# Radiology Team 429

## RADIOLOGY of HEMATOPOIETIC DISORDERS

# Radiology Team 429

**In this team we used the outlines from the:**

**Doctor's slides**

**Lecture notes**

**427 Radiology team**

**Diagnostic Imaging –PETER ARMSTRONG – 6Th Edition**

Sorry we don't hold responsibility for any missing information or perhaps – perhaps -wrong material.

We tried our best to present this lecture in the best way, and we hope what we wrote is enough to cover the subjects.

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Special Thanks to Ibrahem AlSadhan & Mashael Al-towairqi

**Best Wishes : )**

# Pathologies

| Cells | Pathology |
|---|---|
| **RBCs** | Anemia<br>Sickle Cell<br>Thalassemia |
| **WBCs** | Lymphoma<br>Myeloma |
| **Platelets** | Bleeding or Clotting |

| | |
|---|---|
| **Plasma** | Bleeding or Clotting |

**<u>To detect bone density in pictures;</u>** You will notice **thick bone marrow** (expanded) in anemia patients, and **thin bone marrow** in thalassemia and severely anemic patients.

IMP

| Pathology | Body changes in response | Radiological Signs |
|---|---|---|
| **Anemia *(such results are non-specific and happen in chronic anemia)*** | **Reactive increase in bone marrow**<br>Try to produce more RBC (intramedullary hyperplasia) | **1- Expanded bone marrow in bones includinglong bones of hands, feet, limbs, skull**<br>**2- Decreased T1 MRI signal in vertebral bodybone marrow than adjacent discs**<br>Despite the increase in bone marrow function but it is not enough to resolve the anemia ,so other organs will start producing RBC`S (this is rare these days because of successful treatment) |
| | **New marrow areas in potential organs** | **Liver, Spleen, Lymph nodes, Thymus, Paraspinal areas with possible extension into spinal canal outside the dura, Kidneys, Meninges, Skin** |
| | **Transfusions Iron overload** | **Increased CT density (brightness) and changes in MRI signal of liver & spleen** |
| **Sickle Cell Anemia** | **Infections** | **Pneumonias, Osteomyelitis** |
| | **Infarcts** | **Spleen, Kidneys, Brain, Bones, Bowel, Muscles**<br>Due to circulating sickle cell that will block the circulation and causing infarct in different organs commonly the spleen |

# When looking at an image, look for:

**1. INTRA medullary hyperplasia:**

Bone marrow trying to compensate.

- Can be seen in Thalassemia, Sickle cell anemia, Iron deficiency anemia, and 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 and skull.
- Appears as Decreased T1 MRI bone marrow signal than adjacent discs.

**2. EXTRA medullary hematopoiesis:**

Organs are trying to compensate most commonly causing spleenomegaly and parasternal areas extension.

- 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, Meningies, Skin, Lymph nodes and Thymus,
- EXTRA medullary hematopoiesis appears as homogeneous soft tissue masses on imaging.

In **Auto-splenectomy**, the spleen died piece by a piece and so the patient will have no immunity and be predisposed to infections **especially Salmonella (MCQ)**

**3. INFARCTS and INFECTIONS** are both findings in Sickle cell anemia

## 4. Bone infarct vs infection:

- Is important to diagnose early so that antibiotics can be started early to prevent complications.
- Bone infarct is when you see white small areas inside the bone.
- MRI with contrast and ultrasound /CT guided aspiration of fluid collections are very helpful if imaging is unable to differentiate these two.

**Best investigation for bone marrow;** MRI **(MCQ).**

## 5. 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. It usually causes multiple black lesions in the skull

## 6. 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.

# Thalassemia

# Thalassemia

- Generalized decreased bone density
- Coarse trabeculae
- Widening of medullary cavity
- Thin cortex

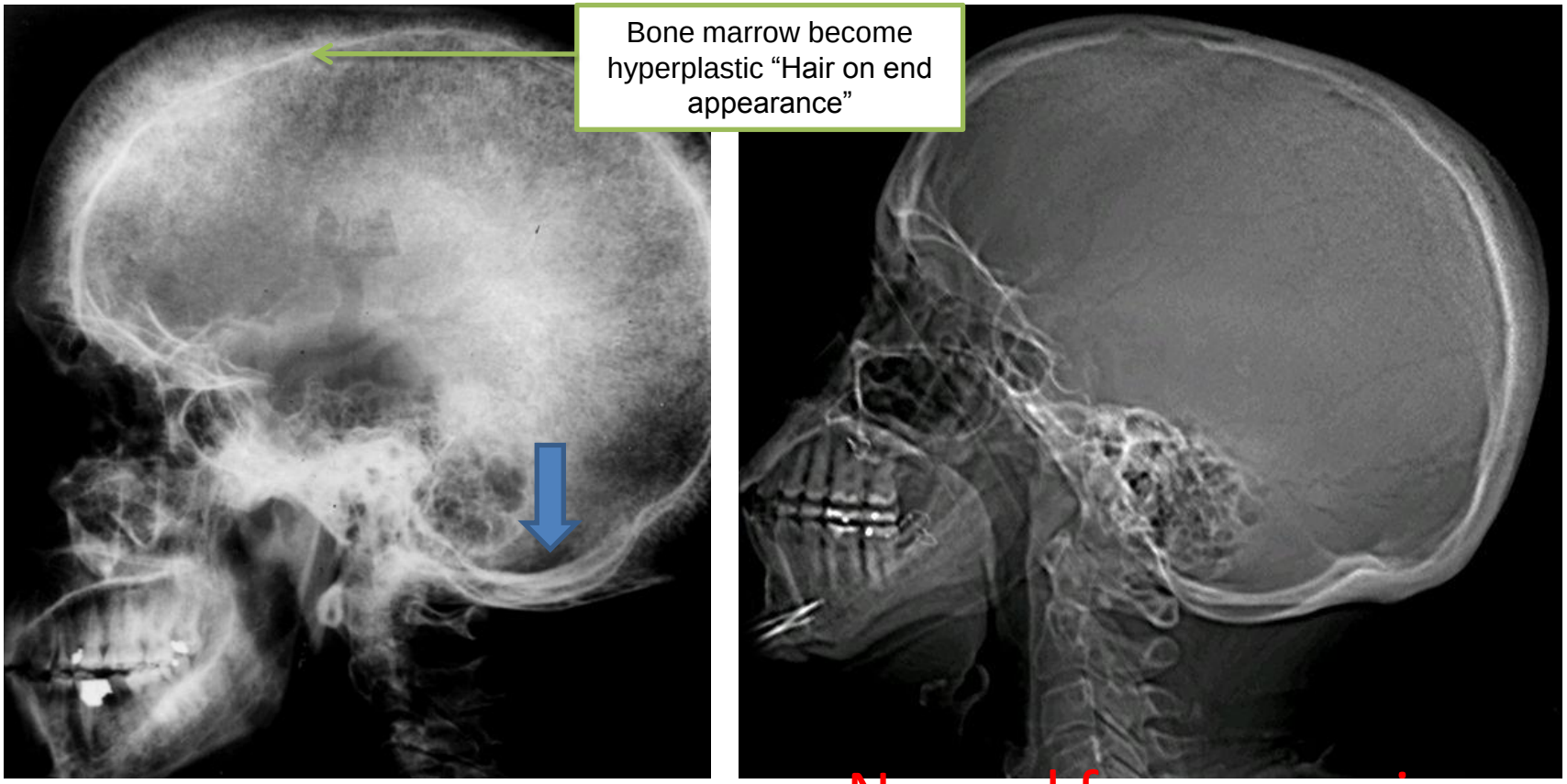
In normal person; the bone marrow is darker than the vertebrae
In patients with blood disorder; the bone marrow is brighter than vertebra.

Expanded bone specially in the metacarpal in the middle portion thickening and very thin cortex

**Trabeculae:** is a soft bony structure present in the center of bone marrow.

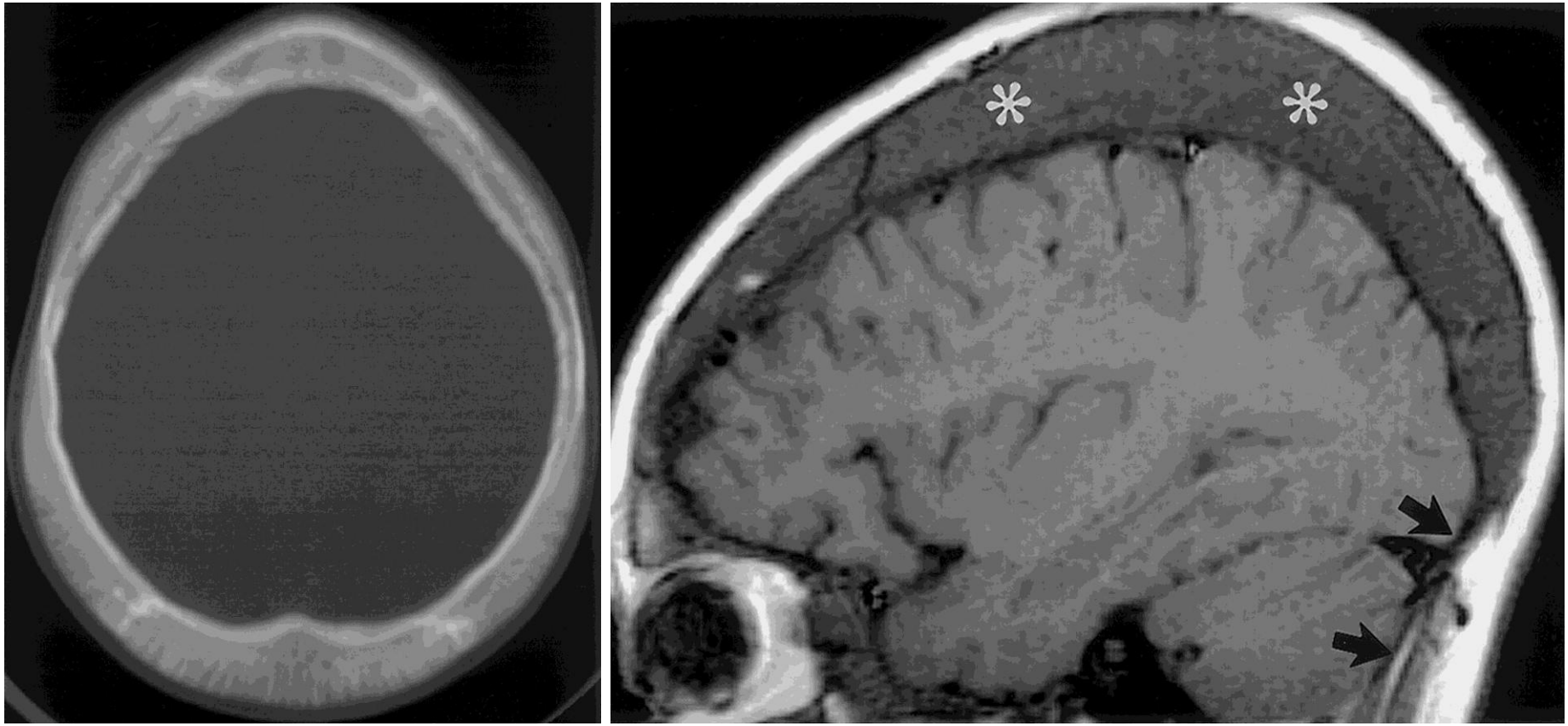
## 25-year-old man with β-thalassemia

- Lateral skull radiograph shows characteristic expansion of diploic space with hair-on-end appearance (hair-like), widened groove for middle meningiealartery
- Spared occipital bone (arrow)




**Georgiades C S et al. AJR 2002;179:1239-1243**
http://www.ajronline.org/content/179/5/1239.full?ijkey=dd5a027292a2a1569d54ebd62eed10b1ba479caf&keytype2=tf_ipsecsha

•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



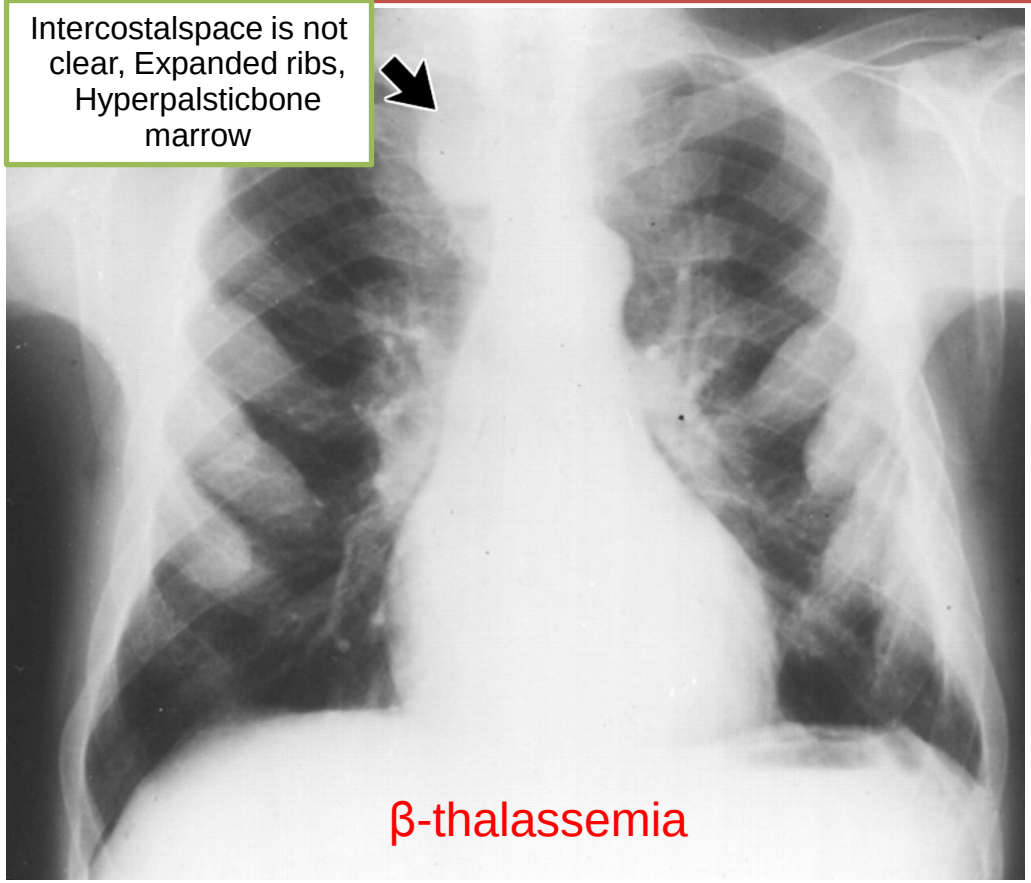

**Lonergan G J et al. Radiographics 2001;21:971-994**
http://radiographics.rsna.org/content/21/4/971.long

RadioGraphics

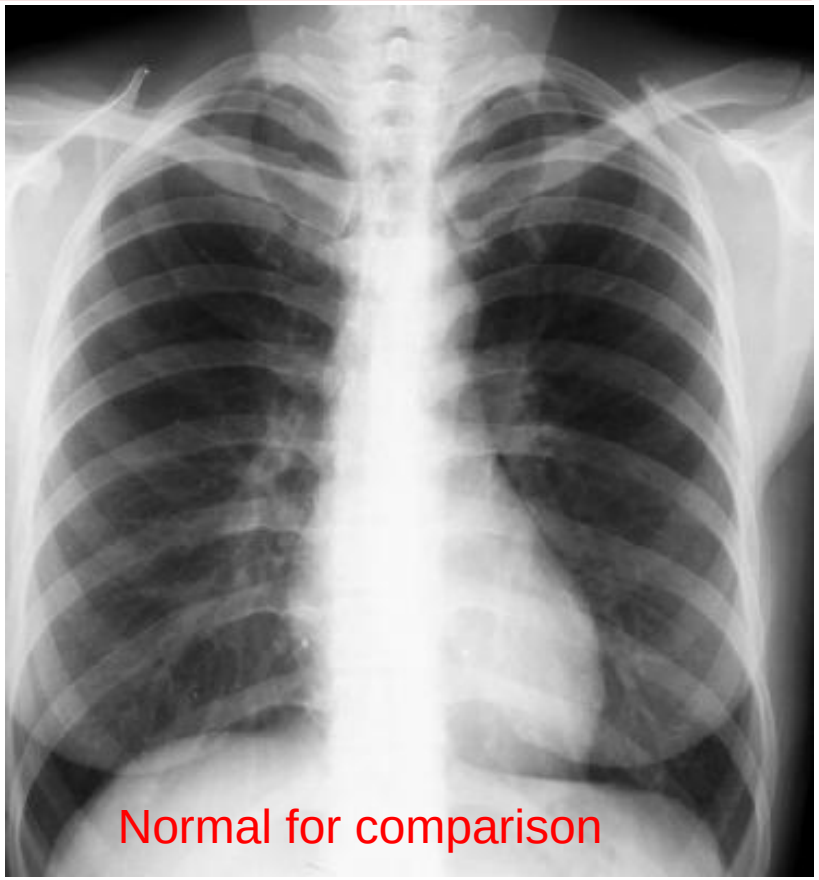
# 25-year-old man with β-thalassemia.

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

Intercostalspace is not clear, Expanded ribs, Hyperpalsticbone marrow



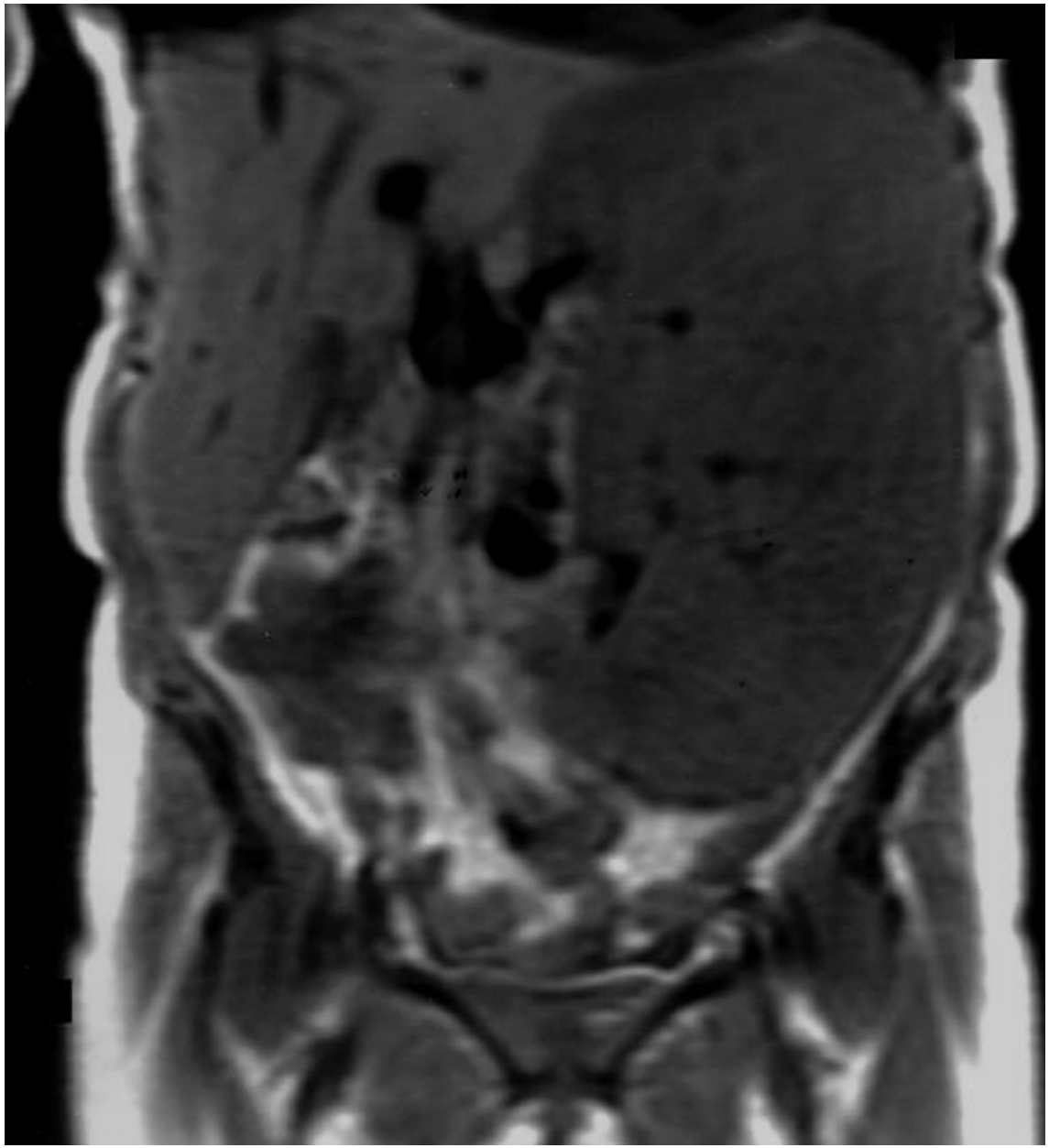
β-thalassemia



Normal for comparison

**Georgiades C S et al. AJR 2002;179:1239-1243**

AJR



**51-year-old woman with myelofibrosis**

- Coronal T1-weighted MR image shows massively enlarged spleen
- Splenic biopsy was followed by splenectomy
- Pathologic examination revealed extramedullary hematopoiesis

Here other sites “spleen” in enlarged trying to produce RBC`s and here it is hugely enlarged and become bigger than the liver

Myelofibrosis→ fibrosis of bone marrow cavity and it is not working so the extra sites will start producing RBC`s

**An important note :**

**Intramedullaryhyperplasia → when the bone marrow expand and try to produce more RBC`s in response to the anemia**

**Extramedullaryhyperplasia→ when the other organs start to produce RBC`s**

**Georgiades C S et al. AJR 2002;179:1239-1243**

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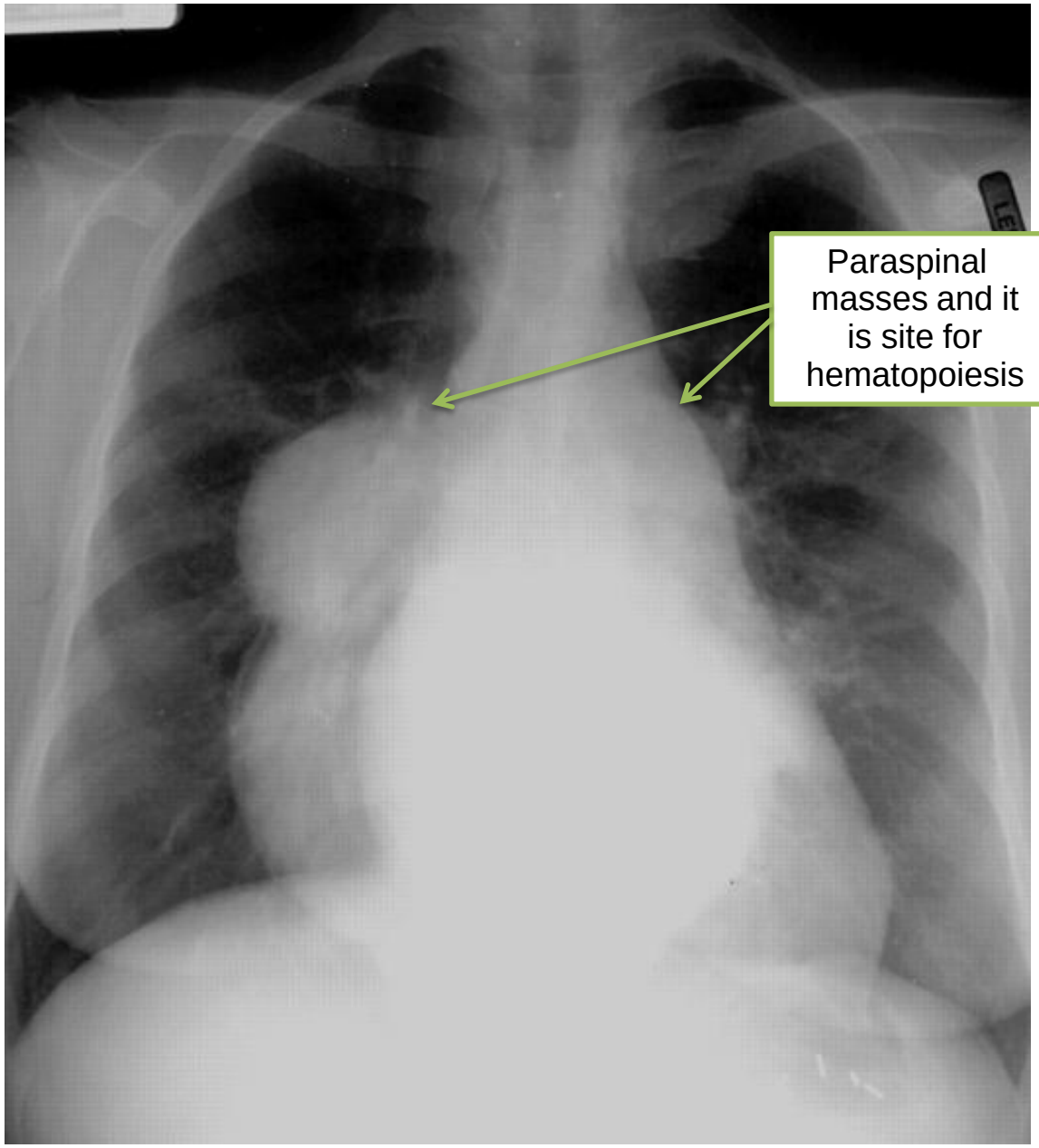



**23-year-old woman with history of thalassemia and known extramedullary hemopoiesis**

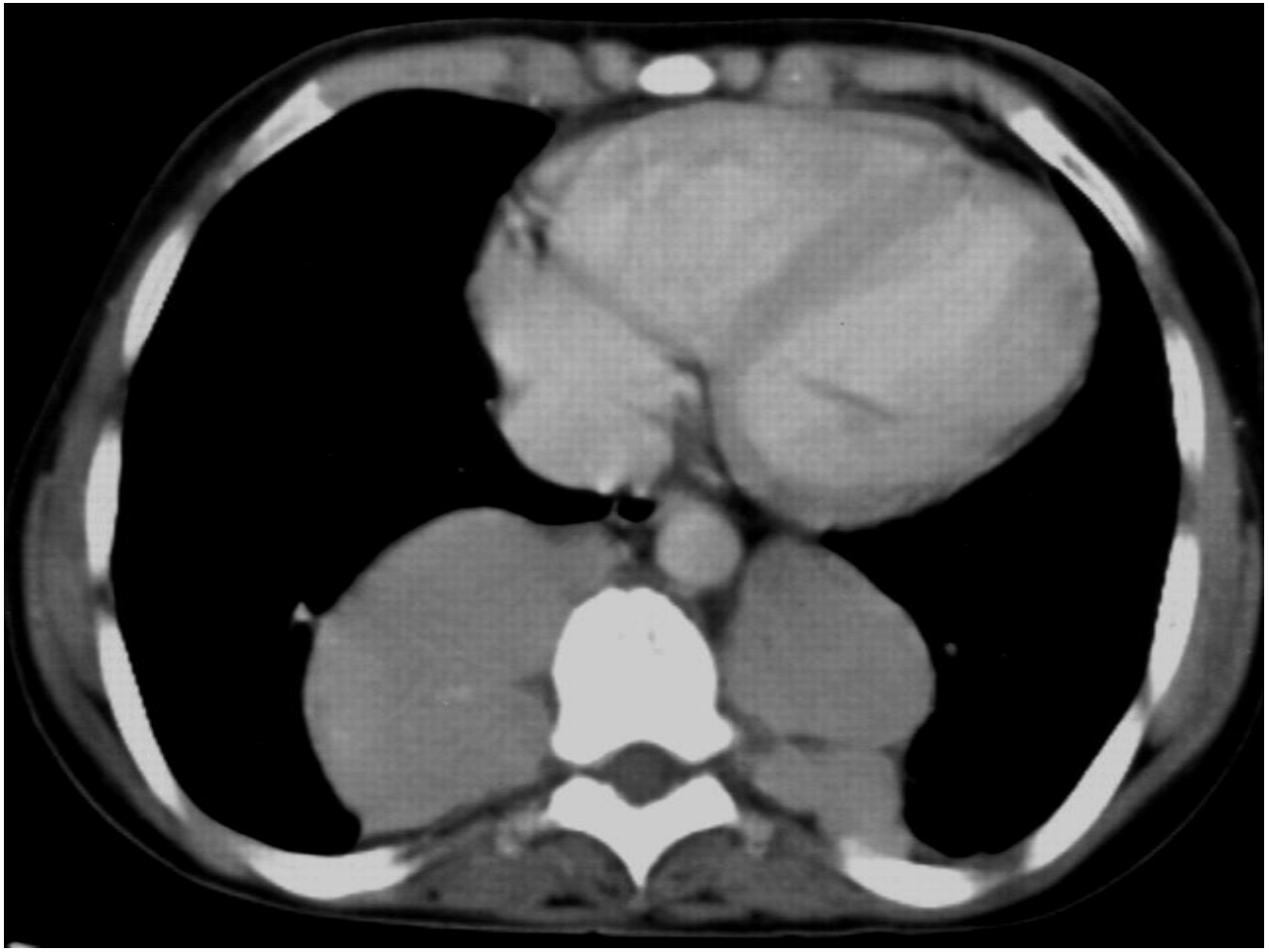
•PA chest film shows well-demarcated bilateral, paraspinal masses compatible with extramedullary hemopoietic tissue

**Georgiades C S et al. AJR 2002;179:1239-1243**

AJR

**23-year-old woman with history of thalassemia and known extramedullaryhemopoiesis**

•Axial contrast-enhanced CT scan through chest shows uniformly enhancing paraspinal hemopoietic masses with no bony erosion.

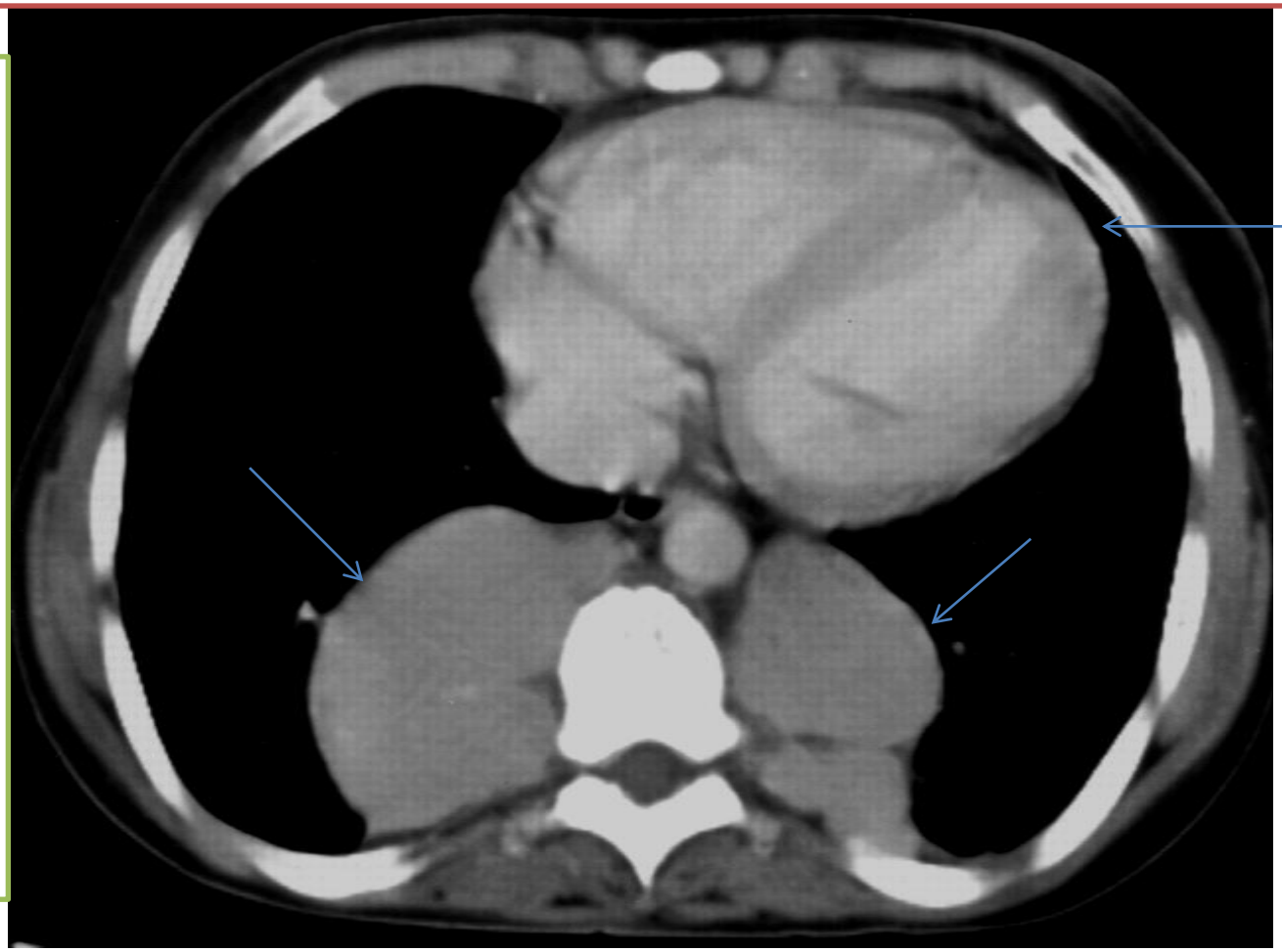


**Georgiades C S et al. AJR 2002;179:1239-1243**

## 40-year-old man with sickle cell disease

- Axial unenhanced CT scan at thoraco-abdominal level reveals two uniformly low-attenuation (compared with liver parenchyma), well-marginated lesions (arrows)
- Percutaneous biopsy showed extramedullary hemopoiesis

Bone marrow tissue on both sides of spine present outside bone marrow as a manifestation of anemia
These masses are not removed because they are helping in producing RBC`s patient needs and when the treatment start they will disappear




**Georgiades C S et al. AJR 2002;179:1239-1243**

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The two masses in the liver that arehematopoie sissites

**Georgiades C S et al. AJR 2002;179:1239-1243**

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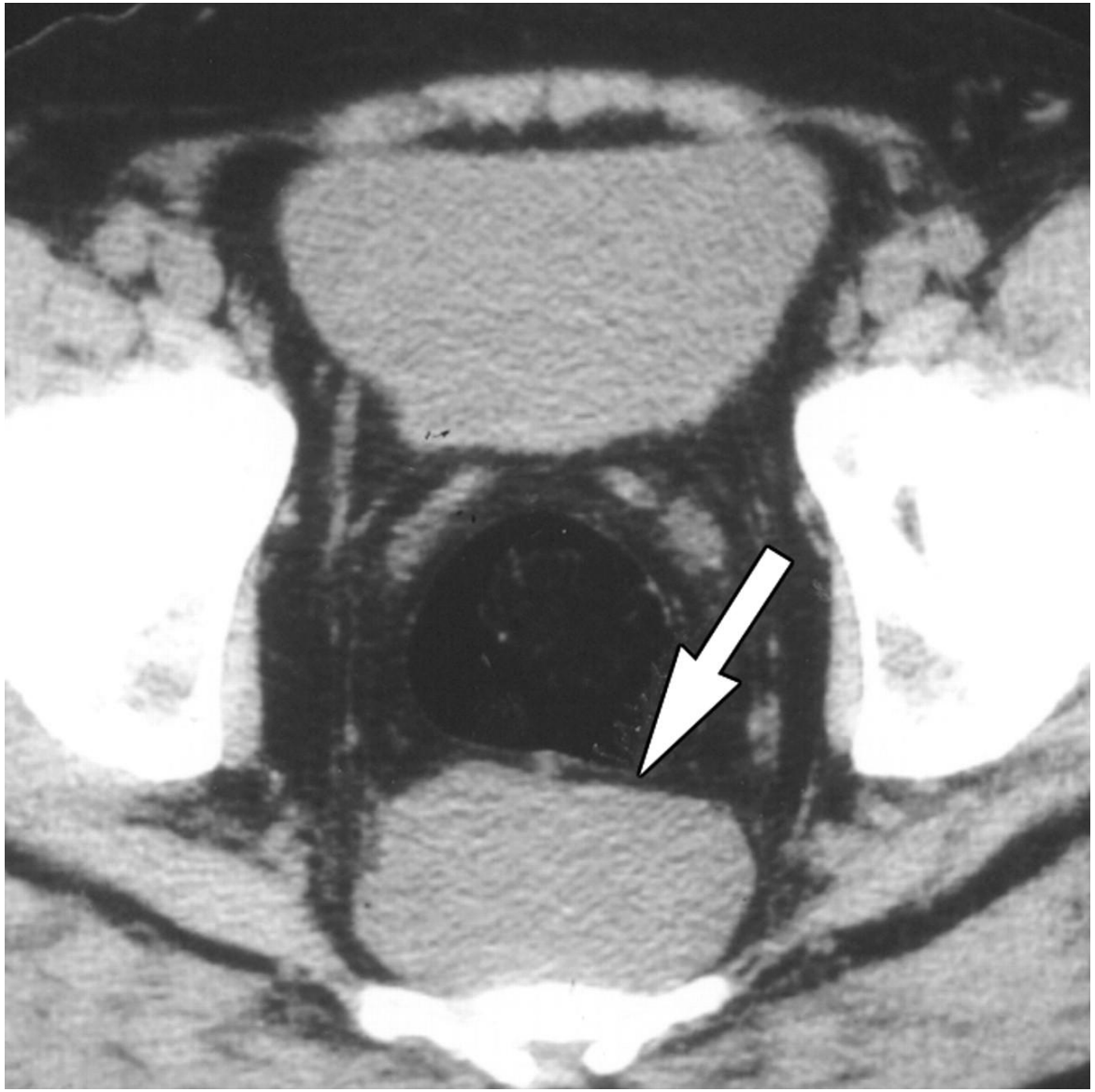
**56-year-old man with myelofibrosis**

- Axial contrast-enhanced CT scan through kidneys reveals bilaterally symmetric enhancing perinephric masses.
- Biopsy showed extramedullaryhematopoiesis in the kidney


**Georgiades C S et al. AJR 2002;179:1239-1243**

AJR



## 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 extramedullaryhematopoiesis in the pelvis

Georgiades C S et al. AJR 2002;179:1239-1243

AJR

# Sickle Cell Anemia

# Sickle Cell Anemia

Sickle cell disease may be manifested as

**1. ANEMIA**

- growth failure, hyperkinetic heart failure
- expansion of intramedullary hematopoiesis
- Presence of extramedullary hematopoiesis

**2. VASO-OCCLUSION**

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

**3. SUPERIMPOSED INFECTION** most common sites:

- Lung, Pneumonia (*Pneumococcus, H. influenzae, Staph. Aureus, Chlamydia, and Salmonella).*
- Bone, Osteomyelitis *(Salmonella).*

From the pictures you cannot till what the type of anemia that cause the changes you can only know there are changes due to severe chronic anemia

Sickle cell anemia lead to infarcts , and te common site for infarcts is he spleen how does it happen? Normally spleen rmoves abnormal RBC`s→ when there are lots of sickle shaped RBC`s→spleenic circulation will be blocked and the blocked part will die , and every time if patient still not reciving adequate treatment small portion die the spleen wil become smaller and smaller and "autospleenectomy" -occurs when a disease damages the spleen to such an extent that it becomes shrunken and non-functional.- will be the result

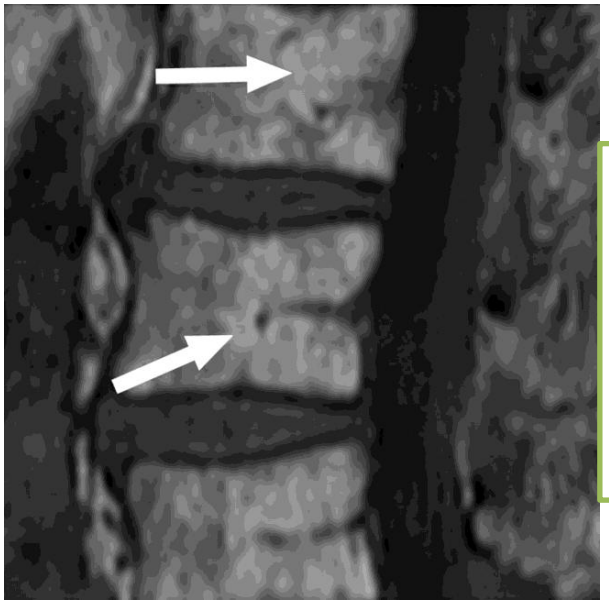
**Lonergan G J et al. Radiographics 2001;21:971-994**
http://radiographics.rsna.org/content/21/4/971.long

RadioGraphics

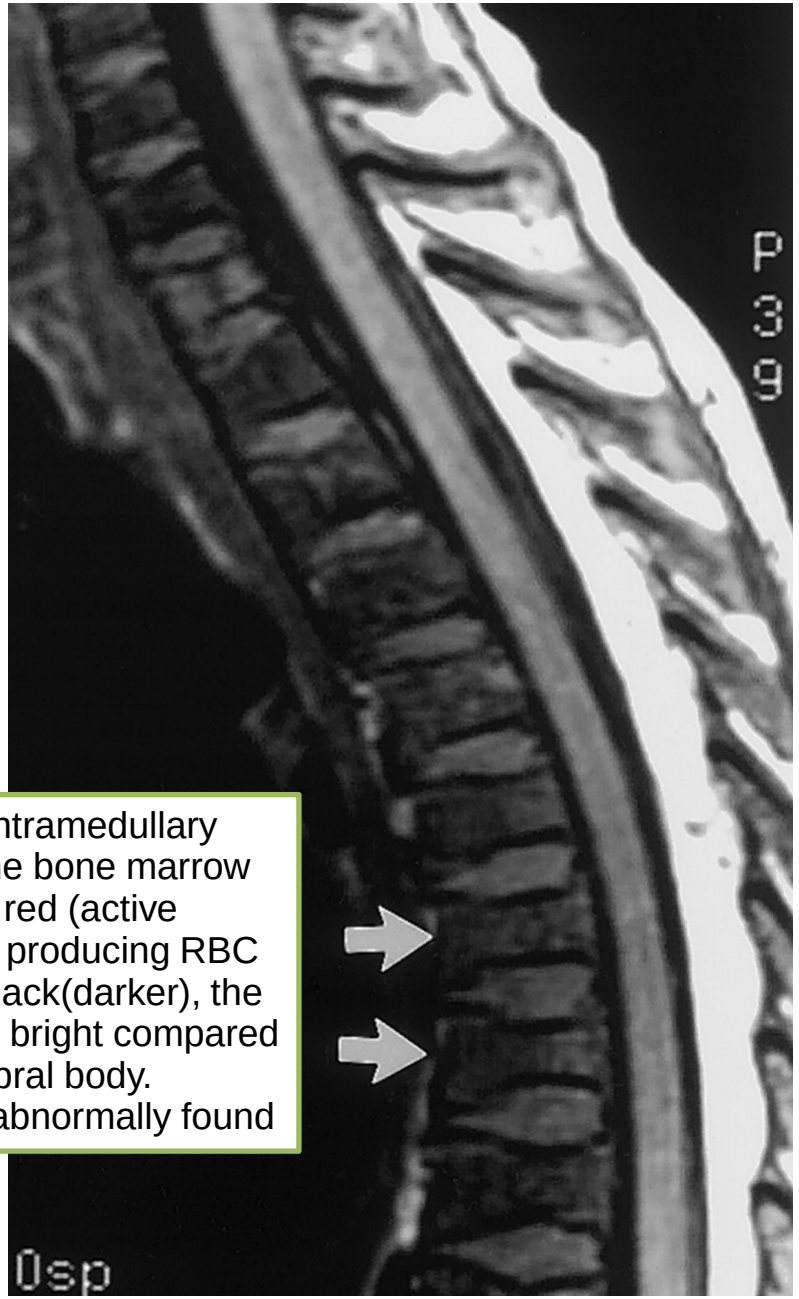
**Red marrow in vertebral bodies in a 7-year-old girl with Sickle Cell Anemia**

- 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

Normal for comparison



Because of intramedullary hyperplasia the bone marrow becomes red (active hematopoitic), producing RBC and become black(darker), the vertebral disc is bright compared to vertebral body.
The H shape is abnormally found

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RadioGraphics

# Bone Infarctions

- Bone infarcts typically occur in the medullary cavities and epiphyses

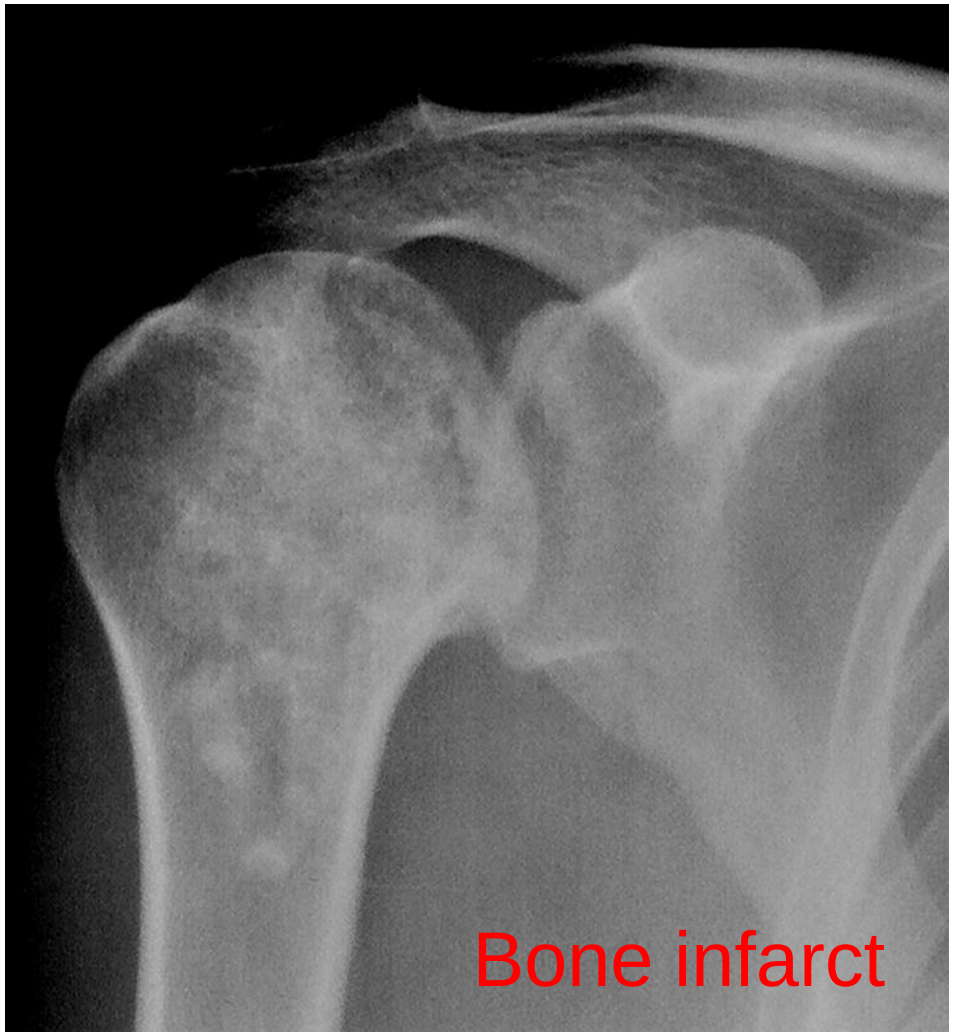
- Epiphyseal infarcts are frequently seen in the femoral and humeral heads, and more often bilateral than avascular necrosis due to other diseases

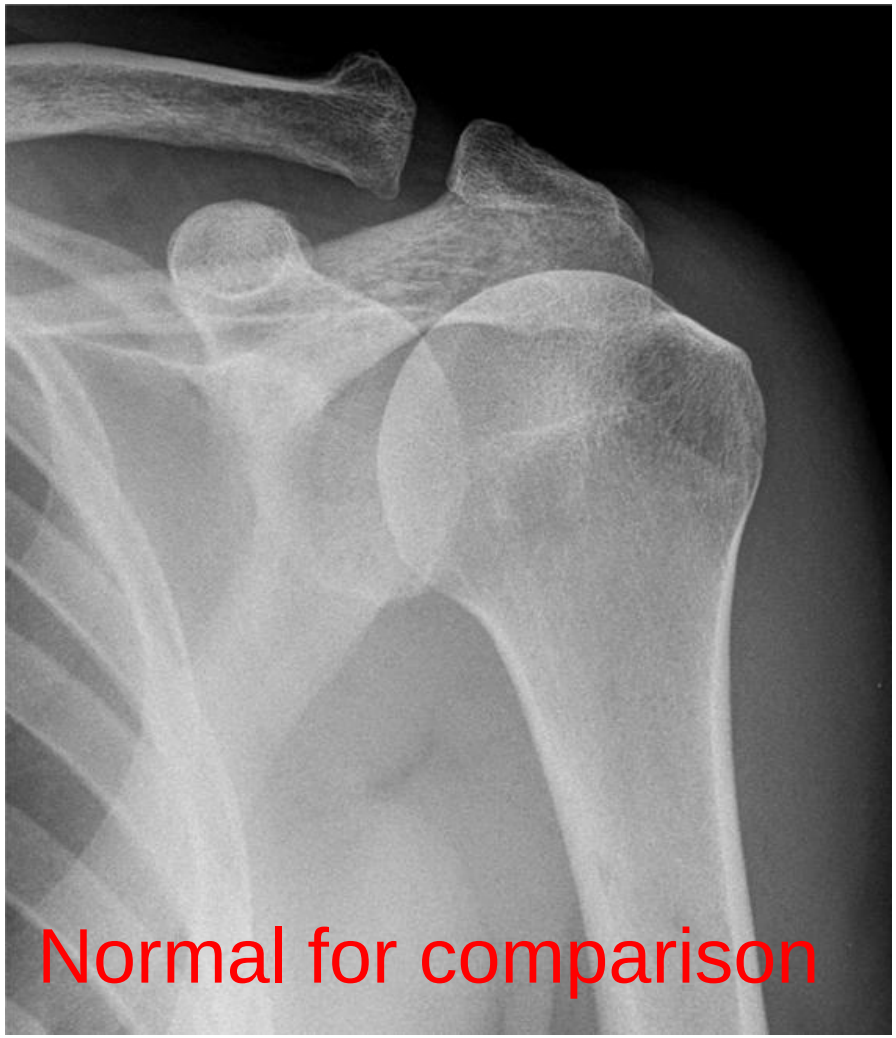
Head of humerus and femur are the most common sites for infarction due to sickle

**Lonergan G J et al. Radiographics 2001;21:971-994**

RadioGraphics

- Medullary bone infarcts in SCA (white small areas inside the bone)
- Frontal radiograph of right shoulder in a 22-year-old patient shows an area of patchy sclerosis and radiolucency

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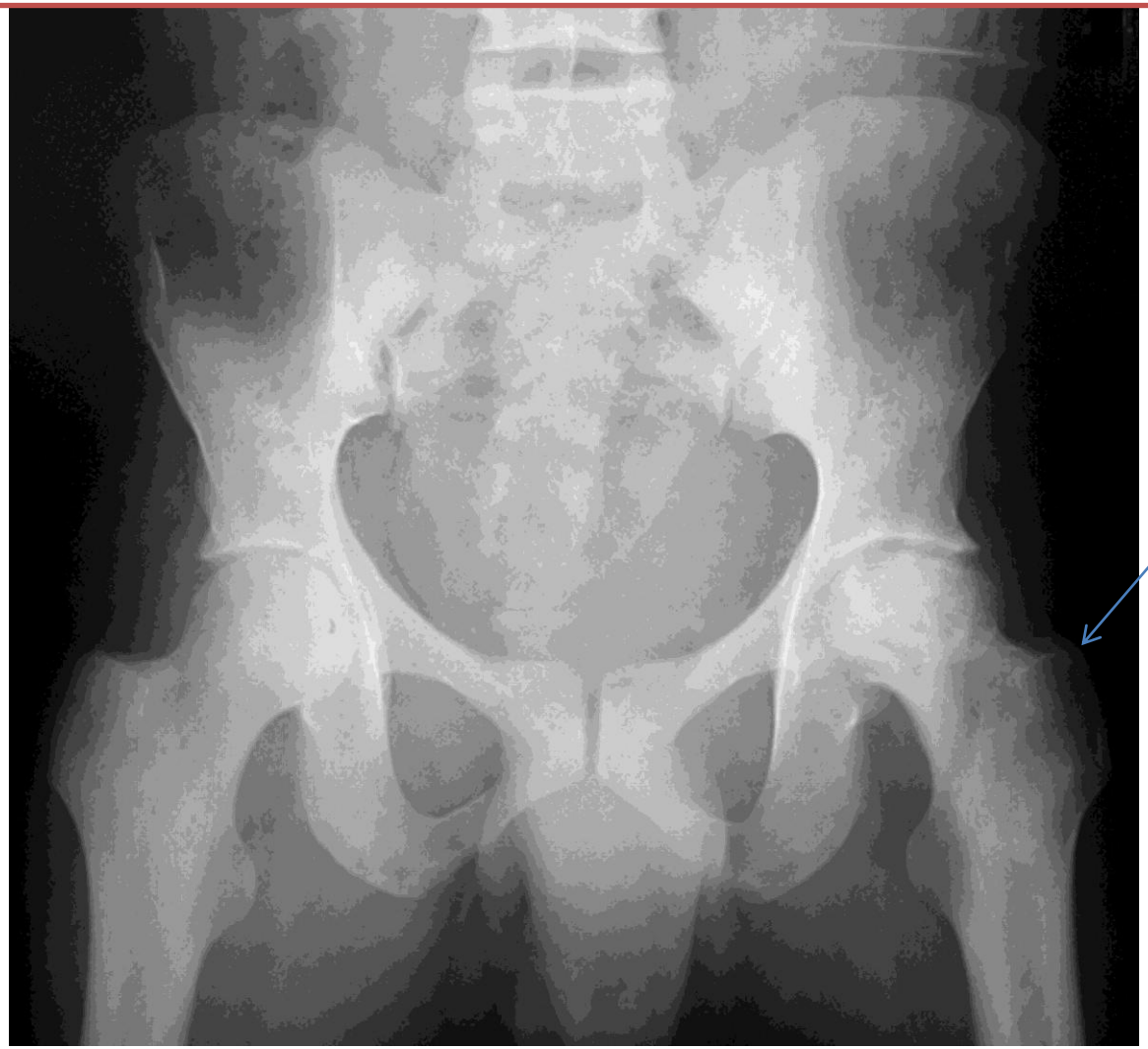
**AP radiograph in a 44-year-old man**

Shows advanced avascular necrosis in left hip and a normal right hip



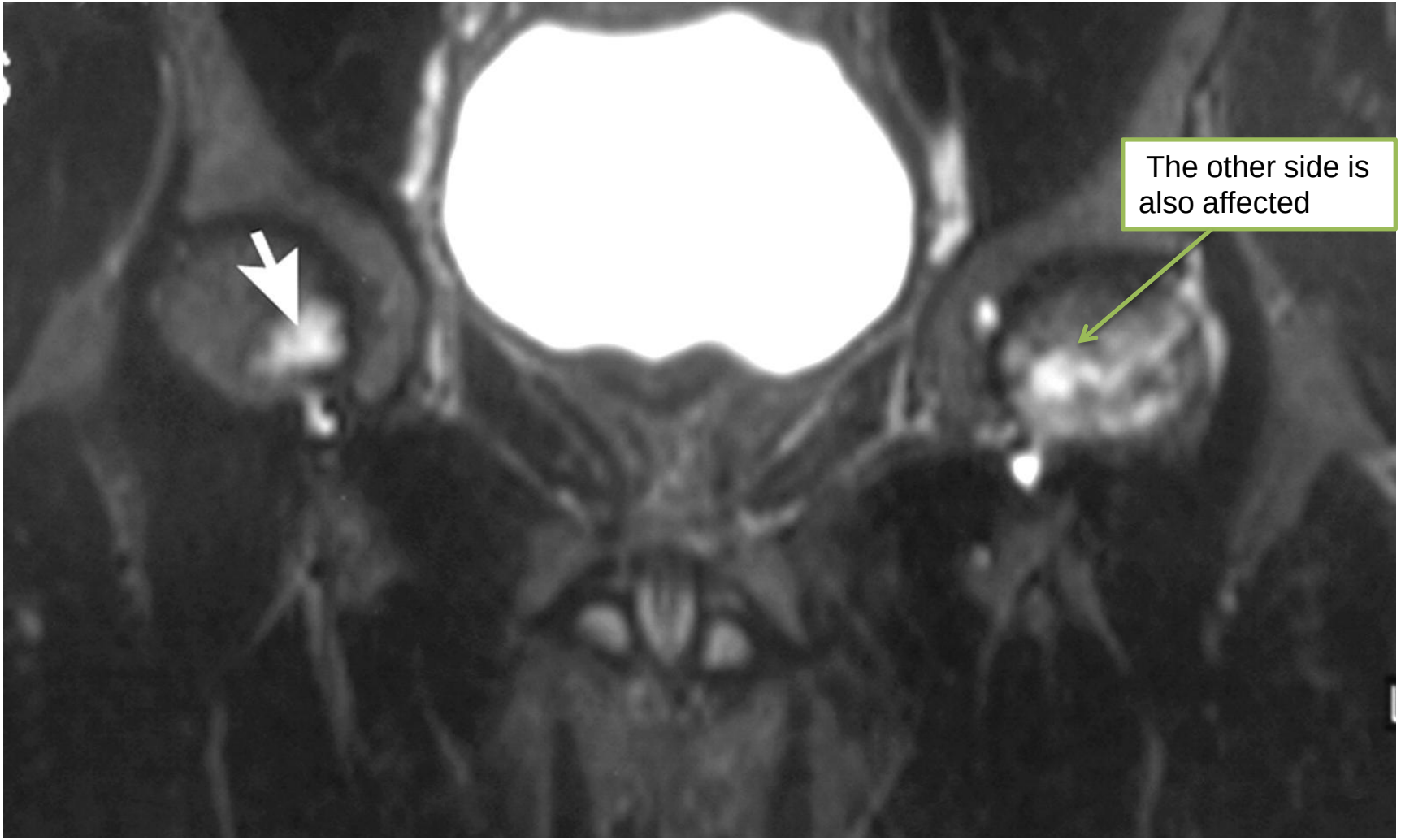
Abnormal head of femur composed of dark and whait area and it is differen form the right side

**Ejindu V C et al. Radiographics 2007;27:1005-1021**

RadioGraphics

## 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

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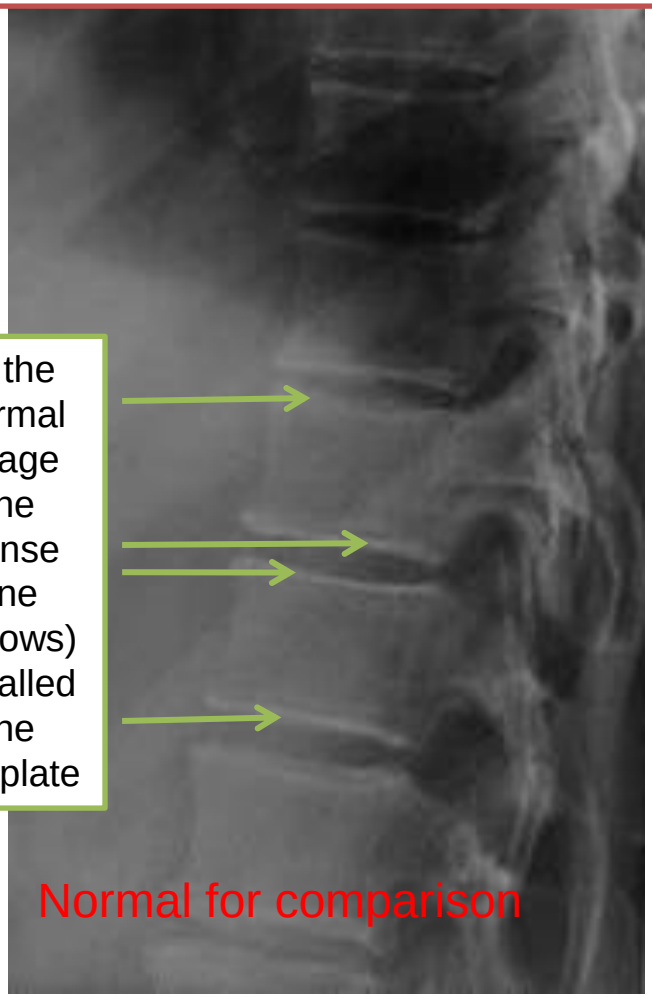
# H-shaped vertebrae in a 15-year-old patient with SCA

- Lateral radiograph of spine shows classic boxlike endplate depressions in middle portion (see the lowest vertebra shown) due to osteonecrosis of the vertebral endplates



In the normal image the dense line (arrows) is called the endplate

Normal for comparison

And here they are depressed as if they are inserted to the vertebral body and that is due to infarct in the endplate. As the infarct increases, with time the vertebral body will look H-shaped

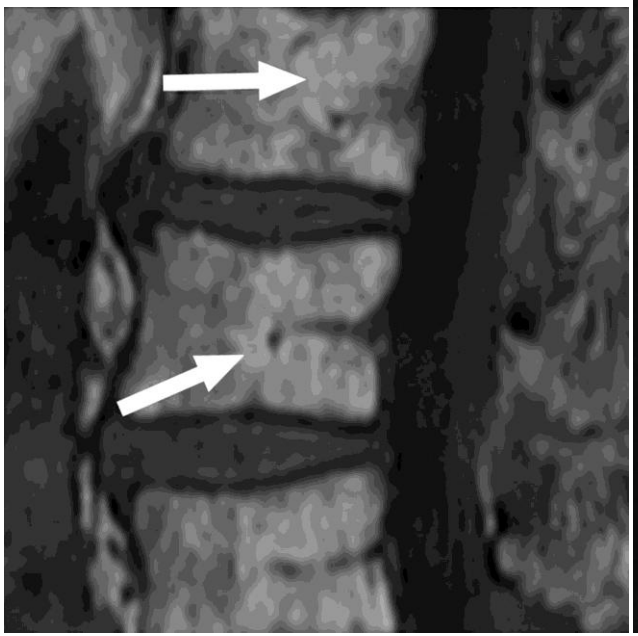
**Lonergan G J et al. Radiographics 2001;21:971-994**

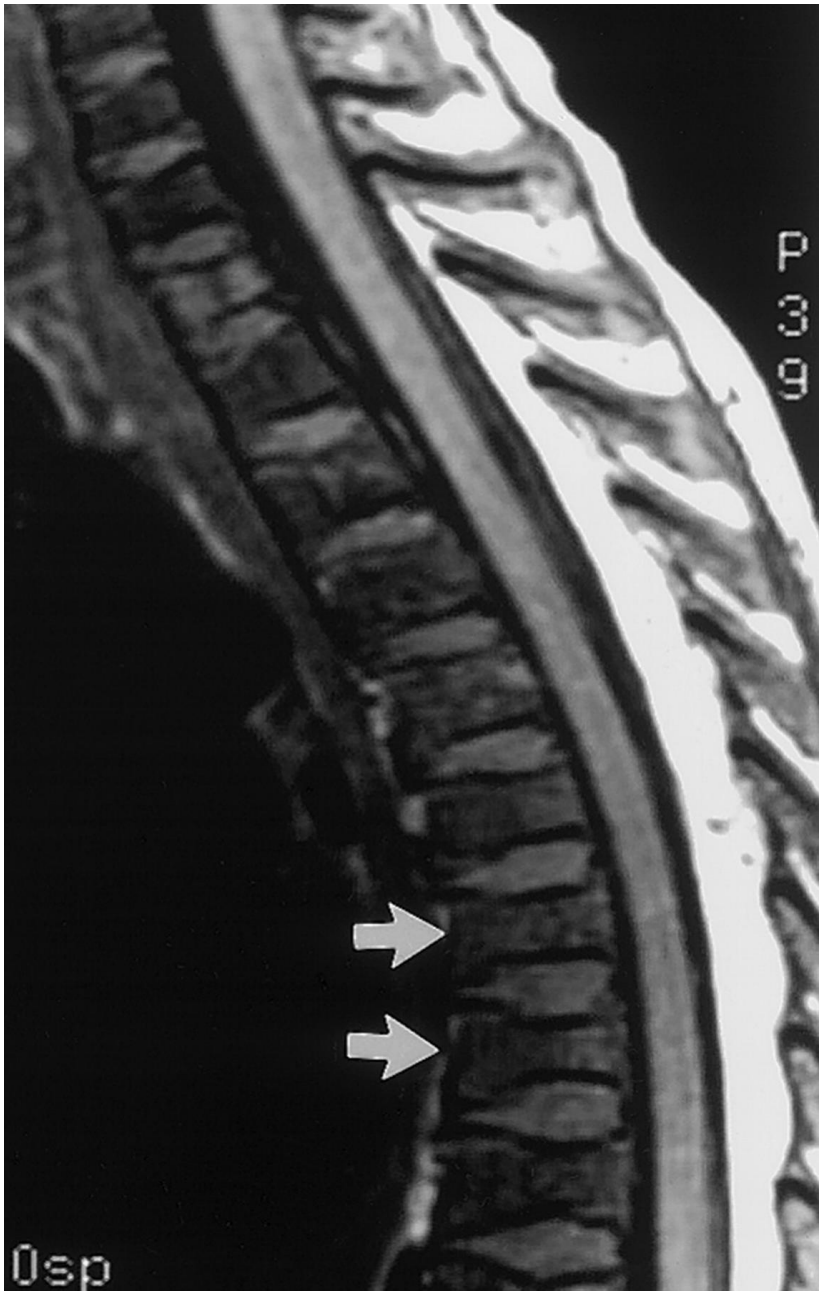
RadioGraphics

**Red marrow vertebral bodies in a 7-year-old girl with SCA**

- Sagittal T1-weighted MRI of spine shows low signal intensity in vertebral bodies compared to discs, and H-shaped vertebrae (arrows in right image) due to osteonecrosis of vertebral endplates

Normal for comparison



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RadioGraphics

# Bone Infarcts and Osteomyelitis How to Diffrenciate

1. On history, clinical examination and plain x-ray images: bone infarcts and Osteomyelitis are difficult to differentiate but it is very important to avoid complications of Osteomyelitis.
   Since the infarcts and infections (ostiomylitis) are common in the sickle cell anemia and the treatment is different between them , how can we differentiate between them? By MRI but might not
2. MRI findings of:

Cortical defects in bone

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

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

The slow process of the occlusions (ischemia) affect mainly the metatarsals and the bones become dense, enlarged and extended

# 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 metatarsal shafts

**Hand Foot Syndrome**; It is not restricted in one bone. It affects multi bones. The bones become ischemic and gradually become dead. And when it becomes dead, it will be dense.

**Lonergan G J et al. Radiographics 2001;21:971-994**

RadioGraphics

**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

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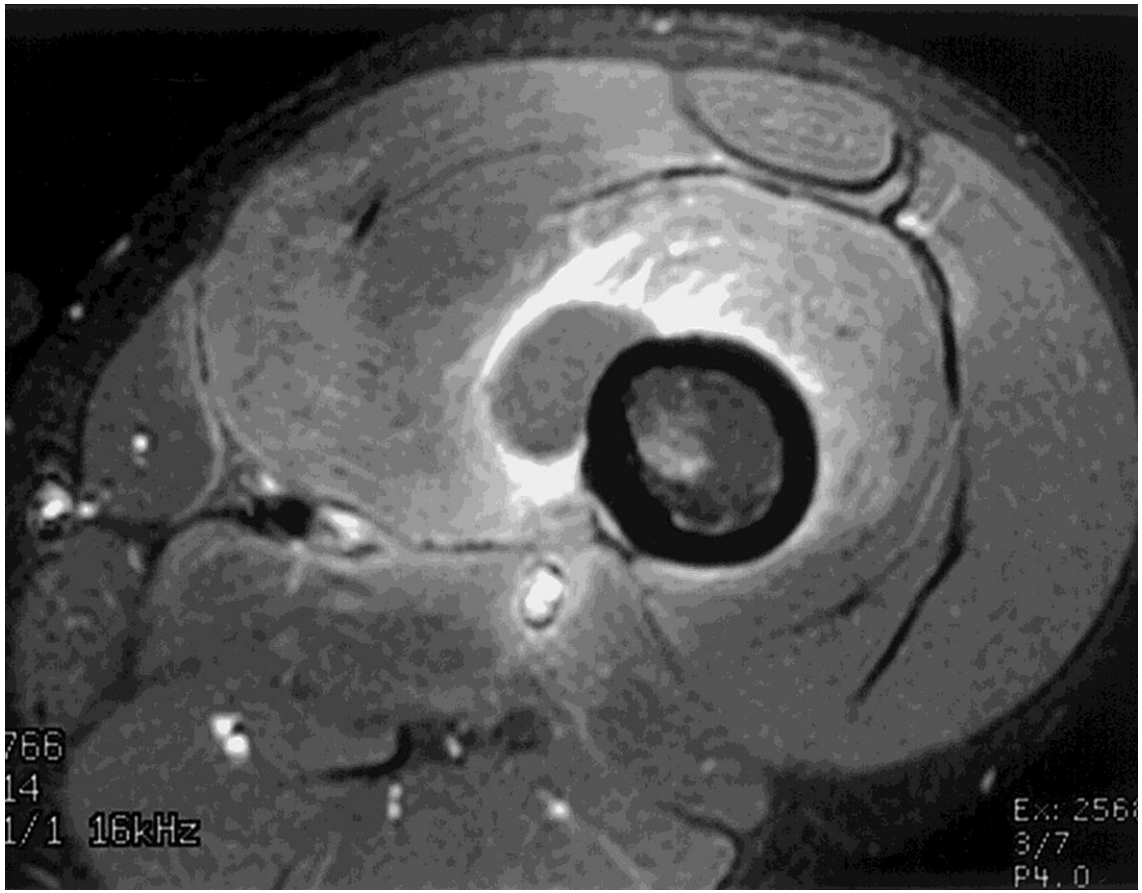
**Osteomyelitis of femur in a 24-year-old patient with SCA**

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

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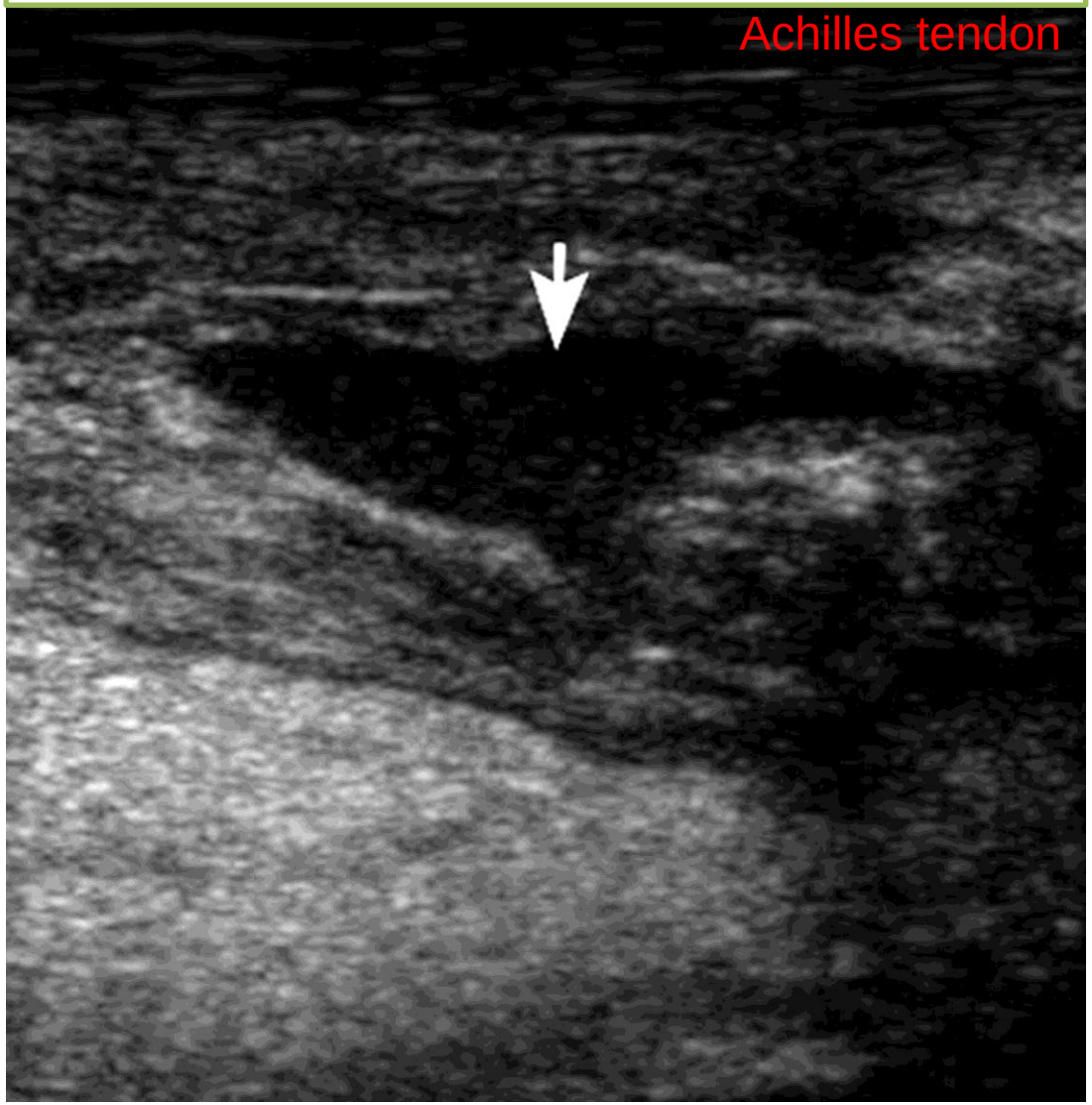
The black area contains fluid that could be infection or infarction.US cannot differentiate but it is helpful when we want to do aspiration to this fluid




**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

**Ejindu V C et al. Radiographics 2007;27:1005-1021**

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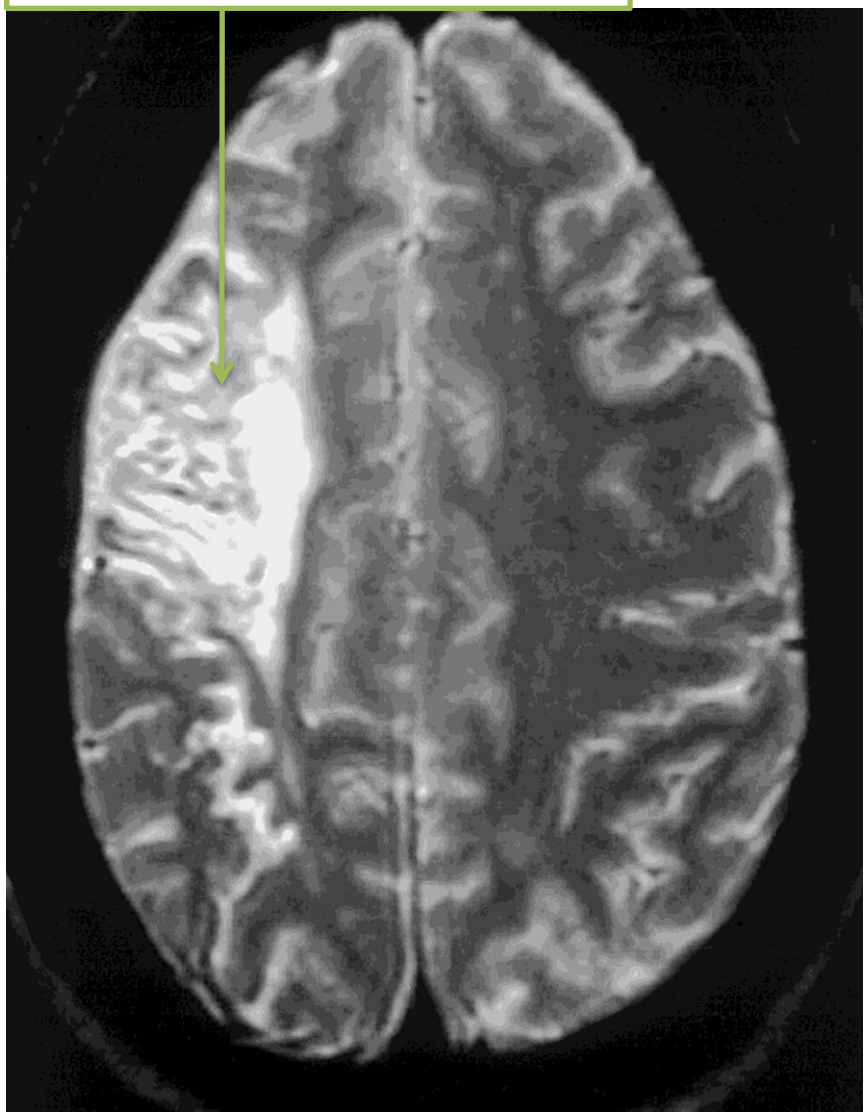


**Chronic infarct in a 19-year-old patient with SCA and longstanding mild left sided weakness**

Axial T2-weighted MRI shows an area of high signal intensity and enlargement of overlying CSF spaces representing chronic infarct & atrophy

**Lonergan G J et al. Radiographics 2001;21:971-994**

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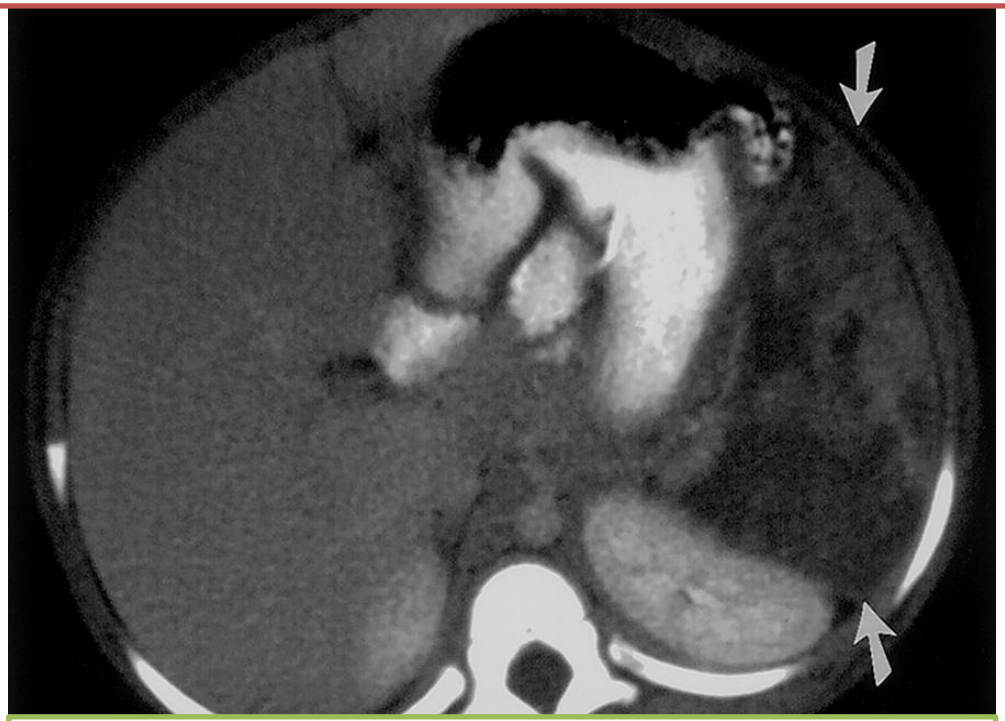
**Sequestration syndrome with splenic infarction in SCA**

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



Multiple Infarction areas in the spleen and gross showing the infarction which are the black areas

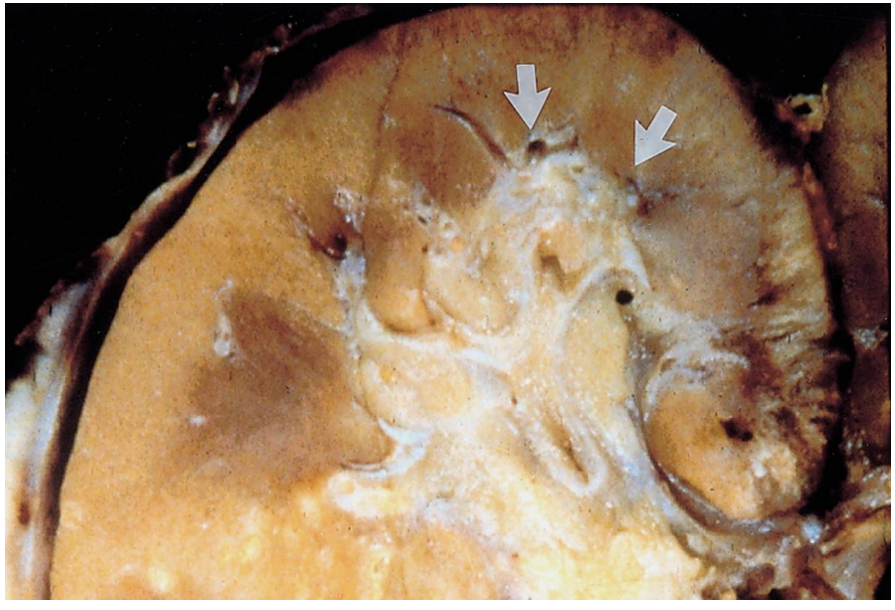
**Lonergan G J et al. Radiographics 2001;21:971-994**

RadioGraphics

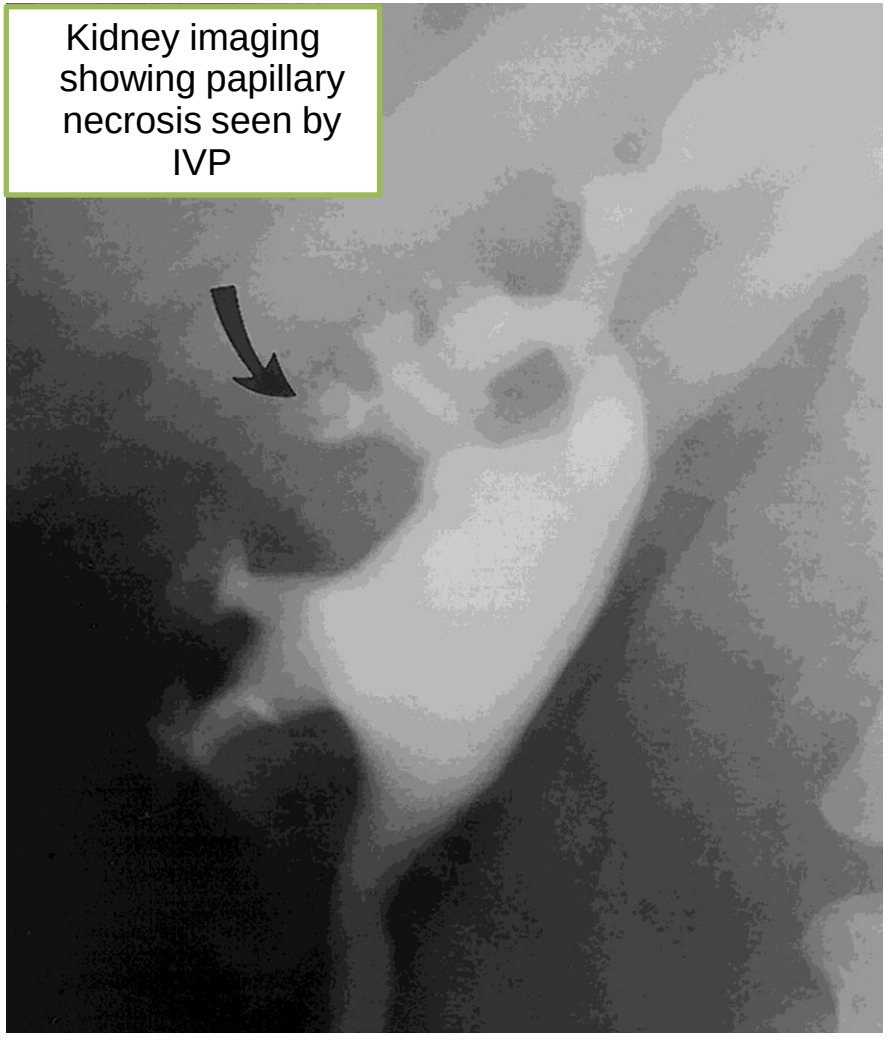
# Papillary necrosis in SCA

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)

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



Kidney imaging showing papillary necrosis seen by IVP



Infarcts in the radius prevents it from growing but the ulna continuous in growing that will lead to deformities
The patient has this deformity in one limb and the other is normal ,there will be unequal limb length

## 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.

**Ejindu V C et al. Radiographics 2007;27:1005-1021**

RadioGraphics

# LYMPHOMA

# Lymphoma

- 1. Hodgkin's Disease
  - Mixed cellularity
  - Lymphocytic depletion
  - Nodular sclerosis - the most common
  - Lymphocytic predominance

- 2. Non Hodgkin's Lymphoma
  - 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

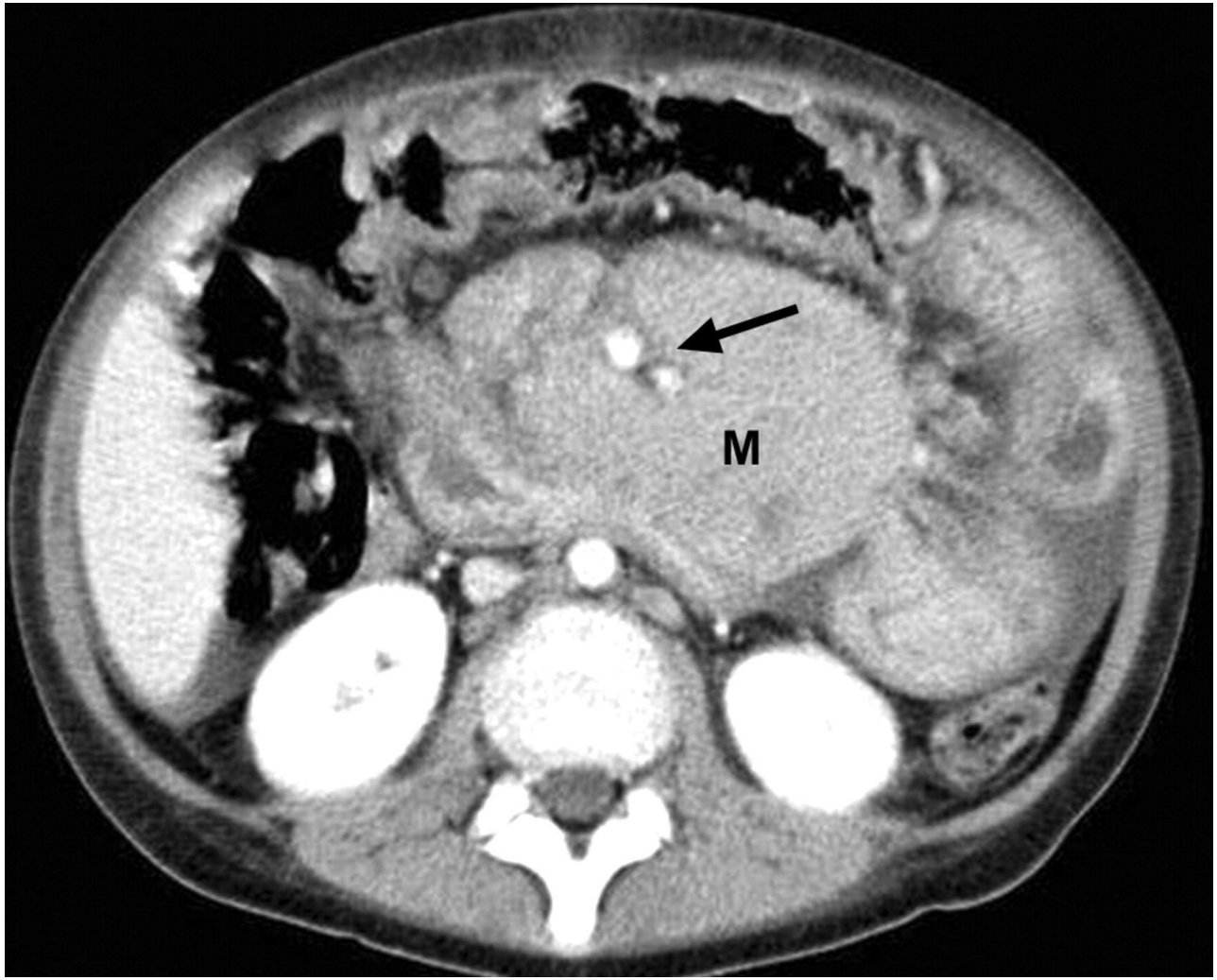
# Lymphoma

Lymphoma can present as mass anywhere in the body

- Radiology in lymphoma is used for staging and evaluation of the extent of the disease and not for diagnosis
- Lymph node biopsy is diagnostic.
- So 1st we do biopsy for diagnosis, then, we do radiology for staging in any lymphoma. If multiple masses were present, we do biopsy to only one of them and confirm lymphoma to all the masses
- The rule of radiology is to evaluate the extent (staging) of the disease , and involvement of other organs, for follow up after treatment and using of CT guided biopsy .
- There is no need to mediastinal or abdominal radiology guided biopsy if there are other lymph nodes in cervical, axillary or inguinal area

**NHL in an 11-year-old boy.**

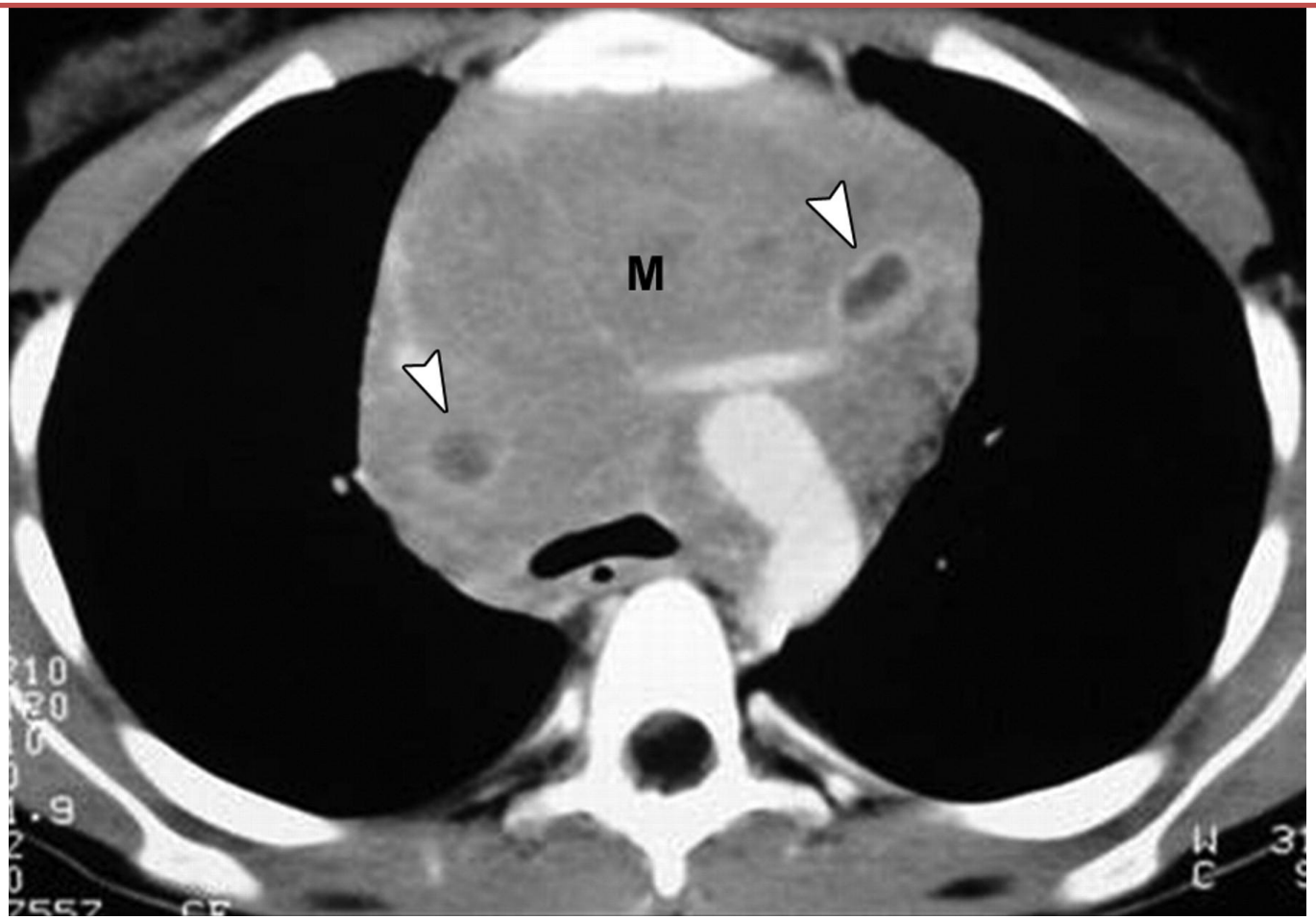
•Axial CT scan shows a large lymphomatous mass (M) encasing the mesenteric vessels (arrow)




**Toma P et al. Radiographics 2007;27:1335-1354**

## 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).

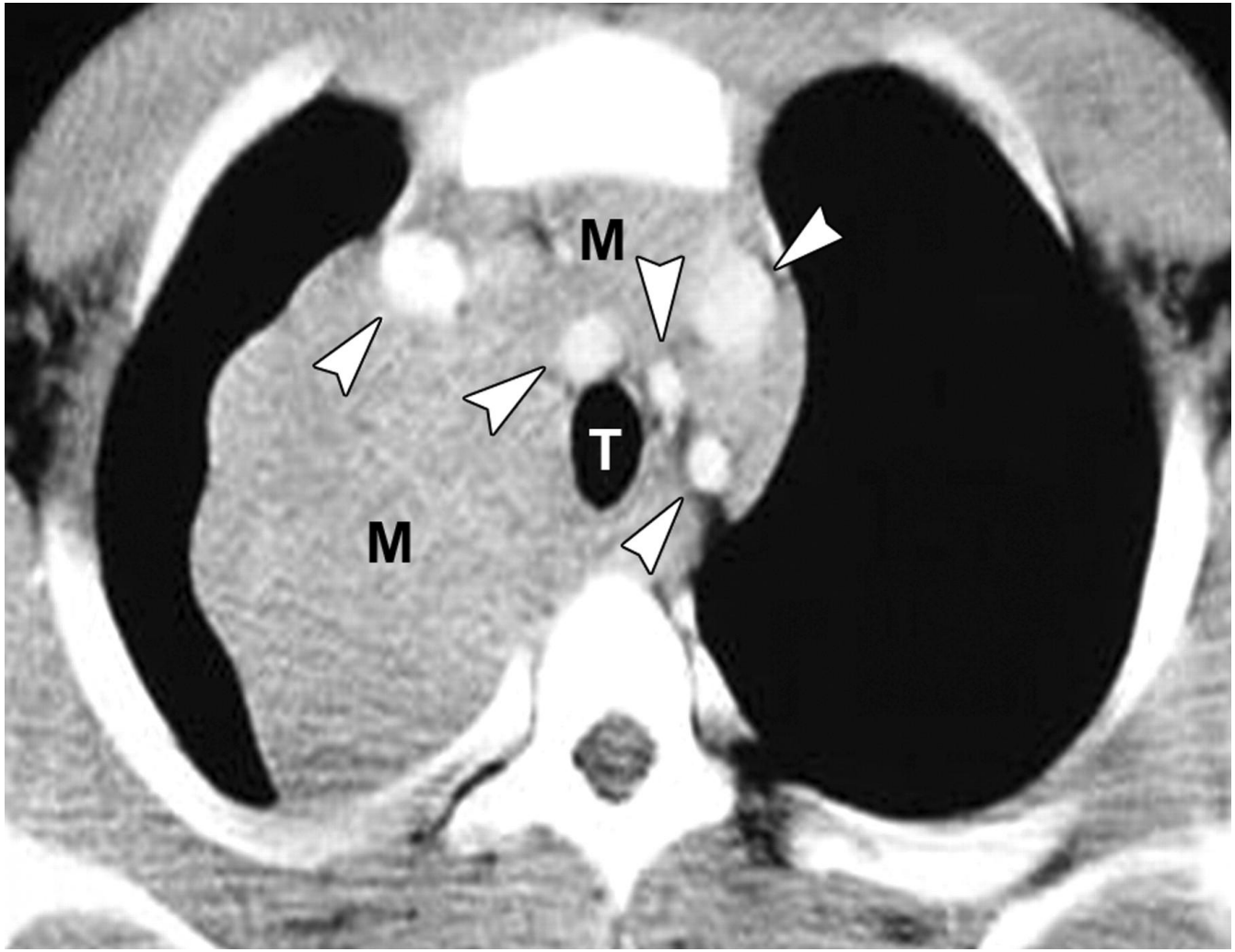



**Toma P et al. Radiographics 2007;27:1335-1354**

RadioGraphics

**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




**Toma P et al. Radiographics 2007;27:1335-1354**

RadioGraphics

**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.

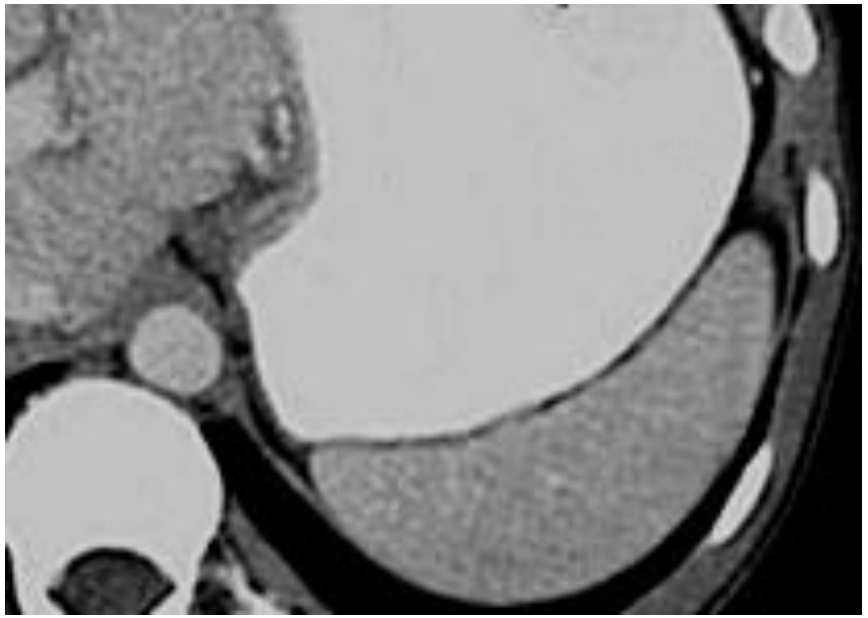
Multiple masses in liver , right kidney and spleen , this image do not identify if this is lymphoma or not that will depend on the histopathology of biopsy or resected organ

**Toma P et al. Radiographics 2007;27:1335-1354**

RadioGraphics


**HD in a 12-year-old girl**

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



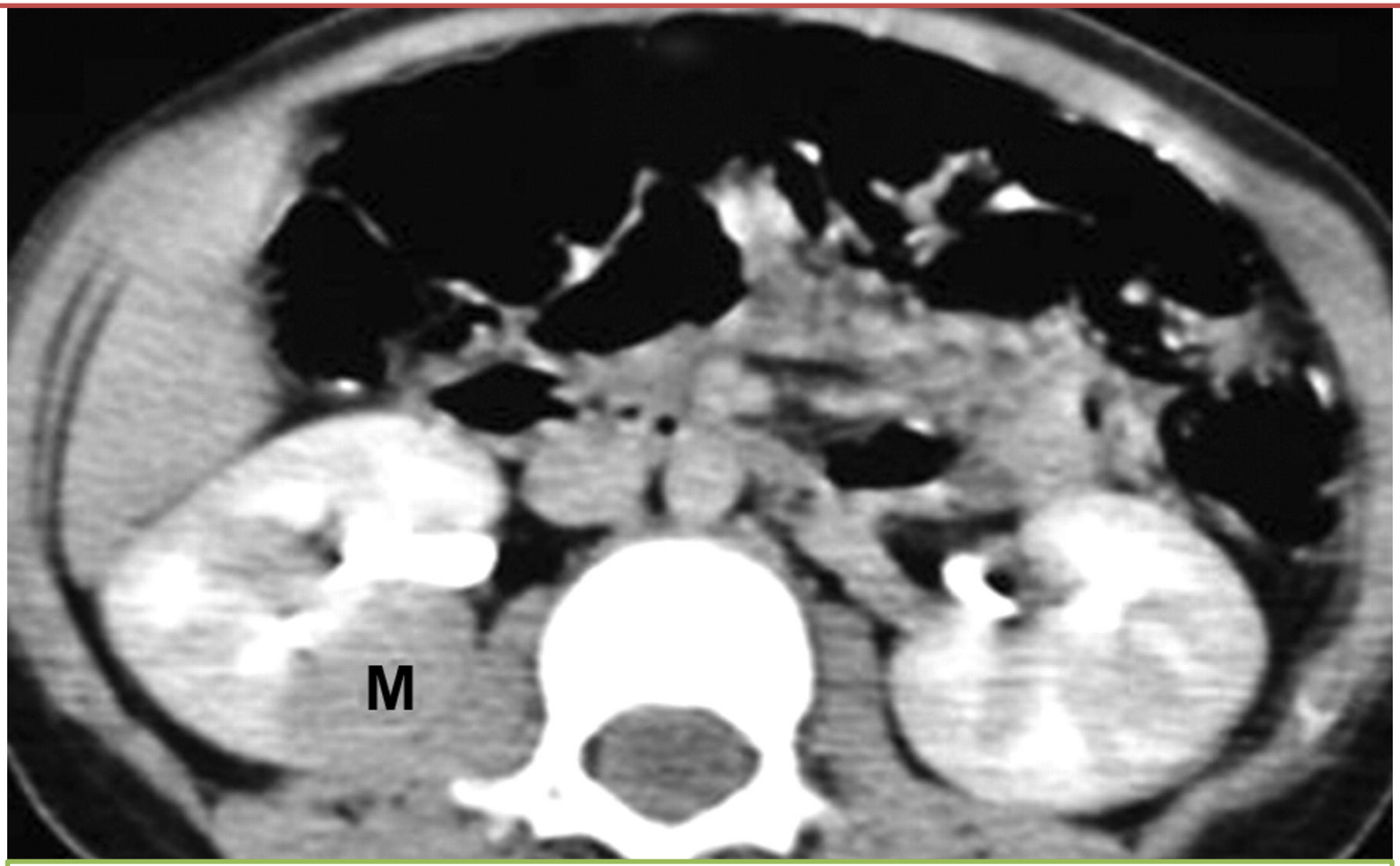
Normal Spleen for comparison

**Toma P et al. Radiographics 2007;27:1335-1354**

RadioGraphics

**NHL in a 14-year-old boy.**

- Contrast-enhanced CT scan shows a well-defined, low-density mass (M) in right kidney




We do not take biopsy from all masses in all organs. One is enough because it is extremely rare to have 2 diseases at the same time. We can start treatment and if all masses responded except one then here we can do biopsy to that mass.

**Toma P et al. Radiographics 2007;27:1335-1354**

RadioGraphics

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

**Leite N P et al. Radiographics 2007;27:1613-1634**

Masses in the brain

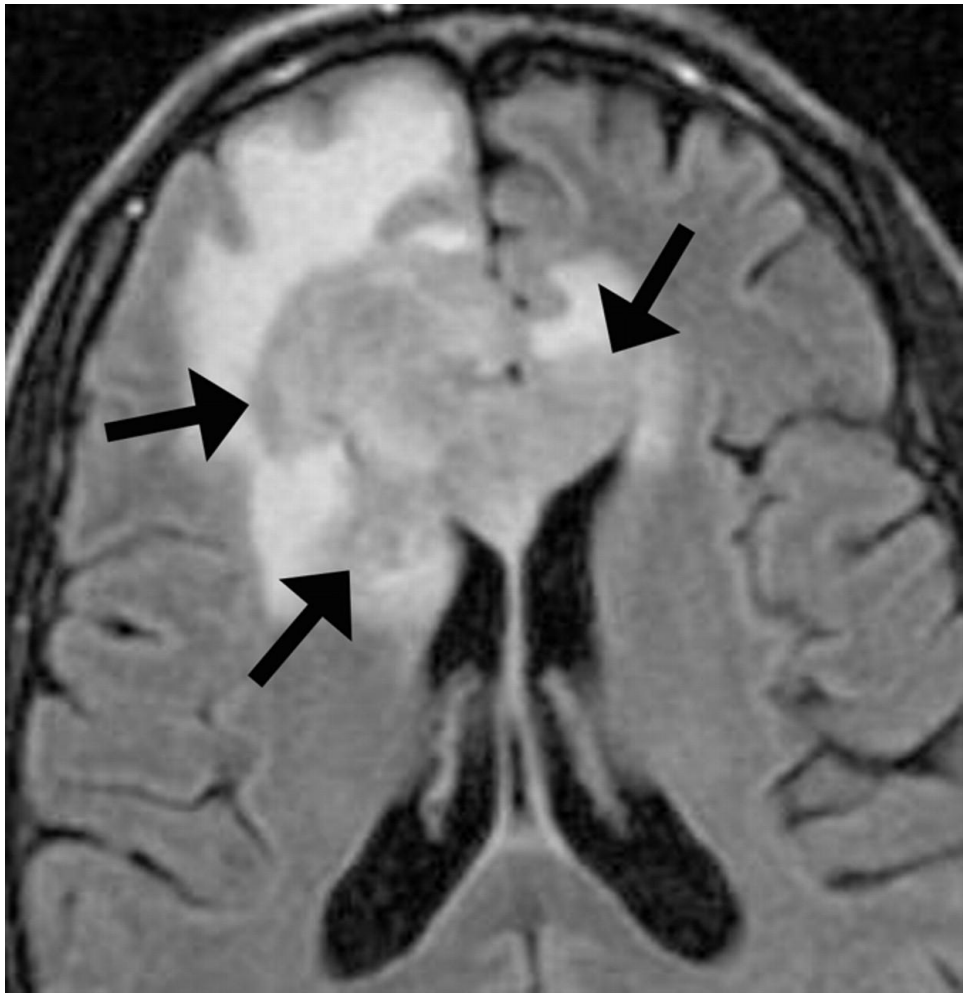
**Slone H W et al. AJR 2005;184:1679-1685**

**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.

AJR

Other masses in brain , brain lesions cannot do biopsy



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

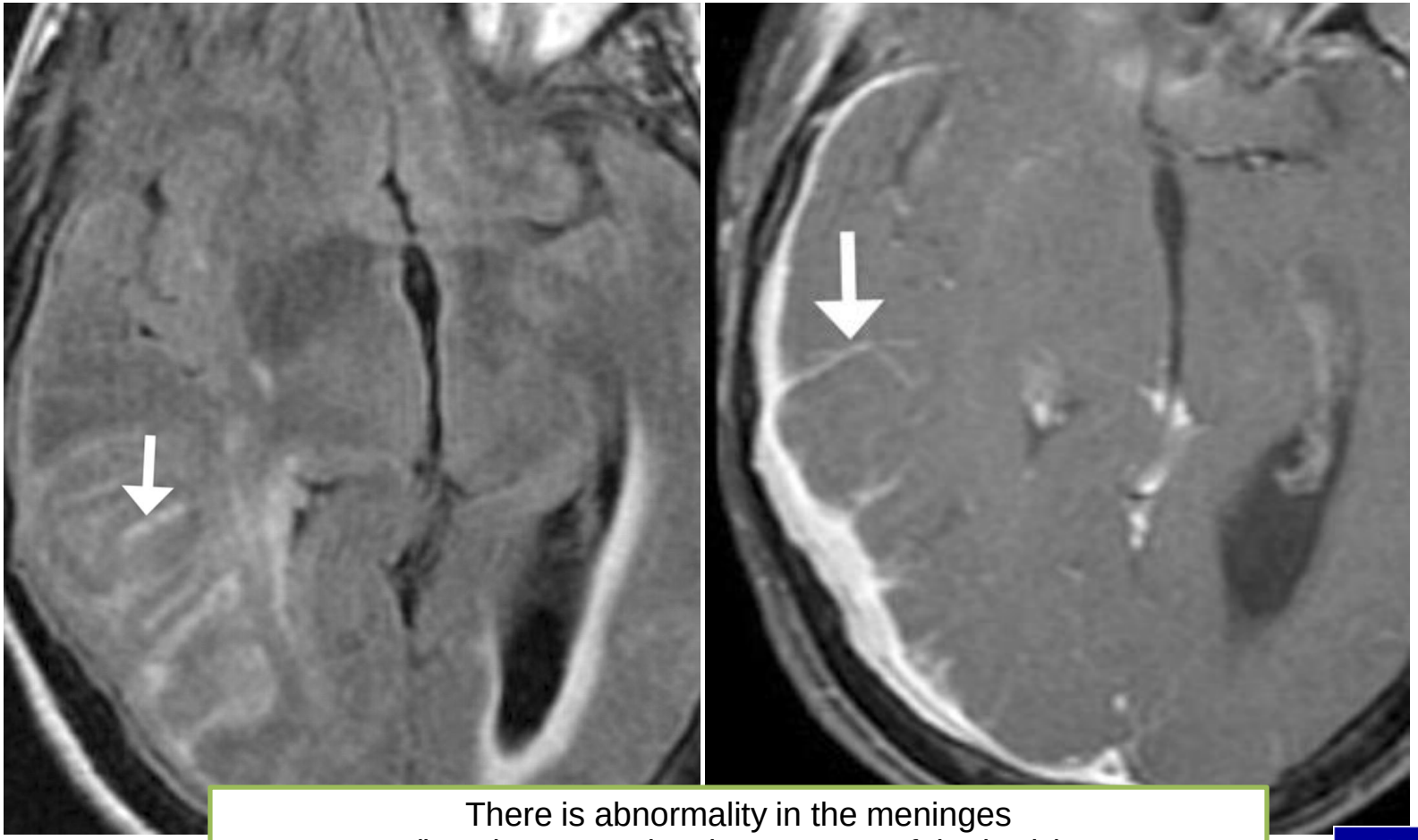
- Axial FLAIR MRI shows lesion isointense to gray matter (arrows).

**Slone H W et al. AJR 2005;184:1679-1685**

AJR

**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



There is abnormality in the meninges
(lymphoma can involve any part of the body)

**Slone H W et al. AJR 2005;184:1679-1685**

AJR

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

Image shows multiple black spots can be due any cause (metastasis, hyperparat hyroidism)

# MCQs

Findings shown here can be seen in

1. any severe chronic anemia
2. thalassemia
3. Sickle cell anemia
4. Lymphoma

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