveolar epithelium, in the septal and interalveolar walls;

The pulmonary venules begin in capillaries, cross the parenchyma (through the interlobar septum);

Big veins → Left atrium. Vstg - AAo→sg arterial (O_2) in the systemic circle.

THE STRUCTURE THE LUNG

THE LYMPHATIC VESSELS OF THE LUNG

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- The Profound/Deep plexus - consorts the pulmonary vessels and the bronchi (2 plexes – submucous and peribronchial) reaching into the tracheobronchial ganglions.;

- Superficial plexus – starts from the visceral pleura, crosses interlobularly, and reaches the hilar ganglions;

- NO lymphatic vessels in alveolar walls (in acini);

- ***The lymphatic collectors which take the lymph ggl. hilo-mediastinal:***
  - The thoracic /left canal/groove (origin in cisterna chyli - abdominal);
  - The right thoracic duct.

THE STRUCTURE
THE LUNG

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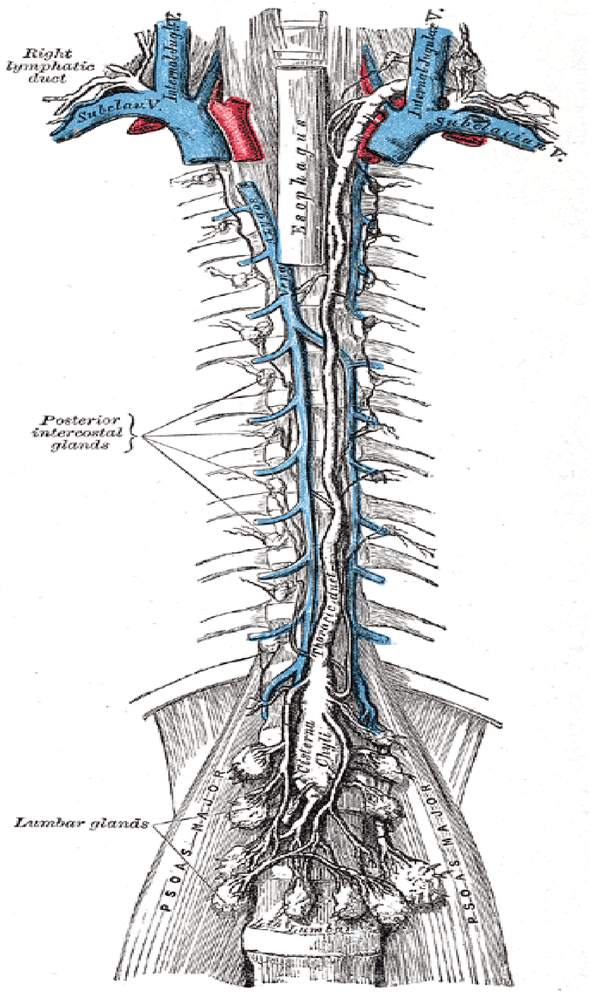
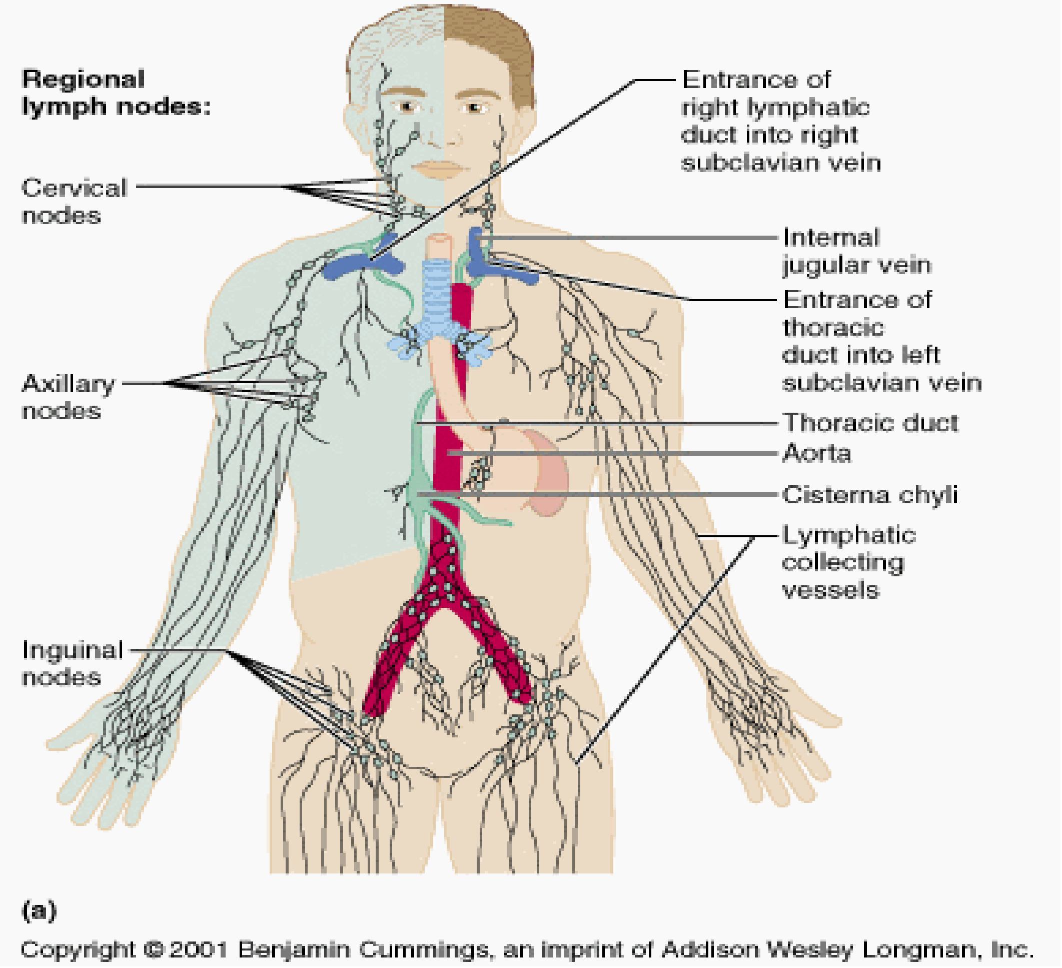
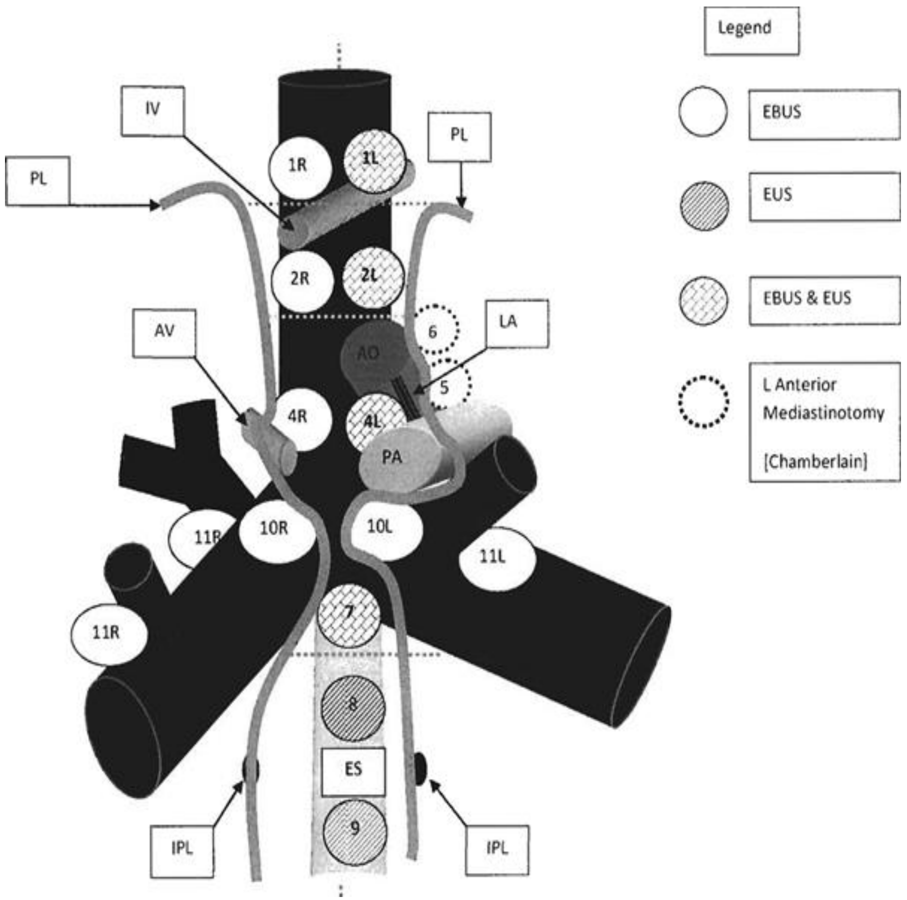
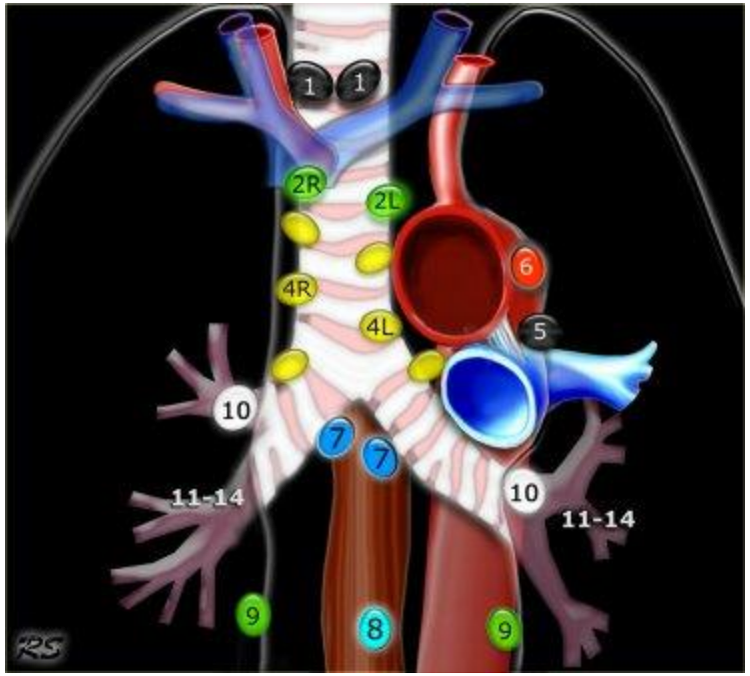




THE STRUCTURE
THE LUNG
THE LYMPHATIC NODES
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



EBUS – Endoscopic ultrasound
EUS – Esophageal endoscopic ultrasound



THE STRUCTURE
THE LUNG

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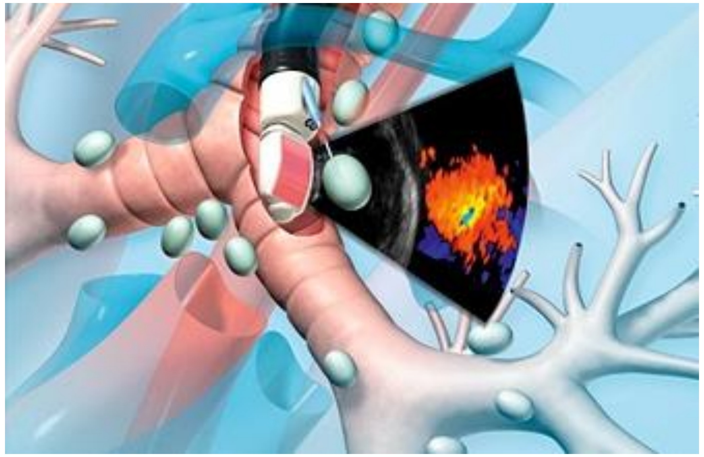
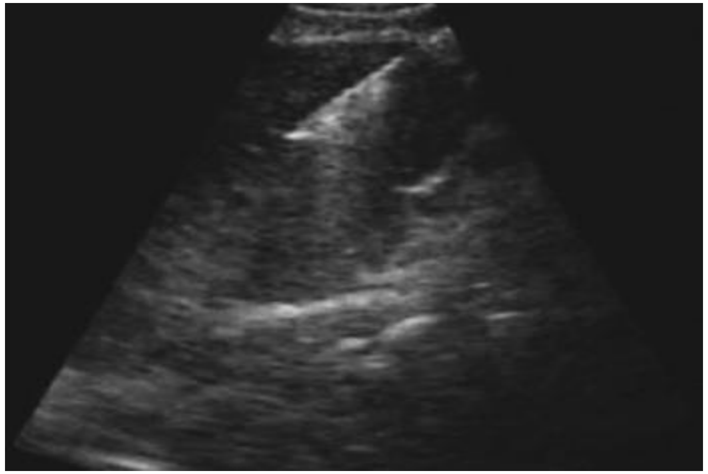
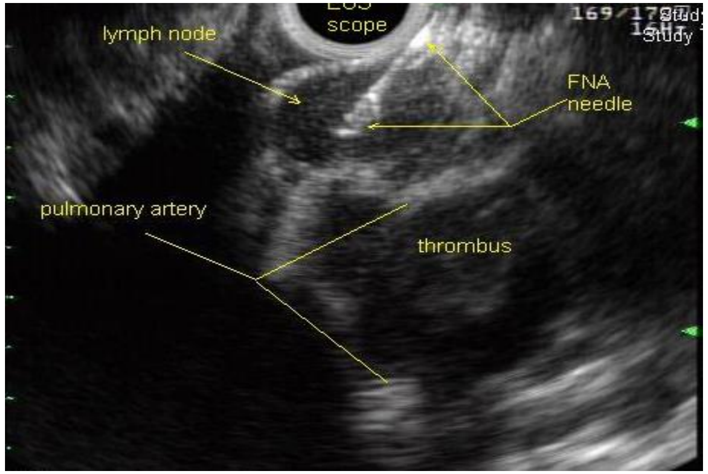
Transbronchial puntion by EBUS, echo guided.







THE PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Each lung has 2 pleural foils/membranes situated one after the other on the level of a reflexive line.
- ***The right pleura*** doesn't communicate with ***the left one.***
- ***The 2 membranes*** (the parietal pleura and the visceral pleura) limit a cavity on each side – the pleural cavity.
- ***The mesothelium*** – the epithelium of the pleura lain on the conjunctive tissue with collagen and elastic fibers.
- ***The subpleural conjunctive tissue*** continues with the interlobular conjunctive tissue and peribronchovascular pina in the hilus.
- ***The lung projections*** are different of those of the recesses projections which are occupied only in the inspiration (even then there exists a complementary space).
- ***The innervation of the pleura.***
- ***The innervation of the parietal pleura*** provides from the intercostal and phrenic nerves.
- ***The visceral pleura*** doesn't contain sensitive terminations.

THE PLEURA

THE VISCERAL PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Thin;
- Transparent;
- It adheres to the pulmonary surface which is almost totally covered by it, except the hilum, where it reflects on the constituents of the pulmonary pedicles;
- It coats the walls of the interlobar fissures - forming incomplete fissures.

THE PLEURA

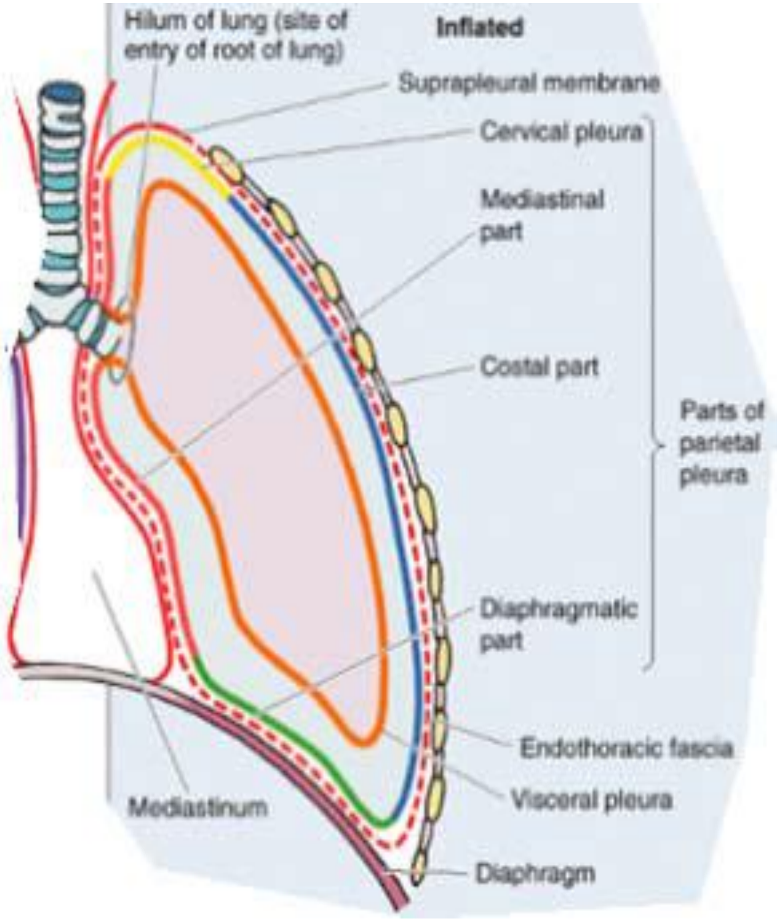
THE PARIETAL PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- It coats the profound face of the lodge - endothoracic fascia (Endothoracic fascia).

The 3 segments:

- The costal segment, the costal pleura;
- The medial segment, the mediastinal pleura;
- The inferior segment, the diaphragmatic pleura.



THE PLEURA

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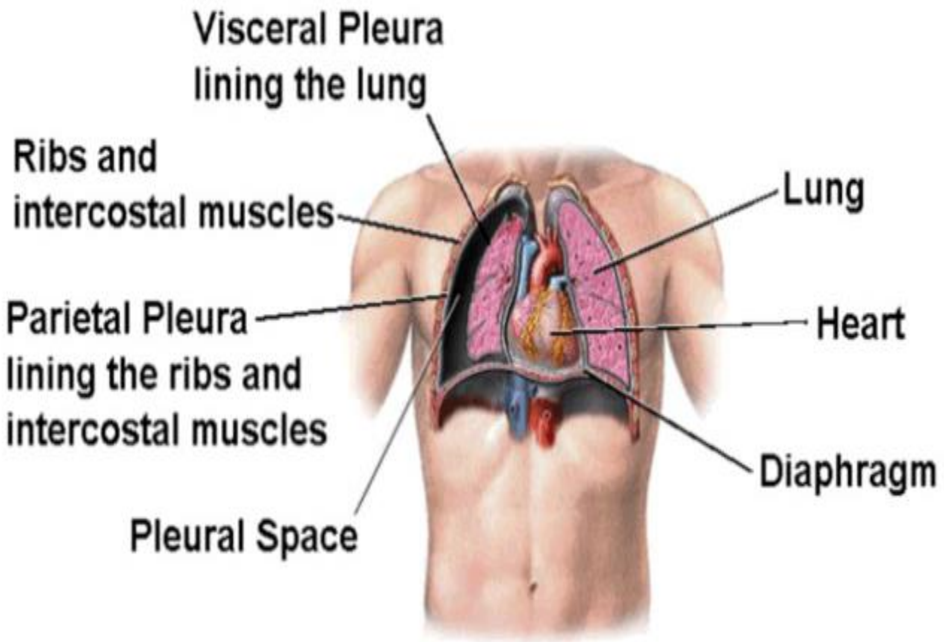
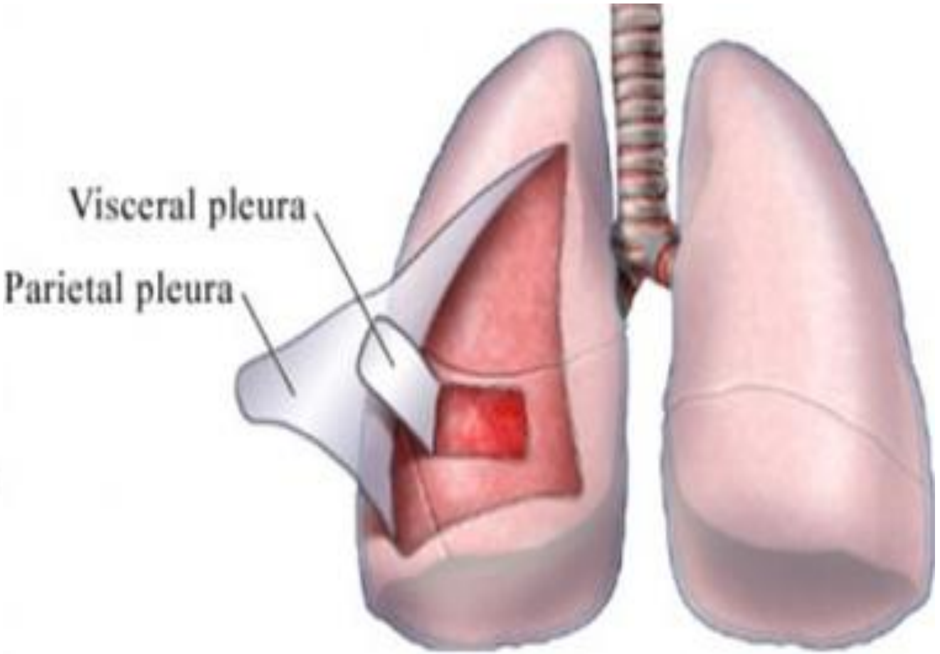
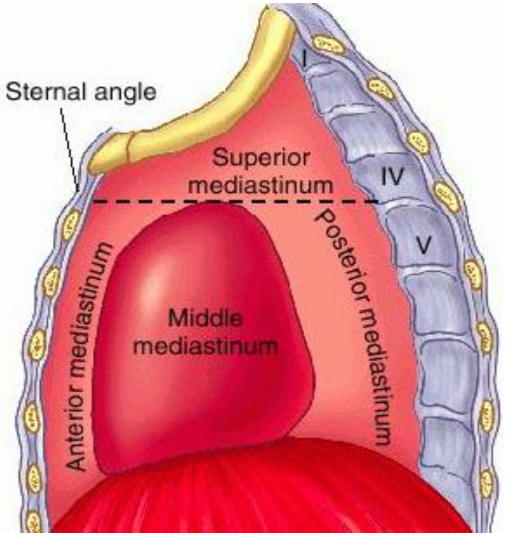
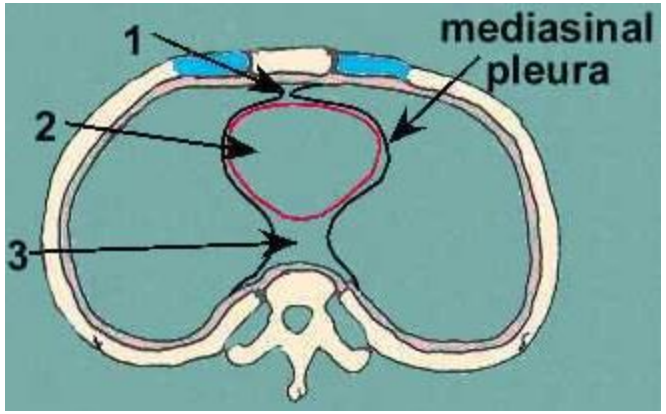


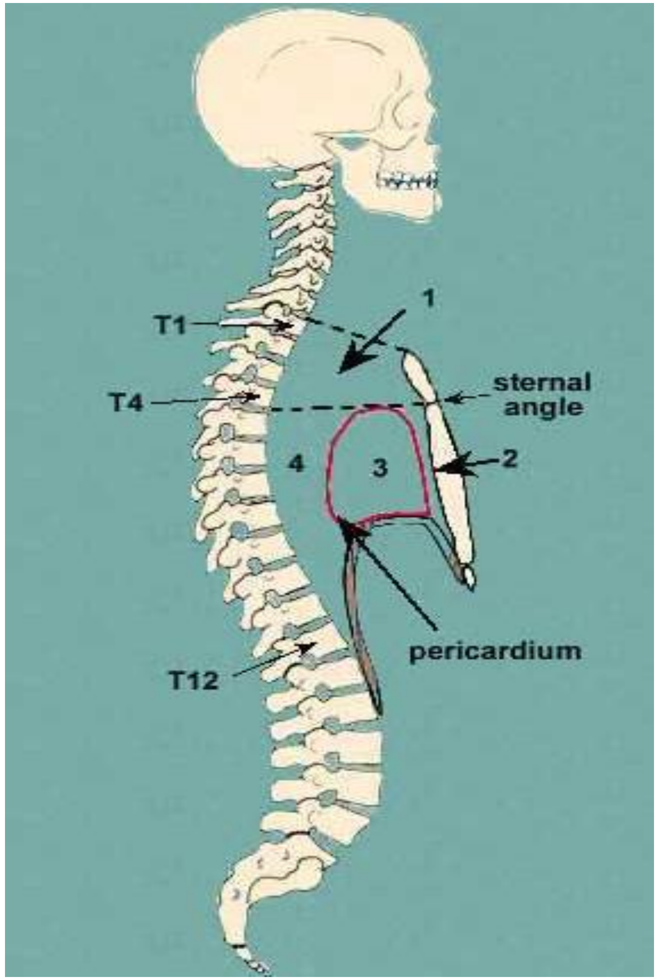


THE MEDIASTINUM

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu







THE STRUCTURE
THE LUNG

Edith Simona Ianosi
Marilena Crisan
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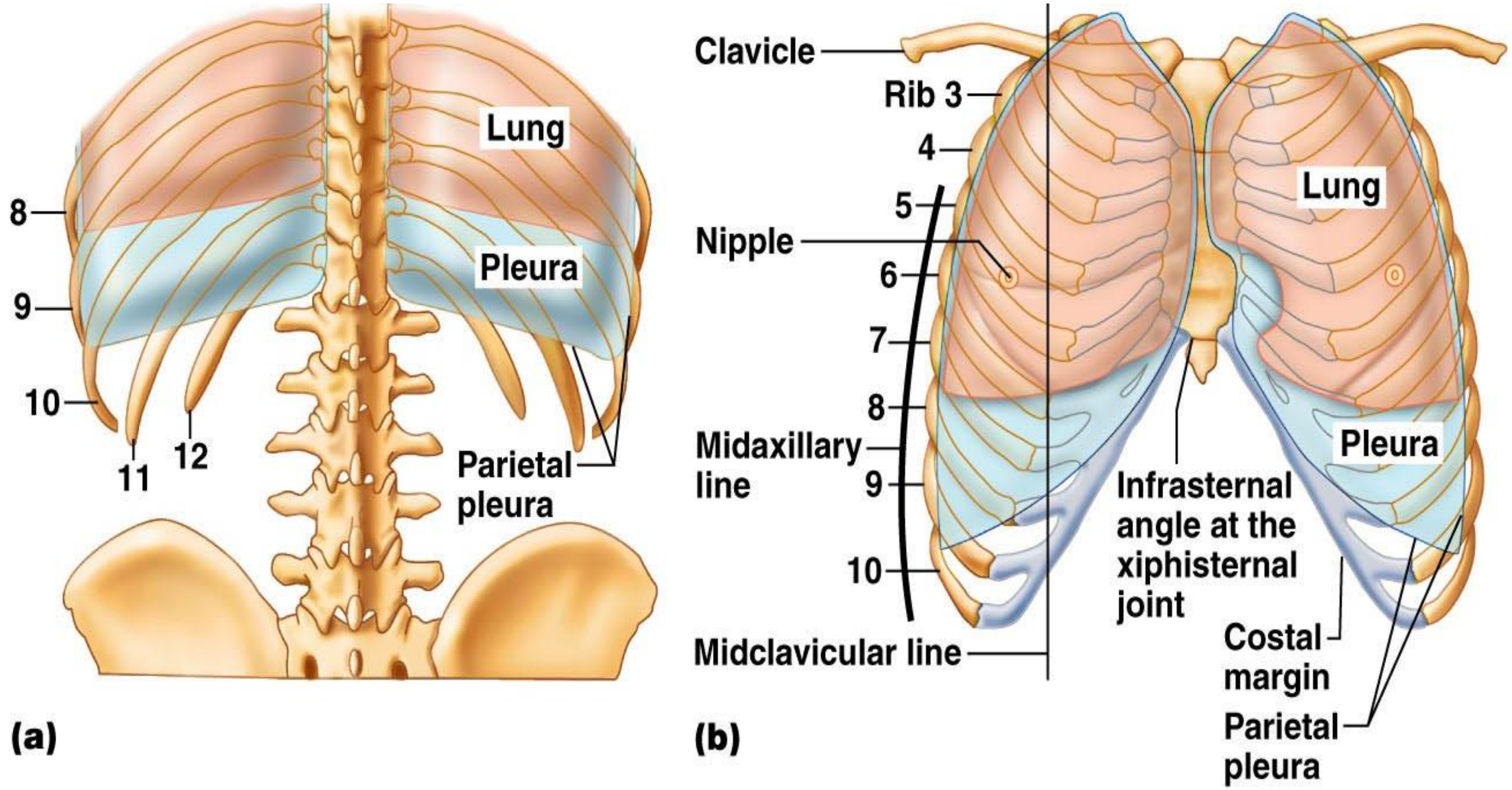
The localisation of the lungs and the pleura in the thoracic cavity



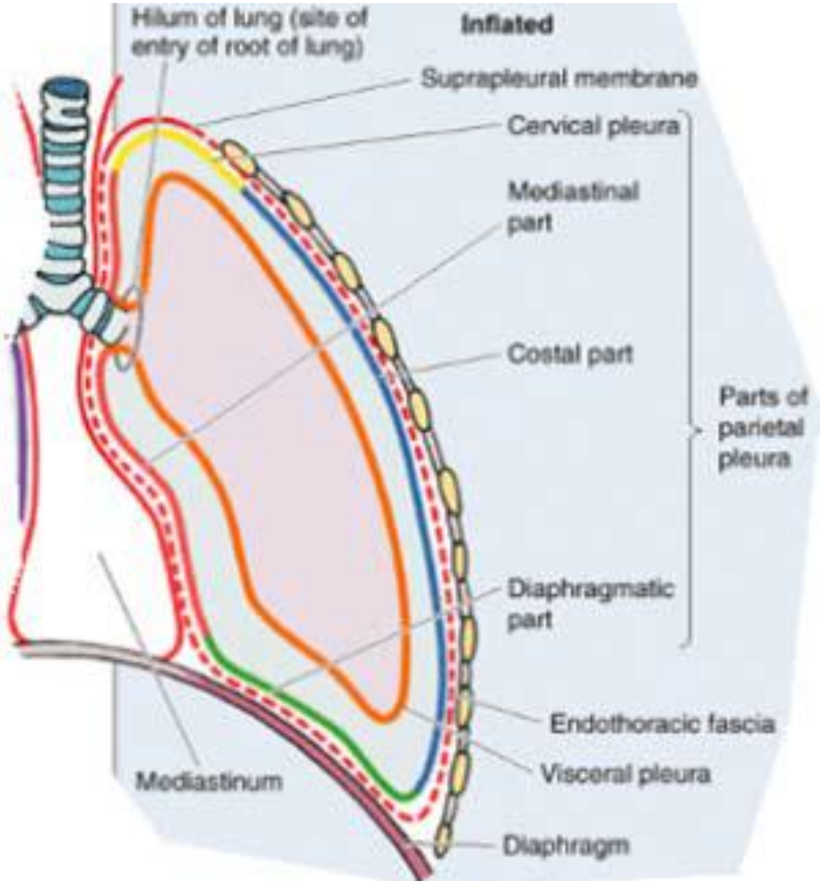
THE PLEURA

THE DIAPHRAGMATIC PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- It coats the internal face of the ribs and the appropriate intercostal spaces.

- ***It reflects:***
- Anteriorly - in off the stern;
- Posteriorly - in off the vertebral grooves;
- Inferiorly - in direct contact with the diaphragmatic pleura.



THE PLEURA
THE DIAPHRAGMATIC PLEURA
THE MEDIASTINAL PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The diaphragmatic pleura:

- Thinner than the costal pleura;
- On the both sides of the pericard;
- It adheres to the diaphragm - intermedium of the endothoracic fascia.

The mediastinal pleura:

- Quasi sagittal, backfront of the posterior stern, towards the posterior laterovertebral grooves.

THE PLEURA

THE MEDIASTINAL PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- ***Thin, coating the lateral faces of the mediastinum –on three levels :***

- **Superior** (suprapedicular) level – it lays with no interruption from the posterior wall of the stern, to the laterovertebral grooves;
- **Middle,** pedicular level - reflects on the hilum contour, in order to coat the two pulmonary pedicles;
- **Inferior** (infrapedicular) level - inferior to pleural reflexive line - forms the pleural ligament.

THE PLEURA

THE PLEURAL RECESSES

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The 4 recesses - pleural sacs (Recessus pleurales):

- **Anterior** - deep costomediastinal, retrosternal;
- **Large** - posterior costomediastinal, laterovertebral;
- **Diaphragmatic** – costomediastinal;
- **Costodiaphragmatic**, the most inferior/lower – being the inferior recess of the pleura.

THE PLEURA

THE PLEURAL RECESSES

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Marilena Crisan
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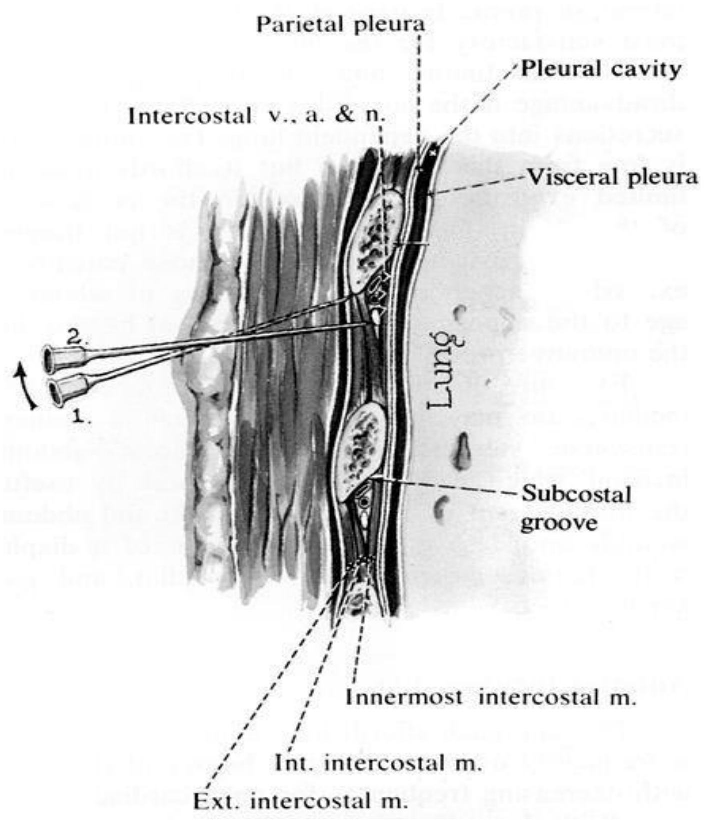

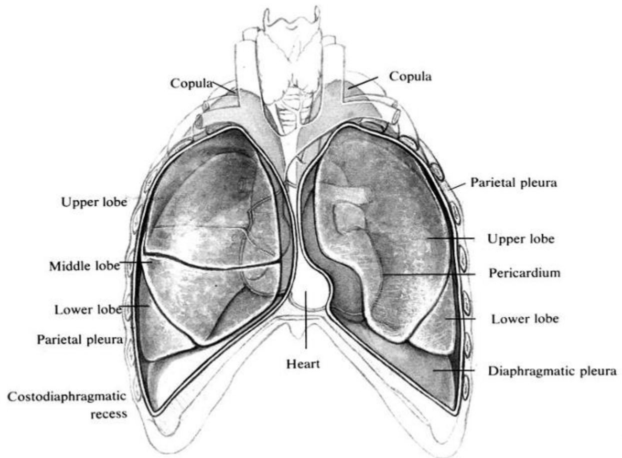

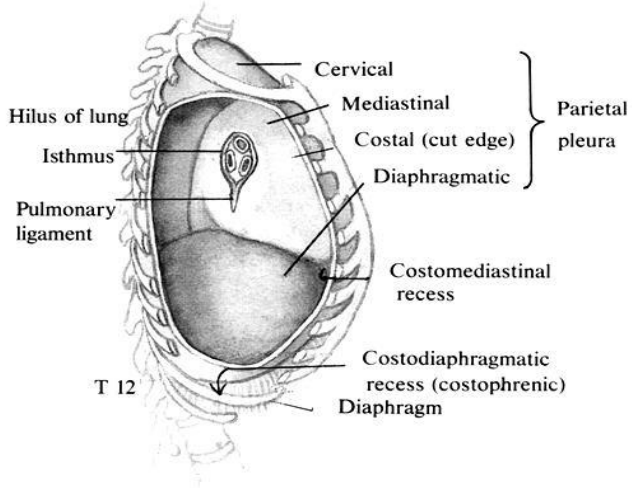

Healey & Hodge 1990

THE PLEURA

THE PLEURAL RECESSES

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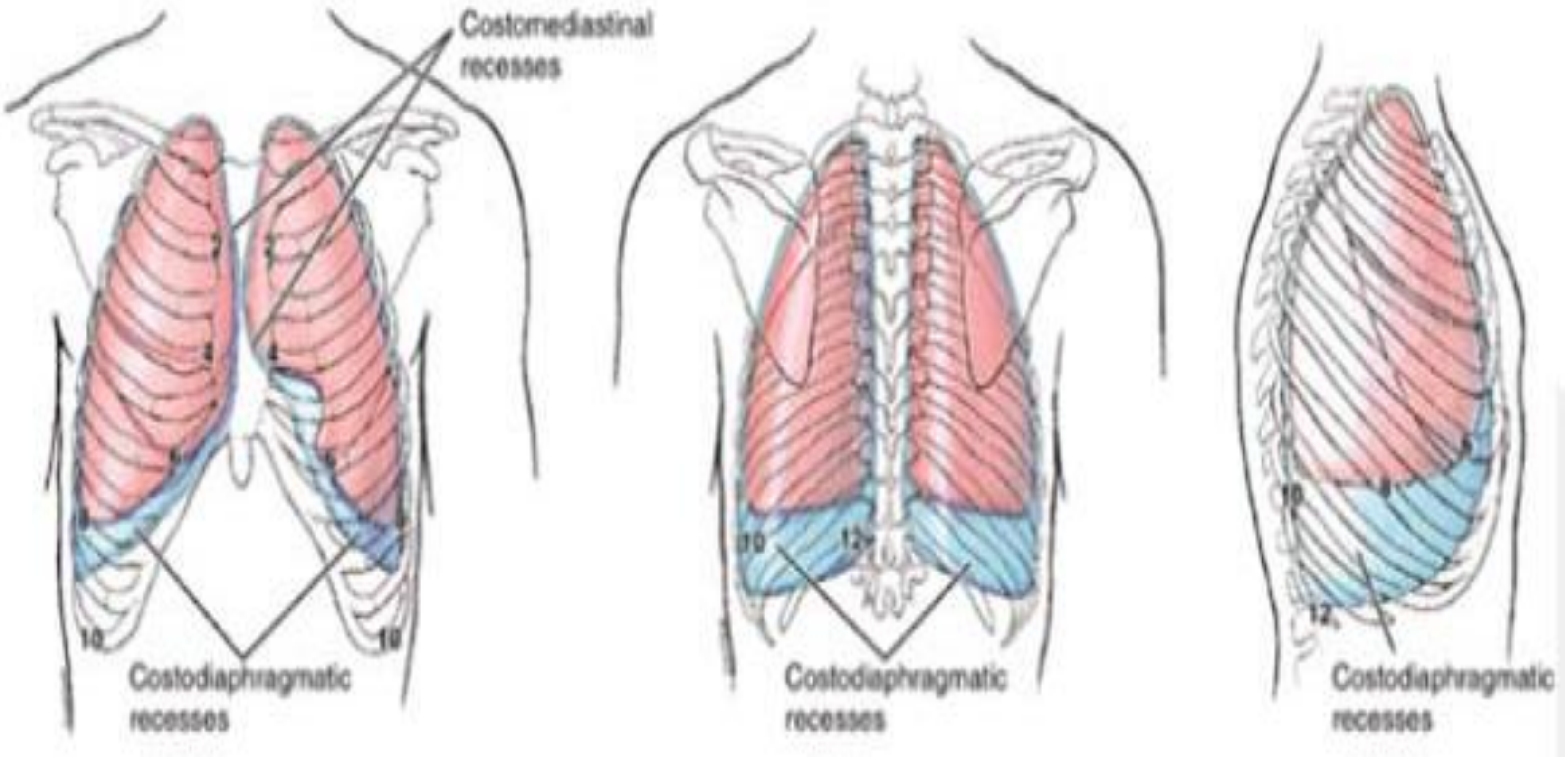

THE PLEURA

THE PLEURAL DOME

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- It ***outgrows*** the first rib with 3-4 cm;
- ***The pleura*** lays ***symmetrical*** in the superior orifice of the thorax;
- *In the middle*, limiting the space for the *trachea*, esophagus and vasculonervous formations;
- It covers *the apex* of the lung - *fibrous formations* described as **the endothoracic fascia.**

THE PLEURA

THE PLEURAL DOME

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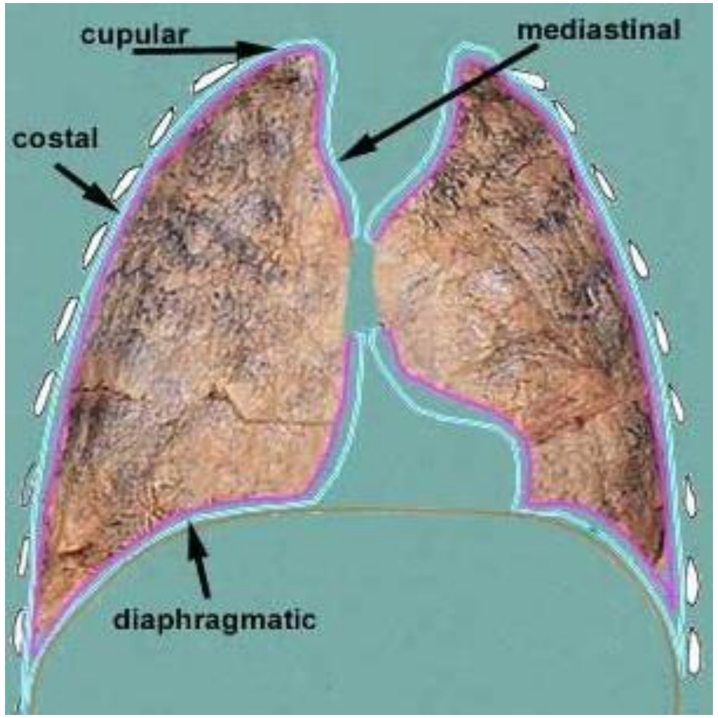
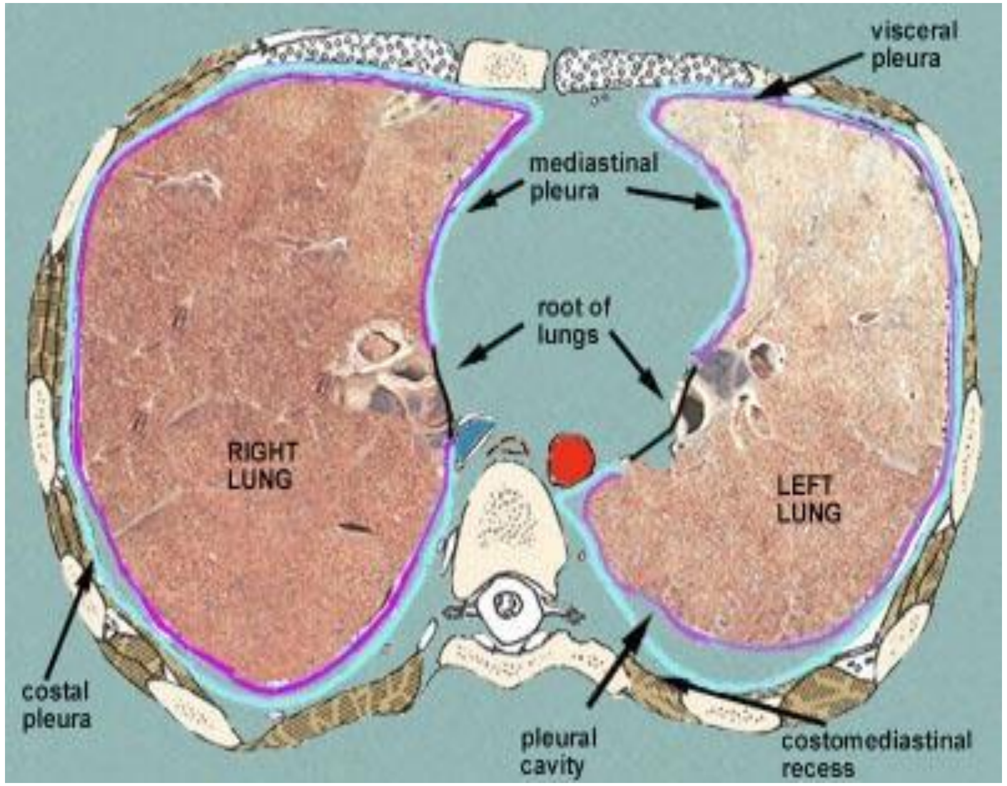
Marilena Crisan
Gabriela Jimboreanu





GROSS ANATOMY

Wilson Martino, Wesley Norman, academic.amc.edu

THE PLEURA

THE PLEULA FIXATION

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The stability of the parietal pleura is being assured by the endothoracic fascia:

Endothoracic fascia (subpleural fascia):

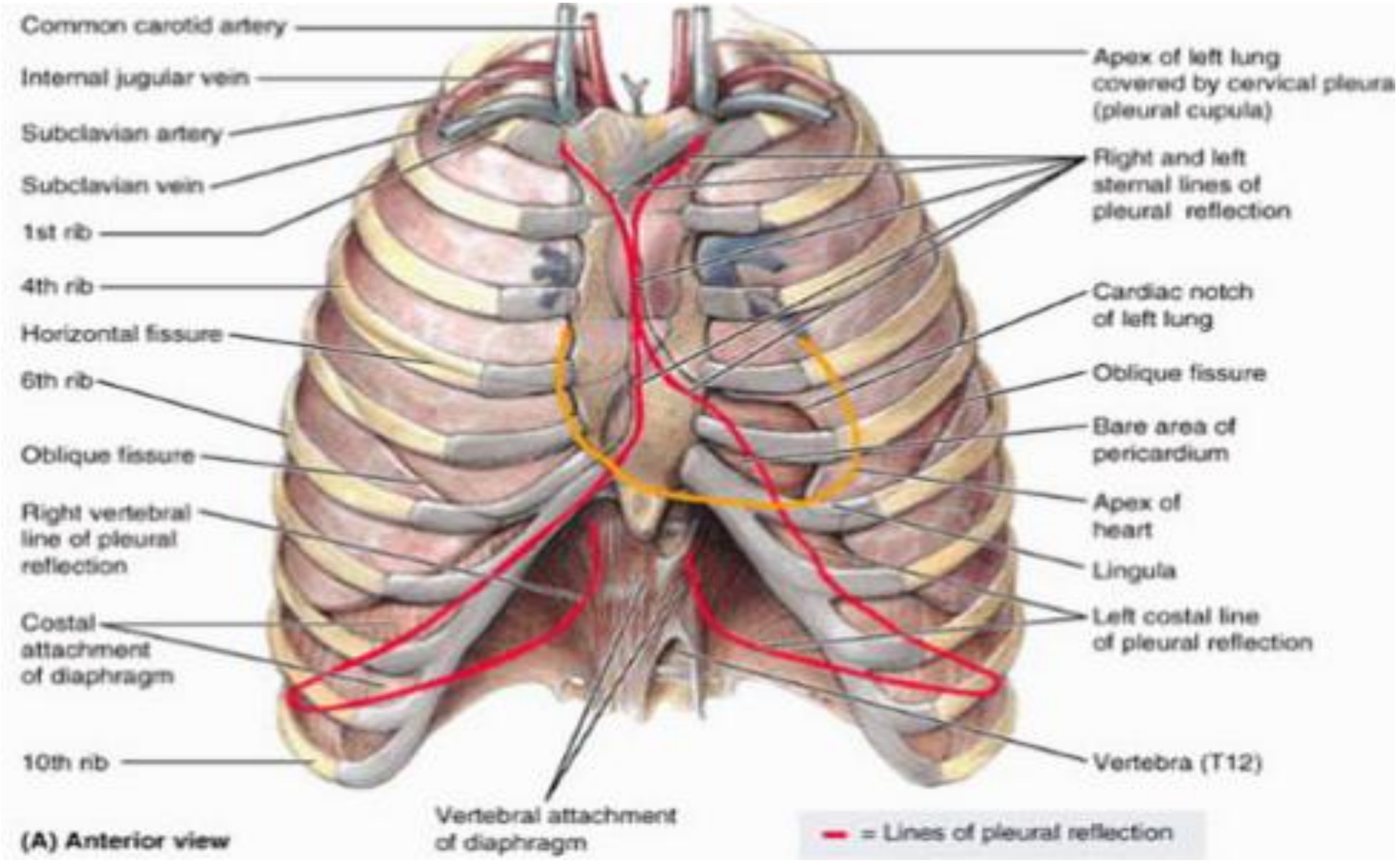
❖ ***celluloadipous tissue layer, lightly vascularised, analog of the extraperitoneal fascia:***

- thick, dense in the costal pleura;
- inexistent in the diaphragmatic pleura;
- the zone of the costodiaphragmatic space - frenicopleural fascia;
- very dense, very thick at the pleural dome - „fibrous cupola”.

THE PLEURA

THE REFLEX ZONES OF THE PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu



THE PLEURA

THE SUSPENSORY LIGAMENTS OF THE PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The 4 parts in connection with the fibers of the pleural dome:

1. ***The anterior scalene muscle*** (small scalene muscle);
2. ***The vertebropleural ligament*** - from the prevertebral fascia to the dome;
3. ***The costopleural ligament*** – units the pleura with the col of the first rib;
4. ***The pulmonary ligament***.

THE PLEURA
THE PULMONARY LIGAMENT
Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The medial margin, in off the mediastinum, reported to:

- *The right margin of the esophagus*, on the right side;
- **Pericardium + thoracic** part of the descendent aorta, on the left side;
- The *lateral margin* in relationship with the *mediastinal face* of the inferior lobe;
- The *superior margin*, on the right inferior side of the pulmonary pedicle, the inferior pulmonary vein;
- The *inferior margin*, quite variable, the two foils can be reflected on the diaphragm or above it.

THE PLEURA

Edith Simona Ianosi
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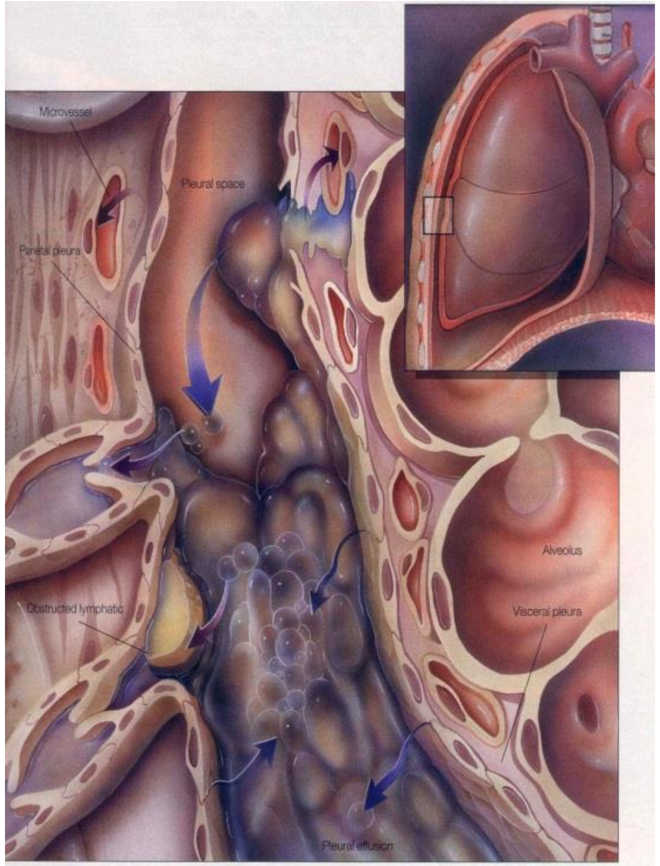
- ***The drainage direction of the pleural fluids*** through the parietal pleural lymphs, which opens in intercostal lymphs and towards the parasternal, periaortic and subdiaphragmatic lymph nodes and vessels.
- ***The efferents*** – toward the thoracic canal which opens in the right subcl. Vein.
- ***The lymphs of the visceral pleura*** - in connection with the bronchial ones, pedicles of the lungs and mediastinum.



Jeffrey M. Shea, Venkatesh Donty, Pulmonary - Critical Care Associates of East Texas

THE ROLES OF THE PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- Role in ***the volume control*** and ***the pleural fluid*** composition, which assures *the efficient mechanic plugging* of the lung to the thoracic wall.

- ***The pleura*** assures the lung motion together with the thoracic wall.
- If the lung *adheres* **directly** to the wall, the *expansion* in inspiration or the retraction in expiration is **smaller** as it happens in *the pleural symphysis* or in *the fibrothorax*.

- ***The visceral pleura assures mechanic support for the lung:***
- ➢ It has contribution in the lungs' shape determination;
- ➢ Due to subpleural conj. tissue as in continuation of the conjunctive tissue of the lung, the visceral pleura helps in the dispensation of the forces produced by the P neg. from the inflation period equal on the whole lung;
- ➢ In this way the superdispensation of the alveoles from the pleural surface is blocked reducing the risk of a PTX.

THE ROLES OF THE PLEURA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

- ***The pleural space*** is *considered* a **„tamponade"** space, for *safety* and *protection* **against** *the alveolar edema* in condition of *growing* hydrostatic P (**cardiac insufficiency**) or **interstitial capillary permeability.**

- ***Forming the transsudatum/hydrothorax*** in **IC** *reflects* **the motion** of *the edema* from *the lung* into a space where *the effects* of *the edema* on **the respiratory functions** are *much more* **smaller.**

- ***The mesothelial cells*** have a *metabolic function*: can *secrete* **macromolecular components** of *the extracellular matrix*, *fibrinolytic substances* and *chemotactic factors* of **the neutrophyles.**

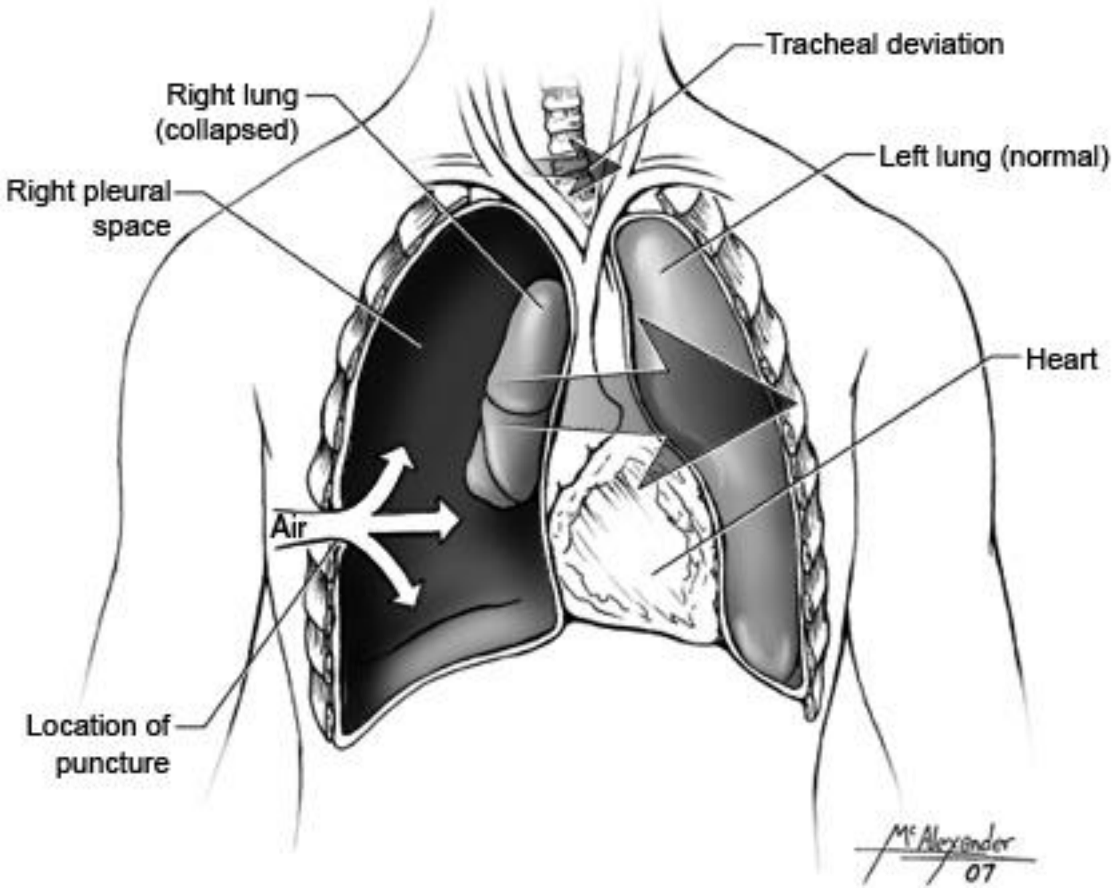
THE PLEURA

THE POSTTRAUMATIC PNEUMOTHORAX

Edith Simona Ianosi

Marilena Crisan

Gabriela Jimboreanu



THE PLEURA

THE TOTAL PNEUMOTHORAX

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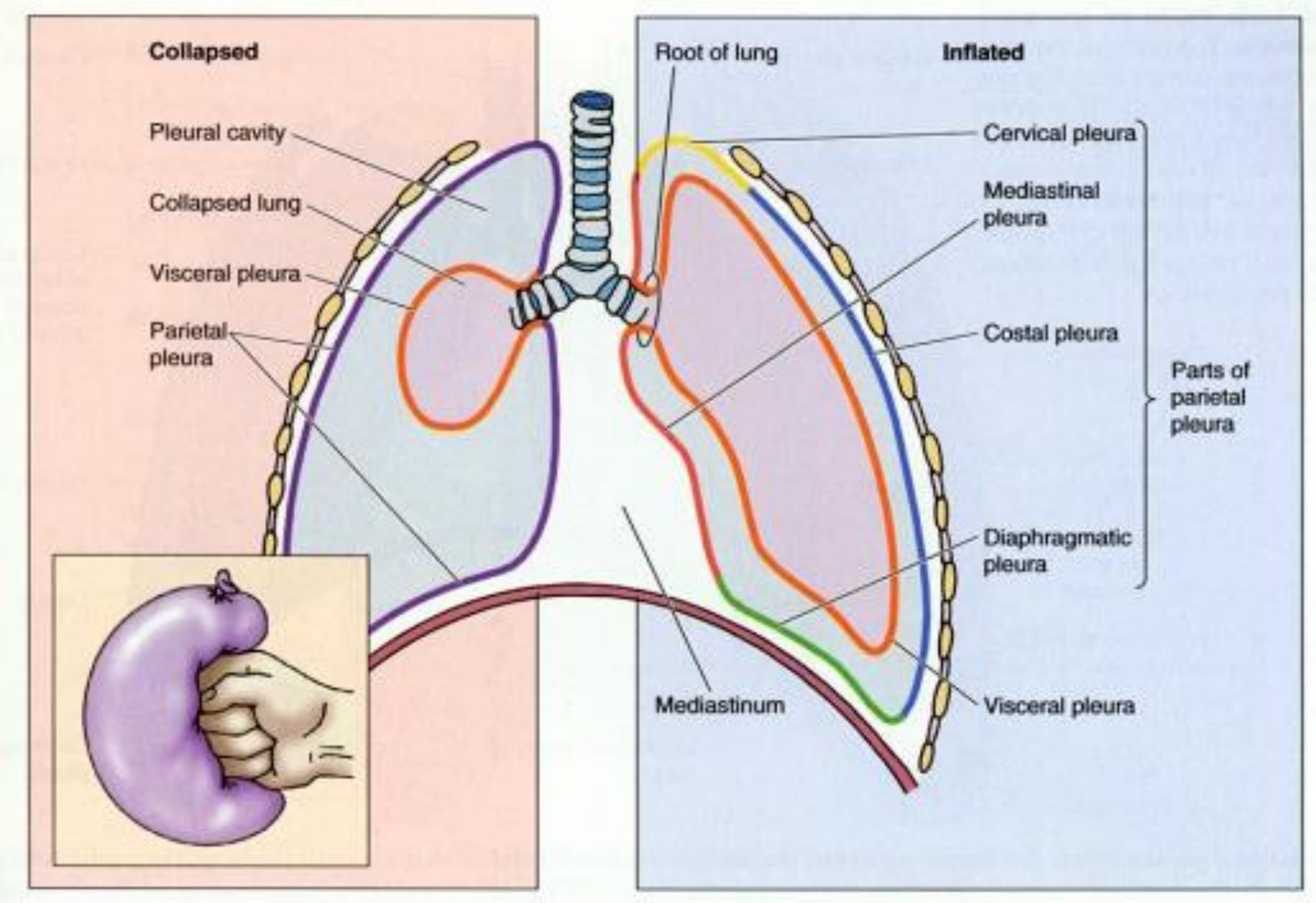
Marilena Crisan
Gabriela Jimboreanu



From Moore & Dalley 1999

THE PLEURA

THE CLASSIFICATION OF THE PNEUMOTHORAX

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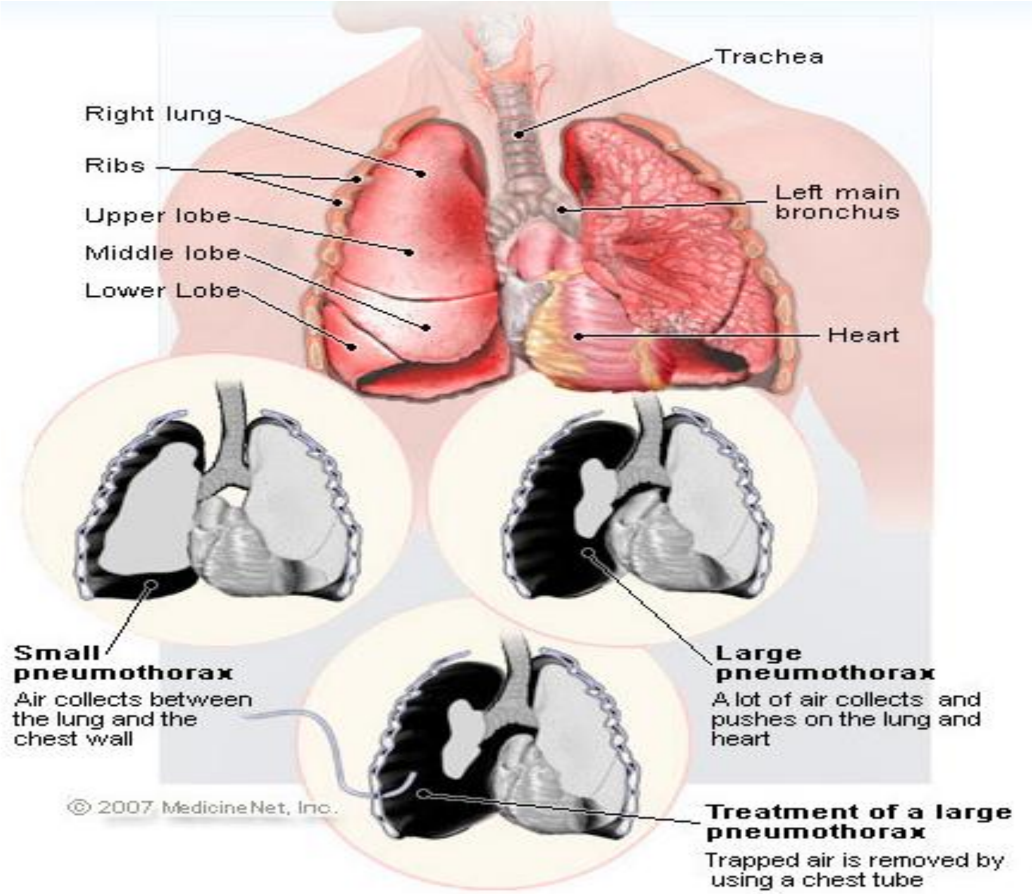
Marilena Crisan
Gabriela Jimboreanu



THE PLEURA

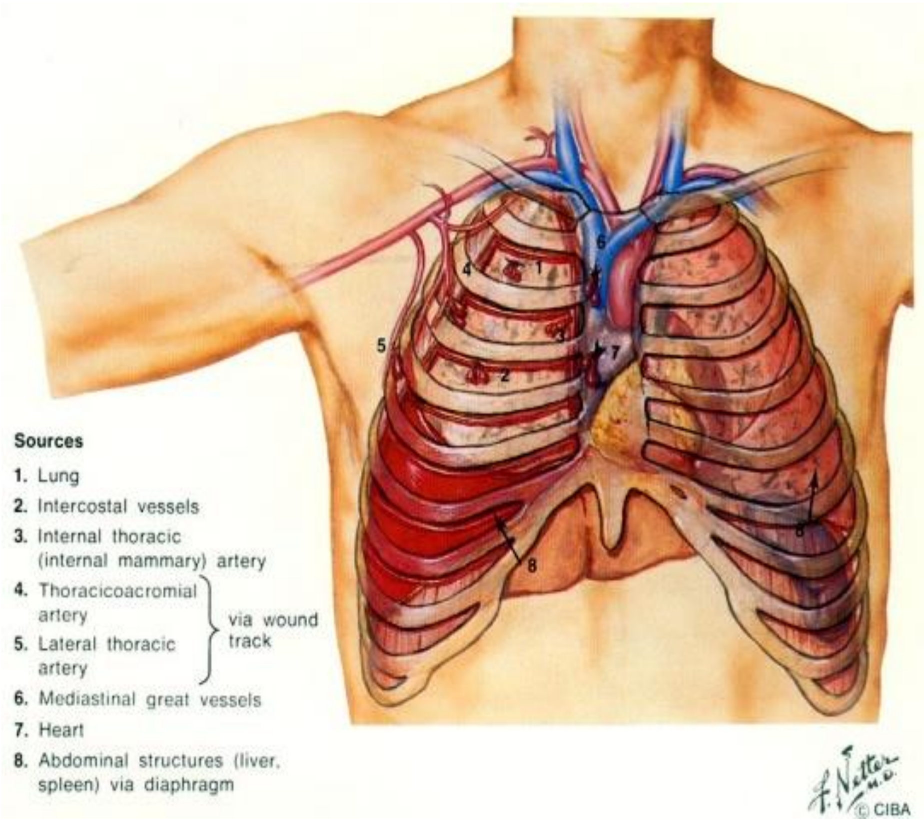
THE HEMOTHORAX

Edith Simona Ianosi

Marilena Crisan

Gabriela Jimboreanu

- Posttraumatic bleeding;
- Numerous resources of bleeding;
- Massive hemothorax - hypovolemic shock;
- Restrictive ventilation;
- Pushing contralaterally of the mediastinum;
- Blood thrombi doesn't cause problems (except in case of a catether).



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THE PLEURA

THE CHYLOTHORAX

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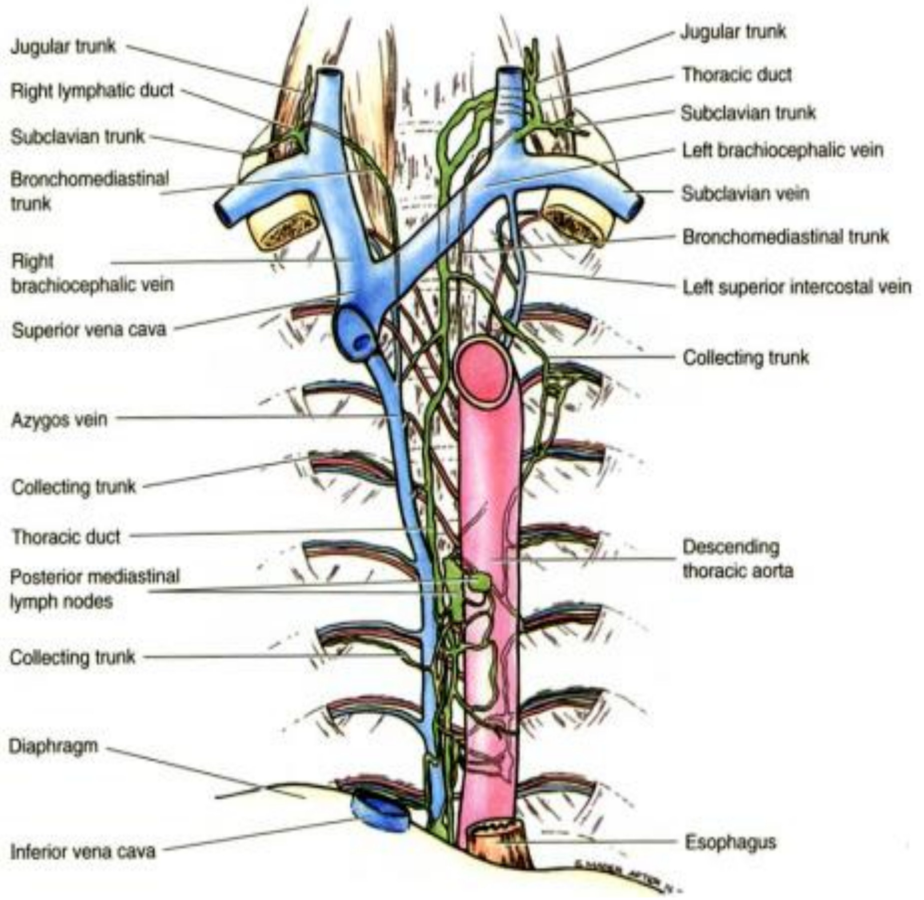

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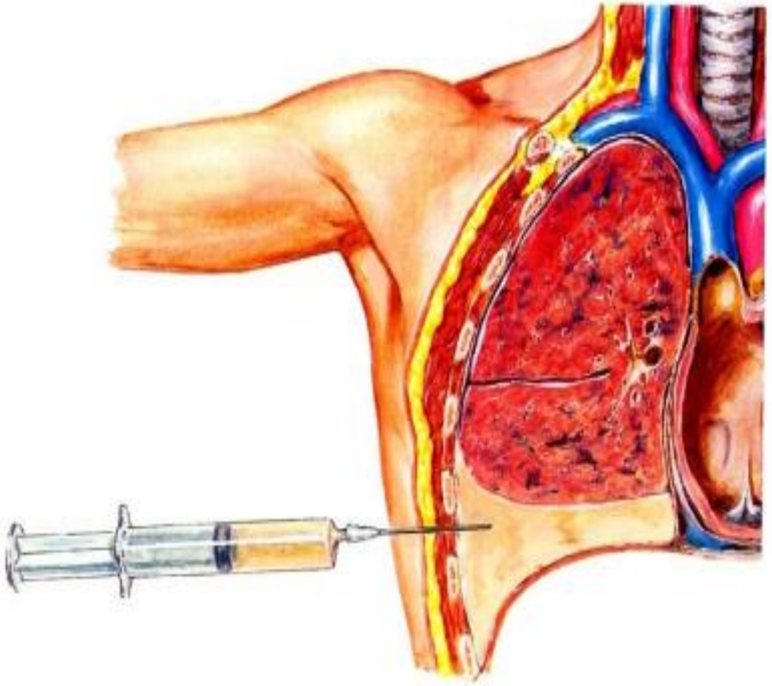

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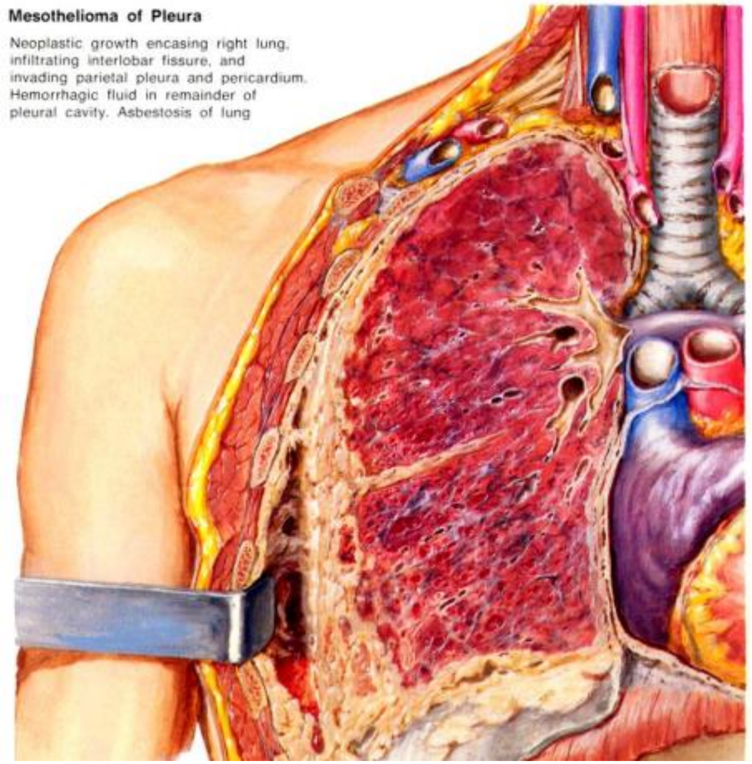
THE PLEURA

THE PLEURAL MESOTHELIOMA

Edith Simona Ianosi
Marilena Crisan
Gabriela Jimboreanu

The Asbestos Exposition:

- More frequently found in the parietal pleura, but also the visceral one;
- Can lead to the compression of all the organs of the affected hemothorax.



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LESSON 2: *The Breathing Physiology And Physiopathology*

Lectors:

Lavinia Davidescu, Oradea, Romania

LESSON 2

THE BREATHING PHYSIOLOGY AND PHYSIOPATHOLOGY

THE MAIN TOPICS:

1: THE MECHANICS OF BREATHING
2: THE COUPLING OF THE LUNG AND THE CHEST WALL
3: PRESSURE-VOLUME RELATIONSHIPS
4: FACTORS INFLUENCING PULMONARY VENTILATION
5: LUNG COMPLIANCE AND LUNG ELASTANCE
6: VOLUMES, CAPACITIES AND FUNCTION TESTS
7: PULMONARY FUNCTION TESTS AND CO2 TRANSPORTATION
9: REGULATION AND CONTROL OF BREATHING
10: THE CENTRAL CONTROLLER AND VENTILATION
11: THE RESPIRATORY MUSCLES AND SENSORS
12: THE CARBON DYOXIDE AND OXYGEN EFFECTS
13: THE GAS EXCHANGE AND GAS TRANSPORT
14: THE EFFECTS OF PARTIAL PRESSURE OF O2

THE MECHANICS OF BREATHING

Lavinia Davidescu

- **Ventilation** is the *exchange* of **air** *between* the *external* **environment** and **the alveoli;**
- Air *moves* by **bulk** flow from *an area* of **high** *pressure* to **low pressure;**
- The **pressure** in the *respiratory system* is relative to the *atmospheric pressure* (760 mm/Hg at sea level).

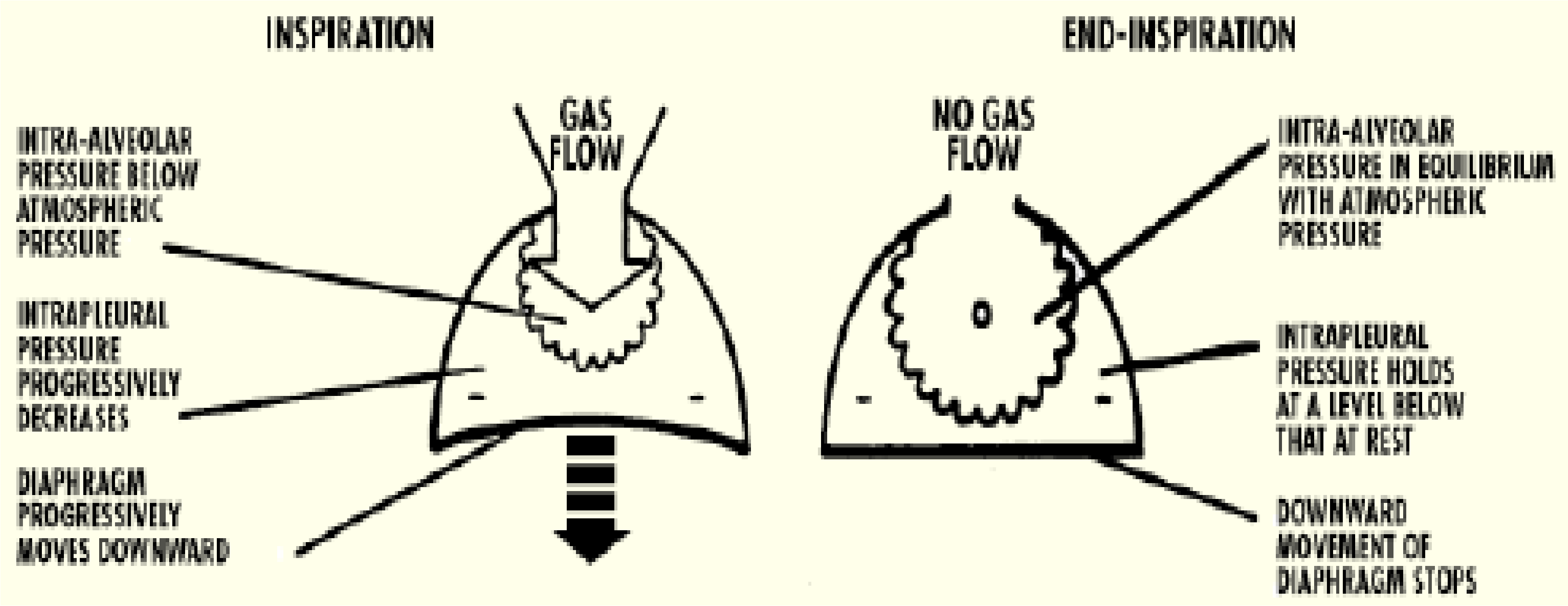
THE MECHANICS OF BREATHING

Lavinia Davidescu

- **Inspiration** - is the *active part* of *the breathing process*, which is **initiated** by **the respiratory control center**;
- **Contraction** of *the diaphragm* and *intercostal muscles* lead to an **expansion** of **thoracic cavity** and a *decrease* in **the pleural space pressure**;
- In **normal** *breathing* **the diaphragm** *moves* **downward** about 1 cm, but *on forced inspiration/expiration* **total** *movement* could **be up to 10cm**;
- **Fresh air** flows *along* **the branching airways** into *the alveoli* until **the alveolar pressure** *equals* to **the pressure** at *the airway opening*.

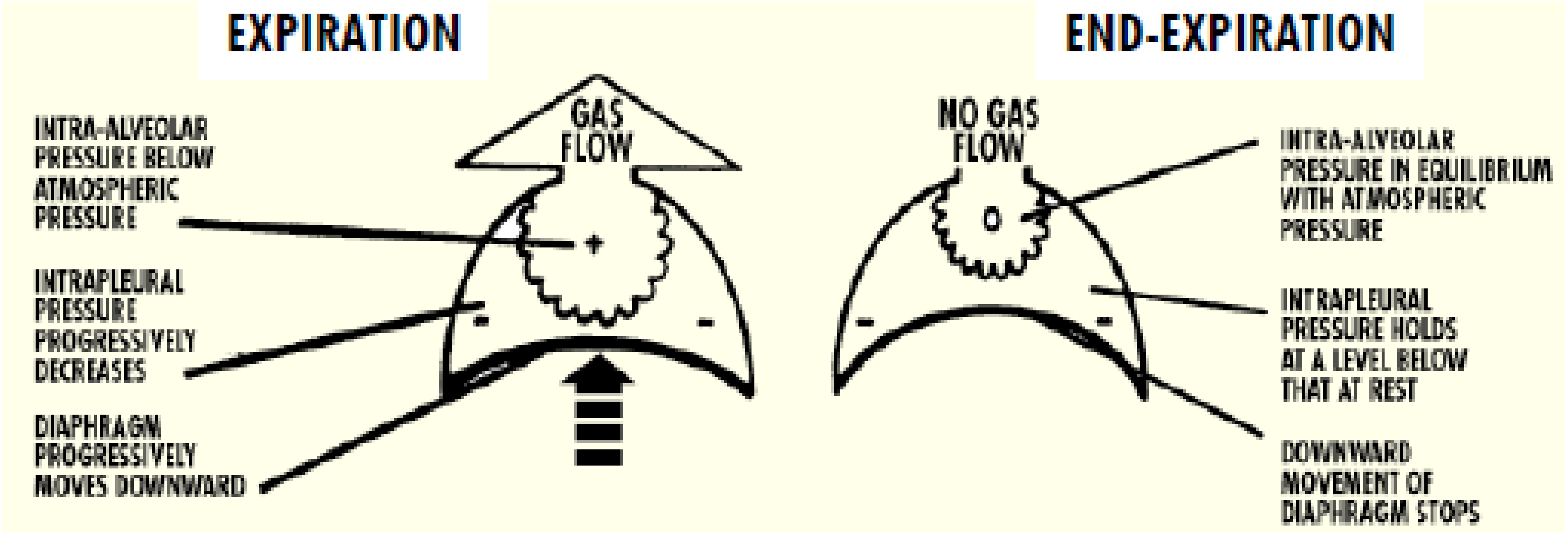
THE MECHANICS OF BREATHING

Lavinia Davidescu



THE MECHANICS OF BREATHING

Lavinia Davidescu



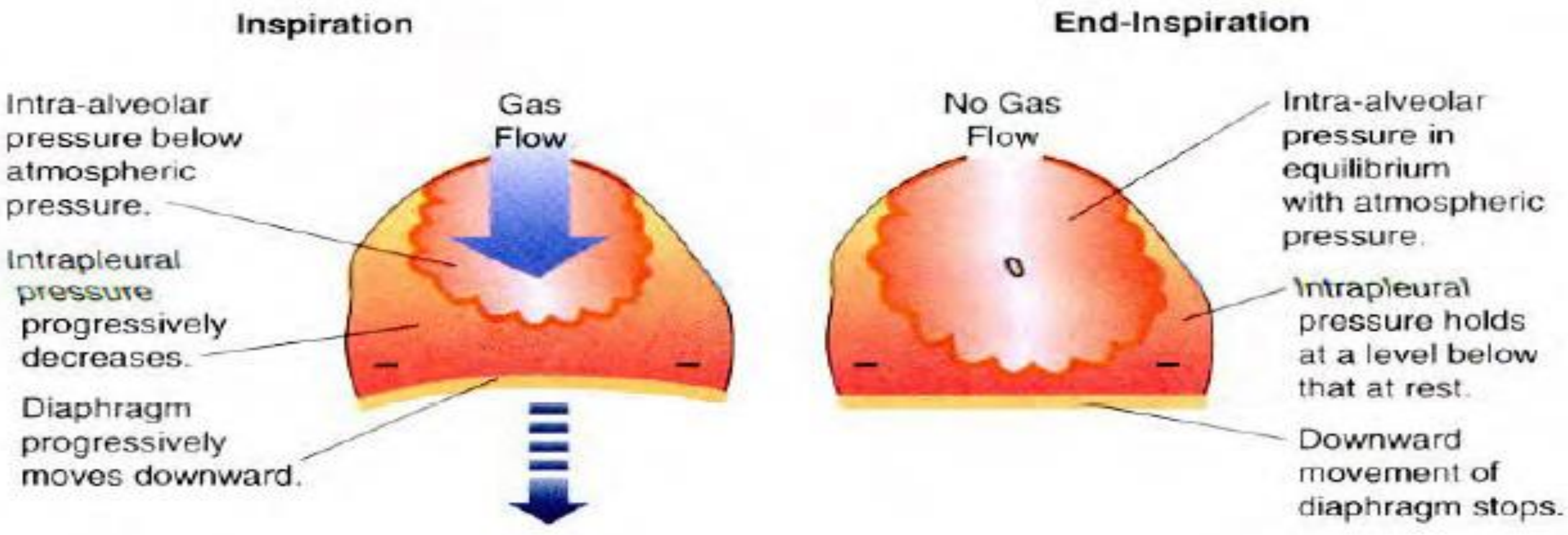
THE MECHANICS OF BREATHING

Lavinia Davidescu

- **Expiration** is a *passive* event due to *elastic recoil* of **the lung**;
- **Diaphragm relaxes** - moves up, *thoracic volume decreases*, lung (pleural) pressure *decreases* air moves out;
- **Quiet expiration (exhalation)** - simple elasticity of the lungs DECREASES volume INCREASED **pulmonary pressure -> movement of air out of the lungs**;
- **Forced expiration** - *contraction of abdominal* **wall muscles** (i.e. oblique & transversus abdominus) further DECREASES volume **beyond** relaxed point ----> further INCREASE in pulmonary pressure ---> more air moves out.

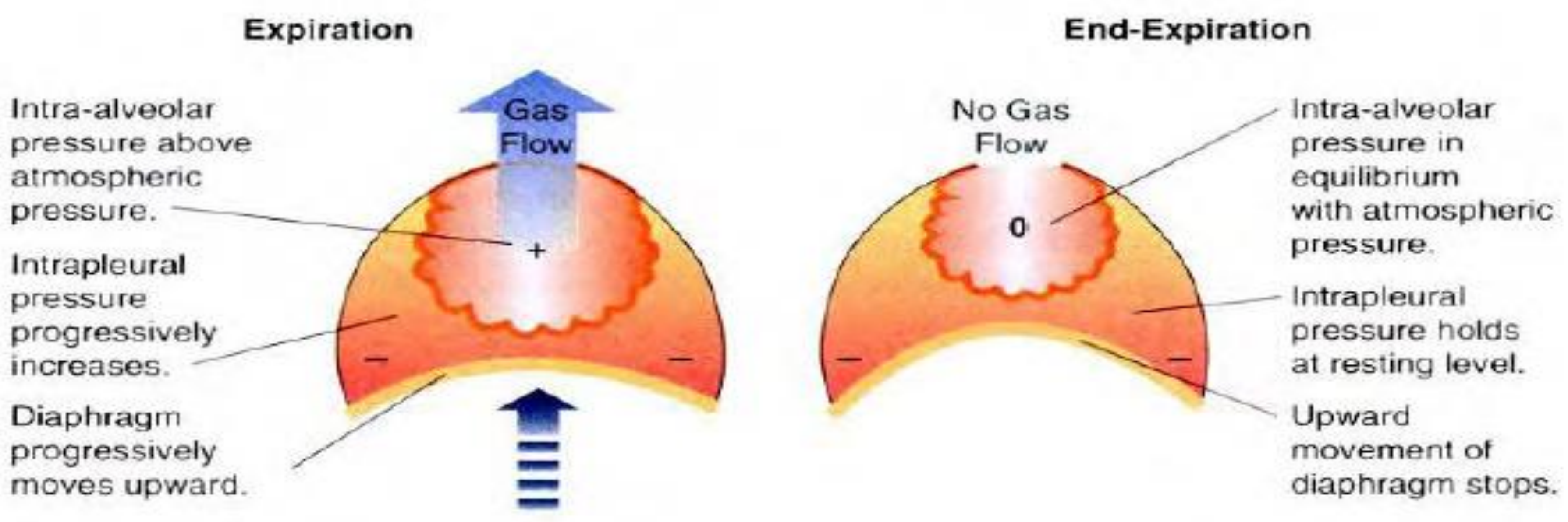
THE MECHANICS OF BREATHING

Lavinia Davidescu



THE MECHANICS OF BREATHING

Lavinia Davidescu



THE COUPLING OF THE LUNG AND THE CHEST WALL

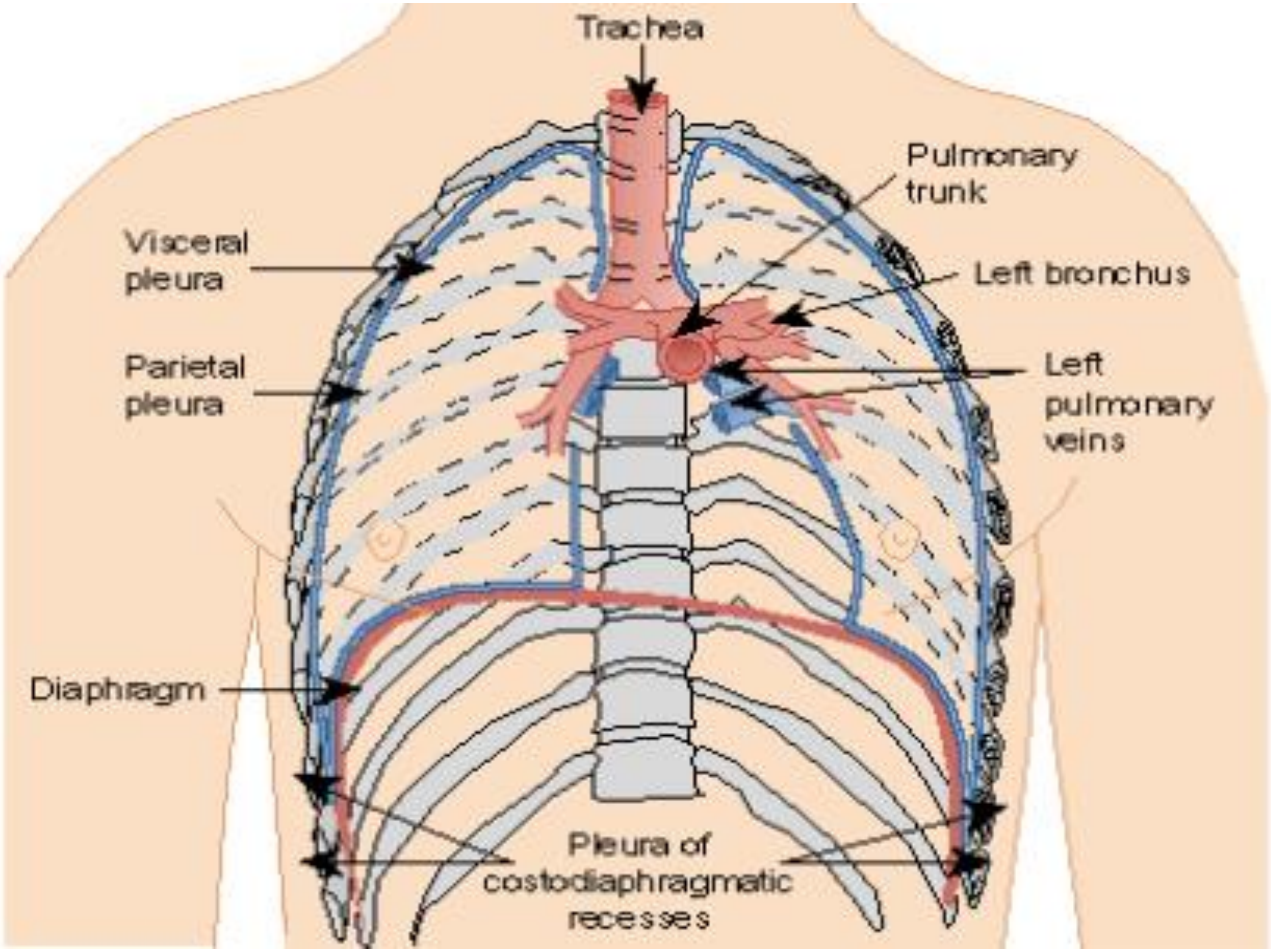
Lavinia Davidescu

- **The lungs** are *not directly* **attached** to *the chest wall* but they *change* their **volume** and **shape** according to the *changes* in **shape** and **volume** of the thoracic cavity.

- **Pleura** covering *the surfaces* of **the lungs** (visceral) or **the thoracic cavity** (parietal) *together* with a thin (20 μ m) *layer of liquid* between *them* create a *liquid coupling*.

THE COUPLING OF THE LUNG AND THE CHEST WALL

Lavinia Davidescu



PRESSURE-VOLUME RELATIONSHIPS

Lavinia Davidescu

- **Atmospheric air pressure** 760 mm Hg (at sea level);
- **Negative air pressure** - LESS than 760 mm Hg;
- **Positive air pressure** - MORE than 760 mm Hg;
- **Intra-pleural pressure** - pressure within the pleural "balloon" which surrounds the lung;
- **Intrapulmonary pressure** - pressure within the alveoli (tiny sacs) of the lung itself.

PRESSURE-VOLUME RELATIONSHIPS

Lavinia Davidescu

Boyle's Law on Volume/Pressure Relationships

- Volume is INVERSELY proportional to Pressure;
- INCREASE in Volume -> DECREASE in Pressure;
- DECREASE in Volume -> INCREASE in Pressure;
- VOLUME change --> PRESSURE change gas flows to equalize the pressure;

FACTORS INFLUENCING PULMONARY VENTILATION

Lavinia Davidescu

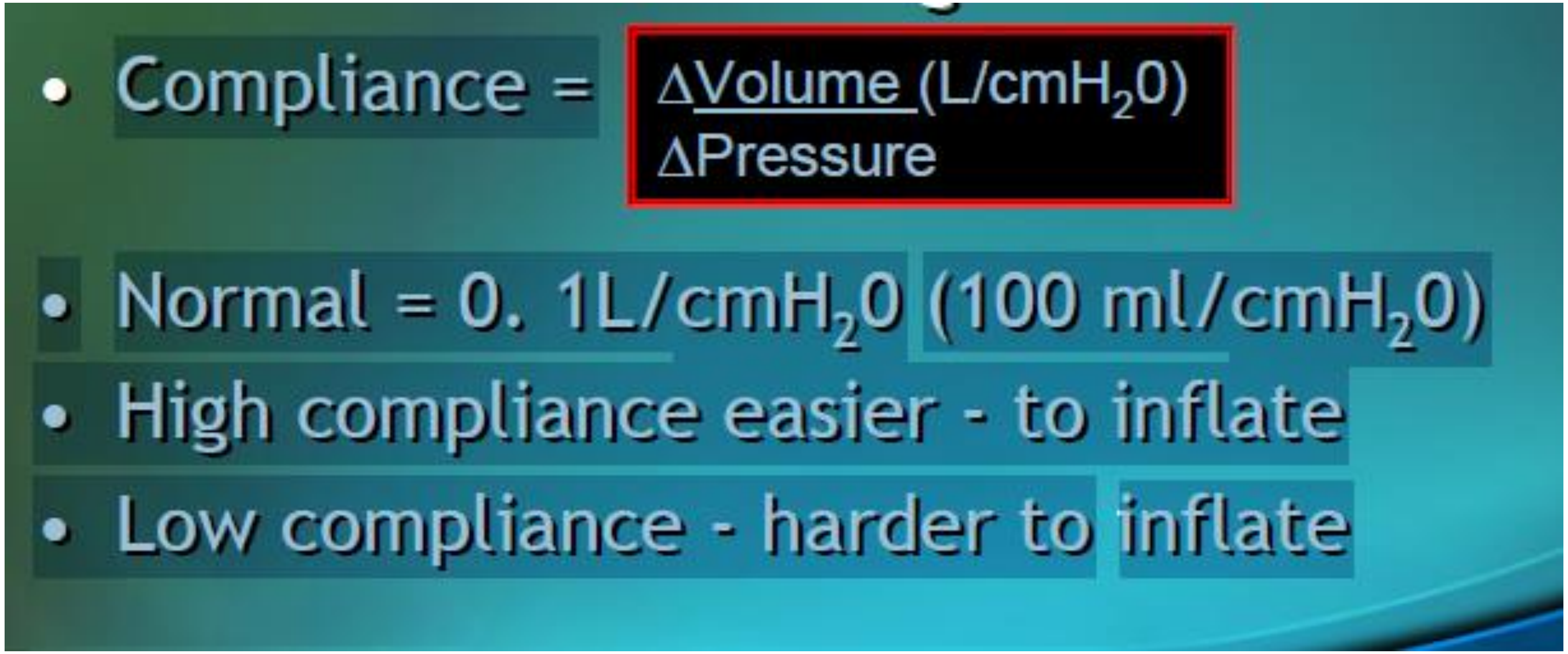
- ***Respiratory Passageway Resistance***;
- ***Upper Respiratory Passageways*** - relatively large, very little resistance to airflow (unless there's an obstruction, such as from food lodging or cancer);
- ***Lower Respiratory Passageways*** - from medium-sized bronchioles on down, can alter diameter based on autonomic stimulation.

a. **Parasympathetic** - causes bronchoconstriction;
b. **Sympathetic** - inhibits bronchoconstriction.

LUNG COMPLIANCE

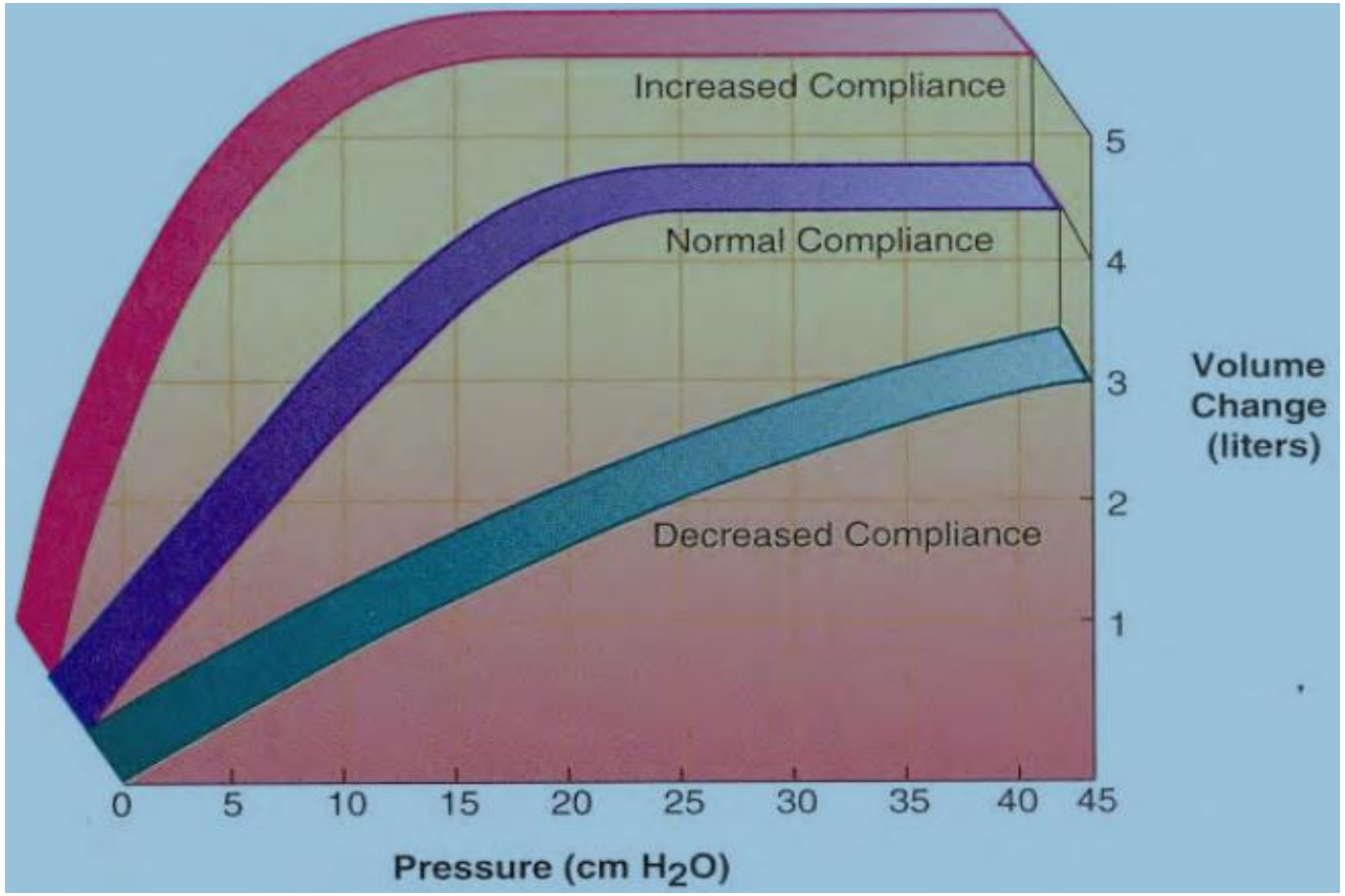
Lavinia Davidescu

- ***Lung Compliance*** - the ease with which lungs can be expanded by muscle contraction of thorax.



LUNG COMPLIANCE

Lavinia Davidescu

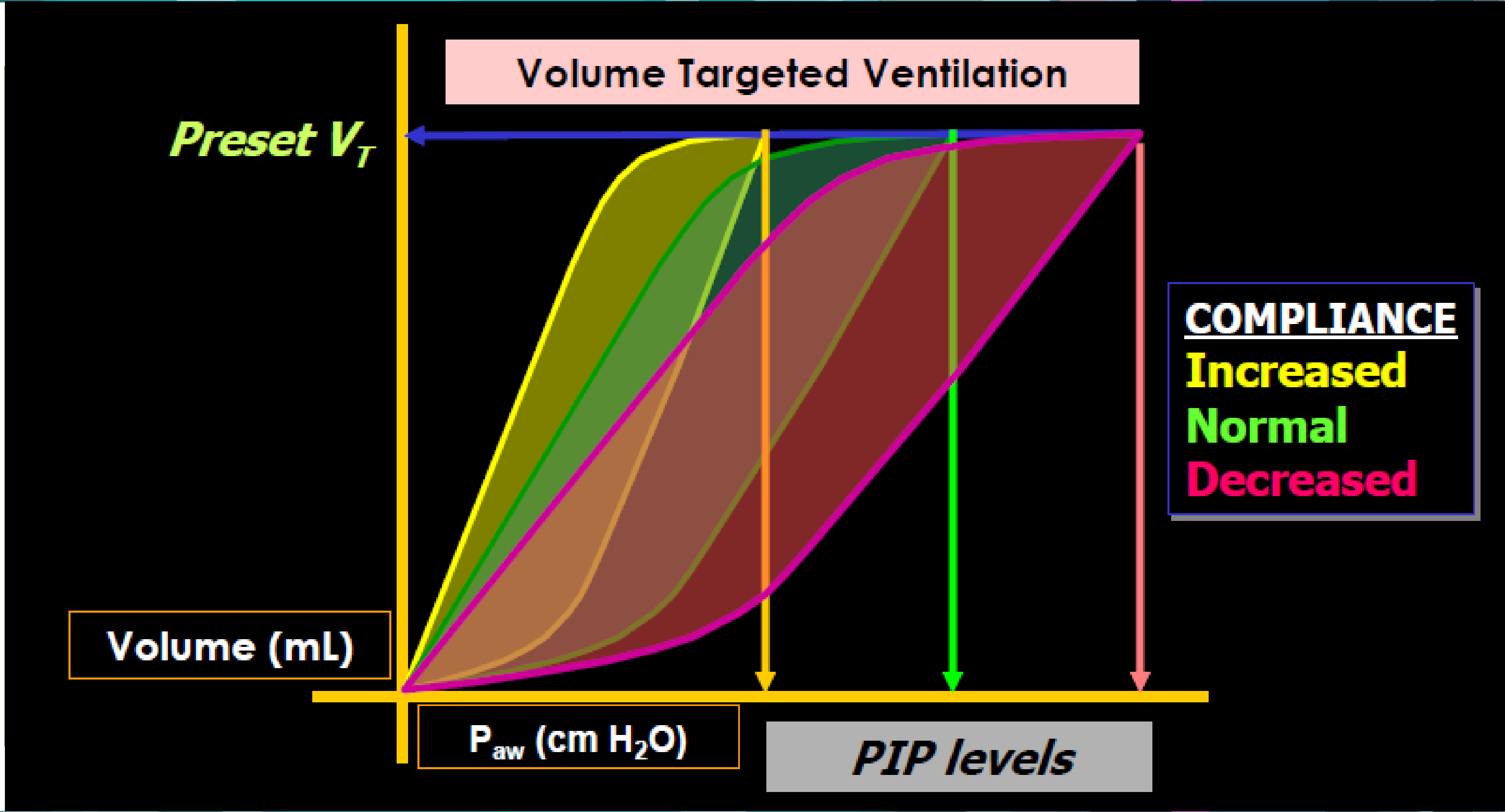


Cardiopulmonary Anatomy and Physiology. Terry Des Jardins. 3rdEd. Delmar. Albany, NY.1998

LUNG COMPLIANCE

CHANGES AND THE PV-LOOP

Lavinia Davidescu



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LUNG COMPLIANCE

OVERDISTENSION

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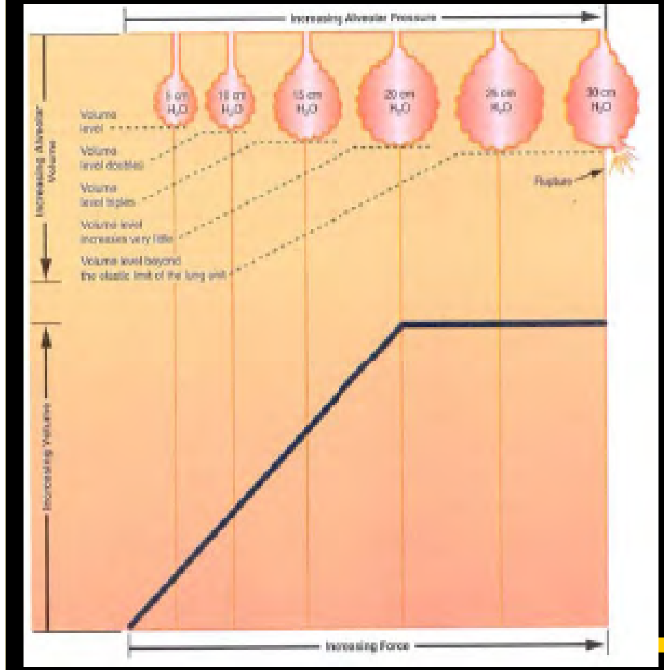

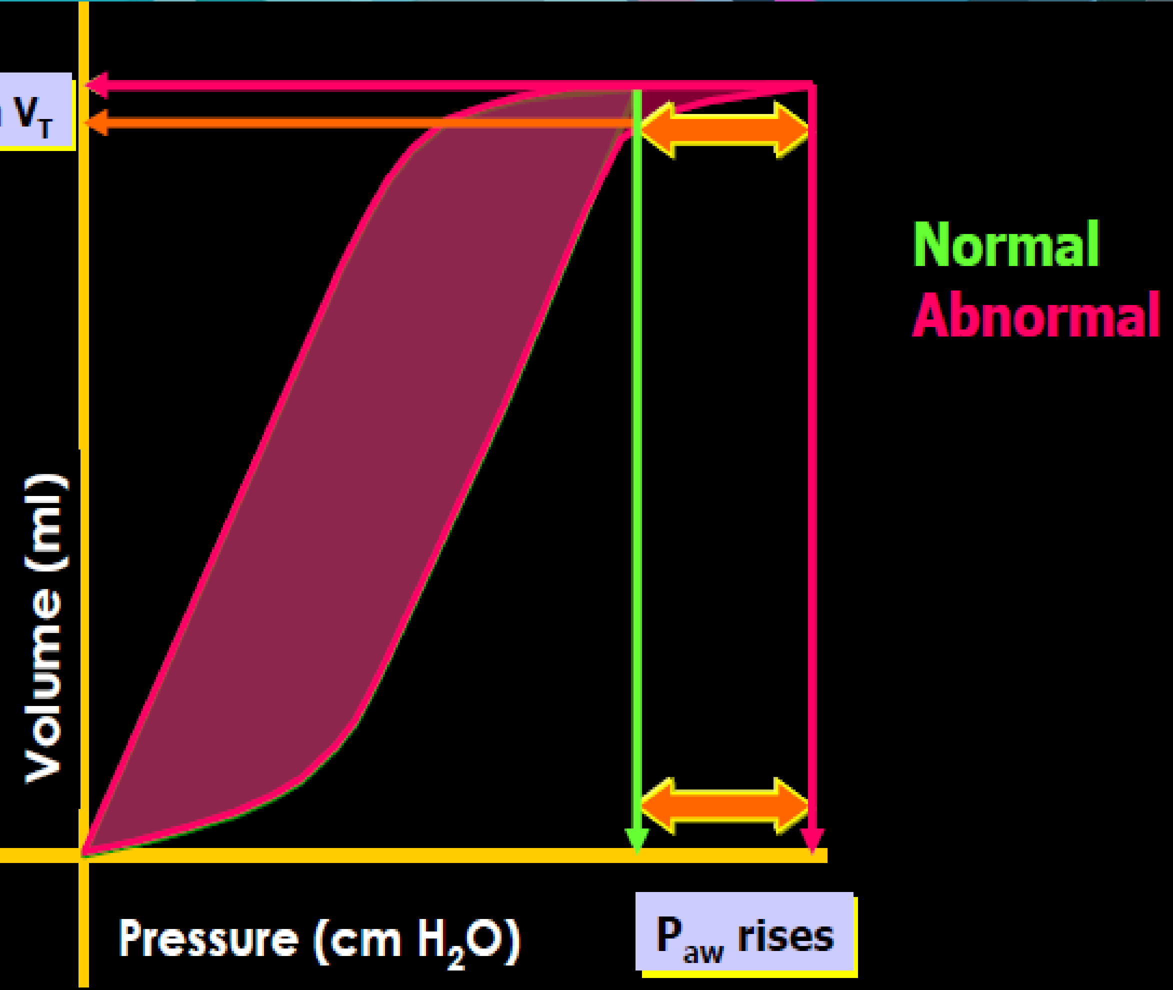

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LUNG COMPLIANCE

Lavinia Davidescu

Compliance is reduced when:

- The pulmonary venous pressure is increased and the lung becomes engorged with blood;
- There is alveolar edema due to insufficiency of alveolar inflation;
- The lung unventilated e.g. atelectasis;
- Diseases causing fibrosis of the lung e.g. chronic restrictive lung disease.

Compliance is increased in:

- Chronic obstructive pulmonary disease, Emphysema.

LUNG ELASTANCE

Lavinia Davidescu

Amount of work required to exhale:

- Elastance = $\frac{\Delta \text{Pressure } (\text{cmH}_2\text{0/L})}{\Delta \text{Volume}}$
- Reciprocal of compliance
- Good compliance = bad elastance
- Bad compliance = good elastance

LUNG RESISTANCE

Lavinia Davidescu

Amount of work required to move air through the lungs:

- Resistance = $\frac{\text{Pressure}}{\text{Flow}}$ ($cmH_20/L/sec$)
- Primarily influenced by airway diameter
- Normal = 0.6 - 2.4 $cmH_20/L/sec$

VOLUMES, CAPACITIES AND FUNCTION TESTS

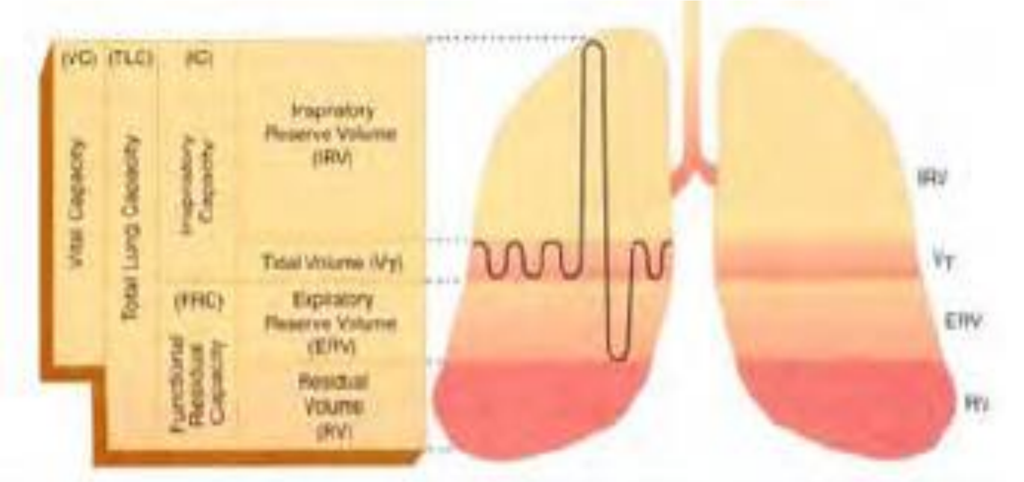
Lavinia Davidescu

VOLUMES:

- Tidal Volume (VT);
- Inspiratory Reserve Volume (IRV);
- Expiratory Reserve Volume (ERV);
- Residual Volume (RV).

CAPACITIES:

- Inspiratory Capacity (IC);
- Vital Capacity (VC);
- Functional Residual Capacity (FRC);
- Total Lung Capacity (TLC);



VOLUMES, CAPACITIES AND FUNCTION TESTS

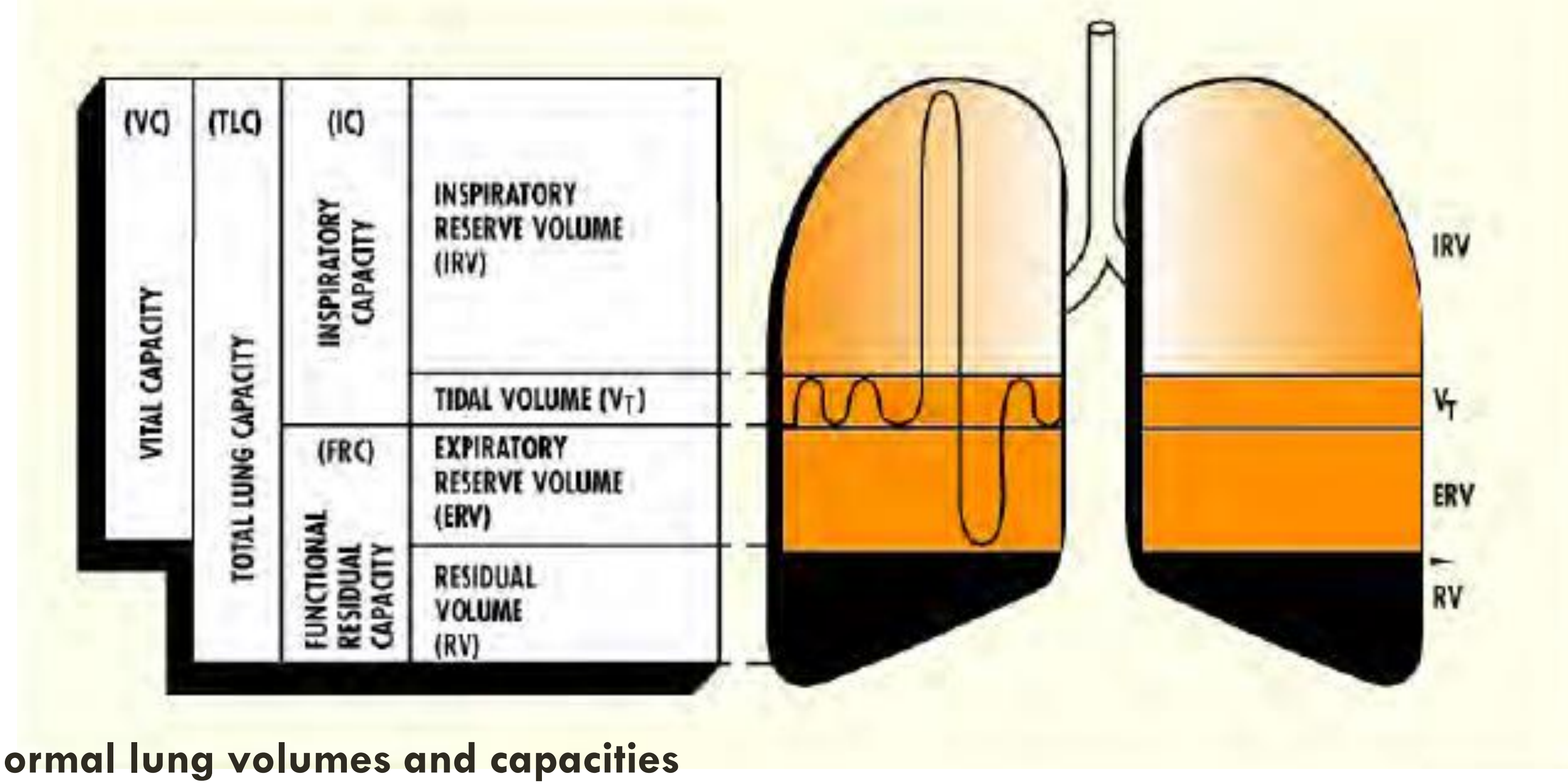
Lavinia Davidescu

Respiratory VOLUMES (20 years old healthy male, 155 lbs.)

- ***Tidal Volume (TV)*** - normal volume moving in/out (0.5 L);
- ***Inspiratory Reserve Volume (IRV)*** - volume inhaled AFTER normal tidal volume when asked to take deepest possible breath (2.1-3.2 L);
- ***Expiratory Reserve Volume (ERV)*** - volume exhaled AFTER normal tidal volume when asked to force out all air possible (1.- 2.0 L);
- ***Residual Volume (RV)*** - air that remains in lungs even after totally forced exhalation (1.2 L).

VOLUMES, CAPACITIES AND FUNCTION TESTS

Lavinia Davidescu



Normal lung volumes and capacities

IRV=Inspiratory Reserve Volume **RV**= Residual Volume **ERV**=Expiratory Reserve Volume **VT**=Tidal Volume **VC**=Vital Capacity **IC**=Inspiratory Capacity **FRC**=Functional Residual Capacity **TLC**=Total Lung Capacity

PULMONARY FUNCTION TESTS

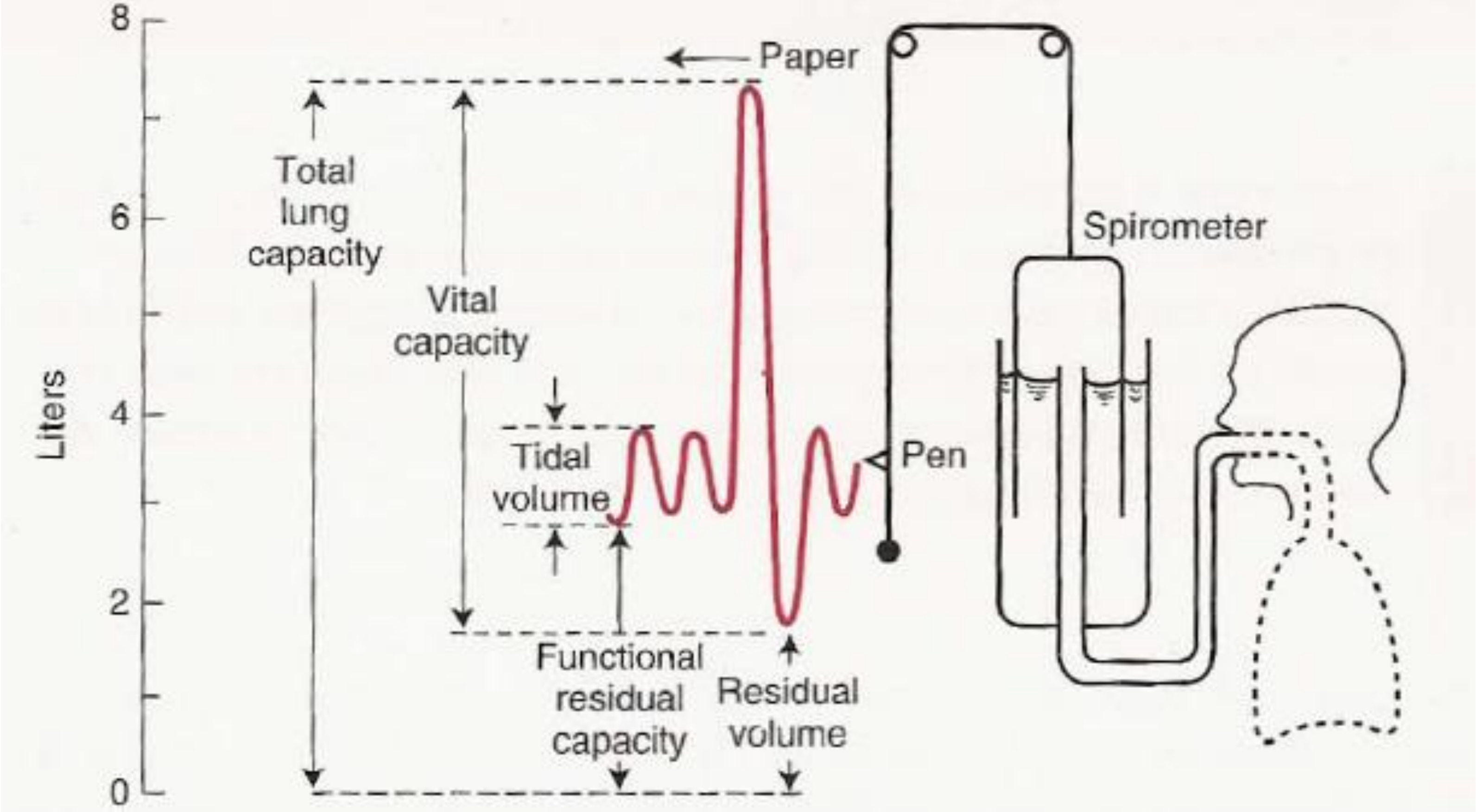
Lavinia Davidescu

Spirometer - measures volume changes during breathing

- **Obstructive Pulmonary Disease** - increased resistance to air flow (bronchitis or asthma);
- **Restrictive Disorders** - decrease in *Total Lung Capacity* (TB or polio)
- *Minute Respiratory Volume* (MRV) - total volume flowing in & out in 1 minute (resting rate = 6 L per minute);
- **Forced Vital Capacity** (FVC) - total volume exhaled after forceful exhalation of a deep breath;
- **Forced Expiratory Volume** (FEV) - FEV volume measured in 1 second intervals (FEV1...).

PULMONARY FUNCTION TESTS

Lavinia Davidescu



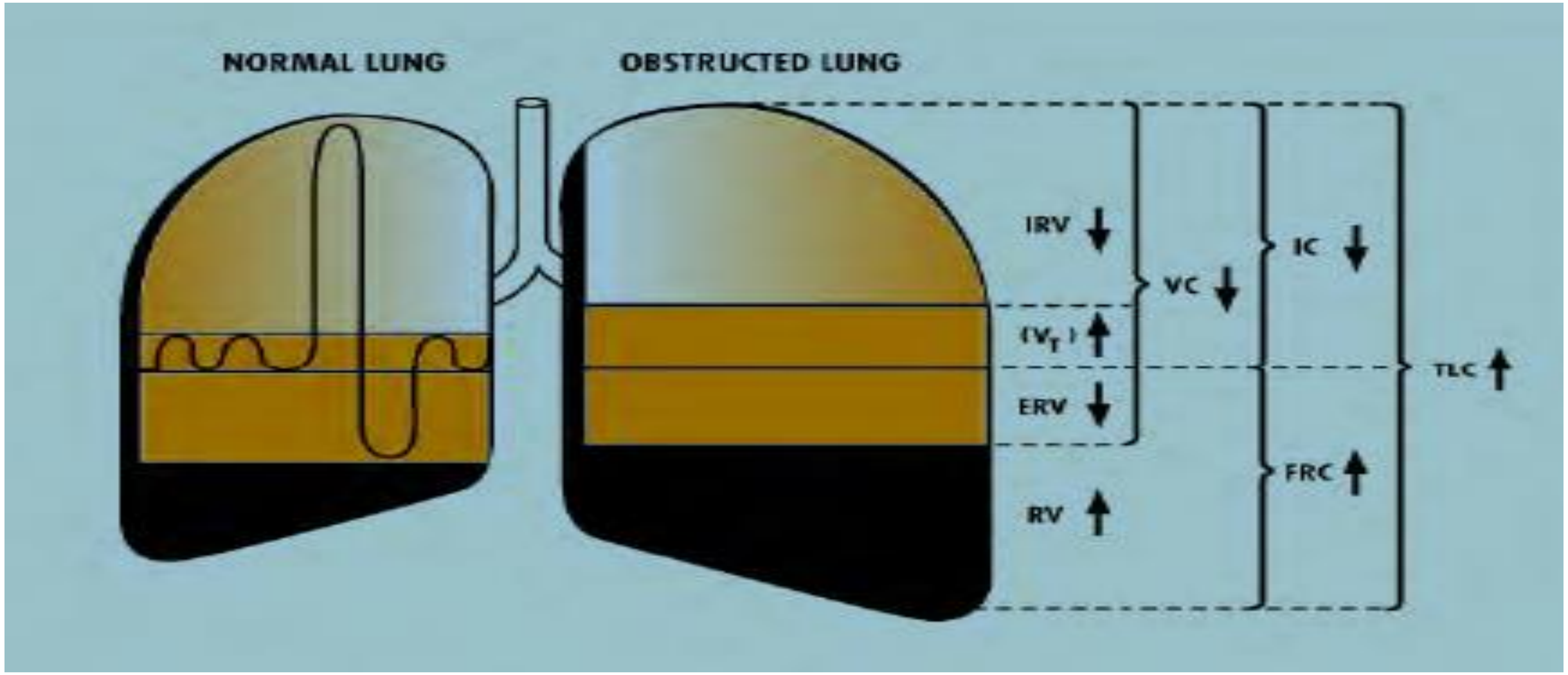
Lung volumes. Note that the total lung capacity, functional residual capacity and residual volume cannot be measured with the spirometer.

Lung Volumes

- Tidal volume and vital capacity can be measured with a simple spirometer;
- Total lung capacity, functional residual capacity and residual volume need an additional measurement by helium dilution or the body plethysmograph.
- Helium is used because of its' very low solubility in blood;
- The body plethysmograph depends on Boyle's Law PV=K at constant temperature.

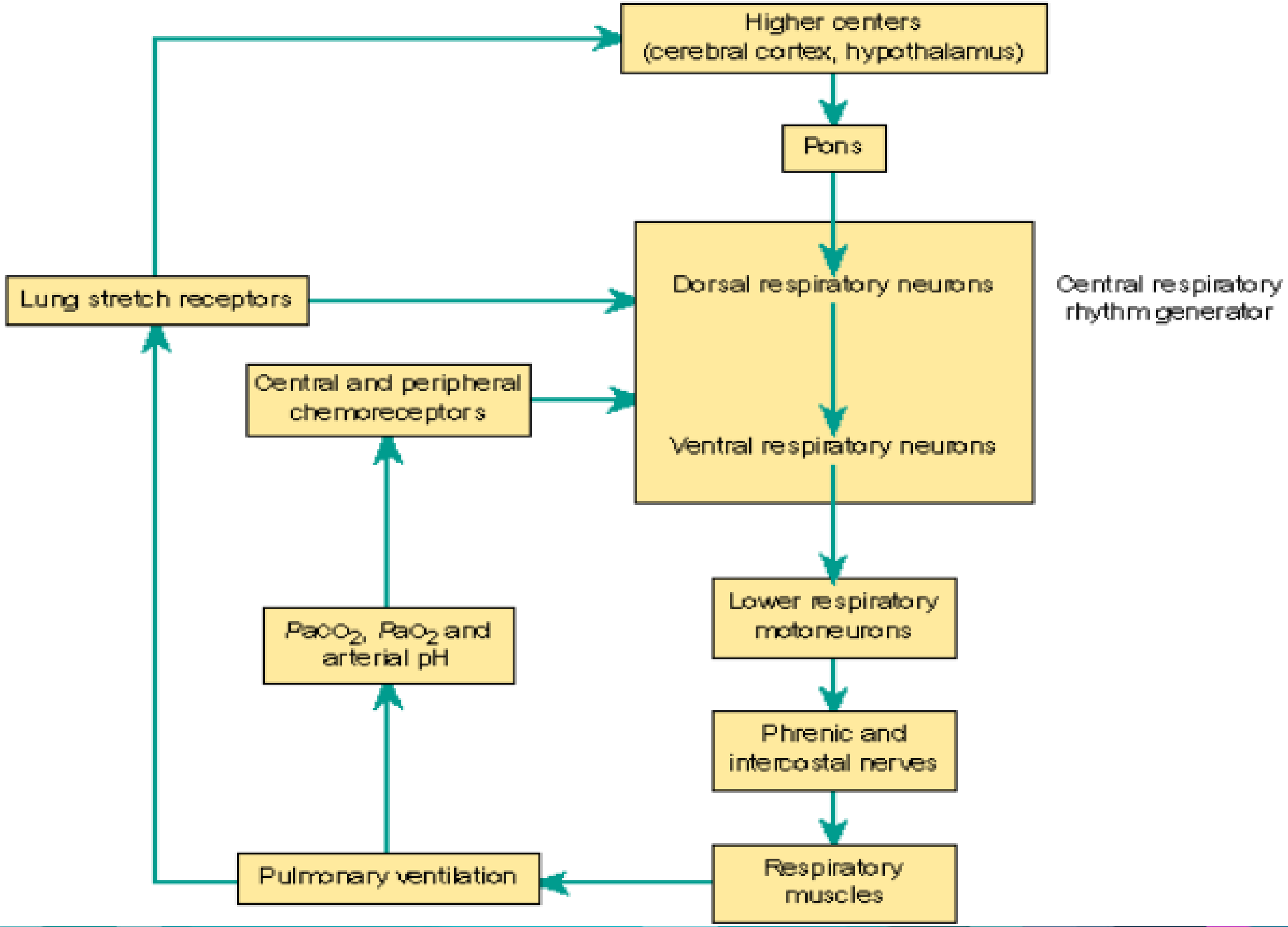
PULMONARY FUNCTION TESTS

Lavinia Davidescu



REGULATION AND CONTROL OF BREATHING

Lavinia Davidescu



REGULATION AND CONTROL OF BREATHING

Lavinia Davidescu

The basic elements of the respiratory control system are:

- Strategically placed sensors;
- The central controller;
- The respiratory muscles

THE CENTRAL CONTROLLER

Lavinia Davidescu

- **Breathing** is mainly controlled at the level of brainstem;
- **The normal automatic** and **periodic nature** of breathing is triggered and controlled by the respiratory centers located in the pons and medulla;

The Medullary Respiratory Center:

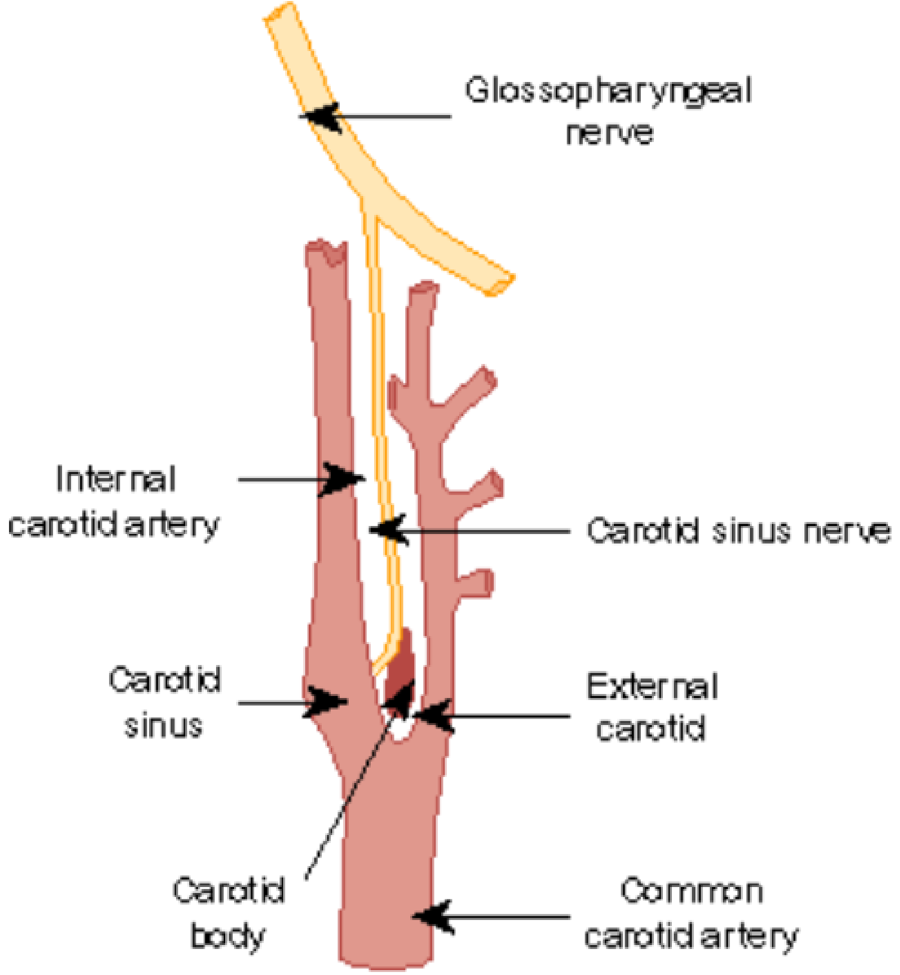
- *Dorsal medullary respiratory neurons* - associated with inspiration;
- *Ventral medullary respiratory neurons* - associated with expiration;
- *Amnestic Centre* - is located in the lower pons;
- *Pneumotaxic center* - is located in the upper pons.

THE RESPIRATORY MUSCLES

Lavinia Davidescu

- **Diaphragm, intercostal muscles** and **the other accessory respiratory muscles** work in co-*ordination* for normal breathing under ***the central controller***;

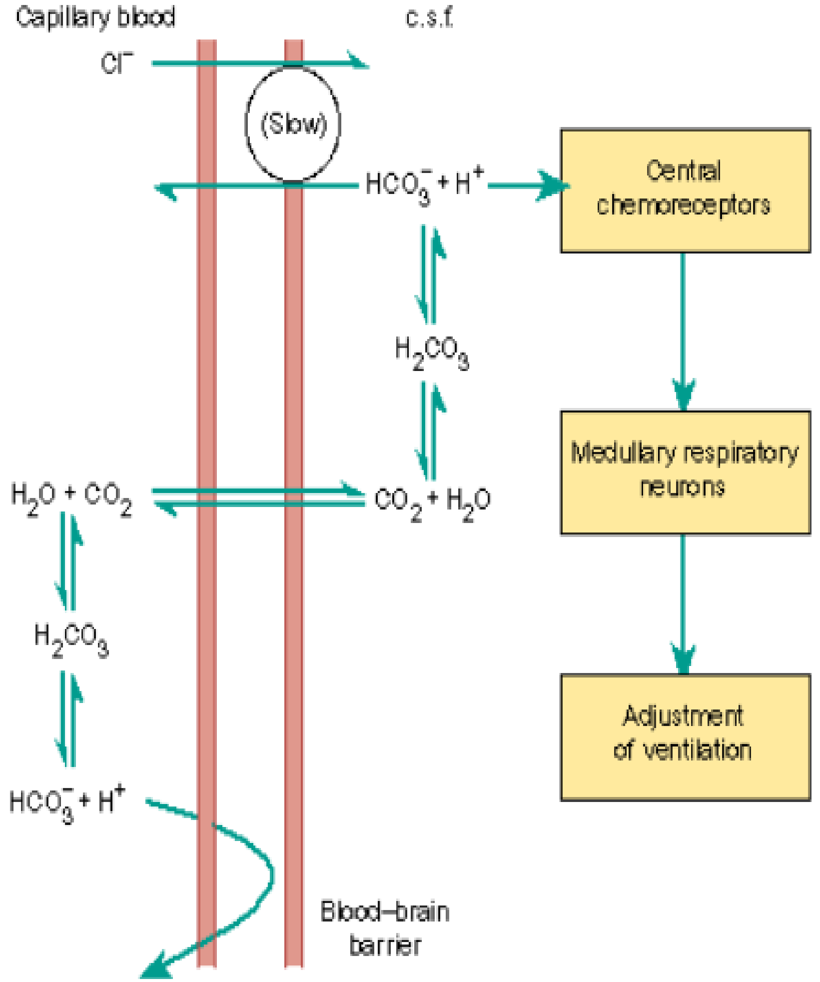
- *In premature new-born babies* this **co-ordination** is not *mature* enough and *this could be* ***responsible*** for the *sudden* infants' *death syndrome.*



SENSORS

Lavinia Davidescu

- **Mechanoreceptors** - are placed in the bronchi and bronchioles walls, the main function of these receptors being to prevent the over inflation;
- **Chemoreceptors** - are specialized neurons activated by changes in O2 and CO2 levels in the blood and in the brain tissue;
- They are *involved* in the regulation of respiration according to the *changes* in **PO2** and **pH;**
- **Peripheral chemoreceptors** - located in the large vessels of neck.



THE CARBON DYOXIDE EFFECTS

Lavinia Davidescu

- **Powerful chemical regulator of breathing** by increasing H+ (lowering pH);

- **Hypercapnia** - Carbon Dioxide increases -> Carbonic Acid increases ->pH of CSF decreases (higher H+)>DEPTH & RATE increase (hyperventilation);

- **Hypocapnia** - abnormally low Carbon Dioxide levels which can be produced by excessive hyperventilation; breathing into paper bag increases blood Carbon Dioxide levels.

THE OXYGEN EFFECTS

Lavinia Davidescu

- **Aortic and Carotid Bodies** - oxygen chemoreceptors;
- **Slight O2 decrease** - modulate CO2 receptors;
- **Large O2 decrease** - stimulate increase ventilation;
- **Hypoxic drive** - chronic elevation of CO2 (due to disease) causes Oxygen levels to have greater effect on regulation of breathing;
- **Acidosis** - acid buildup (H+) in blood, leads to increased RATE and DEPTH (lactic acid).

THE GAS EXCHANGE: LUNGS, BLOOD, TISSUES

Lavinia Davidescu

- ***External Respiration*** (Air & Lungs);
- ***Partial Pressure Gradients & Solubilities;***
- **Oxygen**: alveolar (104 mm) ---> blood (40 mm);
- ***Carbon Dioxide***: blood (45 mm) ---> alveolar (40 mm) (carbon dioxide much more soluble than oxygen);

THE GAS EXCHANGE: LUNGS, BLOOD, TISSUES

Lavinia Davidescu

- ***Alveolar Membrane Thickness*** *(0.5-1.0 micron);*
- It's **very easy** for the gas to **diffuse** across *alveoli*;
- ***Edema*** - increases thickness, decreases diffusion;
- **Total Alveolar Surface Area for Exchange;**
- **Total surface area healthy lung** = 145 sq. meters;
- ***Emphysema*** - decreases total alveolar surface area.

VENTILATION: BLOOD FLOW COUPLING

Lavinia Davidescu

- low *Oxygen* in alveolus -> **Vasoconstriction;**
- high *Oxygen* in alveolus -> **Vasodilation;**
- high *Carbon Dioxide* in alveolus -> **Dilate Bronchioles;**
- low *Carbon Dioxide* in alveolus -> **Constrict Bronchioles.**

GAS TRANSPORT TO THE PERIPHERY

Lavinia Davidescu

- **Oxygen** is carried in the blood in two forms, dissolved and combined with hemoglobin (Hb);
- **Dissolved Oxygen:** the amount of oxygen dissolved in the blood is proportional to its' partial pressure;

- **Oxygen:** blood (104 mm) -> tissues (40 mm);
- **Dissolved CO_2;**
- **Carbon Dioxide:** tissues (>45 mm) -> blood (40 mm).

THE OXYGENS' TRANSPORT IN BLOOD:

HEMOGLOBIN

Lavinia Davidescu

- **Association** & **Dissociation of Oxygen** + **Hemoglobin;**

- **Oxyhemoglobin** (HbO_2) - oxygen molecule bound;
- **Deoxyhemoglobin** (HHb) - oxygen unbound;

$$H - Hb + O_2 \Leftarrow\!\!=\!\!=\!\!=\!\!\Rightarrow HbO_2 + H^+$$

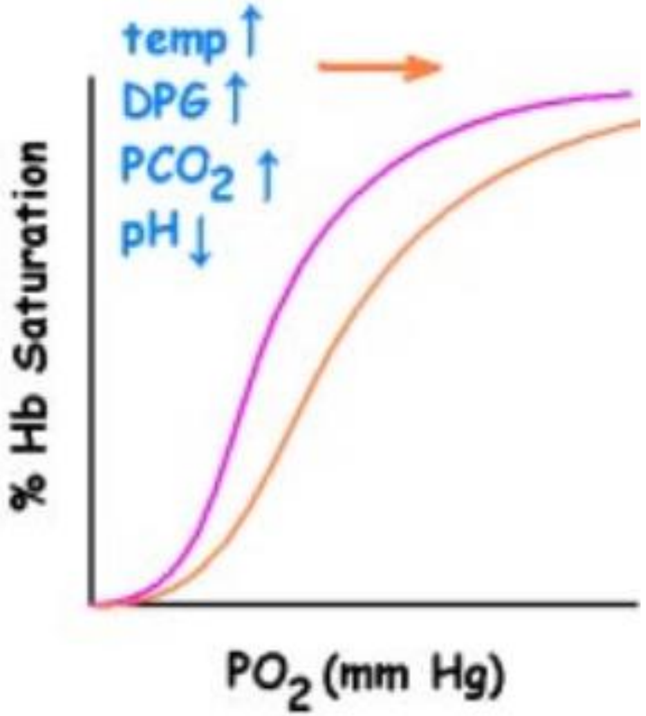
- **Binding** gets more efficient as each O_2 binds;
- **Release** gets easier as each O_2 is released.

THE EFFECTS OF PARTIAL PRESSURE OF O2

Lavinia Davidescu

Oxygen – the hemoglobin dissociation curve

- 104 mm (lungs) - 100% saturation;
- (20 ml/100 ml);
- 40 mm (tissues) - 75% saturation;
- (15 ml/100 ml);
- right shift - Decreased Affinity, more O2;
- unloaded;
- increase in H + concentration;
- increase in pCO2;
- increase in temp.;
- increase in the concentration of "phosphoglycerate" (DPG);
- left shift- Increased Affinity, less O2 unloaded.



THE TRANSPORT OF CARBON DIOXIDE

Lavinia Davidescu

CO_2 is carried in the blood in three forms:

- Dissolved **CO_2** in **Blood Plasma** (7-10%);
- **Bound to Hemoglobin** (20-30%)- carbaminohemoglobin – CO_2 binds to an amino acid on the polypeptide chains;
- **The Haldane Effect** - the less oxygenated the blood is, the more CO_2 it can carry;
- **Tissues** - as Ox is unloaded, affinity for CO_2 increases;
- **Lungs** - as Ox is loaded, affinity for CO_2 decreases, allowing it to be released.

THE TRANSPORT OF CARBON DIOXIDE

Lavinia Davidescu

- Bicarbonate Ion Form in Plasma (60-70%);
- Carbon Dioxide combines with water to form Bicarbonate;

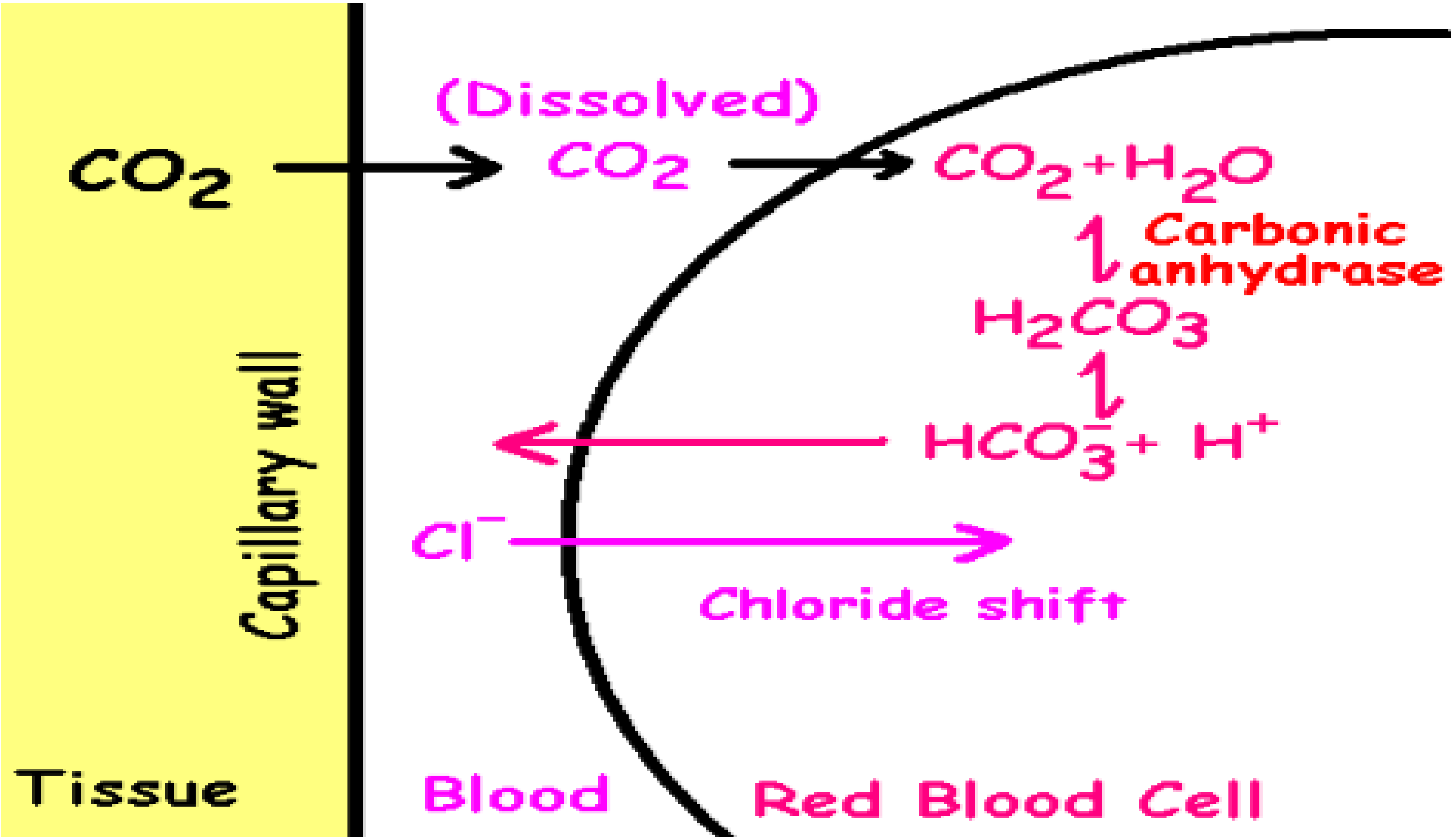
  $CO_2 + H_2O \Longleftrightarrow H_2CO_3 \Longleftrightarrow H^+ + HCO_3^-$
- **The Bohr Effect** – the formation of Bicarbonate (through Carbonic Acid) leads to LOWER pH (H^+ increase), and a lot of unloading of the Ox to tissues.

The Carbon Dioxides' Effects on the bloods' pH:

- low pH--> HCO_3 - binds to H^+;
- high pH--> H_2CO_3 - releases H^+;
- low shallow breaths--> HIGH CO_2--> LOW pH;
- rapid deep breaths--> LOW CO_2--> HIGH pH.

THE TRANSPORT OF CARBON DIOXIDE

Lavinia Davidescu



LESSON 3: *Lungs and Pleura Imagining*

Lectors:

Oreste Straciuc, Oradea, Romania

LESSON 3

LUNGS AND PLEURA IMAGINING

THE MAIN TOPICS:

1: THE RADIOLOGICAL ANATOMY

2: IMAGISTIC METHODS OF DIAGNOSTIC:

CONVENTIONAL METHODS, DIGITAL RADIOGRAPHY, RADIOLOGICAL SEMIOLOGY, COMPUTED TOMOGRAPHY, DETECTIONS AND CALCULATIONS, IMAGE ELEMENTS AND VARIATIONS, CT RECONSTRUCTIONS, HRCT, PET/CT, PROTECTION METHODS, DOSAGE, THE INJECTING, MONITORING, THE PATIENTS PREPARATIONS, THE PNEUMATIC PROCESS, THE ADVANTAGES AND DISADVANTAGES.

Radiological Anatomy

'Thoracic'

Oreste Straciuc

- *The delimitation;*
- *The thoracic wall;*
- *The diaphragm;*
- *The mammary glands.*

Radiological Anatomy
'Pleural'
Oreste Straciuc

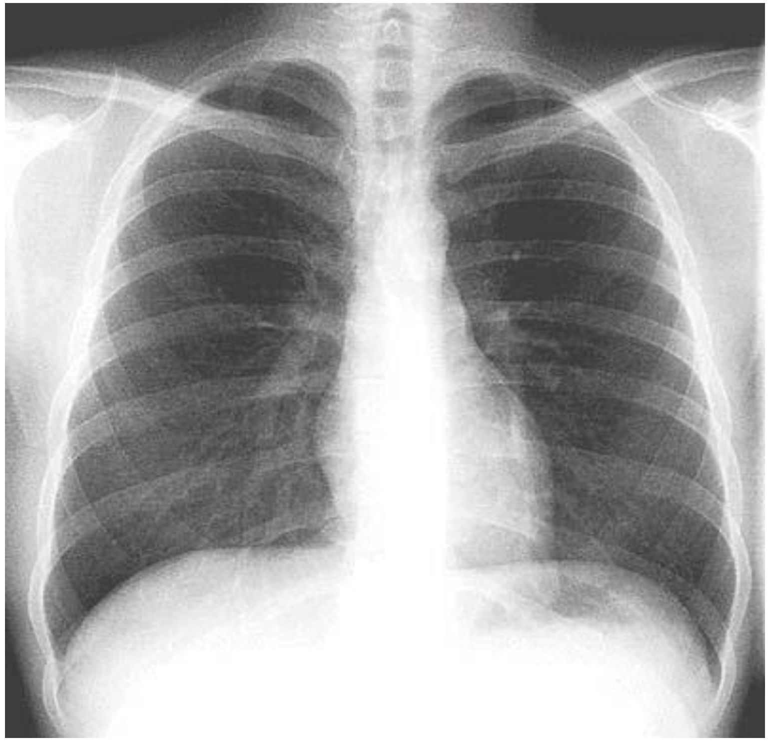
- **The parietal leaf;**
- **The visceral leaf** (furrows).
- **The pleural cavity** - pleural fluid.
- **The casto-phrenic** and **cardio-phrenic sinuses** (recesses, angles).

Radiological Anatomy
'Mediastinal'
Oreste Straciuc

- **Structural and pathological complexity!**
- **anterior-superior** - thymus, VCS, aortic arch and its' branches, trachea;
- **anterior-inferior** and **cardio-pericardial**;
- **posterior** - esophagus, descending aorta , thoracic duct, azigoz - hemiazigoz venous system.

- **The Airspace** - lung alveoli;
- **The Ventilation System** - tracheobronchial tree;
- **The Infusion System** - arteries - capillaries – veins;
- **The Nerves;**
- **The Interstitial space.**

- Radioscopy - Rx;
- Radiography – Rgr.



Imagistic Methods of Diagnostic

The Conventional Methods

RGR

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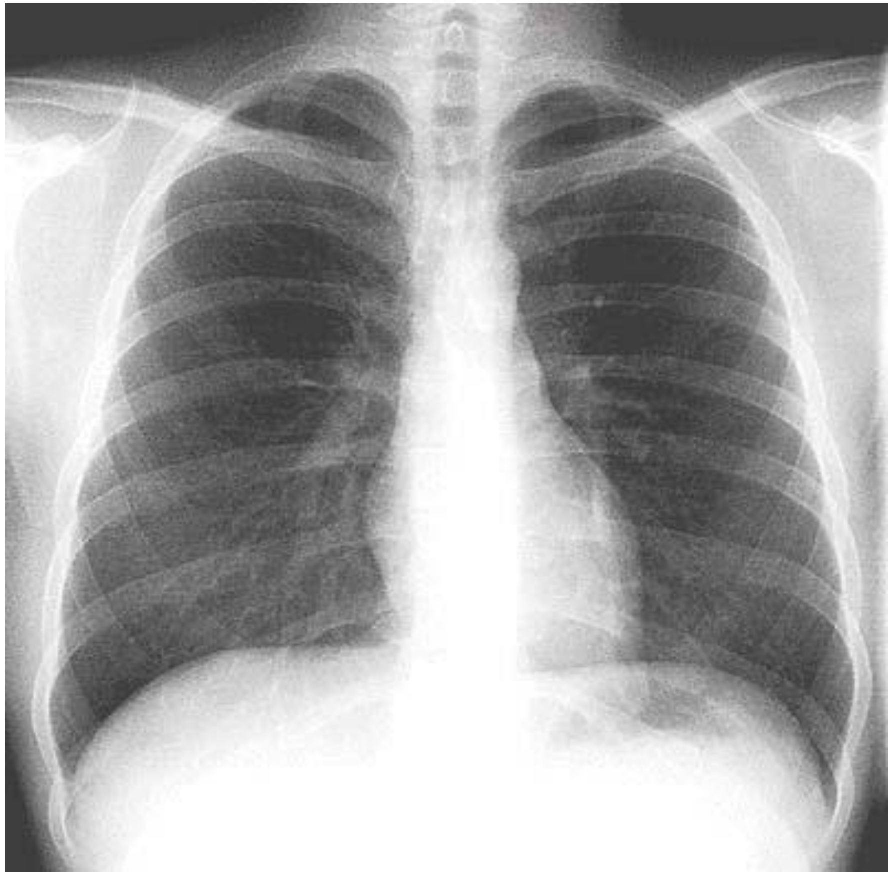

Imagistic Methods of Diagnostic

The Conventional Methods

RGR

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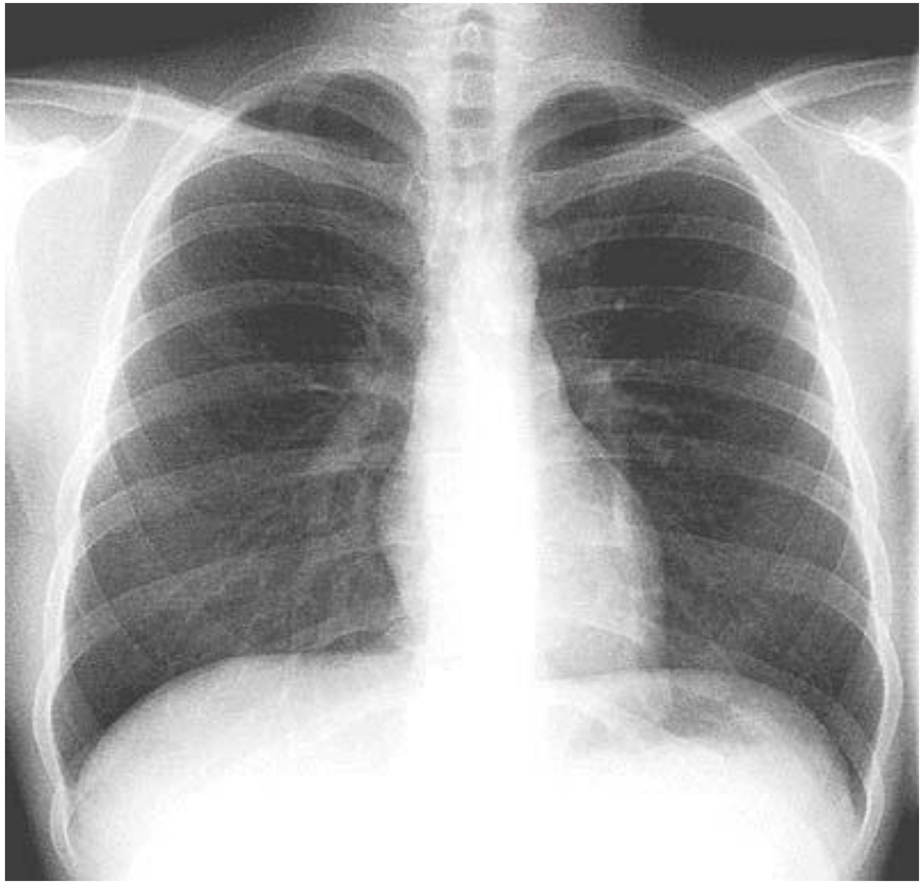

Imagistic Methods of Diagnostic

The Conventional Methods

LSD

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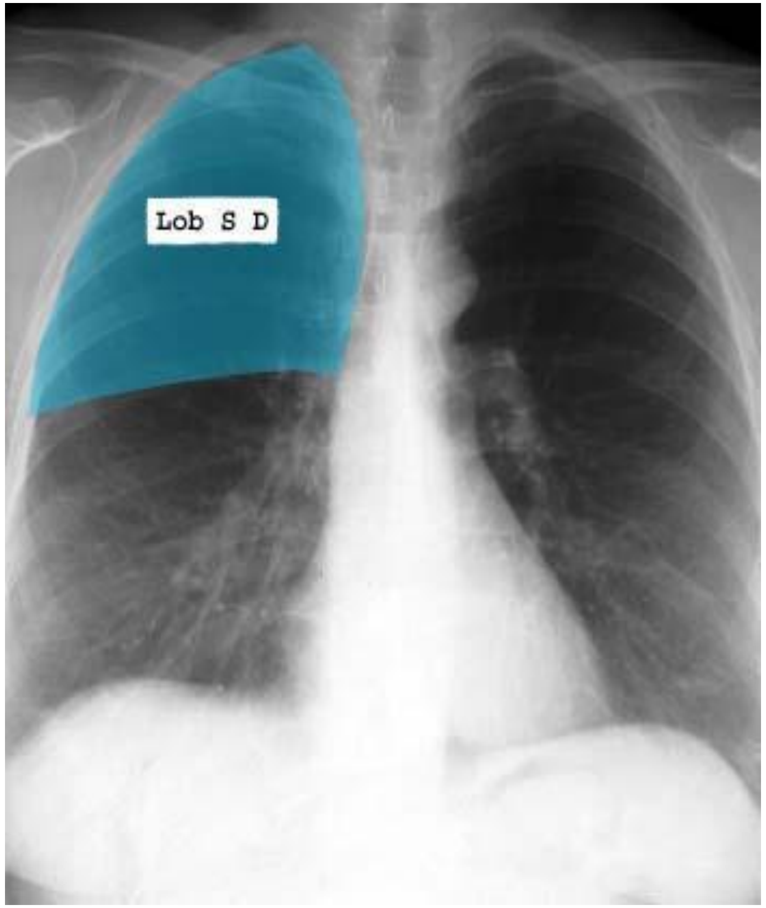

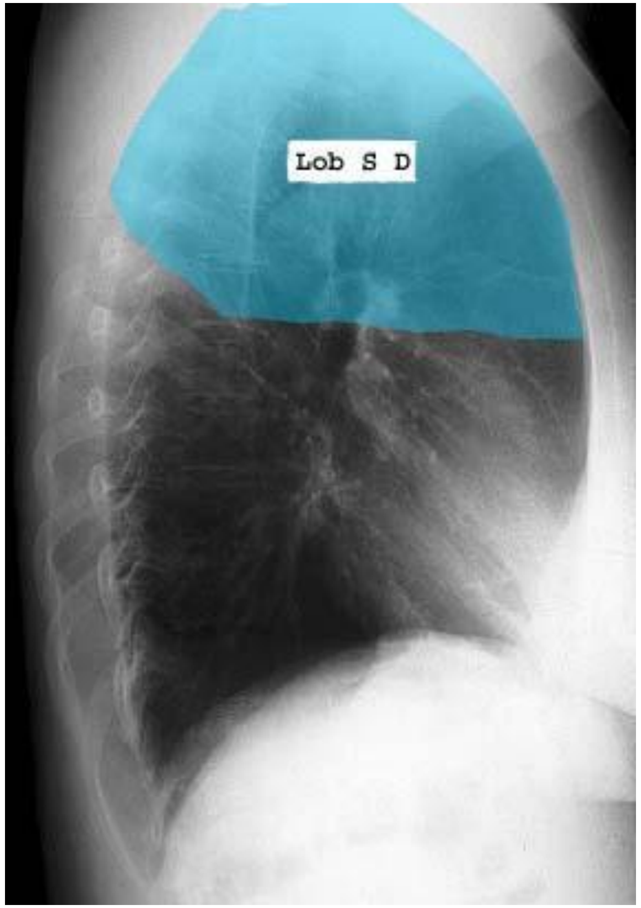

Imagistic Methods of Diagnostic

The Conventional Methods

LM

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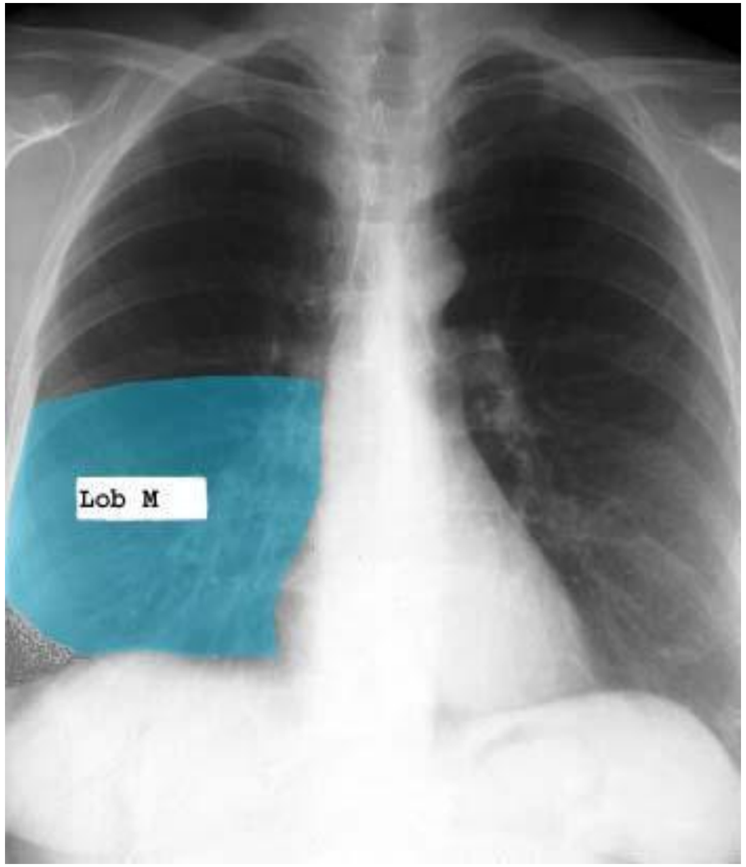

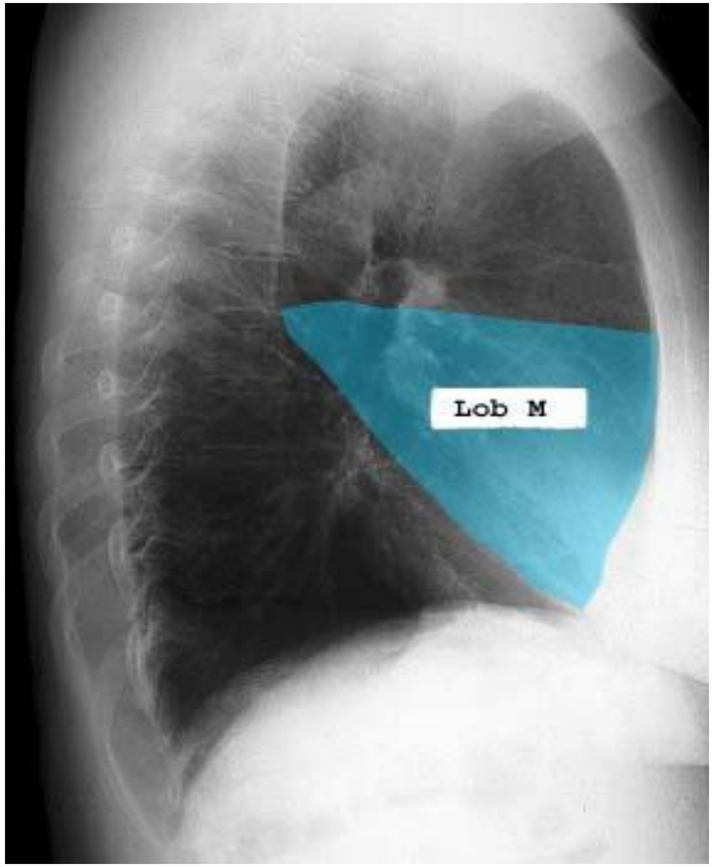

Imagistic Methods of Diagnostic

The Conventional Methods

LID

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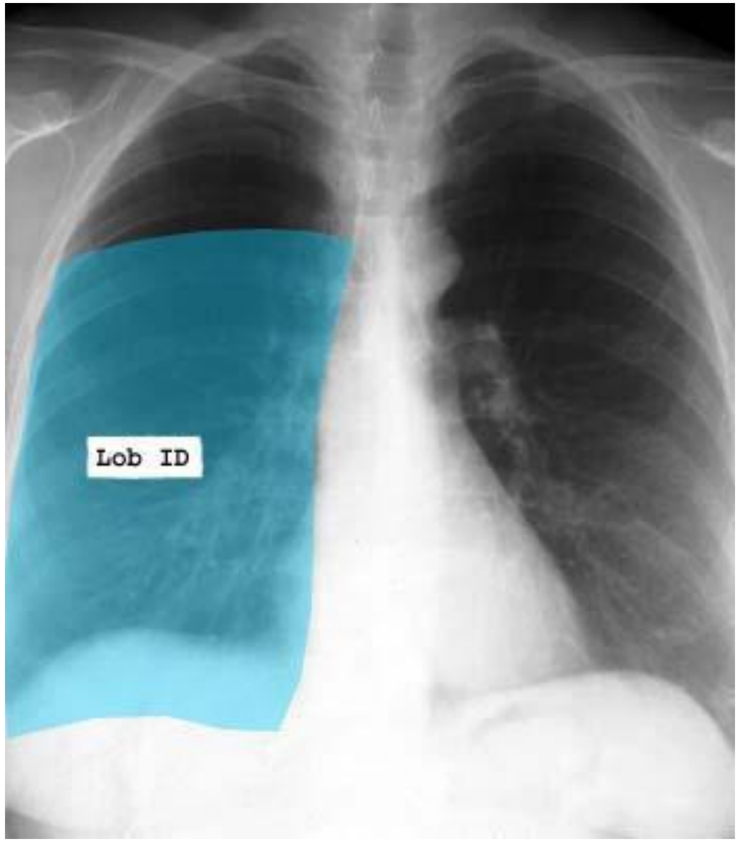

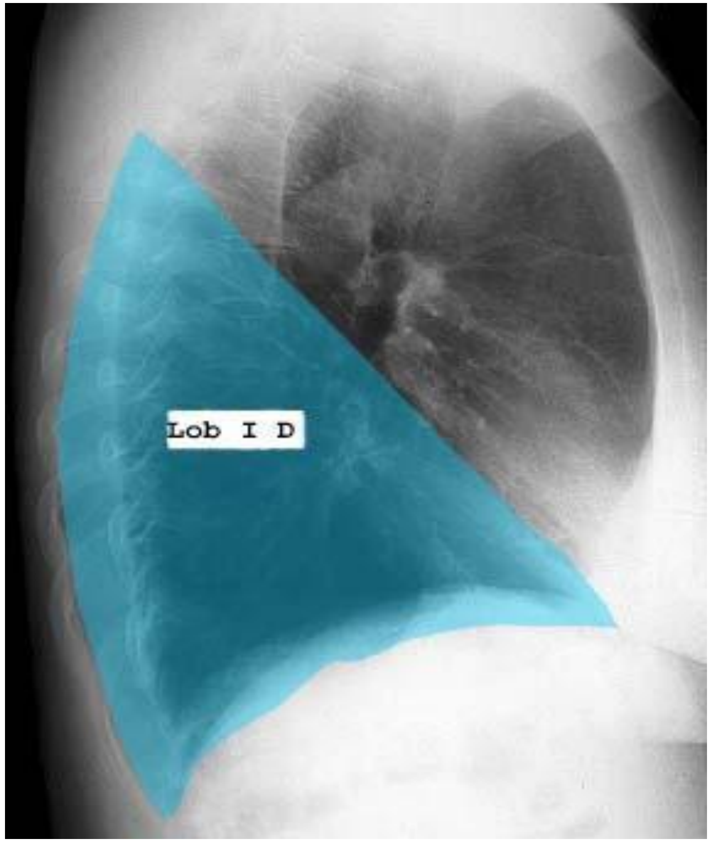

Imagistic Methods of Diagnostic

The Conventional Methods

LSS

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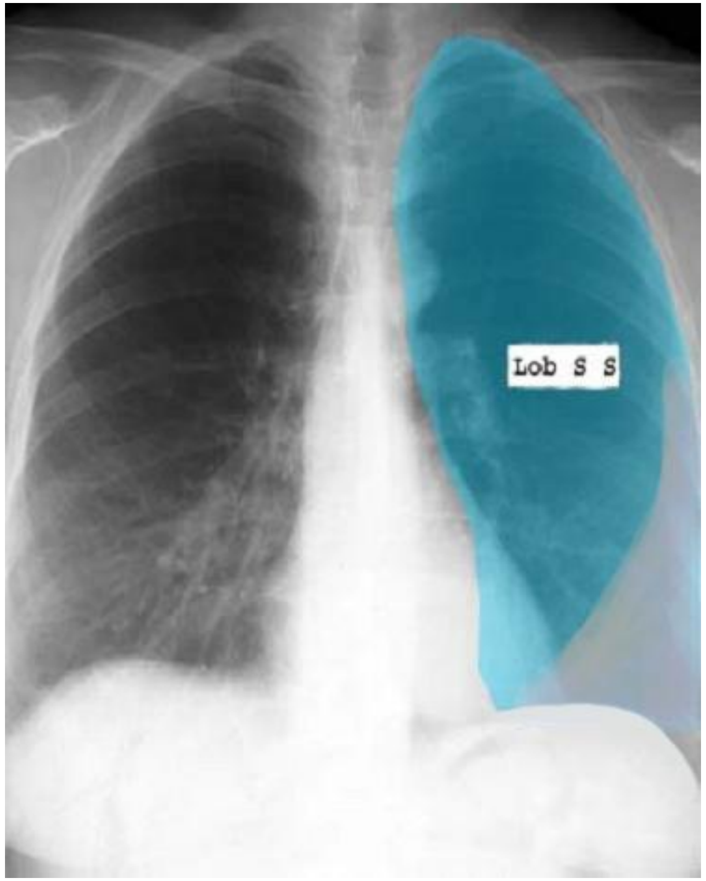
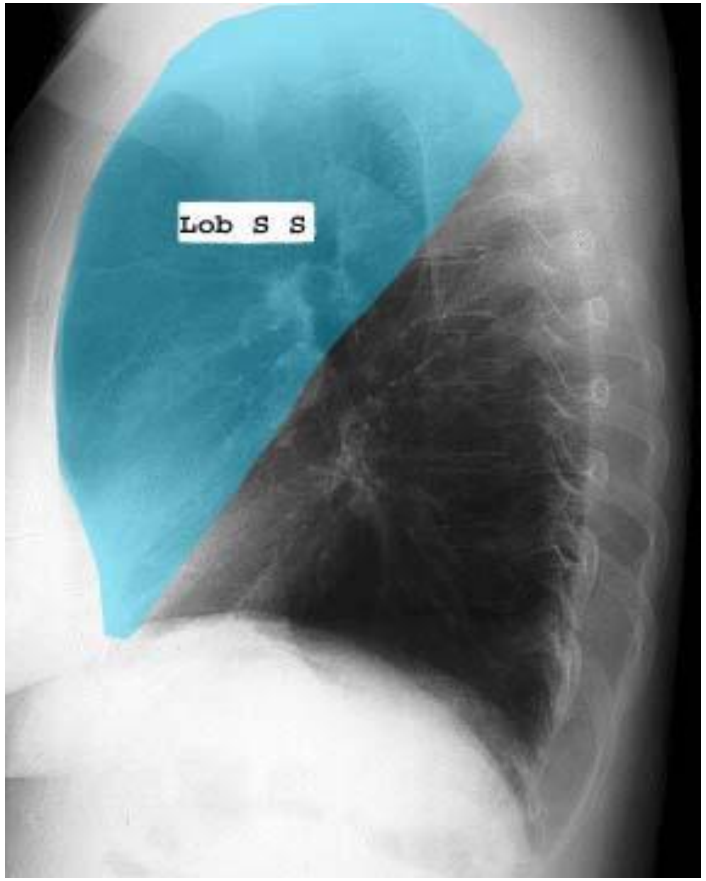




The Conventional Radiological Methods:

– *detector → **image;***

- ***The Imagistic Methods:***

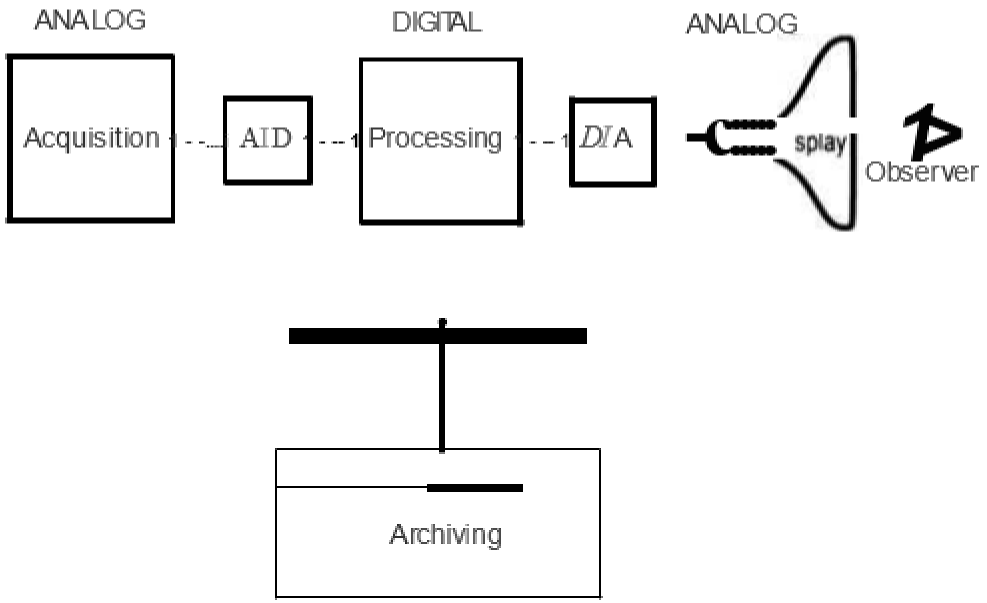
– *detector →analog-digital converter→*

__computer__ →digital-analog converter

*→**image;***

The Digital Imaging System:

Fig 5-1. Functional diagram of a digital imaging system.

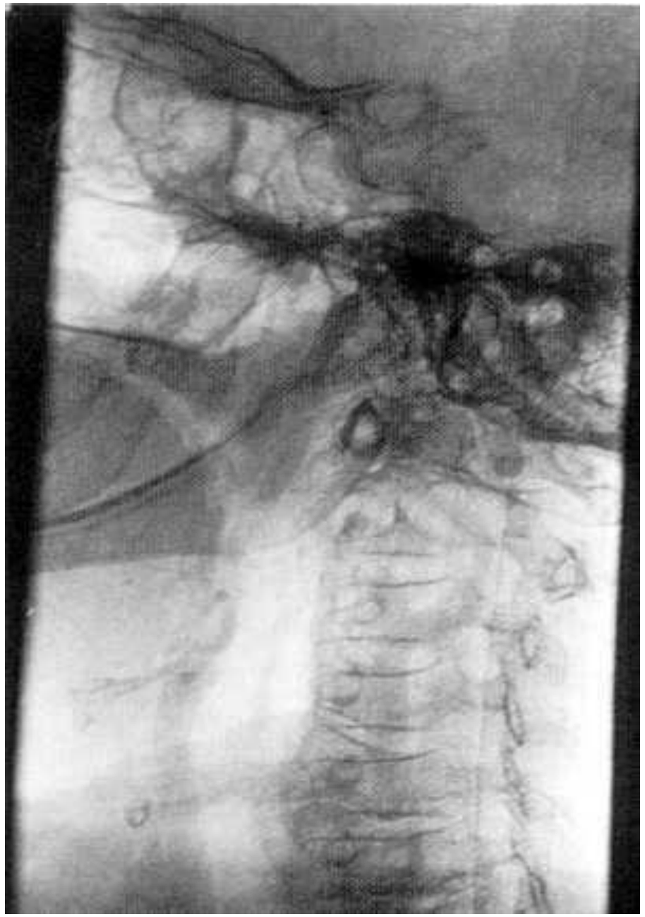


Imagistic Methods of Diagnostic

Digital Radiography

Oreste Straciuc

Digital Radiography



Digital
Bone
Suppression

Imagistic Methods of Diagnostic

Digital Radiography

Oreste Straciuc

Radiological examinations using positive contrast radiopaque substances (iodine):

- Bronchography;
- Pulmonary Arteography;
- Cavography and Azygography;
- Lymphography;
- Fistulography.

Radiological examinations using negative contrast (air):

- Pneumothoracic diagnosis;
- Pneumomediastinal diagnosis;
- Pneumoperitoneum diagnosis.

Analyzation plan for a t-p-m-p radiography:

- Thoracic configuration and symmetry;
- Thoracic skeleton and soft parts;
- Heart configuration and opacity;
- Diaphragm and the gastric gas bubble.;
- Pulmonary transparency;
- Pulmonary drawing;
- Pleura and fissures;
- Costophrenic sinuses – CPS.

Thoracic Pleural Mediastinal Pulmonary Radiography:

- The air in the lungs produces a negative contrast – transparency – subtraction.

Pulmonary drawing:
- Artery;
- Vein;
- Bronchus;
- Interstice.

Opacities:

- condensation, consolidation, value;
- lump:
- miliar;
- micro nodular;
- nodular;
- macro nodular.
- pleural effusion.

Mixed images:

- cavitary lesions with:
  - hyper transparent composition;
  - opaque composition;
  - air-fluid level.

Description plan for a focal lesion:

- 1 – localization – lung regions, areas, lobes;
- 2 – number;
- 3 – form - round, oval, segment, lobe, linear, reticular, ribbon, polycyclic (lobulated);
- 4 – dimensions;
- 5 - margins (contour, limits);
- 6 - intensity (density) – small, medium, large, ribs;
- 7 - structure – homogenous or not, calcified;
- 8 - relations, mass effect;
- 9 – evolution (benchmarking).

Imaging methods:

- Computed Tomography – CT Thoracic Echography;
- Magnetic Resonance Imaging (MRI);
- Lung Scintigraphy: perfusion, ventilation;
-
- Positron Emission Tomography – PET;
- Hybrid Imaging – PET/CT, PET/MR.

The general principle:

- Differentiated absorption of X-rays for tissues with different radio density.

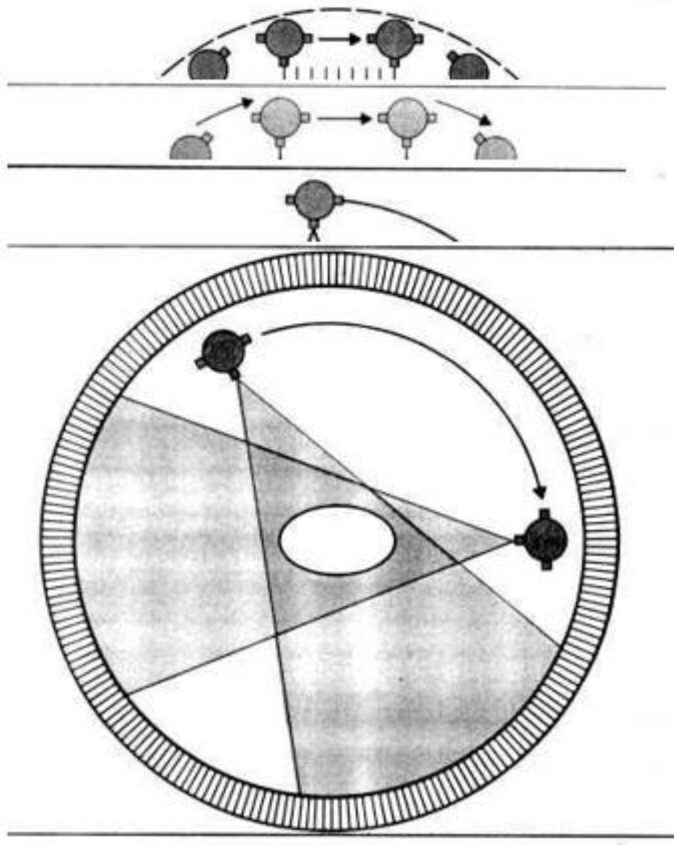
The CT separates itself from conventional radiology by two important aspects:

- The obtained cross-sectional images of the human body have distinctly visible structures on each;
- As opposed to the conventional methods, CT scans can detect much smaller differences of absorption .

- History - Godfrey Hounsfield and A. N. Cormack (1972) – Nobel Prize (1979);
- Biggest step since the discovery of X-Rays (WC Roentgen 1895).

Seven generations of CT devices:

- Single detector - rotation system – translation;
- Multiple detectors – rotation system – translation;
- Rotary Scanner with mobile detectors;
- Rotary Scanner with stationary detectors - spiral CT;
- Rotary Scanner with multiple stationary detectors – Multirow;
- Dual source CT (DSCT);
- Dual energy CT (DECT) – 2 exposures with different parameters.



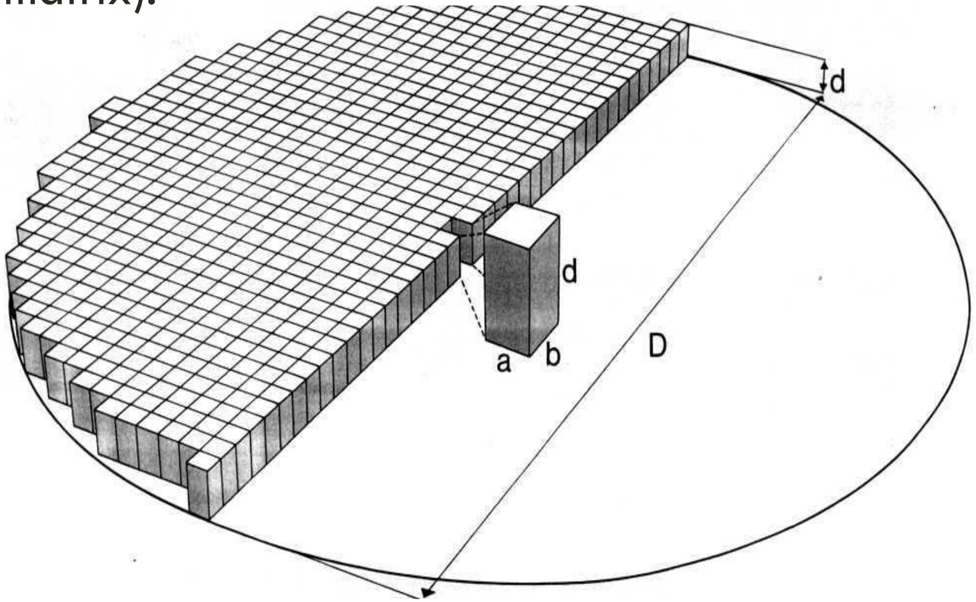
- The amount of X -rays emerging from the scanned body, depending on their degree of absorption - numerically expressed as attenuation values .
- In order to obtain an image, a large number of exposures are made with the ensemble tube - detector located at different positions than the patient. It performs 180 ° rotation.
- At each section the detector records approximately 65,000 attenuation values (attenuation coefficients).
- The data is transmitted to the computer that reconstructs the image dividing these values on a matrix formed from volume units - voxels .
- Each voxel will have its own attenuation value .

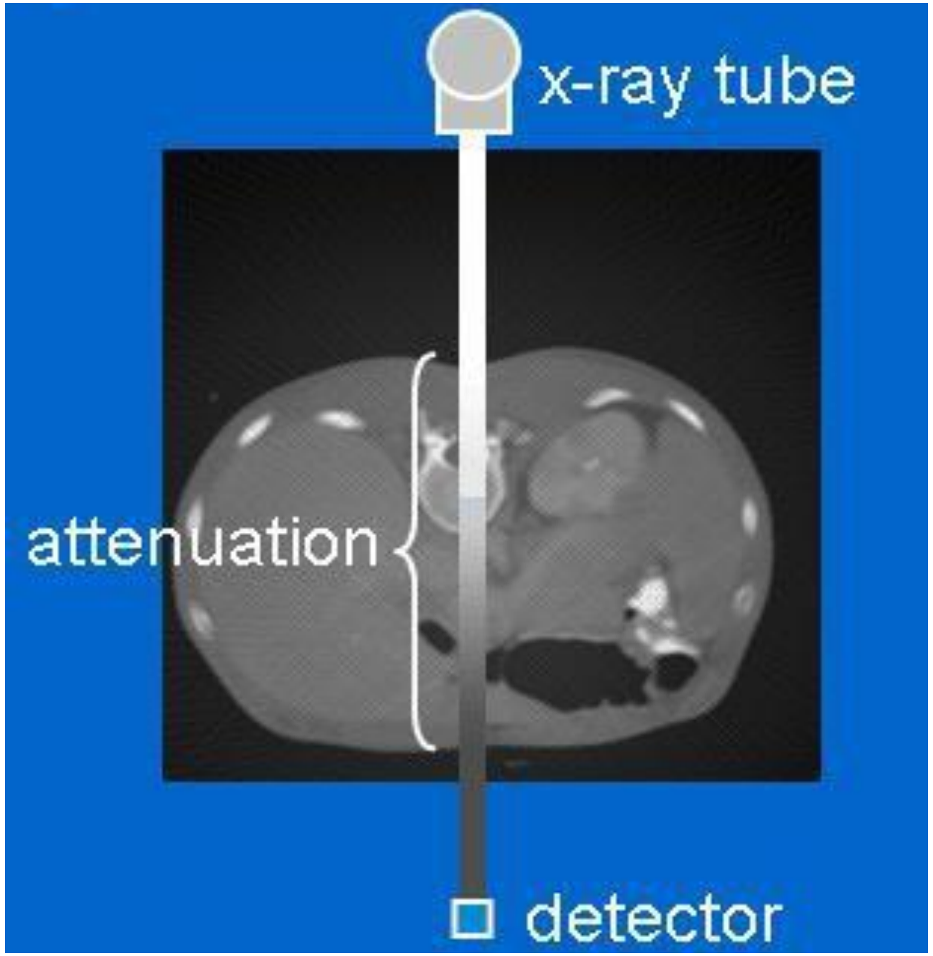
Imagistic Methods of Diagnostic

Oreste Straciuc

The image reconstruction – the matrix:

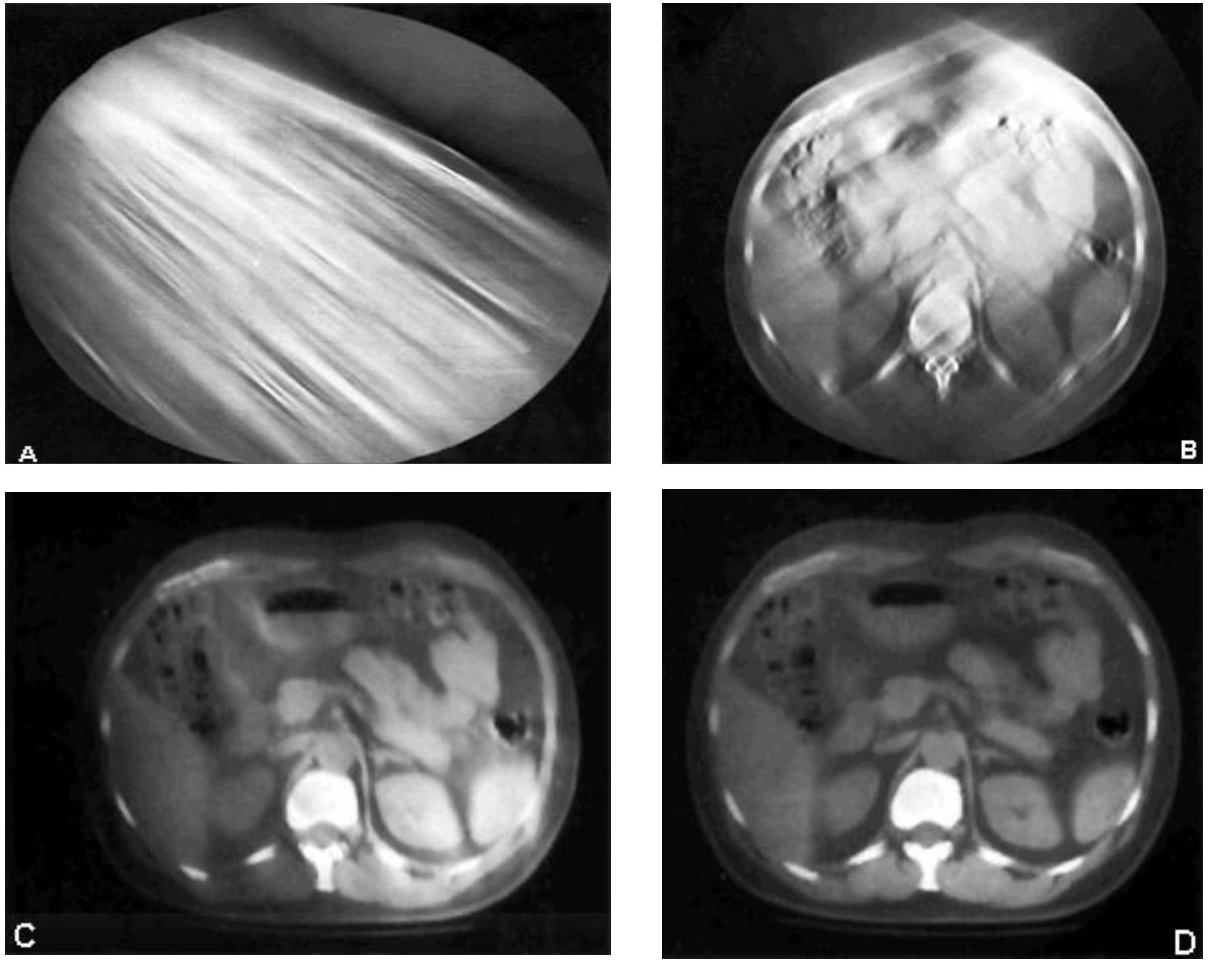
- A **classic thoracic** section:
  - the thickness is about 1 cm (1mm to 10mm);
  - it consists of 256x256 voxels (the matrix).





Imagistic Methods of Diagnostic

Oreste Straciuc



Imagistic Methods of Diagnostic

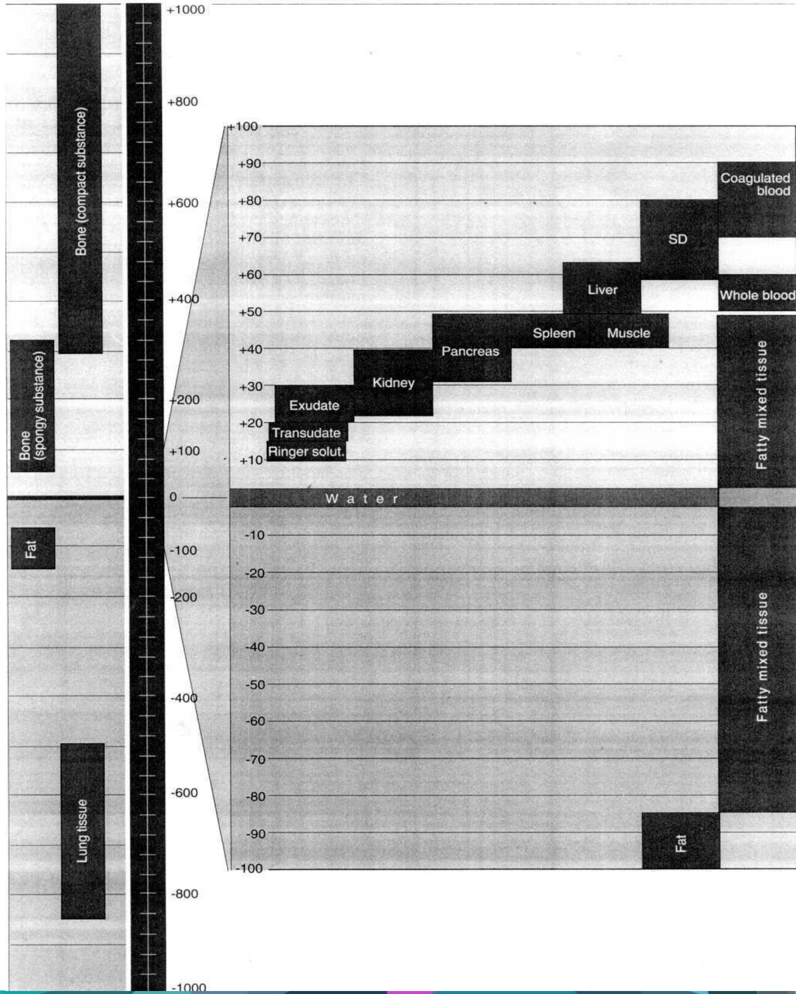
The images' elements

Oreste Straciuc

- The attenuation value of the voxels, represented in the reconstructed image, appear as different shades of gray.
- Each voxel will have a corresponding point in the image, called pixel, as gray as its' attenuation value.

The units of measurement used to define numeric mitigation are:

- Hounsfield densitometry units (UH);
- 1000 UH, for air (min. attenuation) represented as black and 0 UH, for water.



Imagistic Methods of Diagnostic

The images' variation

Oreste Straciuc

- Theoretically there can be displayed 2,000 shades of gray (from -1000 to 1000) but the human eye can only distinguish up to 30 shades.
- So by looking at the picture we can distinguish structures with density difference at minimum 2000/30 = 66 UH.
- The vast majority of human body has the density tissue between -100 and +100 UH. They can be seen separately by choosing a certain range narrowed by densitometry values "windows“.

Table 1-1. Attenuation values for various body tissues and fluids.

Tissue Type	Standard Value (HU)	Scatter (HU)
Bone (compact)	> 250	
Bone (spongy)	130 ± 100	
Thyroid	70 ± 10	
Liver	65 ± 5	45–75
Muscle	45 ± 5	35–50
Spleen	45 ± 5	35–55
Lymphoma	45 ± 10	40–60
Pancreas	40 ± 10	25–55
Kidney	30 ± 10	20–40
Fat	−65 ± 10	−80–(−100)

Fluids	Standard Value (HU)
Blood (coagulated)	80 ± 10
Blood (venous whole blood)	55 ± 5
Plasma	27 ± 2
Exudate (>30 g protein/l)	>18 ± 2
Transudate (<30 g protein/l)	<18 ± 2
Ringer solution	12 ± 2

Imagistic Methods of Diagnostic

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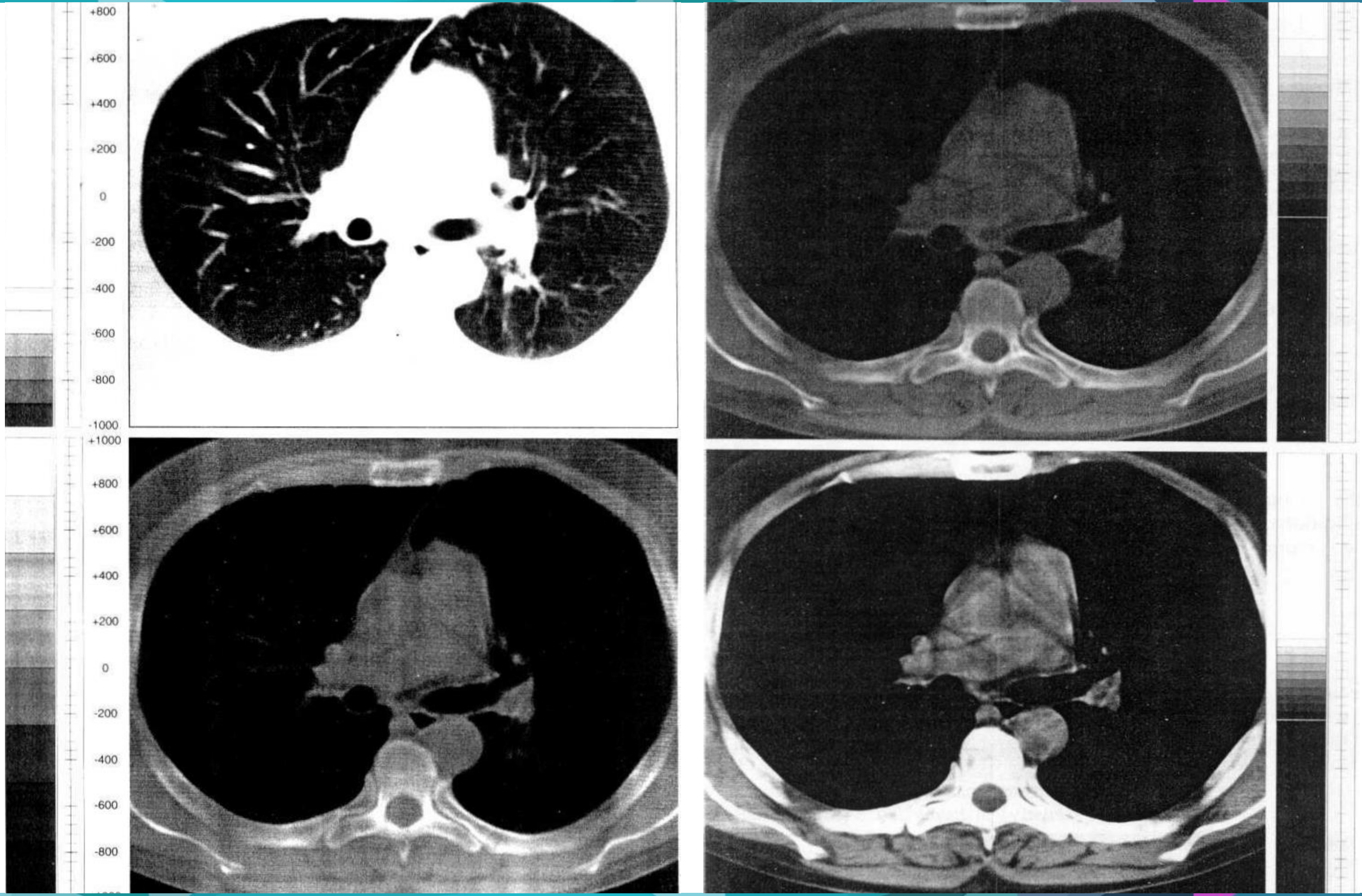

Imagistic Methods of Diagnostic

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Represented by numbers:

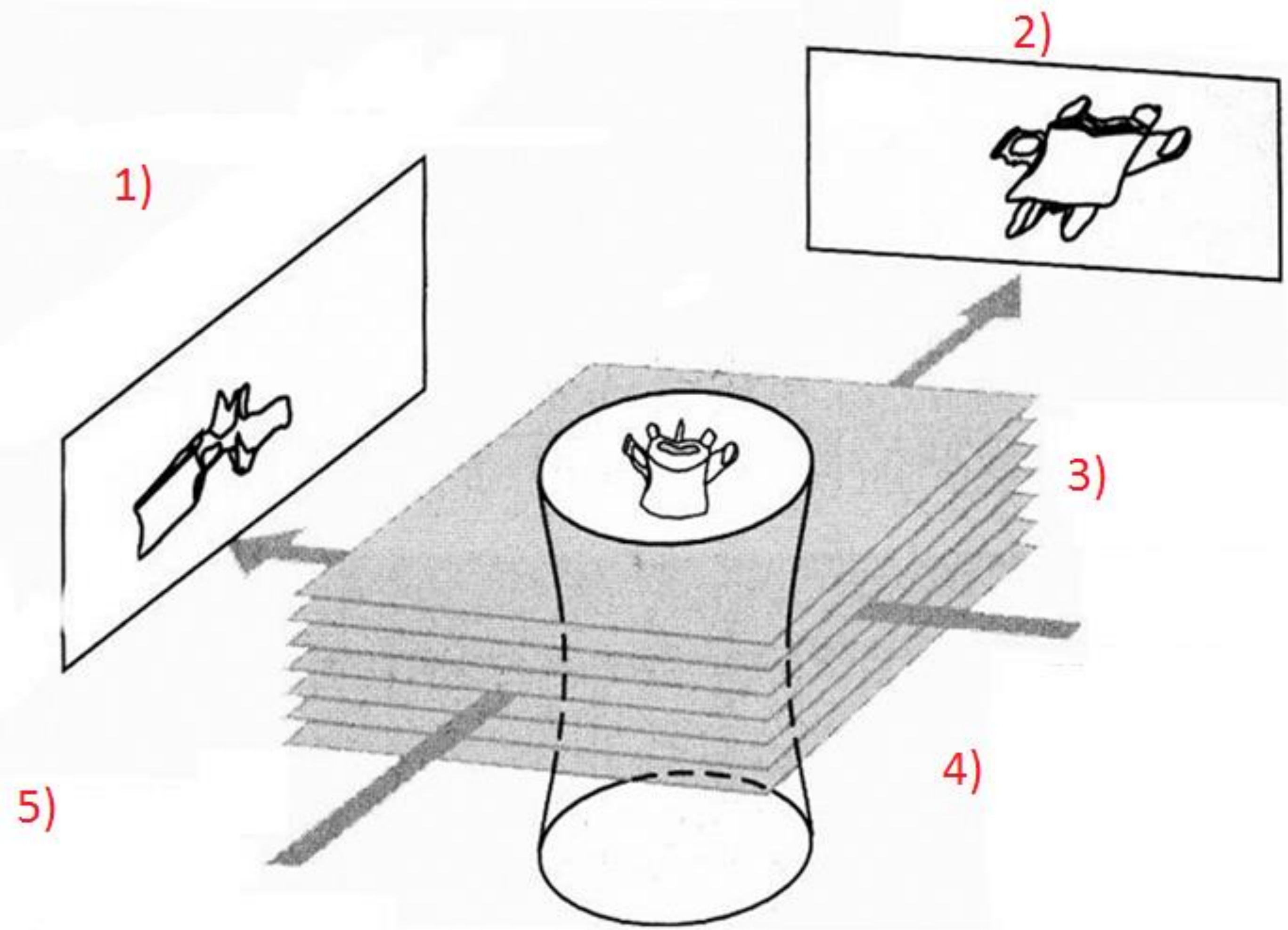
1) Sagittal reconstruction;

2) Coronal reconstruction;

3) Initial axial sections;

4) Lateral sagittal projection;

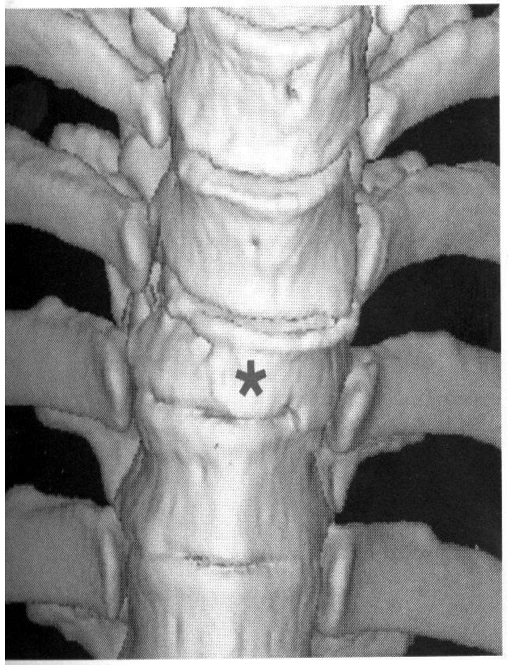
5) Frontal projection-coronal plan.

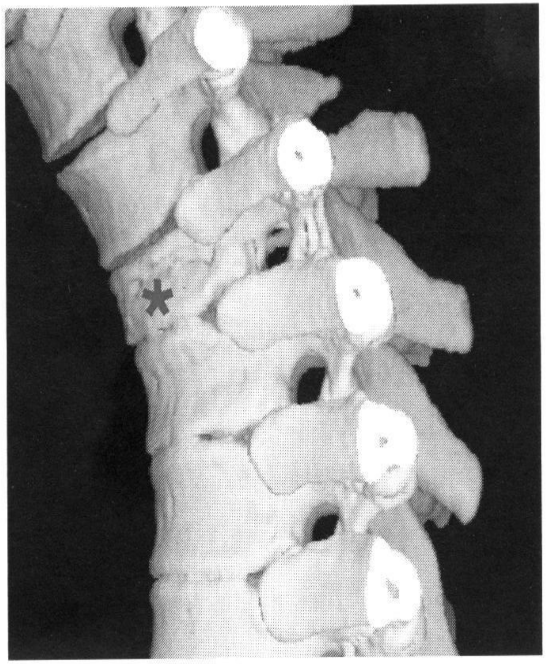


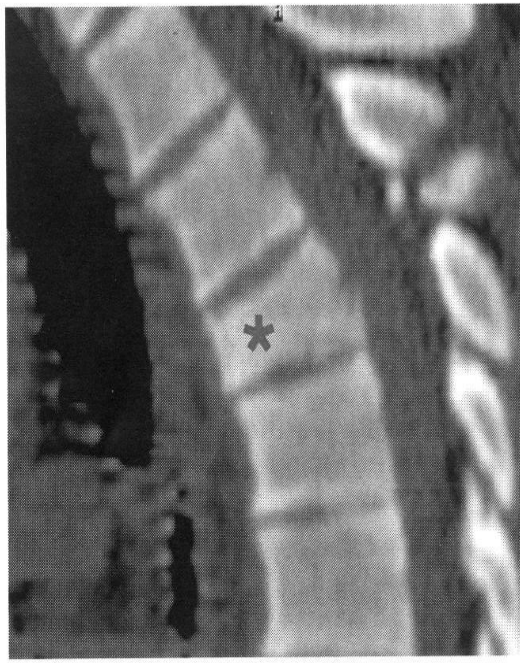
Imagistic Methods of Diagnostic

CT Reconstructions

Oreste Straciuc



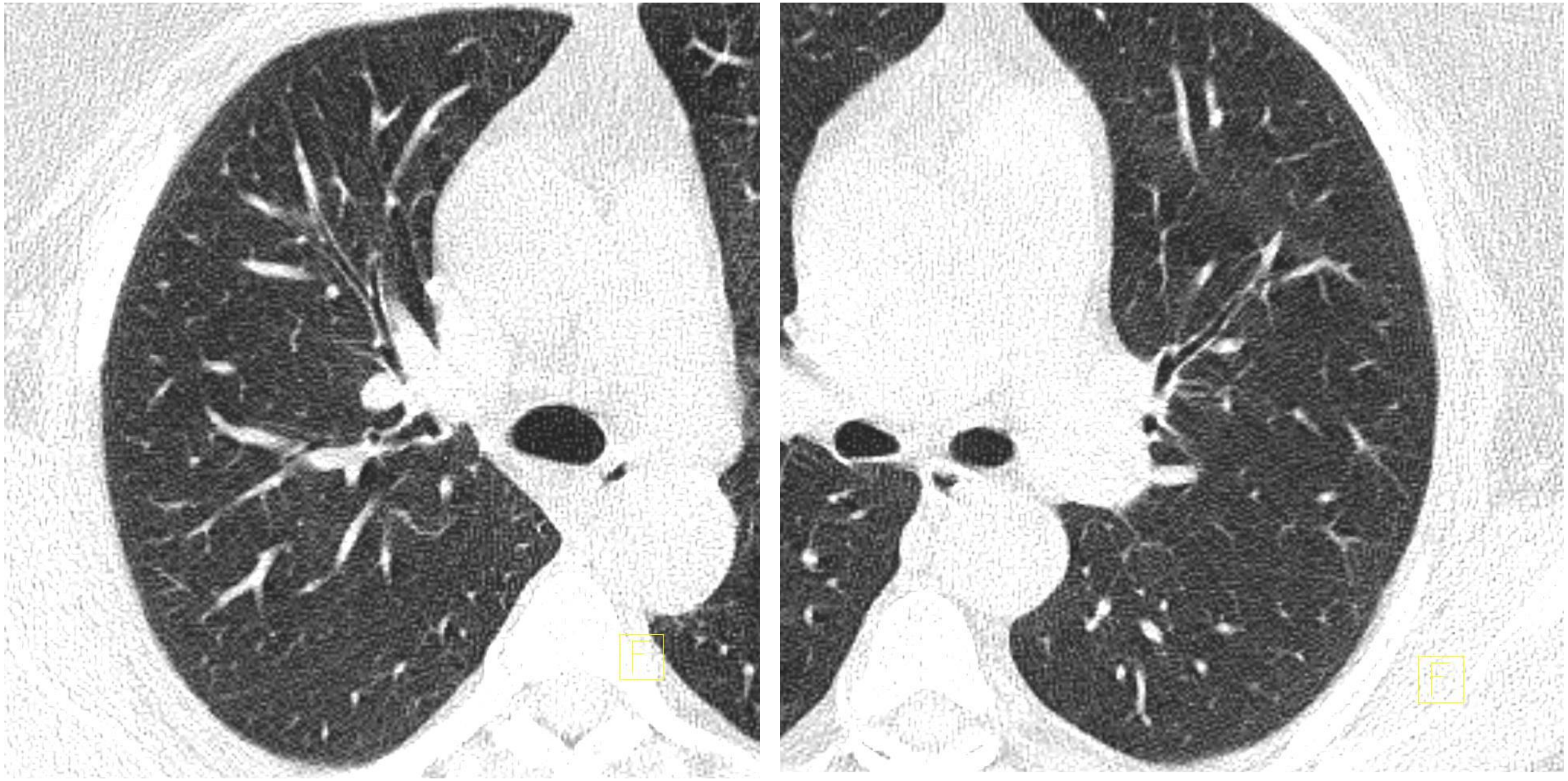




Imagistic Methods of Diagnostic

HRCT-High Resolution Computed Tomography

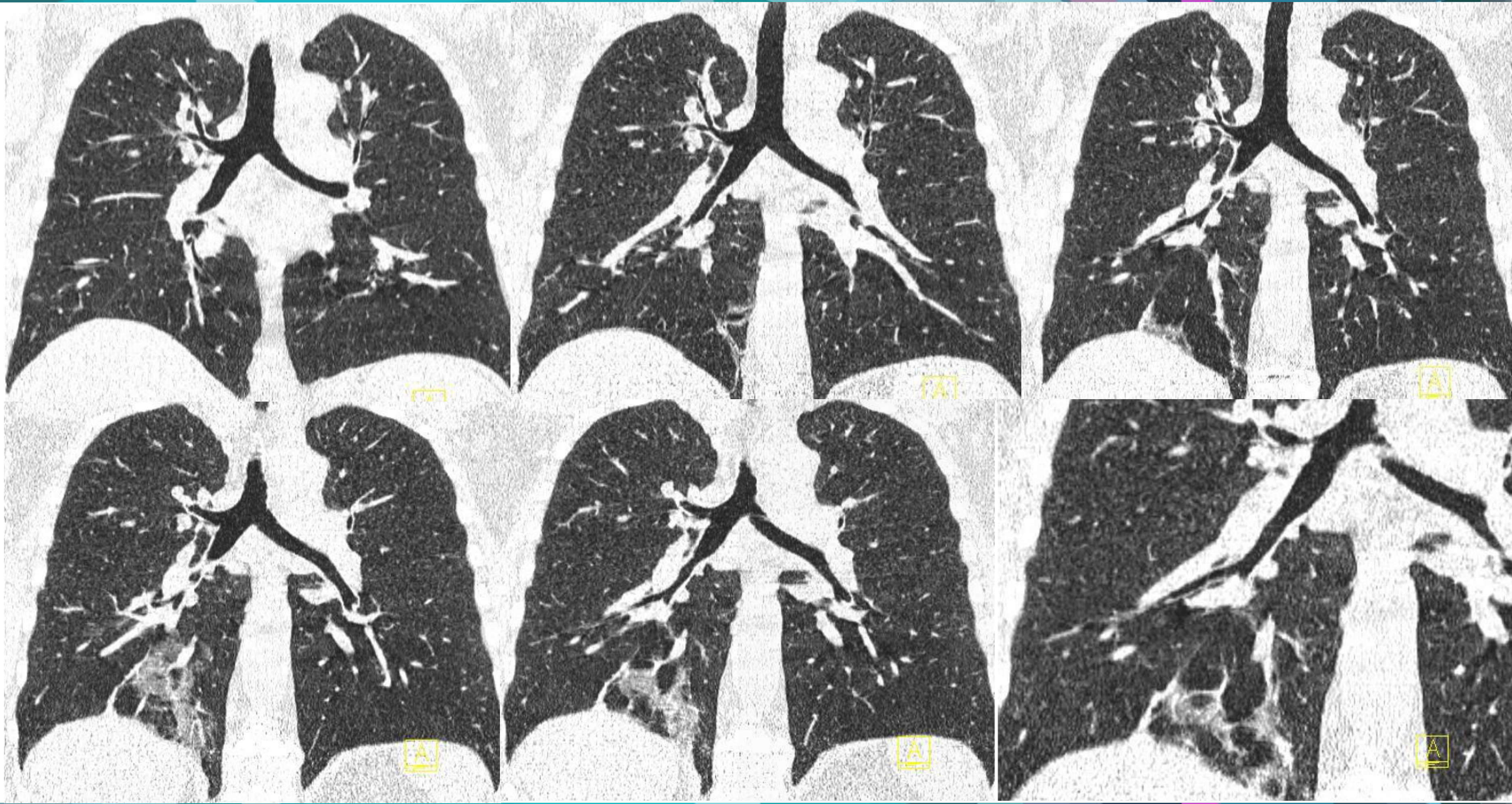
Oreste Straciuc



Imagistic Methods of Diagnostic

HRCT 2D Multiplanar Reconstructions

Oreste Straciuc



Imagistic Methods of Diagnostic

HRCT 2D Multiplanar Reconstructions

Oreste Straciuc

Imagistic Methods of Diagnostic

HRCT 2D Multiplanar Reconstructions

Oreste Straciuc

Imagistic Methods of Diagnostic

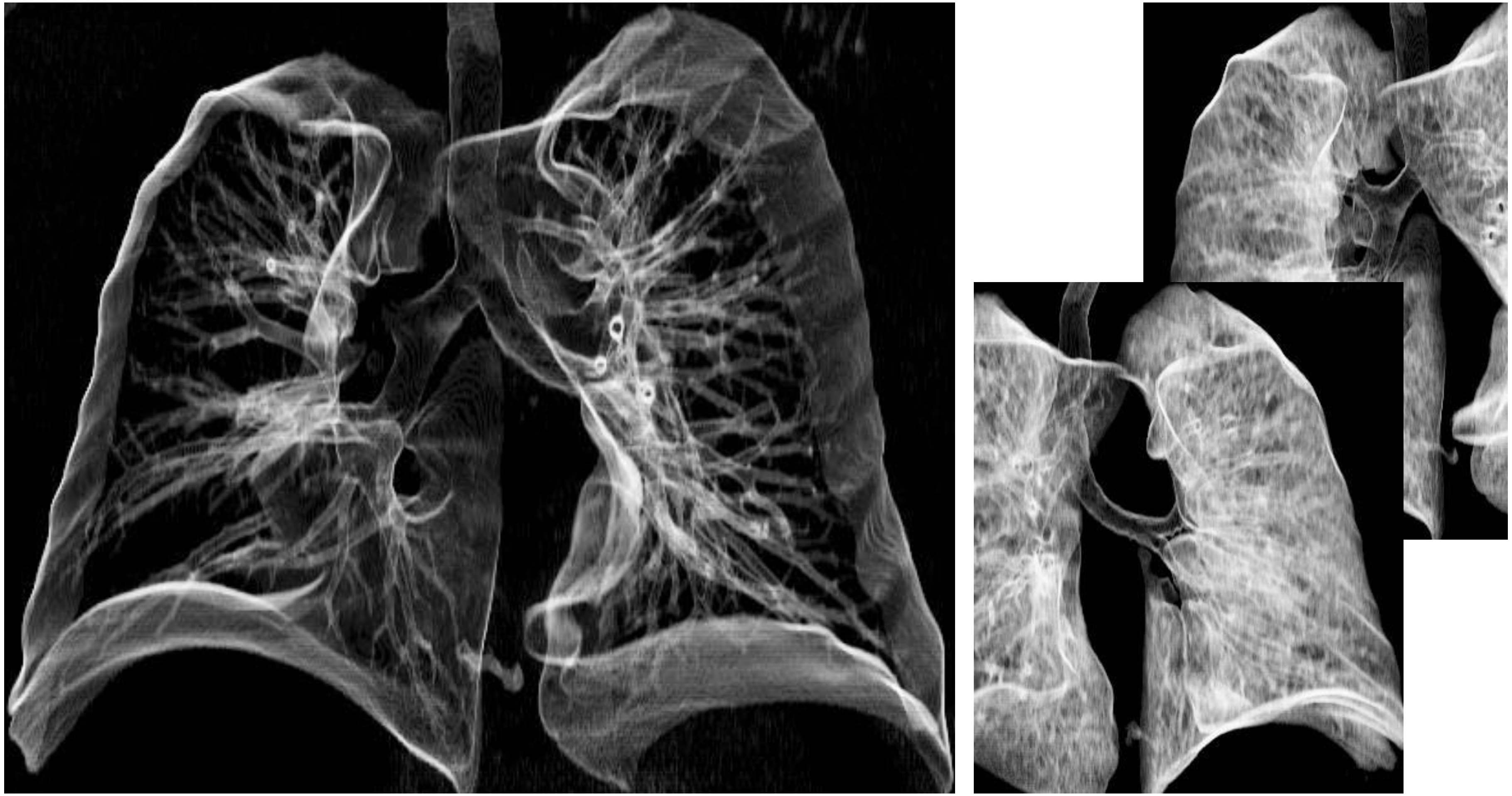
HRCT 2D Multiplanar Reconstructions

Oreste Straciuc

Imagistic Methods of Diagnostic

3D Virtual Bronchoscopy

Oreste Straciuc



Imagistic Methods of Diagnostic

PET/CT

Oreste Straciuc

The integrated technology PET / CT - two different procedures that provide complementary information:

- PET - Positron Emission Tomography;

Function – Pathophysiology.

- CT - computed tomography;

Structure – Pathology.

CT

Function

PET

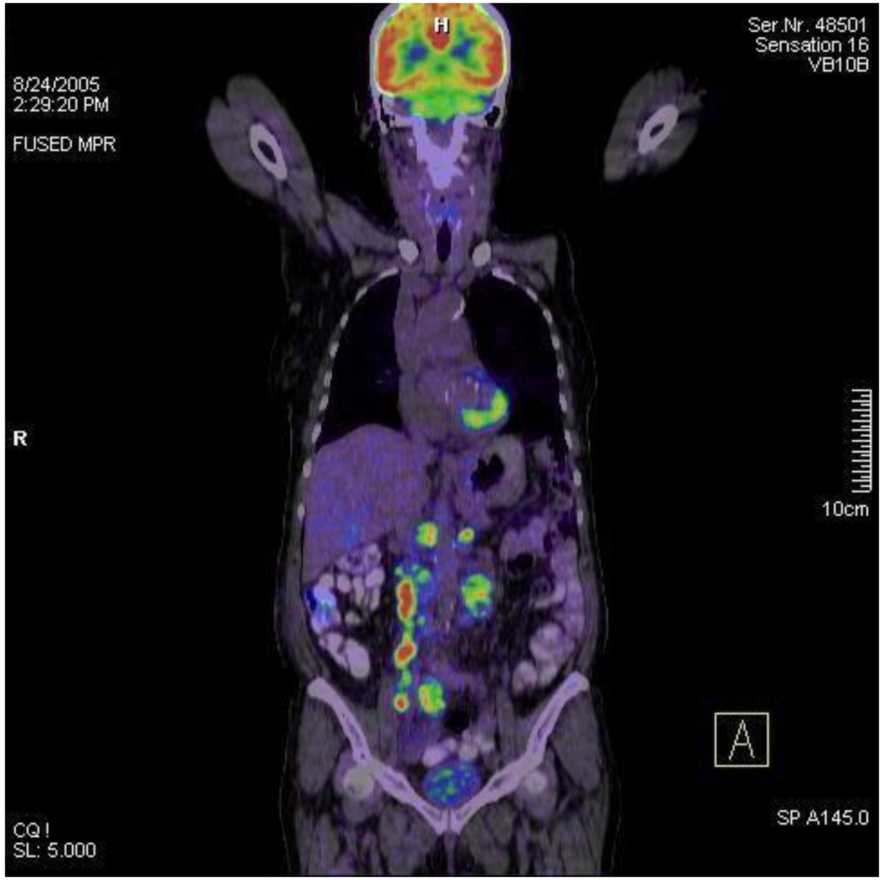
Structure

Imagistic Methods of Diagnostic

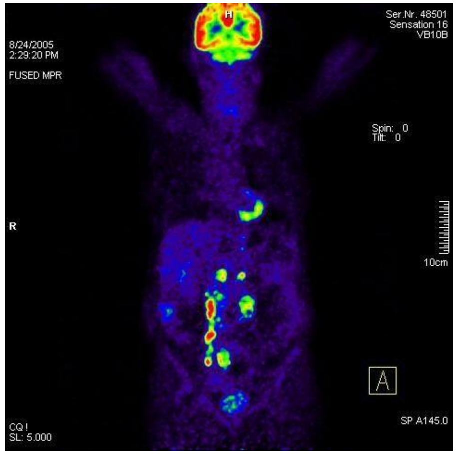
FDG PET/CT

Oreste Straciuc

CT



PET



Imagistic Methods of Diagnostic

Mathematic PET/CT

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PET

Radio Density - UH

CT

Captivation - SUV

Imagistic Methods of Diagnostic

Visual PET/CT

Oreste Straciuc

PET

Shades of Grey

CT

Rainbow Colors

Imagistic Methods of Diagnostic

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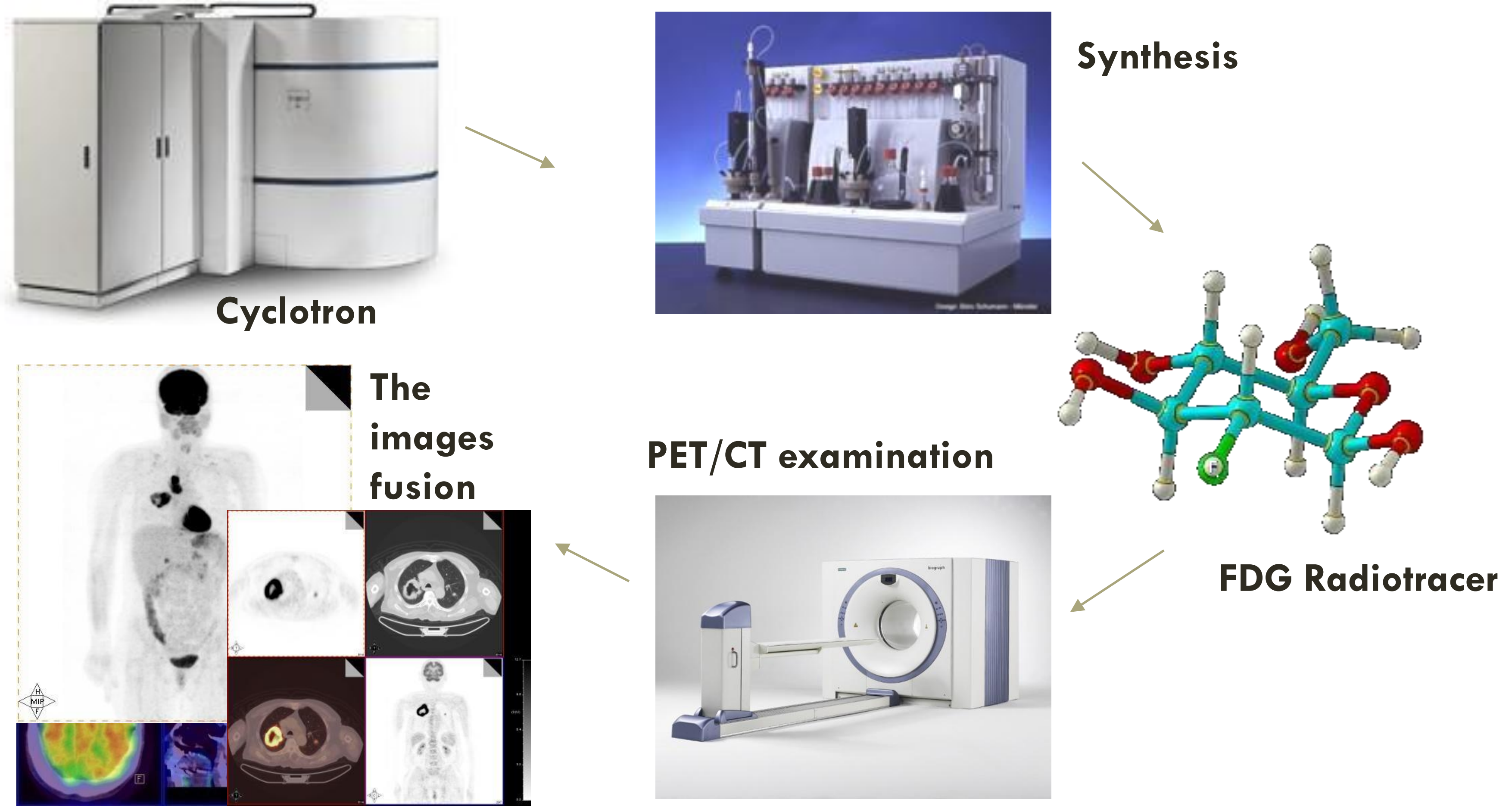
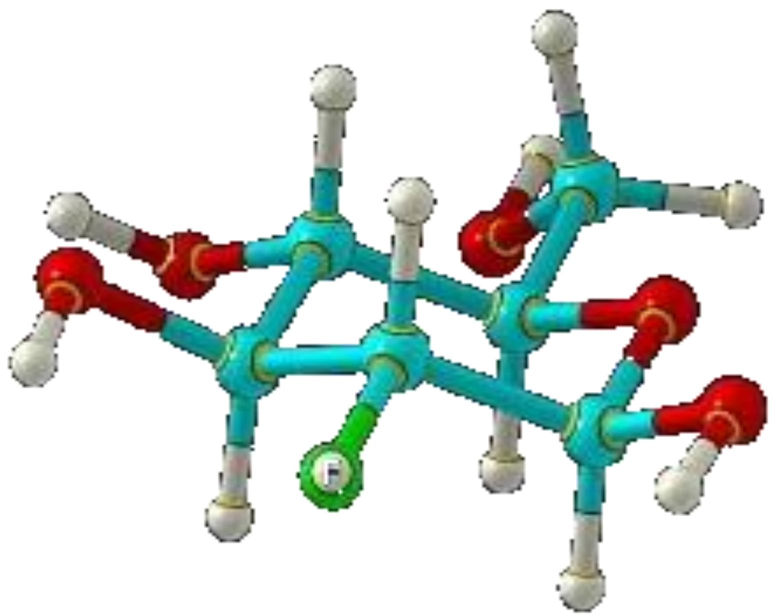


2-deoxy-2-[18F] fluoro-D-glucose (FDG)



The molecule of the 20th century – Dr. Henry Wagner

Oncology:

- -Diagnostic, Staging, Restaging, monitoring therapeutic response.

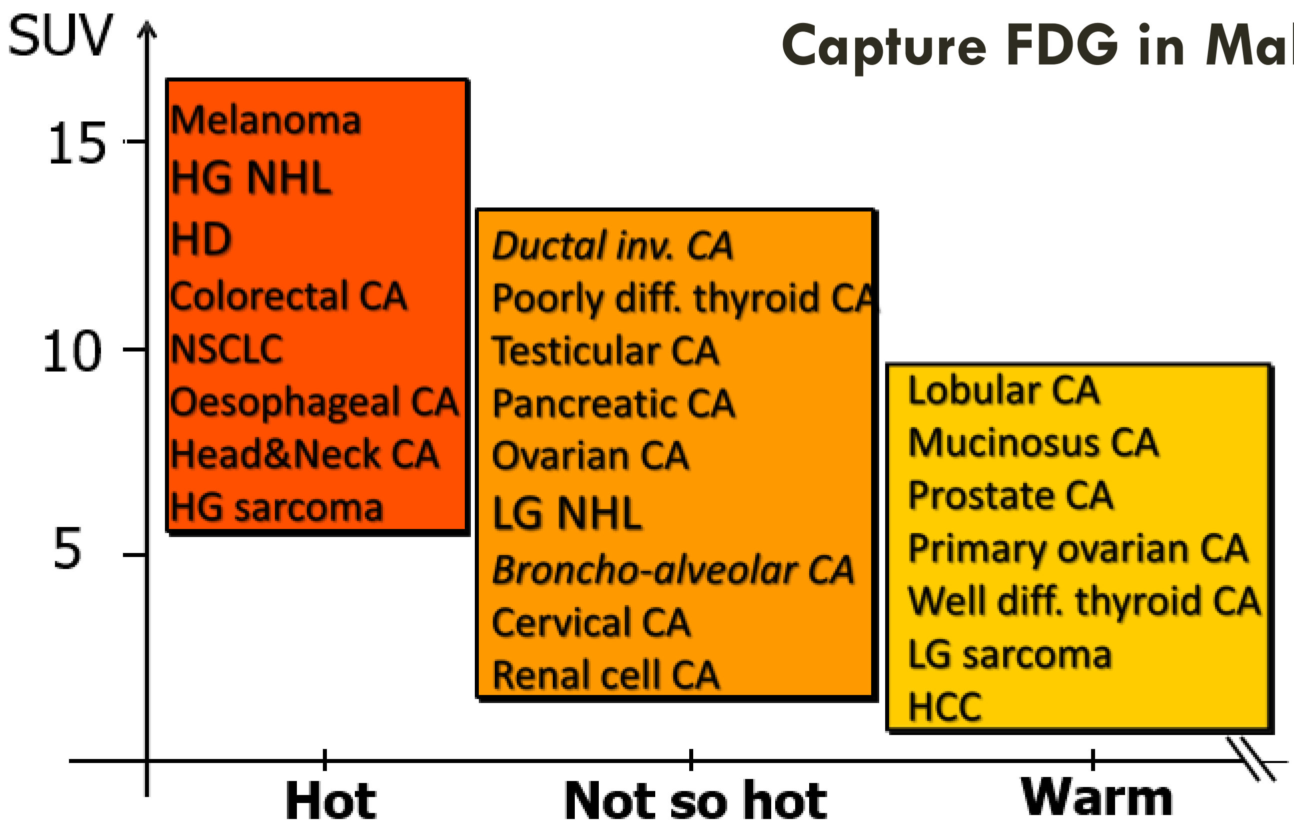
Neuropsychiatry:

- Epilepsy, neurodegenerative changes, dementias.

Cardiology:

- Assessment of myocardial viability after myocardial infarction.

Capture FDG in Malignant Tumors



Imagistic Methods of Diagnostic

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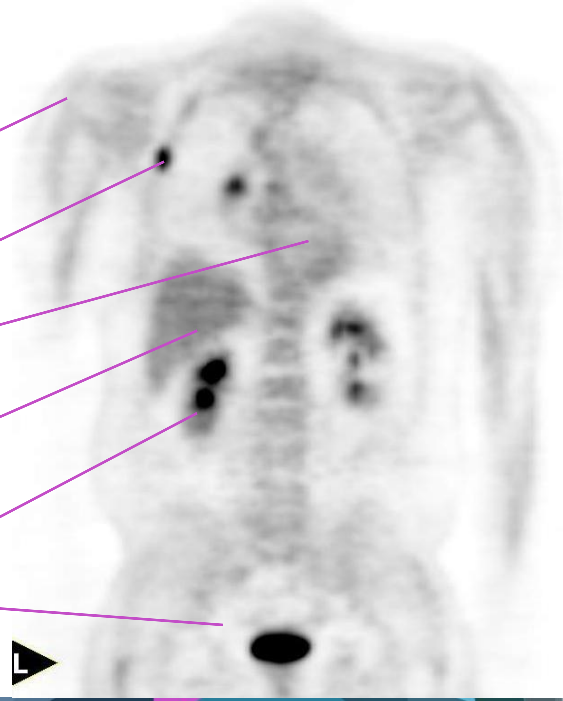
SUV- Standardized Uptake Value

- It's not equivalent to CT (UH) Radio Density nor postcontrast loading;
- SUV= The radioactivity in the tissue/injected dose or the corporal weight;



Imagistic Methods of Diagnostic

Common sources affecting the measurement of SUVs

Oreste Straciuc

Error	Effect on tumor SUV
Blood glucose levels	Lower values with increasing blood glucose levels
Region-of-interest definition	Lower mean uptake for larger regions of interest; larger random errors for small regions of interest
Paravenous ^{18}F-FDG injection, residual activity in syringe	Incorrectly low SUV because area under plasma time–activity curve is smaller
No decay correction of injected activity	Incorrectly low SUV
Incorrect cross-calibration of scanner and dose calibrator	Incorrectly low or high SUV, depending on error of calibration factor
Variable uptake period (time between injection and imaging)	Higher SUV with longer uptake period

(i.v. or oral contrast administration does not affect SUV significantly)

Weber, W.A.,. J Nucl Med, 2005. 46(6): p. 983-95.
Yau et al. J Nucl Med. 2005 Feb;46(2):283-91
Ditzendorf et al J Nucl Med. 2003 May;44(5):732-8

Imagistic Methods of Diagnostic

The Method

Oreste Straciuc

- Radiotracer - FDG - injected intravenously;
- Time for halving - F18 = 110 min;
- Dose - 0.1 - 0.15 mCi / kg. 1mCi = 37MBq;
- The average activity administered - 400MBq;
- Estimated effective dose - 7.6 mSv;
- Examination at 60 minutes post-injection;
- CT acquisition - "low dose" - vertex – thighs;
- PET acquisition - 7-8 portions of 16 cm.

Imagistic Methods of Diagnostic

The Method

Oreste Straciuc

- **Radiotracer** - FDG - injected intravenously;
- It can also be **administered orally,** the dose adjustment is necessary to be administered - artifacts in the digestive tract.

- **Time for halving** - F18 = 110 min;
- **Radioactivity annihilation** - after 7 min;
- **Halving cycles** = 14 hours!

CT acquisition - "low dose" - vertex – thighs;

- **CT diagnosis + c. iv + oral c;**

- **The increase** of the patients' *irradiation dose*;
- **The increase** of the risk of *contamination*;
- **The increases** of the *examination period*;
- **The costs' increase.**

CT acquisition - "low dose" - vertex – thighs

Additional protocols:

- The acquisition of Inspiratory and Apnea lung HRCT;
- Head acquisition - neck + PET;
- Renal and urinary pathology - review by admin. iv diuretic
- Differentiation between lymphadenopathy inflammatory/malignant

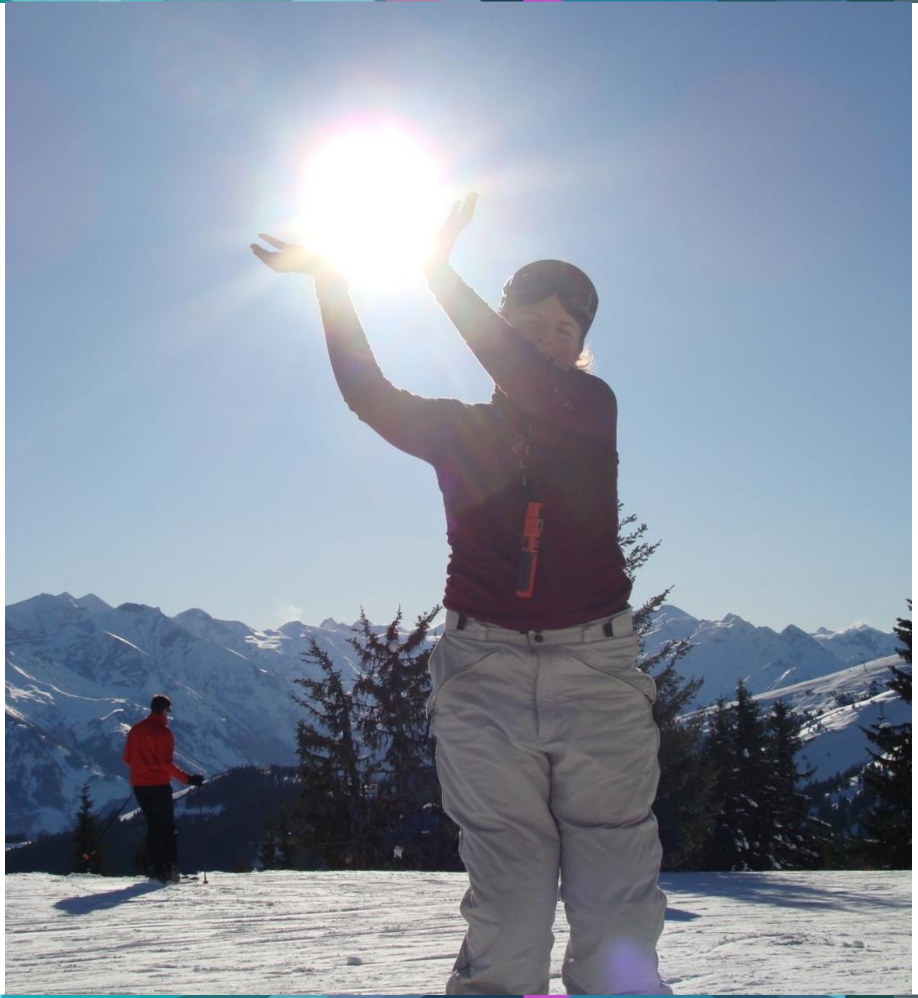
- review after 60 minutes.

Imagistic Methods of Diagnostic

Protection Methods

Oreste Straciuc

- CT - radiation X;
- PET - positron emission tomography;
- Gamma Radiation;
- Control of FDG;
- Production;
- Transport;
- Handling /Dosage;
- Administration;
- Dosage and automatic injection.



Imagistic Methods of Diagnostic

Dosage

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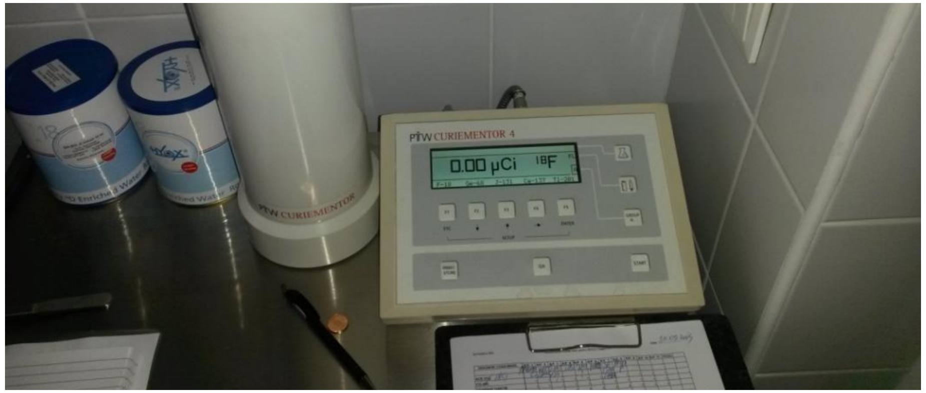

Imagistic Methods of Diagnostic

The Injecting

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Imagistic Methods of Diagnostic

Monitoring the patients
Monitoring the medical staff
Oreste Straciuc

The patients and medical staff are being monitored by surveillance equipment.

Imagistic Methods of Diagnostic

The Patients Preparation

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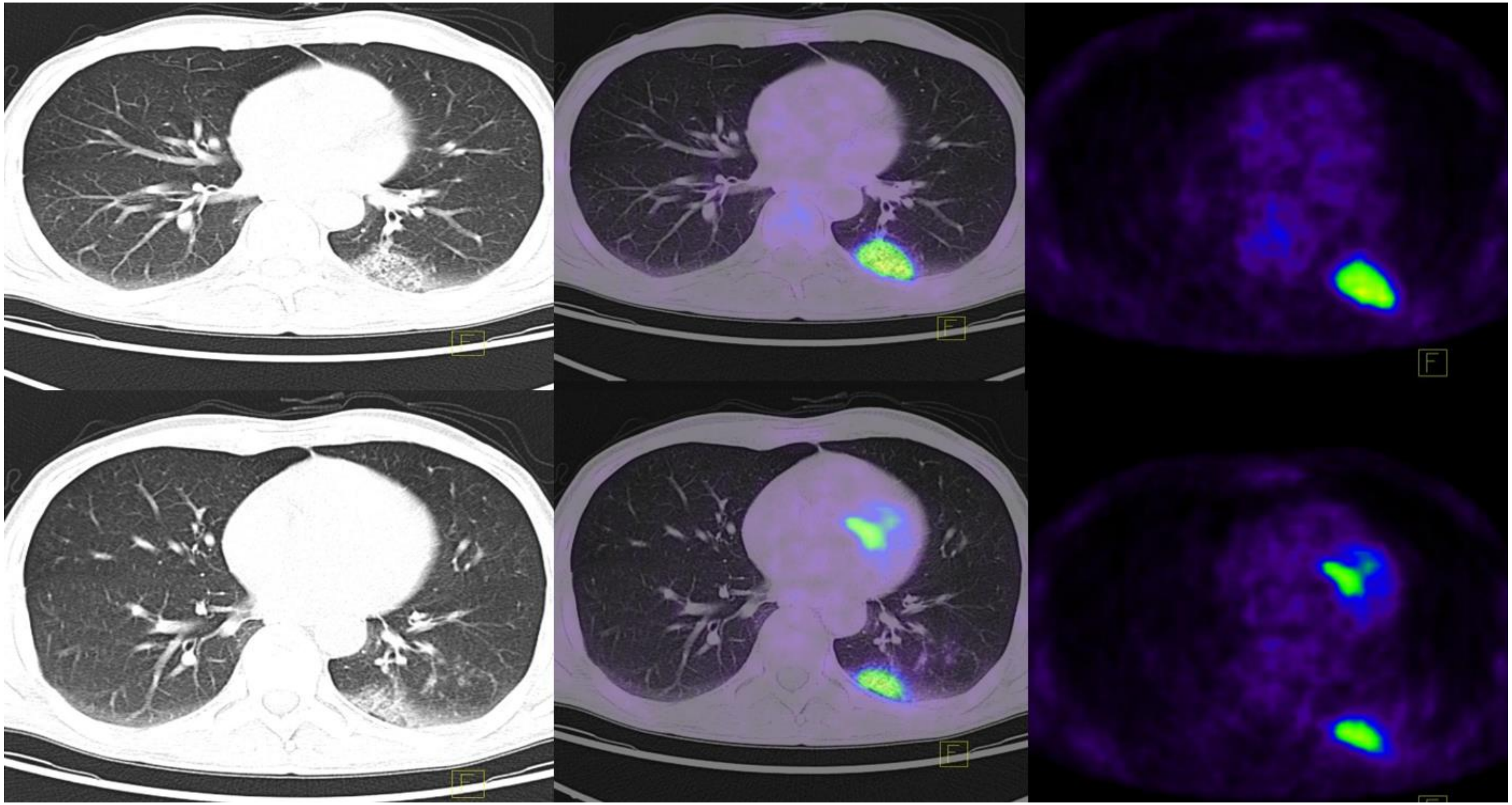
- At least 4 hours fasting;
- Good Hydration;
- Caution in patients with diabetes - blood sugar - less than 144 mg/dl;
- Avoid physical exertion or trauma;
- Thermal Comfort;
- Treatment of inflammation (false positives);
- Sedation – rare;

Imagistic Methods of Diagnostic

The Pneumatic Process

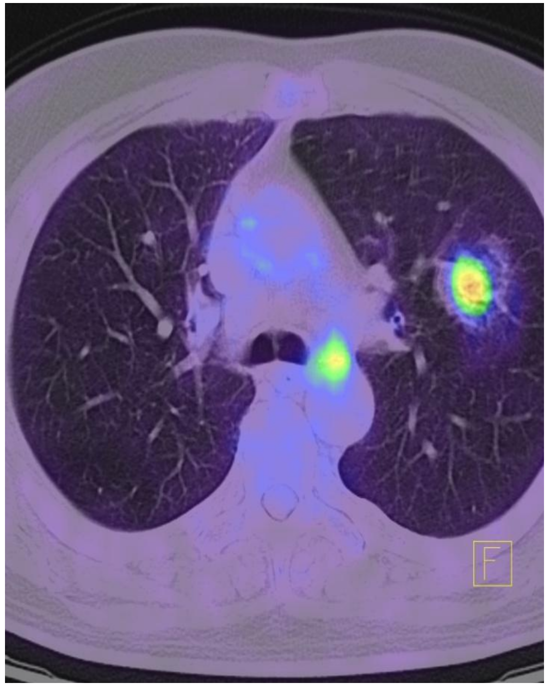
Oreste Straciuc

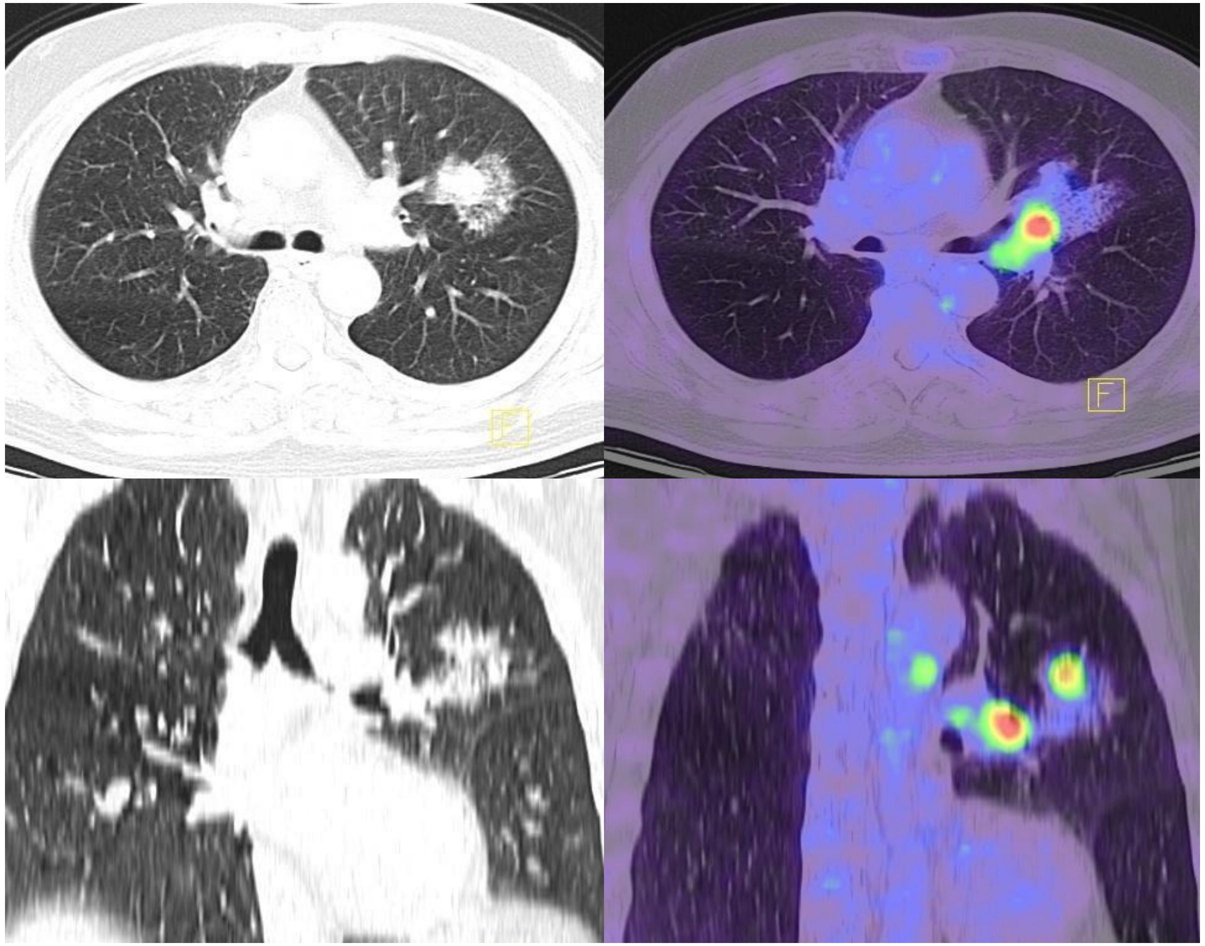


Imagistic Methods of Diagnostic

The Pneumatic Process

Oreste Straciuc

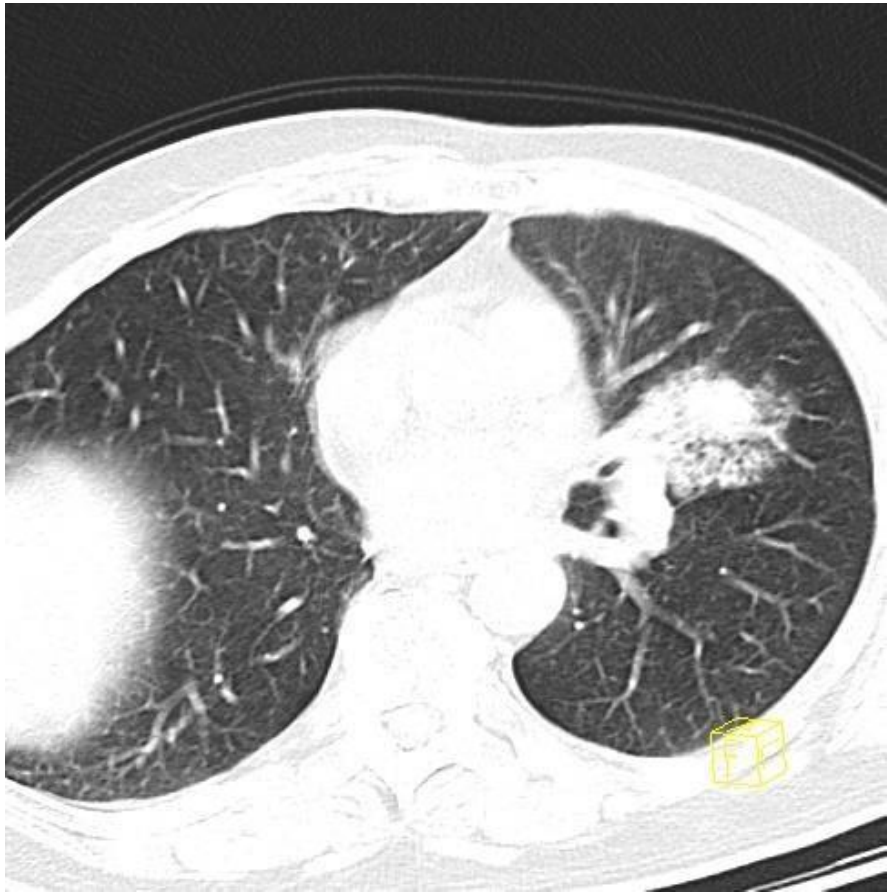


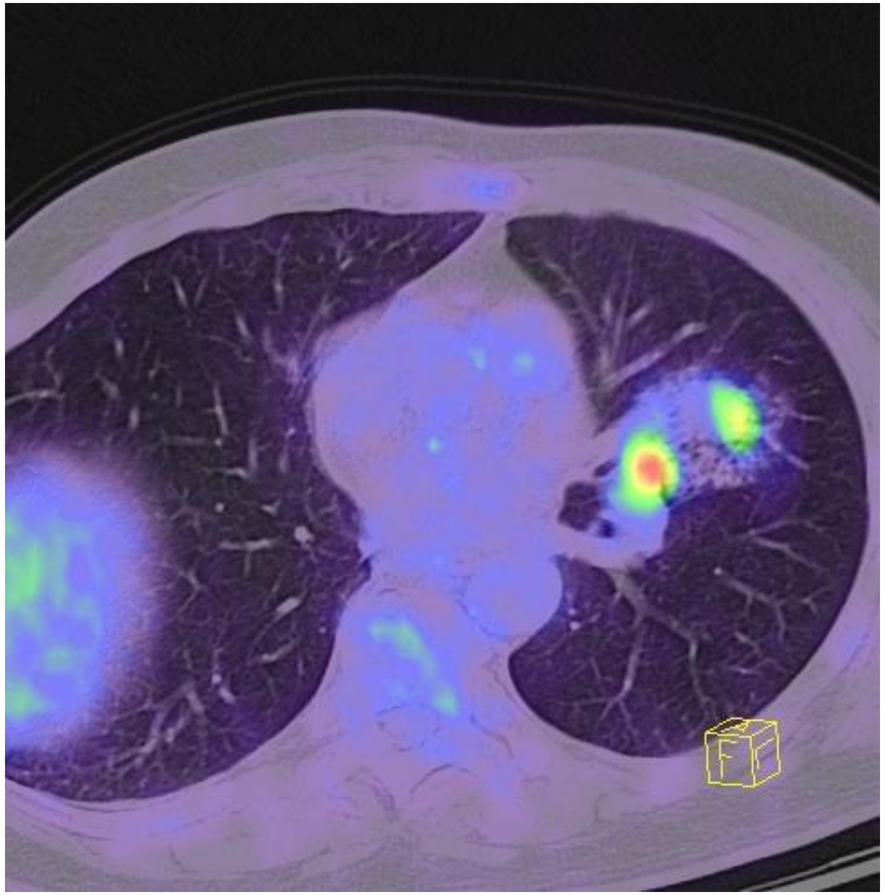


Imagistic Methods of Diagnostic

The Pneumatic Process

Oreste Straciuc

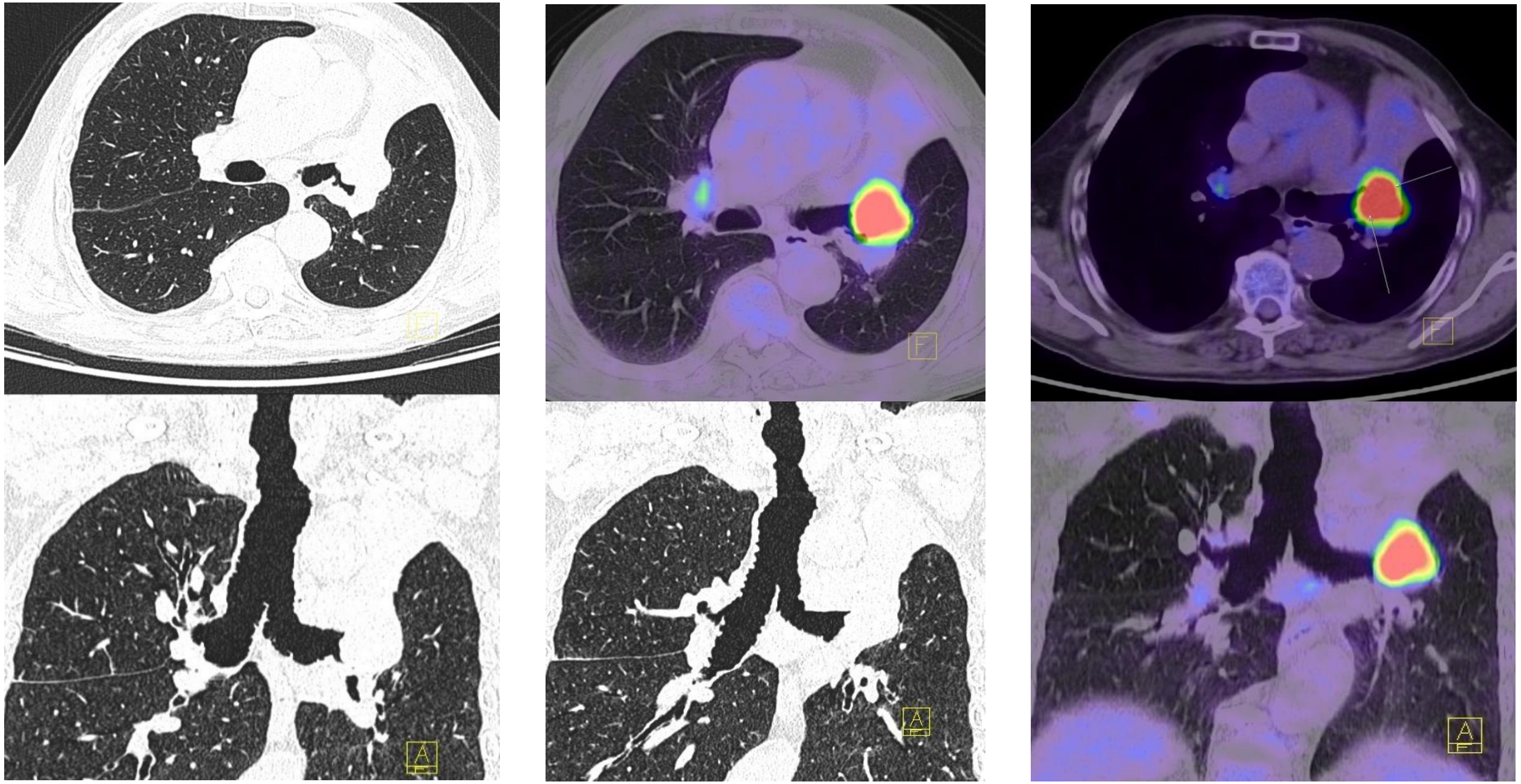




Imagistic Methods of Diagnostic

The Pneumatic Process

Oreste Straciuc



Imagistic Methods of Diagnostic

Oreste Straciuc

- PET / CT allows the detection/delimitation of malignant tumors with the pneumonia or atelectatic masks.
- The bronchoscopy is the first investigation recommended in case of hemoptysis.
- HRCT can select the patients without the indication of bronchoscopy.
- HRCT can guide and streamline the bronchoscopy.
- PET / CT is essential in the correct staging of bronchopulmonary cancers.

Imagistic Methods of Diagnostic

The Advantages

Oreste Straciuc

- A procedure - two investigations (medical imaging + Nuclear Medicine);
- 30 mins "total body“ evaluation;
- Non invasive diagnosis of malignancy;
- The same sensitivity in all the structures of the human body;
- The examination is quick, easily tolerated by the patients;
- Without c-indications;
- The caution for hyperglycemia;
- Maximum diagnostic accuracy;
- Major psycho-emotional impact.

Imagistic Methods of Diagnostic

The Disadvantages

Oreste Straciuc

- The FDG is not a tumor-specific radiotracer;
- The physiological or inflammatory capture - False Positive;
- The existence of non-avid malignancies FDG - False Negative;
- The insufficient characterization of benign lesions;
- The restrictions of irradiation;
- The accessibility and the cost.

Imagistic Methods of Diagnostic

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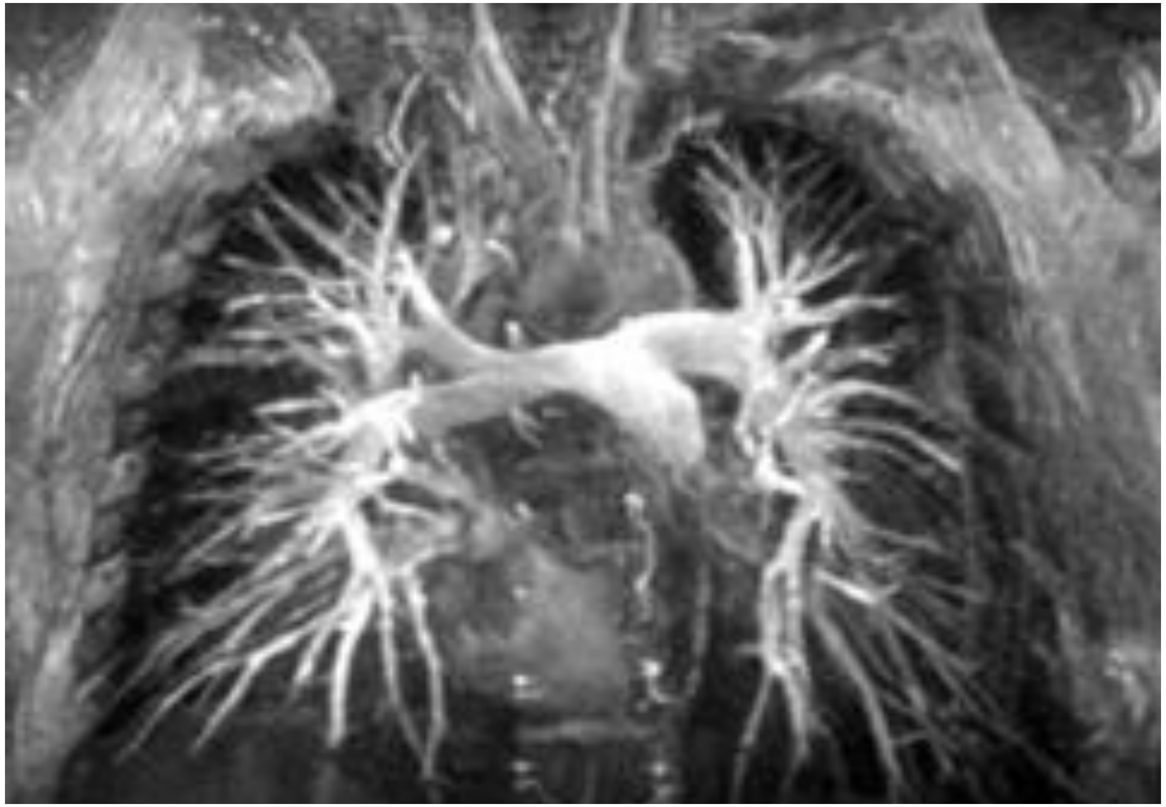
MRI – Magnetic Resonance Imaging



LESSON 4: *Practical Issues for Clinicians*

When is the Transthoracic Ultrasound necessary in pleural effusions?

Lectors:

Ruxandra Ulmeanu, Oradea, Romania

Beatrice Mahler, Oradea, Romania

LESSON 4

PRACTICAL ISSUES FOR CLINICIANS:

When is the Transthoracic Ultrasound necessary in pleural effusions?

THE MAIN TOPICS:

1: TRANSTHORACIC ULTRASONOGRAPHY
2: PLEURAL EFFUSIONS, BIOPSY AND THICKENING
3: ULTRASONOGRAPHIC APPEARANCES
4: EXUDATES TYPES
5: CLASSIFYING THE VOLUME OF AN EFFUSION
6: THE BENEFITIS OF THORACIC ULTRASOUND
7: REAL-TIME ULTRASONOGRAPHIC GUIDANCE
9: THORACENTESIS TECHNIQUES AND COMPLICATIONS
10: CLINICAL CASES
11: IMPORTANT NOTES

TRANSTHORACIC ULTRASONOGRAPHY

Ruxandra Ulmeanu
Beatrice Mahler

- It's ideal for the detection and quantification of pleural effusions;
- It's more sensitive than chest radiography in identifying minimal or loculated effusions.

Kocijancic I, Kocijancic K, Cufer T. Imaging of pleural fluid in healthy individuals. Clin Radiol 2004; 59: 826–829.

TRANSTHORACIC ULTRASONOGRAPHY

Ruxandra Ulmeanu
Beatrice Mahler

- On upright posterior-anterior chest radiograph projections, pleural effusions are generally recognized at a volume of 150–200 cc;
- An upright lateral chest radiograph can be an improvement in the detection of pleural effusions with 50 cc of fluid as the recognized volume;
- Ultrasound has been demonstrated to detect as little as 20 cc of pleural fluid.

M. E. Froudarakis, "Diagnostic work-up of pleural effusions," *Respiration*, vol. 75, no. 1, pp. 4–13, 2008.
M. A. Rothlin, R. Naf, M. Amgwerd, D. Candinas, T. Frick, and O. Trentz, "Ultrasound in blunt abdominal and thoracic trauma," *Journal of Trauma*, vol. 34, no. 4, pp. 488–495, 1993.

TRANSTHORACIC ULTRASONOGRAPHY

Ruxandra Ulmeanu
Beatrice Mahler

Chest radiography has:

- a sensitivity of 65%;
- a specificity of 81%;
- a diagnostic accuracy of 69%.

Ultrasound has:

- a sensitivity of 100%;
- a specificity of 100%;
- a diagnostic accuracy of 100%.

N. Xirouchaki, E. Magkanas, K. Vaporidi et al., "Lung ultrasound in critically ill patients: comparison with bedside chest radiography," *Intensive Care Medicine*, pp. 1–6, 2011.

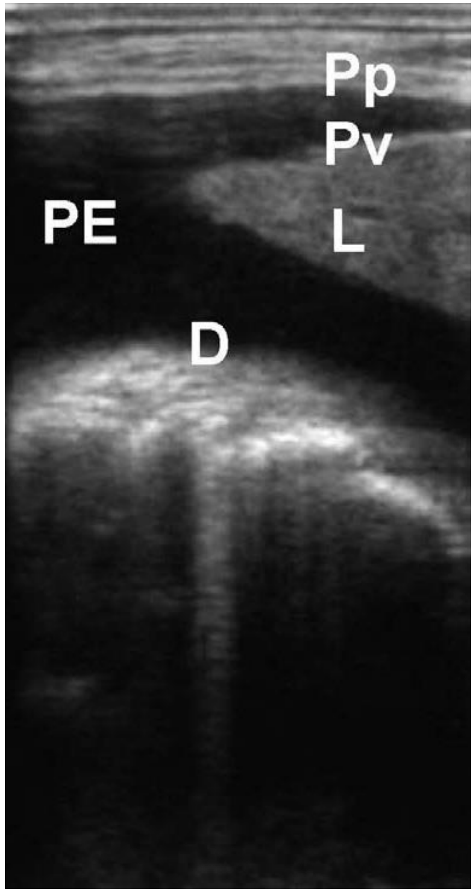
PLEURAL EFFUSIONS

Ruxandra Ulmeanu
Beatrice Mahler

- A pleural effusion is usually seen as a homogeneous, anechoic space between the parietal and visceral pleura.

- How to estimate the size of the pleural effusion:

The effusion size (cc) = 20 × separation(sep)in mm



Florian von Groote- Bidlingmaier, Coenraad F.N. Koegelenberg, A practical guide to transthoracic ultrasound, Breathe , December 2012, Volume 9, No 2.

Ruxandra Ulmeanu
Beatrice Mahler

There are four ultra-sonographic appearances of are recognized based on the internal echogenicity:

1) Anechoic;
2) Complex non-septated;
3) Complex septated;
4) Homogenously echogenic.

Koegelenberg CFN, Bolliger CT, Diacon AH. Pleural Ultrasound, In: Light RW, Lee YC. Textbook of Pleural Disease. 2nd Edn. London, Hodder & Stoughton, 2008; pp. 275–283.

ULTRASONOGRAPHIC APPEARANCES

Ruxandra Ulmeanu
Beatrice Mahler

- Transudates typically appear as anechoic and non-septated free-flowing effusions.
- Exudates are mostly complex septate or echogenic effusions.
- Fresh blood is in a brighter or more hyperechoic shade.
- Pleural empyemas is the presence of gas bubbles within the fluid.

1. Yang PC, Luh KT, Chang DB. Value of sonography in determining the nature of pleural effusion: analysis of 320 cases. AJR Am J Roentgenol 1992; 159: 29–33.
2. Hirsch JH, Rogers JV, Mack LA. Real-time sonography of pleural opacities. Am J Roentgenol 1981; 136: 297–301.
3. Qureshi NR, Rahman NM, Gleeson FV. Thoracic ultrasound in the diagnosis of malignant pleural effusion. Thorax 2009; 64: 139–143.

EXUDATES TYPES

Ruxandra Ulmeanu
Beatrice Mahler

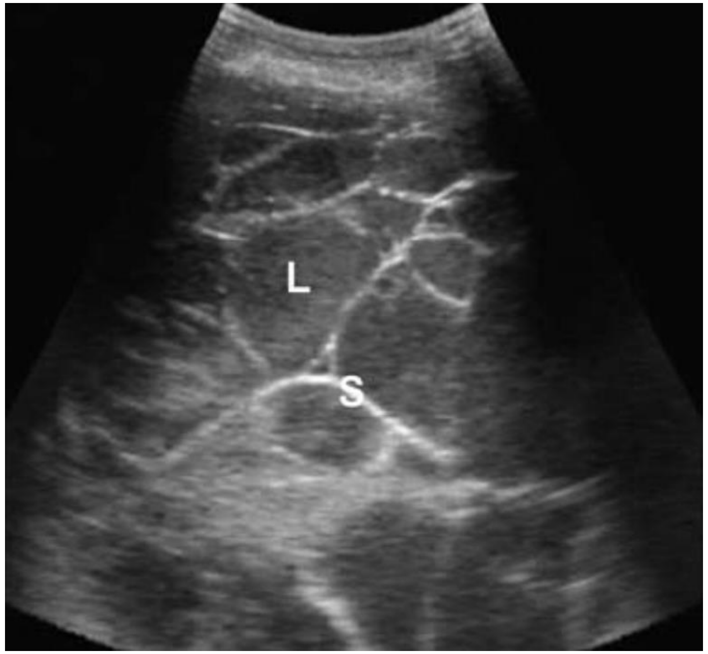
- **Malignant effusions** are often anechoic, their pleural thickening is as mush as 10 mm.
- They also have pleural and diaphragmatic nodularity.
- Diaphragmatic thickening as much as 7 mm is highly suggestive of malignant disease.

EXUDATES TYPES

Ruxandra Ulmeanu

Beatrice Mahler

- **Inflammatory effusions:**
- **Strands of echogenic material** and septa that show more or less mobility with respiration.
- ***Patients with septated effusions needed:***
  - Longer chest tube drainage;
  - Longer hospital care and were more likely to require fibrinolytic therapy;
  - Surgery;



CLASSIFYING THE VOLUME OF AN EFFUSION

Ruxandra Ulmeanu
Beatrice Mahler

- Minimal, if the echo-free space is confined to the costophrenic angle;
- Small, if the space is greater than the costophrenic angle but still within the range of the area covered with a 3.5-MHz curvilinear probe;
- Moderate, if the space is greater than a one probe range but within a two-probe range;
- Large, if the space is greater than a two probe range.

THE BENEFITIS OF THORACIC ULTRASOUND

Ruxandra Ulmeanu
Beatrice Mahler

- It improves the success rate of pleural aspiration;
- It minimizes the risk of visceral puncture;
- It reduces the risk of pneumothorax following aspirations.

Hooper C, Lee YC, Maskell N. Investigation of a unilateral pleural effusion in adults: British Thoracic Society pleural disease guideline 2010. Thorax 2010; 65: Suppl. 2, ii4–ii17.
Chen KY, Liaw YS, Wang HC. Sonographic septation: a useful prognostic indicator of acute thoracic empyema. J Ultrasound Med 2000; 19: 837–843.
Havelock T, Teoh R, Laws D, et al. Pleural procedures and thoracic ultrasound: British Thoracic Society

THE BENEFITIS OF THORACIC ULTRASOUND

Ruxandra Ulmeanu
Beatrice Mahler

- It guides to further decisions regarding the need for tube drainage, intra-pleural fibrinolytic therapy, pleuroscopy or surgical intervention.

- It identifies the optimal site for safe and effective intercostal drainage

REAL-TIME ULTRASONOGRAPHIC GUIDANCE

Ruxandra Ulmeanu
Beatrice Mahler

- It’s used for direct fluid aspiration;
- It’s used for intercostal drainage, to guide dilatation of a tract and deployment of a small bore catheter (8–14 F), these tubes are better tolerated than large bore (20–24 F);
- It’s helpful for guiding biopsies of the pleura.

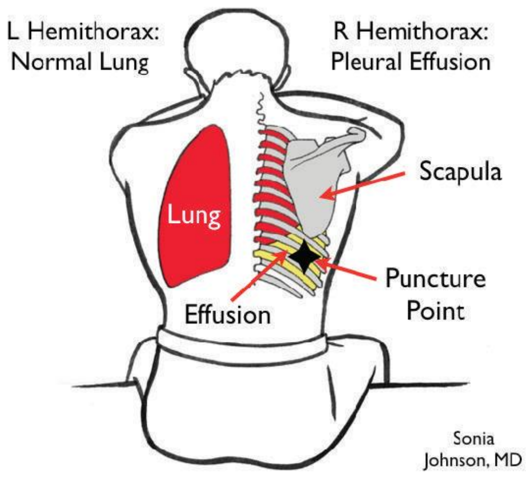
THORACENTESIS TECHNIQUES

Ruxandra Ulmeanu
Beatrice Mahler

- Informed consent should be obtained from the patient;
- Maximal sterile precautions should be used throughout the procedure;
- Skin area should be prepared and draped in a sterile manner;
- Hands should be washed and a mask should be worn;
- A sterile cap, gown and gloves should be used.

THORACENTESIS TECHNIQUES

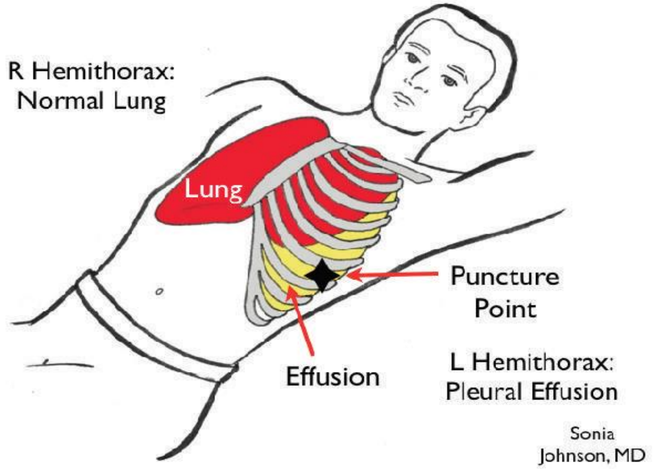
Ruxandra Ulmeanu
Beatrice Mahler



- The patient should be in an upright position leaning forward on a support. This allows access to the posterior approach to thoracentesis

THORACENTESIS TECHNIQUES

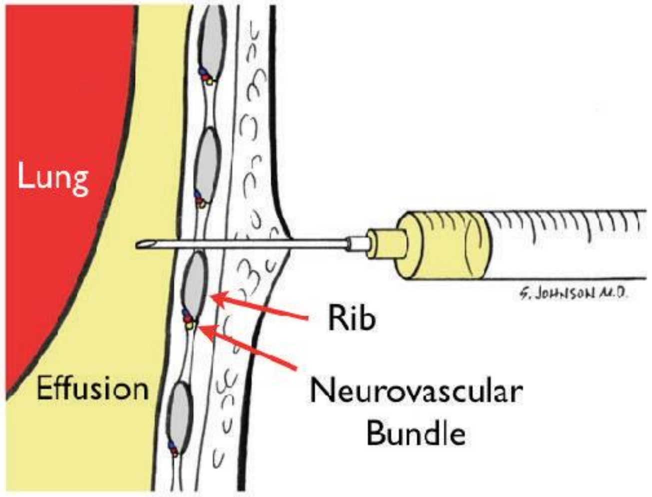
Ruxandra Ulmeanu
Beatrice Mahler



- The supine position, allowing a lateral approach to the chest cavity, may be employed in patients unable to sit up. This would be a similar position to that used for the typical placement of a chest tube.

THORACENTESIS TECHNIQUES

Ruxandra Ulmeanu
Beatrice Mahler



- The optimal needle puncture locations should be determined and local anesthesia should be used to provide maximal patient comfort.

COMPLICATIONS OF THORACENTESIS

Ruxandra Ulmeanu
Beatrice Mahler

Patient related factors:

- the presence of smaller effusions (<250 cc);
- multiloculated effusions;
- underlying coagulopathy;
- Obesity;
- poor patient positioning;
- mechanical ventilation;
- pleural visceral adhesion.

Procedural factors:

- Inexperienced practitioners;
- lack of ultrasound guidance;
- large volume drainage (>1.5 liter).

COMPLICATIONS OF THORACENTESIS

Ruxandra Ulmeanu
Beatrice Mahler

- **Pneumothorax - incidence rate 6.0%**
- **Re-expansion Pulmonary Edema – incidence < 0,5%, patients with >1 liter of fluid removed;**
- **Abdominal Viscus Injury – liver and spleen;**
- **Infection Causing Empyema – incidence rate - 1,2%;**

COMPLICATIONS OF THORACENTESIS

Ruxandra Ulmeanu
Beatrice Mahler

Other complications:

- pain (25%);
- shortness of breath (1%);
- cough (0.8%);
- vagal reaction (0.6%).

PLEURAL BIOPSY

Ruxandra Ulmeanu
Beatrice Mahler

***In pleural malignancy* the positive diagnostic is less than 60%.**

***For pleural tuberculosis* is generally much higher, due to the more homogenous distribution of tuberculous granulomata, and may even be as high as 87%, if at least six specimens are harvested.**

1. Chang BD, Yang PC, Luh KT, et al. Ultrasound-guided pleural biopsy with Tru-Cut needle. Chest 1991; 100:1328–1333.
2. *D. Ghosh, T.Q. Howes*, **How to do it: ultrasound guided pleural biopsy**, Breathe, December 2007, Volume 4 , No 2
3. Diacon AH, Schuurmans MM, Theron J, et al. Safety and yield of ultrasound assisted transthoracic biopsy performed by pulmonologists. Respiration 2004; 71:519–522.
4. Koegelenberg CF, Bolliger CT, Theron J, et al. Direct comparison of the diagnostic yield of ultrasoundassisted Abrams and Tru-Cut needle biopsies for pleural tuberculosis. Thorax 2010; 65: 857–862.

PLEURAL BIOPSY

Ruxandra Ulmeanu
Beatrice Mahler

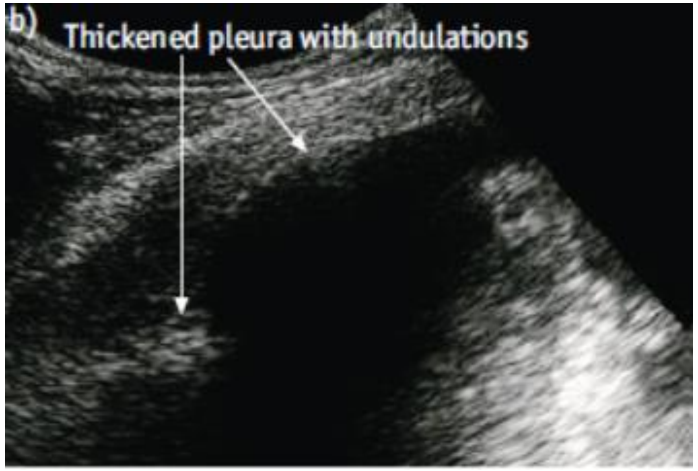
Image-guidance may significantly increase the yield for malignancy while decreasing the risk of complications found the diagnostic yield of ultrasonography guided.

CHANG at all - positive diagnostic of guided pleural biopsy is 77% for malignancies.
DIACON at all showed confirmation for 100% malignant mesothelioma extending at least 20 mm in any accessible dimension on ultrasonography. In a recent study, we found that the yield of an ultra-sonography-assisted Abrams needle may be as high as 83% for malignant effusions.

PLEURAL THICKENING

Ruxandra Ulmeanu
Beatrice Mahler

Pleural thickening is a focal lesion that is greater than 3 mm in width, arising from the visceral or parietal pleura with or without an irregular margin.



Ultrasonography criteria:

- It may appear hypoechoic on ultrasonography;
- It has a relative movement to the chest wall with respiration;
- We can observe the absence of a fluid color sign with the color Doppler scanning.

Marks WM, Filly RA, Callen PW. Real-time evaluation of pleural lesions: new observations regarding the probability of obtaining free fluid. Radiology 1982; 142: 163–164.

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 1

Women at ...years old:

- *Multiple valvular disease;*
- *Cardiac insufficiency;*
- *Depressive syndrome;*
- *Arterial hypertension.*

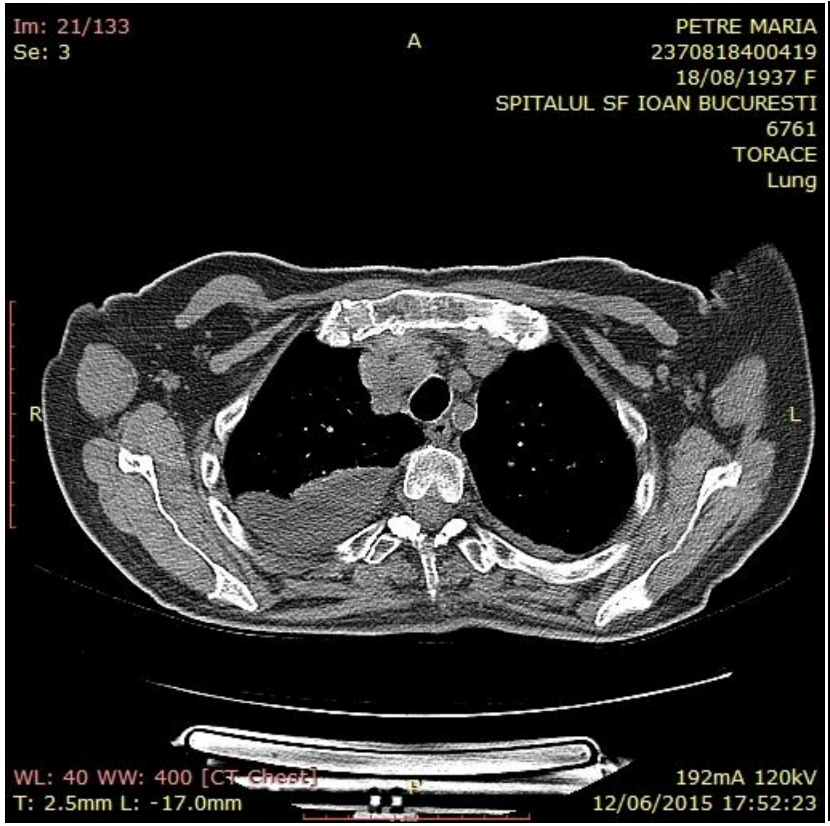
Thoracic Radiology

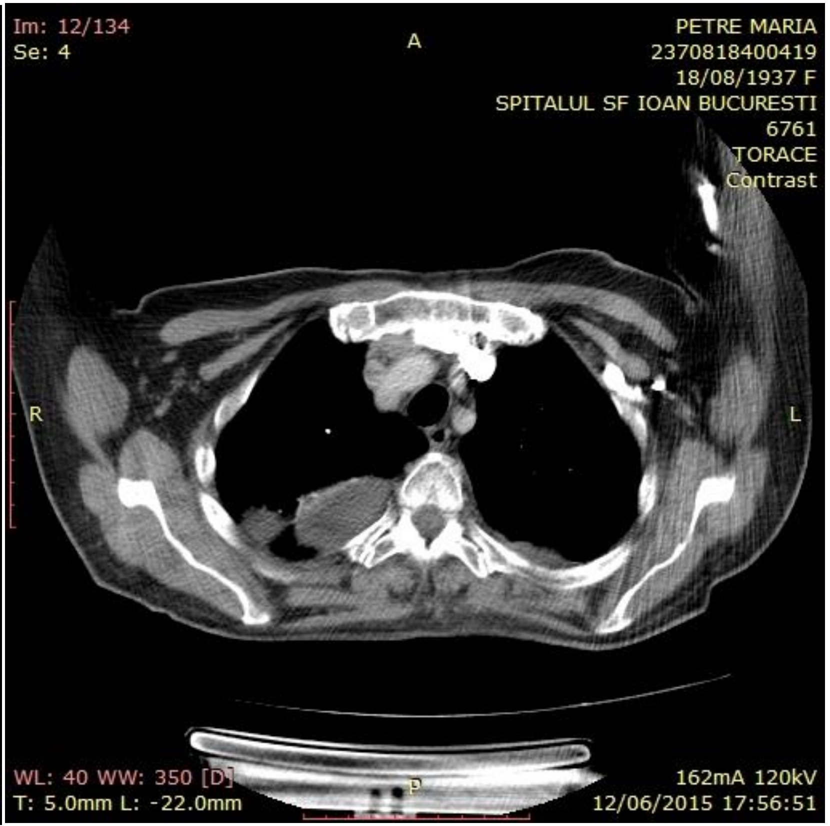
CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 1

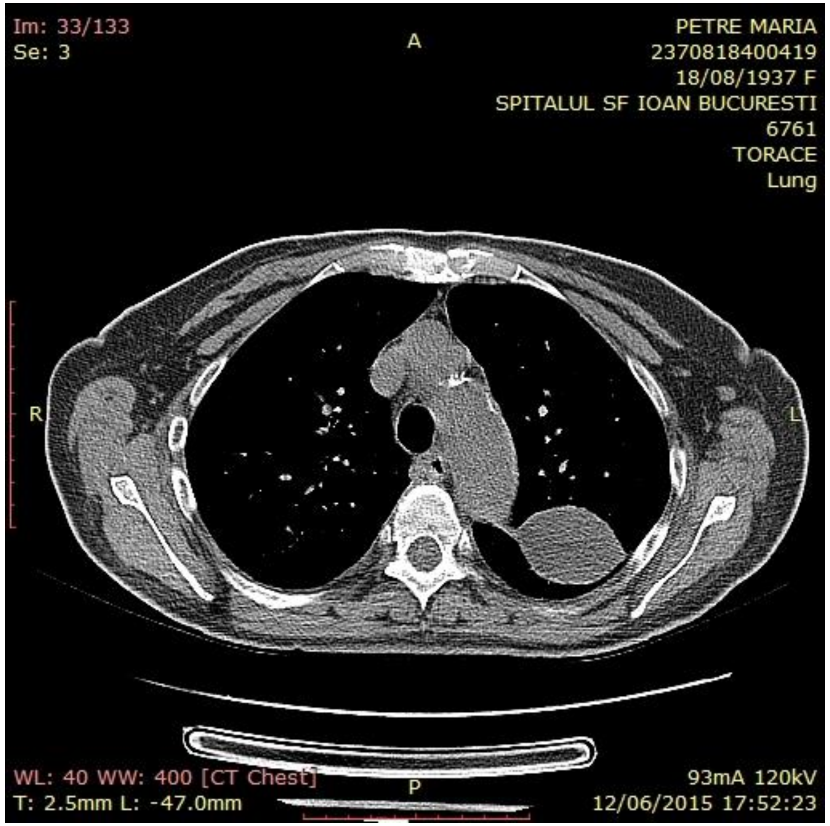


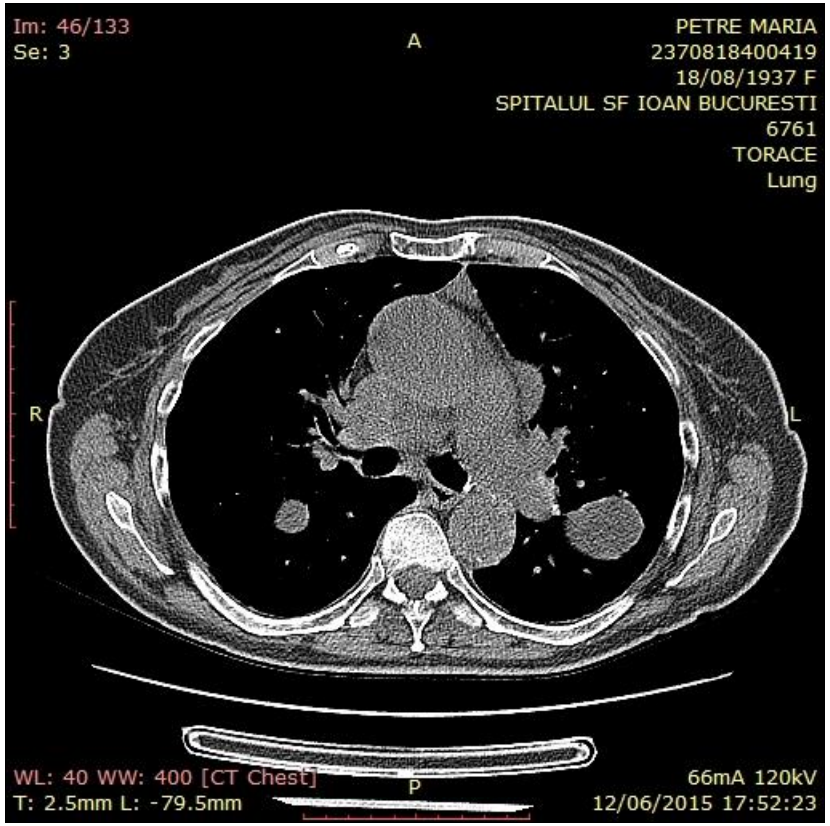


CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 1

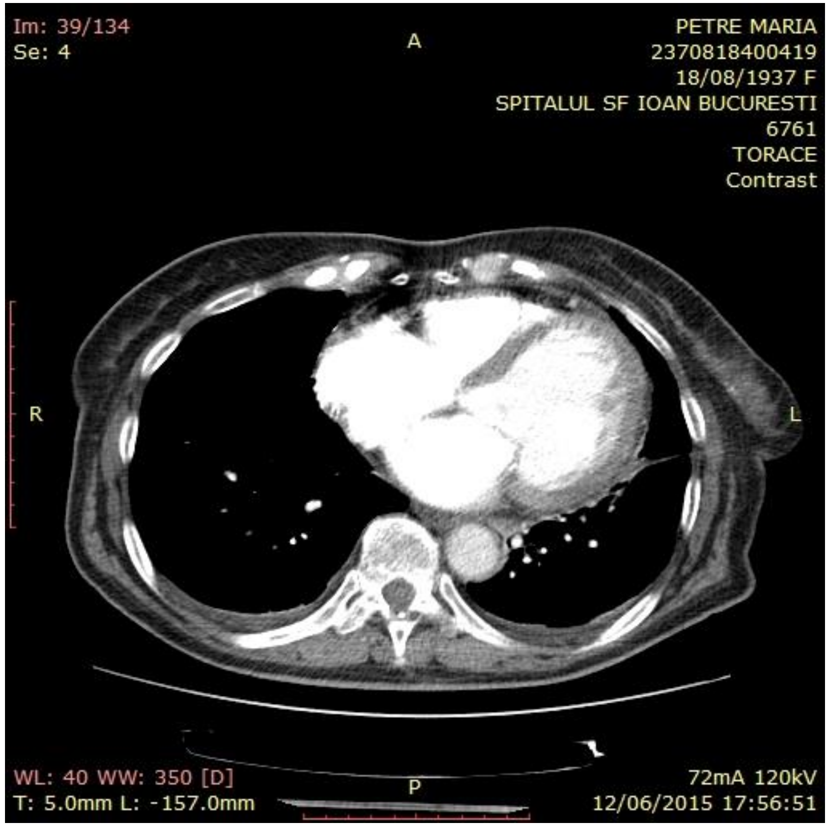


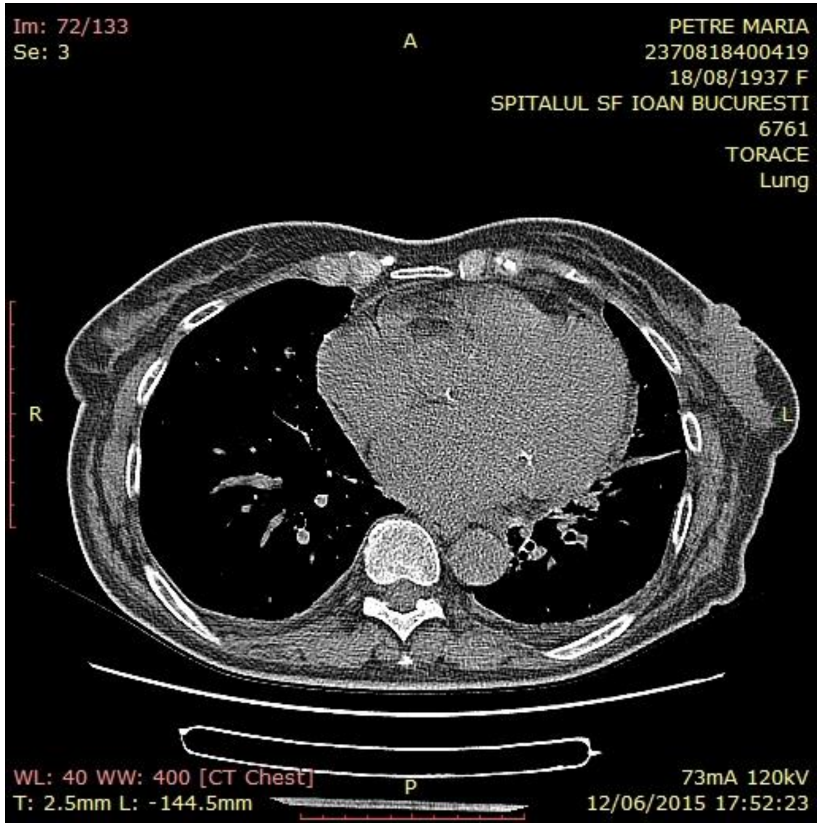


CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 1





CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

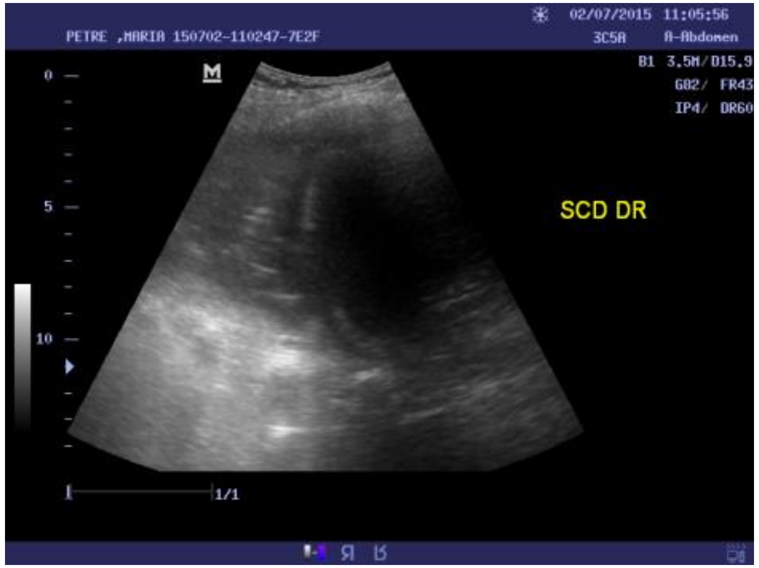
WHAT ARE WE DOING ?

- How to arrive at the correct diagnosis with this lung pathology?
- Did the right lung opacification represent a pleural effusion or a mass?
- Secondly, what was the optimal treatment plan for the patient?
- Would a thoracentesis procedure be indicated in this case to help alleviate respiratory distress?

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

THORACIC ULTRA-SONOGRAPHY



Ruxandra Ulmeanu
Beatrice Mahler

ECOCARDIOGRAPHY

- Global Systolic Dysfunction;
- Moderate Aortic And Mitral Regurgitation;
- Moderate Tricuspid Regurgitation;
- Left Atrial Dilatation;
- Mild Left Ventricular Hypertrophy;
- Minimum Pericarditis;
- I Degree Diastolic Dysfunction;
- Fe 50%.

THE BIOCHEMISTRY OF PLEURAL FLUID

- **Glucose = 87 mg/dl;**
- **LDH = 124 U/L;**
- **Total protein = 2.7 g/dl.**

THE DIAGNOSIS

- **Pleural Transudat;**
- **Cardiac Congestiv Failure;**
- **Minimal Pericarditis.**

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 2

Women T.A,

- **57 years old;**
- **Chronic Myeloid Leukemia – since 2013 march;**
- **Treated with Ditasinib;**
- **Arterial hypertension;**
- **Dyslipidemia.**

CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 2

Women T.A,

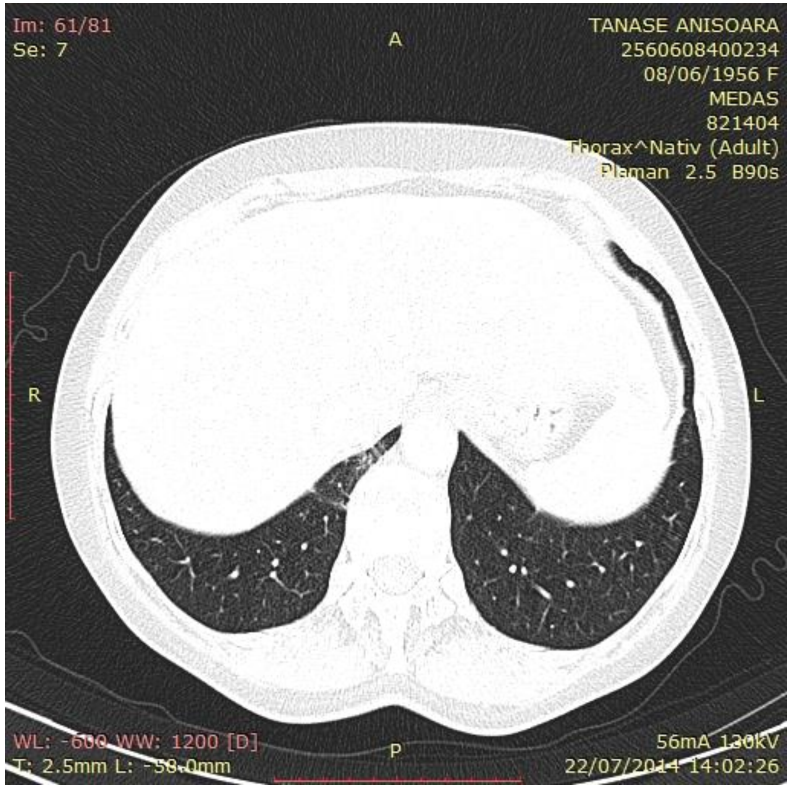
- 57 years old;
- Chronic Myeloid Leukemia – since 2013 march;
- Treated with Ditasinib;
- Arterial hypertension;
- Dyslipidemia;
- Mediastinal Lymphadenopathy;
- Splenomegaly;
- Verdict issued by HP bone marrow biopsy.

CLINICAL CASES

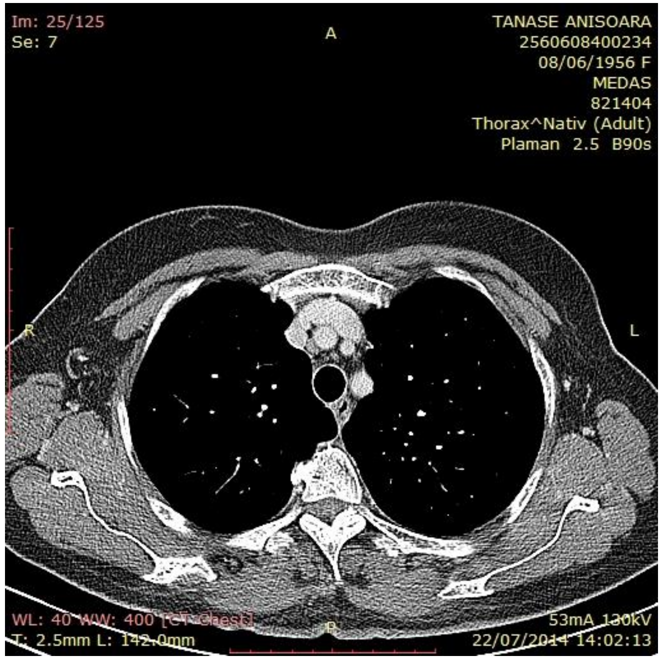
Ruxandra Ulmeanu

Beatrice Mahler

Case no. 2



INTIAL CT SCAN

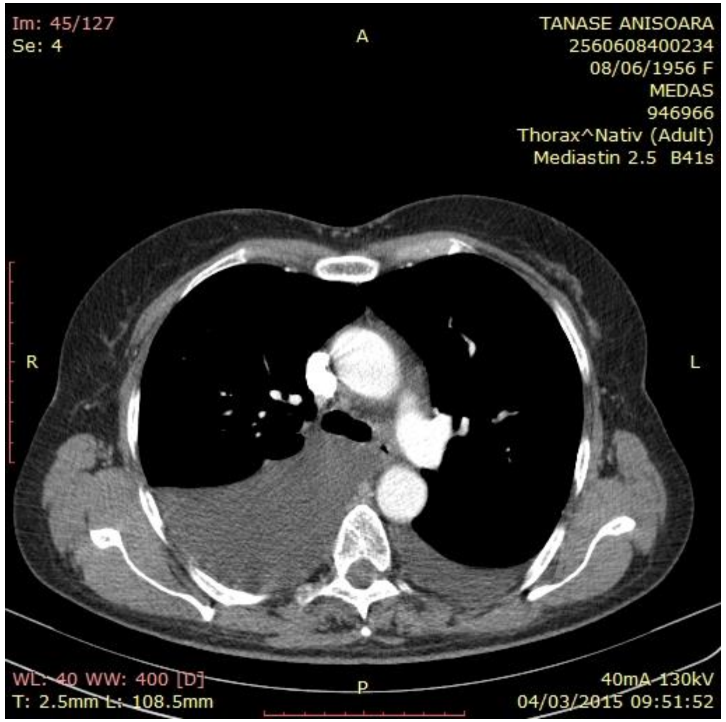


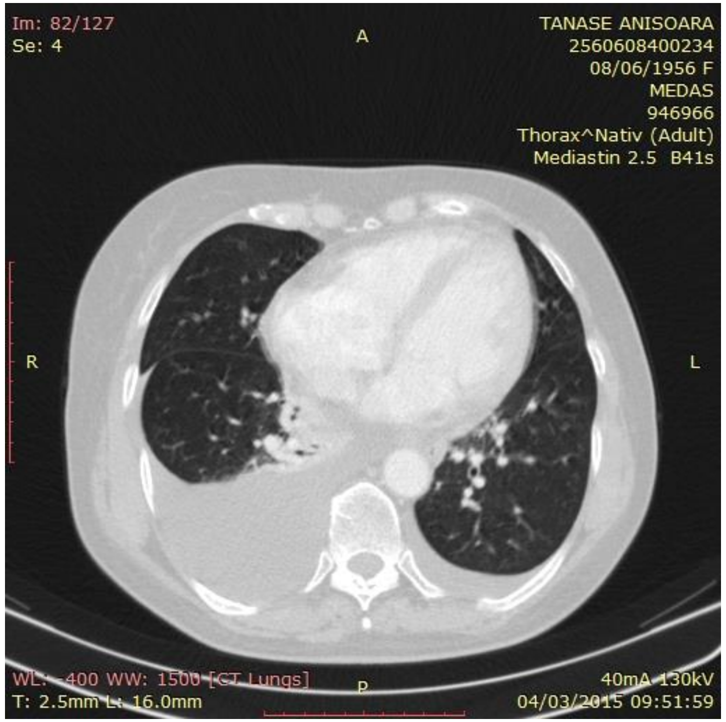
CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 2

CT SCAN AFTER 6 MONTHS





CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

SPIROMETRY

- mixed ventilatory dysfunction with decreased VC with 39% and FEV 1 with 45%.

ECG

- Normal.

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

WHAT ARE WE DOING ?

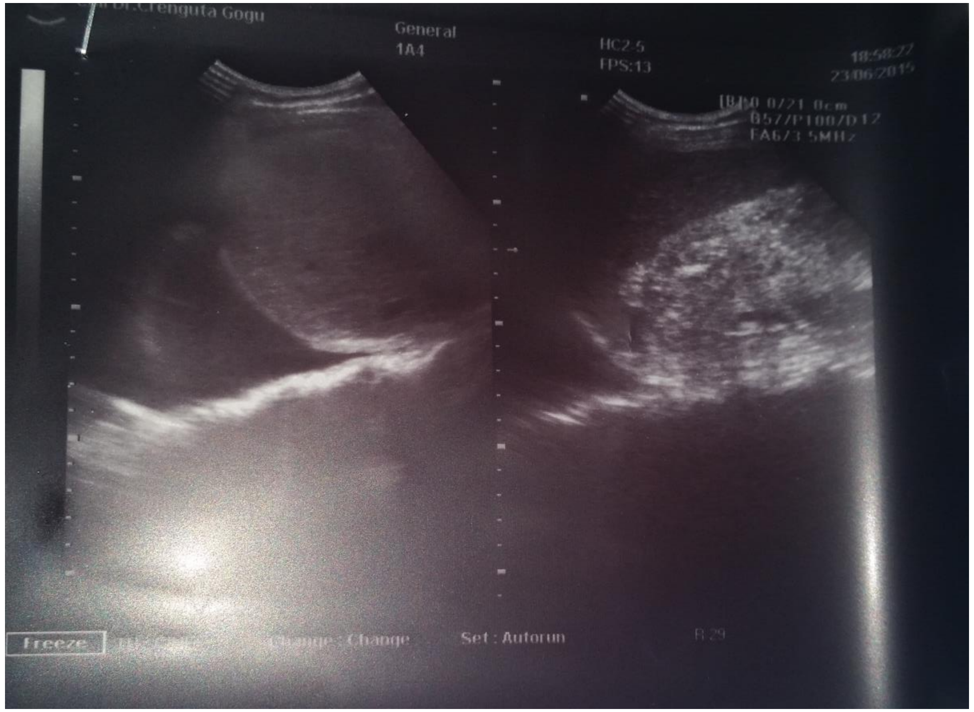
- How to arrive at the correct diagnosis with this hematological pathology?
- What was the optimal treatment plan for the patient?
- Would a thoracentesis procedure be indicated in this case to help alleviate respiratory distress?

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 2

AFTER 6 MORE MONTHS



PLEURAL EFFUSION

Pleural effusion cytology:

- frequently isolated and grouped atypical cells.

Pleural biopsy:

- the inflammation infiltrate pleural effusion fragment.

CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 2

CONCLUSIONS

- **Pleural effusion secondary to hematological treatment;**
- **LLC.**

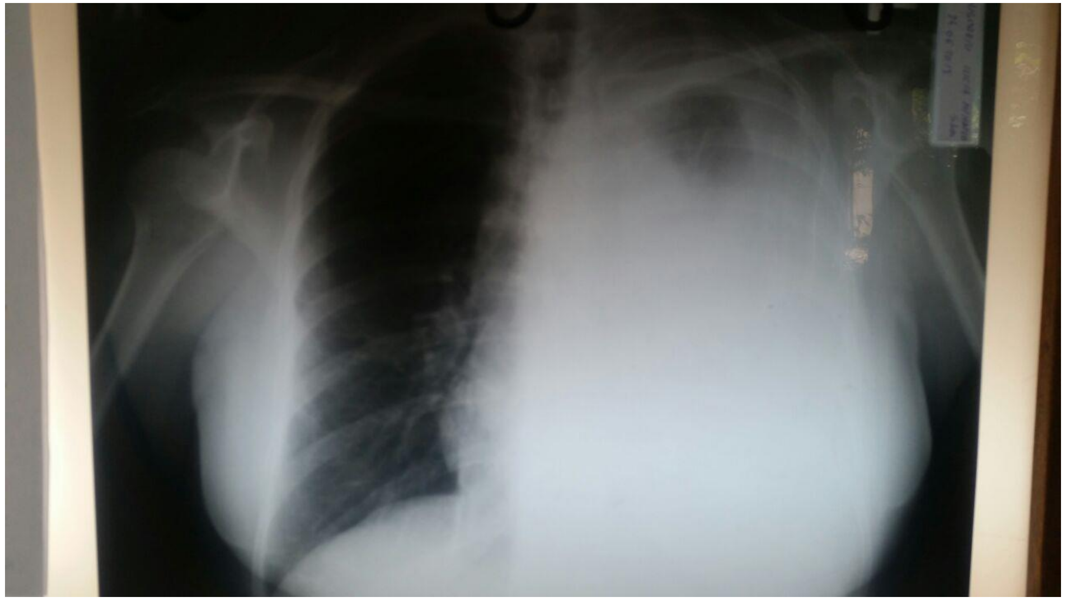
CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 3

- A women who is 51 years old;
- Smoking 16 PA;
- Acute onset with : dyspnea, asthenia, cough.

THORACIC RADIOLOGY



CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 3

BRONCHOSCOPY

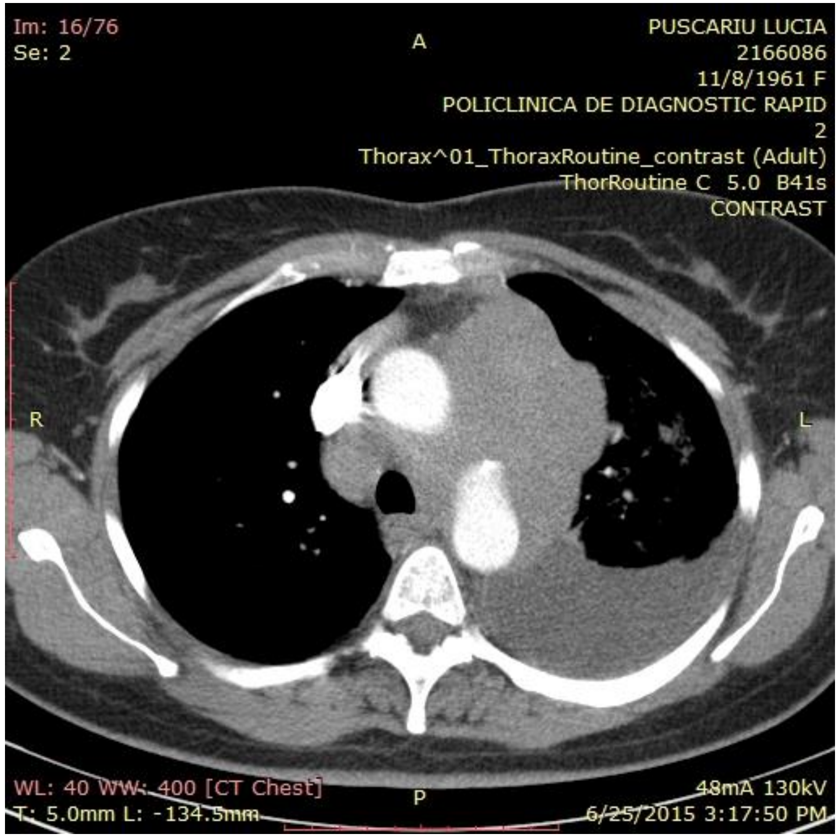
- Extrinsic compression of the left upper lob and left inferior lob, progress towards the distal stenosis;
- The changes described are most strongly visible at higher ridge and bee-stg;
- Biopsy on the left appear bronchia.

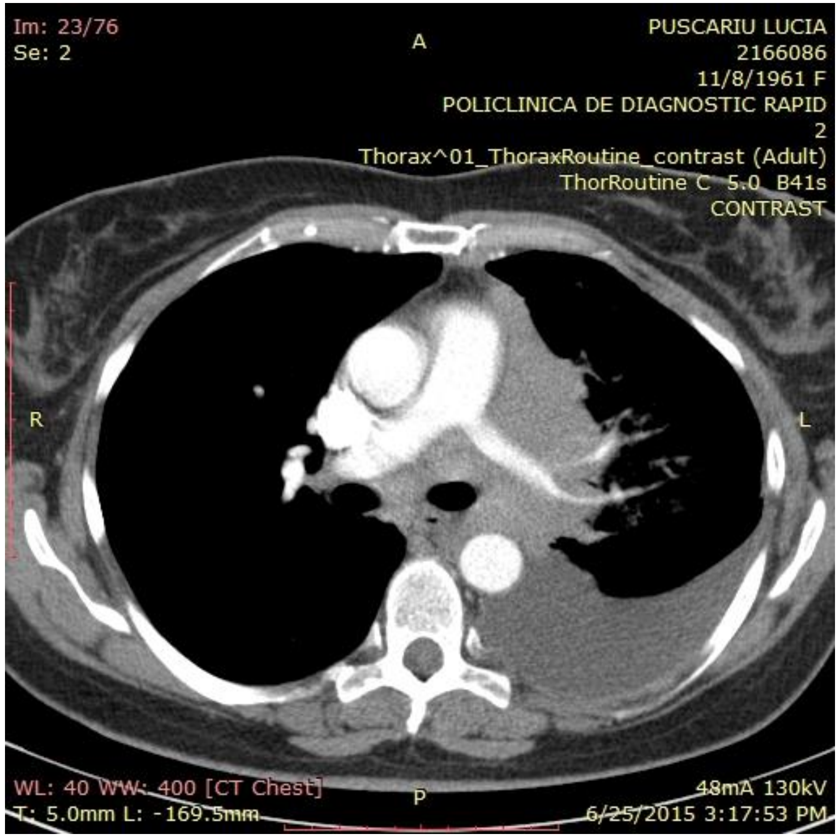
CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 3





CLINICAL CASES

Ruxandra Ulmeanu
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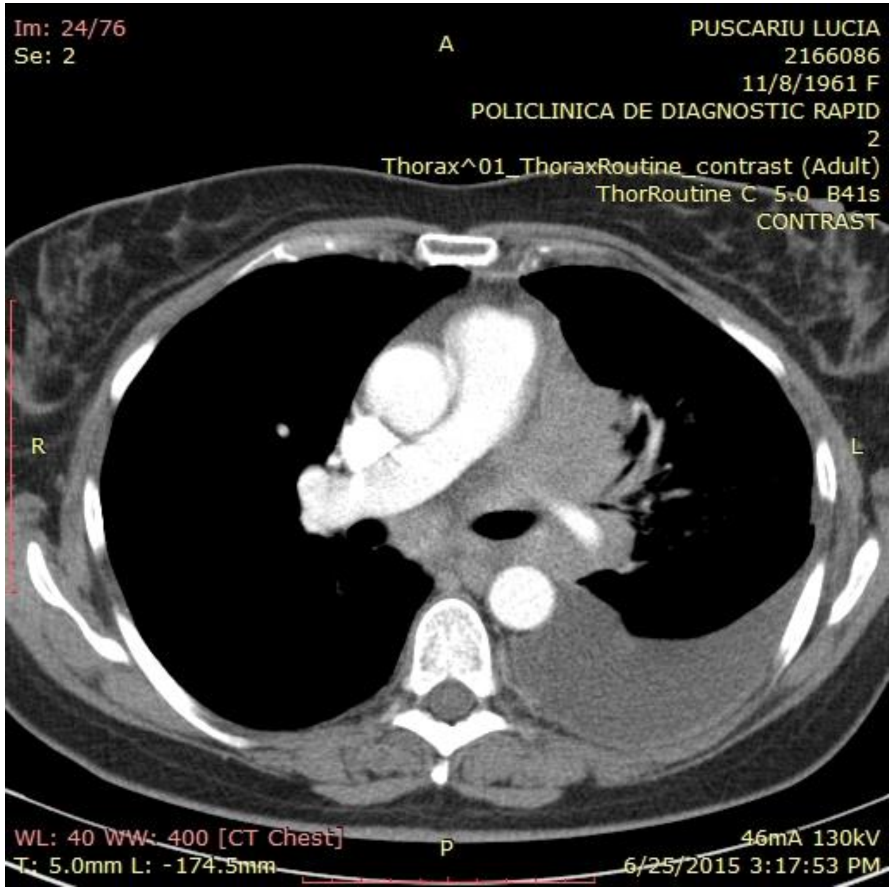
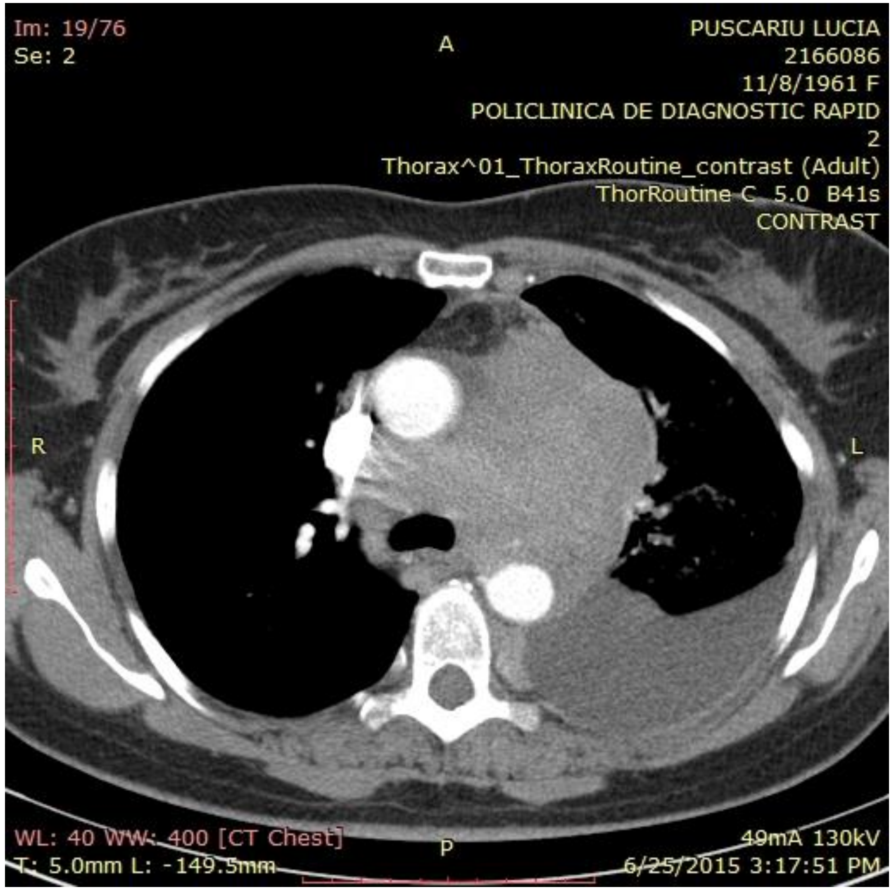
Case no. 3





SPIROMETRY

- Moderate restrictive ventilatory dysfunction with decreased by 40% VC.

CLINICAL CASES

Ruxandra Ulmeanu

Beatrice Mahler

Case no. 3

BREAST ULTRASOUND

- **Left breast:** the normal thickness, suggestive of predominant global ultrasound fat. Without solid or cystic lesions visible by ultrasound at the time of examination. No lymphadenopathy.
- **Right breast**: skin tissue - normal thickness. Without solid or cystic lesions visible by ultrasound at the time of examination. Left armpit: lymphadenopathy diameter 9 / 6mm.

CLINICAL CASES

Ruxandra Ulmeanu

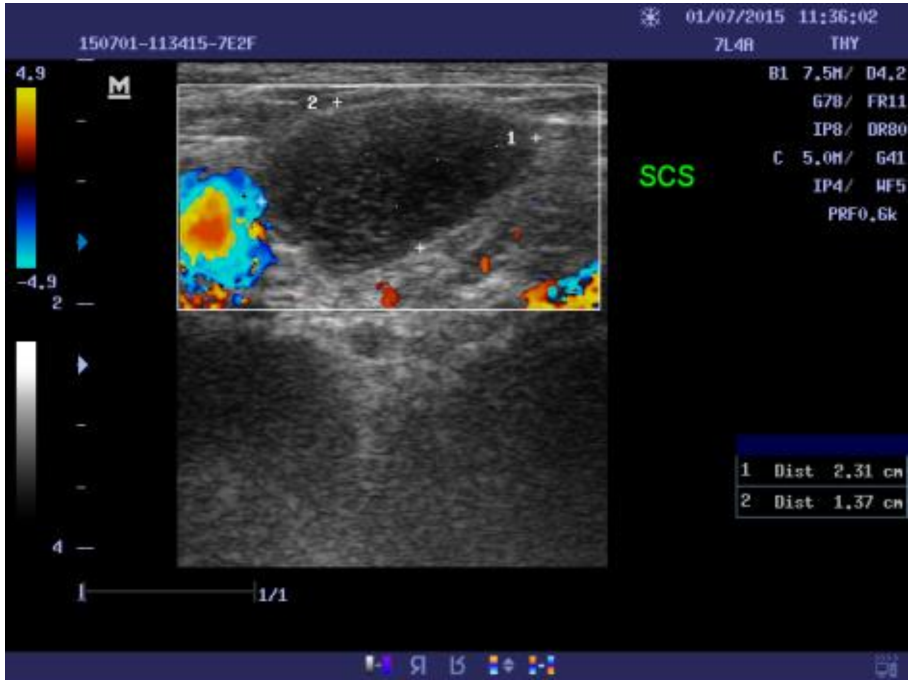
Beatrice Mahler

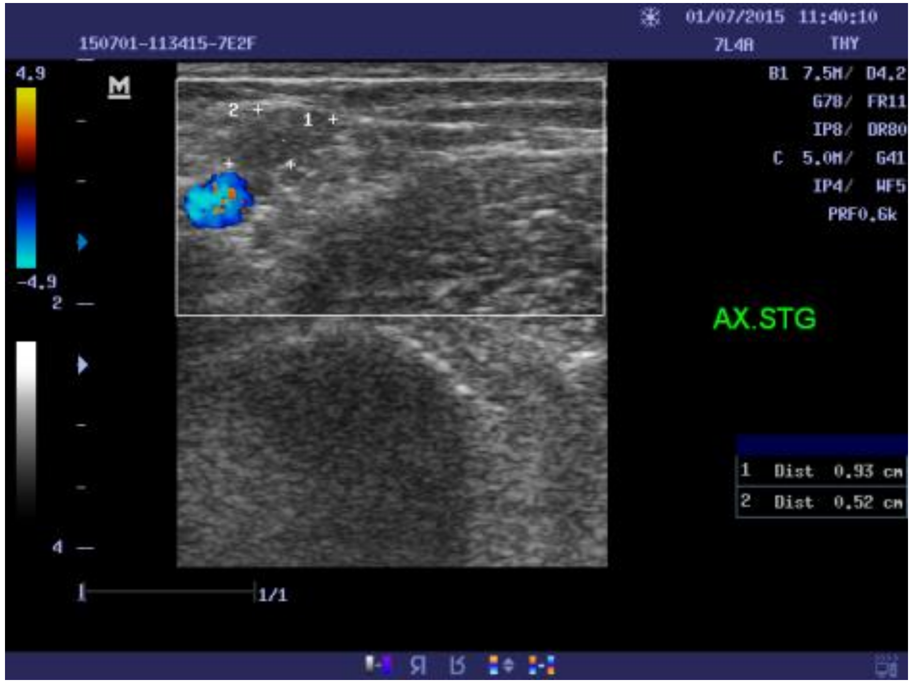
Case no. 3

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 3





CLINICAL CASES

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Beatrice Mahler

Case no. 3

CLINICAL CASES

Ruxandra Ulmeanu
Beatrice Mahler

Case no. 3

PLEURAL FLUID

- pleural aspiration;
- 1700 ml opaque and serocitrin effusion;
- pleural fluid;
- Total cholesterol = 93 mg/dl;
- Glucose = 119 mg/dl;
- HDL = 15 mg/dl;
- LDH = 154 U/L;
- Total protein = 3.7 g/dl;
- Triglycerides = 80 mg/dl.

CITOLOGY OF PLEURAL FLUID

- Rare neoplastic cells, isolated and grouped – Adenocarcinoma.

DIAGNOSTIC

- Pulmonary Adenocarcinoma Stage IV (T4N3M1);
- Malignacy Pleural Effusion;
- Pleural Metastasis.

IMPORTANT NOTES

Ruxandra Ulmeanu
Beatrice Mahler

- Ultrasound serves as a more accurate imaging tool than chest radiography for the diagnosis of pleural effusions;
- Ultrasound has the additional potential benefits that it can be rapidly performed;
- It lacks the ionizing radiation associated with both chest radiographs and computed tomography scans.

IMPORTANT NOTES

Ruxandra Ulmeanu

Beatrice Mahler

- **Bedside ultrasound can allow discrimination of pleural effusions from other lung pathology that may appear similar on a chest radiograph;**
- **Ultrasound allows diagnosis of complicated pleural effusions, such as empyemas and abscesses which may be associated with a higher risk for a drainage procedure;**
- **It comes with a decrease in the overall complication rate associated with thoracentesis.**

LESSON 5: *Ultrasound Technology and Techniques*

Lectors:

Zeno Sparchez, Cluj-Napoca, Romania

LESSON 5

ULTRASOUND TECHNOLOGY AND TECHNIQUES

THE MAIN TOPICS:

1: INTRODUCTION
2: INDICATIONS
3: LIMITS
4: WHAT ARE WE ABLE TO SEE? THE PLEURA
5: THE PULMONARY PARENCHYMA
6: THE TECHNICAL EQUIPMENT
7: THE EXAMINATION POSITIONS AND TECHNIQUES
8: THE CONCLUSIONS

INTRODUCTION

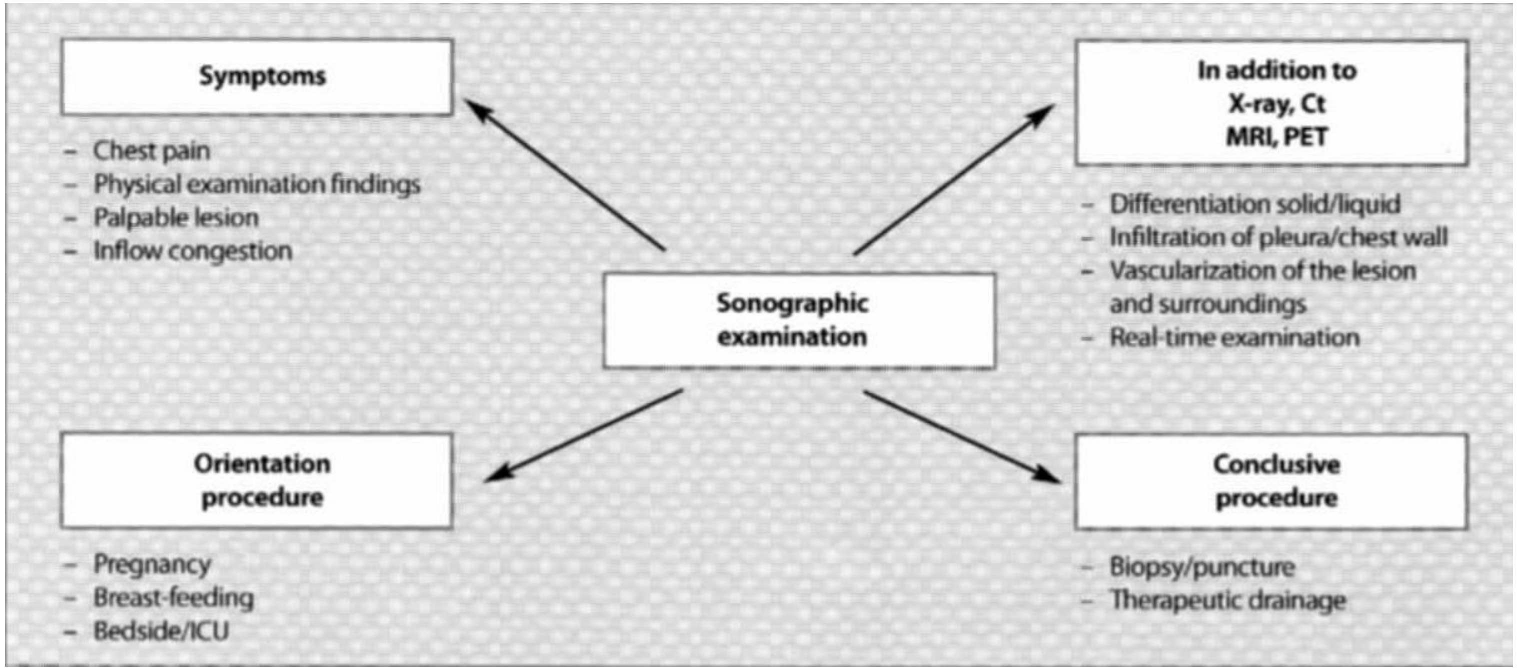
Zeno Sparchez

"…***Ultrasonography*** has no value in the evaluation of pulmonary diseases…"
– *Harrison*, **Principles of Internal Medicine** (1992)

INDICATIONS

Zeno Sparchez

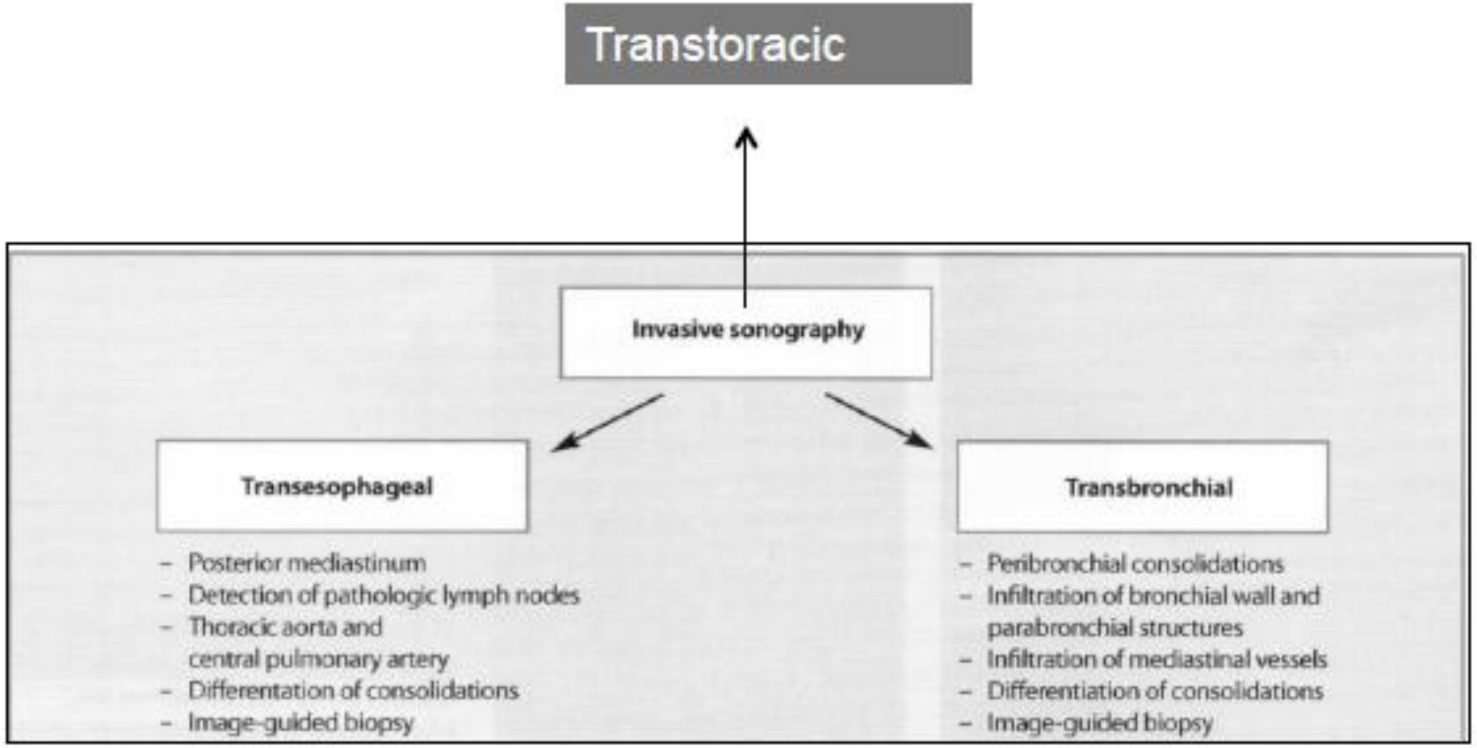
- It is a technique fully dedicated in evaluating pulmonary collections;
- The study of lung formations in contact with the thoracic wall.



INDICATIONS

Zeno Sparchez

- The guidance of interventional maneuvers.



INDICATIONS

Zeno Sparchez

The US spectrum of applications in thoracic diseases extended in the past years.

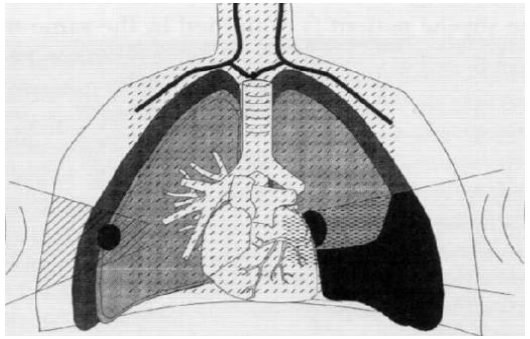
The US assessment in emergencies:

- pleural pain;
- pneumothorax diagnosis;
- pulmonary embolism;
- dg acute dyspnea (pulmonary edema vs COPD exacerbation);
- BN heart failure monitoring;
- diagnosis of cardiac arrest.

The sdr. interstitial evaluation (cellular).

LIMITS

Zeno Sparchez



- Up to 99% of the US waves are reflected in the healthy lung tissue;
- The intrapulmonary processes can be detected by ultrasound only if they extend to the visceral pleura or can be viewed through a good medium for transmitting ultrasound waves, for example a liquid medium or a condensed lungs' tissue;

- ***The US absorption of the bone tissue (sternum, scapula, spine or ribs) determine the acoustic window and thus limits the access:***

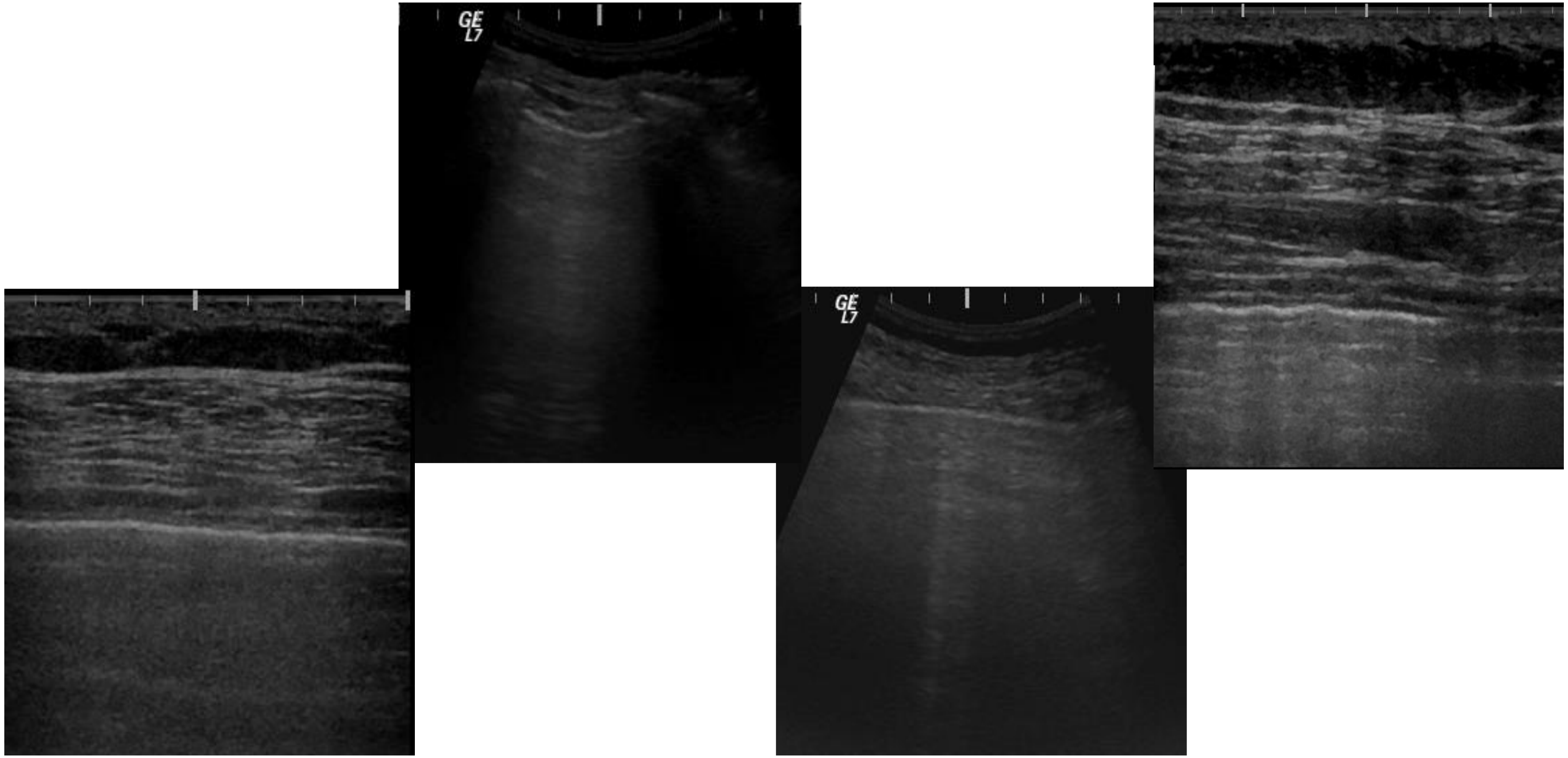
➢ The retrosternal space and the posterior mediastinum;

➢ EUS and transbronchial US.

WHAT ARE WE ABLE TO SEE?

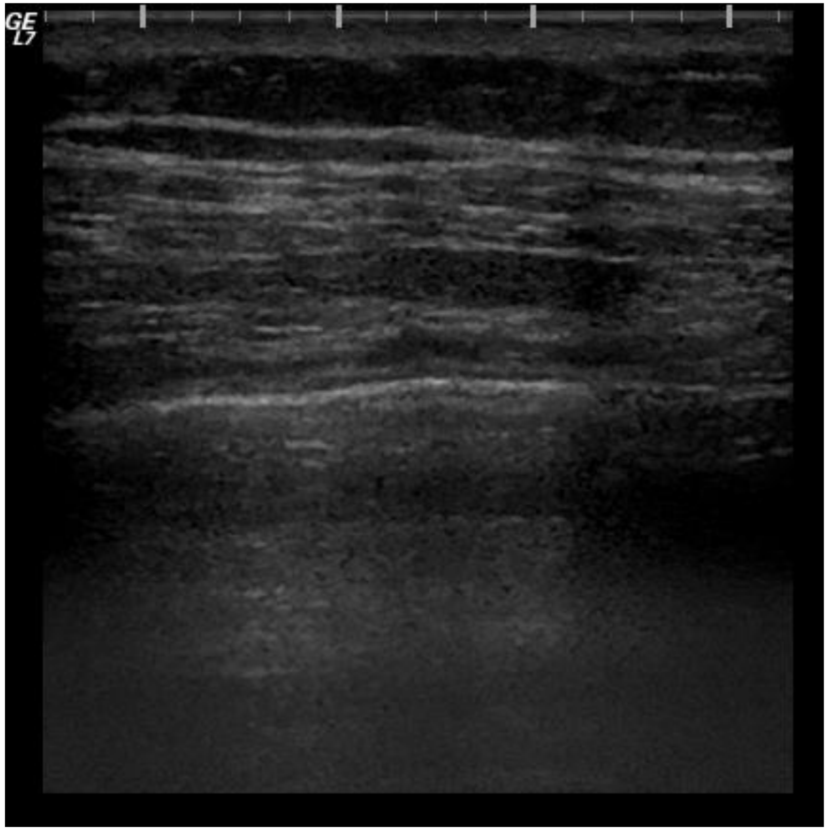
THE PLEURA

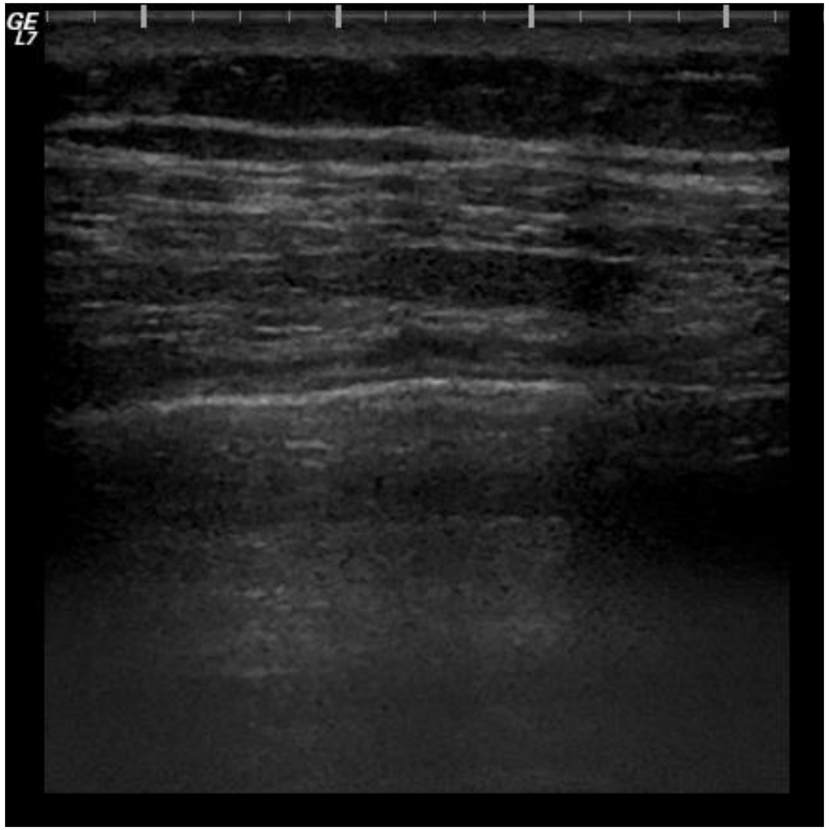
Zeno Sparchez



WHAT ARE WE ABLE TO SEE?

Zeno Sparchez





THE PULMONARY PARENCHYMA

Zeno Sparchez

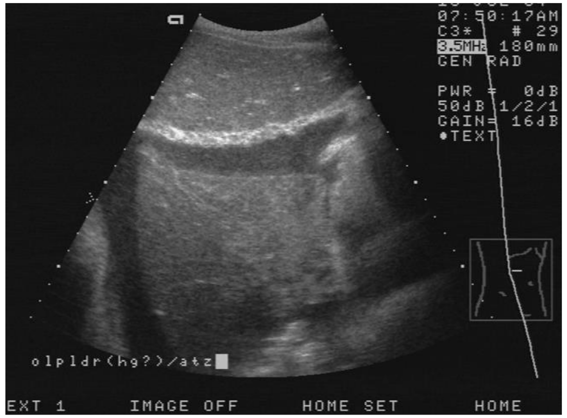
- The lung being full of air determinates a highly reflective interface that blocks the ultrasounds' access;
- Reverberating acoustic artifacts;
- Identified by the slipping sign;
- Comet tail artifacts - caused by the areas' irregularities.

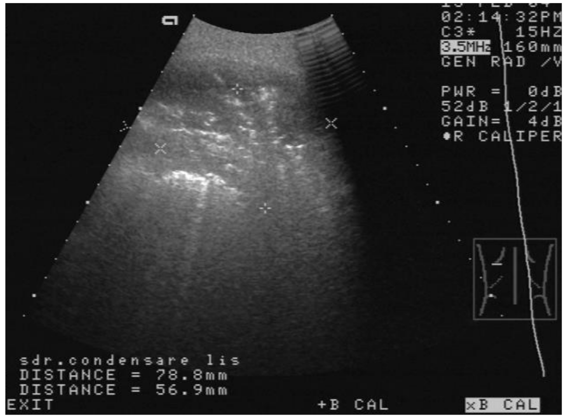
THE PULMONARY PARENCHYMA

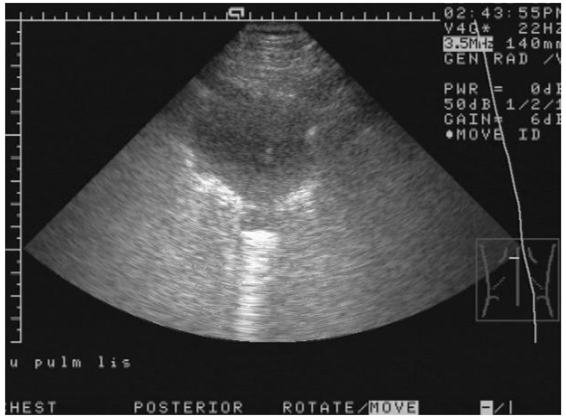
Zeno Sparchez

The lung parenchyma can be viewed only:

- In the case of extended consolidations that go to the visceral pleura;
- through a good medium for transmitting US, for example a liquid medium or condensed lung tissue.







THE TECHNICAL EQUIPMENT

Zeno Sparchez

- Viewing the chest wall and the parietal pleura – high-frequency linear probe (5 - 10 MHz);
- For pleural and pulmonary pathology – a sector or convex probe with low frequency (3.5 – 5 MHz);
- ***Linear probes of high frequency (10 -13 MHz) - provide a very good resolution, a better gray scale contrast and color Doppler angiography for the very small vessels' visualization:***
- lymph nodes (Grinzman 2005);
- pleura;
- the surface of the lung.

THE TECHNICAL EQUIPMENT

Zeno Sparchez

- For the mediastinum are recommended the sector probes or the narrow convex probes (cord);
- 3.5 - 5 MHz;
- The transesophageal ultrasound (EUS) – special probes;
- The endobronchial ultrasound – high-frequency thin special probes (12 - 20 MHz).

THE EXAMINATION POSITIONS

Zeno Sparchez

- For the examination of the anterior and posterior chest, the patient must be seated with his arms raised and his hands clasped behind his head or hanging on the bed;
- Dorsal or lateral decubitus (if the patient can not stay seated);
- Even with these techniques there remain a part of the upper lobes hidden after the scapula;
- The movement of inhalation and exhalation is observed in the pleura;
- The solid lesions near the diaphragm requires special maneuvers like coughing or short inspiration by nose.

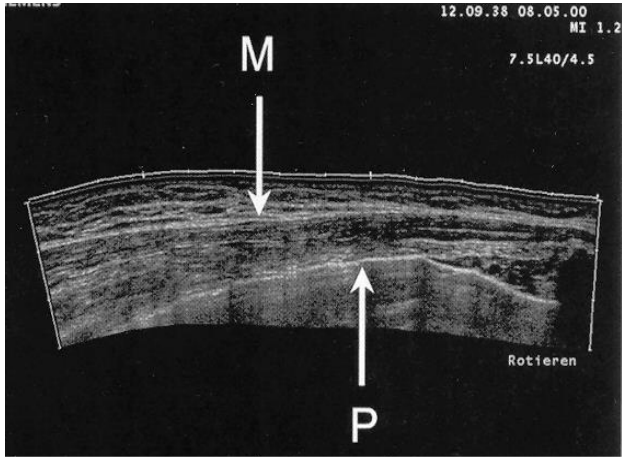
THE EXAMINATION TECHNIQUES

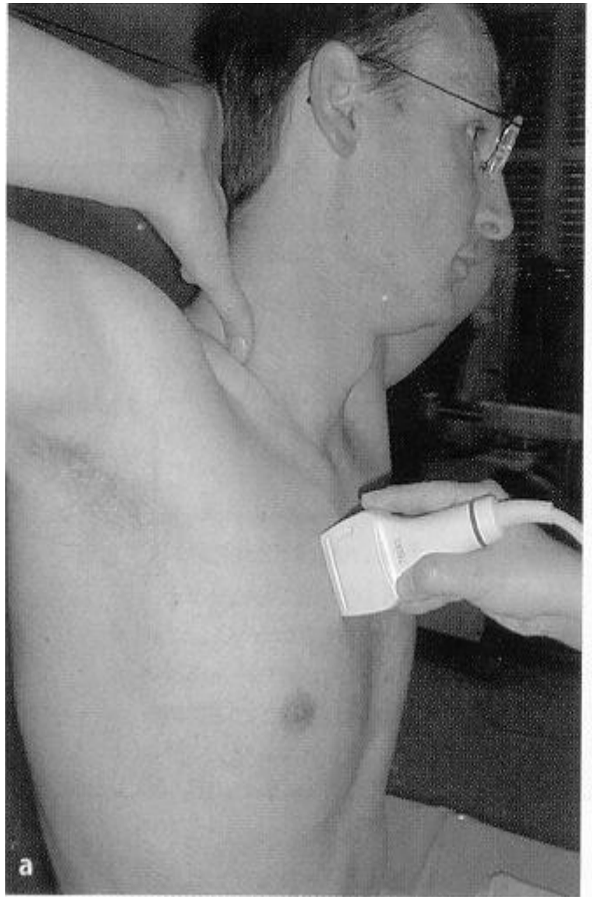
Zeno Sparchez

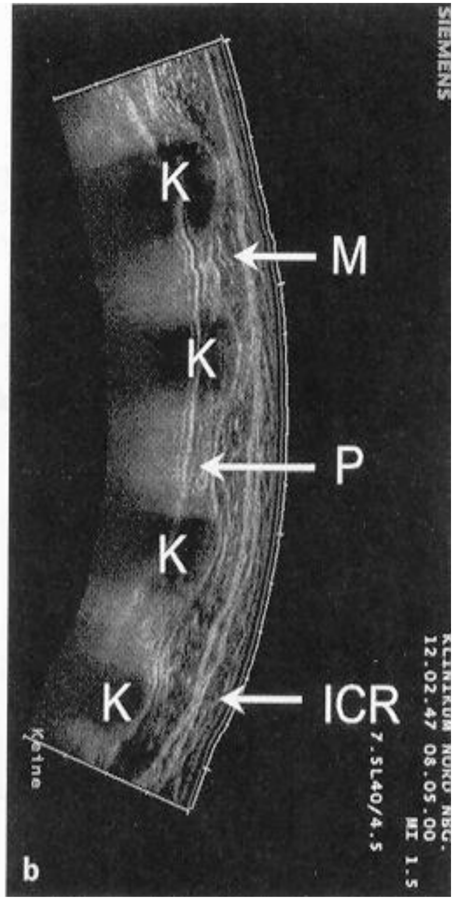
- ***The transducer is moved from the ventral to the dorsal thorax along the longitudinal lines thereof:***
  - Parasternal;
  - Middle and lateral clavicular;
  - Anterior, mid and posterior axillary;
  - Lateral and medial scapular;
  - Paravertebral;
- **And along the intercostal spaces avoiding the ribs.**

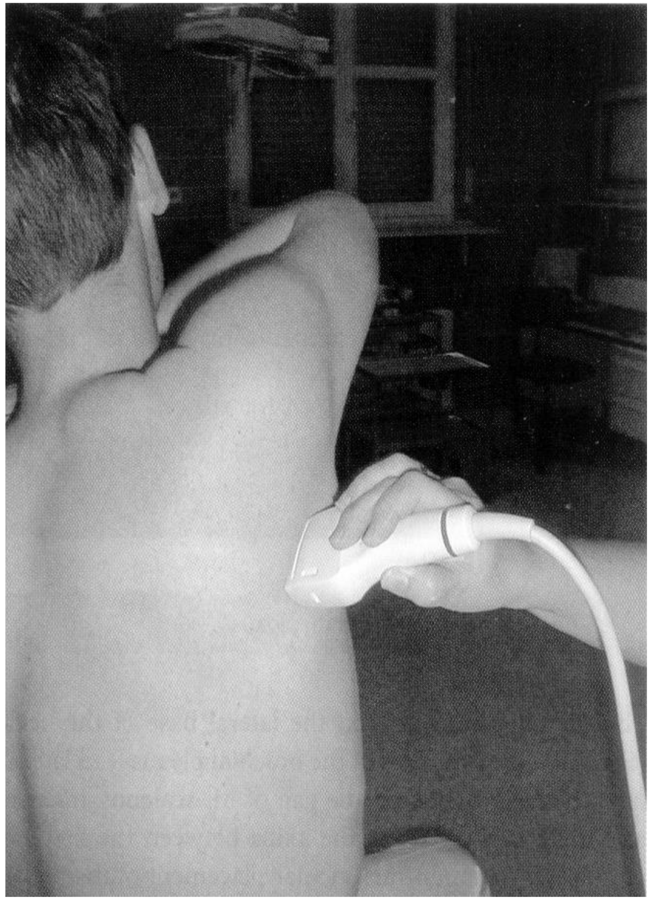
THE EXAMINATION TECHNIQUES

Zeno Sparchez







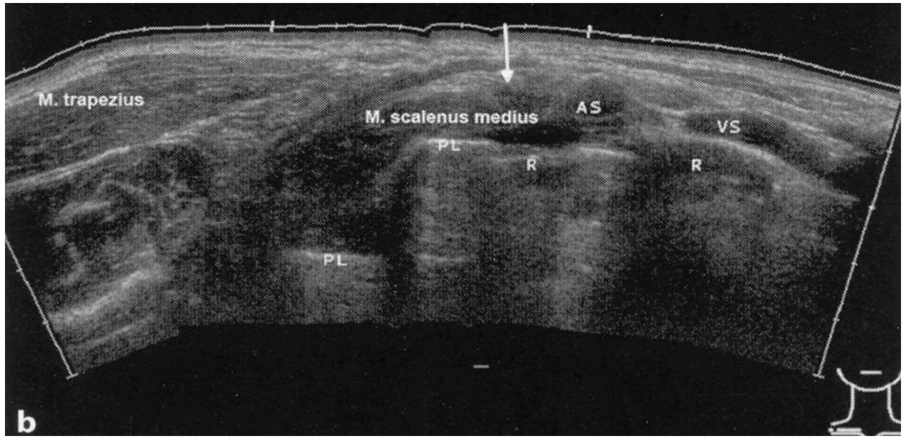


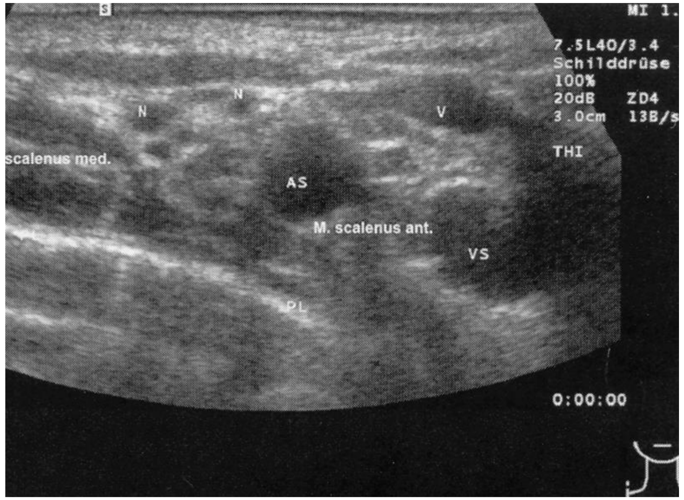
From G. Mathis Chest Sonography, Springer 2008

THE EXAMINATION TECHNIQUES

THE SUPRACLAVICULAR REGION

Zeno Sparchez



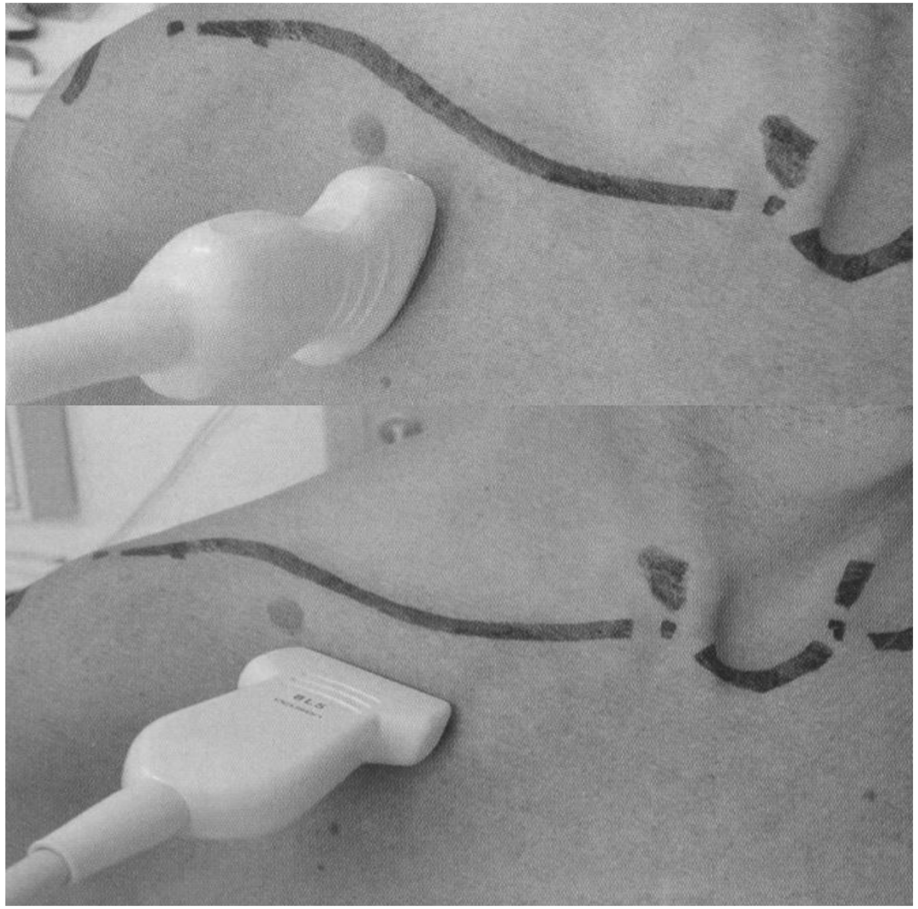


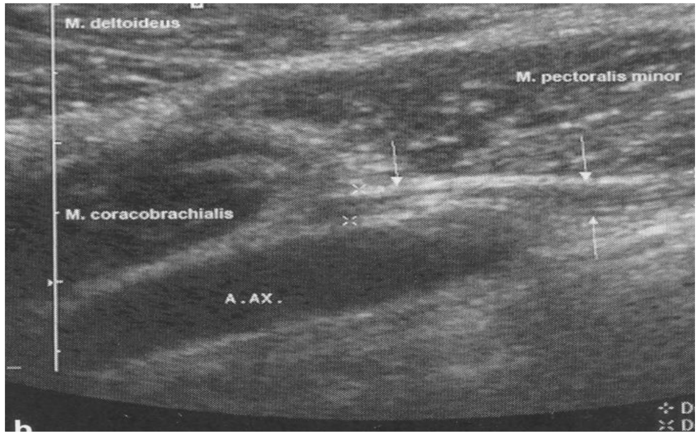
From G. Mathis Chest Sonography, Springer 2008

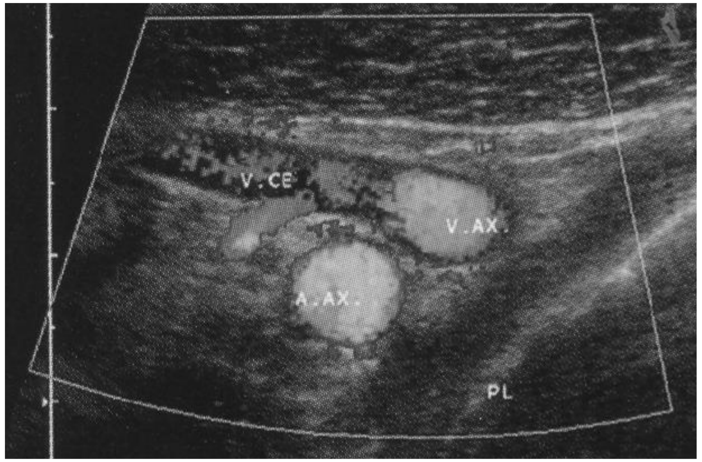
THE EXAMINATION TECHNIQUES

THE INFRACLAVICULAR REGION

Zeno Sparchez





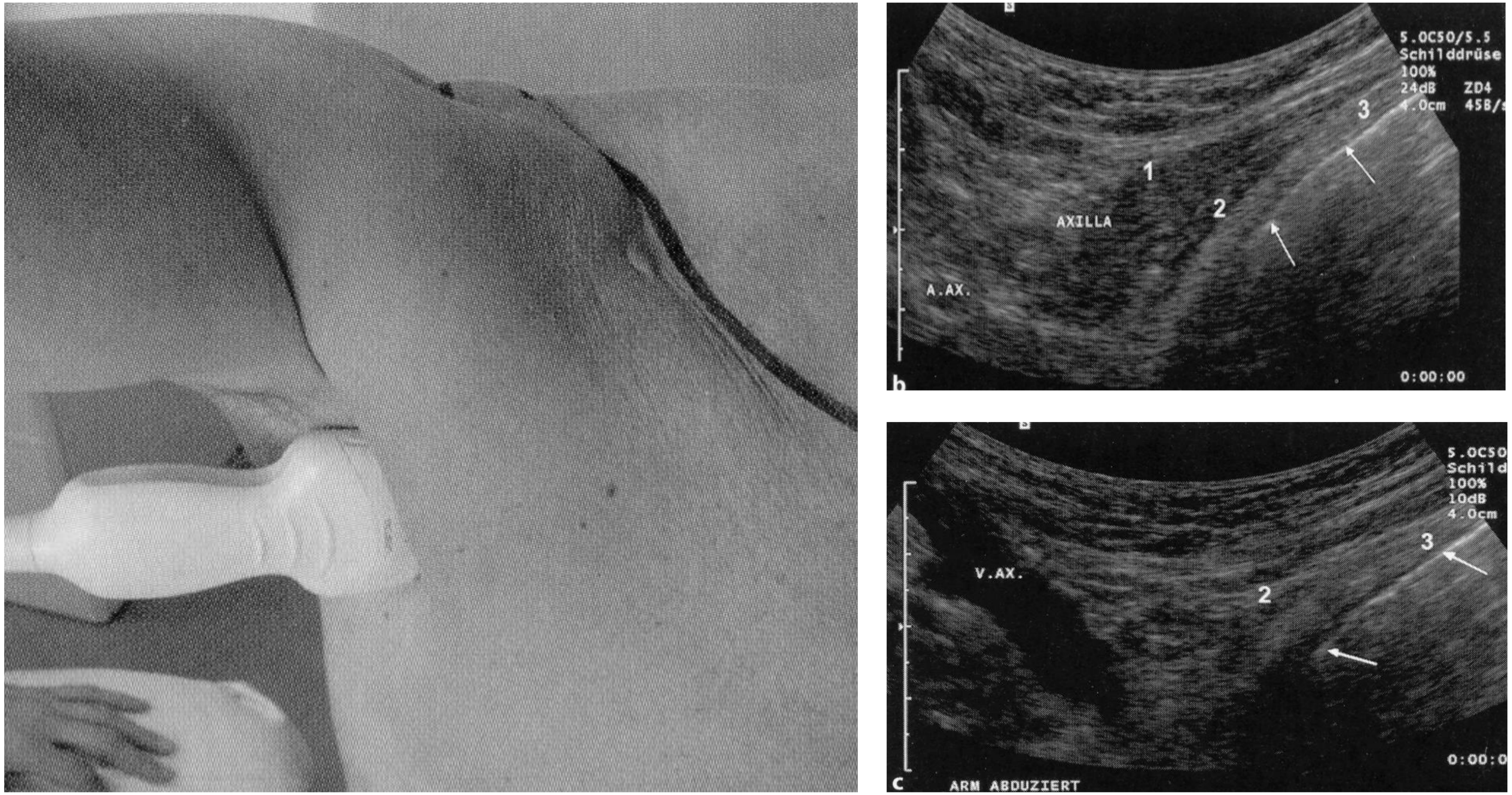


From G. Mathis Chest Sonography, Springer 2008

THE EXAMINATION TECHNIQUES

THE MIDDLE AXILLARY REGION

Zeno Sparchez



From G. Mathis Chest Sonography, Springer 2008

THE EXAMINATION TECHNIQUES

Zeno Sparchez

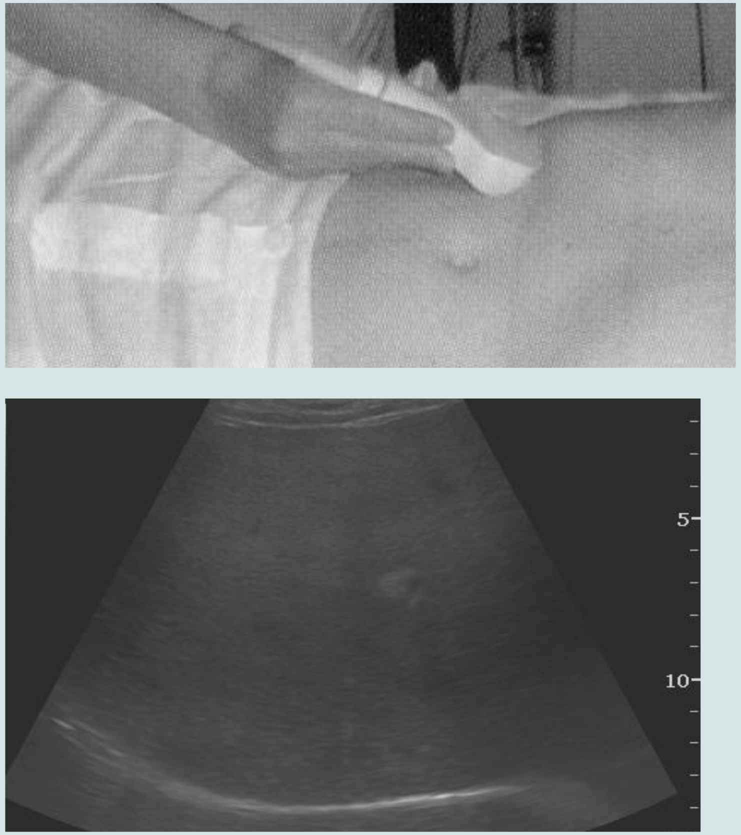
- The caudal segments of the lung can be examined by an abdominal approach;
- The right lung and diaphragm can be examined through the transhepatic abdominal window; the left lung can be visualized through the splenic window.
- The longitudinal plans in flanks allow the visualization of both frencostal processes.

THE EXAMINATION TECHNIQUES

THE TRANSHEPATICAL AND THE RIGHT REGION INTERCOSTAL EXAMINATION

Zeno Sparchez

1)



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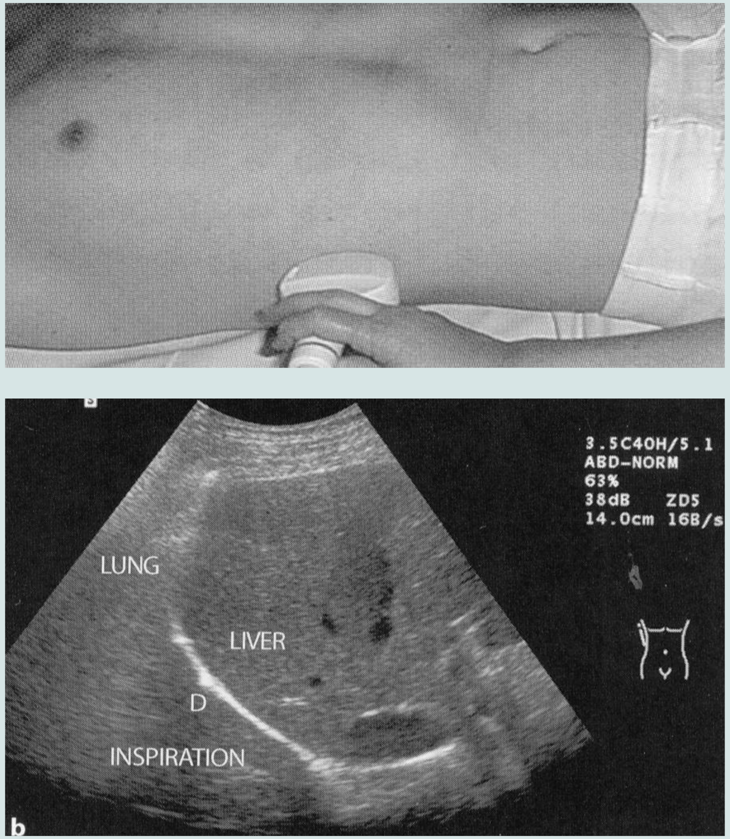


G. Mathis Chest Sonography, Springer 2008

THE CONCLUSIONS

Zeno Sparchez

In chest ultrasound is needed:

- 3 - 5 MHz convex probe for good resolution;
- Micro-convex or sectorial probe for a better access in deeper areas (mediastinal);
- High resolution probe (10 - 13 MHz) for the pleura and supraclavicular regions' examination;

THE CONCLUSIONS

Zeno Sparchez

Due to the high resolution ultrasound image and real-time examination, the percutaneous chest US is a major contributor in thoracic disease diagnosis:

- The chest wall and pleura injuries;
- The lung consolidations that reach the visceral pleura or are situated beyond the acoustic window;
- Anterior and superior mediastinal lesions.

PART TWO

THE FIRST PART OF THE COURSE

LESSON 1: THE LIMITATIONS OF LUNG SONOGRAPHY

LESSON 2: THE SONOGRAPHIC DETECTION OF B-LINES IN PATIENTS WITH NORMAL LUNGS

LESSON 3: THE LUNG'S ULTRASOUND RELEVANCE IN THE DIAGNOSIS OF ACUTE RESPIRATORY FAILURE

LESSON 4: THE ULTRASONOGRAPHIC PROTOCOLS OF RESPIRATORY EMERGENCIES

LESSON 1: *The Limitations of Lung Sonography*

Lectors:

Nicolae - Radu Rednic, Cluj-Napoca, Romania

LESSON 1

THE LIMITATIONS OF LUNG SONOGRAPHY

THE MAIN TOPICS:

1: ARTIFACTS: DEFINITION, INTERACTIONS, ADVANTAGES AND DISADVANTAGES
2: B-MODE ARTIFACTS
3: REVERBERATIONS AND THE ‘BACKGROUND NOISE’
4: MIRROR IMAGES AND THE ‘LENS’ EFFECT
5: ARCHED ARTIFACTS
6: THE DIAPHRAGMATIC ‘ORIFICE’
7: THE POSTERIOR SHADOW
8: THE REAR AMPLIFICATION
9: ARTEFACTS: DOPPLERS’ COLOR
10: TRAPS

ARTIFACTS

Nicolae Rednic

Definition:

- Immanent artificial images (produced by a ultrasound system, undetermined by an outside interaction).

Interactions:

- Ultrasound physics (reflection, absorption, scattering, refraction, dispersion, attenuation)

Disadvantages :

- It distorts the structures: size, form, position, echogenicity.
- Limits the view of the area.
- Suggests some false areas.

Advantages :

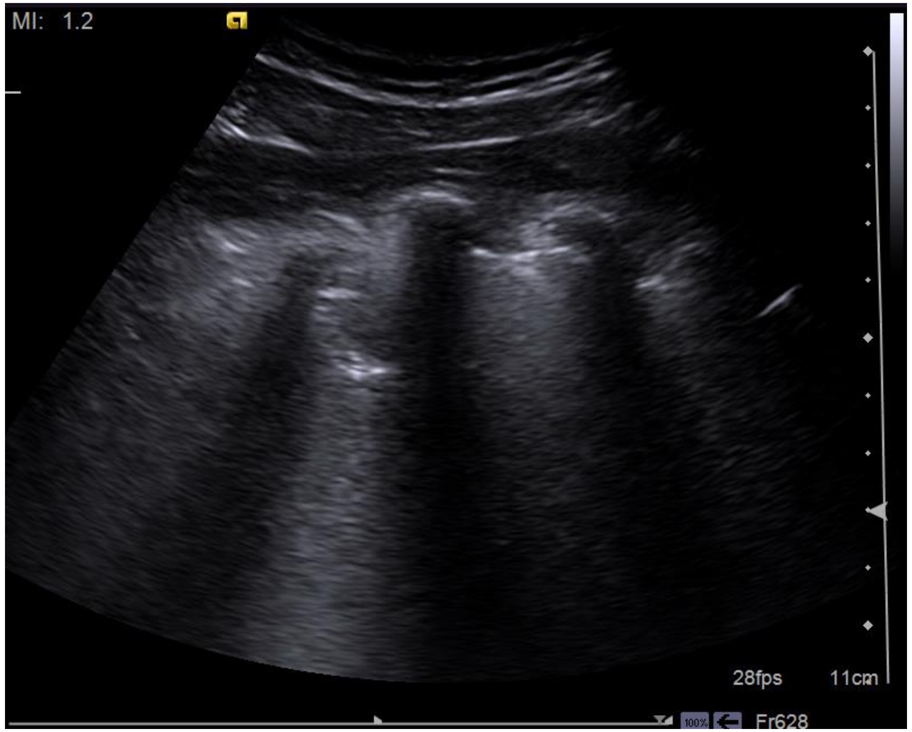
- Essential elements for some of the diagnosis stages.

ARTIFACTS

Nicolae Rednic

Thoracic ultrasound = numerous artifacts

Air **Bone**



ARTIFACTS B-MODE

Nicolae Rednic

- Reverberations;
- Mirror images;
- Ring Down;
- Reflections;
- Marginal shadow;
- Reflections;
- Attenuation;

- Posterior shadow;
- Enhancement;

- Resolution Artifact (Ultrasound Noise);
- Comet Tail;
- Artifacts caused by foreign objects.

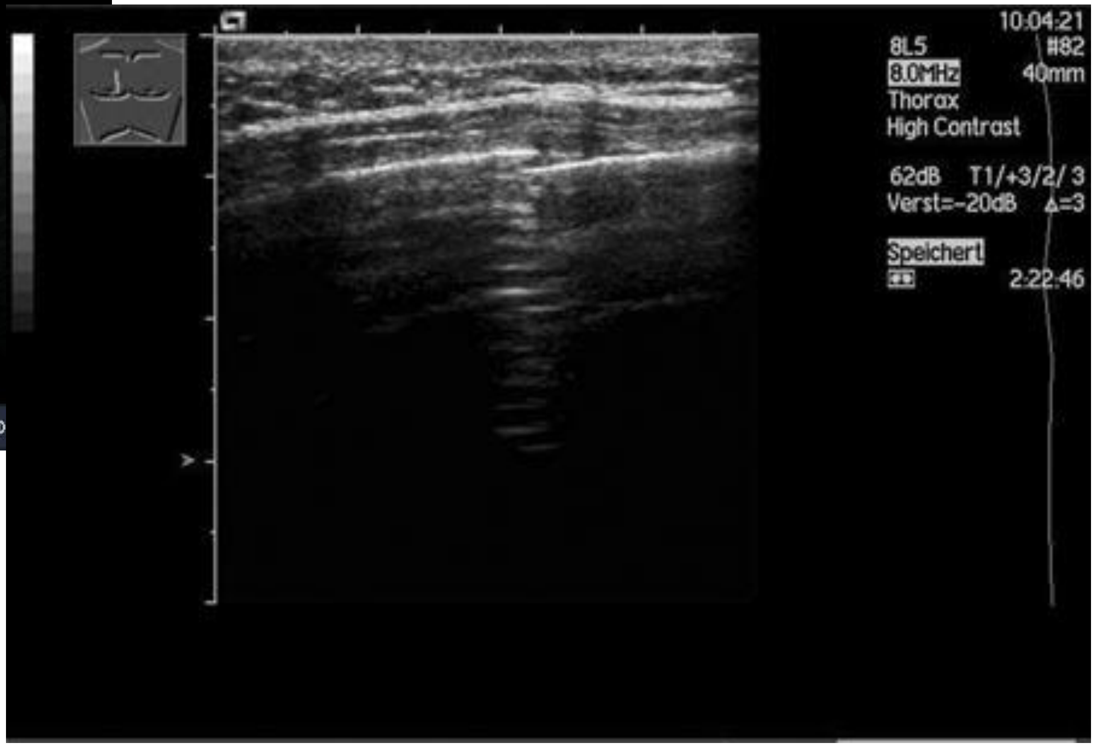
REVERBERATIONS

Nicolae Rednic

Equally spaced lines due to the almost complete reflection of the ultrasounds between the air and tissue.

REVERBERATIONS

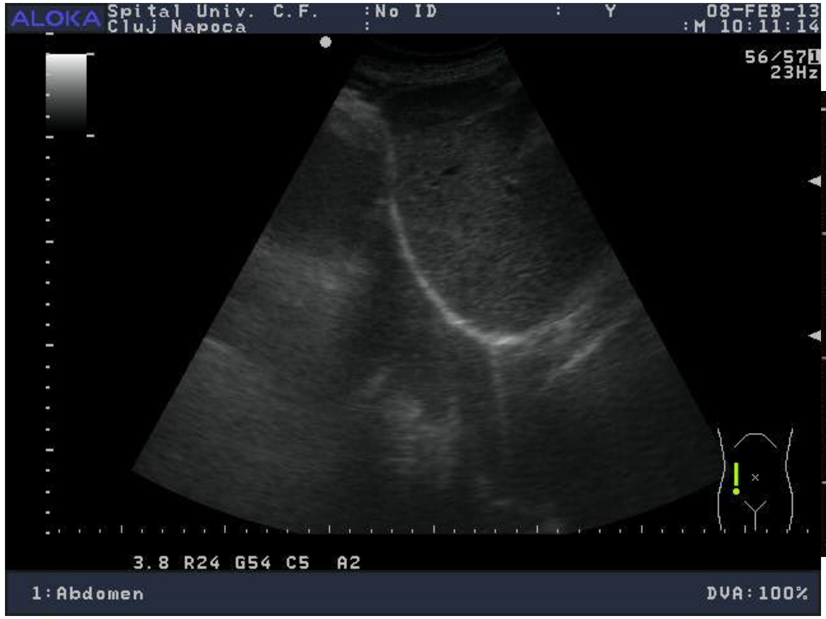
Nicolae Rednic

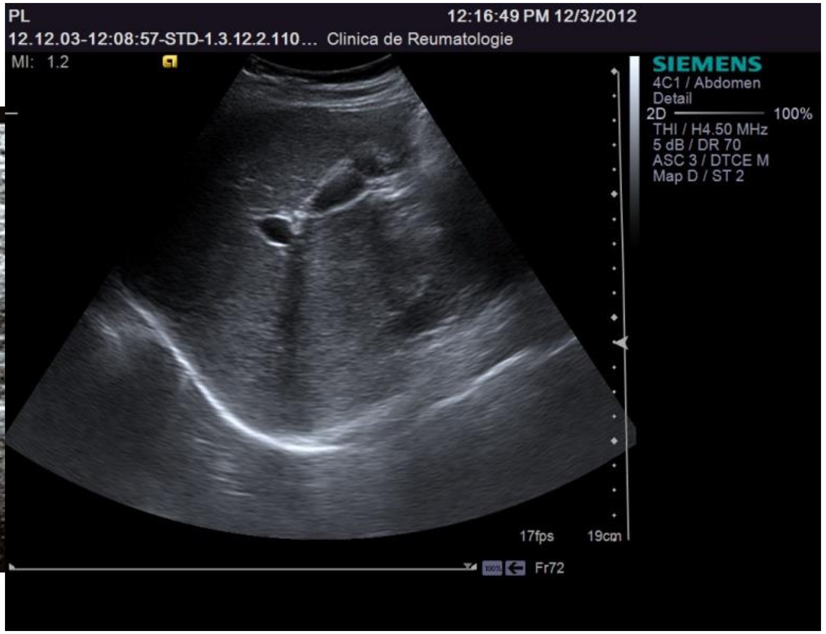


MIRROR IMAGES

Nicolae Rednic

False image of a anatomical structure and a smooth reflector such as the diaphragm, due to repeated oblique reflections of the ultrasound.

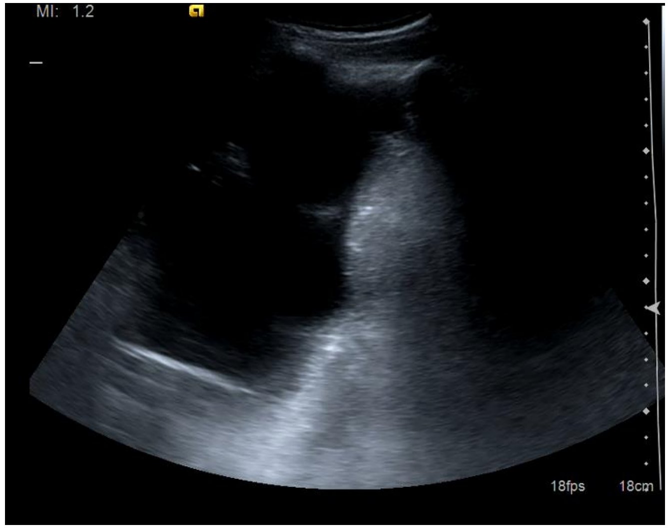




ARCHED ARTIFACTS

Nicolae Rednic

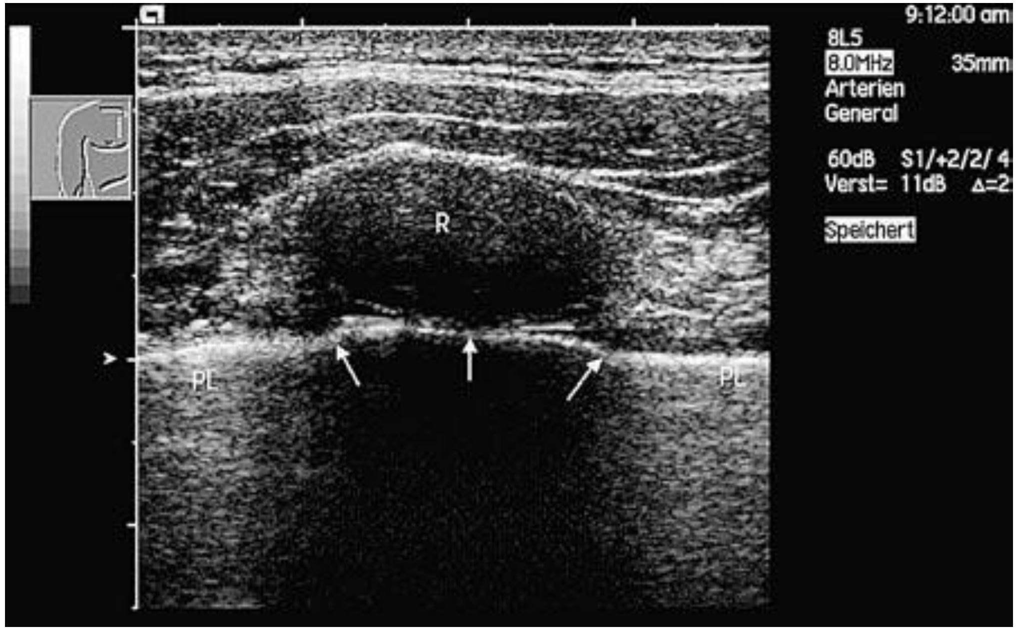
False arched images produced by the ultrasound reflection of bone tissue or air.

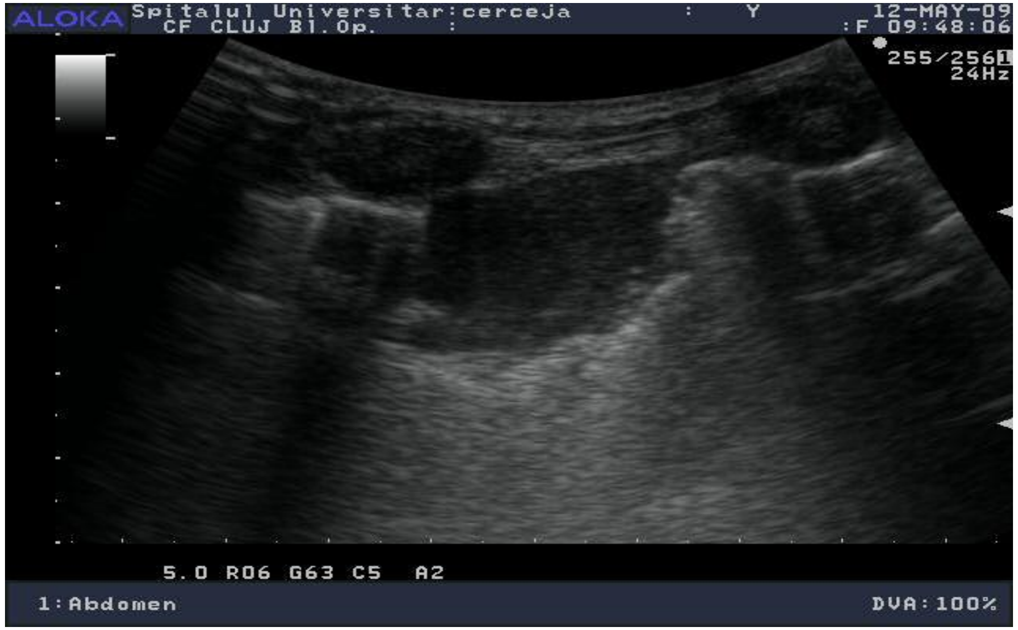


THE 'LENS' EFFECT

Nicolae Rednic

The presence of "pseudo injuries" behind some structures (costal cartilage) which bounce the ultrasound at different speeds.

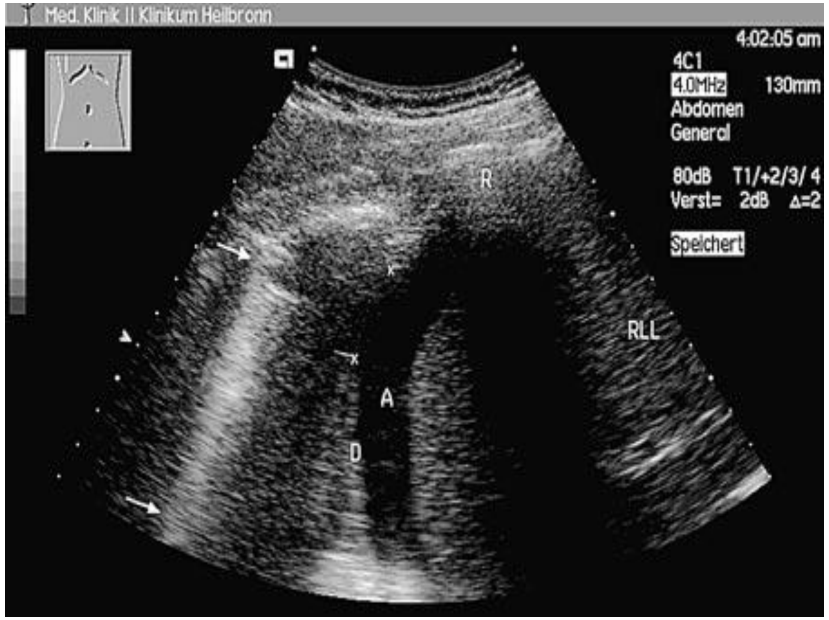




THE DIAPHRAGMATIC ‘ORIFICE’

Nicolae Rednic

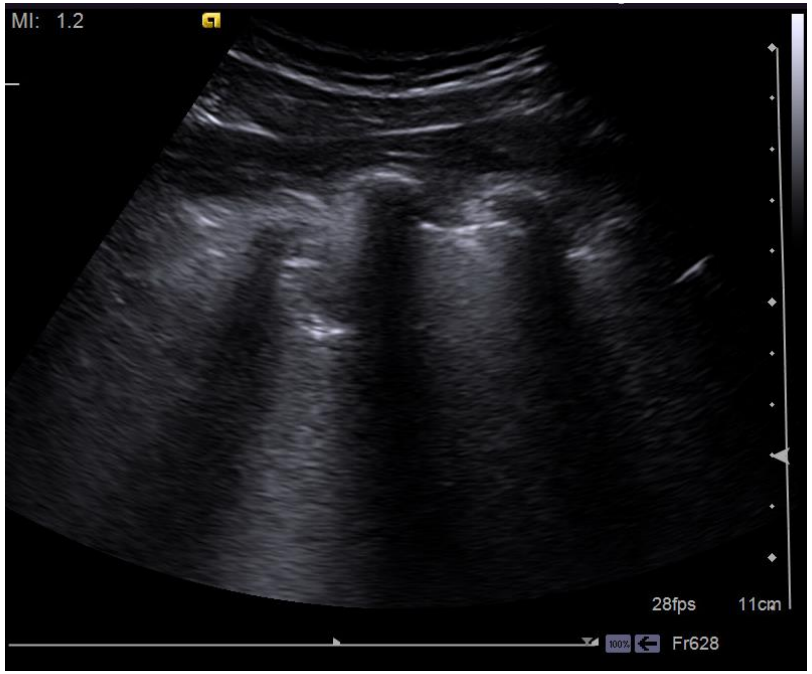
The presence of an “orifice” in the diaphragm due to some diffraction phenomena and ultrasound refraction at the interaction with oblique interfaces.

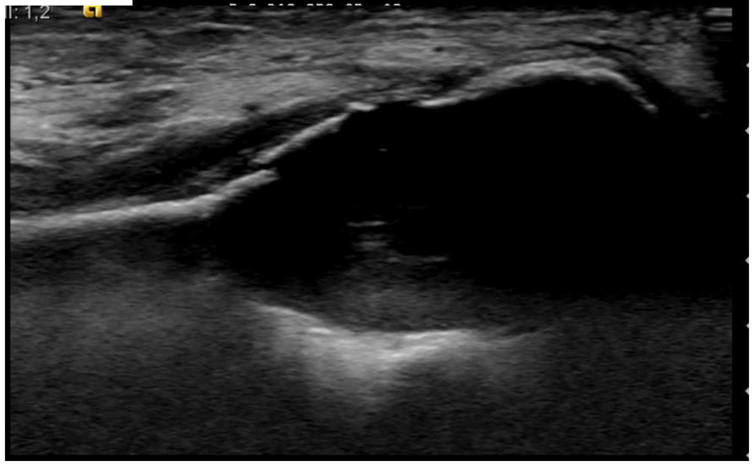


THE POSTERIOR SHADOW

Nicolae Rednic

The lack of the ultrasounds' signal behind the structures that absorb the ultrasounds (the bone).





THE REAR AMPLIFICATION

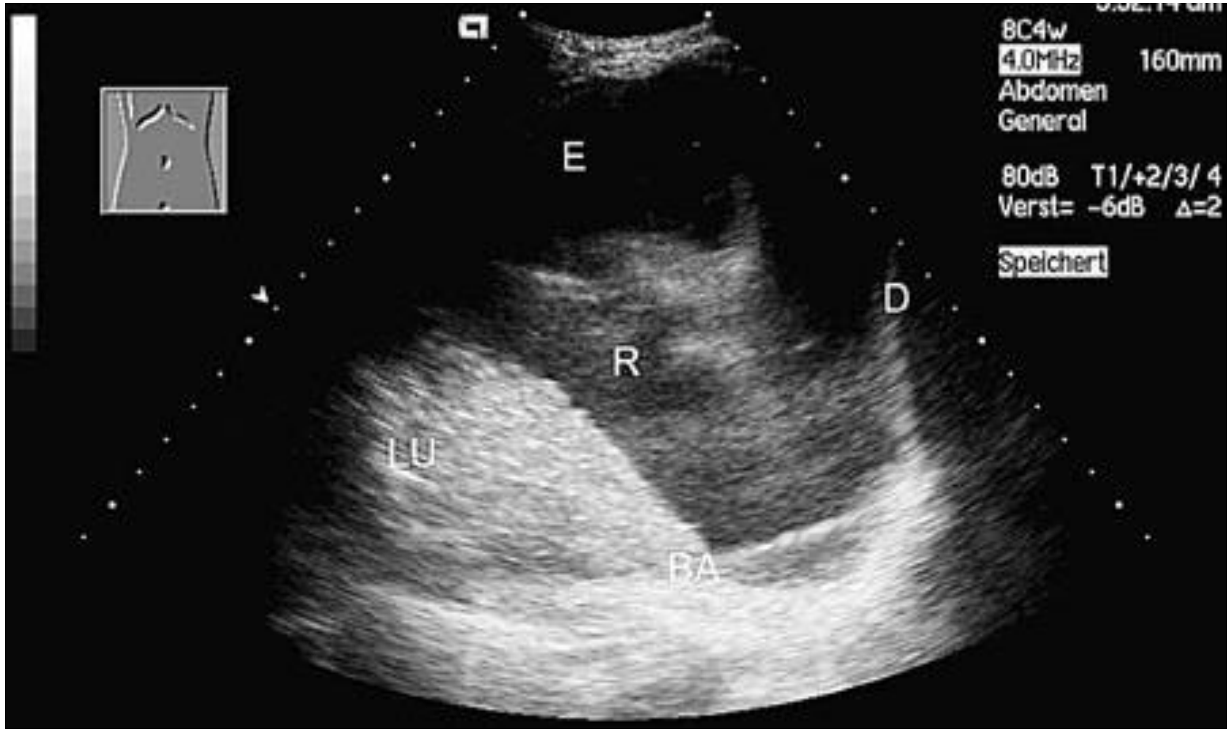
Nicolae Rednic

Hyperechoic area behind some structures that barely absorb ultrasounds (liquid).

THE 'BACKGROUND NOISE'

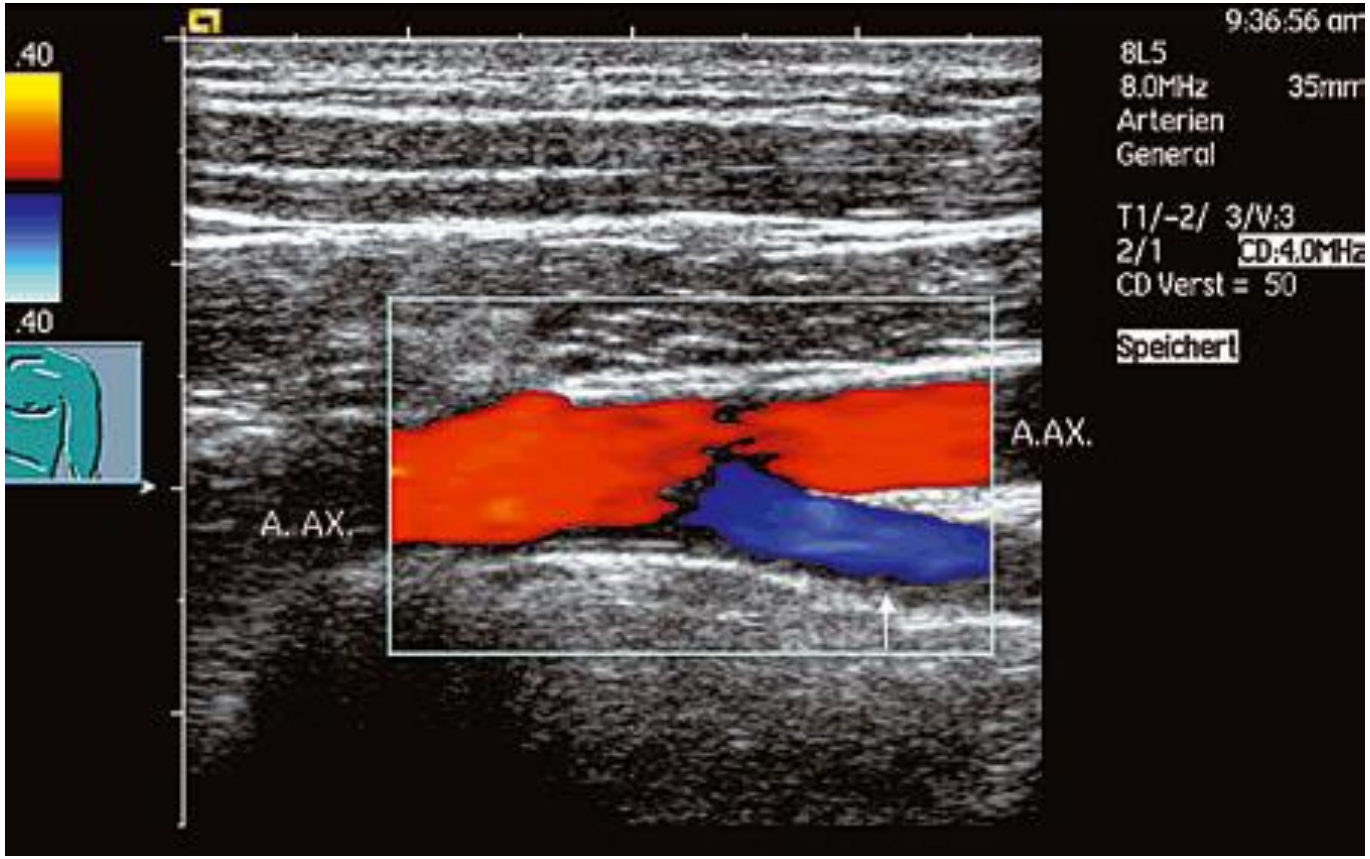
Nicolae Rednic

The occurrence of some echoes in strict transonic structures due to the different reflections of ultrasounds at the walls' level



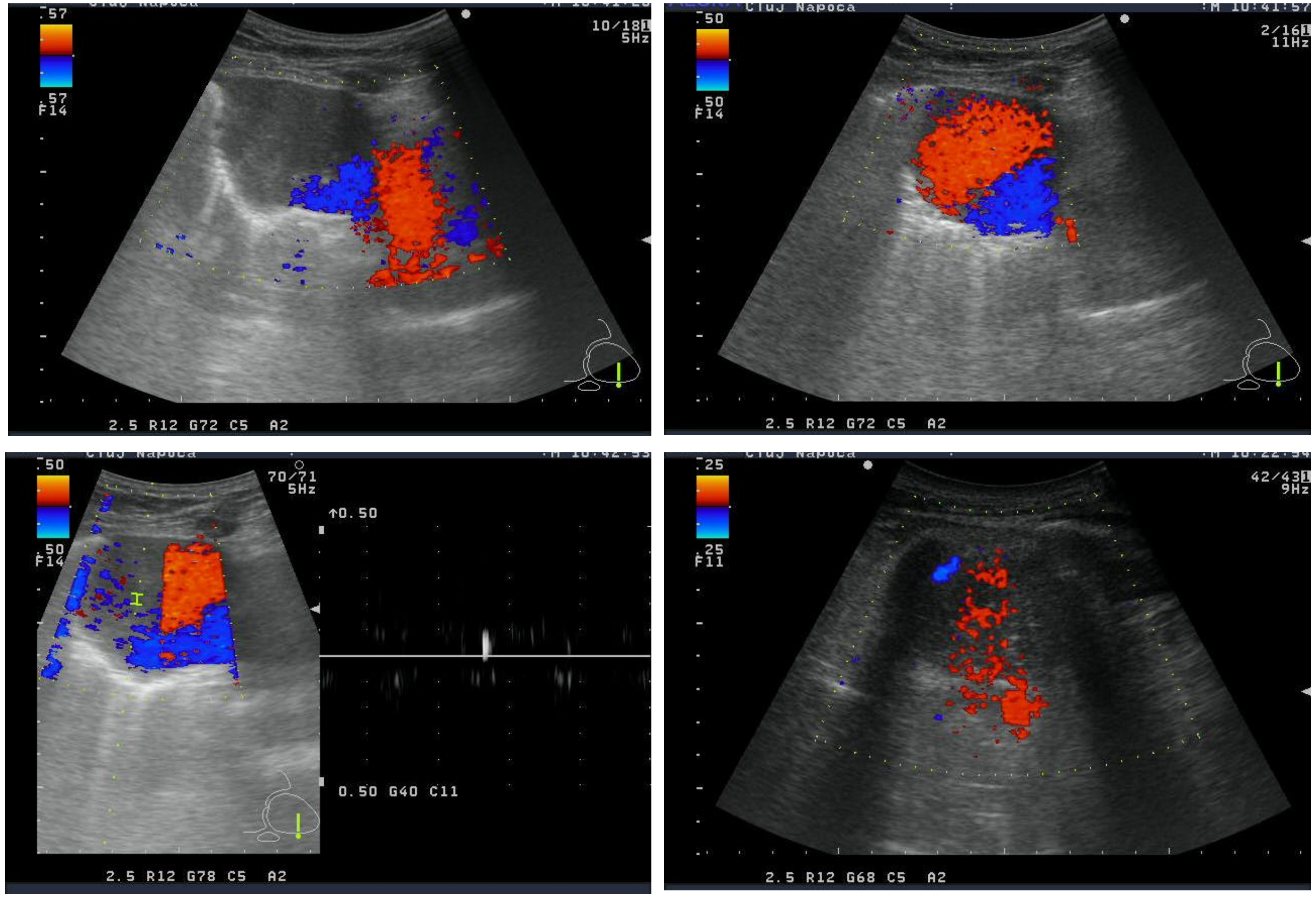
ARTEFACTS
DOPPLERS' COLOR
THE DIRECTION ARTEFACTS
Nicolae Rednic

A result of the blood flow direction color coding system (when the color changes a dark back zone appears).

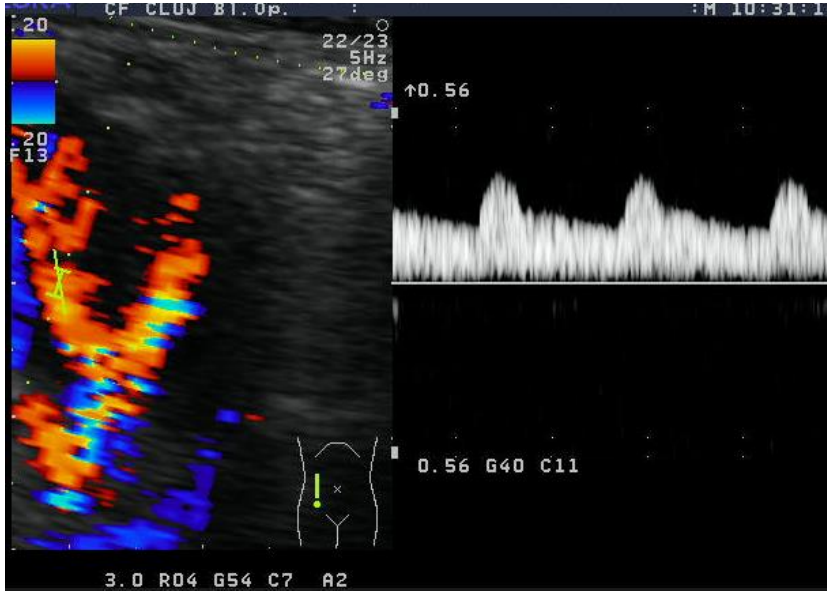


ARTEFACTS
DOPPLERS' COLOR
THE MOVEMENT ARTEFACTS
Nicolae Rednic

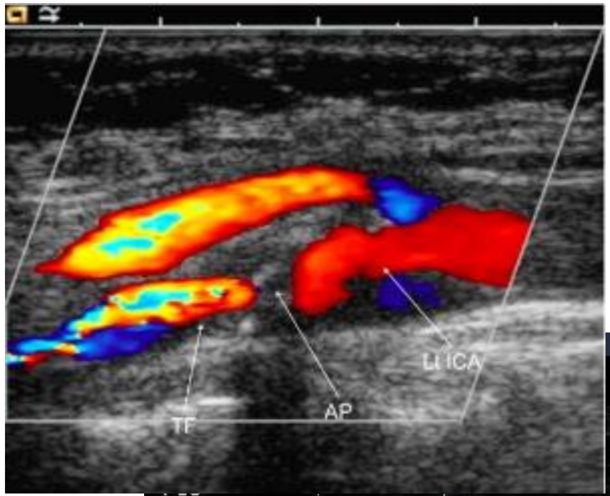
Color images that don't represent blood flows due tot the incorrect setting of the device

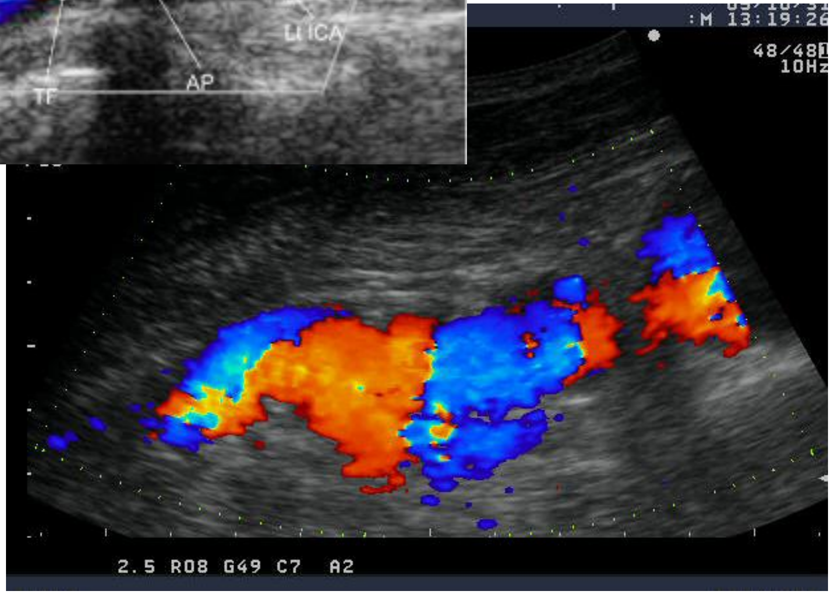


ARTEFACTS
DOPPLERS' COLOR
THE ALIASING
Nicolae Rednic



When the red-blue colors change it becomes a mosaic of bright colors, due to the incorrect setting of the device





TRAPS

THE ALIASING

Nicolae Rednic

Wrong interpretations of the examiner due to:

- **The lack of knowing some important clinic elements.**
- **The lack of knowing the topographic anatomy of the examined region;**
- **The insufficiency in the differential ultrasound diagnostic**
- **The limitations of ultrasound sonography.**

LESSON 2: *The Sonographic Detection of B-lines in Patients with Normal Lungs*

Lectors:

Zeno Sparchez, Cluj-Napoca, Romania

LESSON 2

THE SONOGRAPHIC DETECTION OF B-LINES IN PATIENTS WITH NORMAL LUNGS

THE MAIN TOPICS:

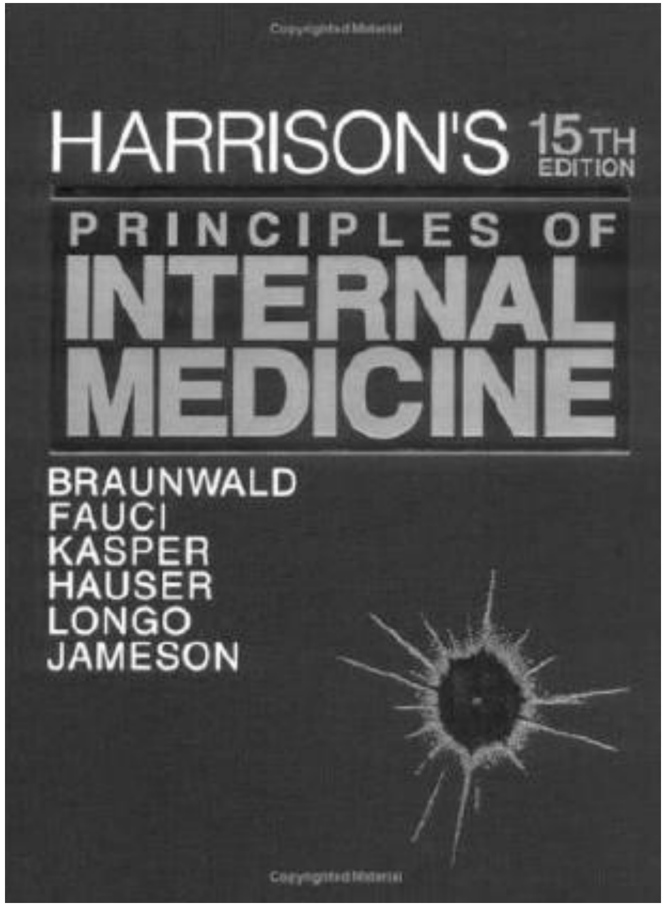
1: THE LIMITS OF THE LUNG ULTRASONOGRAPHY
2: THE CHARACTERISTICS OF B-LINES
3: THE SONOGRAPHIC DETECTION OF B-LINES
4: PATIENTS WITHOUT PULMONARY PATHOLOGY
5: DIFFUSE INTERSTITIAL SYNDROME AND THE DIAGNOSTIC CRITERIA
6: THE INTERSTITIAL SYNDROME
7: THE CONCLUSIONS

The limitations are:

- The presence of the air in the lung;
- The technique of surface imaging.

THE LIMITS OF THE LUNG ULTRASONOGRAPHY

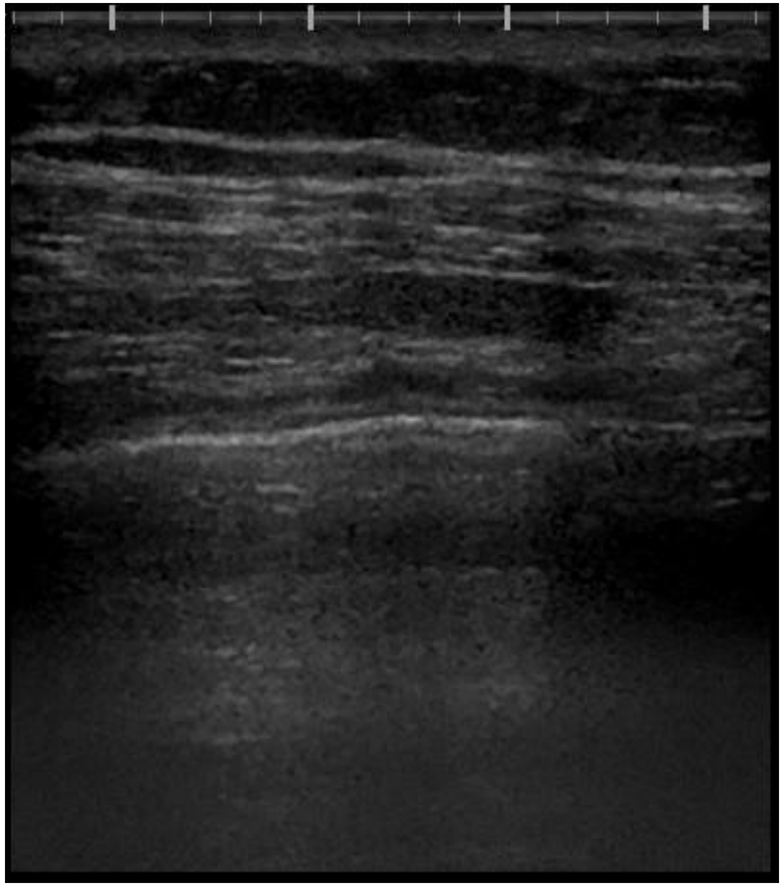
Zeno Sparchez



"Ultrasound does not pass through air or bone, so the lungs themselves and the ribs are major limitations on its' usefulness in the chest."

THE LIMITS OF THE LUNG ULTRASONOGRAPHY

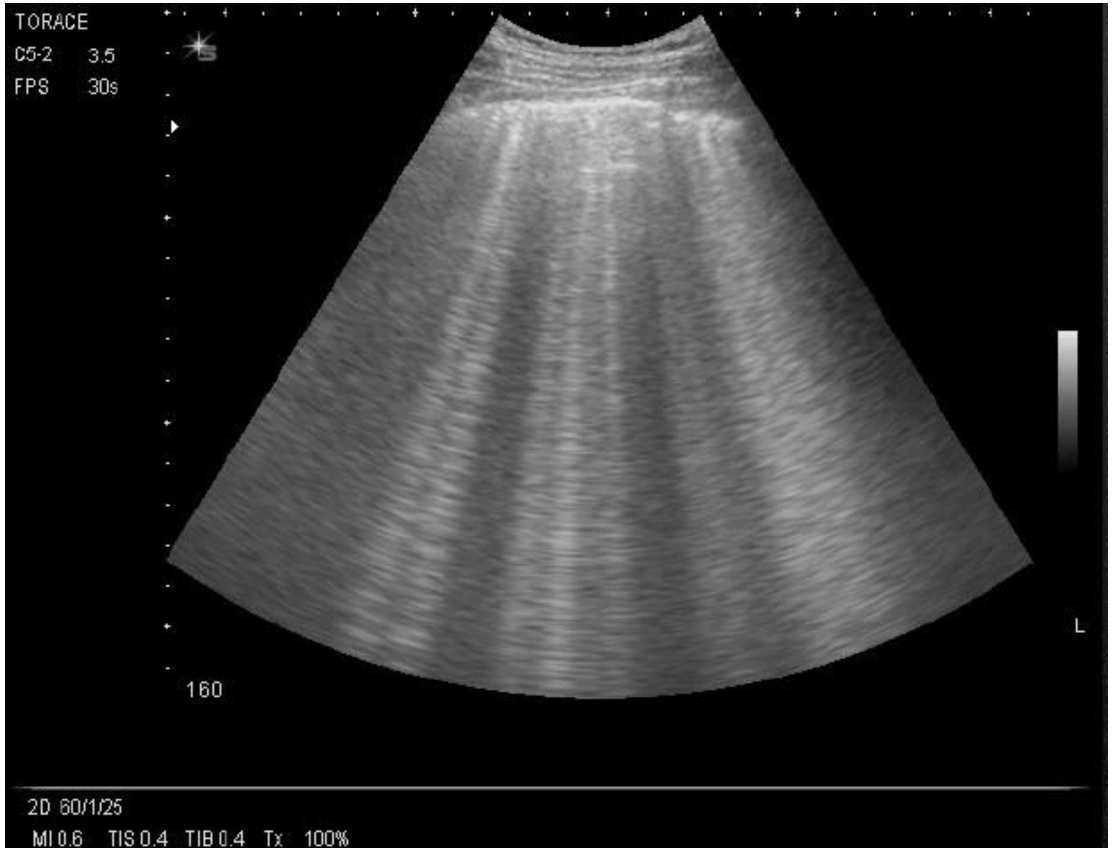
Zeno Sparchez



THE LIMITS OF THE LUNG ULTRASONOGRAPHY

Zeno Sparchez

B-LINES



THE CHARACTERISTICS OF B-LINES

Zeno Sparchez

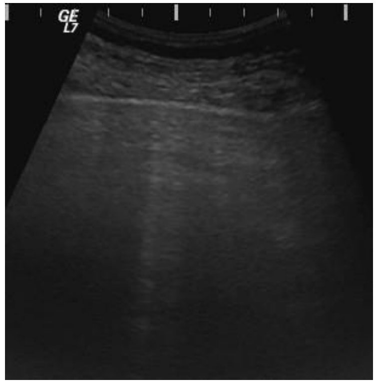
Comet tail artifact with 4 binding characteristics:

- It starts from the well defined pleural line (laser beam);
- It spreads to the edges of the display without fading;
- It moves with the lungs' motion.

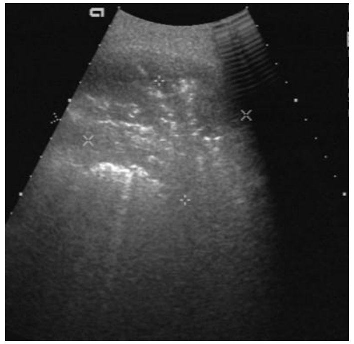
THE CHARACTERISTICS OF B-LINES

Zeno Sparchez

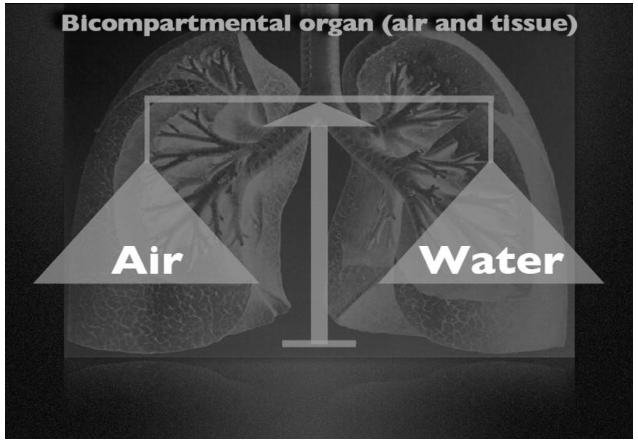
Normal aerated lung = Mirror pattern

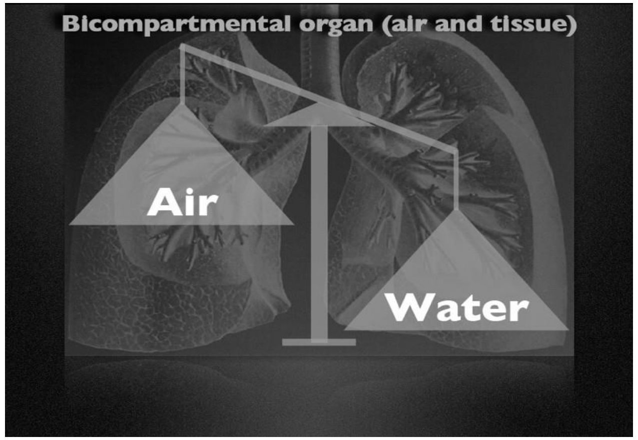


Slightly increase of fluid and loss of air= interstitial syndrom with B lines



Loss of air = consolidated pattern





THE SONOGRAPHIC DETECTION OF B-LINES

Zeno Sparchez

@2013 The American Institute of Ultrasound Medicine

"…by the fact, lung ultrasound works like a real densitometer highly sensitive to variations of the pulmonary content and balance between air and fluids."

Lung Sonography

Giovanni Volpicelli, MD, FCCP

The Comet-tail Artifact

An Ultrasound Sign of Alveolar-Interstitial Syndrome

DANIEL LICHTENSTEIN, GILBERT MÉZIÈRE, PHILIPPE BIDERMAN, AGNES GEPNER, and OLIVIER BARRÉ

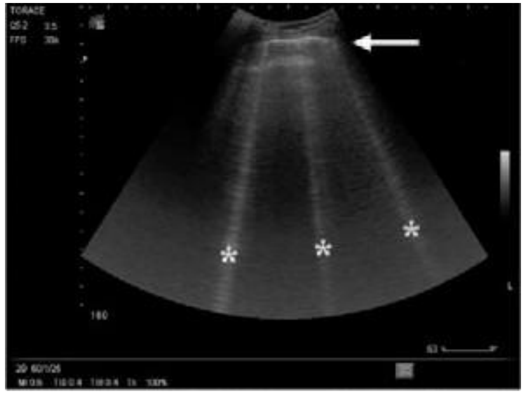
Service de Réanimation Médicale and Service de Radiologie, Hôpital Ambroise-Paré, Boulogne (Paris), and Service de Réanimation Polyvalente, Centre Hospitalier Général, Saint-Cloud (Paris), France

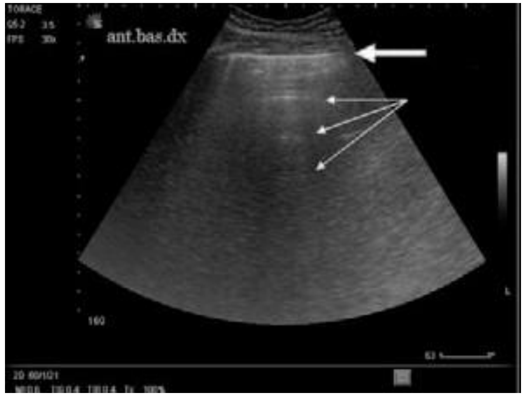
Can ultrasound be of any help in the diagnosis of alveolar-interstitial syndrome? In a prospective study, we examined 250 consecutive patients in a medical intensive care unit: 121 patients with radiologic alveolar-interstitial syndrome (disseminated to the whole lung, n = 92; localized, n = 29) and 129 patients without radiologic evidence of alveolar-interstitial syndrome. The antero-lateral chest wall was examined using ultrasound. The ultrasonic feature of multiple comet-tail artifacts fanning out from the lung surface was investigated. This pattern was present all over the lung surface in 86 of 92 patients with diffuse alveolar-interstitial syndrome (sensitivity of 93.4%). It was absent or confined to the last lateral intercostal space in 120 of 129 patients with normal chest X-ray (specificity of 93.0%). Tomodensitometric correlations showed that the thickened sub-pleural interlobular septa, as well as ground-glass areas, two lesions present in acute pulmonary edema, were associated with the presence of the comet-tail artifact. In conclusion, presence of the comet-tail artifact allowed diagnosis of alveolar-interstitial syndrome. **Lichtenstein D, Mézière G, Biderman P, Gepner A, Barré O. The comet-tail artifact: an ultrasound sign of alveolar-interstitial syndrome.**

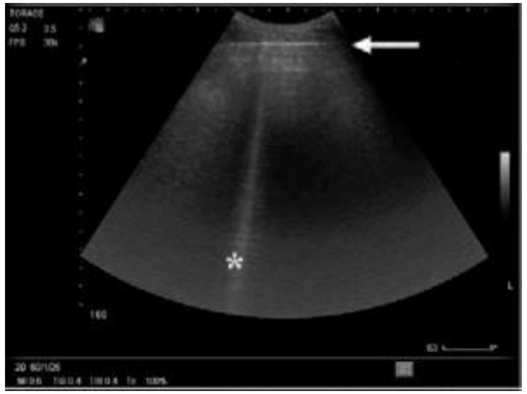
AM J RESPIR CRIT CARE MED 1997;156:1640–1646.

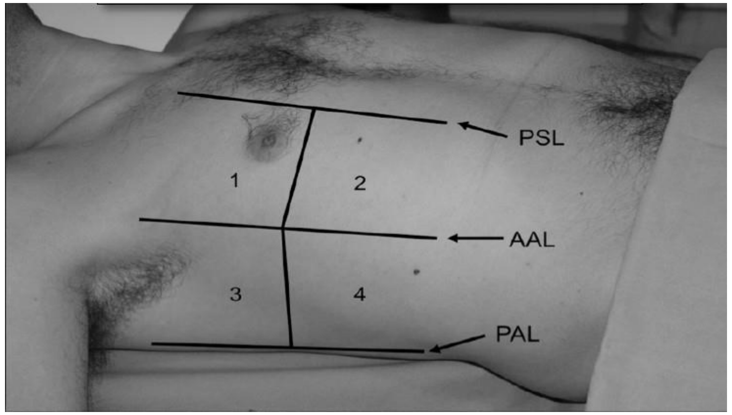
THE SONOGRAPHIC DETECTION OF B-LINES

Zeno Sparchez







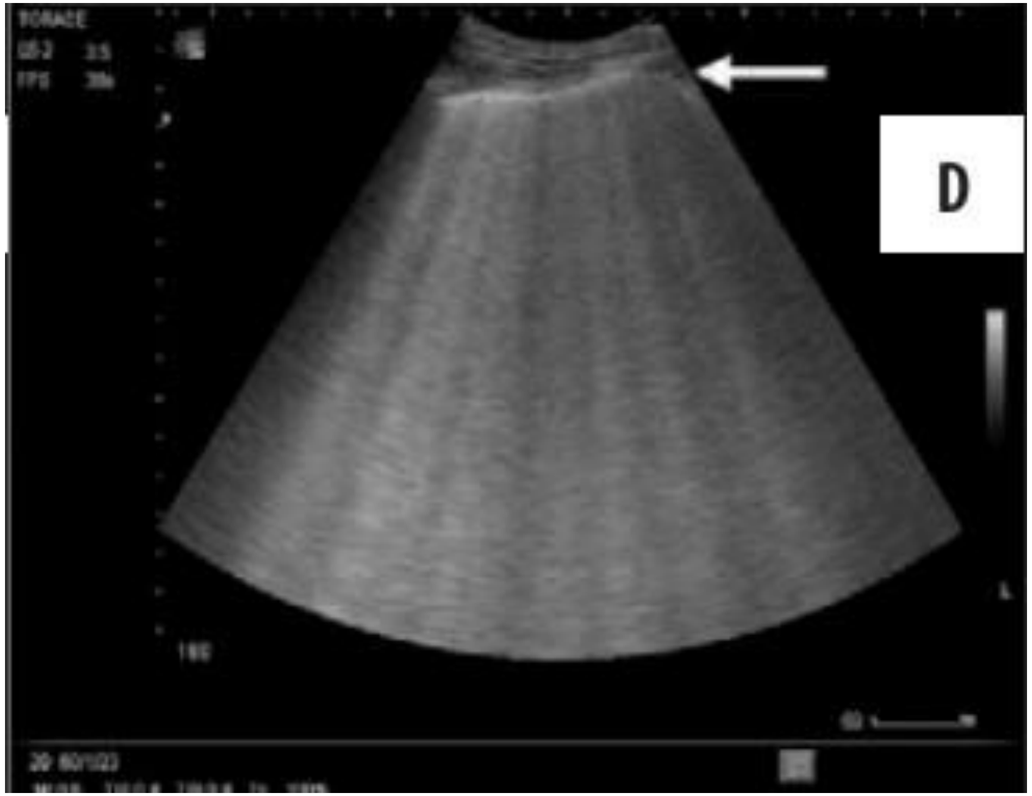


The Examination Technique

Volpicelli G et al. Detection of sonographic B-lines in patients with normal lung or radiographic alveolar consolidation. Med Sci Monit, 2008; 14(3): CR122-128

THE SONOGRAPHIC DETECTION OF B-LINES

Zeno Sparchez



Pathologic B-lines

Volpicelli G et al. Detection of sonographic B-lines in patients with normal lung or radiographic alveolar consolidation. Med Sci Monit, 2008; 14(3): CR122-128

PATIENTS WITHOUT PULMONARY PATHOLOGY

INDIVIDUAL FEATURES

Zeno Sparchez

- 21-27% of the cases;
- at > de 7 mm one from the other (>3 linii, < 7mm pattern B+) predominantly posterior basal;
- may occur in the vicinity of consolidation.

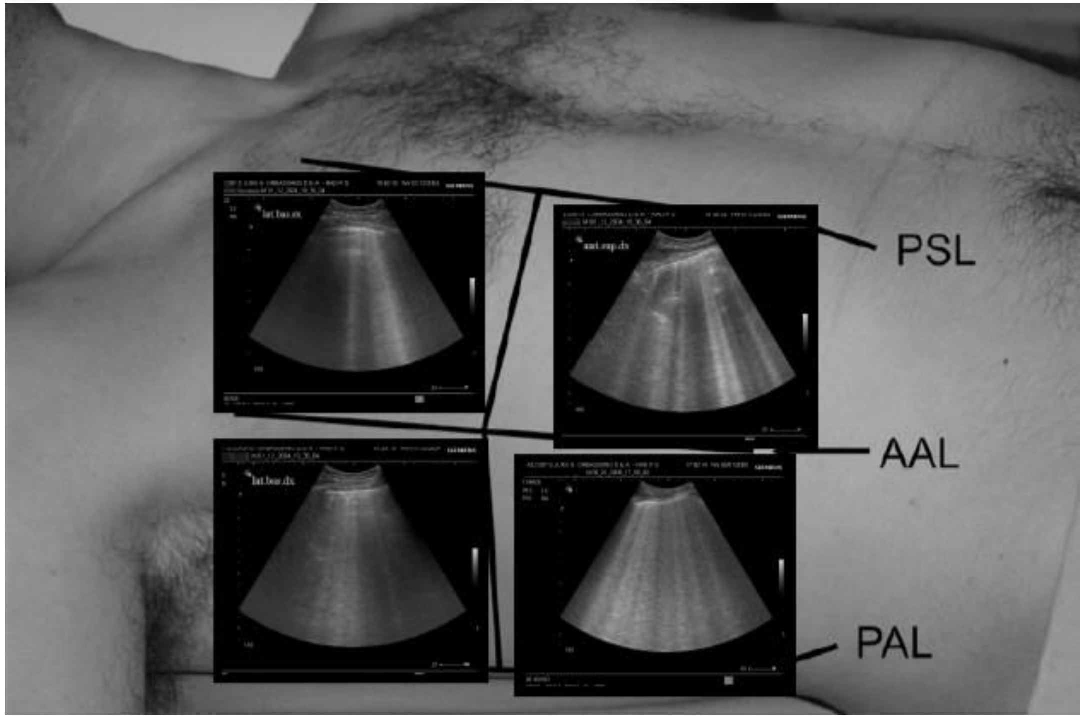
Areas of thoracic ultrasound	Positive scans	%
Upper anterior right	4	2.8
Lower anterior right	4	2.8
Upper lateral right	7	4.8
Laterobasal right	27	18.6
Upper anterior left	3	2.1
Lower anterior left	4	2.8
Upper lateral left	3	2.1
Laterobasal left	33	22.8

Volpicelli G et al. Detection of sonographic B-lines in patients with normal lung or radiographic alveolar consolidation. Med Sci Monit, 2008; 14(3): CR122-128

DIFFUSE INTERSTITIAL SYNDROME DIAGNOSTIC CRITERIA

Zeno Sparchez

Two or more positive bilateral regions

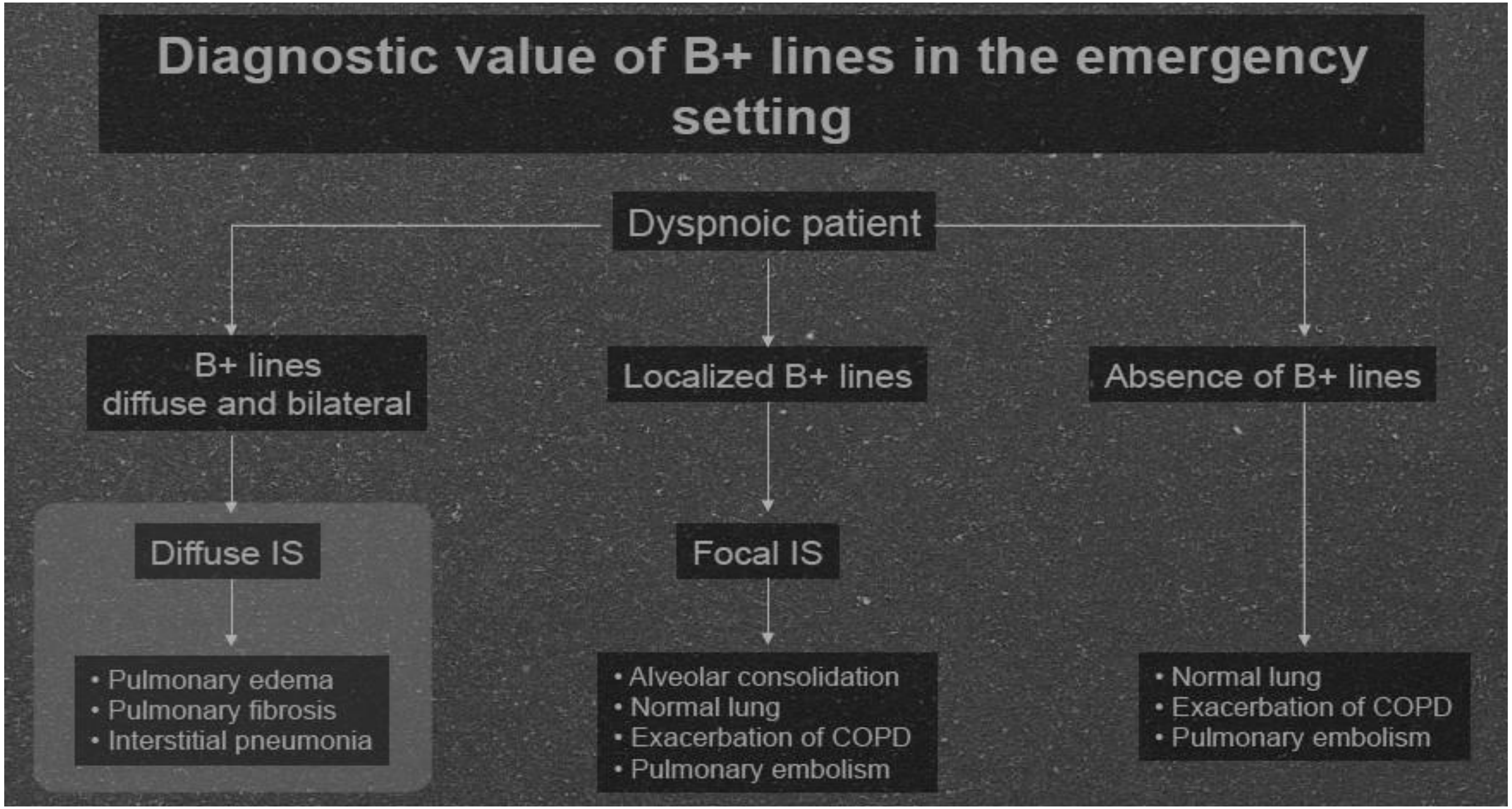


Volpicelli G et al. Bedside lung ultrasound in the assessment of alveolar-interstitial syndrome. American Journal of Emergency Medicine 2006;24:689–696

THE INTERSTITIAL SYNDROME

CLINICAL IMPLICATIONS

Zeno Sparchez



THE CONCLUSIONS

Zeno Sparchez

- The alveolar air and chest bones are not absolute limits of the lung ultrasonography;
- The lung ultrasonography is sensitive to increased lung density (more conditions with less fluid and air);

There can be differentiated three basic ultrasound patterns:

- normally aerated lung (the "in mirror" model);
- slightly increase in the amount of fluid and air loss (interstitial model with B-lines);
- the complete loss of air (the consolidated model).

- The ultrasound is an imaging pulmonary surface technique that does not allow the assessment of deep lesions;
- The interstitial syndrome characterizes several pulmonary pathological conditions that have in common the lungs' air leakage and the increased loss of interstitial fluid (edema, fibrosis, etc.).

LESSONS 3 - 4:

The Lungs' Ultrasound Relevance in the Diagnosis of Acute Respiratory Failure & The Ultra-sonographic Protocols of Respiratory Emergencies

Lectors:

Adela Golea, Cluj-Napoca, Romania

LESSON 3-4

The Lungs' Ultrasound Relevance in the Diagnosis of Acute Respiratory Failure(3)
and
The Ultra-sonographic Protocols of Respiratory Emergencies(4)

THE MAIN TOPICS:

1: IMPORTANT QUESTIONS AND Q&A
2: TOOLS, THE OUTBREAK OF PULMONARY CONDENSATION AND THE ACUTE PNEUMONIA
3: THE EXAMINATION OF THE THRACHEA
4: THE TRACHEAL RING AND THE OBSTRUCTION OF AIR
5: THE LUNG AND PLEURAS' NORMAL APPEARANCE
6: THE ELEMENTS OF NORMAL SEMIOLOGY
7: THE EXAMINATION AND THE PLEURAL COLLECTION
8: ACUTE DYSPNEA AND MONITORING THE US IN EPA
9: ULTRASOUND ASSISTED ALVEOLAR RECRUITMENT
10: THE REEVALUATION OF THE CONDENSATION AREA
11: THE DIAPHRAGMATIC DYSFUNCTION AND RUPTURE
12: PNEUMOTHORAX EXAMINATION AND THE RUSH PROTOCOL

- **US became** an imaging method incorporated into the algorithm of diagnosis and therapeutic management of the critical patients.

- **US transversal** examination can answer specific binary type questions and provides morphological support for making quick decisions.

- **When dealing with critical patients:**
- US allows the patients to be screened and monitored at their bedside.
  - Does not irradiate;
  - It can be performed dynamically;
  - It improves the quality of the care the patients receive by evaluating the information in a morphological manner and it is functional in real time.

	US examination	Ultra-sonographic aspects	Ultra-sonographic aspects	Ultra-sonographic aspects
Shock	Exam. of the heart: collections, large vessels. The goal: to identify the causes and type of shock with immediate impact on therapy	**Hypovolemic shock:** -ICV in collapse, collections; -parenchymal, organ injuries; -AAA dissection, rupture;	Obstructive shock: -VCI relaxed> 2.5 cm without inspiratory collapse; -signs of tamponade; -the pneumothorax.	Cardiogenic shock: - Myocardial contractility; - valvular changes; - ventricular aneurysm.
PE	Examination of the heart and embolic sources	Pulmonary hypertension signs: -right ventricular dilatation: VD>VS; relaxed VCI > 2,5 cm, no respiratory collapse.	Thrombi identif. in the pulmonary artery - difficult, it's not obligatory when in emergency with unstable patients	The diagnostic on embolic sources: - The thrombi into the cavities of the heart; - The thrombi in the VCI; - TVP at the lower limbs' level.
Acute Respiratory Failure	Examination of the lungs and pleura [D Liechtenstein 1998 2002 G. Volpicelli, 2005	The Pneumothorax: The absence of sliding movement of the lung ("lung sliding"); The absence of the comet tail artifact ("the comet tail"); The rapid viewing of the area limits, "lung sliding" sign.	The Hydrothorax: - quantity, disposition, appearance; - the impact on the lungs' dynamics (collaboration parenchyma).	The diff. bet. the acute pulmonary edema and the acute COPD: The exam. at the bilateral thoracic anterior walls' level; The comet tails' artefact emerged from the lung-wall interface is characteristic to alveolo- interstitial edema. The pattern on the surface of multiple artifacts on the anterior and lateral lung, highlighted by ultrasound diffuse infiltrative pulmonary disease are characteristic. pulmonary edema and ARDS, lacking in COPD.

IMPORTANT QUESTIONS

Adela Golea

- What is the cause?
- What is the optimal therapy?
- What are the threats?
- Can it be monitored clinically and by US?
- Does it require other imaging investigations?

TOOLS
Adela Golea

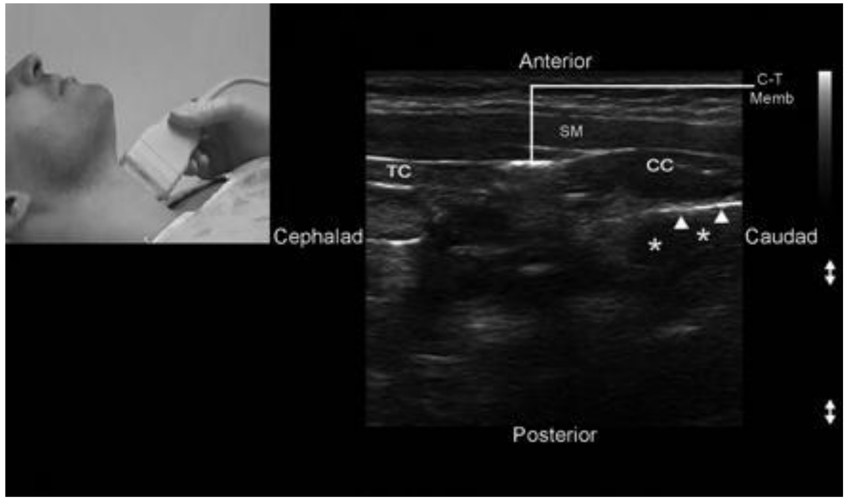
There is used:

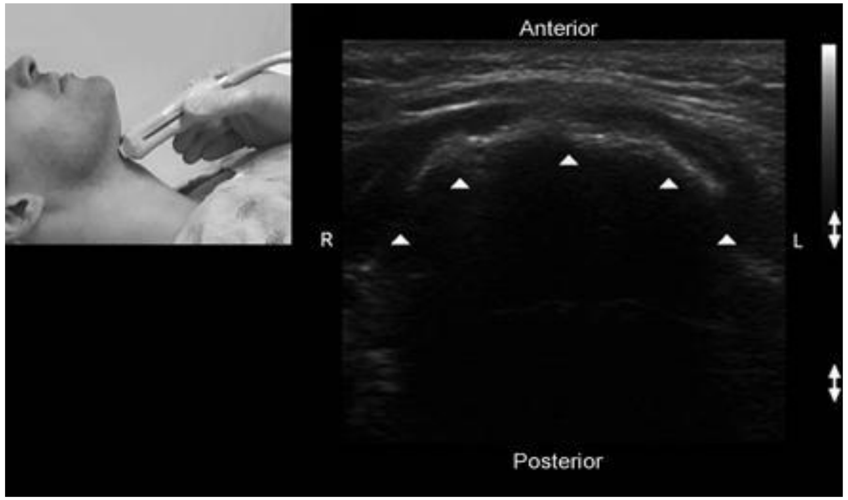
- An US appliance with possibility of classic 2D examination;
- A Transducer;
- A Convex - 3-5MHz;
- A 5-9 MHz Linear;
- Micro-convex - 4-8 MHz;
- The most recommended utility is a 5 MHz Micro-convex.

THE EXAMINATION OF THE THRACHEA

Adela Golea

- A Linear Transducer of 5-9MHz;
- longitudinal on midline (sagittal section);
- longitudinal 2cm lateral to the midline (parasagittal section);
- transversal on the anterior region of the neck (transversal section).

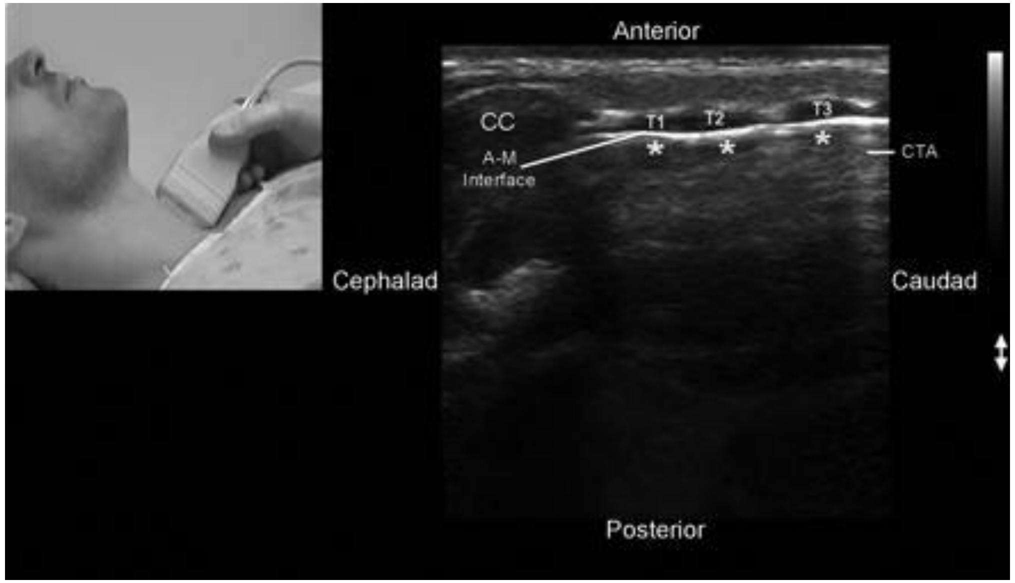


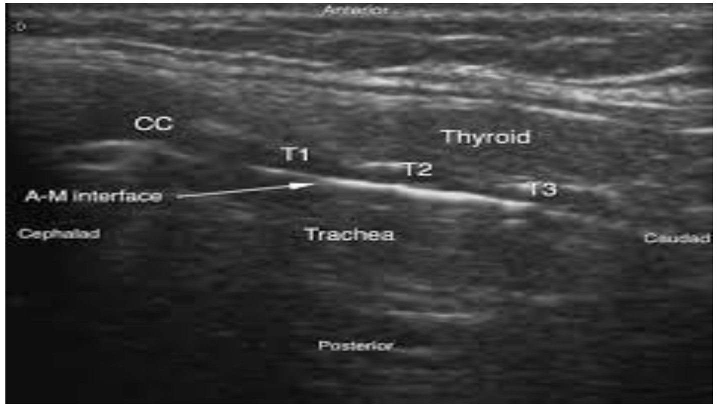


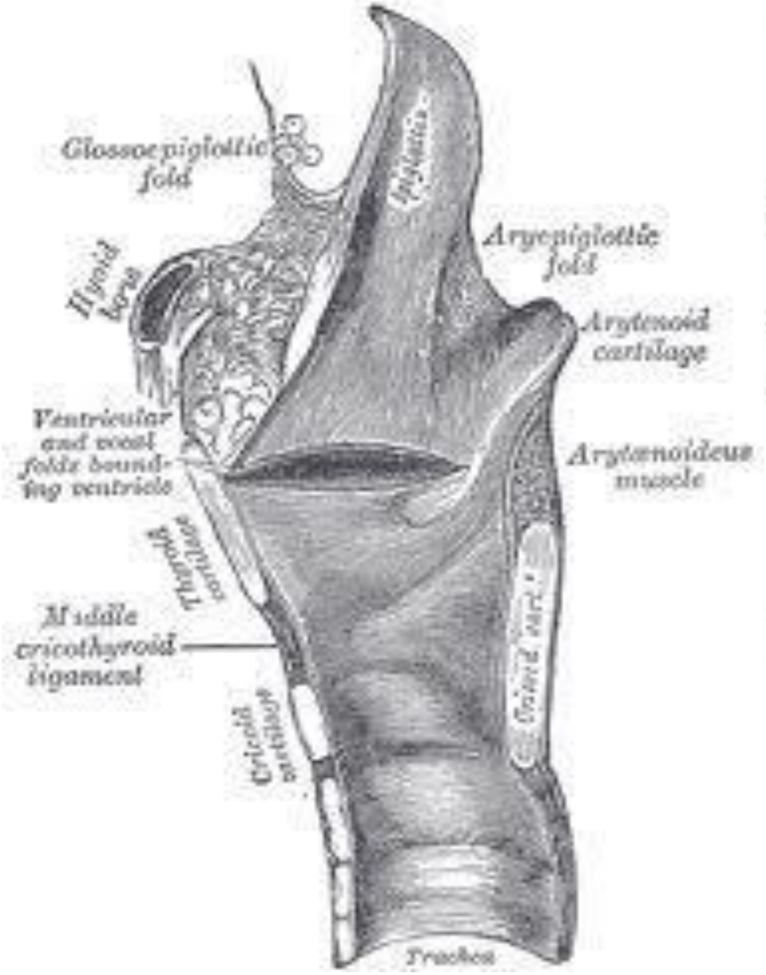
THE TRACHEAL RING

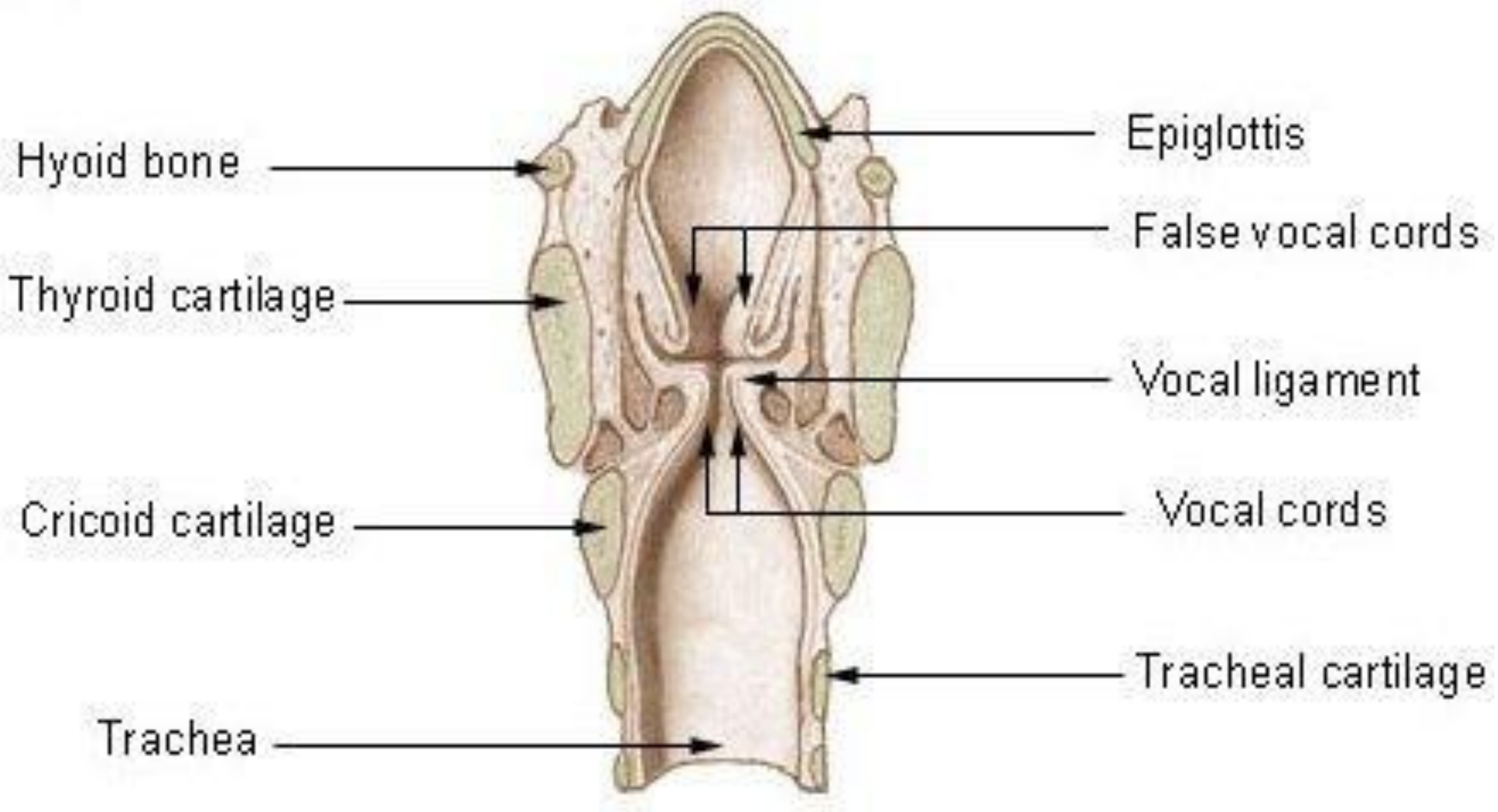
Adela Golea

- The tracheal mucous;
- The movement of the air leakage;
- Mirror imaging of the mucous.





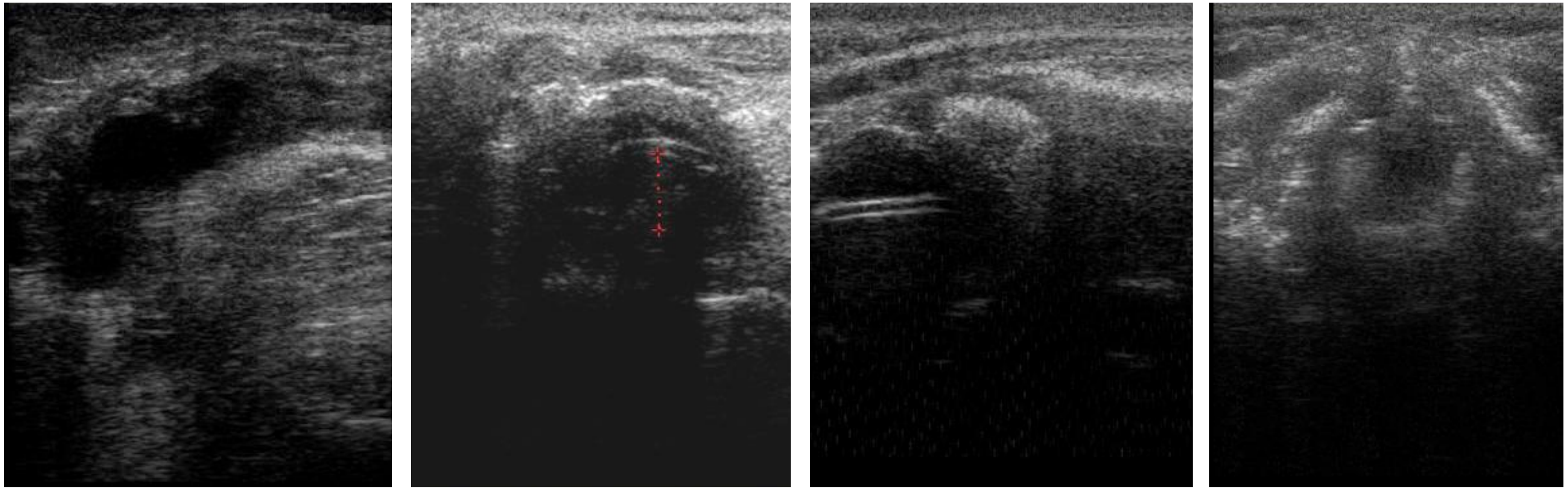

Glossoepiglottic fold
Epiglottis
Hyoid bone
Aryepiglottic fold
Arytenoid cartilage
Ventricular and vocal folds bounding ventricle
Arytænoideus muscle
Thyroid cartilage
Middle cricothyroid ligament
Cricoid cartilage
Cricoid cart.
Trachea


Hyoid bone
Epiglottis
False vocal cords
Thyroid cartilage
Vocal ligament
Cricoid cartilage
Vocal cords
Tracheal cartilage
Trachea

THE OBSTRUCTION OF AIR

Adela Golea

- The swelling of the vocal cords;
- The extrinsic compression;
- Endolumenal content;
- Absence of pulmonary ventilation ("Sliding sign absent");
- The appearance of the IOT probe.



THE LUNG AND PLEURAS' NORMAL APPEARANCE

Adela Golea

- The intercostal window is used;
- The examination is based on analyzing artifacts;
- It can be performed in any position the patient has;

"In our opinion, artifacts that provide information CAN BE vital to life-saving. Artifact analysis is the basis of long ultrasonography. "- Daniel Lichtenstein.

- The report of the air-fluid is analyzed;
- The collection is made when near zero;
- Condensation - reduced air leakage caused by remaining Broncho-gram;
- Pneumothorax – increased.

THE LUNG AND PLEURAS' NORMAL APPEARANCE

Adela Golea

The elements of normal semiology:

The picture of the rib;

- Echogenic;
- Rear conic obscurity;
- On approx. 2 cm in adults;

The air leakage pattern:

- Ecogen with rear reverberations (echogenic lines equidistant with reflectory transducer interface)

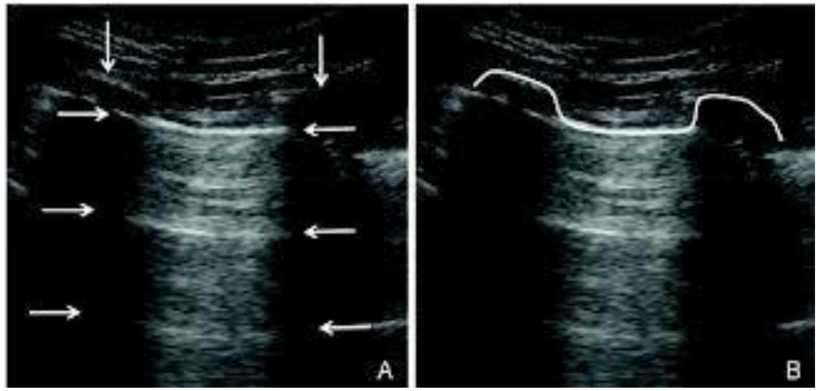
The pleural line – echogenic:

- Parietal tissue (rich in fluid);
- Lung tissue (air);
- Rear reverberations;
- On approx. 2.5 cm in adults

THE ELEMENTS OF NORMAL SEMIOLOGY

Adela Golea

- The movement of the pleura (“sliding sign");
- Appearance of bat wings ("bat signal");
- Line A - echogenic line, horizontal, parallel to the pleural line, equidistant with the skin-pleura;
- Line A - between the A lines;
- Air leakage Broncho-gram;



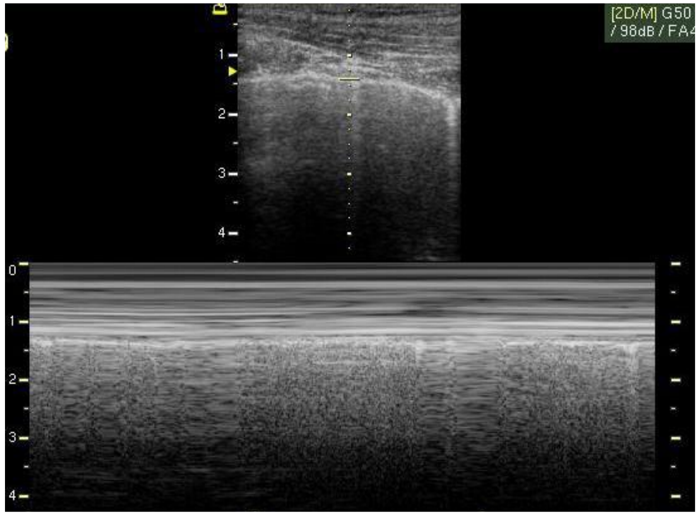
THE ELEMENTS OF NORMAL SEMIOLOGY

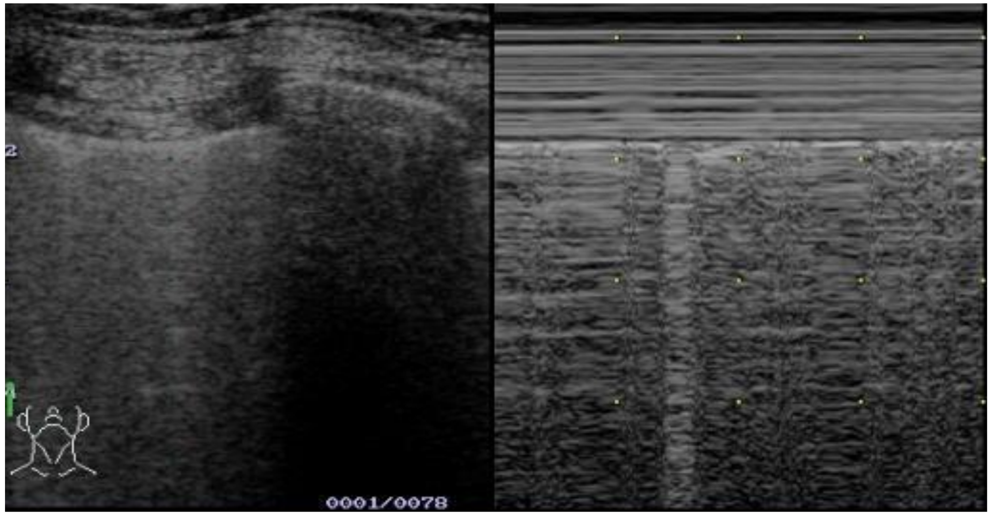
Adela Golea

Isolated comet tail artifacts:

- B lines - start from the pleura and go to until seen deeply into the core;
- Z lines - start from the pleura and get lost;

The M Mode: the 'seashore' sign and the 'beach' sign.

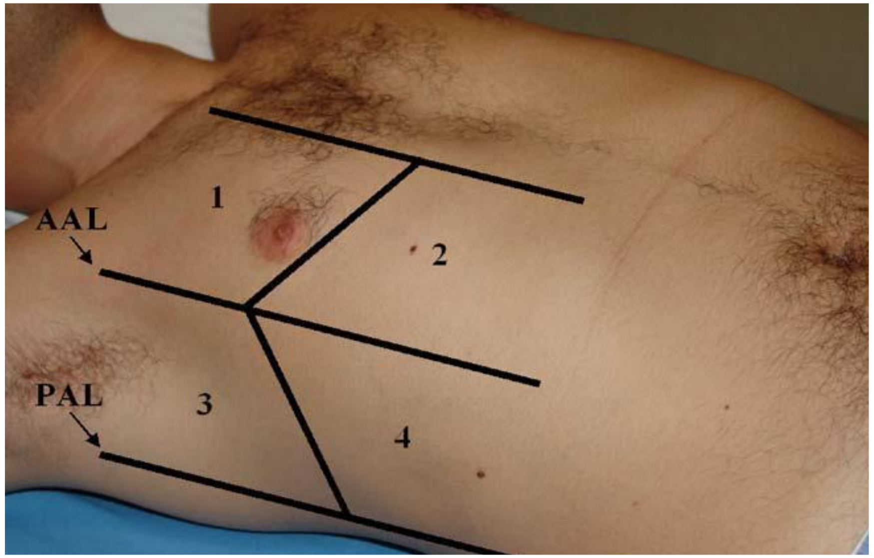


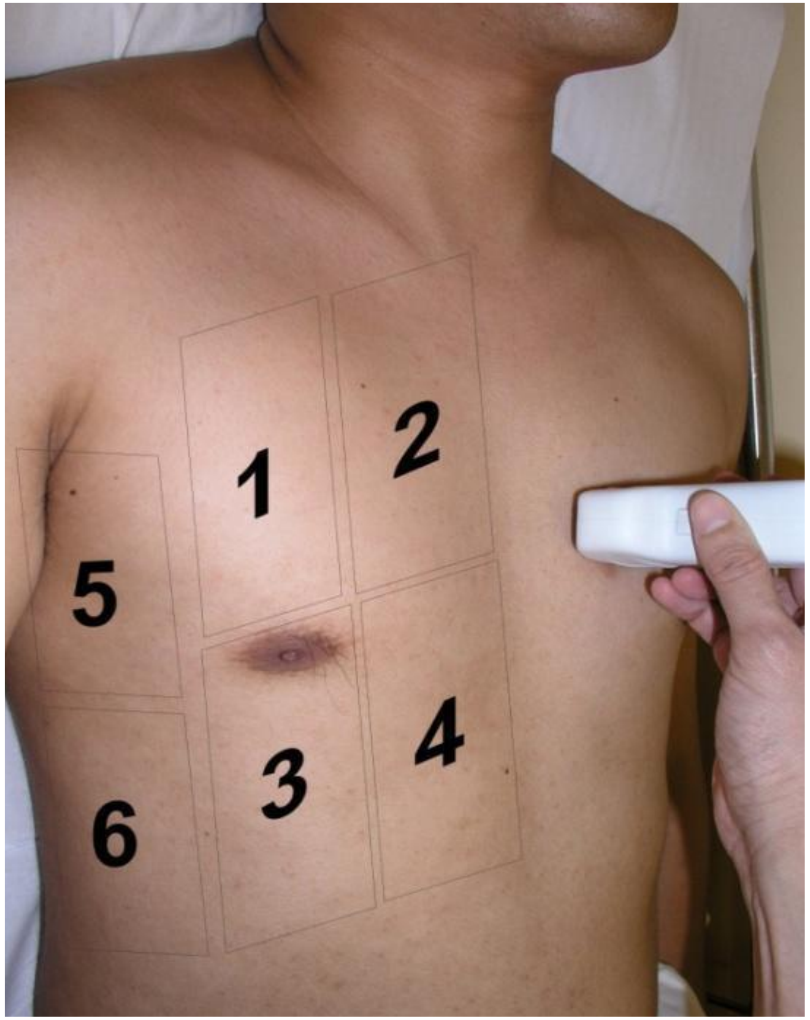


THE EXAMINATION

Adela Golea

1) The Longitudinal examination.
2) The Supine Examination:
   - previously;
   - Laterally;
   - Rearly;





THE PLEURAL COLLECTION

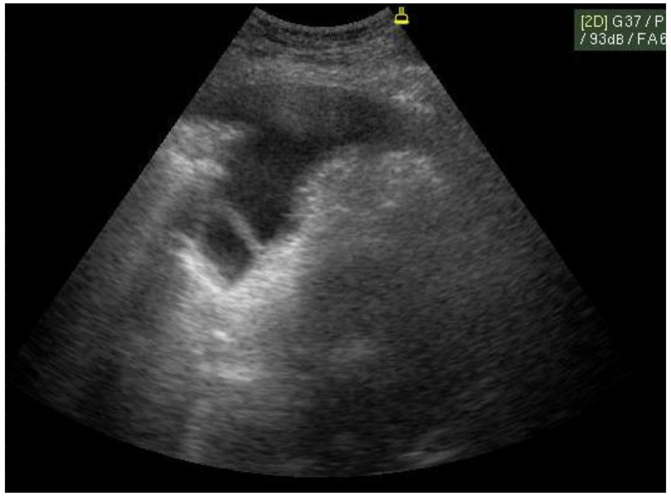
Adela Golea

The appearance of the liquid:

- Transonic;
- The rear sound – strengthened;

The appearance of the fluid/air:

- Transonic with strengthened acoustics;
- Hyperechoic with artefact “comet-tail” aspect.

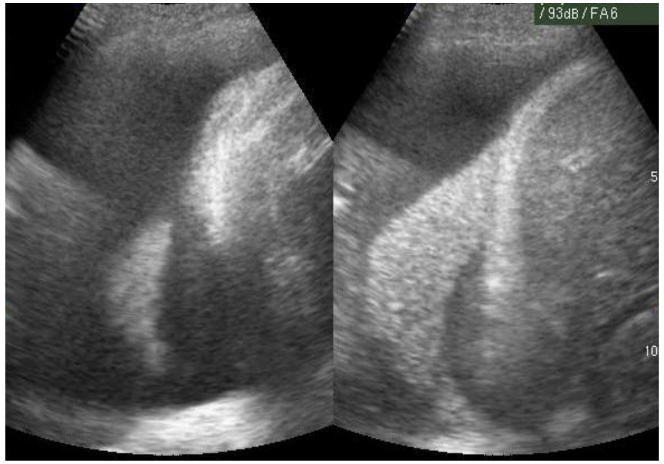


THE PLEURAL COLLECTION

Adela Golea

The examination is made from the base to the apex:

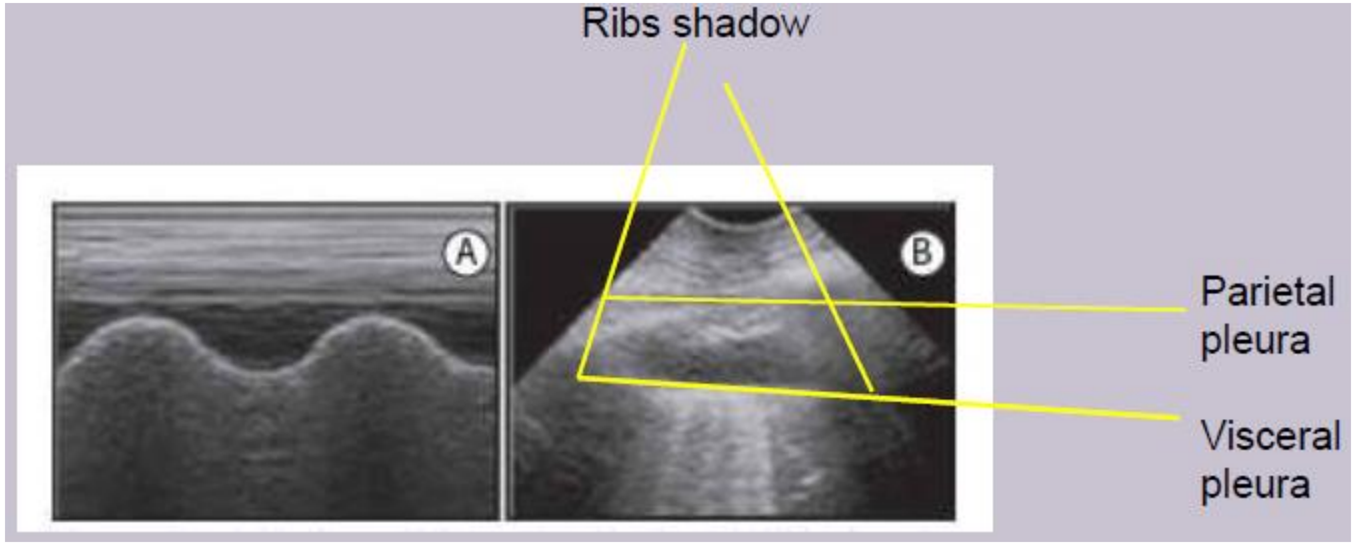
- The diaphragm;
- The pleural space;
- The presence of the “jelly fish” - the movement of the lungs when breathing.



THE PLEURAL COLLECTION

Adela Golea

- The movement of the lung among the thoracic wall while breathing.
- Quad Sign: the 4 side delimitation of the rib shadows' collection and the parietal pleura.



Q&A

Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

- **The presence and the impact of pleural collections.**
- **The examination of the posterior thorax in supine position.**
- ***The amount of:***

- US starting at 20 ml;
- RGR from 175 ml supine position;
- 50 ml in the orthopnea position;

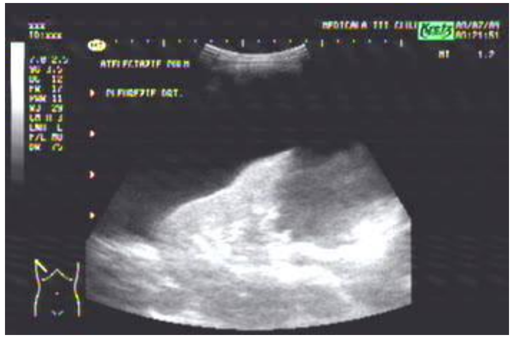
- **The distribution.**

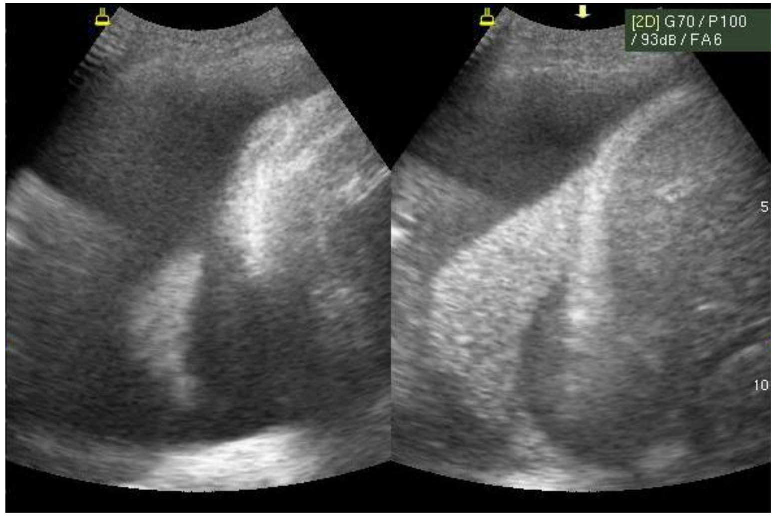
Q&A
Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

The presence and impact of functional pleural effusions:

- Aspect;
- Lung collapse;
- Air leakage bronchogram.

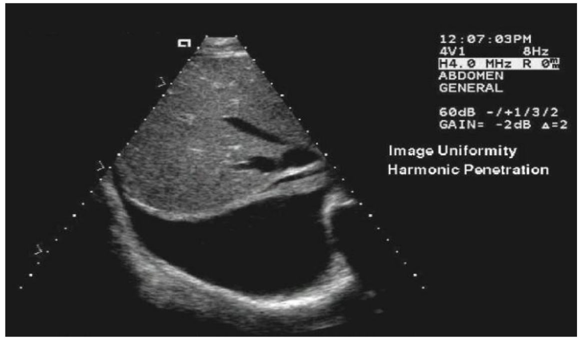


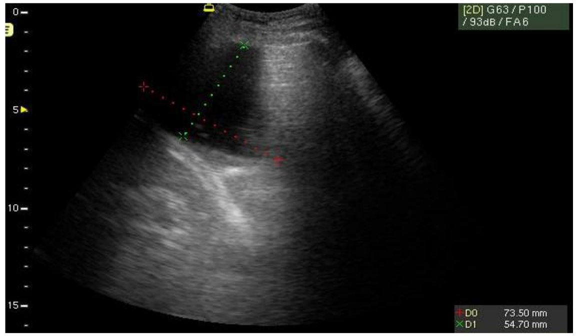


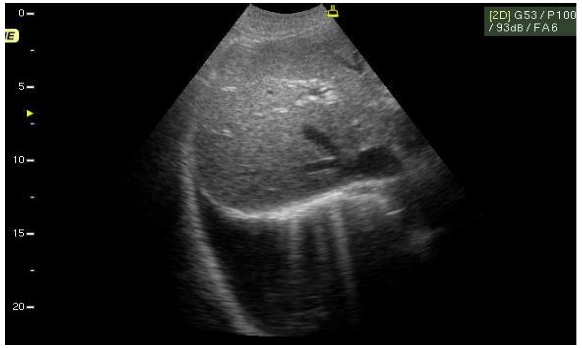
Q&A

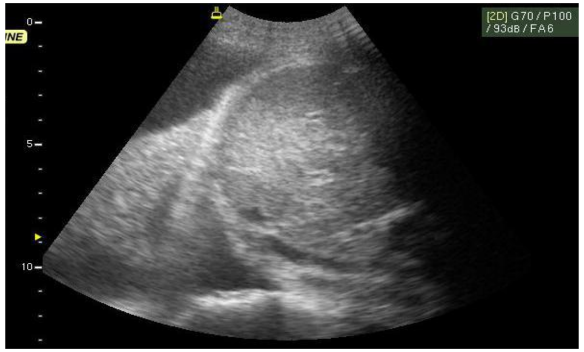
Adela Golea

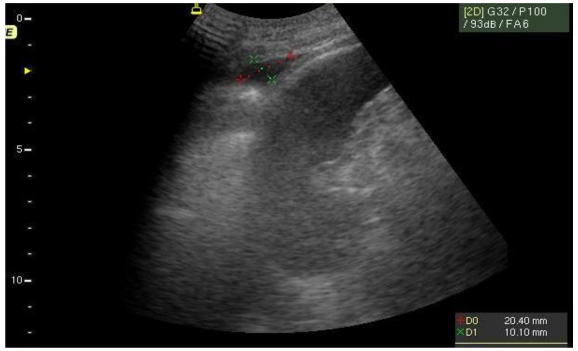
What is our aim in the examination of the patient with acute respiratory failure?











THE PLEURAL COLLECTION

Adela Golea

Assessment:

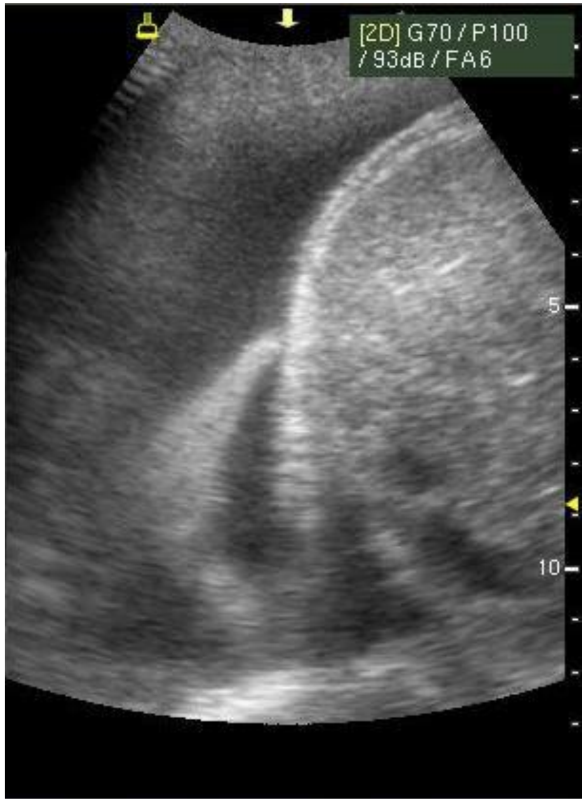
- Quantity - at the base or 5th intercostal space;
- at 3 cm inferior from the lung pole;
- > 5cm, probably > 500ml.

Intensive Care Med (2010) 36:656–664
DOI 10.1007/s00134-010-1769-9

ORIGINAL

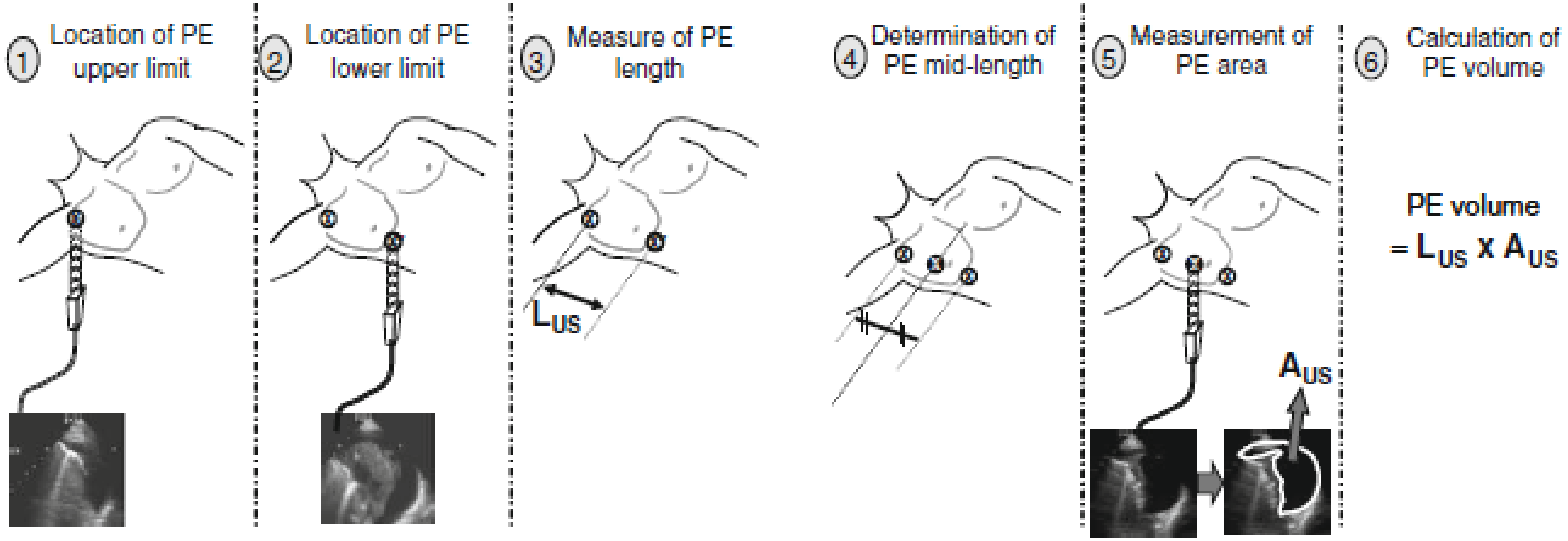
Francis Remérand
Jean Dellamonica
Zhang Mao
Fabio Ferrari
Belaïd Bouhemad
Yang Jianxin
Charlotte Arbelot
Qin Lu
Carole Ichaï
Jean-Jacques Rouby

Multiplane ultrasound approach to quantify pleural effusion at the bedside



THE PLEURAL COLLECTION

Adela Golea



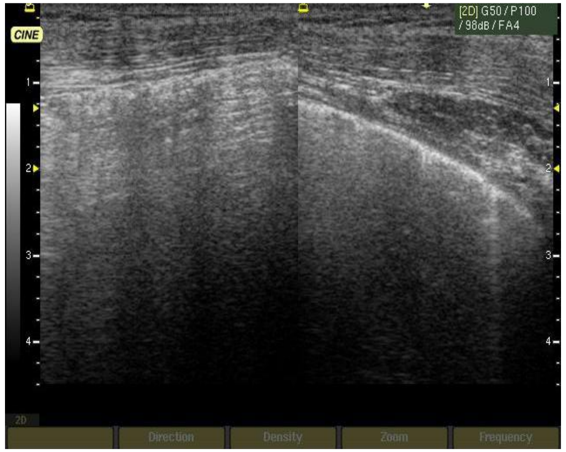
Q&A

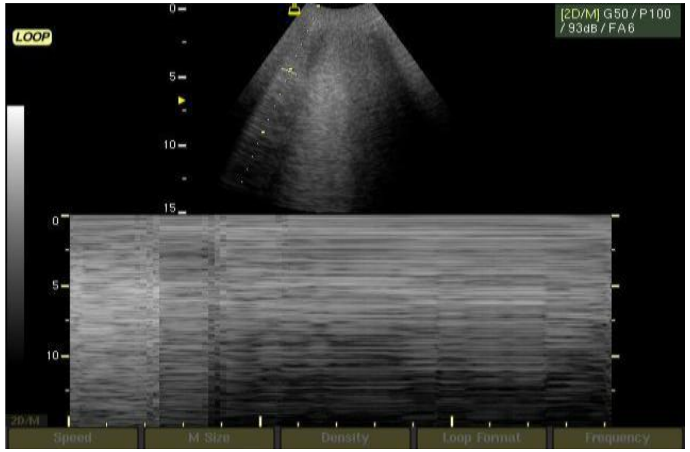
Adela Golea

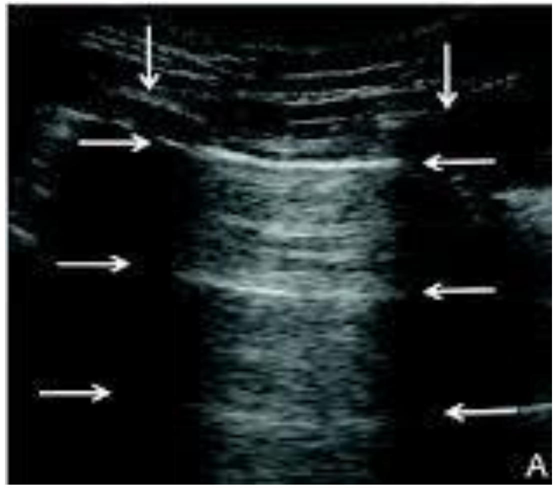
What is our aim in the examination of the patient with acute respiratory failure?

The appearance of the pneumothorax:

- The absence of lung sliding movement ("long sliding");
- The M mode disappears the sign "seashore" and the “stratosphere” sign appears;
- The absence of the comet tail artifact ("comet tail");
- The appearance of the A line: the horizontally artifact starting from the pleural line;
- The M mode: pattern of horizontal lines that reproduce the transducer-pleura distance;
- Sensitivity 92% compared to 52% for RX.







Occult Traumatic Pneumothorax Diagnostic Accuracy of Lung Ultrasonography in the Emergency Department

Chest - Volume 133, Issue 1 (January 2008)

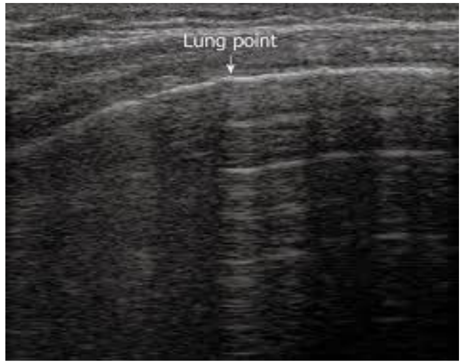
Q&A

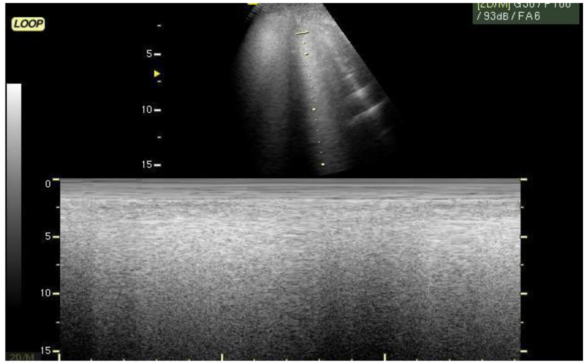
Adela Golea

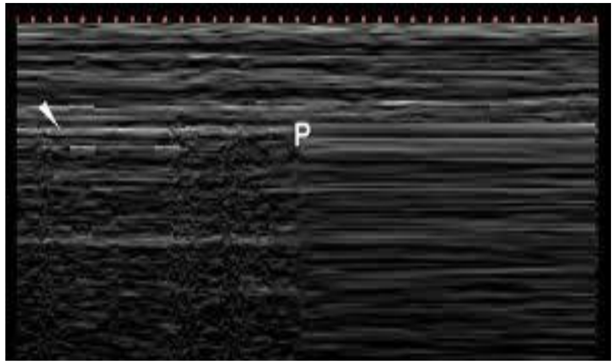
What is our aim in the examination of the patient with acute respiratory failure?

The appearance of the pneumothorax:

- **Long Point** - normal lung interface with pneumothorax;
- **Subcutaneous emphysema** - the reverberations appearance of surface;







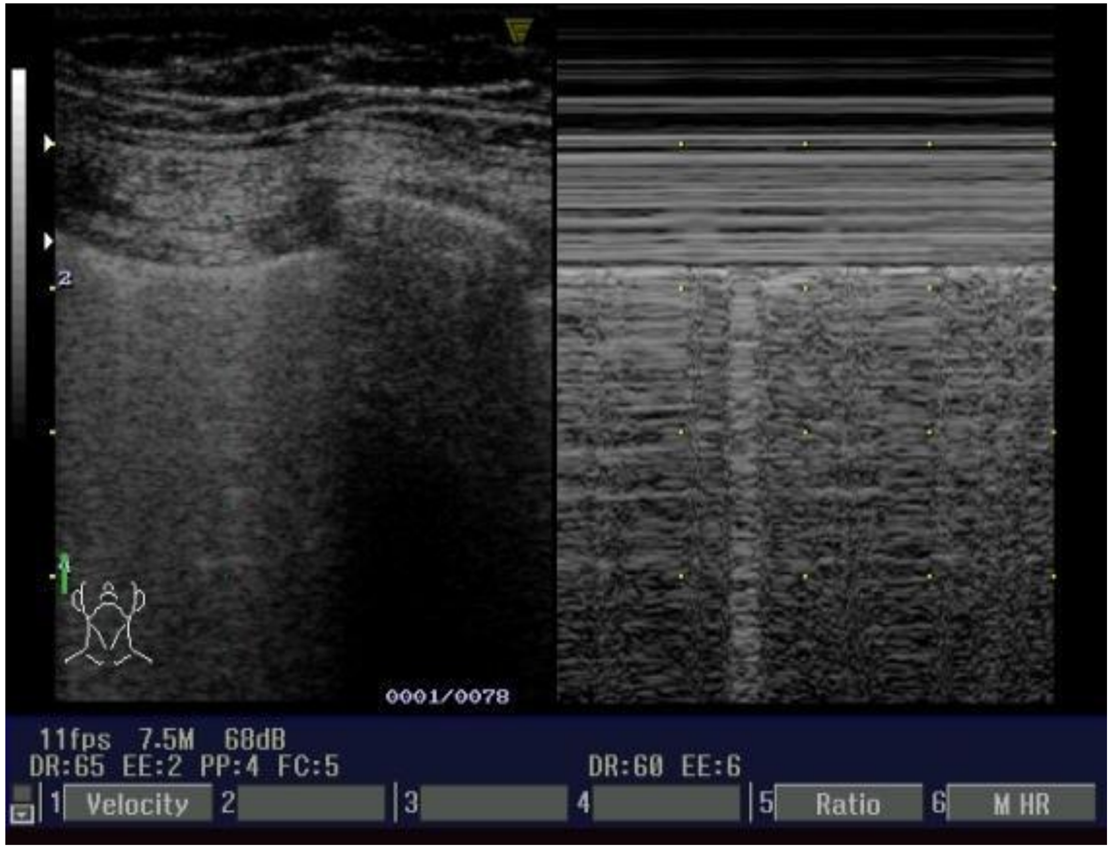
Q&A

Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

The interstitial edema:

- **Line B**: from the pleural line, vertical artifact “comet-tail” type, good definition without any attenuation;
- **Multiple B lines**: "Lung rockets" (3 - 7mm);
- **Z lines**: from the pleural line, they get lost, they are not visible to the core.



D. A. Lichtenstein, General Ultrasound in the critically ill, Springer 2002, 2010

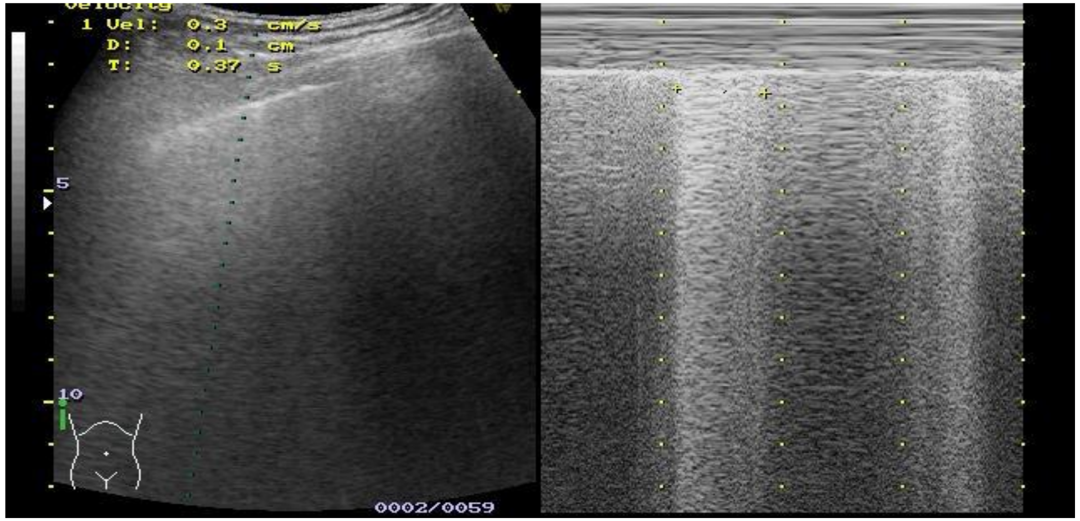
ACUTE DYSPNEA

THE WET LUNG

Adela Golea

The interstitial edema:

- **B lines:** vertical reverberations from the pleural lines' level ("comet tails") visible to the core, moving synchronously with the pleural line;
- **Broad B lines:** "Lung rockets" (3 - 7mm);
- VCI > 25 mm;
- **No respiratory collapse.**

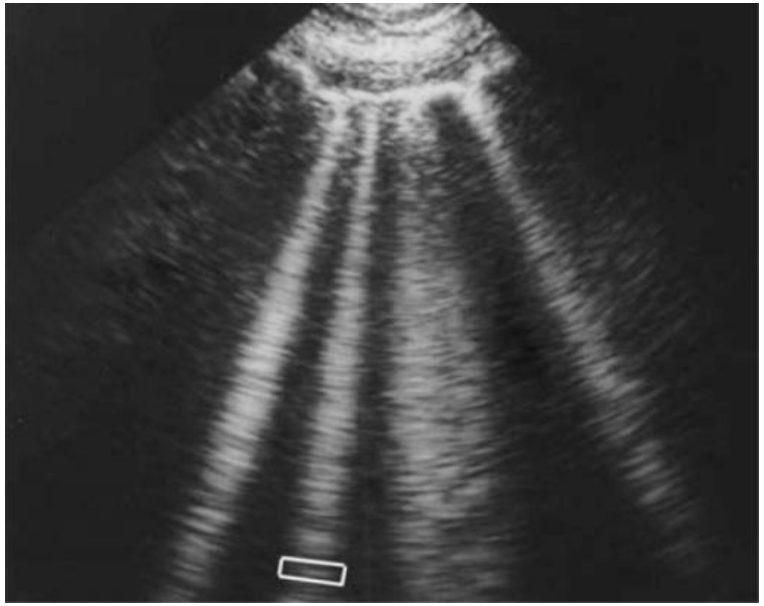


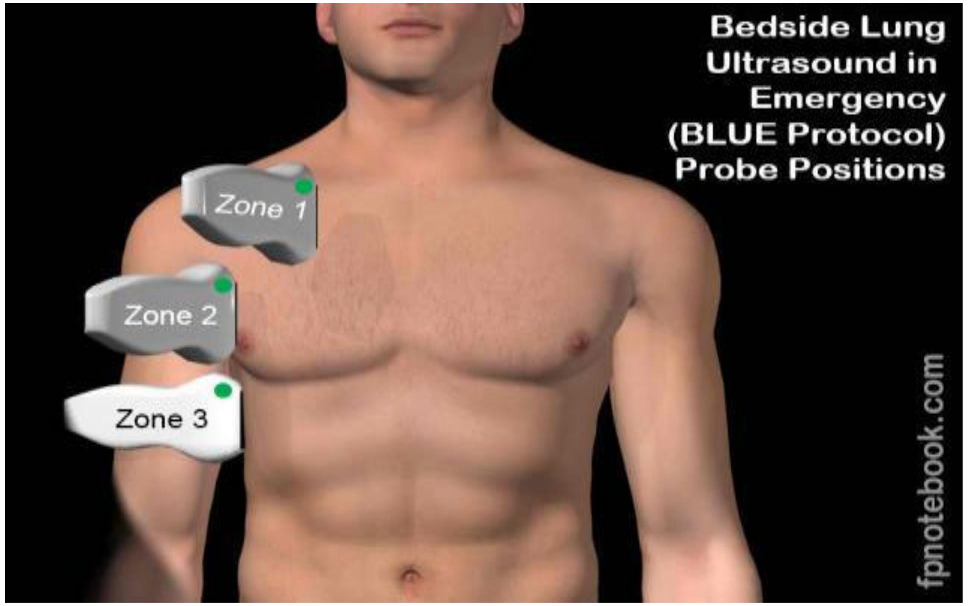
D. A. Lichtenstein, General Ultrasound in the critically ill, Springer 2002, 2010

MONITORING THE US IN EPA

Adela Golea

- **'Comet tail' score** - quantifies the number of B lines in 3 lung areas;
- **Wet – dry**; **white – black**; The 'B-pattern' describes the pulmonary edema (better defines than the phrase 'lung rockets' or "B-plus").





REAL-TIME RESOLUTION OF SONOGRAPHIC B-LINES IN A PATIENT WITH PULMONARY EDEMA ON CONTINUOUS POSITIVE AIRWAY PRESSURE AMERICAN JOURNAL OF EMERGENCY MEDICINE - VOLUME 28, ISSUE 4 (MAY 2010) LICHTENSTEIN D., MEZIERE G.: A LUNG ULTRASOUND SIGN ALLOWING BEDSIDE DISTINCTION BETWEEN PULMONARY EDEMA AND COPD: THE COMET-TAIL ARTIFACT. *INTENSIVE CARE MED* 24. 1331-1334.1998; ABSTRACT

Q&A

Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

The atelectatic zone:

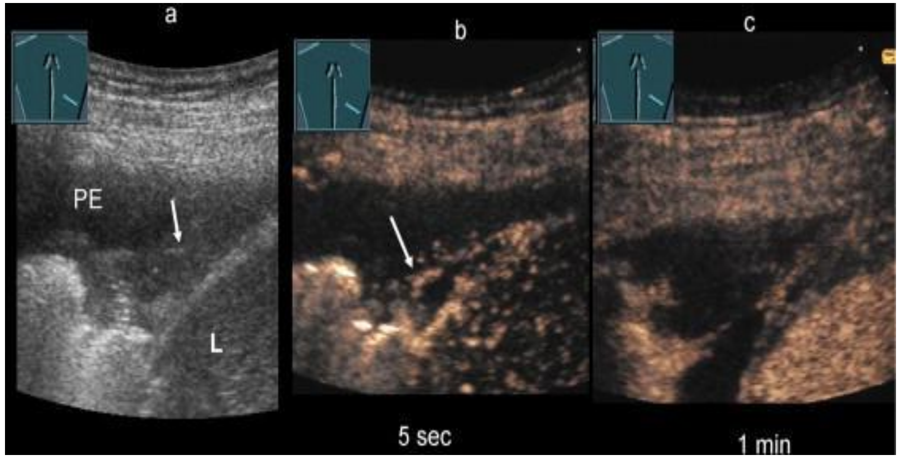
- The W line: the ‘comet tail’ artifact starts from below the pleural line;
- Pulmonary condensation: parenchymal aspect mass starts below the pleural line;
- Static air leakage bronchogram in atelectasis resorption;

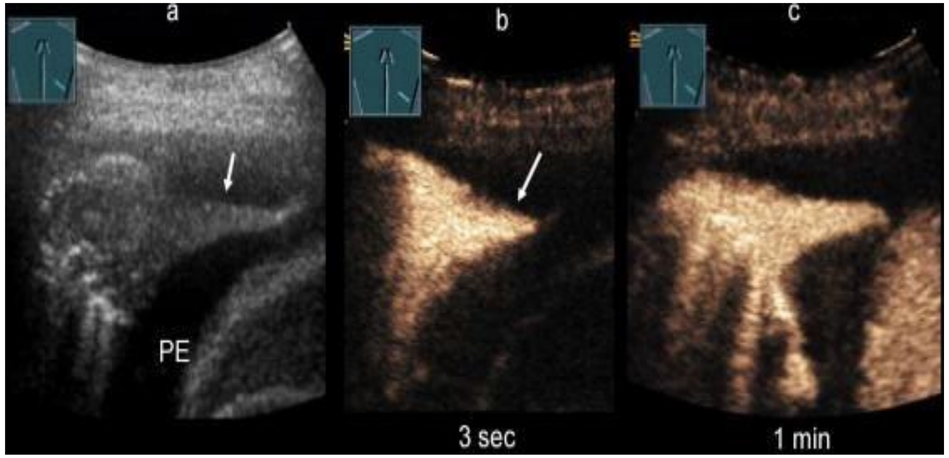
D. A. Lichtenstein, General Ultrasound in the critically ill, Springer 2002, 2010

Q&A
Adela Golea

The Acute Dyspnea - Atelectasis or not?

- Patients with sudden breathlessness – **MET**;
- Patients with progressive dyspnea installed – **Atelectasis**.



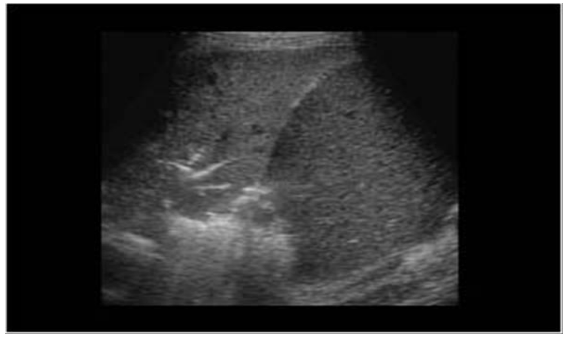


THE OUTBREAK OF PULMONARY CONDENSATION

Adela Golea

PNEUMONIA:

- Pulmonary consolidation;
- Dynamic air leakage bronchogram - 1 cm progress in inhalation;
- Tubular aspect in the exhalation process;
- Appearance of hepatization - irregular - irregular margins;
- Association collection near the building area;
- The absence of the sinusoid sign in the M mode.

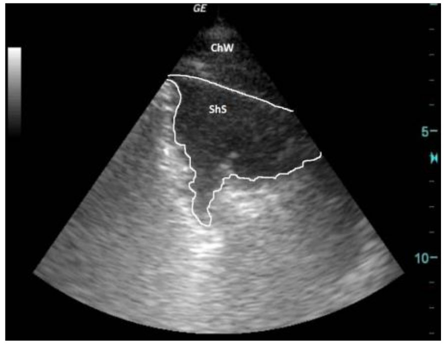


The dynamic air bronchogram. A lung ultrasound sign of alveolar consolidation ruling out atelectasis, Daniel Lichtenstein, chest ultrasonography volume 135, issue 6 (June 2009)

THE ACUTE PNEUMONIA

Adela Golea

- **The consolidation area**: - tissue like sign - constant sizes during respiration;
- ***Dynamic air leakage bronchogram***:
  - *The inhalation*: 1cm move to the periphery;
  - *The exhalation*: tubular hyperechoic appearance;
- **The shred sign** - irregular area between the normal lung and the condensation area.



The Dynamic Air bronchogram A Lung Ultrasound Sign of Alveolar Consolidation Ruling Out Atelectasis , Daniel Lichtenstein, Chest Ultrasonography Volume 135, Issue 6 (June 2009)

ULTRASOUND ASSISTED ALVEOLAR RECRUITMENT

Adela Golea

Each region of interest will be quantified in four stages of pulmonary aeration before and after the therapy:

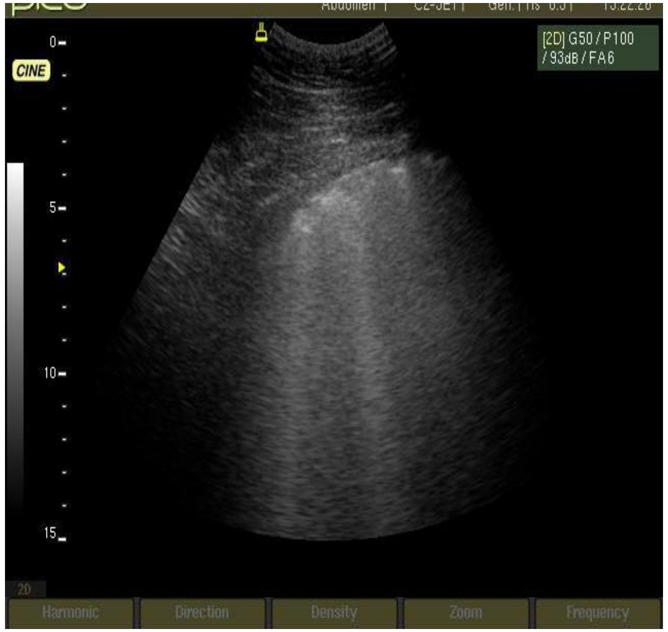
- Normal;
- Sdr. interstitial (B line - 7 mm);
- Sdr. interstitial alveolar (B line less than 3 mm);
- Sdr. alveolar consolidation.

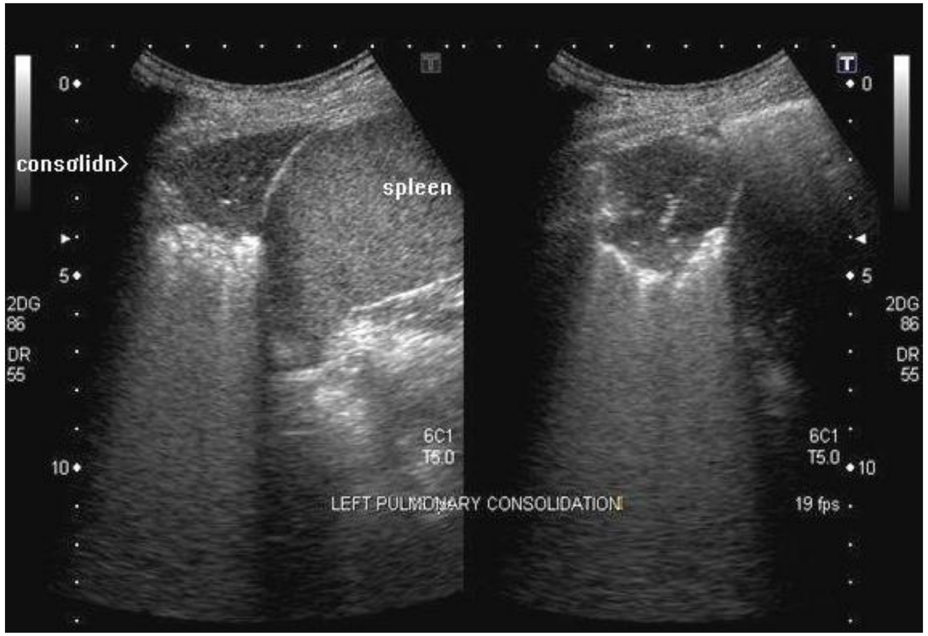
Clinical review: Bedside lung ultrasound in critical care practice. Bélaïd Bouhemad, Mao Zhang, Qin Lu and Jean-Jacques Rouby. Critical Care 2007, 11:205 doi:10.1186/cc5668)

THE REEVALUATION OF THE CONDENSATION AREA

Adela Golea

- ***The presence of the B lines*** – Sdr. Interstitial and alveolar;
- *Laterally* and *rearly* lung aspect;
- ***The presence of the static bronchogram*** – differentiate from the *Atelectasis*;





THE DIAPHRAGMATIC DYSFUNCTION

Adela Golea

- **Scan the patient** in the supine position;
- **Choose the intercostal position** on the axillary line to view the diaphragms' inhalation/exhalation;
- **Evaluate** three movements and **choose** between them, the one with **the maximum amplitude movement;**
- ***Normal diaphragm excursion:***
  - 0.5 -1.6 cm;
  - *Frequently*: 10 - 20 mm;
  - <5 mm is pathological;

THE DIAPHRAGMATIC RUPTURE

Adela Golea

- ***The "Rip's absent organ"*** - the spleen and heart are not viewed;
- ***The reduced diaphragmatic movement***;
- The diaphragm in the raised position;
- ***The "Liver - sliding sign"*** (without the lungs' sliding movement);
- Pleural effusion;
- Subfrenic collection;
- ***The spleen*** is visualized in the thorax.

Q&A

Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

- ***Lets' exclude cases that require immediate therapy***: pneumothorax, hemo/massive effusion;
- ***Guiding thoracentesis*** - when needed;
- ***Orienting diagnosis***: EPA, hydro-thorax;
- ***Avoiding irradiation.***

Q&A
Adela Golea

What is our aim in the examination of the patient with acute respiratory failure?

- ***We should*** assist IOT and its' *complications*;
- Monitor **ventilation therapy**;
- *Air leakage bronchogram* in ventilated patients;
- Developments of *the atelectatic* and *condensation* **areas**;
- The *ventilatory dynamics*.

ACUTE DYSPNEA

Adela Golea

"In our opinion, artifacts provide vital information that can be life-saving. The artifacts' analysis is the basis of lung ultrasonography." – Daniel Lichtenstein

- **The fluid-air report can be analyzed as such:**

Aspect	Air	Fluid
Normal	Sliding sign	Zero
Collection	Zero	Pleural
Consolidation	Rare Bronchogram	Zero
Pneumothorax	High Quantity	Zero
Pulmonary Edema	Yes	Interstitial

Table 1. *Performance of ultrasound compared with computer tomography scan as gold standard*

	Sensitivity (%)	Specificity (%)
Pleural effusion[13]	94	97
Alveolar consolidation[14]	90	98
Interstitial syndrome[15]	93	93
Complete pneumothorax[16]	100	95
Occult pneumothorax[17]	79	100

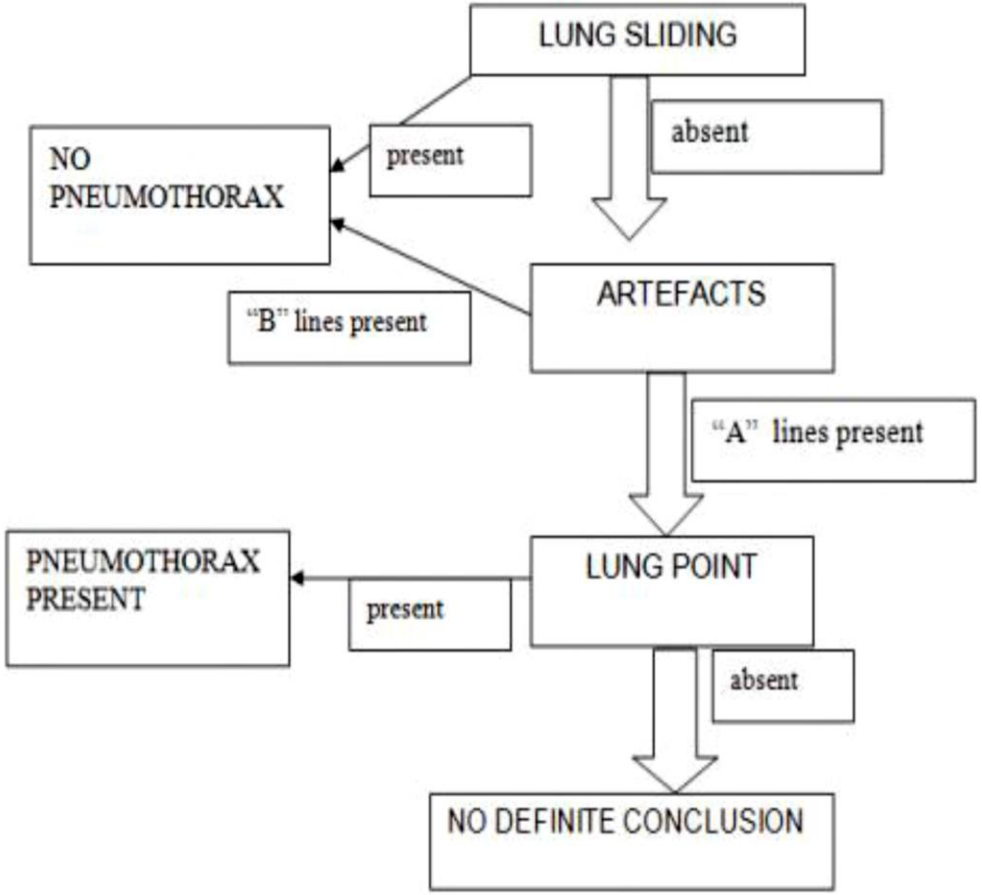
ACUTE DYSPNEA
US EXAMINATION
Adela Golea

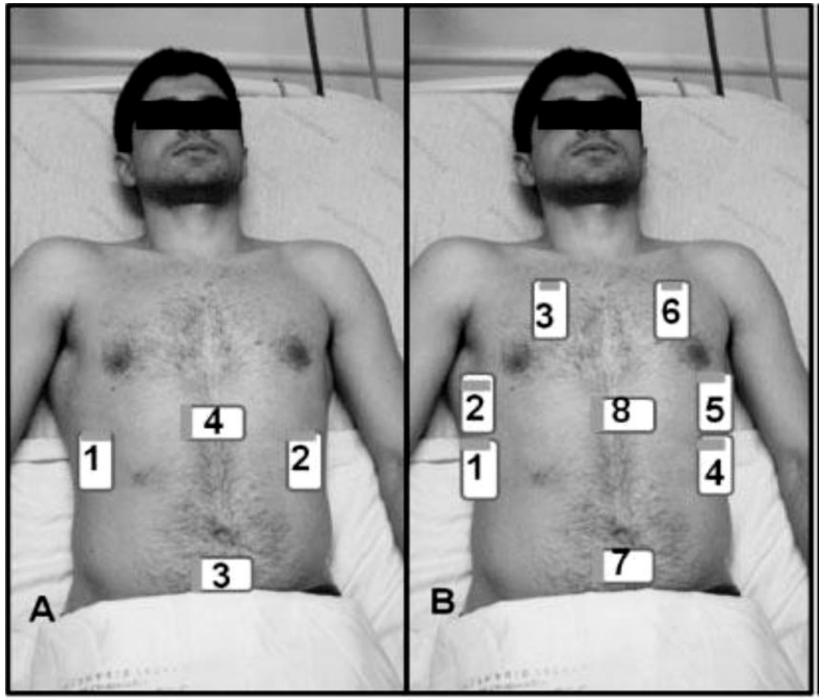
lung sliding:	☐ **present**	☐ **absent**	☐ **indeterminate**	
lung point sign:	☐ present	☐ absent	☐ indeterminate	
Interstitium:				
a-lines:	☐ present	☐ absent	☐ indeterminate	
b-lines:	☐ present	☐ absent	☐ indeterminate	
anterior/ superior region:	☐ present (greater than 3 per view)			☐ absent
inferior/ lateral region:	☐ present (greater than 3 per view)		☐ absent	
pleural effusion:	☐ **present**	☐ **absent**	☐ **indeterminate**	
If present:	☐ **small**	☐ **large**		
	☐ **anechoic**	☐ **complex**		
lung consolidation:	☐ present	☐ absent	☐ indeterminate	
air bronchograms:	☐ present	☐ absent	☐ indeterminate	
	☐ other: ______________________			

Emergency Ultrasound Standard Reporting Guidelines: Introduction and Statement of Purpose --- Developed by members of the ACEP Emergency Ultrasound Section

PNEUMOTHORAX EXAMINATION PROTOCOL

Adela Golea





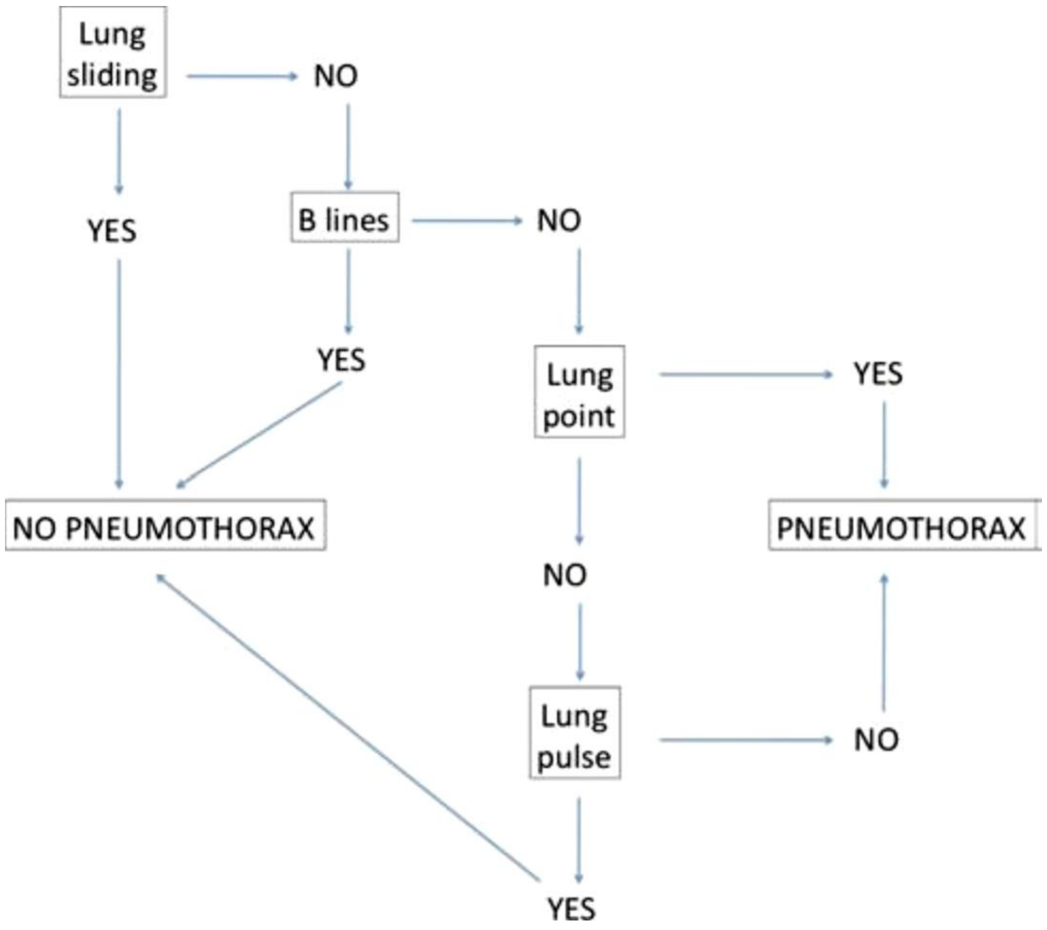
FAST - Focused Assessment with Sonography for Trauma; EFAST – Extended Focused Assessment with Sonography for Trauma.

Figure 2- FAST (A) and EFAST (B) anatomical references.

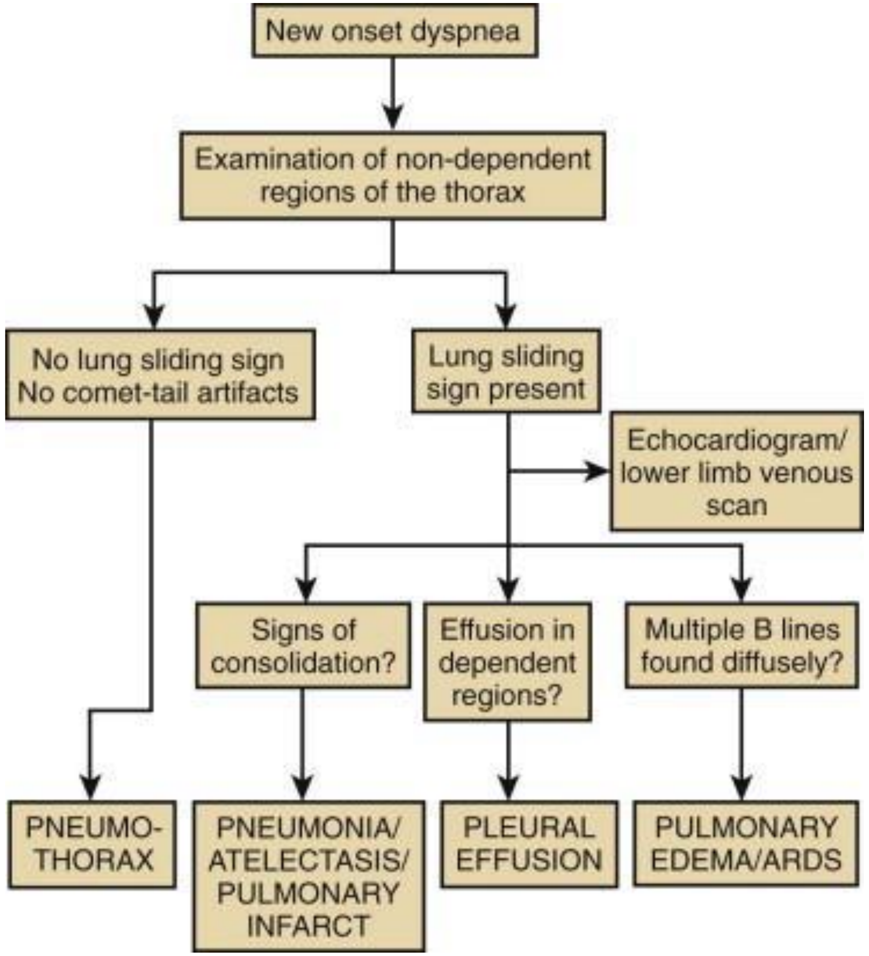
D. A. Lichtenstein, General Ultrasound in the critically ill, Springer 2002, 2010

ACUTE DYSPNEA

Adela Golea



ACUTE DYSPNEA
US EXAMINATION PROTOCOL
Adela Golea

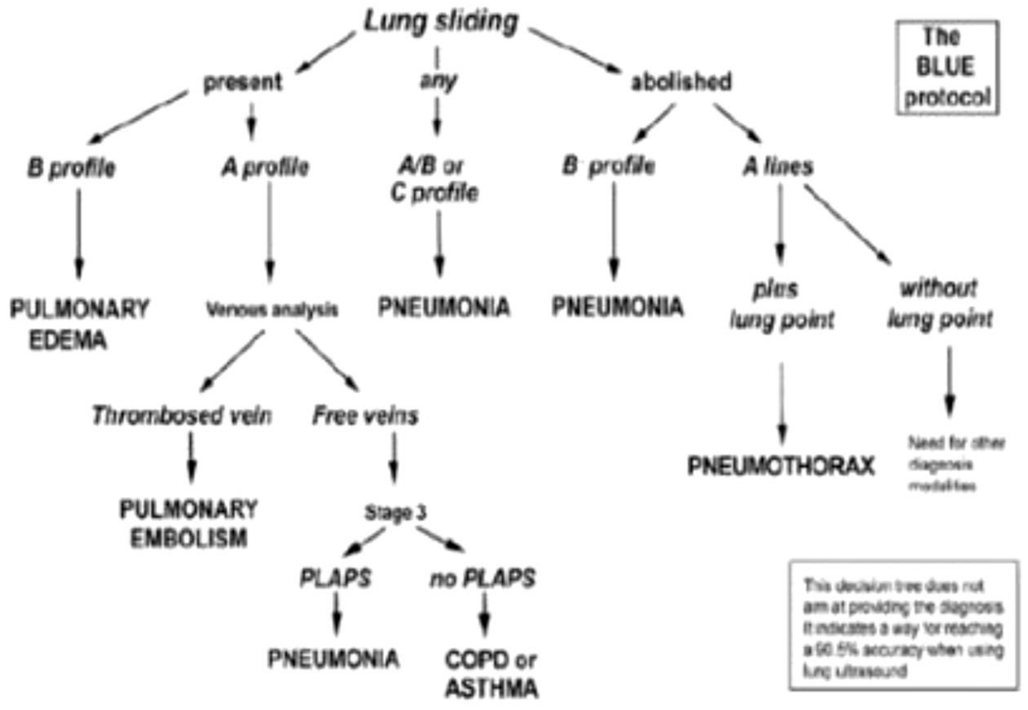


Mason: Murray and Nadel's Textbook of Respiratory Medicine, 5th ed., 2010

ACUTE DYSPNEA

US EXAMINATION

Adela Golea



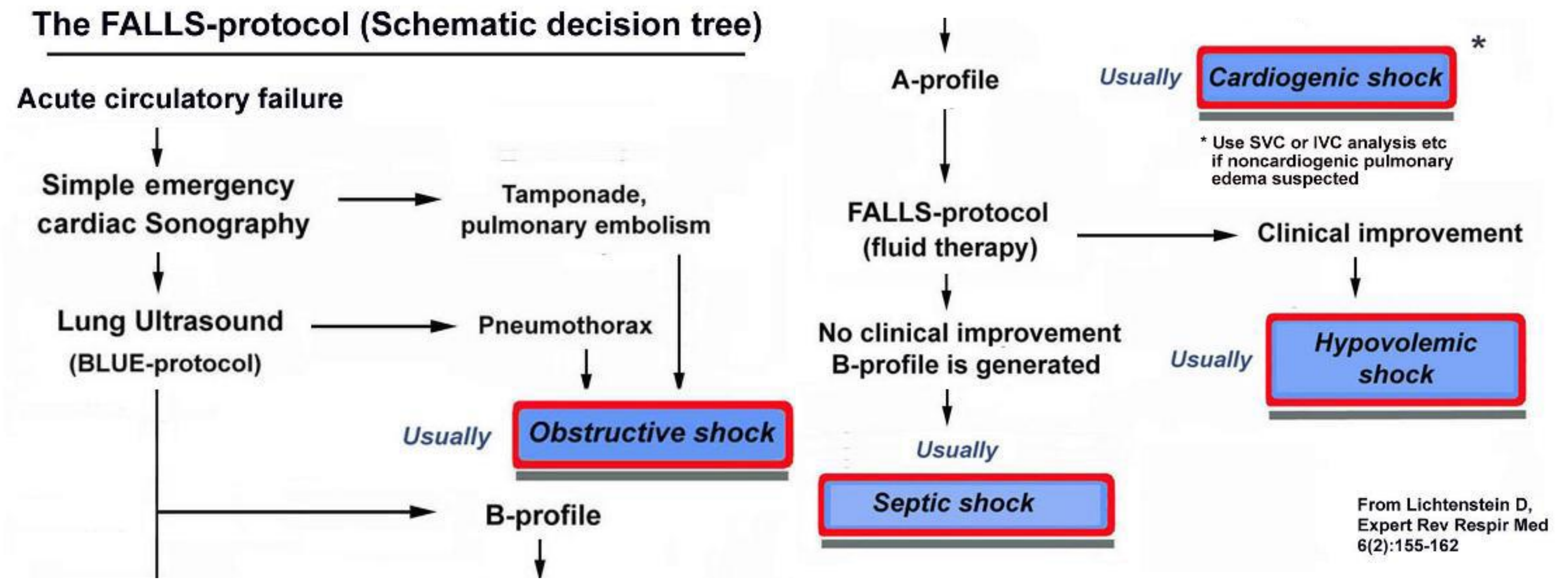
A profile means predominantly A lines
B profile means predominantly multiple anterior diffuse B lines
A / B profile means predominant A lines on one side and predominant B lines on the other side.
C profile means anterior alveolar consolidation(s)
PLAPS means ***posterolateral alveolar and/or pleural syndrome*** detected on a lateral sub-posterior sonological examination.

1) D. A. Relevance of Lung Ultrasound in respiratory failure the Blue Protocol. Lichtenstein at al chest July 2008 134: 117-125 2) Clinical Review: Bedside Lung Ultrasound in critical care. Bouhemad et al Critical care; 11(1):20.5 3) Real Time Chest Ultrasound S. Beckh et al Chest 2002:122;1759-73

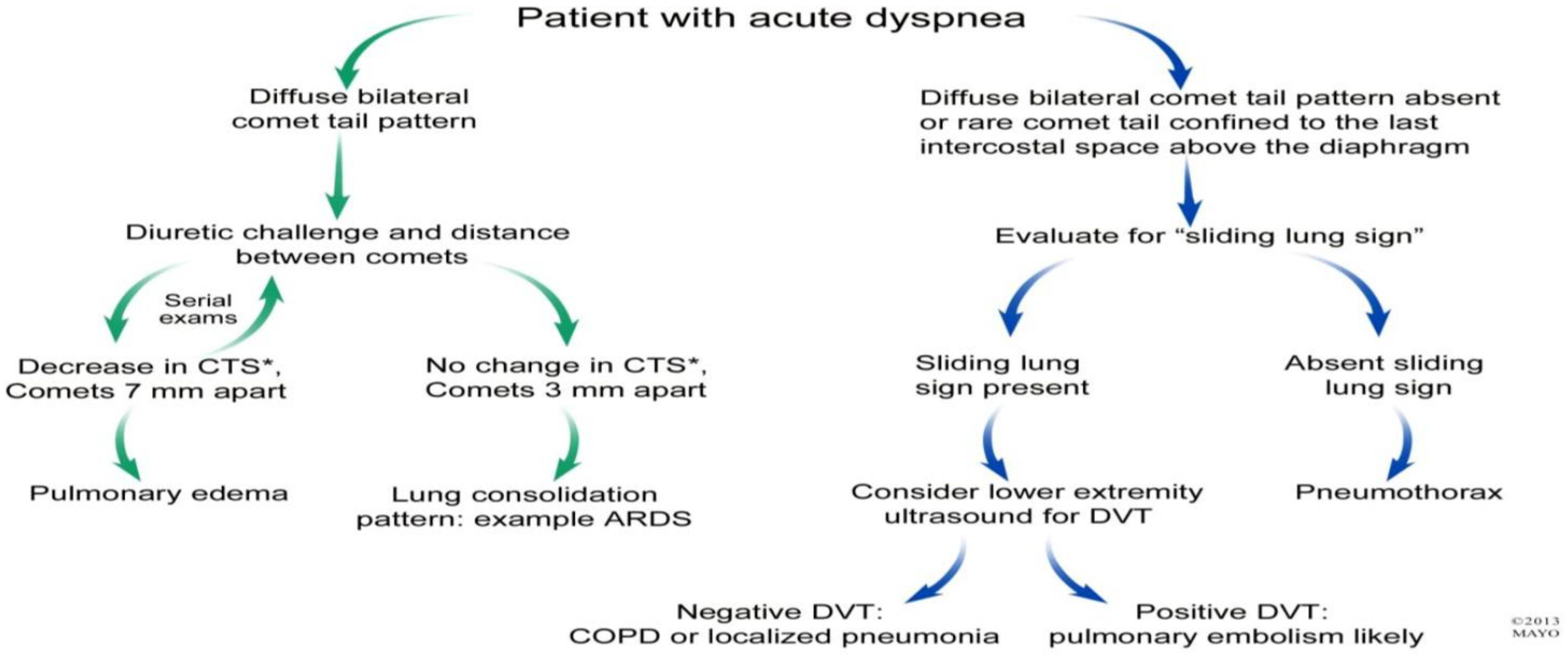
ACUTE DYSPNEA
US EXAMINATION
Adela Golea

	Acute Cardiogenic Pulmonary Edema	Chronic Heart Failure	ALI/ARDS	Pulmonary Fibrosis
Clinical Setting	Acute	Chronic	Acute	Chronic
B-lines Number	++++	+/++/+++	++++	+/++/+++
B-lines Distribution	Multiple, diffuse, bilateral (white lung)	Multiple, diffuse, bilateral following decubitant regions (black and white lung)	Non-homogenous distribution, presence of spared areas	More frequently posterior at lung basis
Other LUS signs	Pleural Effusion	Pleural Effusion	Pleural Effusion, pleural alterations, parenchymal consolidations of various size	Pleural thickening
Echocardiogram	Abnormal	Abnormal	Likely normal	Likely normal

Source: Cardiovascular US @1999-2011 BioMed Central Ltd



The FALLS-protocol (Schematic decision tree)
Acute circulatory failure
Simple emergency cardiac Sonography
Tamponade, pulmonary embolism
Lung Ultrasound (BLUE-protocol)
Pneumothorax
Usually
Obstructive shock
B-profile
A-profile
Usually
Cardiogenic shock
*
* Use SVC or IVC analysis etc if noncardiogenic pulmonary edema suspected
FALLS-protocol (fluid therapy)
Clinical improvement
No clinical improvement B-profile is generated
Usually
Hypovolemic shock
Usually
Septic shock
From Lichtenstein D, Expert Rev Respir Med 6(2):155-162


Patient with acute dyspnea
Diffuse bilateral comet tail pattern
Diuretic challenge and distance between comets
Serial exams
Decrease in CTS*, Comets 7 mm apart
Pulmonary edema
No change in CTS*, Comets 3 mm apart
Lung consolidation pattern: example ARDS
Diffuse bilateral comet tail pattern absent or rare comet tail confined to the last intercostal space above the diaphragm
Evaluate for "sliding lung sign"
Sliding lung sign present
Consider lower extremity ultrasound for DVT
Negative DVT: COPD or localized pneumonia
Positive DVT: pulmonary embolism likely
Absent sliding lung sign
Pneumothorax
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American Journal of Emergency Medicine (2008) 26, 585–591

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The American Journal of Emergency Medicine

www.elsevier.com/locate/ajem

Original Contribution

Bedside ultrasound of the lung for the monitoring of acute decompensated heart failure☆

Giovanni Volpicelli MD[a,*], Valeria Caramello MD[a], Luciano Cardinale MD[b], Alessandro Mussa MD[a], Fabrizio Bar MD[a], Mauro F. Frascisco MD[a]

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[b]Institute of Radiology, San Luigi Gonzaga Hospital, 10043 Orbassano, Torino, Italy

Table 3 Number of patients admitted for ADHF showing each clinical variable, at admission (phase 1) and control (phase 2) (n = 70)

Variables	Phase 1, n (%)	Phase 2, n (%)	*P* (*W*)
Lower extremity edema	35 (50)	2 (2.9)	<.001
Pulmonary rales/wheezing	59 (84)	3 (4.3)	<.001
Jugular venous distention	15 (21)	1 (1.4)	<.001
Orthopnea	63 (90)	3 (4.3)	<.001
High respiratory rate (>25 breaths per minute)	50 (71)	0	<.001
Low pulse oxymetric saturation (<90%)	44 (62)	3 (4.3)	<.001
NYHA class			
I	0	20 (28)	
II	1 (1.4)	42 (60)	
III	10 (14)	8 (11)	
IV	59 (84)	0	

Table 4 Positive ultrasound lung scans in the 11 individualizable thoracic areas at admission (phase 1) and control (phase 2) in 70 patients admitted for ADHF

Thoracic area	Phase 1[a]	Phase 2[a]	*P* (*W*)
Anterior superior right	51 (73%)	3 (4.3%)	<.001
Anterior medium right	54 (77%)	2 (2.9%)	<.001
Anterior basal right	65 (93%)	4 (5.7%)	<.001
Lateral superior right	64 (91%)	5 (7.1%)	<.001
Lateral medium right	67 (96%)	10 (14%)	<.001
Lateral basal right	68 (97%)	21 (30%)	<.001
Anterior superior left	52 (74%)	6 (8.6%)	<.001
Anterior medium left	58 (83%)	6 (8.6%)	<.001
Lateral superior left	63 (90%)	6 (8.6%)	<.001
Lateral medium left	70 (100%)	11 (16%)	<.001
Lateral basal left	70 (100%)	20 (29%)	<.001

[a] Data are presented as number of positive scans and percentage.

Table 5 Total score from each radiologic variable calculated at admission (phase 1) and after treatment (phase 2) in 70 patients admitted for ADHF

Variables	Phase 1	Phase 2	*P* (*W*)
Hilar vessels			
Enlarged	55	25	<.05
Increased in density	10	0	<.05
Blurred	105	12	<.05
Kerley lines			
A	72	8	<.05
B	148	24	<.05
C	12	8	NS
Micronoduli	12	16	NS
Widening of interlobar fissures	64	20	<.05
Peribronchial and perivascular cuffs	188	40	<.05
Extensive perihilar haze	80	12	<.05
Subpleural effusion	120	35	<.05
Diffuse increase in density	45	10	NS

Intern Emerg Med (2012) 7:65–70
DOI 10.1007/s11739-011-0709-1

EM - ORIGINAL

Diagnostic accuracy and reproducibility of pleural and lung ultrasound in discriminating cardiogenic causes of acute dyspnea in the Emergency Department

Gian Alfonso Cibinel · Giovanna Casoli · Fabrizio Elia · Monica Padoan · Emanuele Pivetta · Enrico Lupia · Alberto Goffi

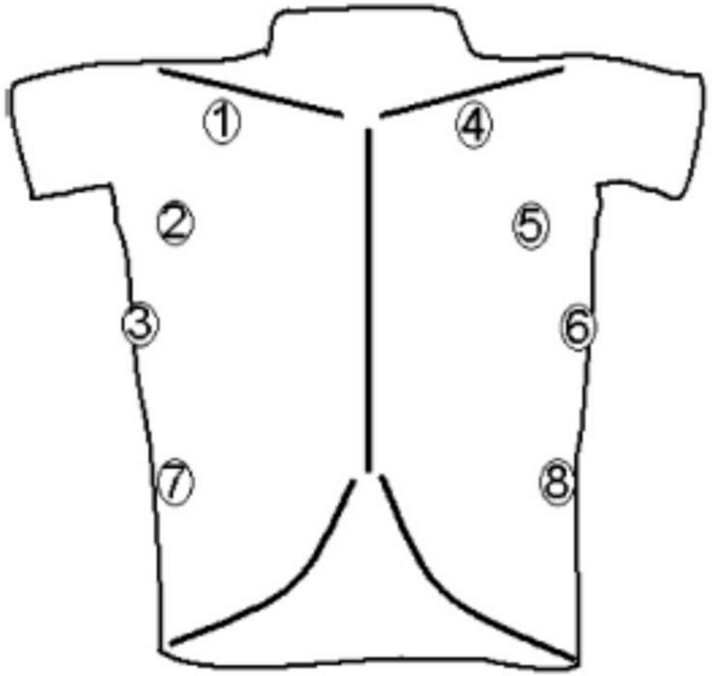
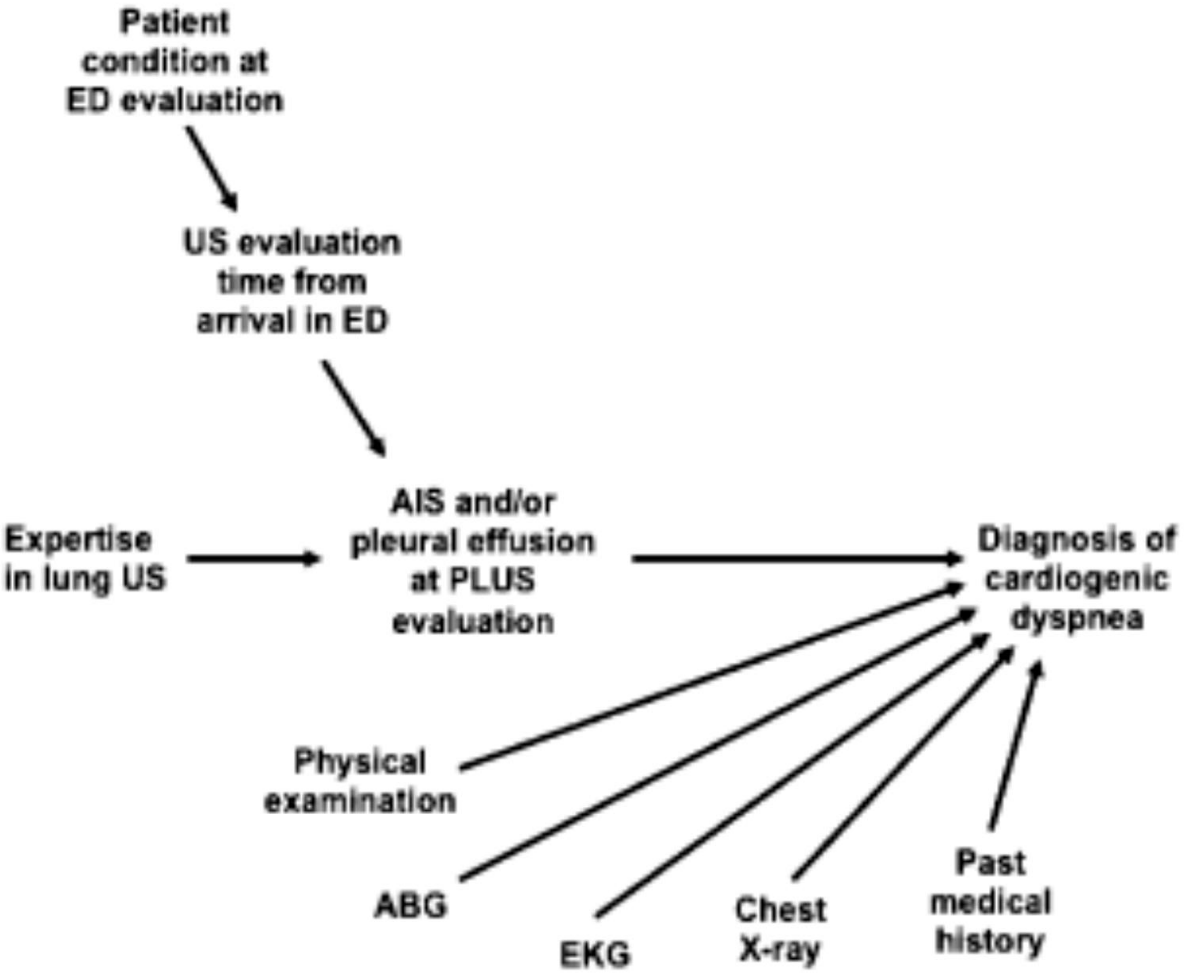
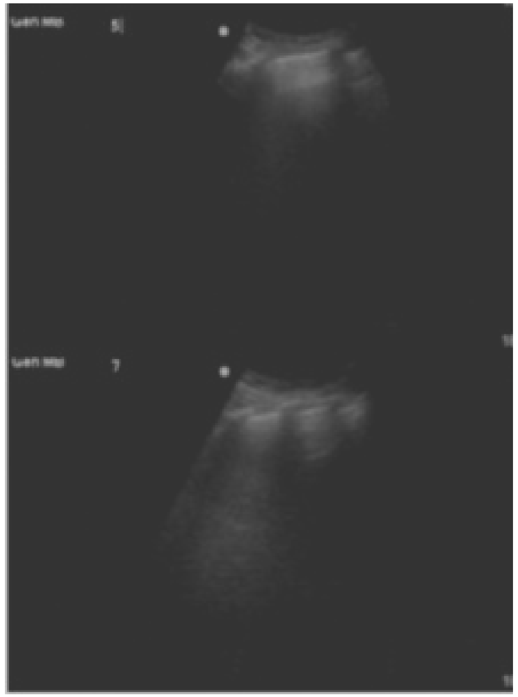
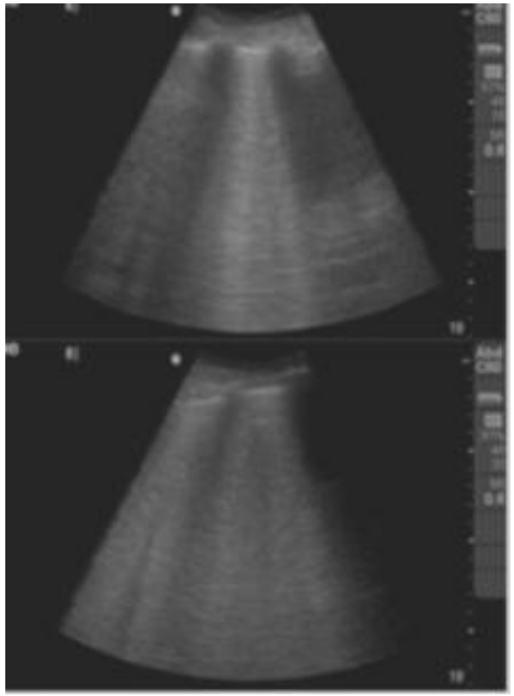


Fig. 2 PLUS scanning scheme, adapted from Volpicelli et al. [6]. The chest wall was divided in four areas for each side. Two areas were localized anteriorly in the 2° intercostal space on the hemiclavicular line (scan 1 and 4, respectively, for right and left side) and the 4° intercostal space on the hemiclavicular line (scan 2 and 5, respectively); one area was localized laterally in the 5° intercostal space on the medium axillary line (scan 3 and 6, respectively); a further area was localized basally on the posterior axillary line (scan 7 and 8, respectively)


Patient condition at ED evaluation
US evaluation time from arrival in ED
Expertise in lung US
AIS and/or pleural effusion at PLUS evaluation
Diagnosis of cardiogenic dyspnea
Physical examination
ABG
EKG
Chest X-ray
Past medical history



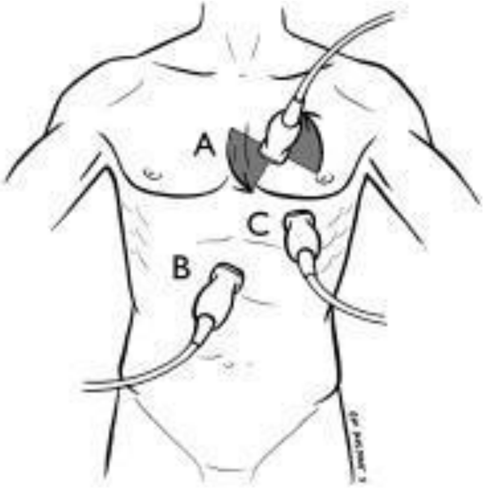


RUSH Protocol (pump, VCI, AA)

A) Parasternal Views
Long / Short Axis

B) Subxiphoid View

C) Apical View



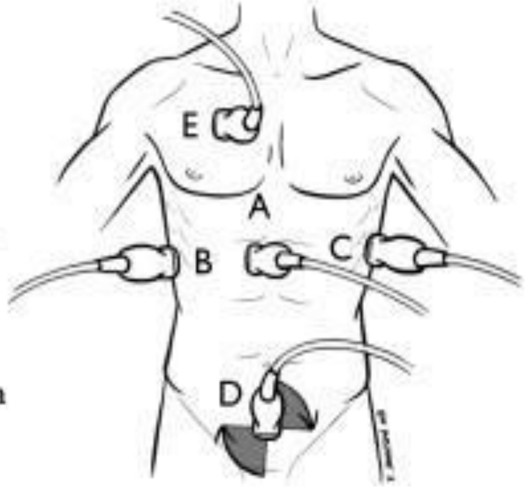
A) IVC Long Axis

B) FAST / RUQ
Add Pleural View

C) FAST / LUQ
Add Pleural View

D) FAST / Pelvis

E) Pneumothorax
Pulmonary Edema



A) Suprasternal Aorta

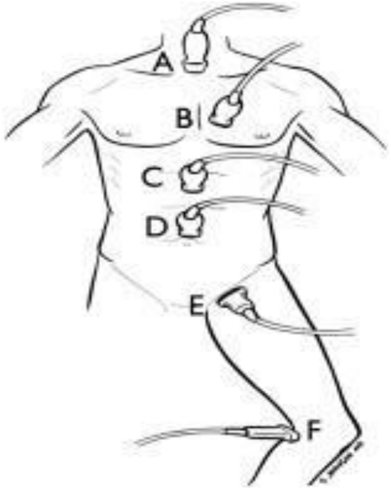
B) Parasternal Aorta

C) Epigastric Aorta

D) Supraumbilical Aorta

E) Femoral DVT

F) Popliteal DVT



The RUSH Exam: Rapid Ultrasound in SHock in the Evaluation of the Critically Ill
Emergency Medicine Clinics of North America - Volume 28, Issue 1
(February 2010)

The Journal of Emergency Medicine, Vol. ■, No. ■, pp. 1–8, 201
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Printed in the US
0736-4679/$ - see front matt
doi:10.1016/j.jemermed.2012.02.032

Ultrasound in Emergency Medicine

A PILOT STUDY EXAMINING THE VIABILITY OF A PREHOSPITAL ASSESSMENT WITH ULTRASOUND FOR EMERGENCIES (PAUSE) PROTOCOL

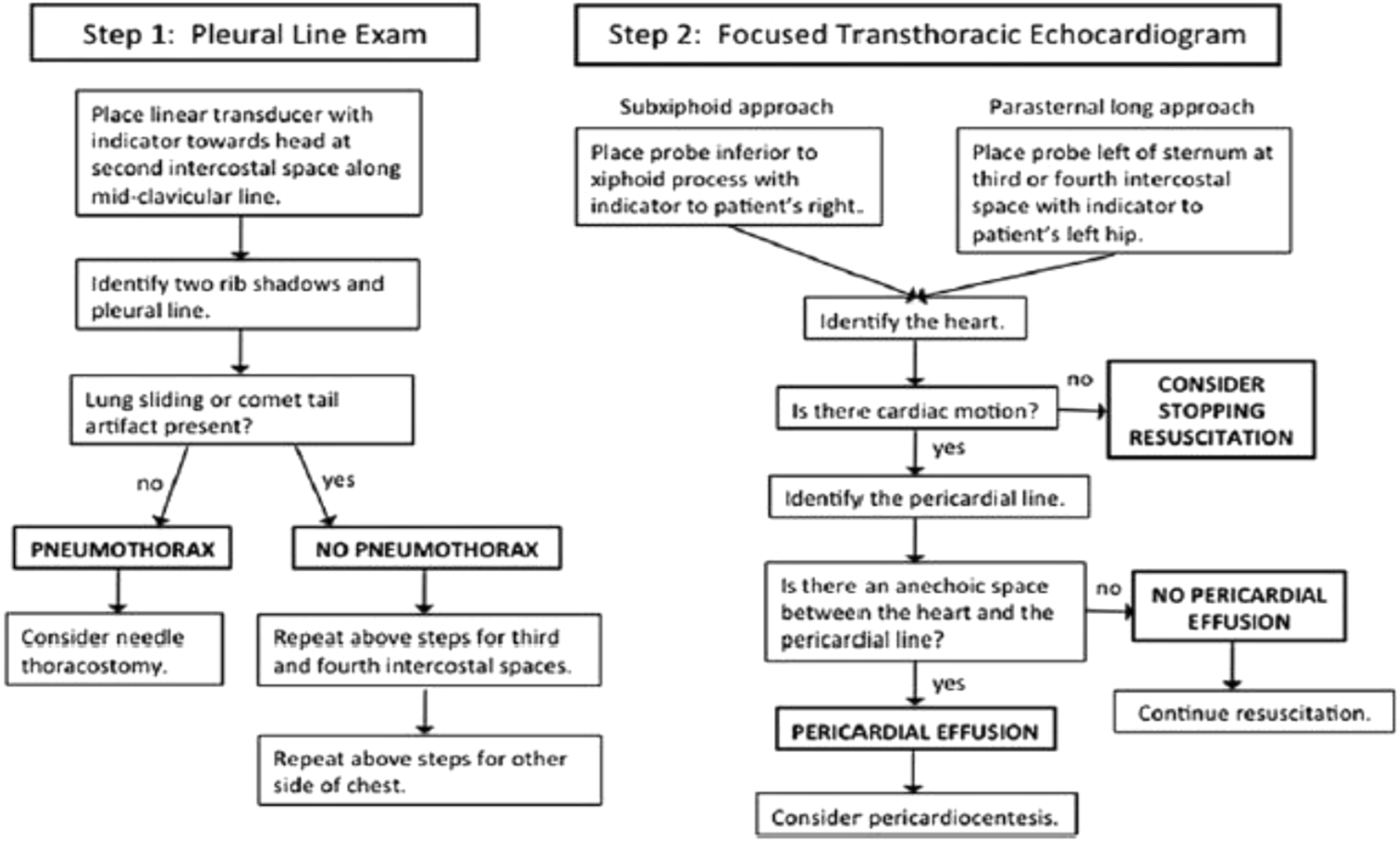
Eric J. Chin, MD,* Connie H. Chan, MD,† Rod Mortazavi, BS,† Craig L. Anderson, PHD,†
Christopher A. Kahn, MD, MPH, RDMS,† Shane Summers, MD, RDMS,* and J. Christian Fox, MD, RDMS†

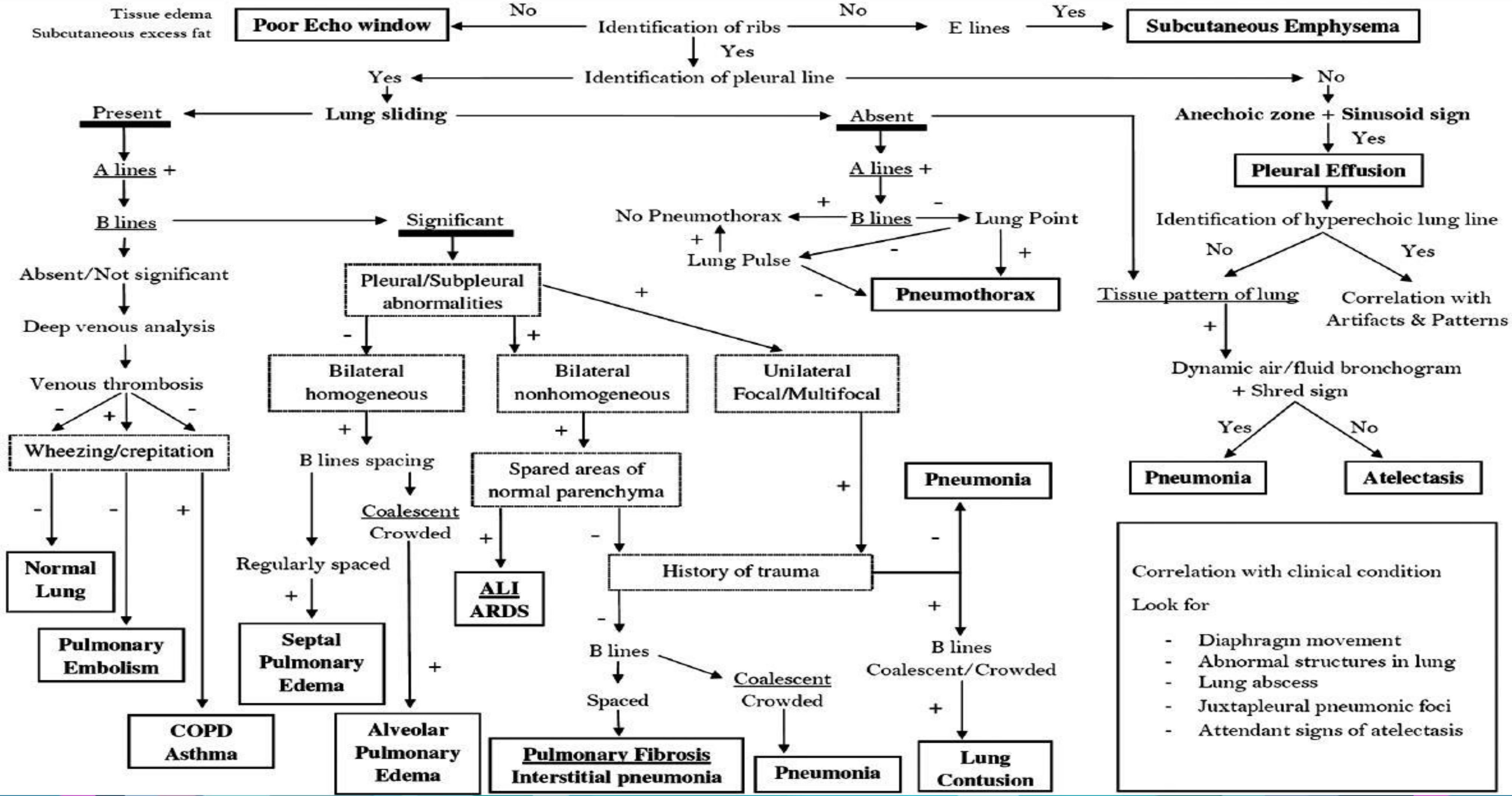
Inclusion criteria:

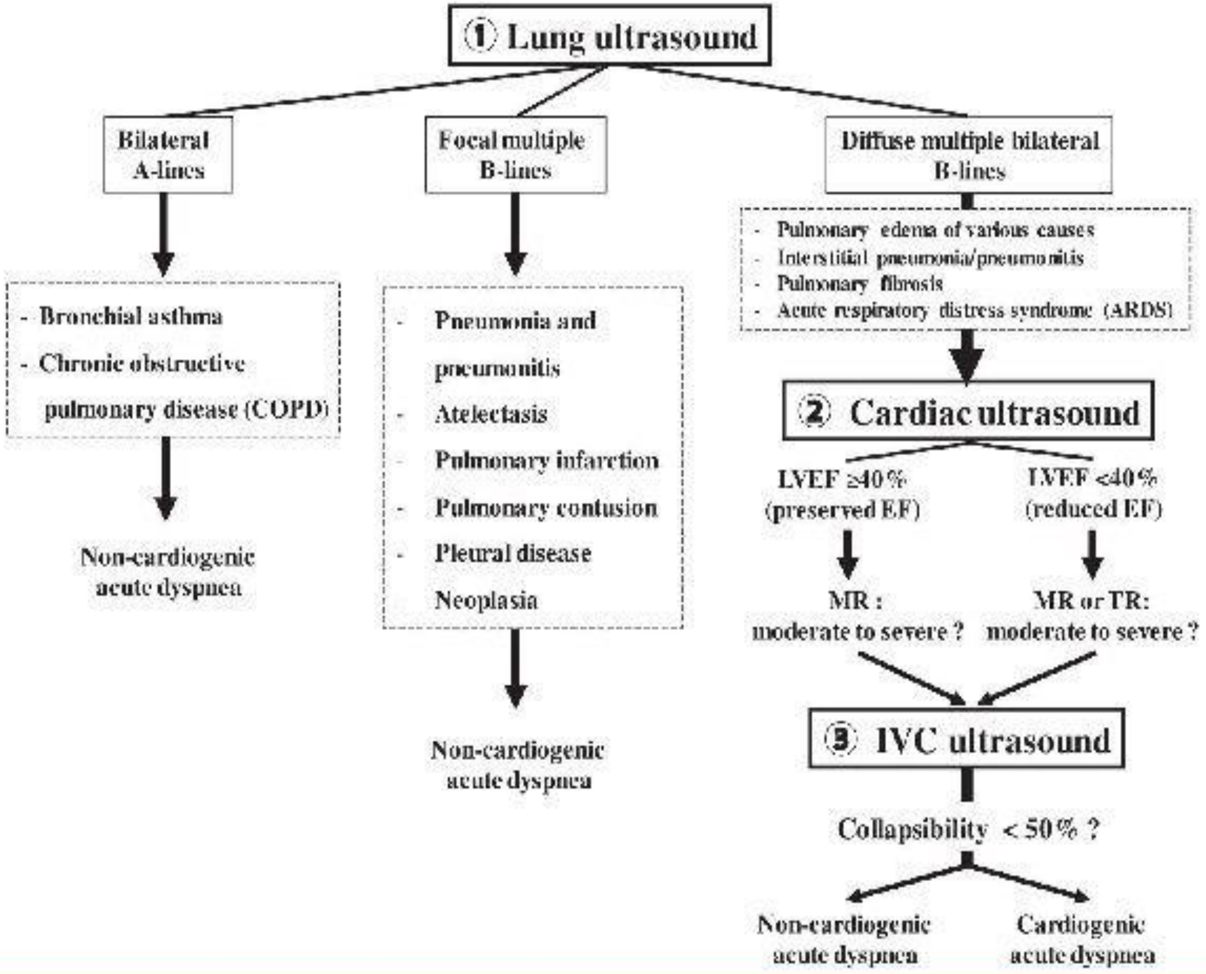
- Critically ill trauma patients;
- Symptomatic Penetrating Trauma Patients;
- Severe Respiratory Distress;
- Traumatic and Medical cardiac arrest patients.

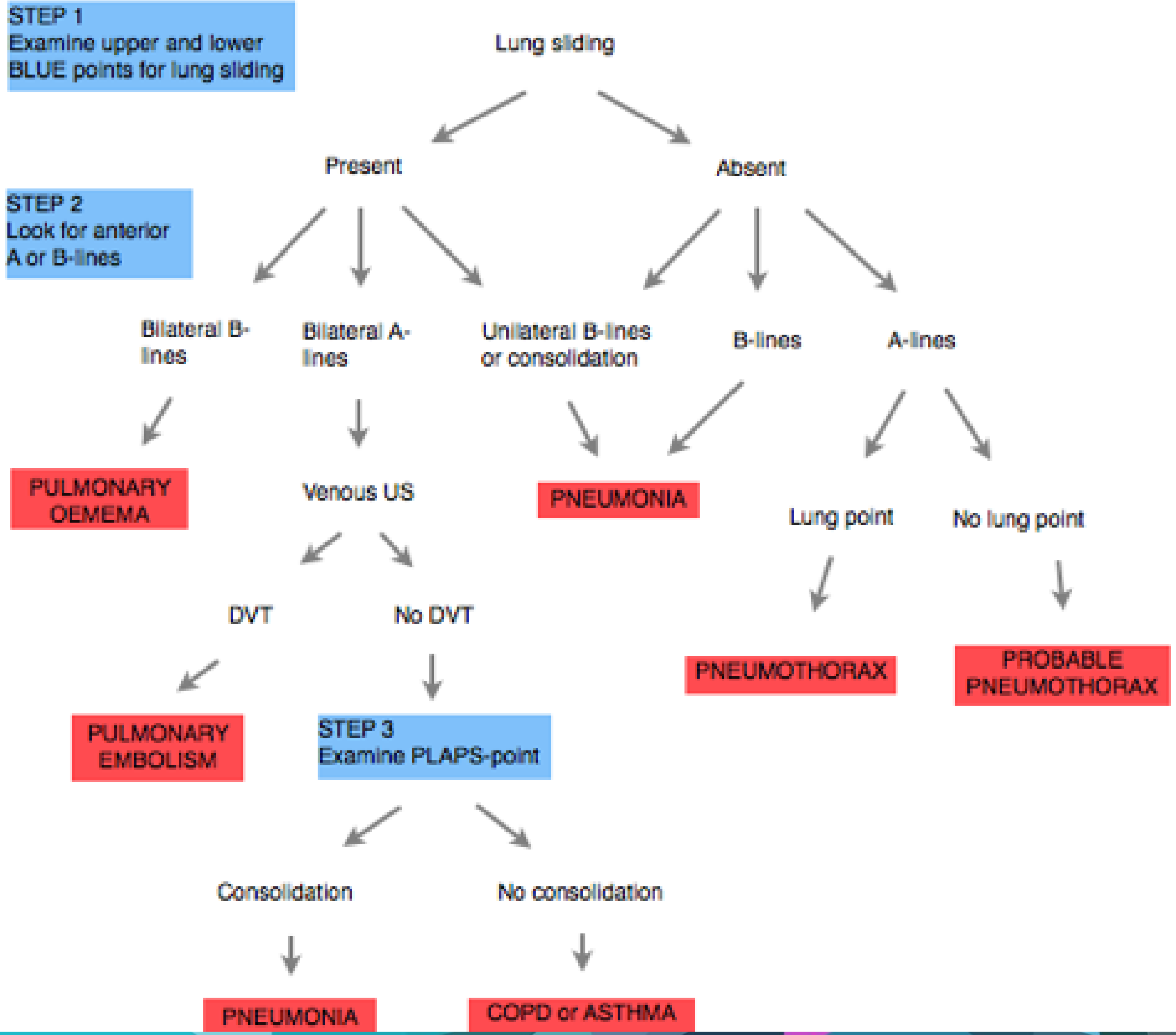
Exclusion criteria:

- Asymptomatic Patients.




Tissue edema
Subcutaneous excess fat
Poor Echo window
No
Identification of ribs
No
E lines
Yes
Subcutaneous Emphysema
Yes
Yes
Identification of pleural line
No
Present
Lung sliding
Absent
Anechoic zone + Sinusoid sign
Yes
Pleural Effusion
A lines +
A lines +
B lines
Significant
No Pneumothorax
B lines
Lung Point
Identification of hyperechoic lung line
No
Yes
Lung Pulse
Absent/Not significant
Pleural/Subpleural abnormalities
Pneumothorax
Tissue pattern of lung
Correlation with Artifacts & Patterns
Deep venous analysis
Dynamic air/fluid bronchogram
+ Shred sign
Venous thrombosis
Bilateral homogeneous
Bilateral nonhomogeneous
Unilateral Focal/Multifocal
Yes
No
Wheezing/crepitation
B lines spacing
Spared areas of normal parenchyma
Pneumonia
Pneumonia
Atelectasis
Coalescent
Crowded
Normal Lung
Regularly spaced
ALI
ARDS
History of trauma
Correlation with clinical condition
Look for
- Diaphragm movement
- Abnormal structures in lung
- Lung abscess
- Juxtapleural pneumonic foci
- Attendant signs of atelectasis
Pulmonary Embolism
Septal Pulmonary Edema
B lines
B lines
Coalescent/Crowded
Spaced
Coalescent
Crowded
COPD
Asthma
Alveolar Pulmonary Edema
Pulmonary Fibrosis
Interstitial pneumonia
Pneumonia
Lung Contusion


① Lung ultrasound
Bilateral A-lines
Focal multiple B-lines
Diffuse multiple bilateral B-lines
- Bronchial asthma
- Chronic obstructive pulmonary disease (COPD)
Non-cardiogenic acute dyspnea
- Pneumonia and pneumonitis
- Atelectasis
- Pulmonary infarction
- Pulmonary contusion
- Pleural disease
Neoplasia
Non-cardiogenic acute dyspnea
- Pulmonary edema of various causes
- Interstitial pneumonia/pneumonitis
- Pulmonary fibrosis
- Acute respiratory distress syndrome (ARDS)
② Cardiac ultrasound
LVEF ≥40% (preserved EF)
LVEF <40% (reduced EF)
MR : moderate to severe ?
MR or TR: moderate to severe ?
③ IVC ultrasound
Collapsibility < 50% ?
Non-cardiogenic acute dyspnea
Cardiogenic acute dyspnea


STEP 1
Examine upper and lower BLUE points for lung sliding
Lung sliding
Present
Absent
STEP 2
Look for anterior A or B-lines
Bilateral B-lines
Bilateral A-lines
Unilateral B-lines or consolidation
B-lines
A-lines
PULMONARY OEMEMA
Venous US
PNEUMONIA
Lung point
No lung point
DVT
No DVT
PNEUMOTHORAX
PROBABLE PNEUMOTHORAX
PULMONARY EMBOLISM
STEP 3
Examine PLAPS-point
Consolidation
No consolidation
PNEUMONIA
COPD or ASTHMA