Imaging of Respiratory Disorders: M2 Pathology correlated with Radiology

by

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This material has been prepared as reference material for an undergraduate lecture at the Yong Loo Lin School of Medicine, Singapore; and should used as reference material as part of a professional training program.

eLecture website link

(e)Lecture Outline

Section 1: Introduction
and
Pre-lecture reflection questions / recall and review if necessary Y1 material

Section 2: Learning objectives

Section 3: Pre-test

Section 4: Lecture proper

Part 1 - review of basic principles of CXR production and tissue characterization

Part 2 - review of the CXR findings in six major diseases

Section 5: Post-test
Section 1: Introduction

Let's start by revising what we have covered last year. This exercise to recall what you know follows recommendations from the educational literature on how to promote learning. By first revisiting, reviewing and recalling what has been learnt previously. The process of recalling information provides the foundation for new learning. Learning something new is built on a foundation of prior knowledge. Repetition, review and recall promotes learning.

Please reflect on each of the following questions, pause after each question, write down your answer, and reflect upon your answer.

1. What is the relevance of diagnostic imaging/radiology in your future clinical practice?

2. How are CXRs and CT scans of the chest produced?

3. How do different tissues appear on CXRs and CT scans? Why does bone appear white? Air black? Soft tissues varying shades of grey?

4. Can you identify normal anatomy on a CXR? CT scan of the chest?

5. Do you know where to find the lecture material on this topic presented in Year 1?

If you are unsure of the answer to any of these questions, please revisit and review the relevant sections in the Y1 lecture and interactive eLecture on the websites below.

http://learningchestradiology.blogspot.sg/2013/10/the-chest-radiograph.html
(Revision - Y1 radiology anatomy correlation lecture website address above)

http://radiologymasterclass.co.uk/tutorials/chest/chest_home_anatomy/chest_anatomy_start.html
(Revision - CXR anatomy, Interactive radiology masterclass/tutorial website address above)
Section 2 : Learning objectives of this (e)Lecture

Recall that radiology allows you (as future doctors), to see "living" anatomy, and "in vivo" pathology.

This ability to visualise what is going on in the patient in front of you, in both health and disease will be a useful diagnostic tool for you as doctors.

The easiest way to make sense of what you see on a radiology examination is to recall what you have been exposed to and learnt recently in gross pathology.

For those of you who are focused on more immediate concerns, the assessment items on radiology that you will be faced with will evaluate your ability to recognise major examples of pathology on common radiological examinations. For example on the chest radiograph or CXR.

To review again the learning objectives of the undergraduate radiology program in the medical curriculum, you can see how radiology translates what you have learnt in Y1 anatomy, to give you the ability to see "in vivo" living anatomy in your future patients.

And visualise in vivo pathology in your patients.
Section 3 : Pre-test

Let's do an assessment exercise now to not only show you what potential future examination assessment items might be, but also to illustrate how radiology (on the following CXRs) allows you to visualise gross pathology in your patient.

Please try and match the five diagnoses (A to E) with the CXRs provided (1 to 6). There are two examples on the CXRs provided of one of the five diagnoses.

This exercise begins the process to introducing you to the typical appearance of common and important clinical problems that your patient may present with.
Section 4: (e)Lecture proper

We will focus on two major areas. Firstly review basic principles of CXR production and interpretation. And then review the key features of six major clinical problems on CXRs.

We first very briefly review basic principles behind the production of a CXR, and why different tissues have different densities on XRs (white, shades of grey, and black).

Recall that XRs are produced by placing you patient between an XR source, and a recording medium; which may be an XR film, or digital recording plate. The XR is therefore a record of the absorption of XRs as they pass through different organs and tissues in your patient.

By convention, on a XR, black represents areas of greatest XR absorption, and white the least absorption of XRs. On this normal CXR, you can see the radiographic densities of five categories of tissue. Air being blackest, with gradually lighter shades of grey with fat, soft tissue/blood/muscle, bone and metal. You will appreciate how fat being less dense than soft tissue will absorb less XRs, and appear a darker shade of grey than soft tissues or muscle.
This difference in XR absorption between different tissues and organs allows you to distinguish the edge or surface between different tissue layers and organs. Because XRs travel in straight lines through your patient, the interface between different tissues is highlighted and visible at tissue interfaces tangential to the path of the XR beam. This is referred to as the "silhouette sign". A simple analogy helps you visualize this is to recall the silhouette of an object looks like when placed between a candle or light source and a background surface. The edge of the projected "shadow" is the silhouette making the edge between absorbed and transmitted light.
We use the silhouette phenomenon on a CXR to detect the edge between the normal left heart border, and adjacent aerated normal lung which contains air. We also use this to see the normal lung markings, due to difference in XR absorption between the blood within the pulmonary vessels and the adjacent normal lung. In disease, when the alveoli or air spaces in the lung are filled with fluid, blood or pus, we lose the ability to see these edges, allowing us to infer that the air spaces in the lung are not aerated or air filled.

Finally, an appreciation of the geometry of the XR beam passing through your patient allows you to understand how the heart, which you recall lies anteriorly on the front of the chest cavity is less magnified on a PA (posterior anterior) CXR, where the beam passes from back to front of the patient, compared to an AP (anterior posterior) CXR. Because patients have different chest front to back thicknesses, an AP film does not give you a good estimate of the transverse width of the heart, compared with the internal side to side chest diameter. The ratio of the widest side to side width of the heart divided by internal chest diameter (widest at that level) should be less than 50% in patients who do not have cardiomegaly; and is more reliably assessed on PA rather than AP CXRs, since we are not able to appreciate the front to back diameter of patients on CXRs; and cannot correct for this magnification factor when viewing AP CXRs.
We will now focus on the key radiological features of a few major disease categories on the CXR.

These 6 diseases are not only common, but need to be recognised quickly, accurately and confidently by you as future doctors in the EMD, wards and clinics; as your patient may require urgent treatment.

This is also why testing your ability to recognise these diseases on radiological examinations will take place not only in the radiology section of the examination, but radiology images will also be shown to you as part of the work up and assessment of your patients.

In this second major section of the (e)Lecture, we will review six major diseases and their CXR findings. Please review the description of the key features of each disease, and then a typical CXR of each disease.

**Pneumothorax**

A pneumothorax is an abnormal collection of air in the pleural space.

- Detected as an opacity (nearly) collection between chest wall/mediastinum and visceral pleural surface of the adjacent lung.
- May be area spontaneously from the rupture of a visceral pleural bleb. May be associated with pleural effusion or effusion, or be associated with complicated subcutaneous
  - Pneumothorax, both chest fractures
- A “tension” pneumothorax, associated with shift of mediastinal structures and depression of the diaphragm requires urgent action – insertion of a chest tube.

*Pneumothorax video mp4 format link*
Pleural effusion

- A pleural effusion is an abnormal collection of fluid in the pleural space.
- Detected as area of fluid/soft tissue density layering between the chest wall/mediastinum and adjacent lung/visceral pleural edge.
- May be loculated in the fissures or against the chest wall.
- May be transudates associated commonly with cardiac failure/liver failure/renal failure, or exudates associated with adjacent pneumonia, tumours (lung parenchymal or pleural), or lung contusions/injuries/rib fractures (hemothorax).

Pleural effusion video mp4 format link
Rib fractures

- Best way to evaluate the ribs is to look from top to down, evaluate posterior ribs, lateral ribs, then anterior ribs
- Look for interruption in the continuity of the cortical surfaces of the ribs

Rib fractures video mp4 format link
Pneumonia

Pneumonia

- Pathologically involves inflammatory exudate filling the alveolar spaces of the lung parenchyma
- Characterized radiologically by poorly defined soft tissue density opacities, unless the pleuropneumonic process abuts the pleural wall.
- May appear as "ill defined opacities" or "bloody streaking" or "arborization"
- Loss of aerated lung parenchymal markings (may see these normally due to the surrounding aerated lung parenchyma)
- The larger branches if they remain aerated will also be branching lobe structures within the consolidated lung – "air bronchograms"
- Pus, fluid, expected contained, blood to turk test (light the lesion) appear similar in areas of consolidation – use the clinical context and associated radiological signs to help make a definitive diagnosis.

Pnemonia video mp4 format link

Follow up sequential CXRs below show resolution of pneumonia with appropriate antibiotic treatment.
Lung mass

Pulmonary mass

- Common causes are granulomas, primary lung carcinoma or metastases
- Tumors growth is progressive from single focus giving rise to spherical or irregular masses generally with well defined margins (surrounding lung parenchyma is usually normally aerated unless there is associated consolidation, atelectasis or peritumoral hemorrhage).
- In contrast, areas of "round" pneumonia generally have poorly defined margins unless abutting a pleural surface, mediastinum or diaphragm.

Lung mass video mp4 format link
Cardiac Failure with pulmonary oedema

Cardiac failure

- CXR signs include cardiomegaly, prominent interstitial markings, lung consolidation and pleural effusions.
- The horizontal width of the heart should be 50% or less of the inter width of the bony chest wall at the level of the diaphragm.
- The appearance of pleural effusions and lung consolidation have been discussed earlier.
- Interstitial pulmonary oedema manifests as blurring of the appearance of the pulmonary vessels, and the presence of non-branching septal lines, often radiating from the hilum or subpleural in location.

Cardiac failure video mp4 format link

Example of interstitial pulmonary oedema before and after diuretic therapy.
Section 5 : Answers to the pre-test

We conclude this (e)Lecture by revisiting the quiz presented to you at the beginning of this lecture. The answers should be quite obvious to you after this presentation, and are given on the single slide below. Please review the content of this lecture again, focusing on any area you might be unsure about. Please post any questions you might also have on the padlet digital wall below and you classmates are invited to discuss each question with you on the digital wall before the lecture. I will address these questions both live during the lecture, as well as on the digital wall.

http://padlet.com/dnrgohps/cxrY2pathology
(Padlet digital wall website address)

Thank you.