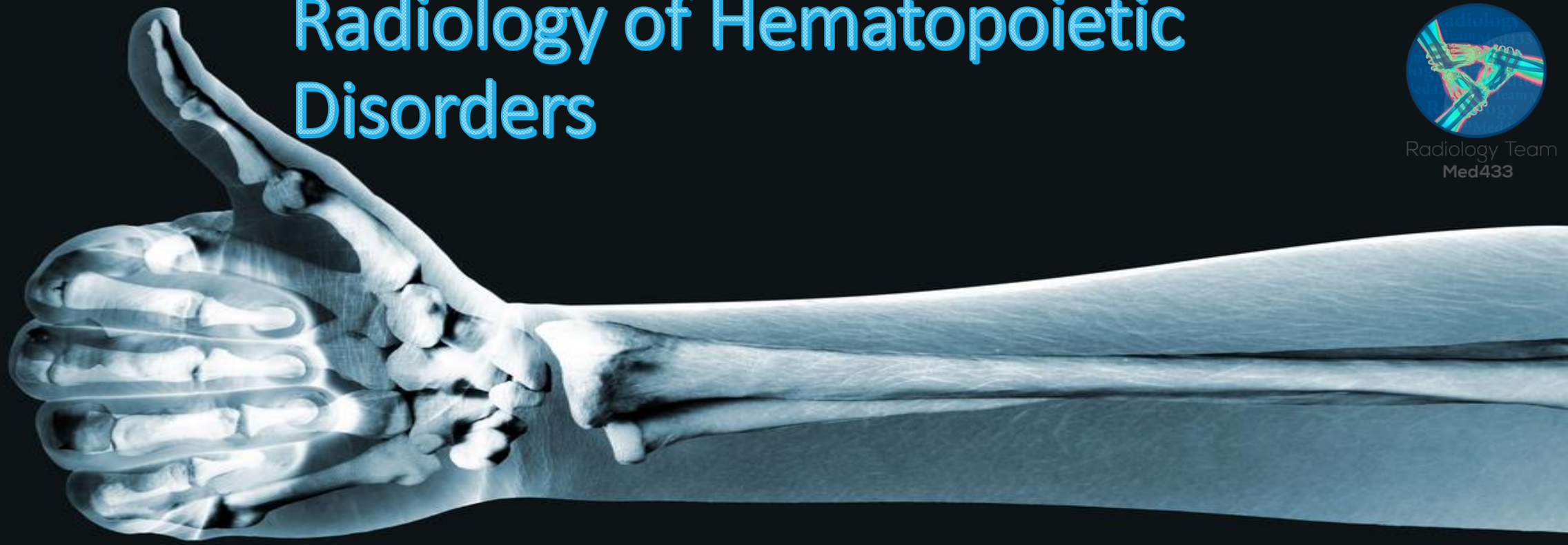
Lecture 1:

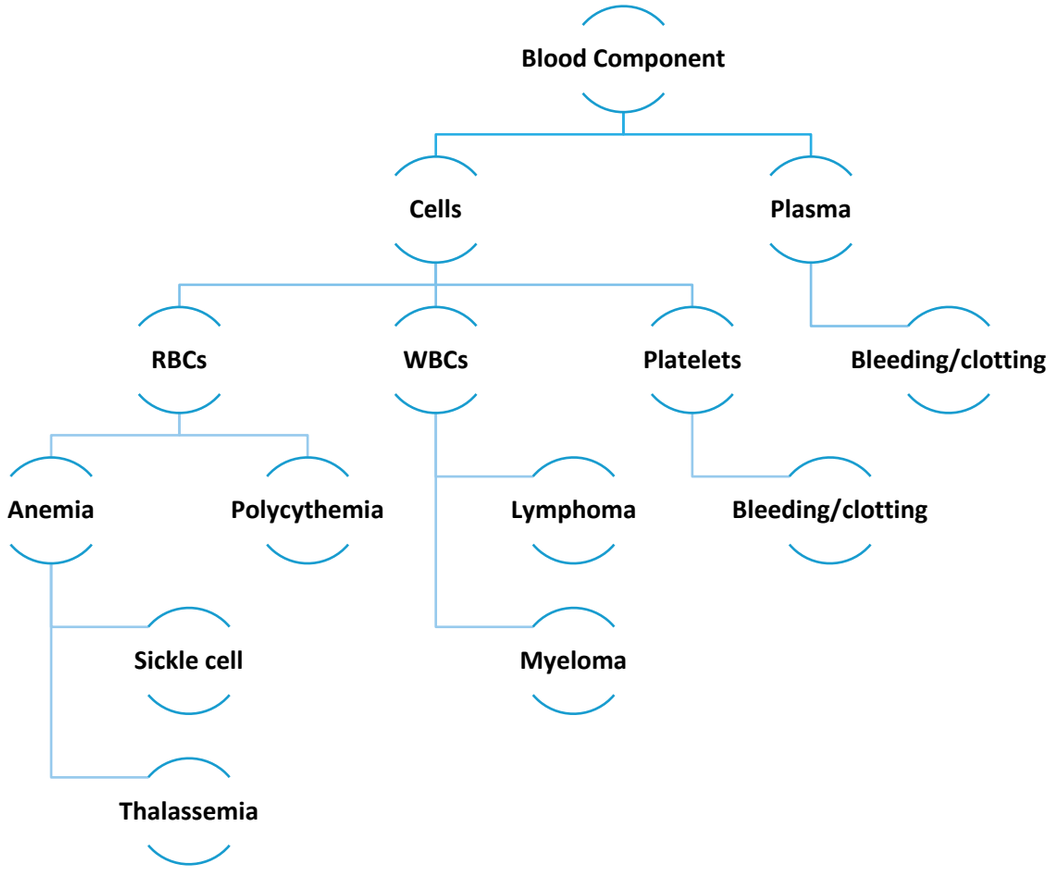
Radiology of Hematopoietic Disorders



Radiology Team
Med433

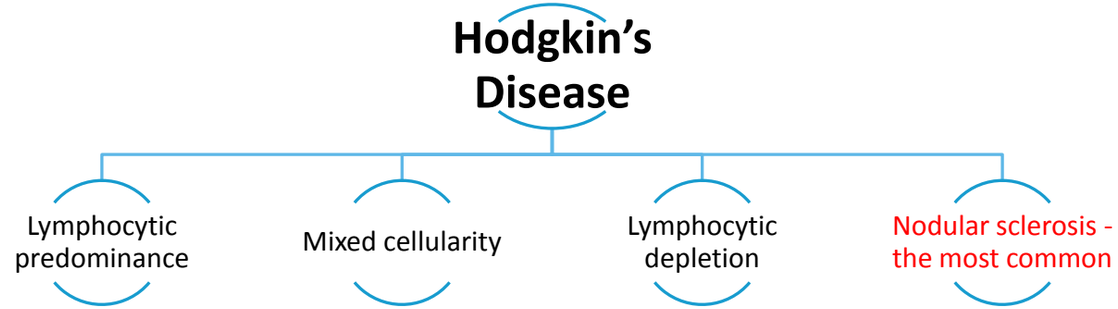
● Slides ● Explanation ● Notes ● Additions ● Important

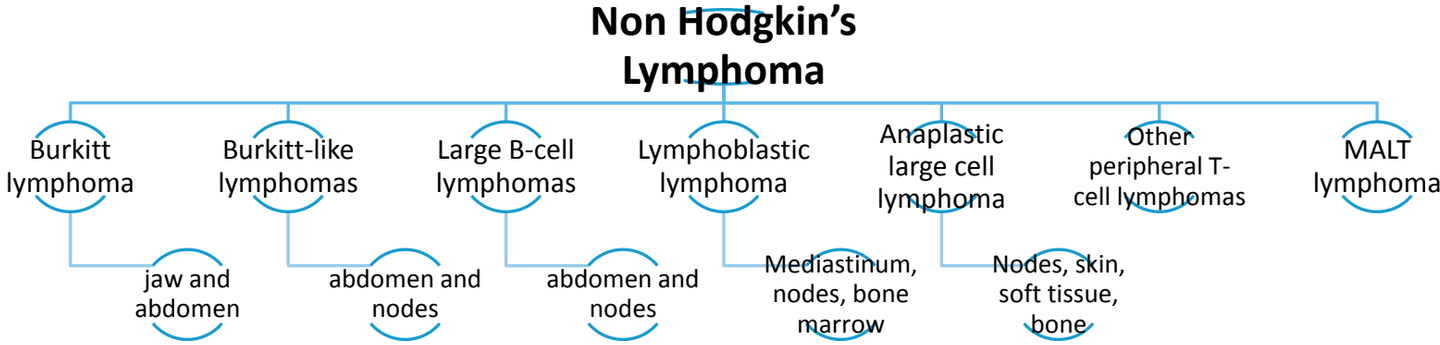
Type of Disease According to Blood Component:



Plasma, polycythemia and platelet do not have that much in radiology, they're managed clinically and laboratory.

LYMPHOMA





Anemia

Whenever there is anemia, there will be:

1- Reactive increase in red bone marrow: (Intra medullary hematopoises)

- 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. (bone will be wider)
- Most of bone marrow in adult are inactive
- In MRI we can see the active and inactive bone marrow

2- New marrow areas in potential organs: (was active in Intrauterine life)

Liver, Spleen, Lymph nodes, Thymus, Paraspinal areas with possible extension into spinal canal outside the dura, Kidneys, Meninges, Skin.

3- Transfusions Iron overload:

Increased CT density (brightness) and changes in MRI signal of liver & spleen.

Q: if a patient took iron supplement too much (tablet), is that will result in iron overload? Why?
No, it will not be absorbed.

Sickle Cell Anemia

In addition to

1- Reactive increase in red bone marrow
2- New marrow areas in potential organs
3- Transfusions Iron overload

4- Infections

- Pneumonias
- Osteomyelitis

5- Infarction

- Spleen
- Kidneys
- Brain
- Bones

Sickle Cell Disease may be manifested as:

ANEMIA

- Growth failure, hyperkinetic heart failure.
- Expansion of intramedullary hematopoiesis.
- Presence of extramedullary hematopoiesis.

VASO-OCCLUSION

- **Infarcts** in spleen, bone marrow, kidney, bowel, brain, muscles.
- **Bone infarcts** typically occur in the **medullary cavities** and **epiphyses**.
- **Epiphyseal infarcts** are frequently seen in the **femoral and humeral heads,** and more often **bilateral** than avascular necrosis due to other diseases.

SUPERIMPOSED INFECTION

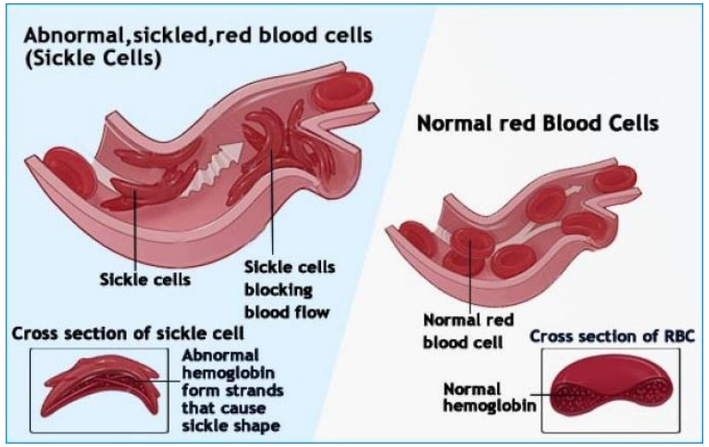
- **Pneumonia** (*Pneumococcus, H. influenzae, Staph. aureus, Chlamydia, and Salmonella)*
- **Osteomyelitis** *(Salmonella)*

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.**
(early diagnosis = antibiotics can be started early to prevent complications.)

MRI (with contrast) findings that are **highly suggestive of infection**:

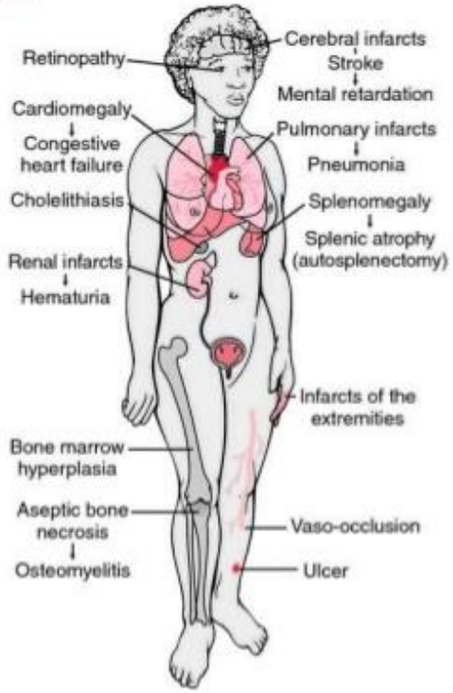
1. **Cortical defects in bone**
2. **Adjacent fluid collections in soft tissue**
3. **Bone marrow enhancement**

Ultrasound/CT guided aspiration of fluid collection around the involved bone can be **confirmatory.**



Common Organs Affected in Sickle Cell Disease

- Bones
  - Chronic bone ischemia leading to infection and bone degeneration
- Liver
  - Hepatomegaly
  - Scarring
  - Cirrhosis
- Spleen
  - Infarcts leading to fibrosis and increased risk of infection



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.
  - **Decreased T1 MRI bone marrow signal** than adjacent discs.

EXTRA Medullary Hematopoiesis:

- Can be seen in **all severe chronic 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.
- Appears as **homogeneous soft tissue masses** on imaging.

Multiple Myeloma:

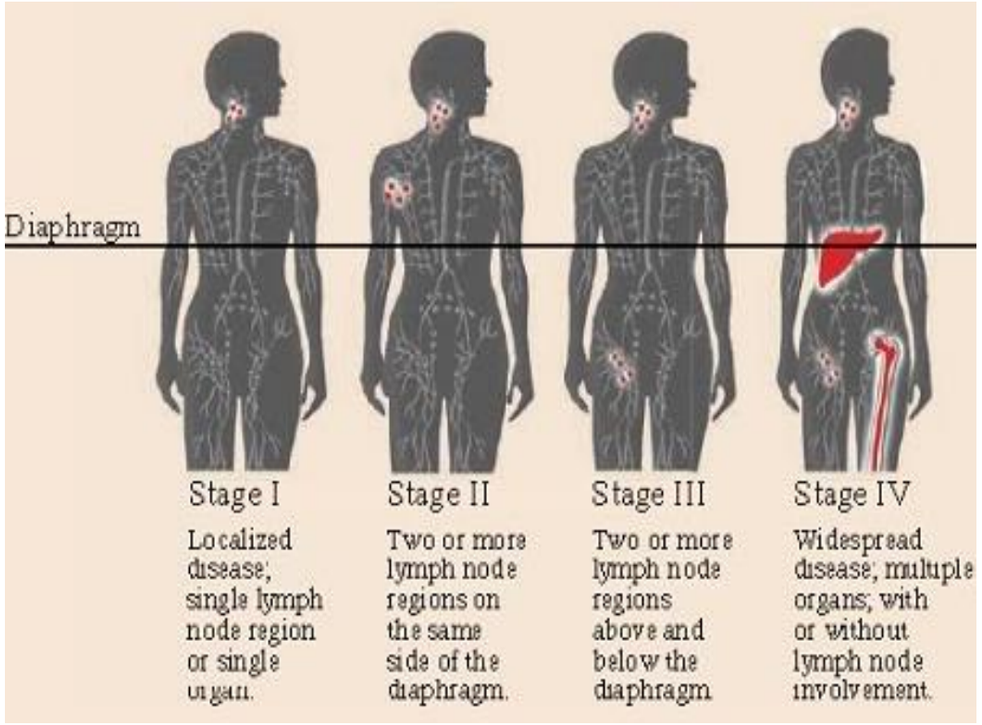
- Produces punched out **lytic lesions in bones** with background bone appearing normal.
- Opposite to bony metastases, **myeloma more often involves intervertebral discs and mandible**, and **less often involves pedicles**.

Lymphoma:

- Lymphoma is uncontrolled proliferation of Lymphatic cell.
- Lymphoma can present as 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**.
- Radiology have no roll in diagnosis.
- Radiology's roll in Lymphoma:
  - Diseases extent. (staging)
  - Nodal vs extra nodal.
  - Biopsy guided.

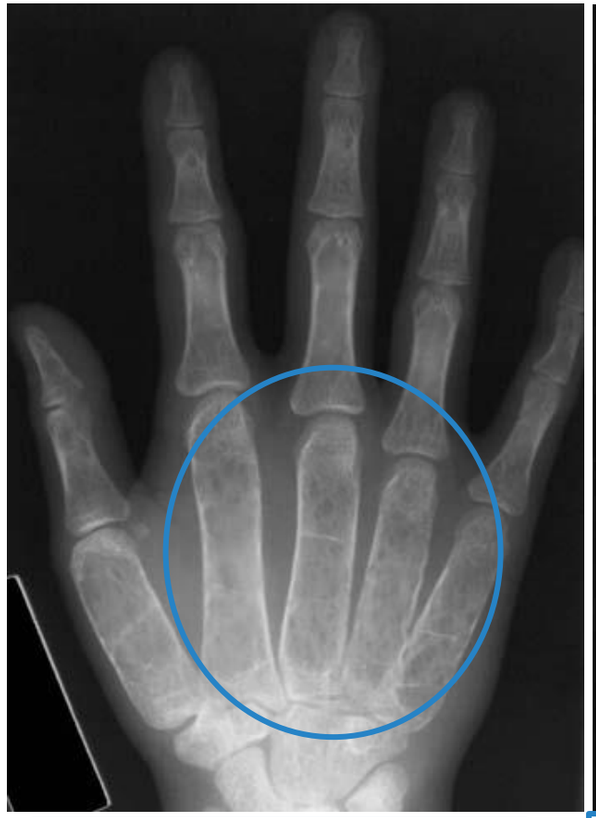
Lymphoma Staging:

we use CT scan for staging

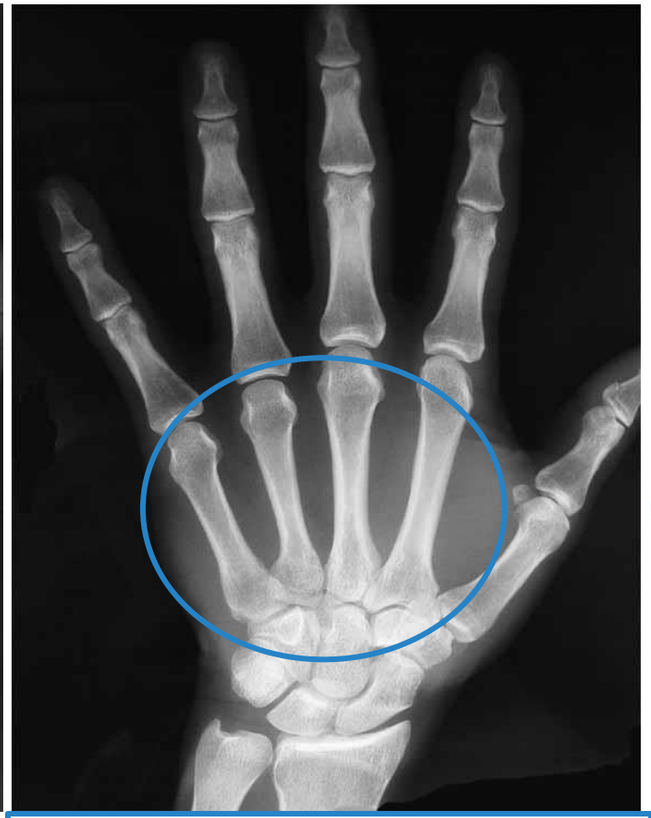


Thalassemia:

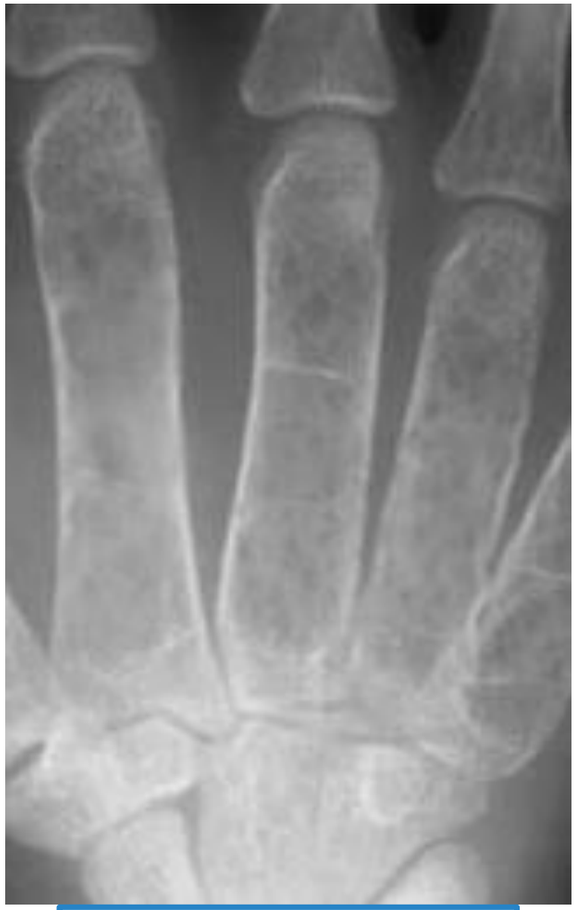
- Decreased bone density with coarse trabeculae.
- Wide medullary cavity with thin cortex.



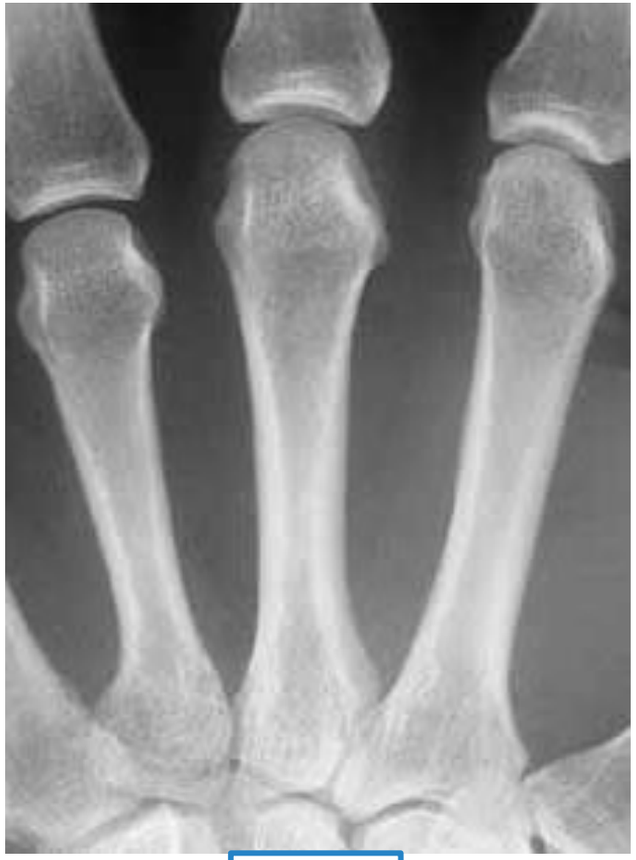
Low density with thin cortex



Normal (thinner is in the middle of the bone and are broad at the edges)



Severe chronic anemia



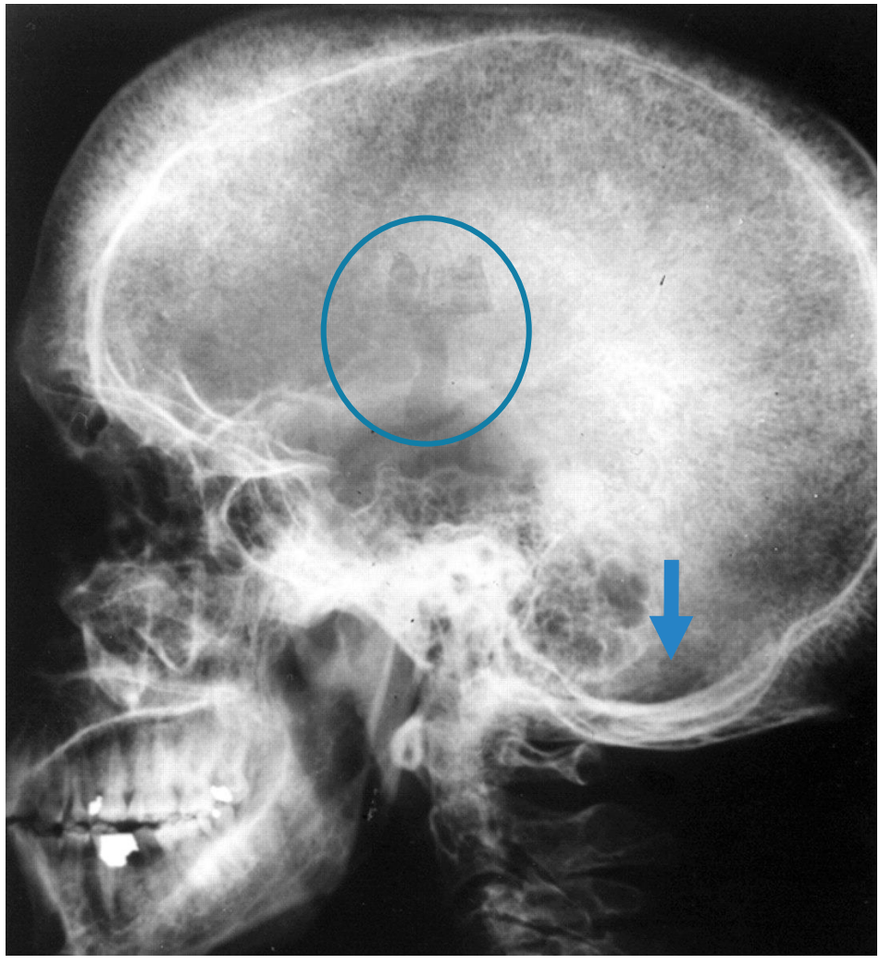
Normal

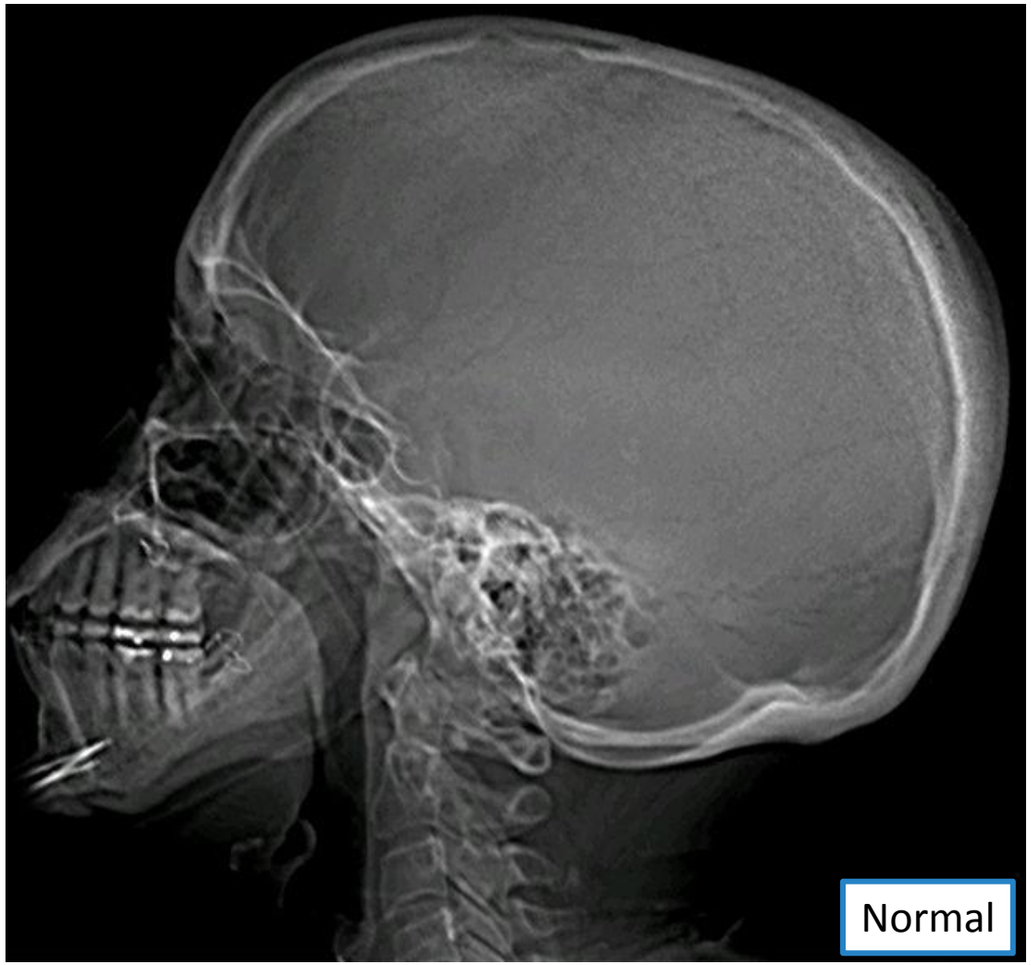
(This is not specific for thalassemia, it is for all type of anemia.)

Thalassemia (cont.)

25-year-old man with β-thalassemia.

- Lateral skull radiograph shows **expansion of diploic space** with **hair-on-end appearance**, widened groove for **middle meningeal artery** (circle).
- Spared occipital bone (arrow).
- skull is very thickened, expanded and cortical thinning that's due to bone hyperplasia.





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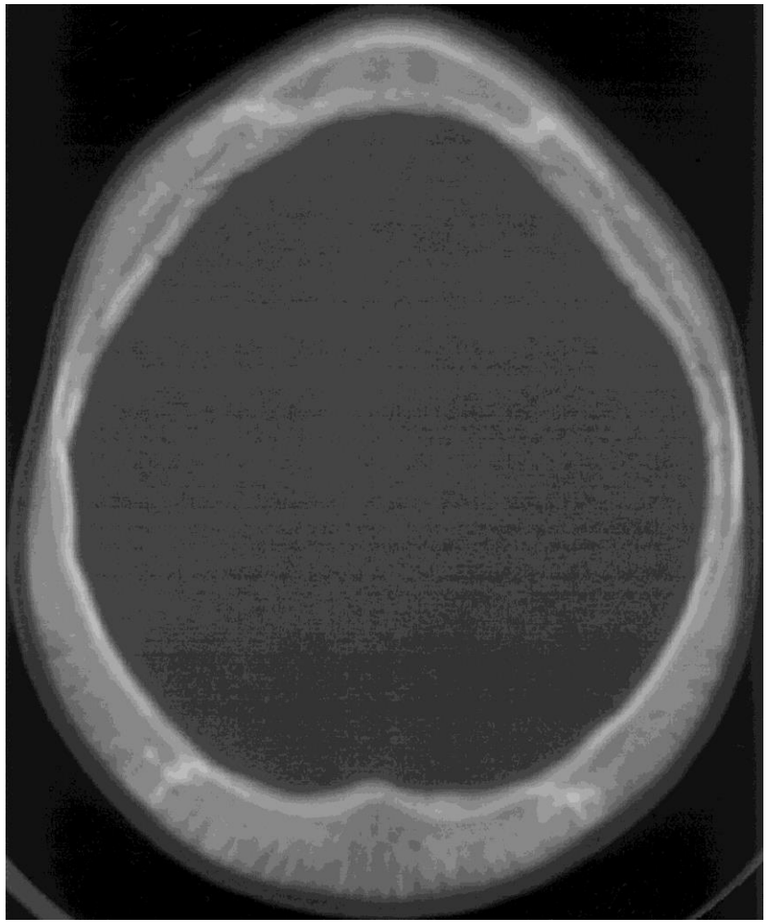
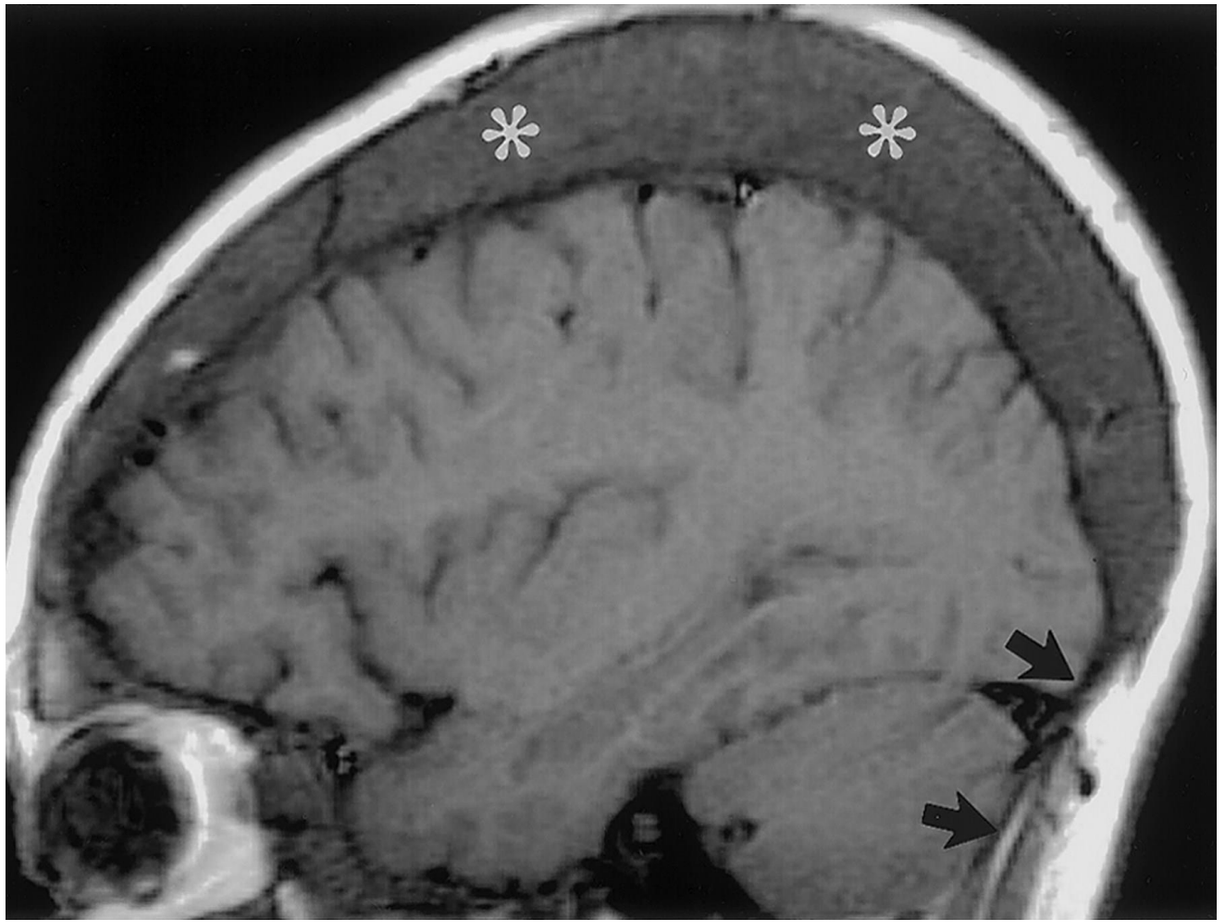


Axial CT image of upper skull shows:

- Diploic space widening and trabecular prominence.



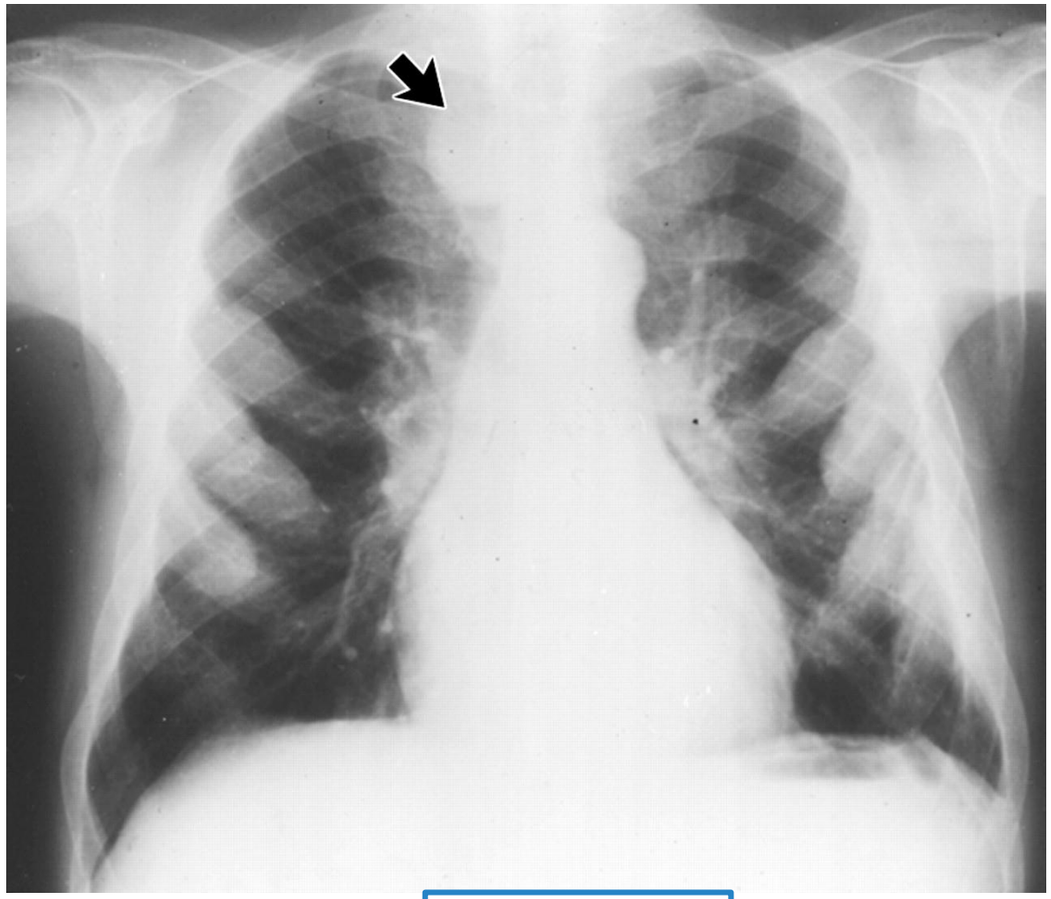
Sagittal MRI of brain shows:

- Diploic space widening representing red marrow (*).
- Spared occipital bone (arrows), which has no marrow elements.
- In occipital area, there is no bone marrow therefore if there is proliferation in bone marrow it will not affect this area.

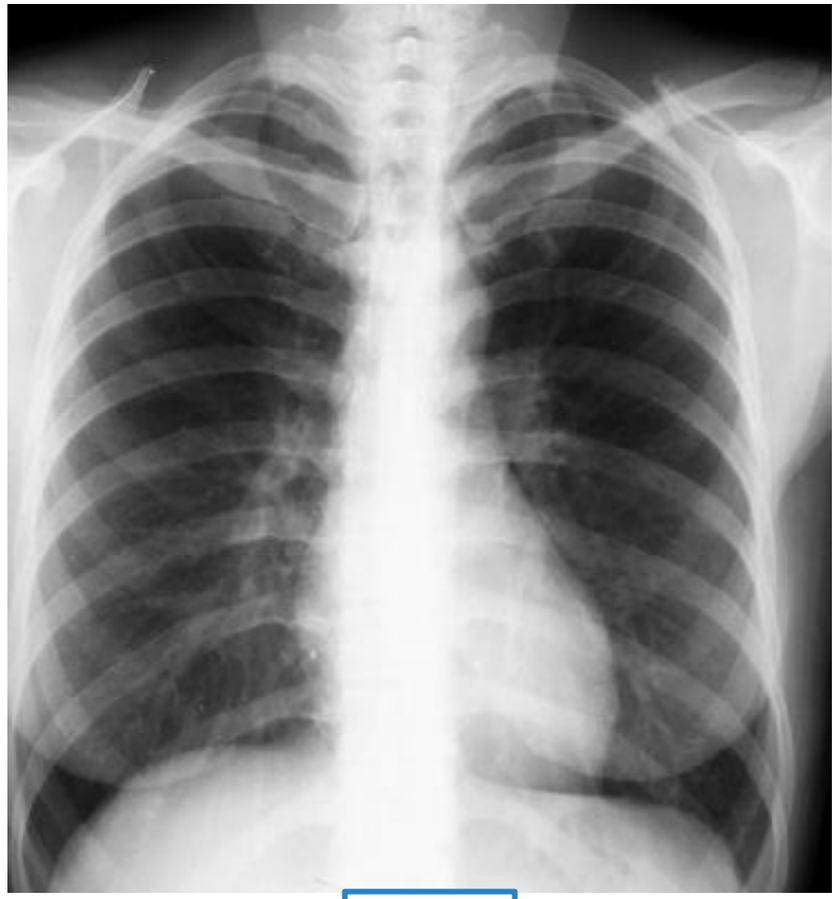
Thalassemia (cont.)

25-year-old man with β-thalassemia.

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



β-thalassemia



Normal

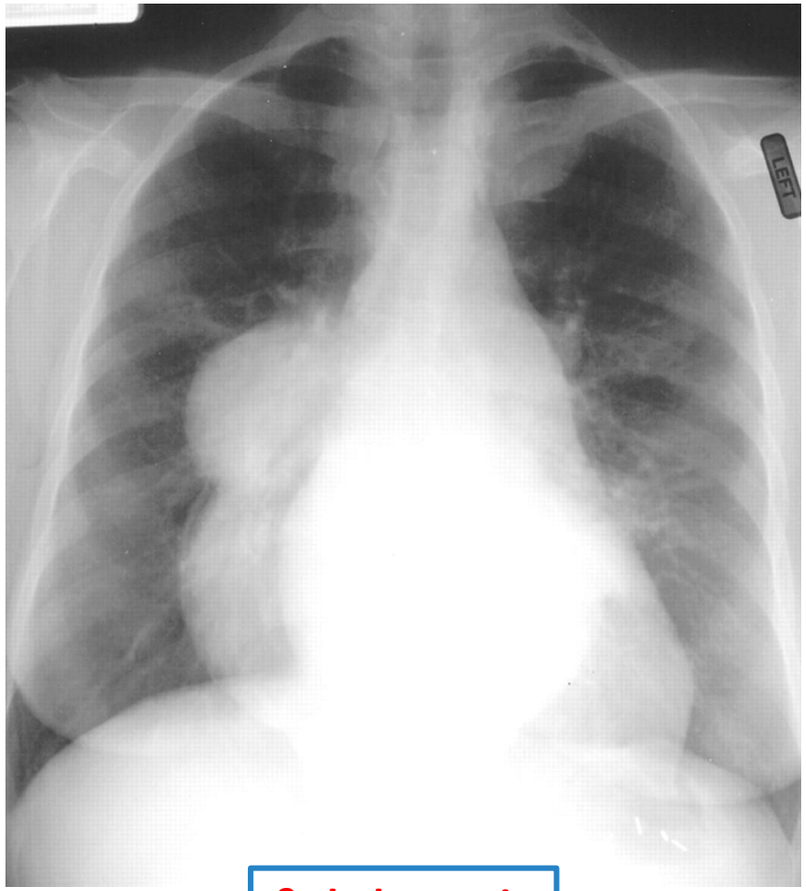
(This is not specific for thalassemia, it is for all type of anemia.)

Thalassemia (cont.)

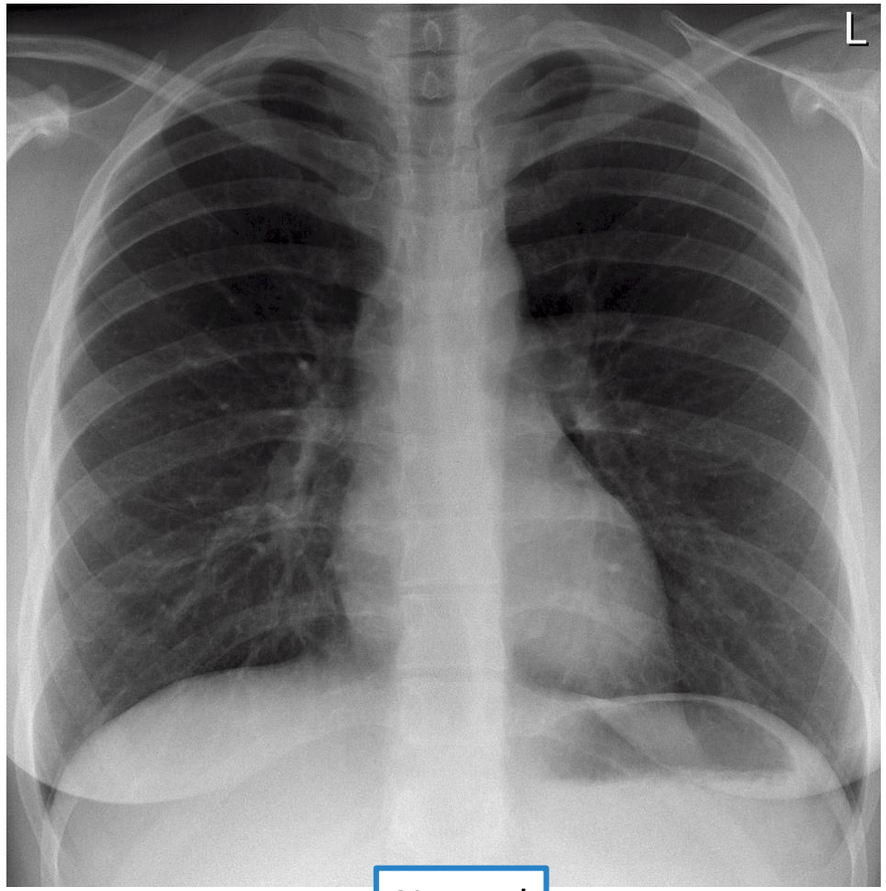
23-year-old woman with history of thalassemia and known extramedullary hemopoiesis.

- PA chest film shows well demarcated bilateral, paraspinal masses compatible with **extramedullary hemopoietic** tissue.

- If the patient known case of anemia we expect to see extramedullary hematopoiesis, biopsy is not needed. **Treat anemia this tissue will disappear.**



β-thalassemia



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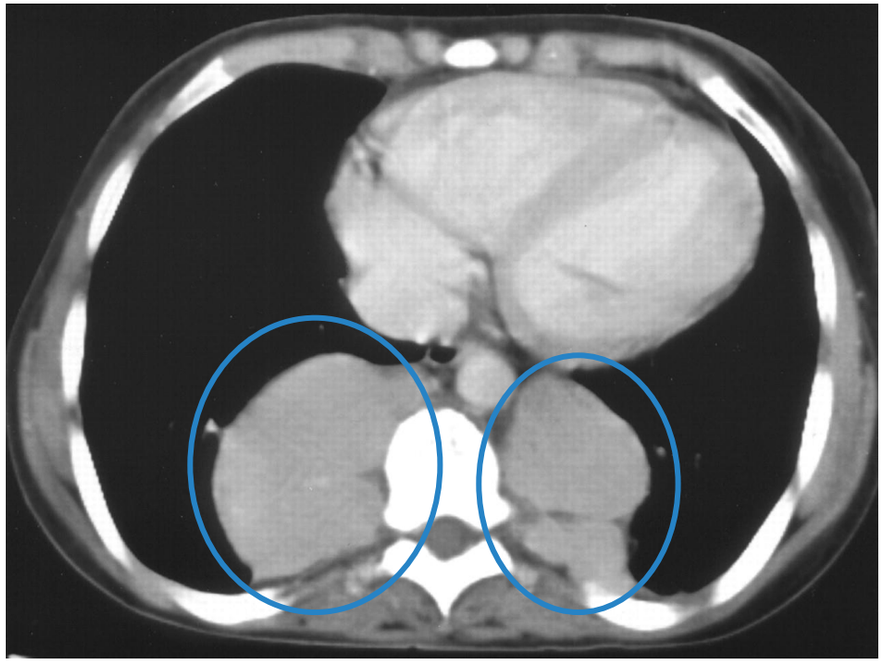


Axial contrast-enhanced CT scan through chest shows:

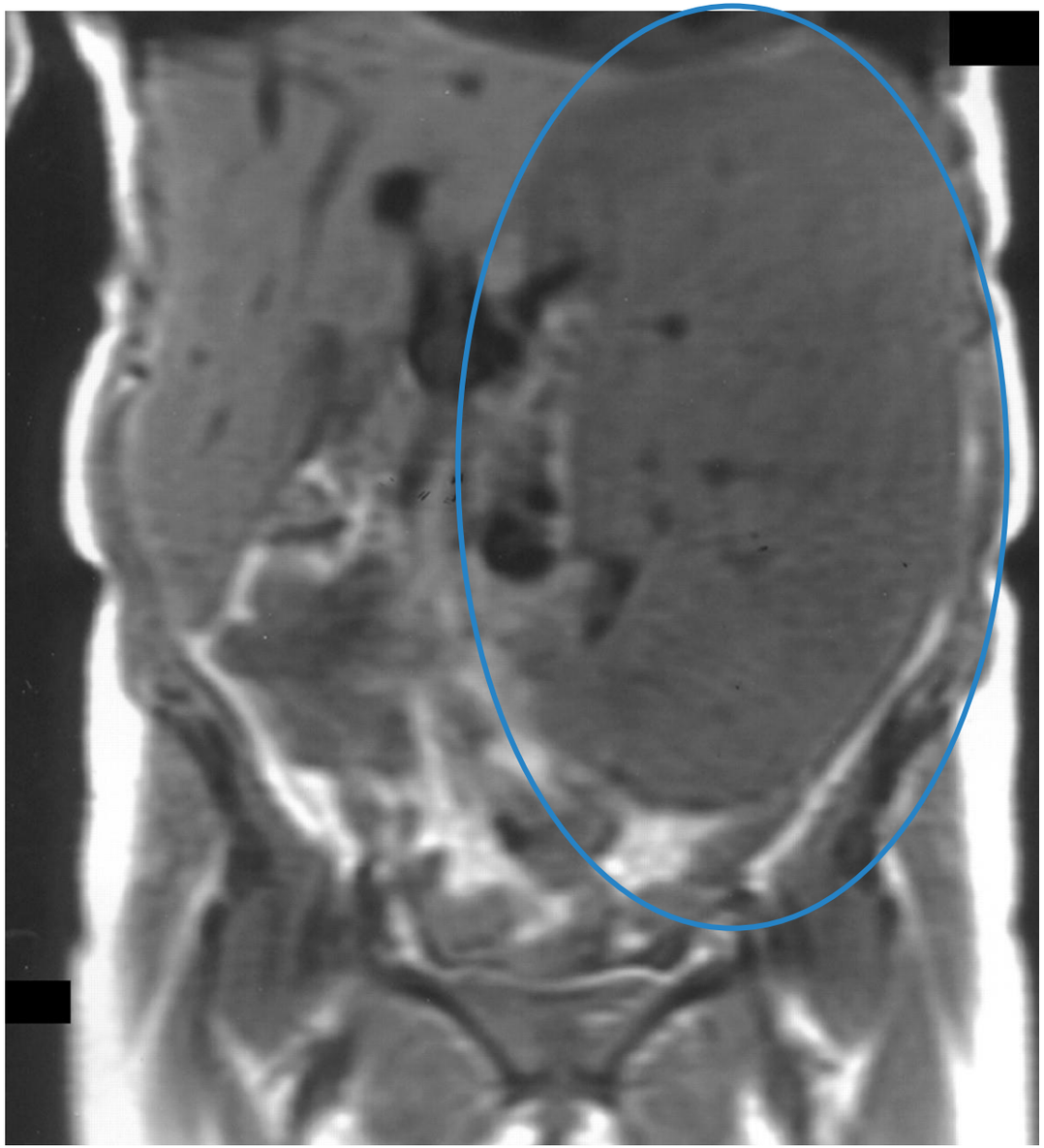
- uniformly enhancing paraspinal hemopoietic masses (circles) with no bony erosion.

Myelofibrosis:

51-year-old woman with myelofibrosis.

- Coronal T1-weighted MR image shows: massively enlarged spleen (arrow).
- Splenic biopsy was followed by splenectomy.
- Pathologic examination revealed: **extramedullary hematopoiesis.**
- **The patient will have fibrosis in the bone marrow and there will be no RBCs**

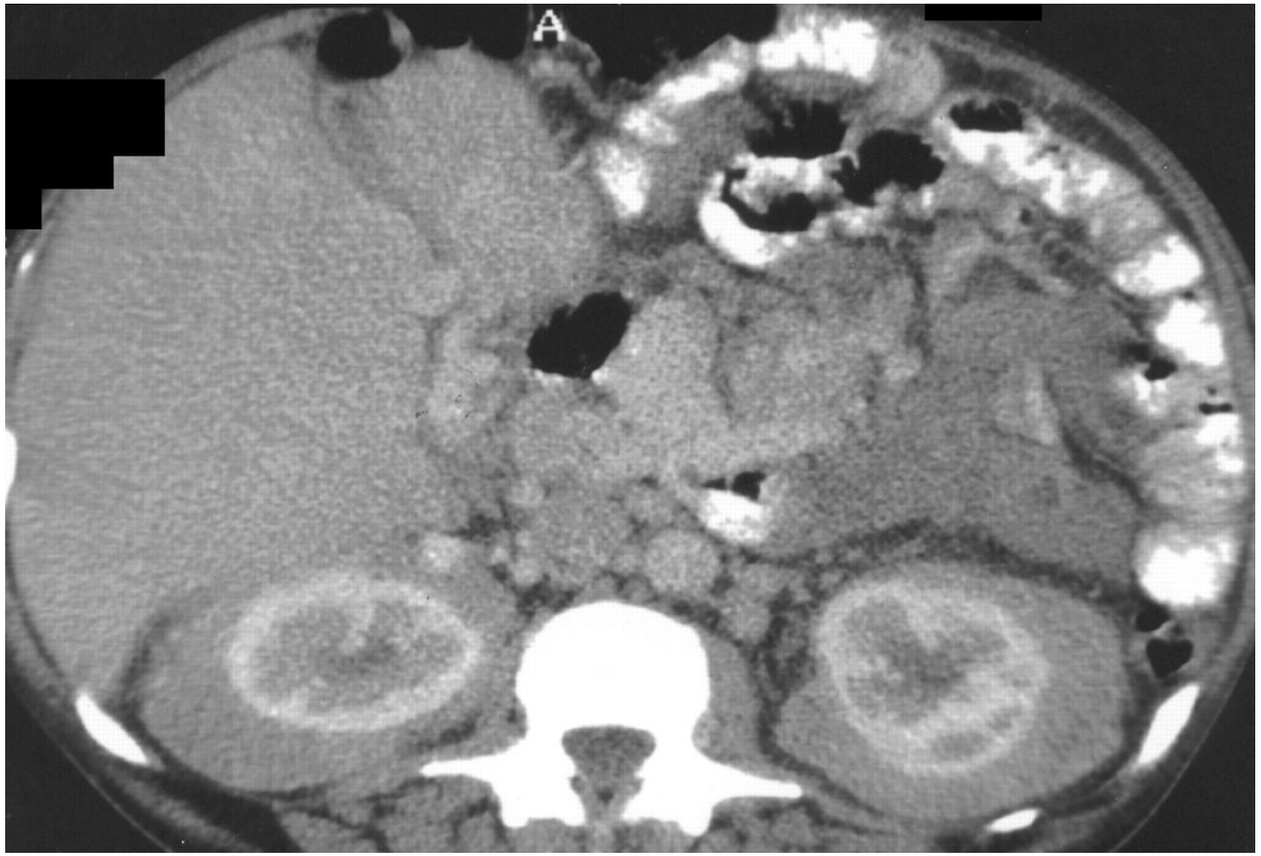
Production which will lead to enlarged spleen



Myelofibrosis (cont.)

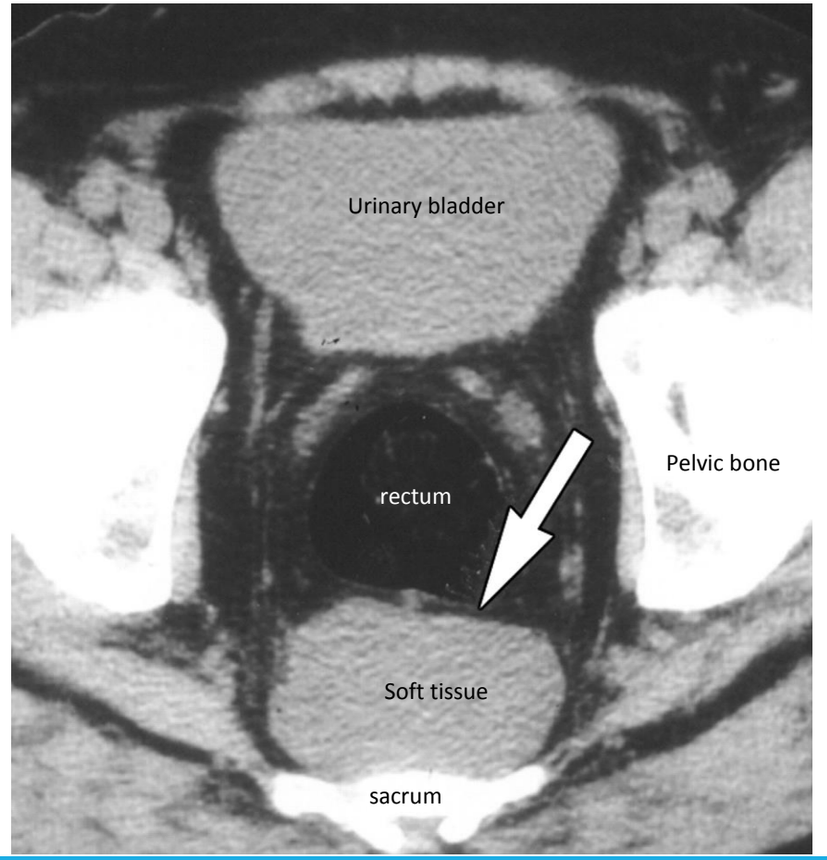
56-year-old man with myelofibrosis.

- Axial contrast-enhanced CT scan through kidneys reveals: bilaterally symmetric enhancing perinephric masses.
- Biopsy showed: **extramedullary hemopoiesis.**



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 showed: **extramedullary hemopoiesis.**
- **Here biopsy is needed because this site is not usual site for extramedullary hematopoiesis.**

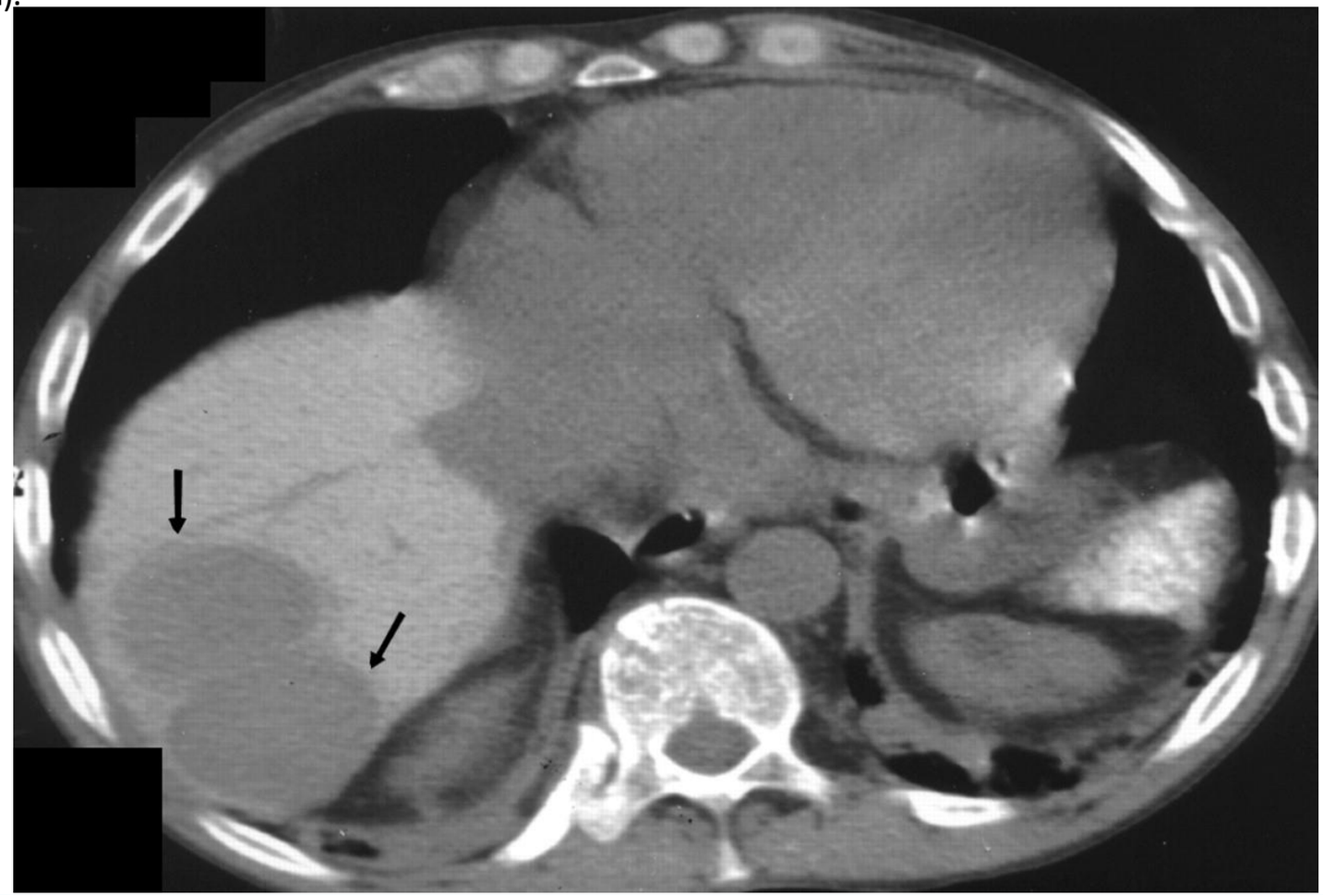


Sickle Cell Disease:

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-marginated lesions (arrows).
- Liver is brighter than other tissue due to iron over load.

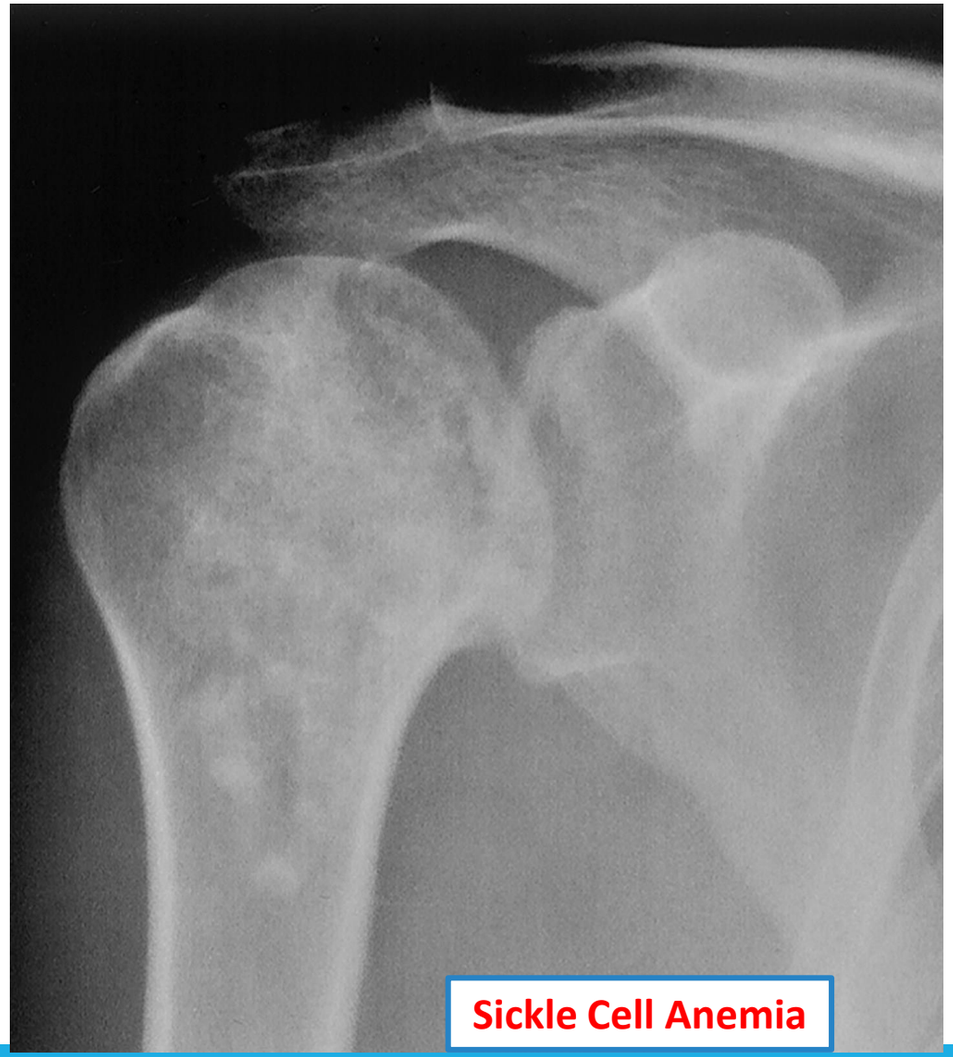
- Percutaneous biopsy showed: extramedullary hemopoiesis.

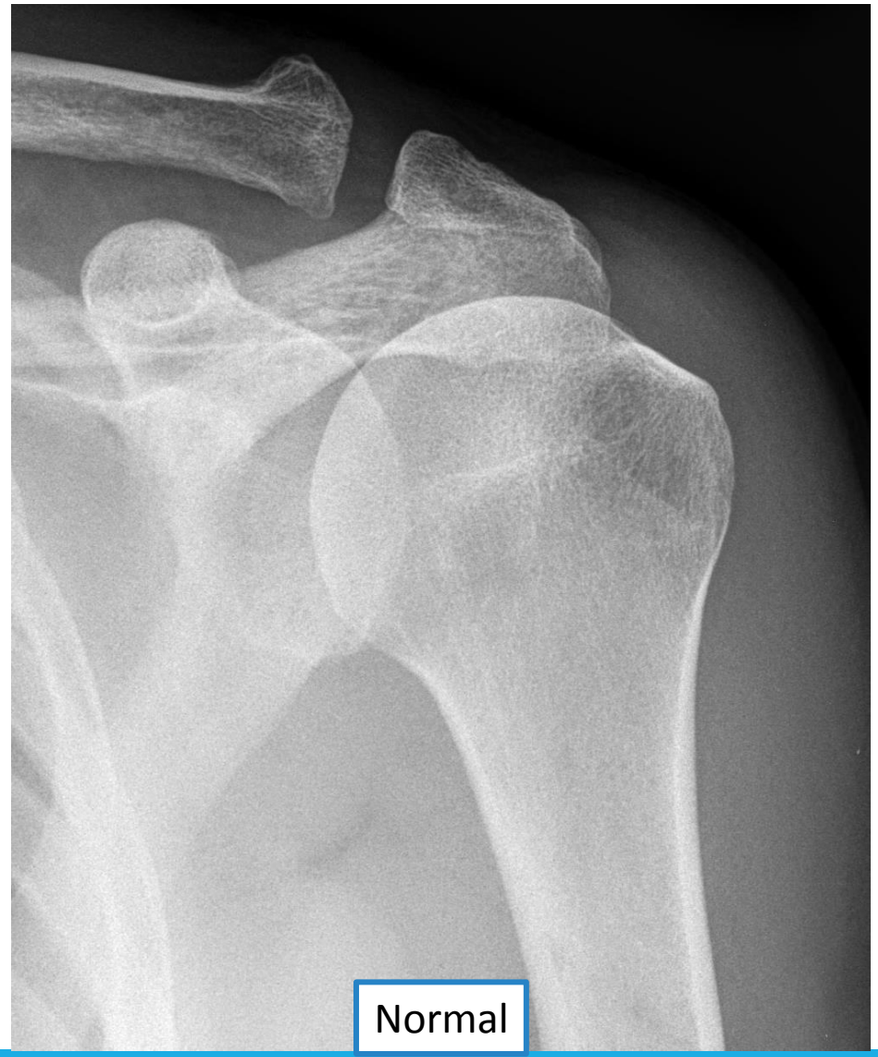


Sickle Cell Anemia (cont.)

Medullary bone infarcts in a 22-year-old patient with SCA.

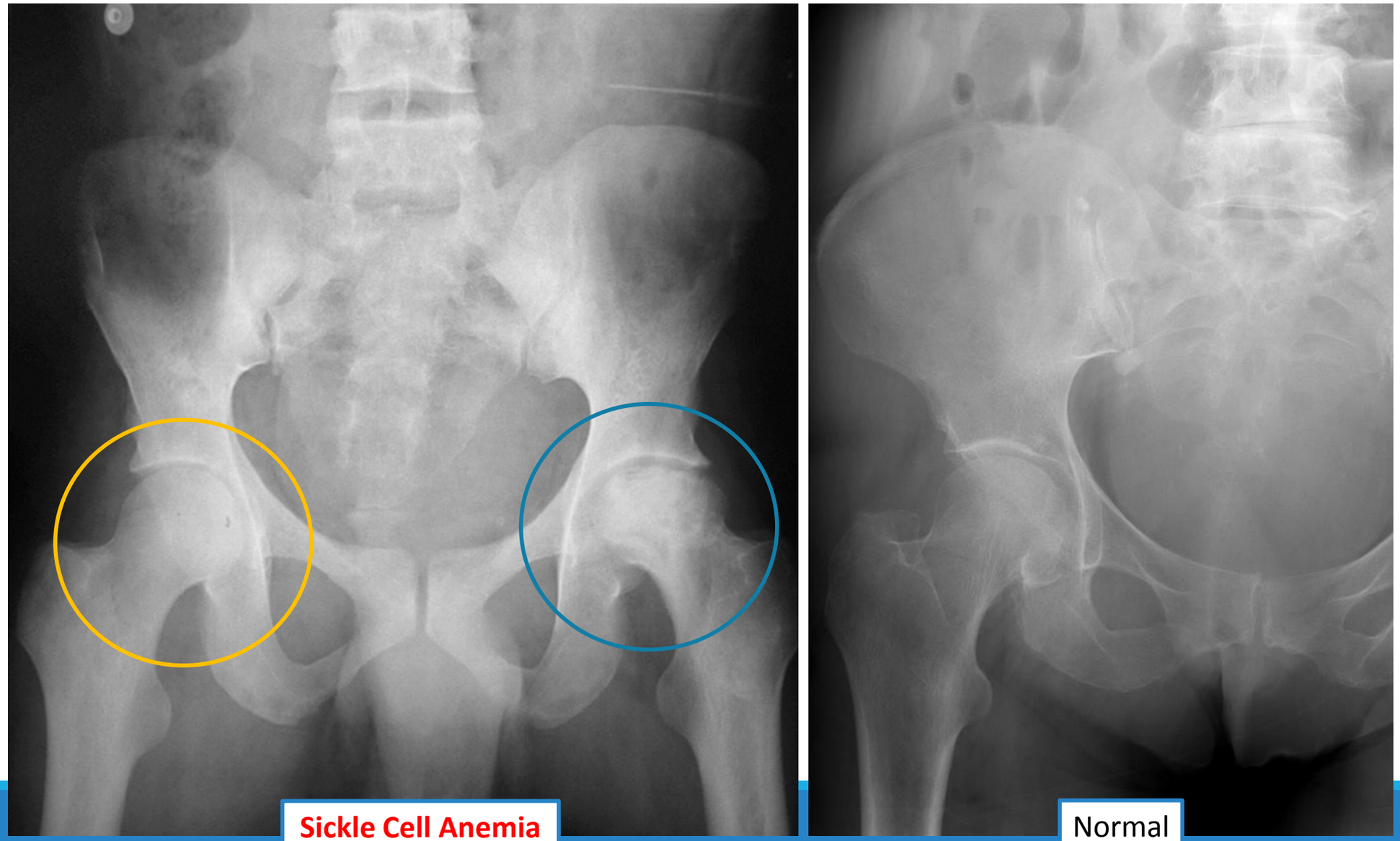
- Frontal radiograph of right shoulder shows: an area of patchy sclerosis and radiolucency.



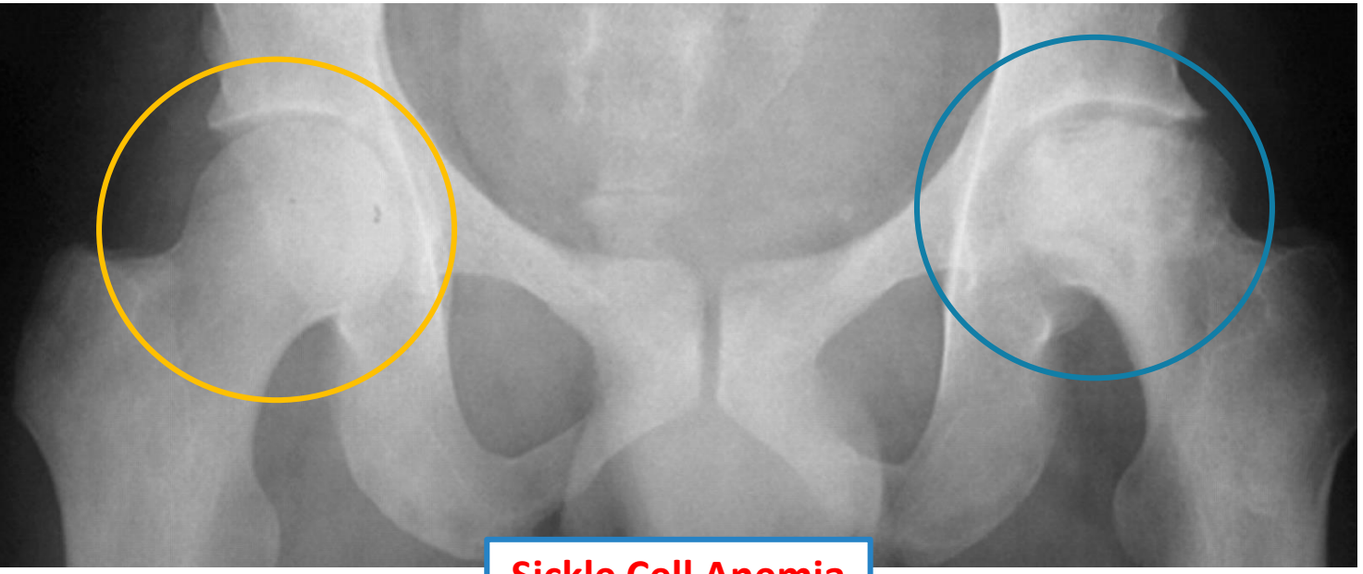


Sickle Cell Anemia (cont.)

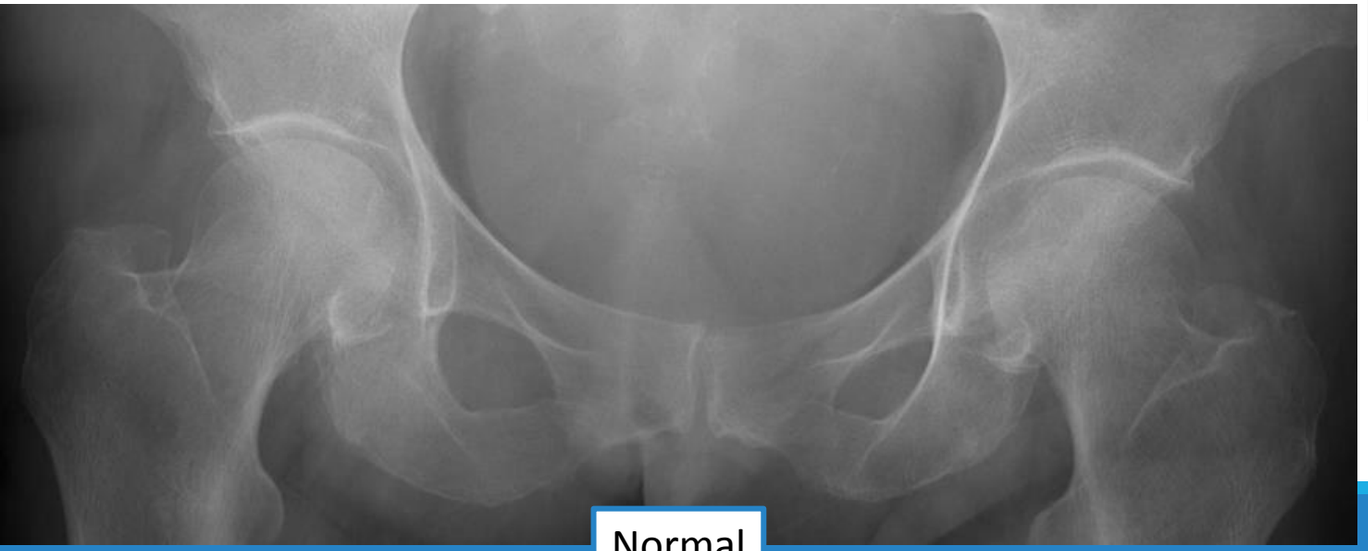
AP radiograph in a 44-year-old man shows: advanced avascular necrosis in left hip (blue circle) and a normal right hip (orange circle).



Sickle Cell Anemia (cont.)



Sickle Cell Anemia



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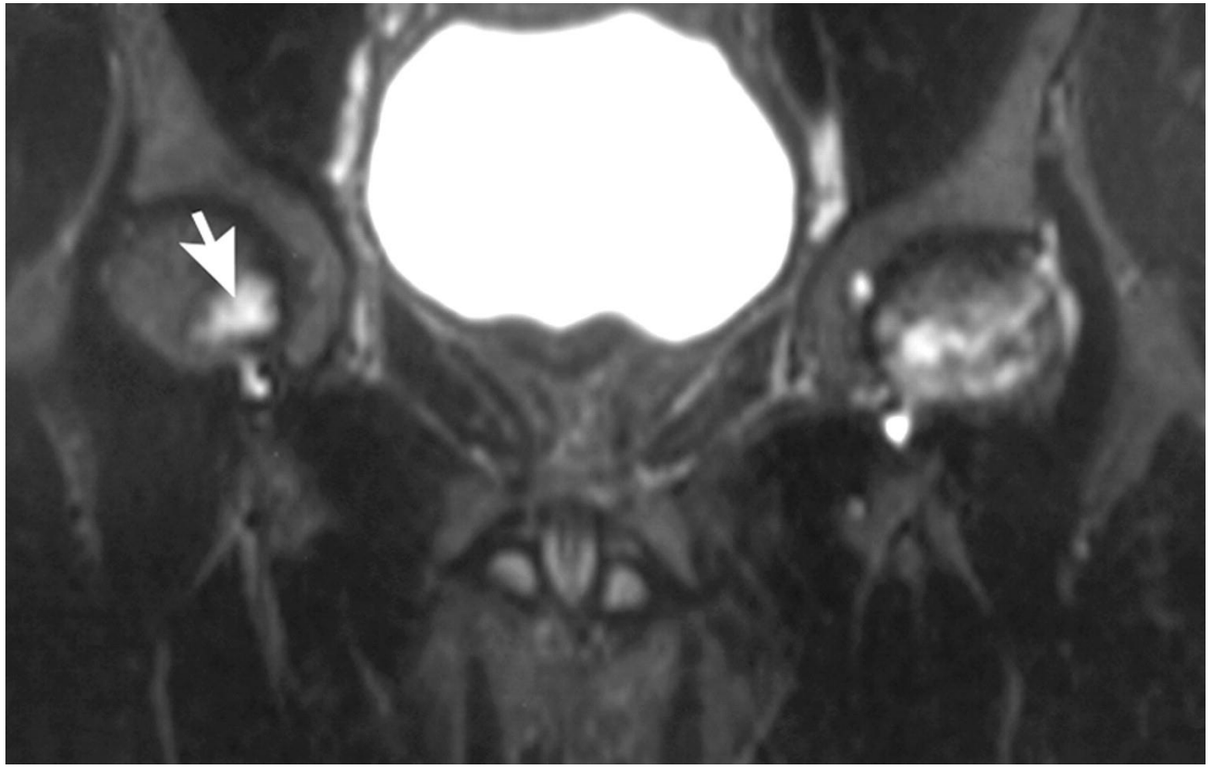


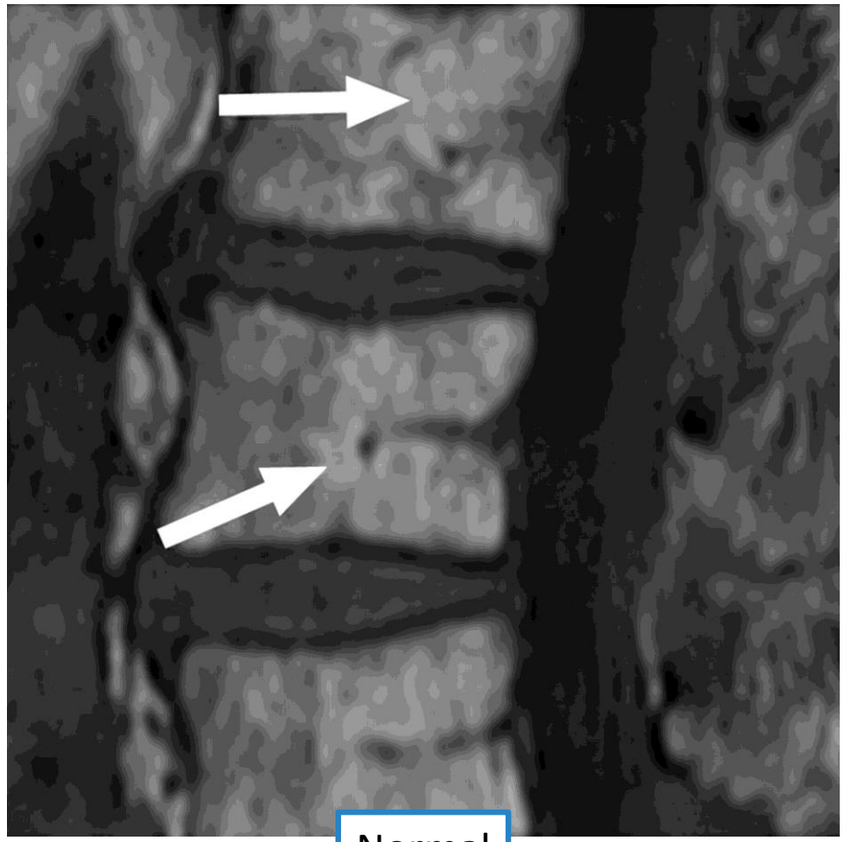
Coronal STIR MR image in the same patient shows:

- **Stage 1 avascular necrosis** in right hip (arrow).
- Advanced changes of avascular necrosis of left femoral head.
- After we did MRI there is a minor change on the right that was look normal on x-ray.

Sickle Cell Anemia (cont.)

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.
- H-shaped vertebrae (arrows in right image) due to **osteonecrosis** of vertebral endplates.
- The normal looking for the disk is dark while the bone is white.



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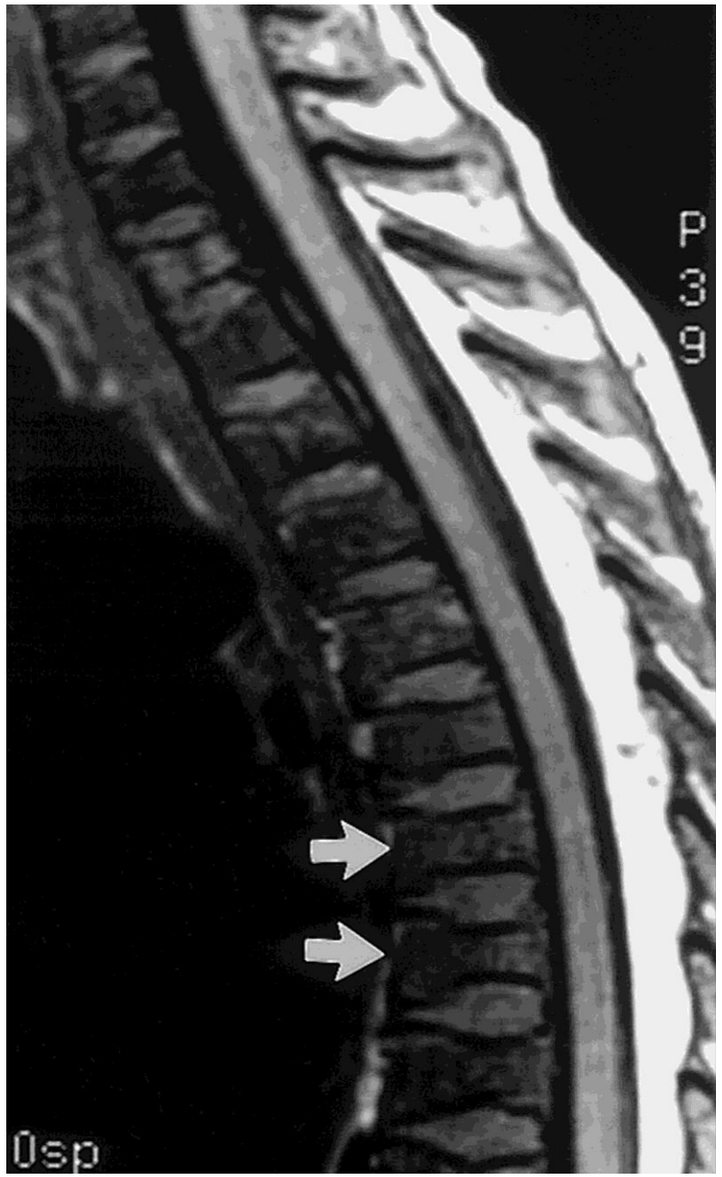
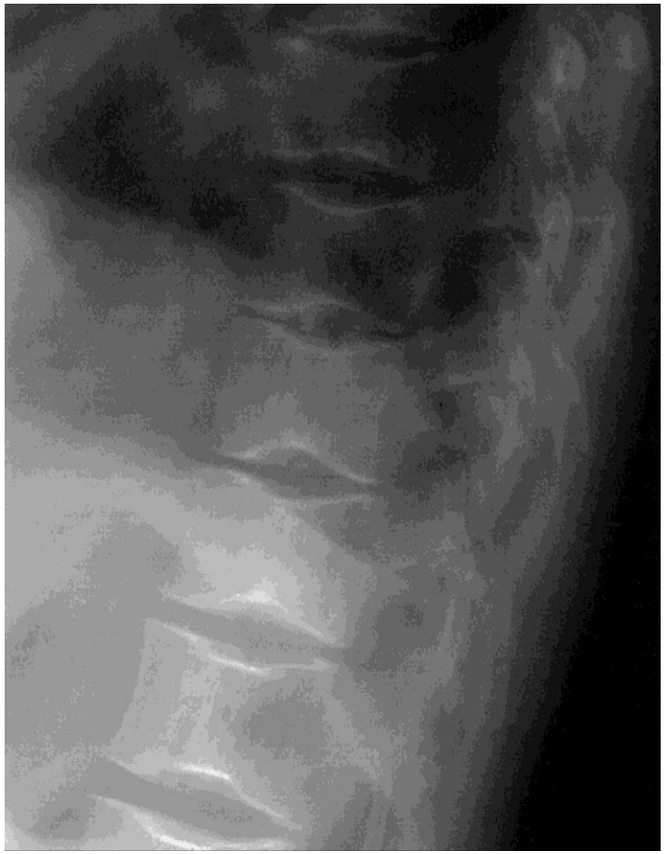
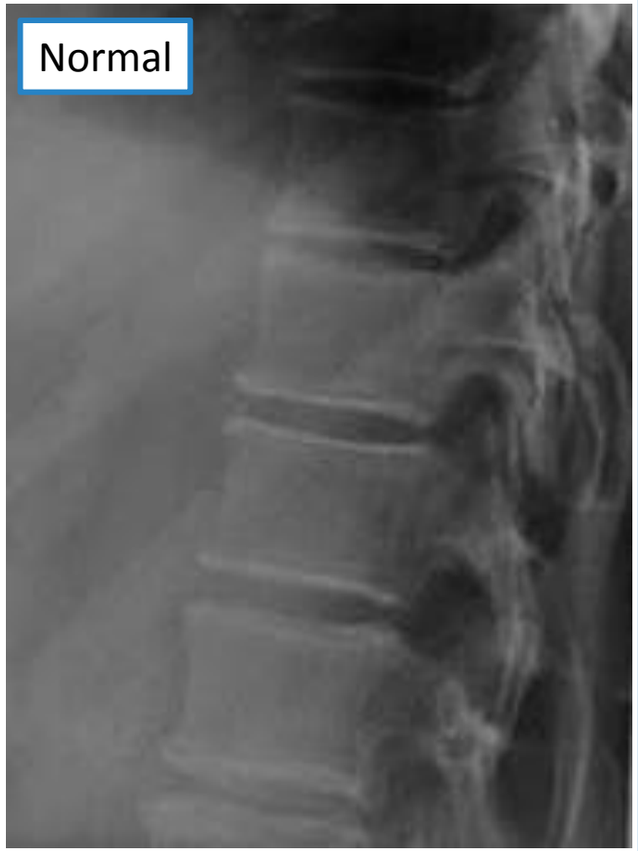


Sickle Cell Anemia (cont.)

A 15-year-old patient with SCA.

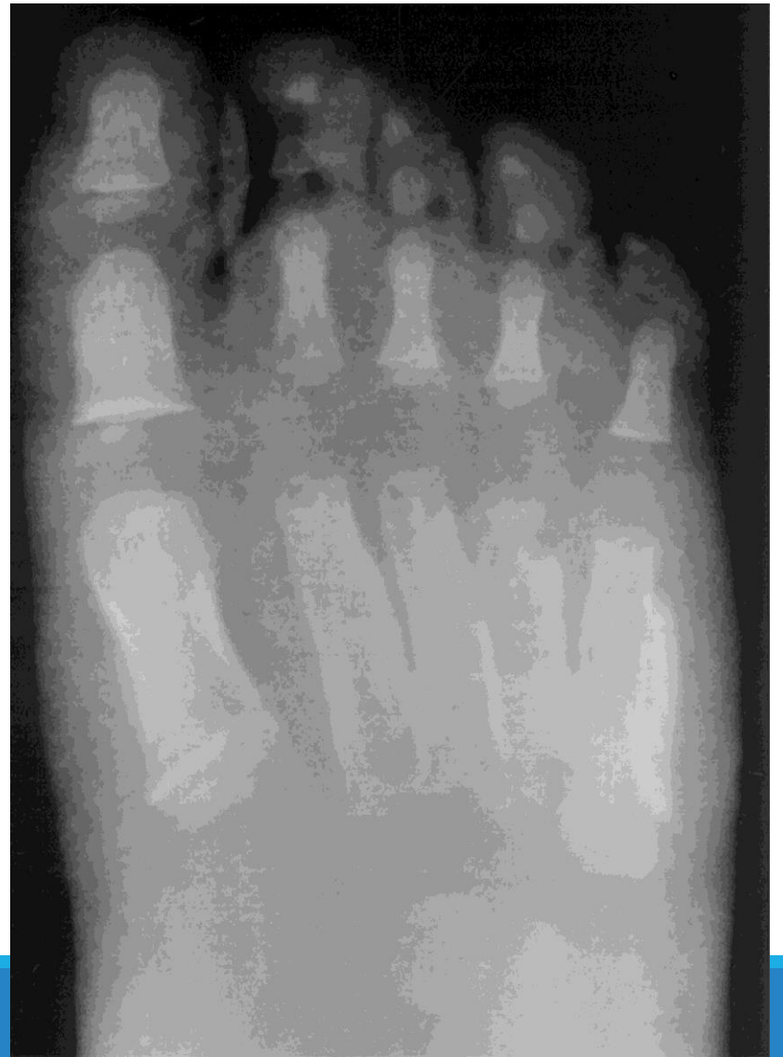
- Lateral radiograph of spine shows:
- Classic boxlike endplate depressions in middle portion (see the lowest vertebra shown) due to **osteonecrosis** of the vertebral endplates. **(H-shaped vertebrae)**





A 3-year-old girl with **Hand-foot syndrome (Dactylitis).**

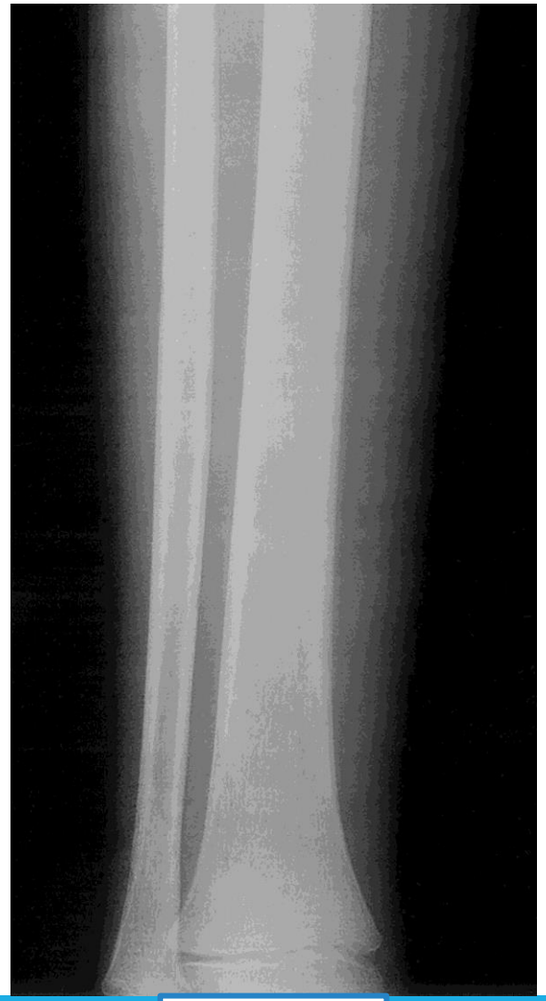
- Frontal radiograph of right foot shows: thick periostitis and subperiosteal new bone along the metatarsal shafts.
- These changes are due to chronic ischemia.



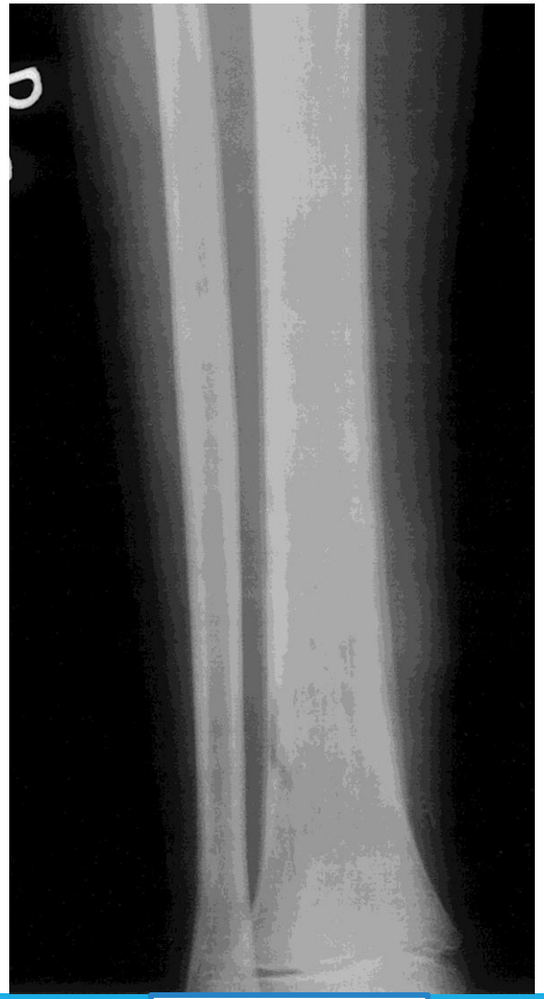
Sickle Cell Anemia (cont.)

Salmonella osteomyelitis in a 10-year-old boy with SCA.

- Initial film (left) at onset of lower shin pain and fever is normal.
- Film 7 days later (right) shows: mottled attenuation of lower tibial shaft and diffuse periostitis of the lower diaphysis.

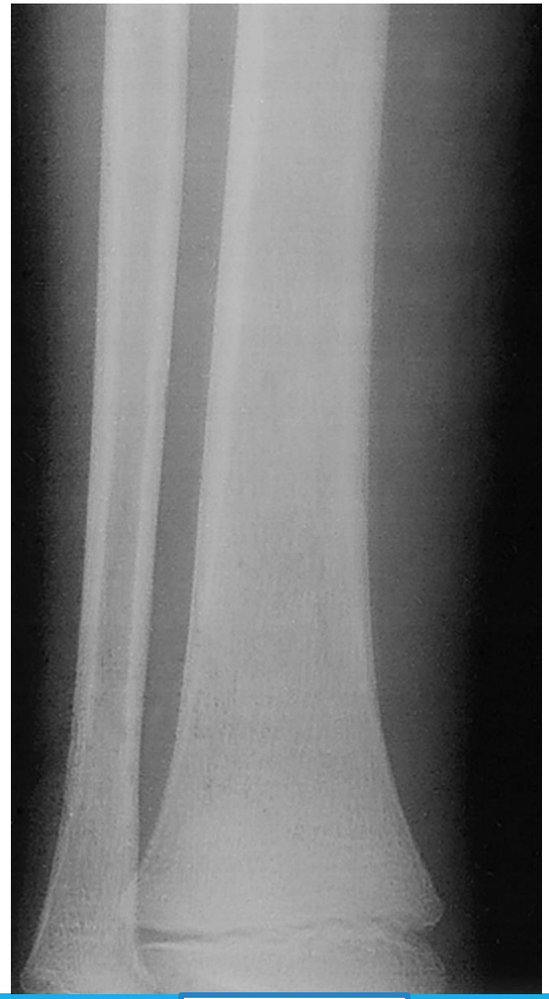


Initial film



7 days later

Zoom



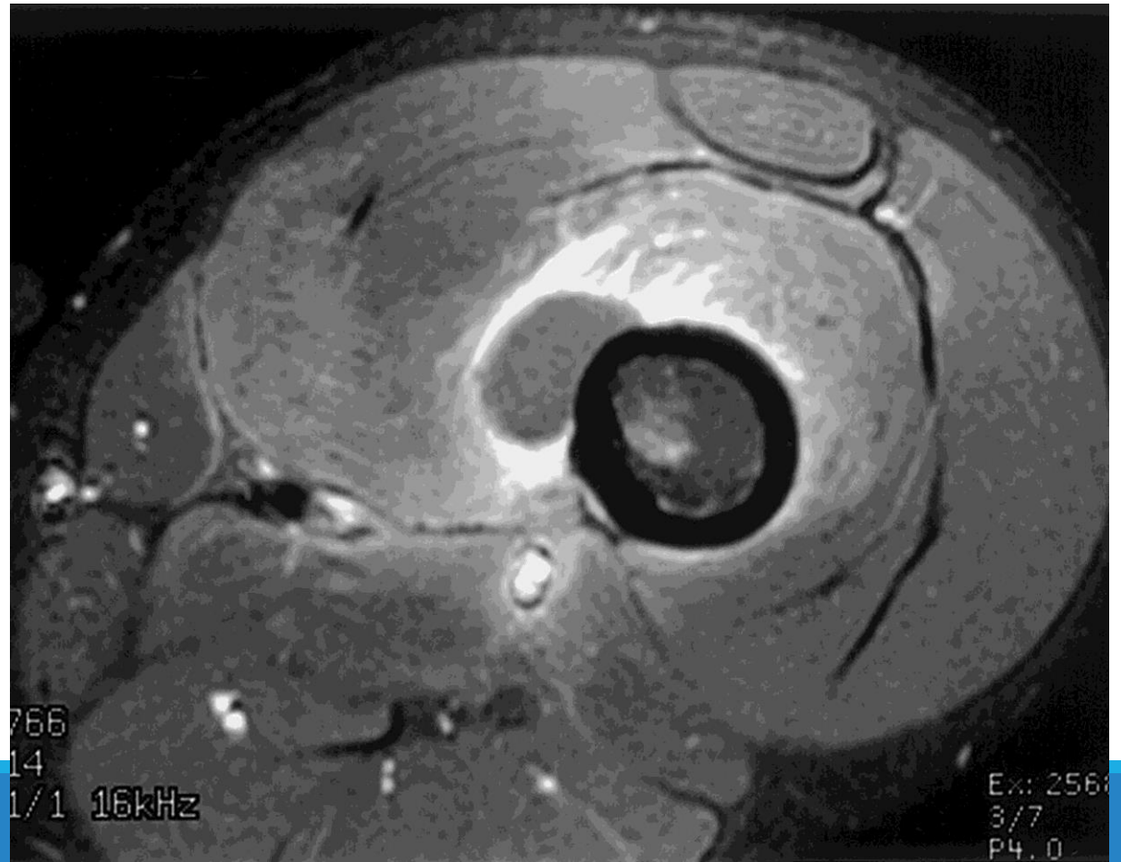
Initial film

7 days later

Sickle Cell Anemia (cont.)

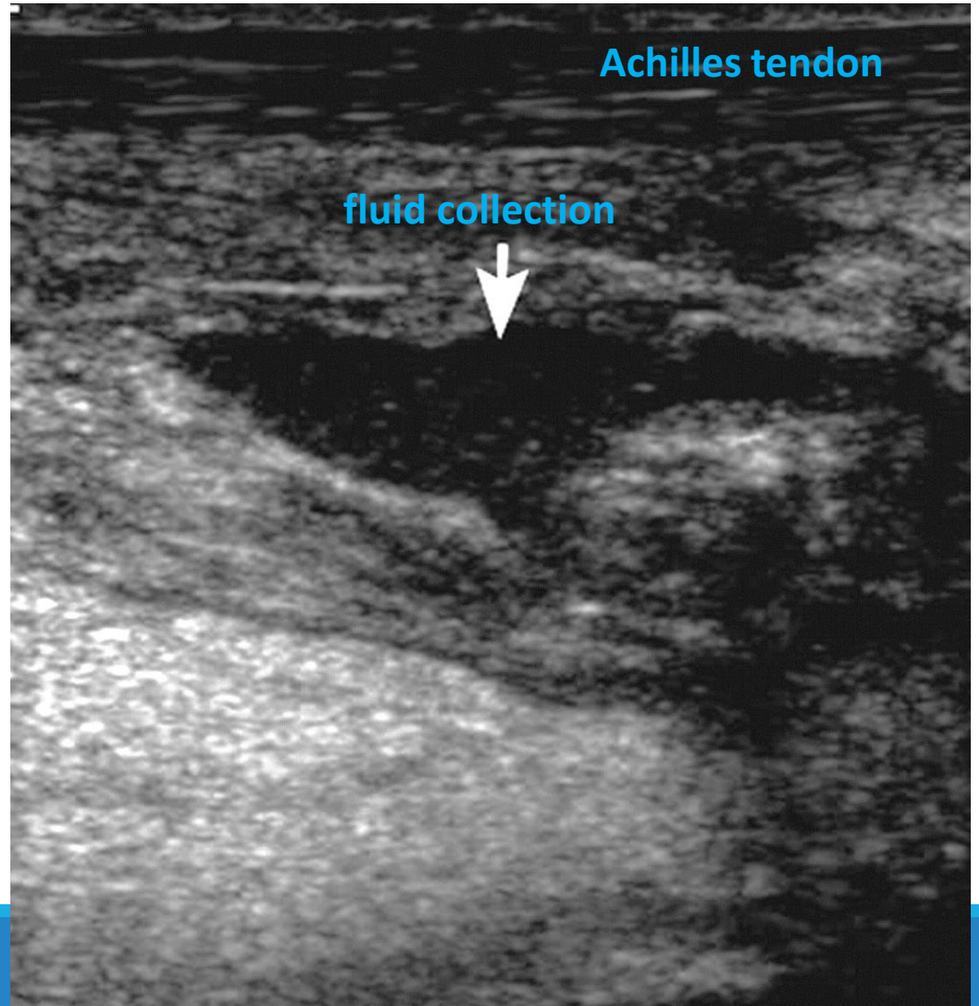
Osteomyelitis of femur in a 24-year-old patient with SCA.

- Axial T1-weighted MRI after contrast shows:
- Heterogeneous enhancement of marrow cavity.
- Rounded low-signal-intensity area adjacent to the shaft that is non-enhancing (fluid collection).
- Enhancement of the soft tissues around the shaft and of the adjacent musculature.
- Areas of enhancement are likely infected.



Soft-tissue infection in a 52-year-old man with homozygous sickle cell disease.

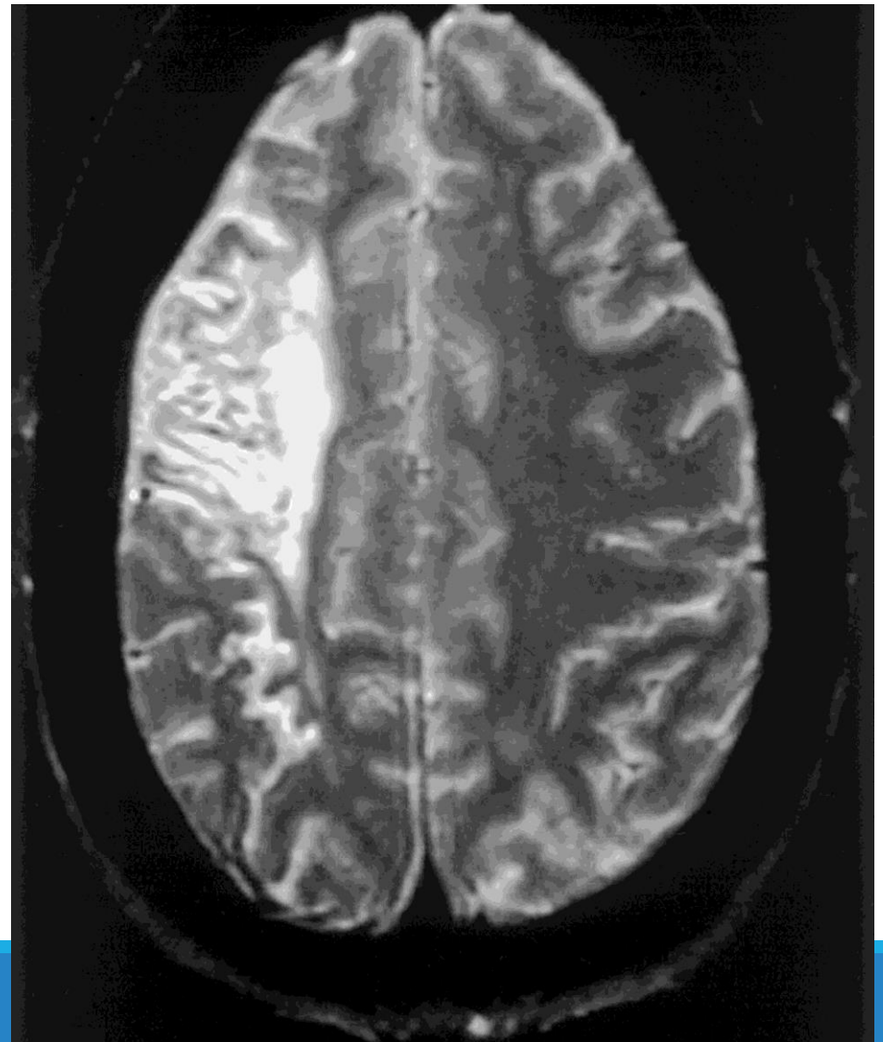
- Longitudinal high-resolution ultrasound image of left ankle shows: a hypoechoic (dark) fluid collection (arrow) deep to Achilles tendon.
- Thick pus was aspirated from this area under ultrasound guidance.



Sickle Cell Anemia (cont.)

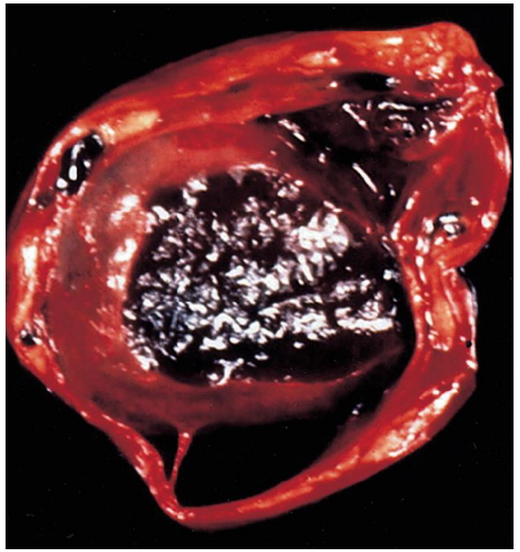
Chronic infarct in a 19-year-old patient with SCA and longstanding mild left sided weakness.

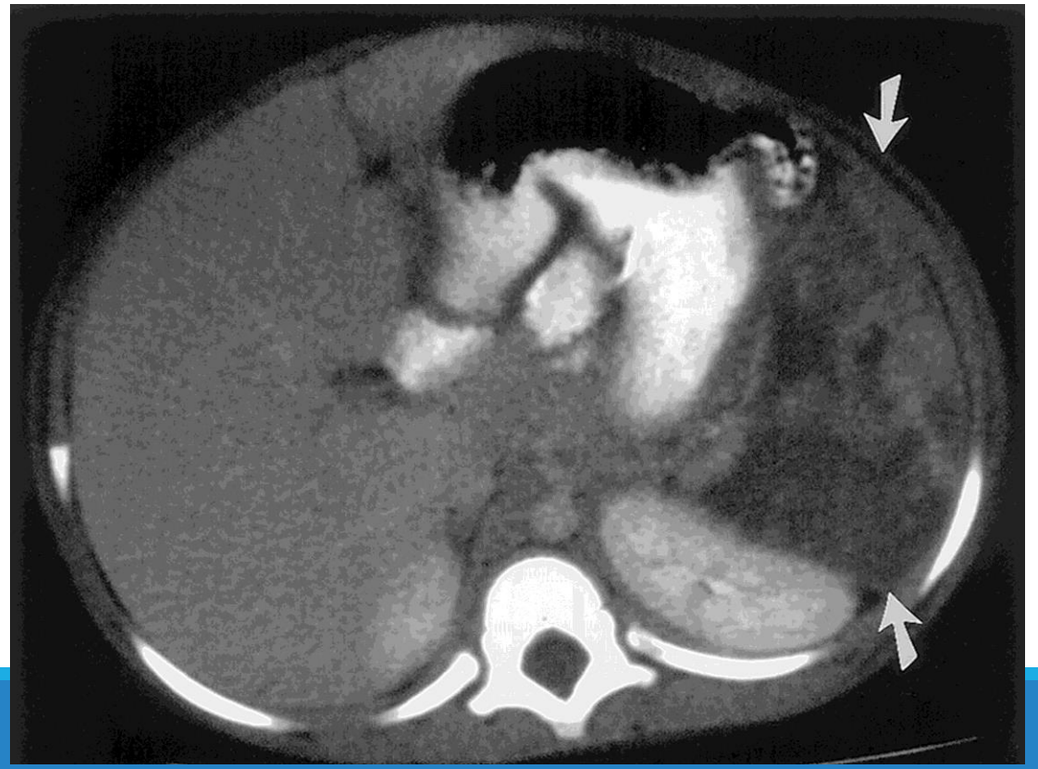
- Axial T2-weighted MRI shows: an area of high signal intensity and enlargement of overlying CSF spaces, compatible with **chronic infarction and atrophy.**



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.

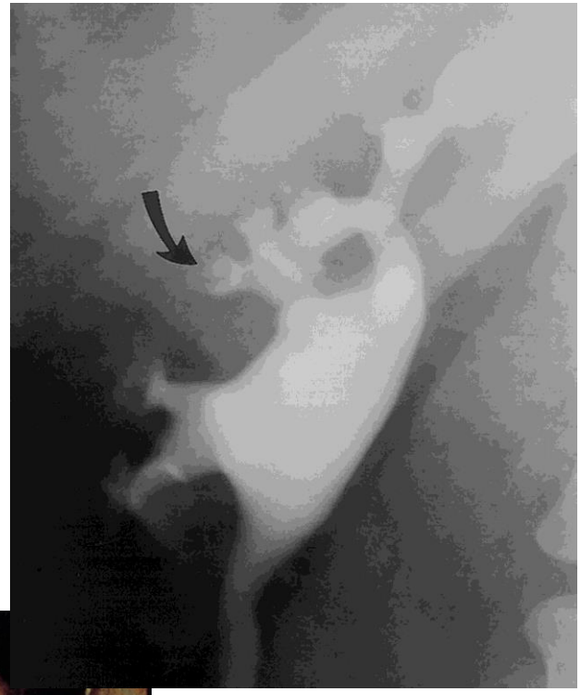




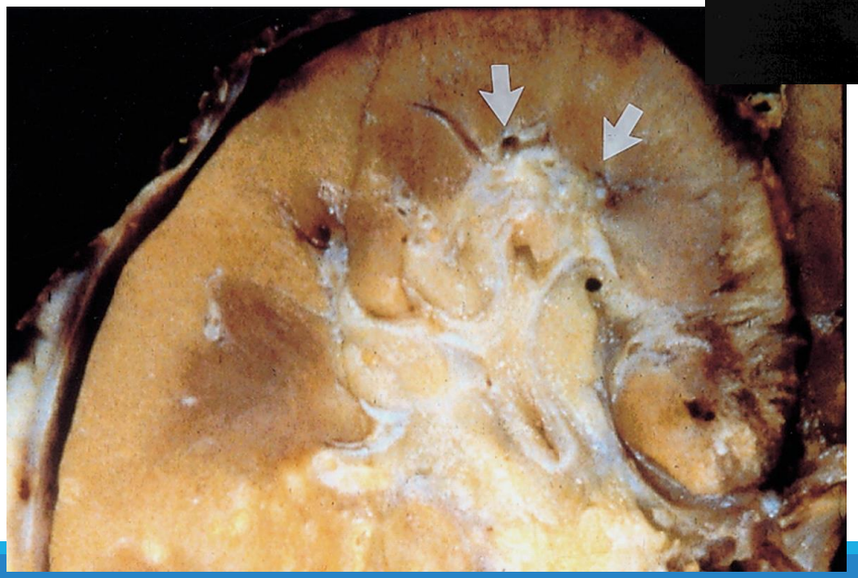
Sickle Cell Anemia (cont.)

Papillary necrosis in a 32-year-old man with SCA

- Frontal view of kidney during excretory urography shows: a small, round collection of contrast material in a missing papillary tip (arrow).

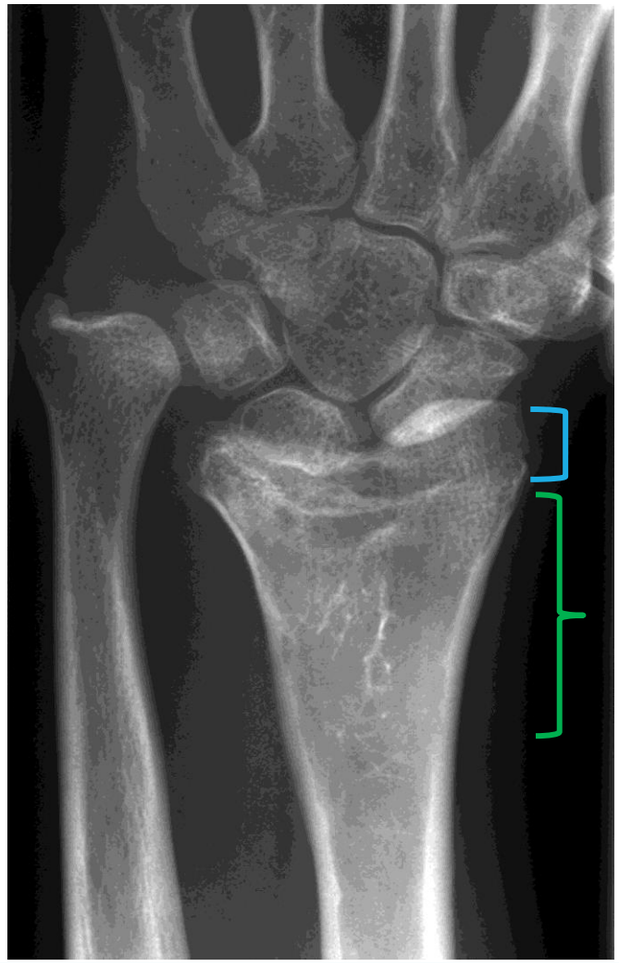


- Photograph of a kidney from a different patient shows loss of papillary tips in some upper pole pyramids (arrows).



Growth disturbance in distal radius in a 12-year-old girl.

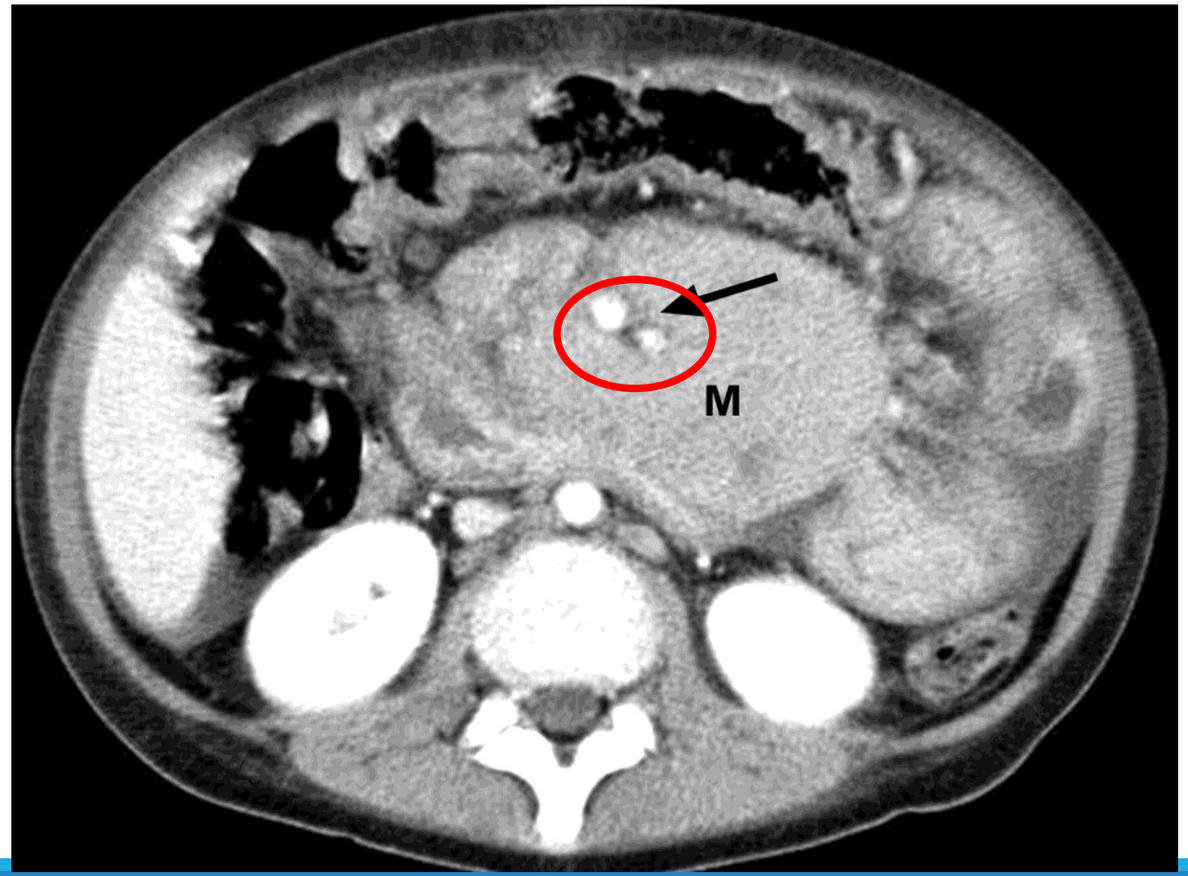
- Anteroposterior (AP) radiograph of left wrist shows:
  - Epiphyseal shortening (blue arrow).
  - A cup deformity of adjacent metaphysis (green arrow).
  - Changes of old bone infarct in distal radius.



LYMPHOMA

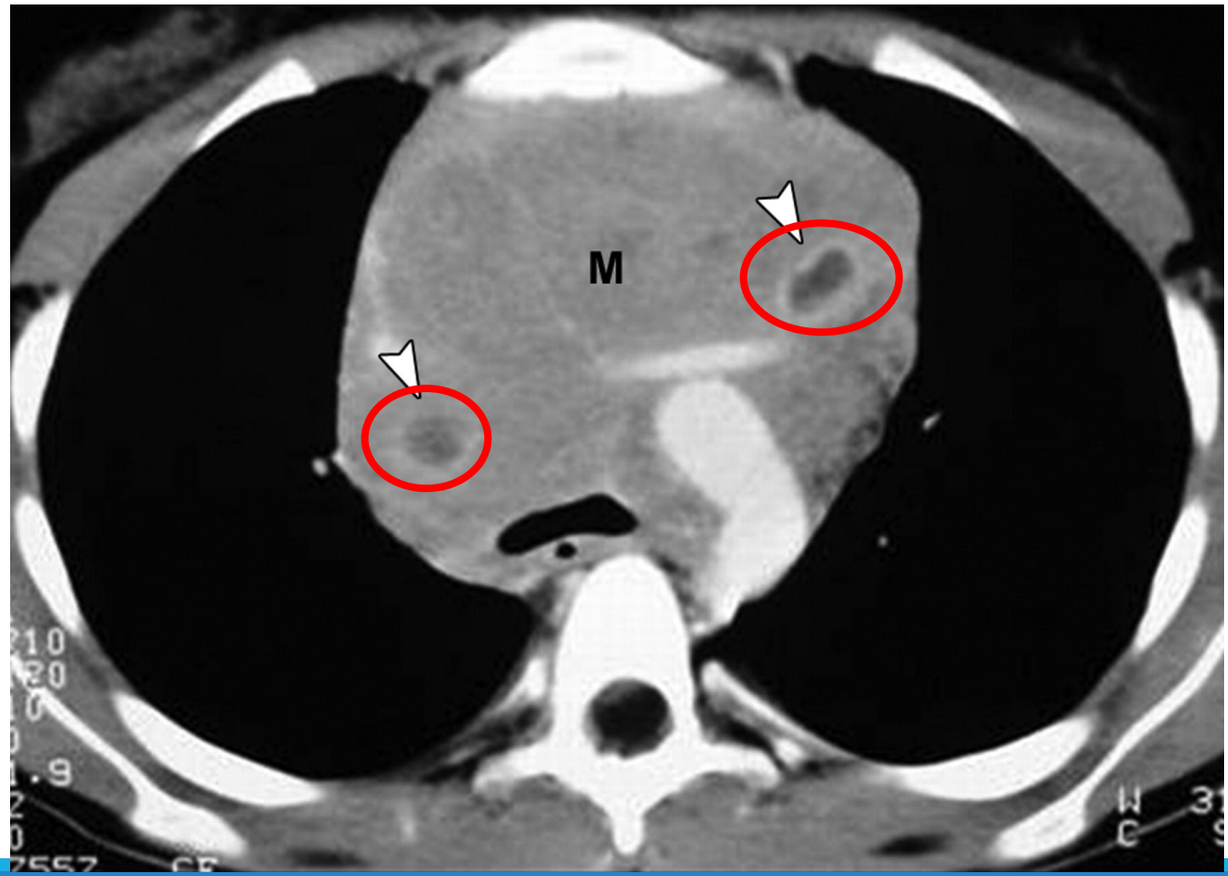
NHL in an 11-year-old boy.
Axial CT scan shows:

- Large lymphomatous mass (M) encasing the mesenteric vessels (arrow).



NHL in a 14-year-old boy.
Contrast-enhanced CT scan shows:

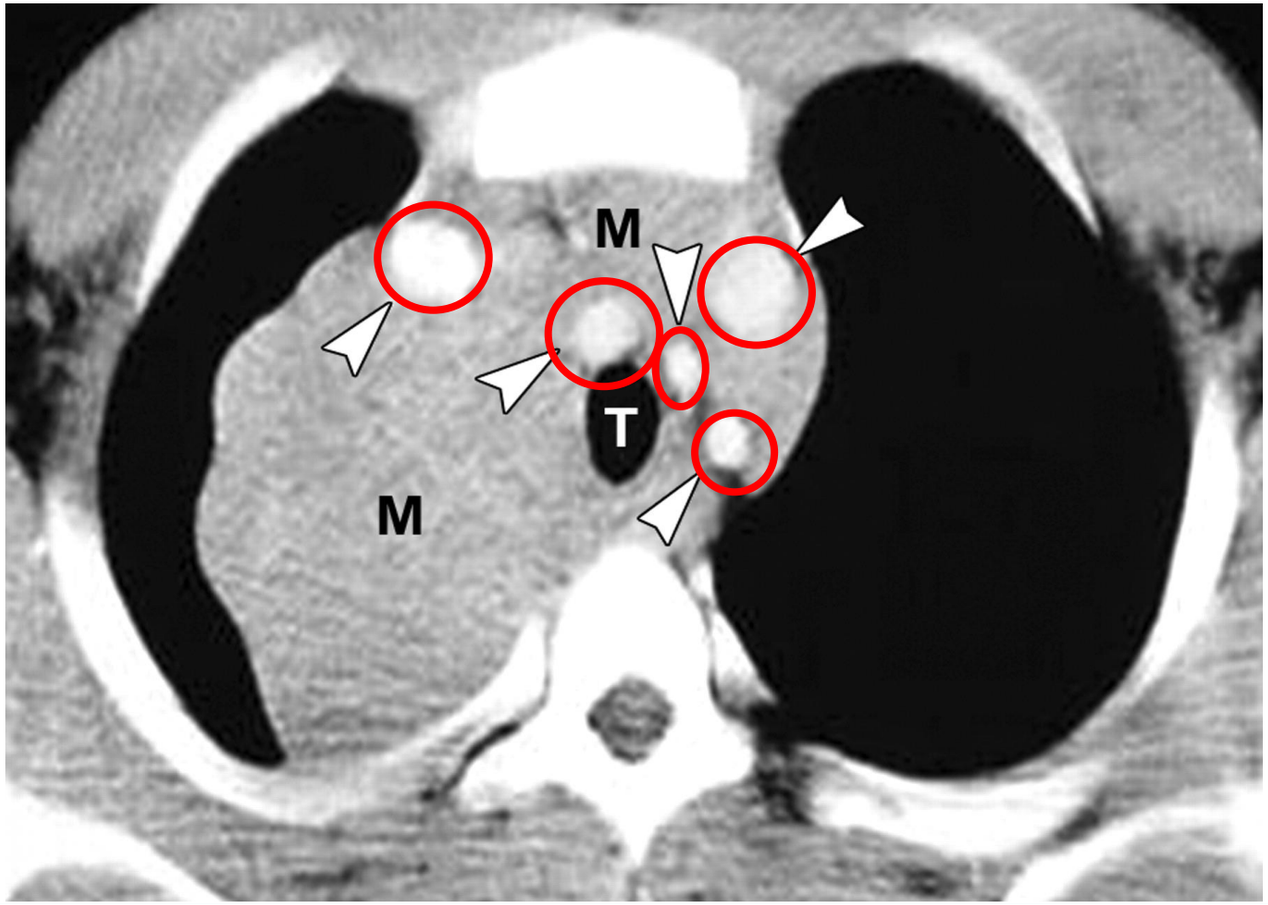
- A large anterior mediastinal mass (M) that originates from thymus.
- A few cysts with central low attenuation.
- Peripheral enhancing ring are present (arrows).



Lymphoma (cont.)

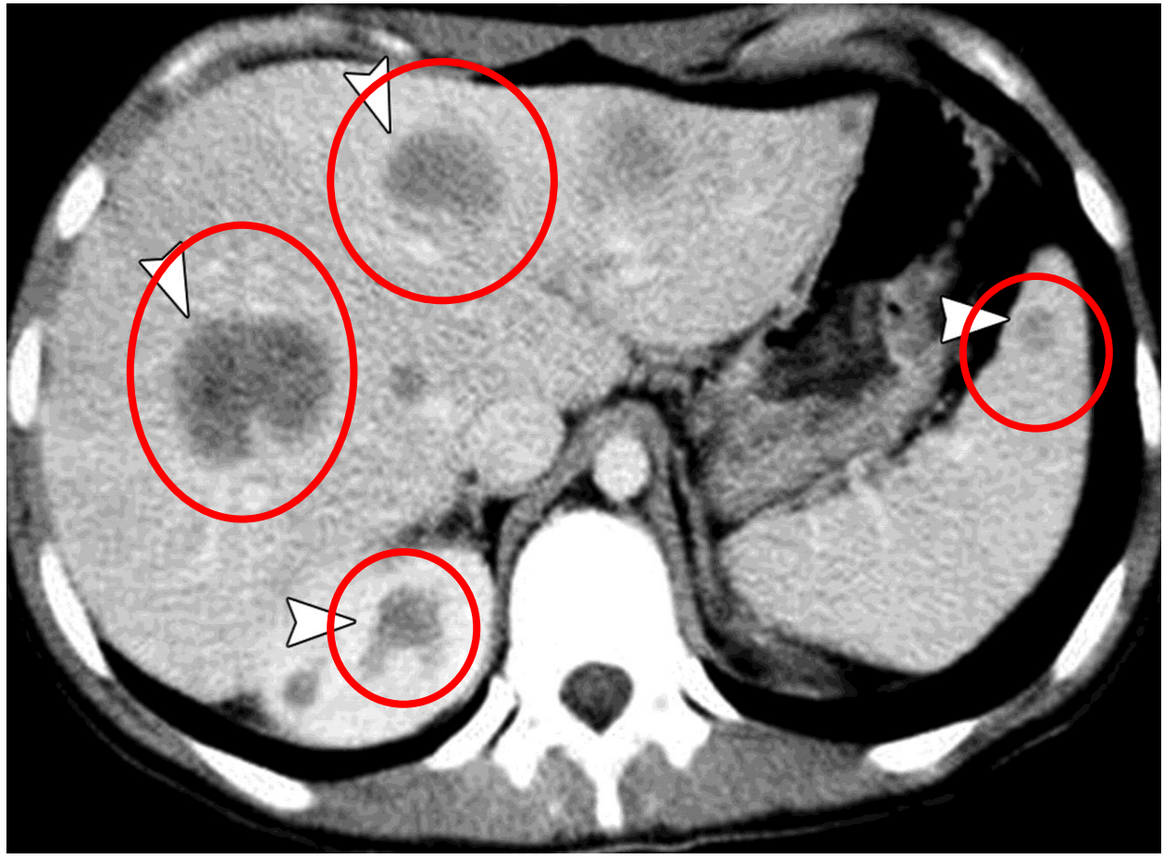
HD in a 17-year-old boy.

- Contrast-enhanced CT scan shows:
- A large mediastinal mass (M).
- Trachea (T) is compressed.
- Great vessels (arrows) are displaced.



NHL in a 16-year-old girl.

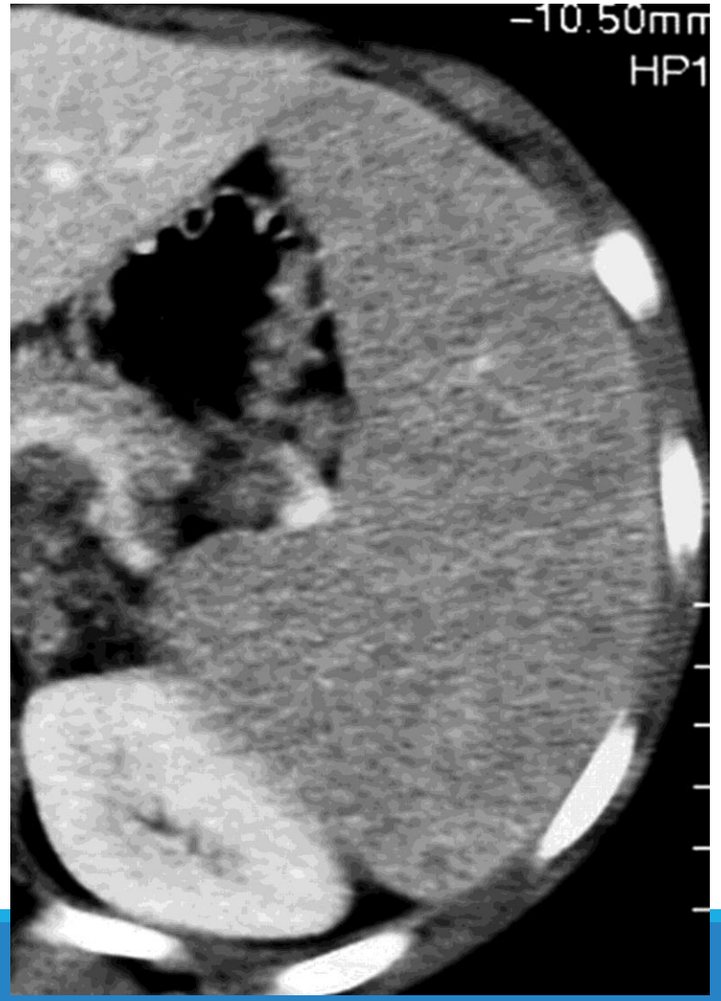
- Contrast-enhanced CT scan shows:
- Low-density lesions (arrows) in both hepatic lobes.
- With small nodules in spleen and right kidney.



Lymphoma (cont.)

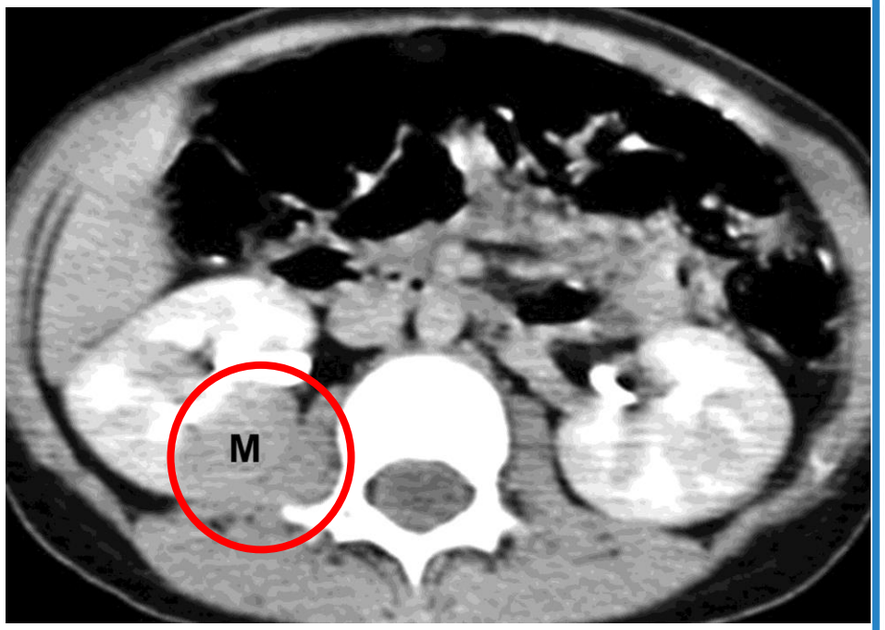
HD in a 12-year-old girl

- Contrast-enhanced CT scan shows: an enlarged spleen with a diffusely inhomogeneous appearance.



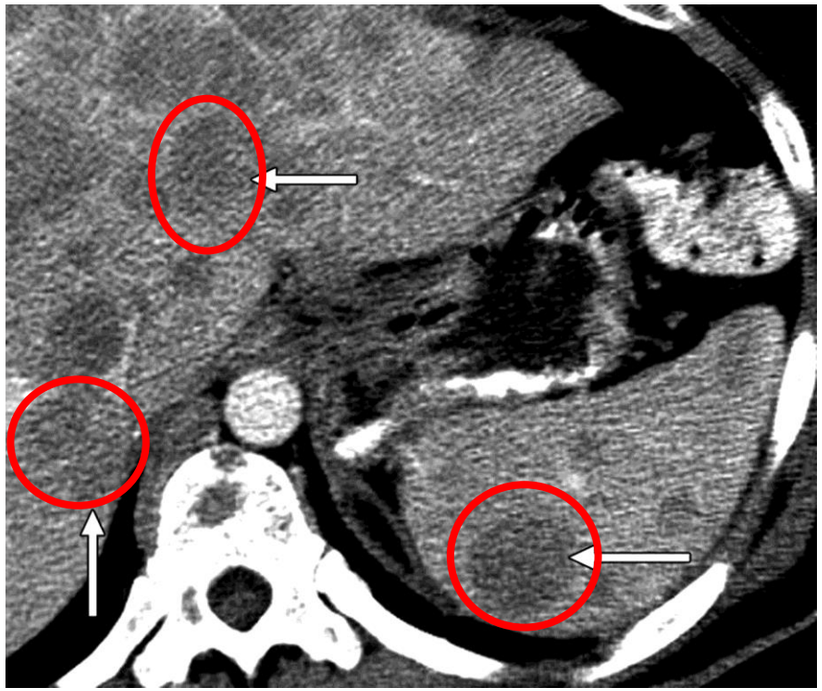
NHL in a 14-year-old boy.

- Contrast-enhanced CT scan shows: single well-defined, low density focus (M) in right kidney.



Diffuse hepatosplenic involvement in lymphoma.

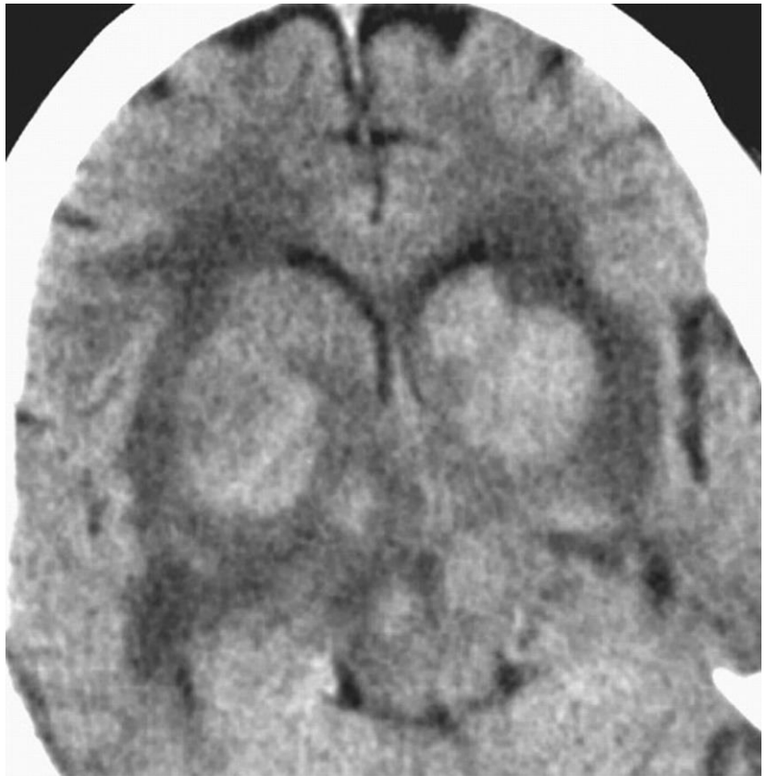
- Axial CT scan shows: multiple round, homogeneous, low density nodules (arrows) in liver and spleen.



Lymphoma (cont.)

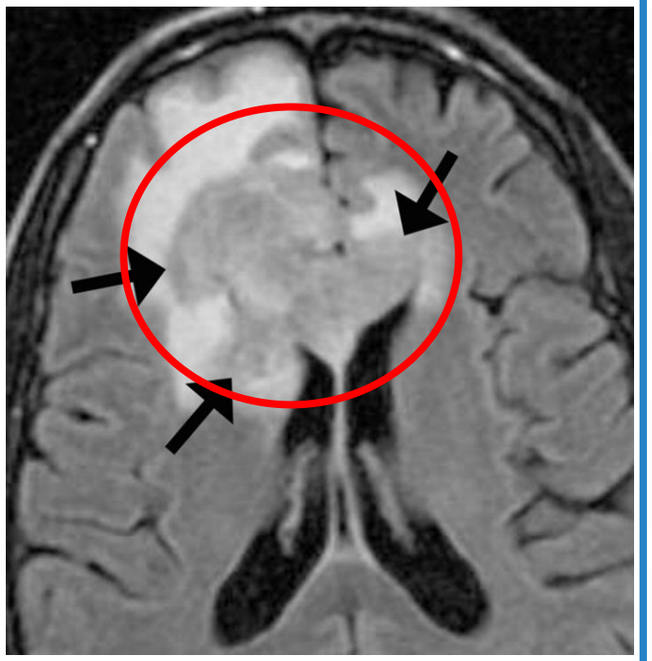
72-year-old immuno-competent woman with **primary CNS non-Hodgkin's B-cell lymphoma**.

- Unenhanced CT image shows: classic hyperdense masses involving deep white and gray matter.



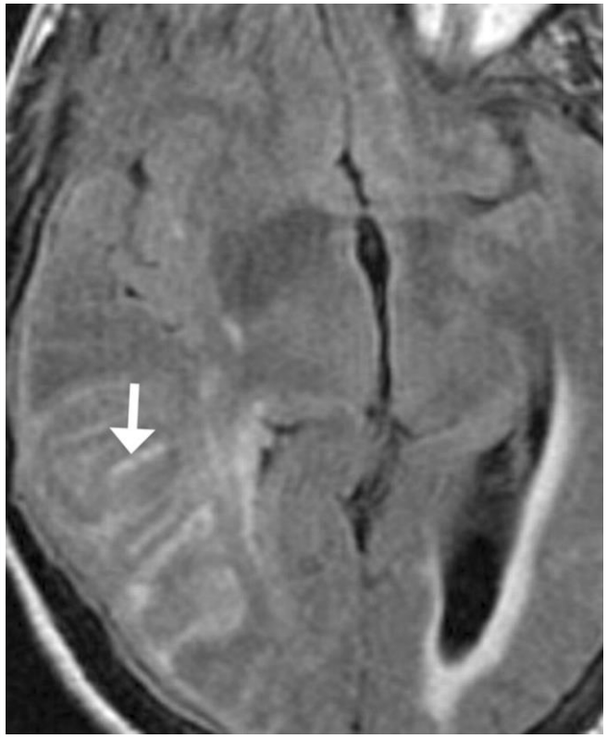
44-year-old HIV-positive woman with **primary CNS non-Hodgkin's B-cell lymphoma**.

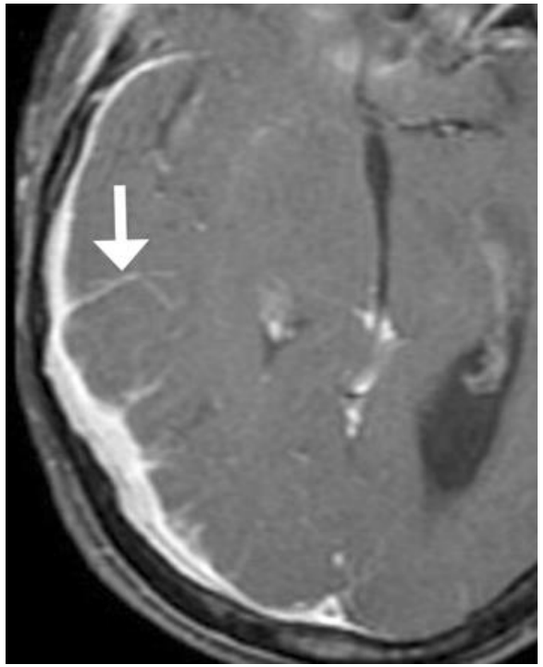
- Axial FLAIR MRI shows: lesion isointense to gray matter (arrows).



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.

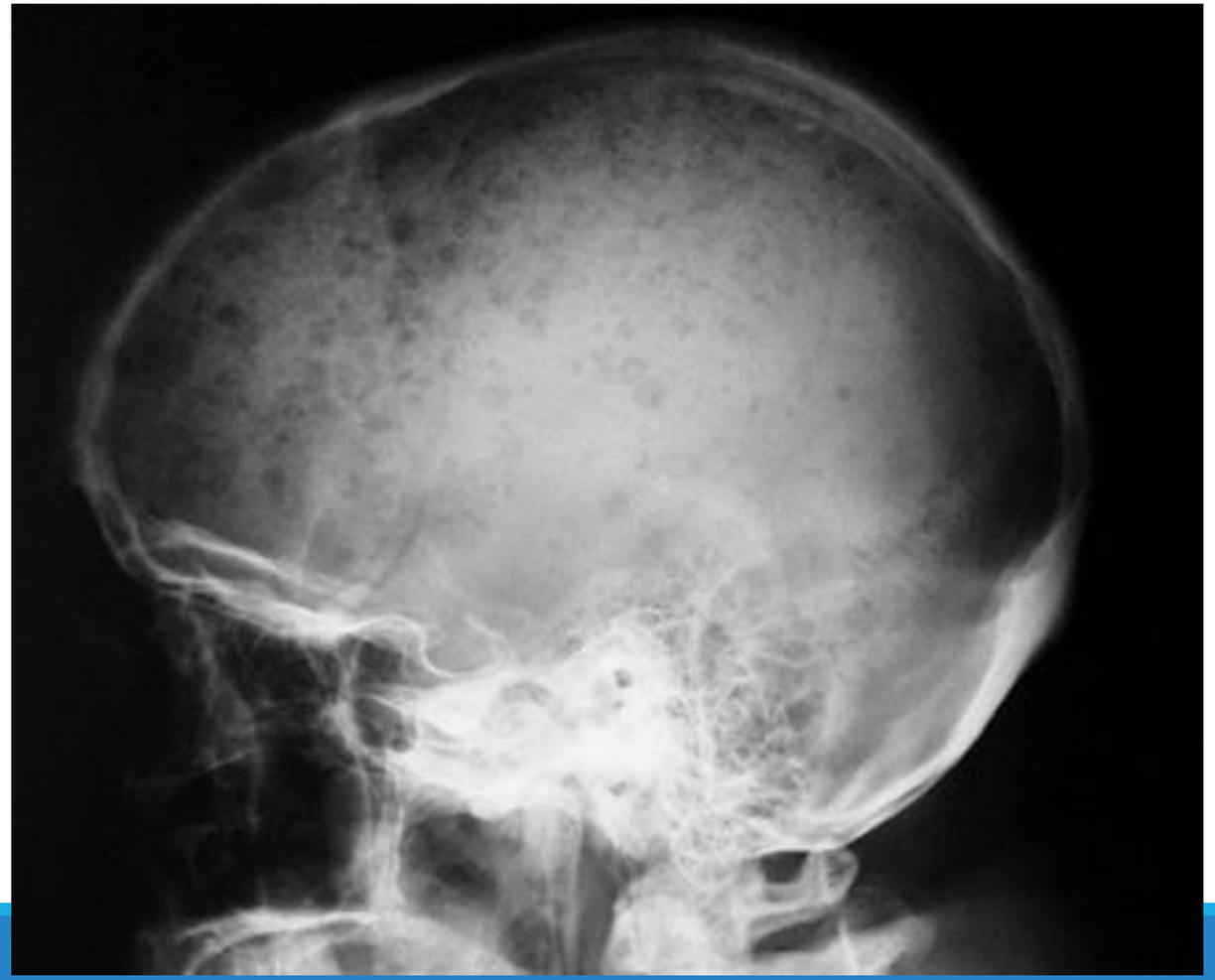




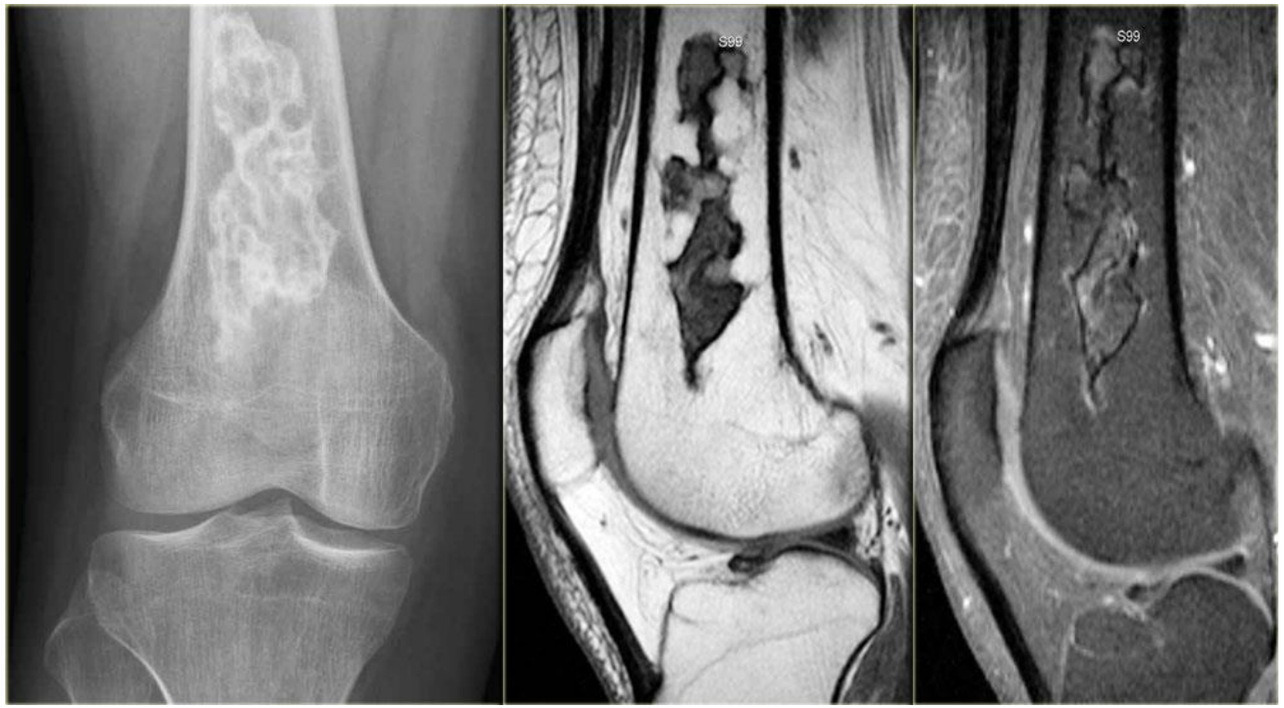
Multiple Myeloma:

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

- Collection of **plasma cell in the bone** that eat up the bone and make it looks like **dots appearing**.



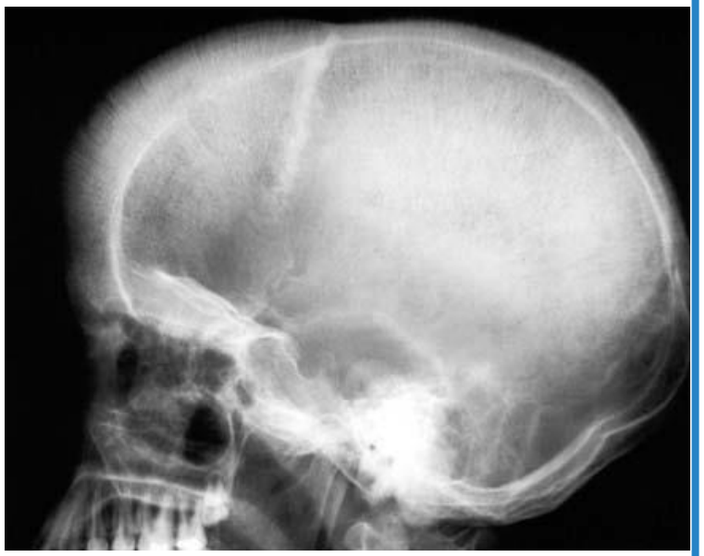
Notes & MCQs from the doctor:



Sickle cell anemia – Bone infarction.

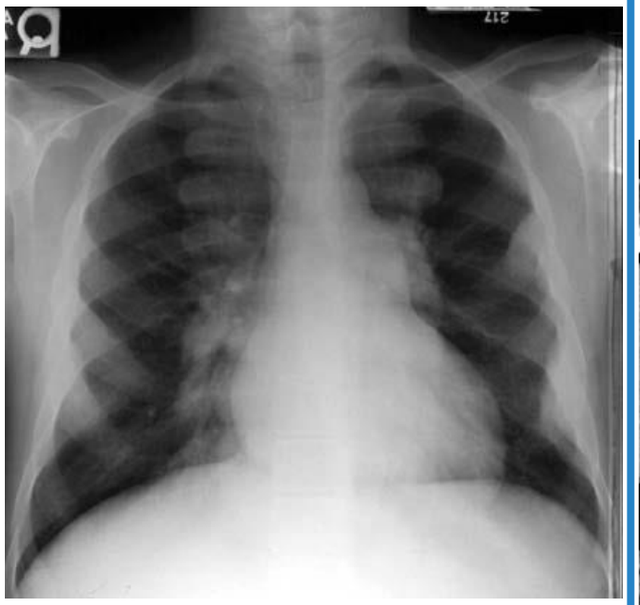
(Keep in mind that bone infarction can be associated with many diseases, but for this lecture this is a sickle cell anemia).

Notes & MCQs from the doctor:



1. Findings shown here can be seen in:

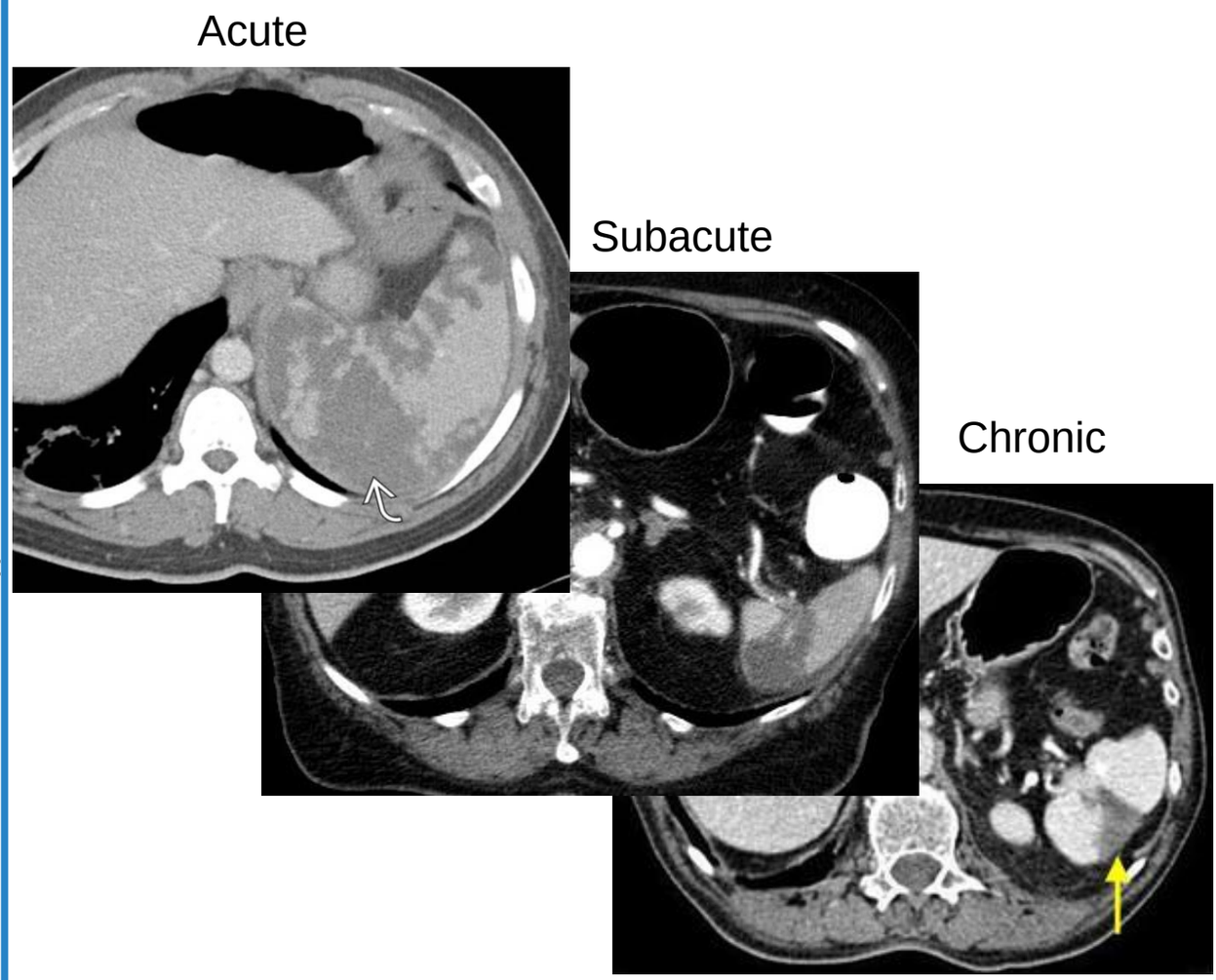
A. Thalassemia
B. Sickle cell anemia
C. Lymphoma
D. Lymphoma
E. Any severe chronic anemia



2. Findings shown here can be seen in:

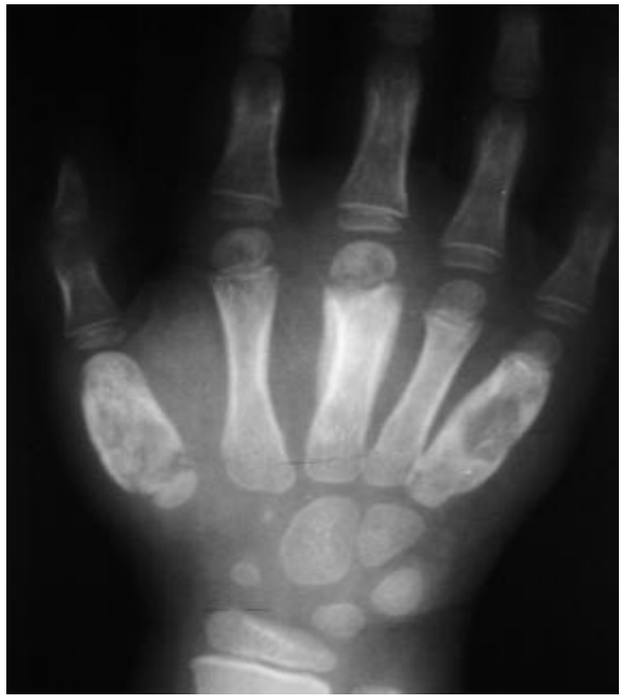
A. Thalassemia
B. Sickle cell anemia
C. Lymphoma
D. Lymphoma
E. Any severe chronic anemia

Various Patterns of Splenic Infarcts:

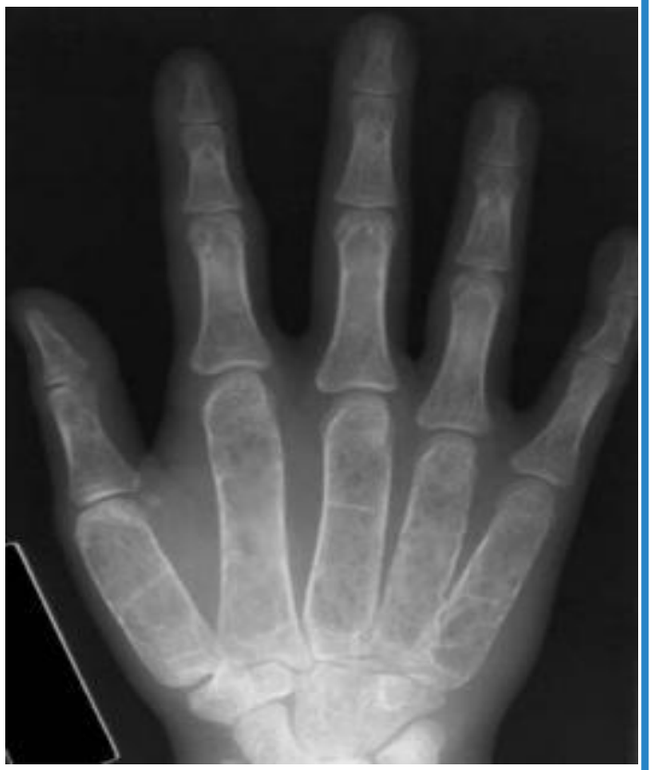


Answers: 1. E 2. E

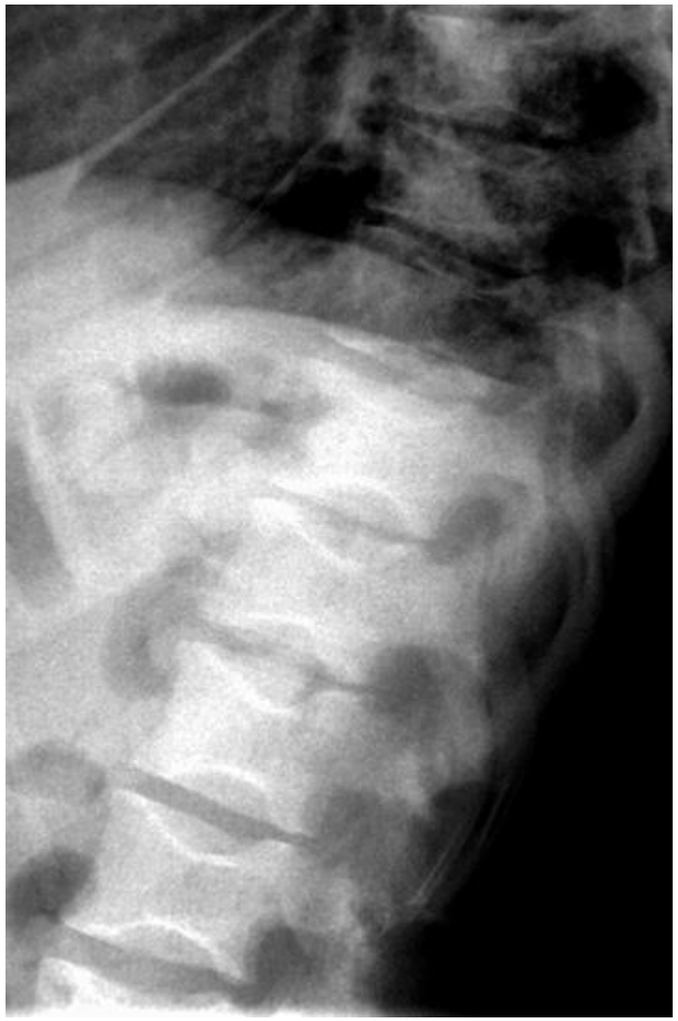
Notes & MCQs from the doctor:

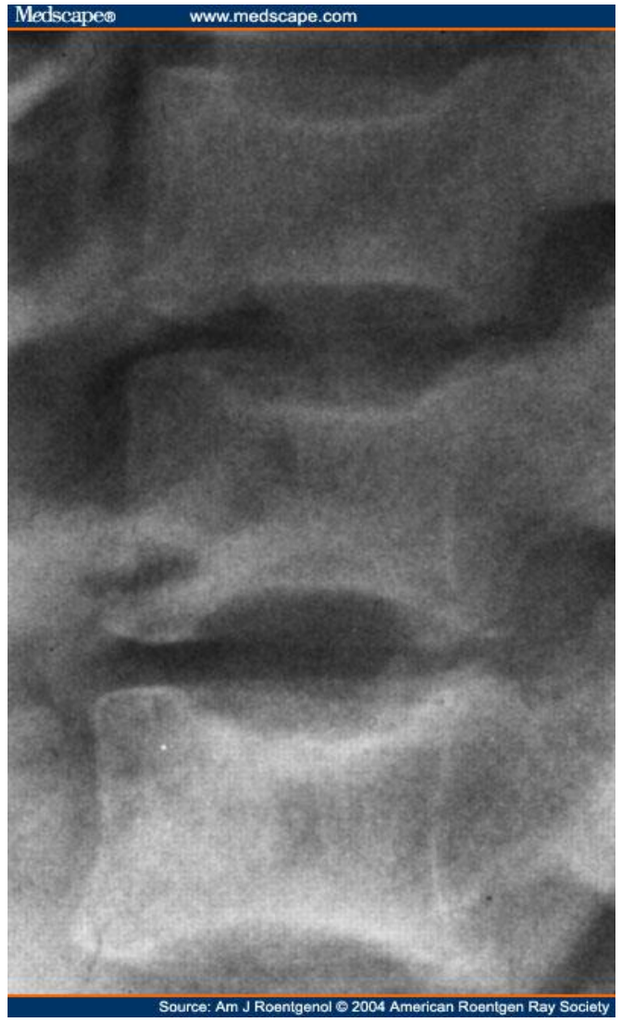


Sickle cell anemia with **infarct in 3rd metacarpal**, and **infection in 1st and 5th metacarpals**.



Any severe chronic anemia with **marrow hyperplasia.**





Sickle cell anemia – depressed central portion of vertebral end plates.

Thank You!

We hope you found this helpful and informative.

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- Abdullatif Alhassan

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