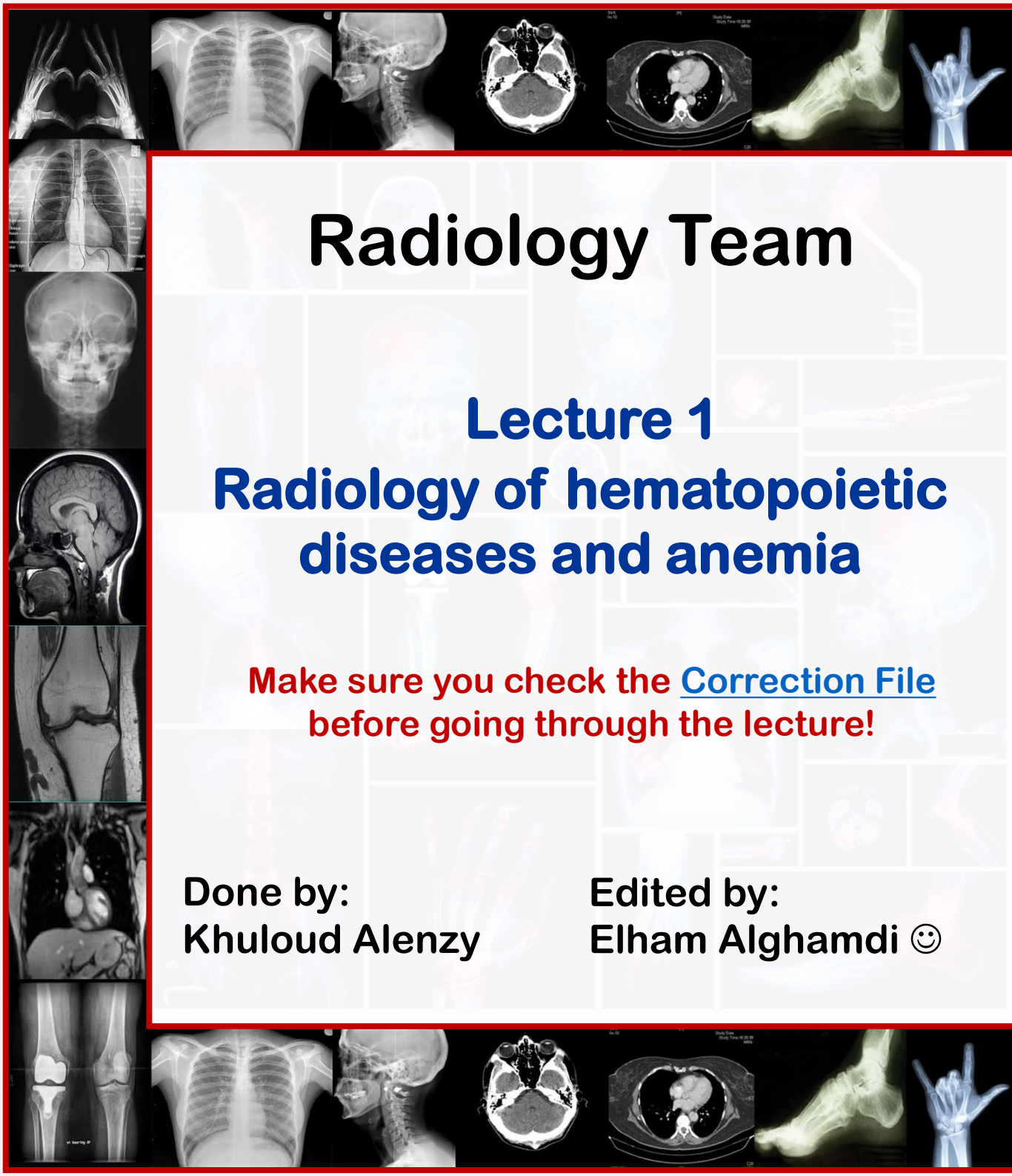
جامعة الملك سعود
King Saud University
1957

RADIOLOGY TEAM 434



Radiology Team

Lecture 1
Radiology of hematopoietic diseases and anemia

Make sure you check the Correction File before going through the lecture!

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Color Index:

• Important • notes • Explanations

introduction

When talking about Hematopoietic diseases, there are many to talk about (e.g. RBCs (Hb) problems (anemia or polycythemia) WBCs problems (lymphomas and multiple myeloma) and finally if platelets or plasma get affected, either bleeding or clotting is going to result), However, from a radiology point of view, we're concerned with the diseases that can be signified on radiology pictures.

Not all types of anemia are significant radiologically, (iron-deficiency anemia and anemia of chronic diseases can NOT be pointed at by imaging, only Thalassemia and sickle cell anemia are!, because of their indicative signs they have on different imaging modalities)

The red topics will be covered clearly by the end of this lecture, Hopefully ☺

Anaemia

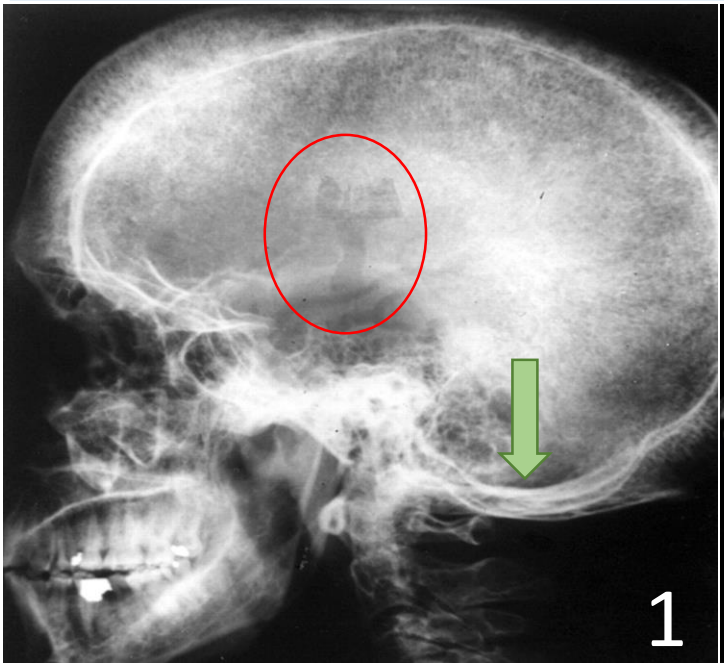
Normal body reaction to chronic anemias (in order to over-counter the deficiencies):

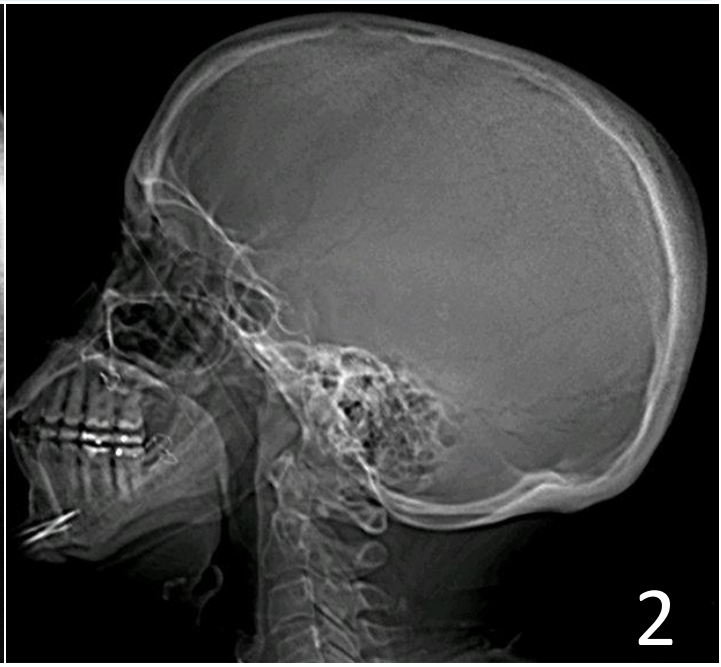
1- at early stages: Reactive increase in red bone marrow (intra-medullary hematopoiesis):
Expanded bone marrow in bones including long bones of hands, feet, limbs, skull Decreased T1 MRI signal in vertebral body bone marrow than adjacent discs (red marrow exceeds the fatty one, and fat is T1 signaled on MRI, meaning that in T1 MRI image, fat appears bright, in this case fatty marrow is replaced by red marrow, so less fat is signaled vertebral bodies,> decreased brightness!)

2-in late stages: New marrow areas in potential organs (extra-medullary hematopoiesis):
Liver, Spleen, Lymph nodes, Thymus, Paraspinal areas with possible extension into spinal canal outside the dura,
Kidneys, Meninges, Skin (these organs have an unusual ability to produce bone marrow when extreme anemias are over-encountered)

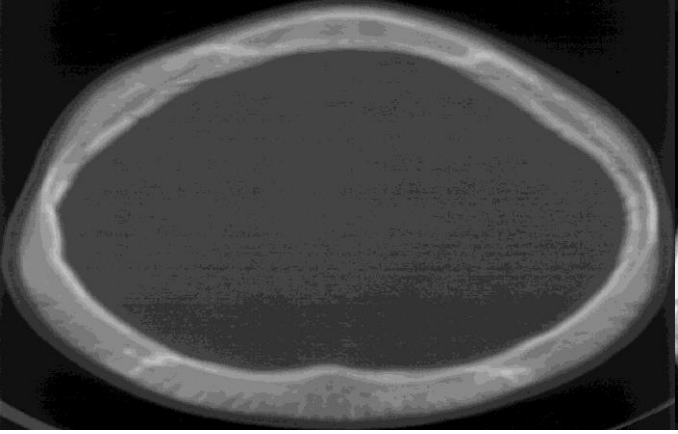
3- some types of chronic anemia are sometimes treated by repeated Blood transfusion, resulting the so-called transfusion iron-overload (treatment-related anemia):
Increased CT density (brightness) and changes in MRI signal of liver & spleen.
Note: anemia has to be long-standing and severely enough, for these changes to occur.
Other than these signs above Sickle Cell Anemia has its own clinical symptoms, such as:
1-infarcts: in Spleen (most common; resulting in the so-called: auto-spleenectomy), Kidneys, Brain and Bones.
2-Infections: Pneumonias, Osteomyelitis (the spleen has an immune functions, in SCA, capsulated bacteria bypass the spleen immune response because of the auot-spleenectomy)

1-Decreased bone density with coarse trabeculae Wide medullary cavity with thin cortex (Severe chronic anemia)
2-Normal for comparison

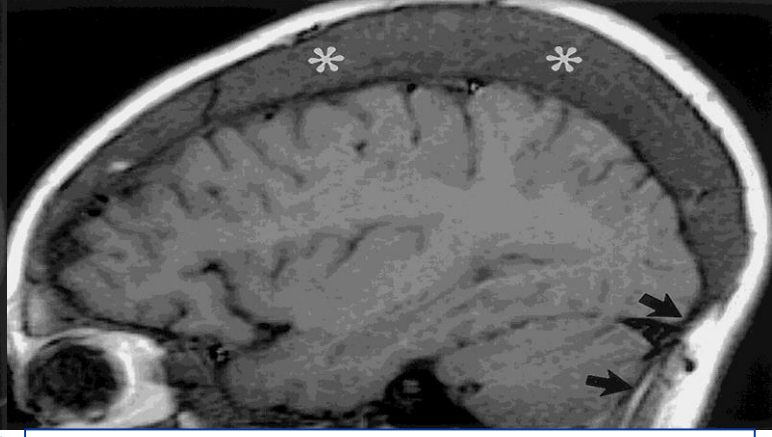




Lateral skull radiographs showing:
1-expansion of diploic space with hair-on-end appearance, widened groove for middle meningeal artery (circle) (in order to increase blood supply to bone marrow) with spared occipital bone (arrow) (this occipital sparing differentiates anaemia from skeletal diseases or hyperparathyroidism), (Severe chronic anemia)
2-Normal for comparison
Important note:
These radiographs are for a known pt. with thalassemia, However, you never differentiate causes of anemia radiologically, unless labs and blood smear results are provided!! What you see in these pics. Are only indicative of severe chronic anemia!

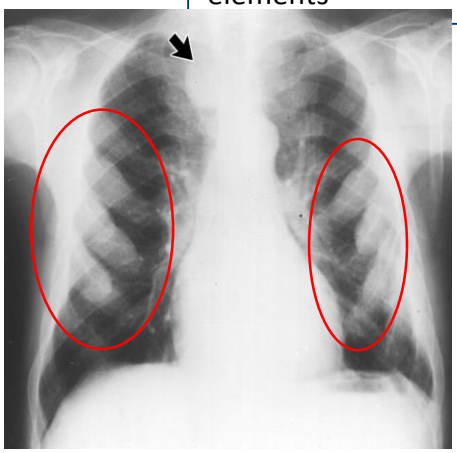


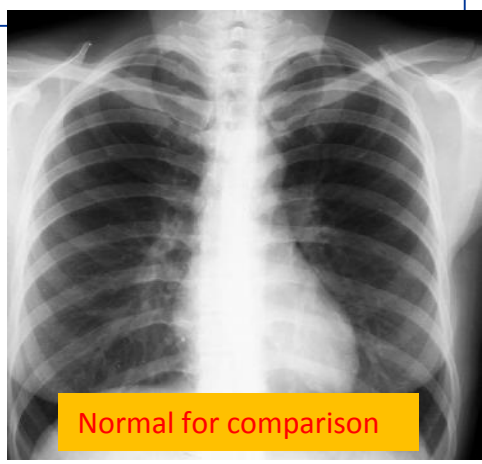
Axial CT image of upper skull (left) shows diploic space widening and trabecular prominence

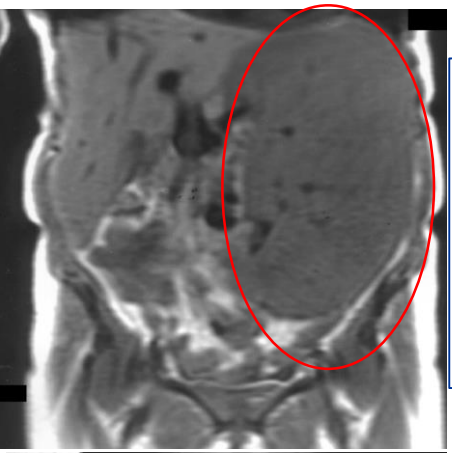


Sagittal MRI of brain (right) shows diploic space widening representing red marrow (*). Note spared occipital bone (arrows), which has no marrow elements

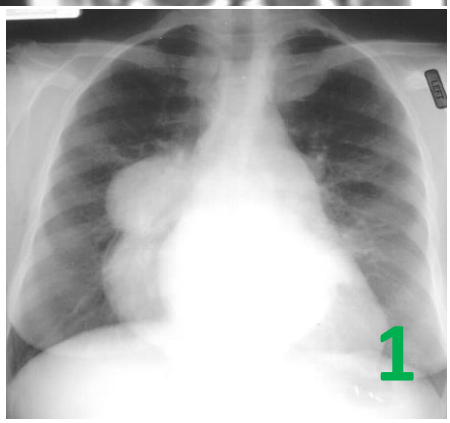
PA radiograph of chest shows: diffuse expansion of ribs (circle) and right upper paraspinal thoracic mass (arrow) compatible with extramedullary hemopoiesis.



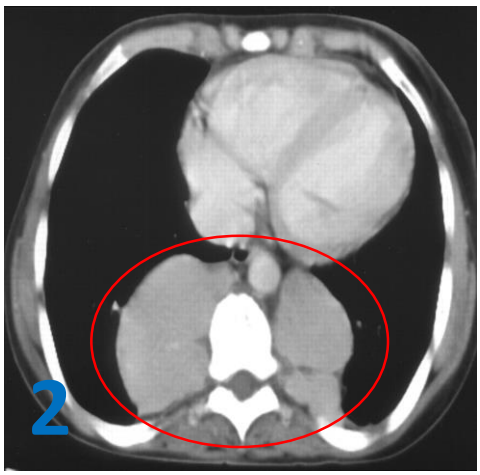




- 51-year-old woman with myelofibrosis.
- Coronal T1-weighted MR image shows massively enlarged spleen (circle)
- Splenic biopsy was followed by splenectomy
- Pathologic examination revealed extramedullary hematopoiesis (pathogists reported that's a bone marrow, howver, we know it's been biopsied from an area other than where bone marrow usually exists)

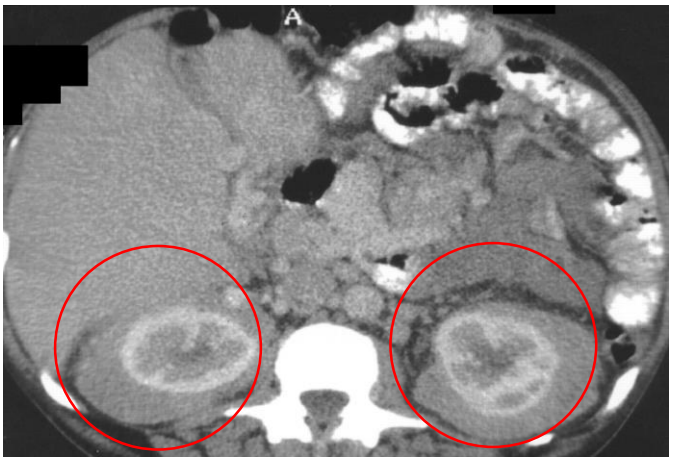


- **1-** 23-year-old woman with history of thalassemia and known extramedullary hemopoiesis
- PA chest film shows well-marginated bilateral, paraspinal masses compatible with extramedullary hemopoietic tissue

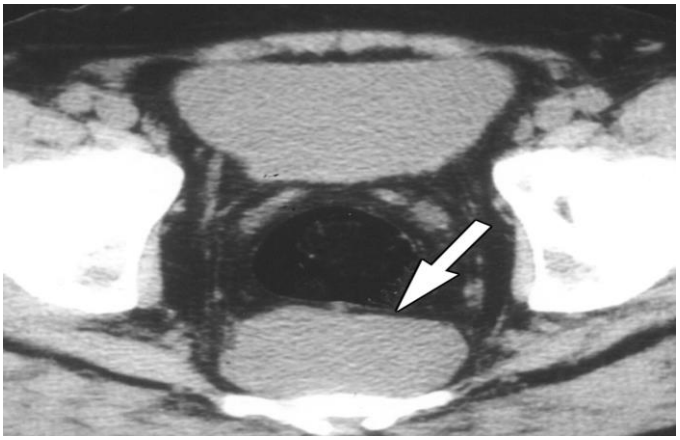


2- Same pt. as the left image but diiferent modaltity & view!
Axial contrast-enhanced CT scan through chest shows uniformly enhancing paraspinal hemopoietic masses with no bony erosion (circle)

40-year-old man with sickle cell disease
Axial unenhanced CT scan at thoracoabdominal level reveals two uniformly low-attenuation (compared with liver parenchyma), well circumscribed lesions (arrows)
Percutaneous biopsy showed extramedullary hemopoiesis



56-year-old man with myelofibrosis
Axial contrast-enhanced CT scan through kidneys reveals bilaterally symmetric enhancing perinephric masses. Biopsy showed extramedullary hematopoiesis



48-year-old man with hemolytic anemia and myelofibrosis
Axial CT scan through pelvis shows:
- well-marginated presacral soft-tissue mass (arrow) with no bony erosion
- Biopsy (not often needed) showed extramedullary hematopoiesis

Sickle cell disease may be manifested as

- **ANEMIA**

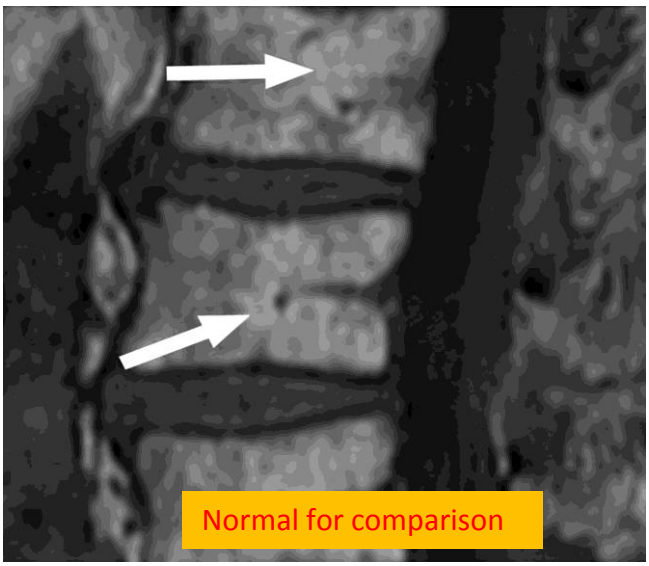
Growth failure
Hyperkinetic heart failure
Expanded intramedullary hematopoiesis
Presence of extramedullary hematopoiesis

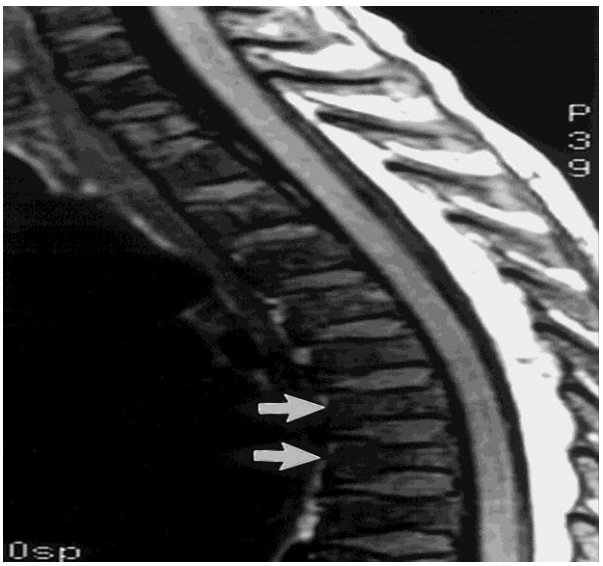
- **VASO-OCCLUSION**

Infarcts in spleen, bone marrow, kidney, bowel, brain, muscles etc.

- **SUPERIMPOSED INFECTION**

Pneumonia (*Pneumococcus, H. influenzae, Staph. aureus, Chlamydia, and Salmonella)*
Osteomyelitis *(Salmonella)*





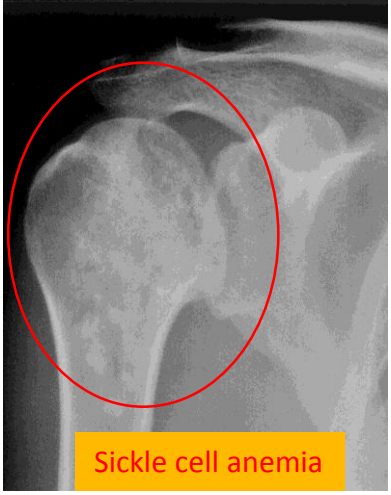
- Red marrow in vertebral bodies in a 7-year-old girl with Sickle Cell Anemia.
- Sagittal T1-weighted MRI of spine shows
- Low signal intensity in vertebral bodies compared to discs (red marrow exceeds the fatty one, and fat is T1-signaled on MRI, meaning that in T1 MRI image, fat appears bright, in this case fatty marrow is replaced by red marrow, so less fat is signaled in vertebral bodies> decreased brightness!)
- H-shaped vertebrae (arrows in right image) due to osteonecrosis (small infarcts) of vertebral endplates.

In this case you have 2 important findings: H-shaped vertebral bodies + decreased intensity of vertebral bodies on T1 MRI = a sign of anemia + infarcts.
Give a diagnosis based on these previous findings: Sickle Cell Anemia

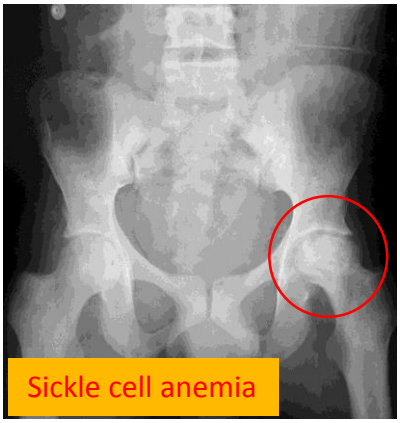
H-shaped vertebrae in a 15-year-old patient with SCA
Lateral radiograph of spine shows classic boxlike endplate depressions in middle portion (see the lowest vertebra shown) due to osteonecrosis (due to infarcts) of the vertebral endplates.

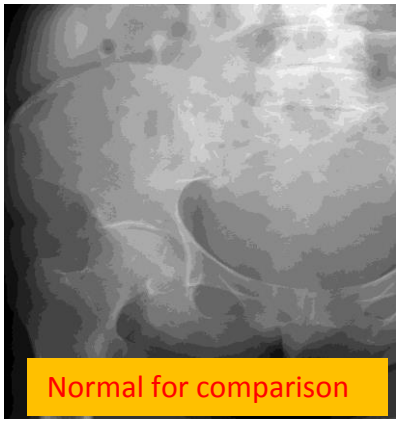
- Bone infarcts typically occur in the medullary cavities (vertebral bodies) and epiphyses.
- Epiphyseal infarcts are frequently seen in the femoral and humeral heads, and more often bilateral than avascular necrosis due to other diseases.

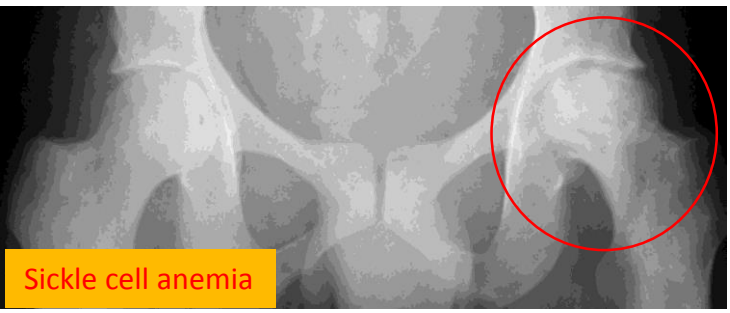
Medullary bone infarcts in SCA
Frontal radiograph of right shoulder in a 22-year-old patient shows an area of patchy sclerosis and radiolucency

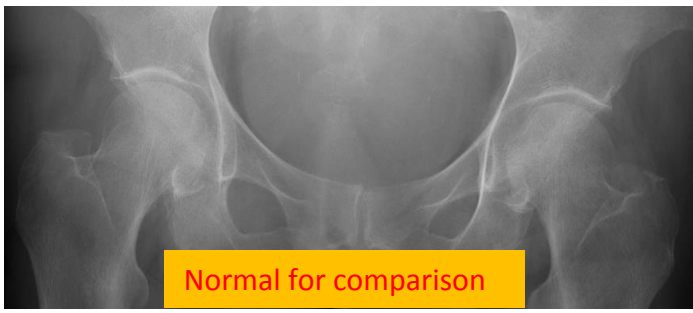


AP radiograph in a 44-year-old man shows advanced avascular necrosis in left hip and a normal right hip

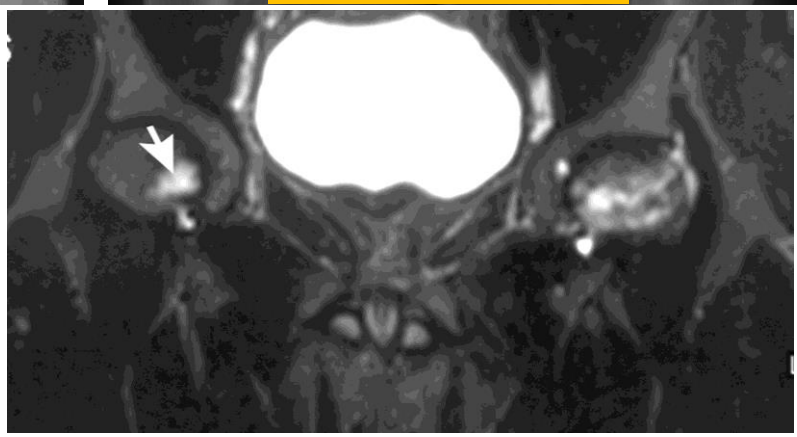






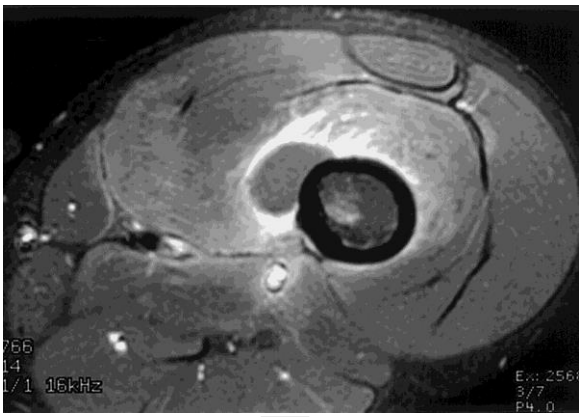


Coronal STIR MR image in the same patient shows **stage 1** avascular necrosis in right hip (arrow) as well, in addition to advanced changes of avascular necrosis of left femoral head

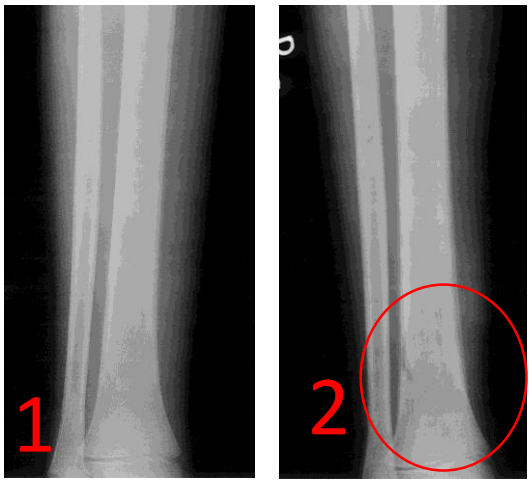


Note:
It's important to keep in mind that X-ray modality is not sensitive to early stages of bone necrosis !! In this 44-year-old case, x-ray only was able to detect the necrosis in its late stages, whilst this the MRI modality detected even the early changes in the right hip!

Hand-foot syndrome (dactylitis) in SCA:
Frontal radiograph of right foot in a 3-year-old girl shows thick periostitis and subperiosteal new bone along the metatarsal shafts



Osteomyelitis of femur in a 24-year-old patient with SCA
Axial T1-weighted MRI after contrast shows heterogeneous enhancement of marrow cavity, a rounded low-signal-intensity area adjacent to the shaft that is non-enhancing (fluid collection), and enhancement of the soft tissues around the shaft and of the adjacent musculature. Areas of enhancement are likely infected



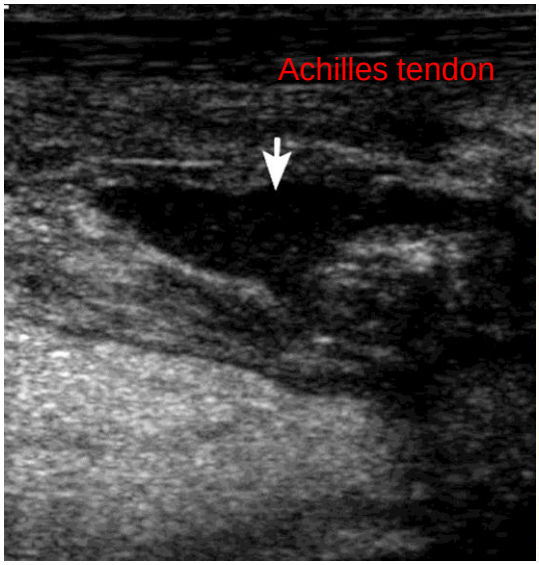
Salmonella osteomyelitis in a 10-year-old boy with SCA:
1- Initial film (left) at onset of lower shin pain and fever is normal
2- Film 7 days later (right) shows mottled lower tibial shaft and diffuse lower diaphysis

- Bone infarcts and osteomyelitis are difficult to differentiate on history, clinical examination and plain x-ray images but are very important to avoid complications of osteomyelitis (meaning that you can't delay or treat non-specifically)
- MRI findings of Cortical defects in bone:

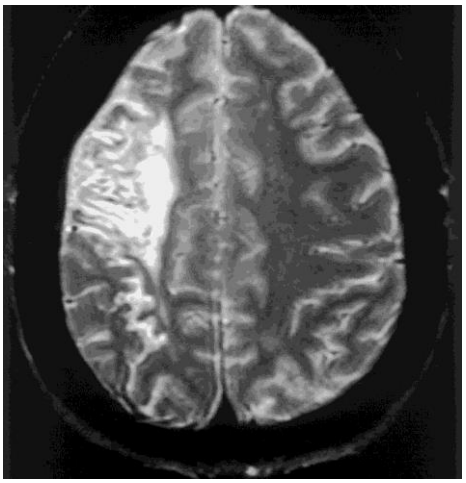
Adjacent fluid collections in soft tissue And Bone marrow enhancement are highly suggestive of infection

- Ultrasound guided aspiration of fluid collection around the involved bone can be confirmatory

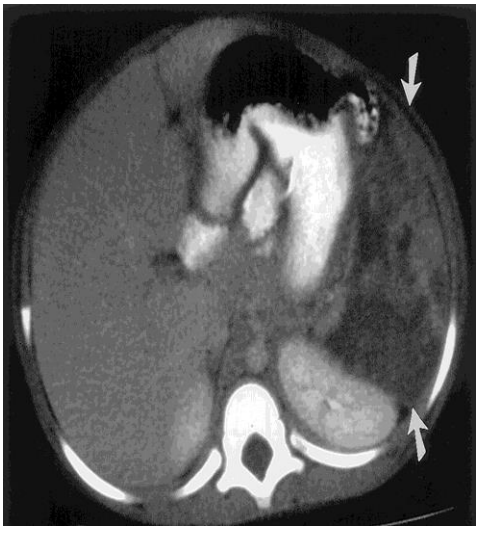
So MRI is the BEST (it can also show pus inside the bone, US can't) to differentiate between osteomyelitis and infarction, to Confirm US is used (it's an advantage over the MRI as it provides guided aspiration of the pus-bucket)



- Soft-tissue infection in a 52-year-old man with homozygous sickle cell disease.
- Longitudinal high-resolution ultrasound image of left ankle shows a hypoechoic (dark) fluid collection (arrow) deep to Achilles tendon. Thick pus was aspirated from this area under ultrasound guidance (advantage over MRI)



- Chronic infarct in a 19-year-old patient with SCA and longstanding mild left sided weakness
- Axial T2-weighted MRI shows an area of high signal intensity and enlargement of overlying CSF spaces, compatible with chronic infarction and atrophy



- Sequestration syndrome with splenic infarction in SCA
- Axial CT after contrast shows enlarged spleen that enhances heterogeneously and minimally with large non-enhancing areas (arrows)
- Photograph of spleen in a different patient shows areas of congestion and central necrosis

In Acute setting, spleenectomy has to be done to prevent perforation & internal bleeding!

Papillary necrosis in SCA

- (right) Frontal view of kidney during excretory urography in a 32-year-old man with SCA shows a small, round collection of contrast material in a missing papillary tip (arrow)
- (Left) Photograph of a kidney from a different patient shows loss of papillary tips in some upper pole pyramids (arrows).

- Growth disturbance in distal radius in a 12-year-old girl
- Anteroposterior (AP) radiograph of left wrist shows epiphyseal shortening and a cup deformity of adjacent metaphysis.
- Also changes of old bone infarct in distal radius (circle).

Notice that Ulna is overgrown (it's normally growing, while the radius is not!)

Lymphoma

Doctor did not go through it

Lymphoma

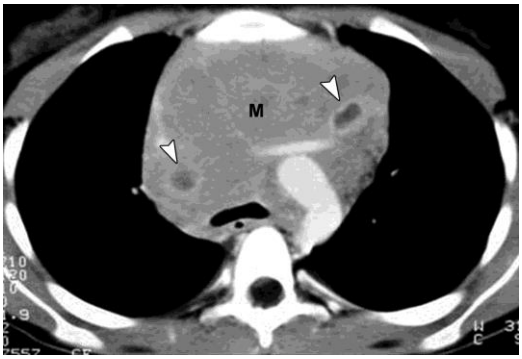
Hodgkin's Disease	Non Hodgkin's Lymphoma
• Lymphocytic predominance • Mixed cellularity • Lymphocytic depletion • Nodular sclerosis - the most common	• Burkitt lymphoma (jaw and abdomen) • Burkitt-like lymphomas (abdomen and nodes) • Large B-cell lymphomas (abdomen and nodes) • Lymphoblastic lymphoma (Mediastinum, nodes, bone marrow) • Anaplastic large cell lymphoma (Nodes, skin, soft tissue, bone) • Other peripheral T-cell lymphomas • MALT lymphoma

Lymphoma can present as mass anywhere in the body

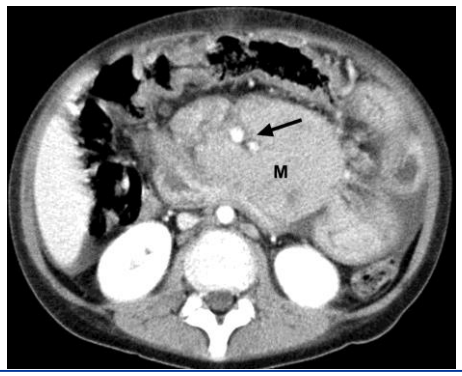
To be clear:

Diagnosis and Treatment are done by histopathology and surgery or chemotherapy. So what is the rule of Radiology in Lymphoma?

Radiology assess the extent lymphoma (a head-to-toe CT scan can assess any presence of lymphoma masses anywhere throughout the body!)

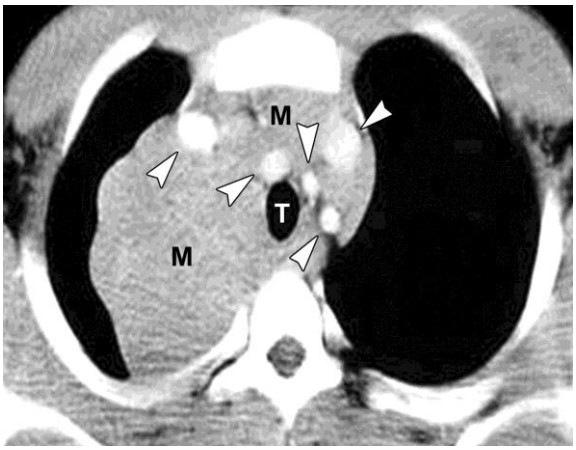


NHL in a 14-year-old boy. Contrast-enhanced CT scan shows a large anterior mediastinal mass (M) that originates from thymus. A few cysts with central low attenuation and a peripheral enhancing ring are present (arrowheads).

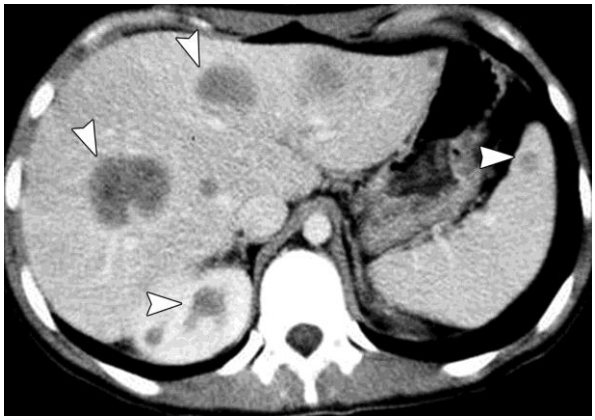


NHL in an 11-year-old boy. Axial CT scan shows a large lymphomatous mass (M) encasing the superior mesenteric vessels (arrow)

HD in a 17-year-old boy. Contrast-enhanced CT scan shows a large mediastinal mass (M). Trachea (T) is compressed, and great vessels (arrowheads) are displaced



HD in a 12-year-old girl
Contrast-enhanced CT scan shows an enlarged spleen with a diffusely inhomogeneous appearance.

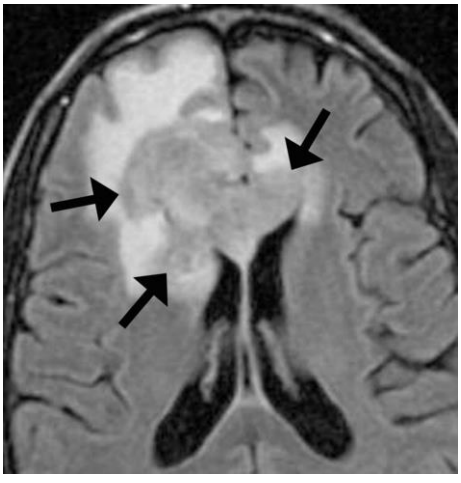


NHL in a 16-year-old girl. Contrast-enhanced CT scan shows low-density lesions (arrowheads) in both hepatic lobes, with small nodules in spleen and right kidney.

NHL in a 14-year-old boy. Contrast-enhanced CT scan shows single well-defined, low density mass (M) in right kidney

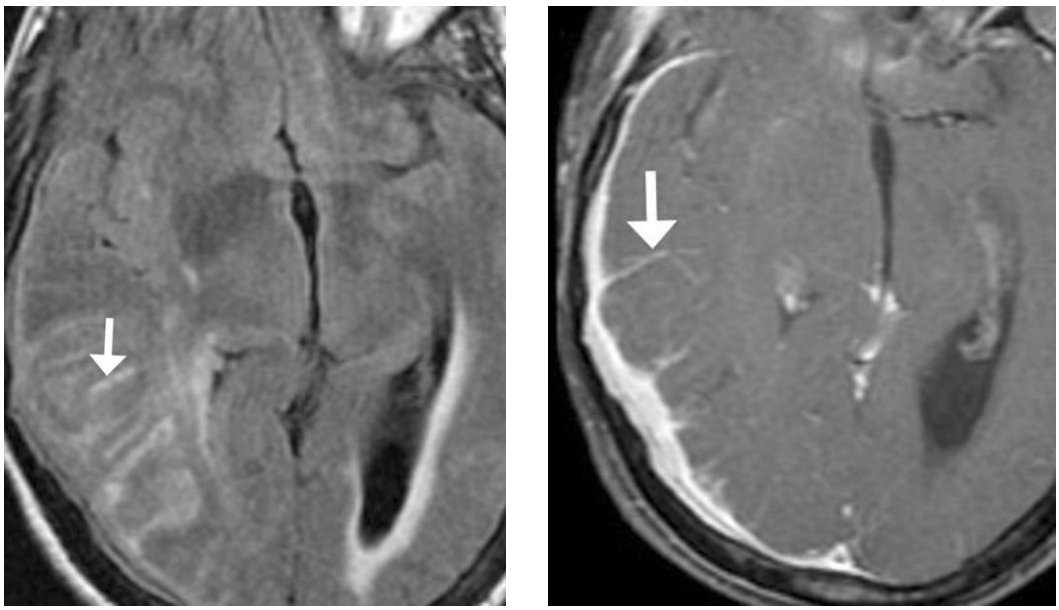
- Diffuse hepatosplenic involvement in lymphoma
- Axial CT scan shows multiple round, homogeneous, low density nodules (arrows) in liver and spleen

- 72-year-old immunocompetent woman with primary CNS non-Hodgkin's B-cell lymphoma
- Unenhanced CT image shows classic hyperdense masses involving deep white and gray matter.



44-year-old HIV-positive woman with primary CNS non-Hodgkin's B-cell lymphoma

Axial FLAIR MRI shows lesion isointense to gray matter (arrows).



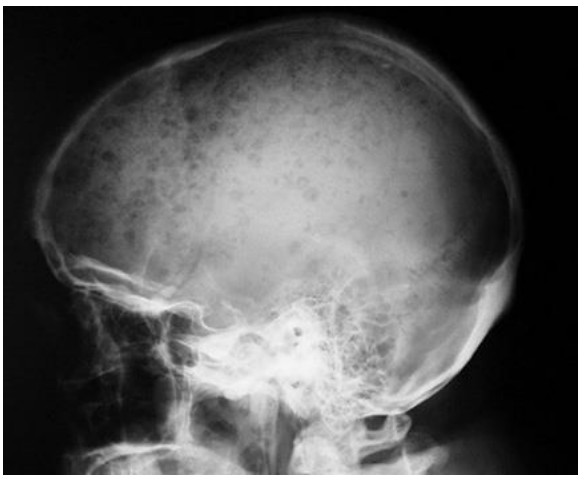
- 63-year-old woman with primary meningeal lymphoma
- Axial FLAIR (left) and post contrast T1 weighted (right) MR images show hyperintensity and enhancement (arrows) involving sulci and leptomeninges

Diagnosis of lymphoma:

- If accessible area, then open-surgery-Biopsy is often performed (e.g. Axilla and groin)
- If not accessible, CT guided biopsy is done to reach final diagnosis
- MRI is not commonly used unless you suspecting a lymphomatous lesion in a specific area (e.g.brain)!!

(forget about MRI, it's NOT used to assess lymphoma (pt. can't waight 3-4 hours waiting for you to vuisualize him, while you have an excellent modality (CT scan)that takes only 2-3 mins!!!)

Multiple Myeloma



Lateral skull radiograph showing multiple very sharply outlined **(punched out)** lytic lesions of multiple myeloma

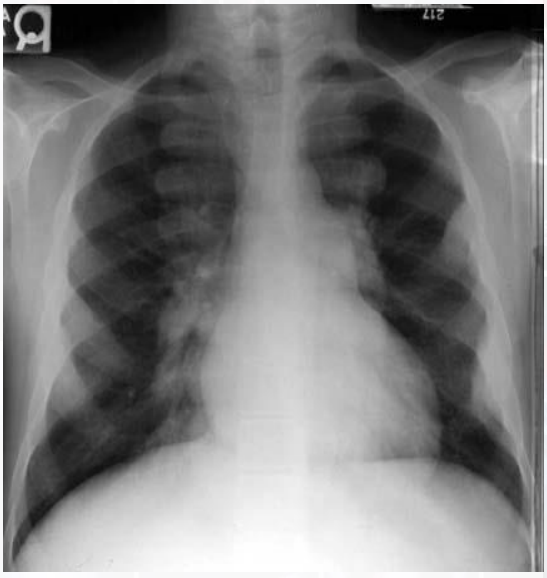
The key feature to differentiate between Multiple Myeloma & other diseases such as (hyperparathyroidism) is that the background Bone (skull) is NORMAL in MM!!!

Questions!

Findings shown here can be seen in
A. any severe chronic anemia
B. thalassemia
C. Sickle cell anemia
D. Lymphoma

Because you can't differentiate between types of Aaemias Radiologically, you have to have background Lab and Blood Smear results!

Findings shown here can be seen in
A. any severe chronic anemia
B. thalassemia
C. Sickle cell anemia
D. Lymphoma



Same justification above

1-A 2-A

Don’t Forget !

- INTRA medullary hyperplasia can be seen in Thalassemia, Sickle cell anemia, Iron deficiency anemia, Any severe chronic anemia except bone marrow failure
- Signs of INTRA medullary hyperplasia include: Expanded bone marrow in bones including long bones of hands, feet, limbs, skull and/or Decreased T1 MRI bone marrow signal than adjacent discs
- EXTRA medullary hematopoiesis can be seen in ALL SEVERE CHRNIC ANEMIAS
- Sites of EXTRA medullary hematopoiesis include Liver, Spleen, Paraspinal areas with possible extension into spinal canal outside the dura, Kidneys, Meninges, Skin, Lymph nodes, Thymus
- EXTRA medullary hematopoiesis appears as homogeneous soft tissue masses on imaging
- INFARCTS and INFECTIONS are additional findings in Sickle cell anemia
- Bone infarct vs infection is important to diagnose early so that antibiotics can be started early to prevent complications. MRI with contrast and ultrasound /CT guided aspiration of fluid collections are very helpful if imaging is unable to differentiate these two
- Multiple myeloma produces punched out lytic lesions in bones with background bone appearing normal. Opposite to bony metastases, myeloma more often involves intervertebral discs and mandible, and less often involves pedicles.
- Lymphoma can produce a mass anywhere in the body. CT is often used to scan whole body to evaluate the disease extent (staging), and to do CT-guided biopsy to make tissue diagnosis if not already diagnosed. Rest is all by laboratory and clinical based.