RADIOLOGY of HEMATOPOIETIC DISORDERS

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OBJECTIVES:

By the end of this lecture, the students should be able to:

1. Recognize the applications and limitations of radiology for various hematologic disorders
2. Understand the appearance of common forms of anemias and possible differentiation.
3. Identify the common locations and appearance of lymphoma
4. Explain the appearance of multiple myeloma

BLOOD

CELLS

- RBCs
- WBCs
- Platelets

PLASMA

BLOOD

CELLS

RBCs

Sickle cell
Anemia Thalassemia
Others – nutritional, hemolysis etc.
Polycythemia

WBCs

Platelets

PLASMA

BLOOD

CELLS

RBCs
- Sickle cell Anemia
- Thalassemia
- Others – nutritional, hemolysis etc.
- Polycythemia

WBCs
- Lymphoma
- Leukemia
- Multiple myeloma

Platelets

PLASMA

BLOOD

CELLS

RBCs
- Sickle cell Anemia Thalassemia
- Others – nutritional, hemolysis etc.
- Polycythemia

WBCs
- Lymphoma
- Leukemia
- Multiple myeloma

Platelets
- Bleeding / clotting disorders

PLASMA

ANEMIA

Reactive increase in red bone marrow → 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

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

SCA

Infections → Pneumonias, Osteomyelitis

Infarcts → Spleen, Kidneys, Brain, Bones

Thalassemia

Decreased bone density with coarse trabeculae

Wide medullary cavity with thin cortex

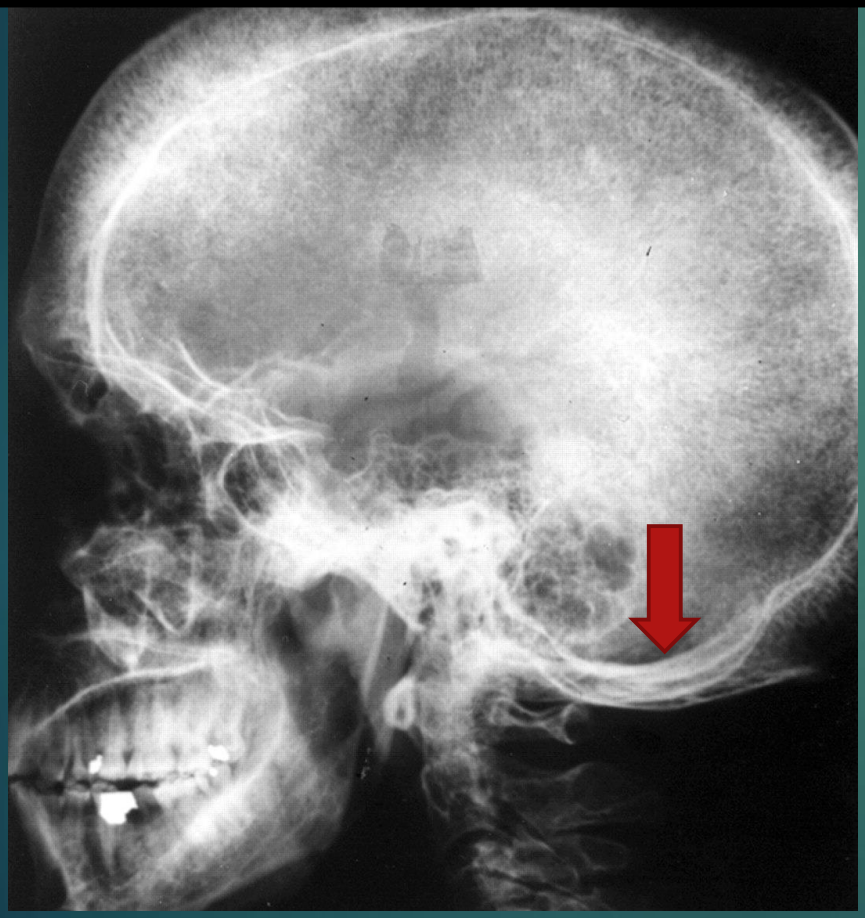
Normal for comparison

Severe chronic anemia

Normal for comparison

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

Spared occipital bone (arrow)



Normal for comparison

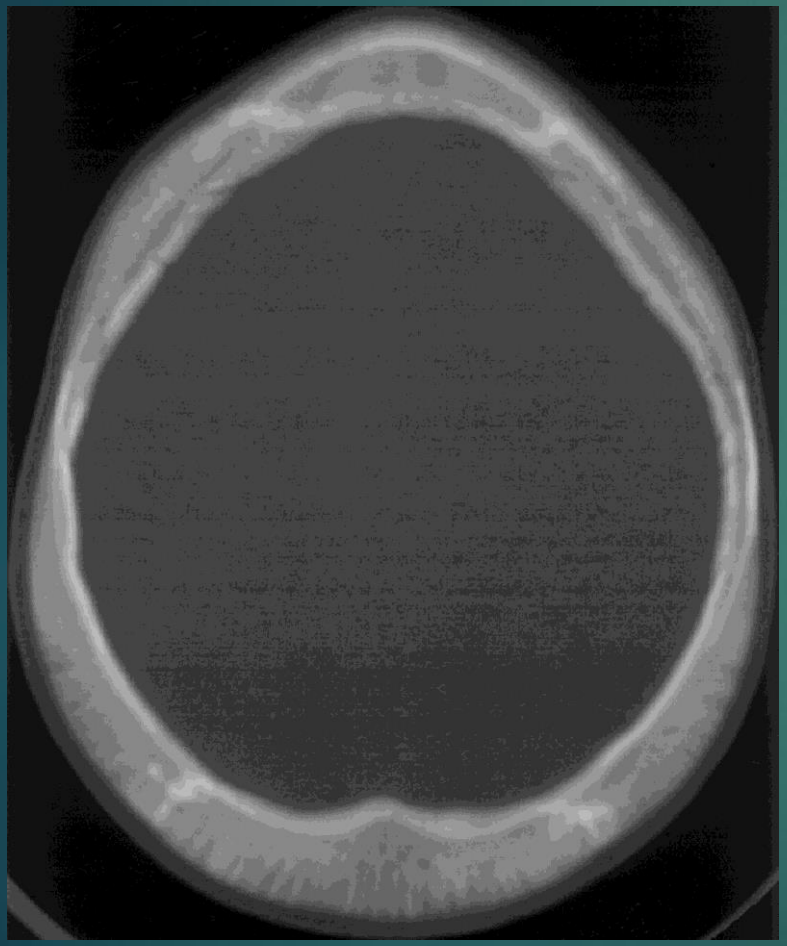
Georgiades C S et al. AJR 2002;179:1239-1243

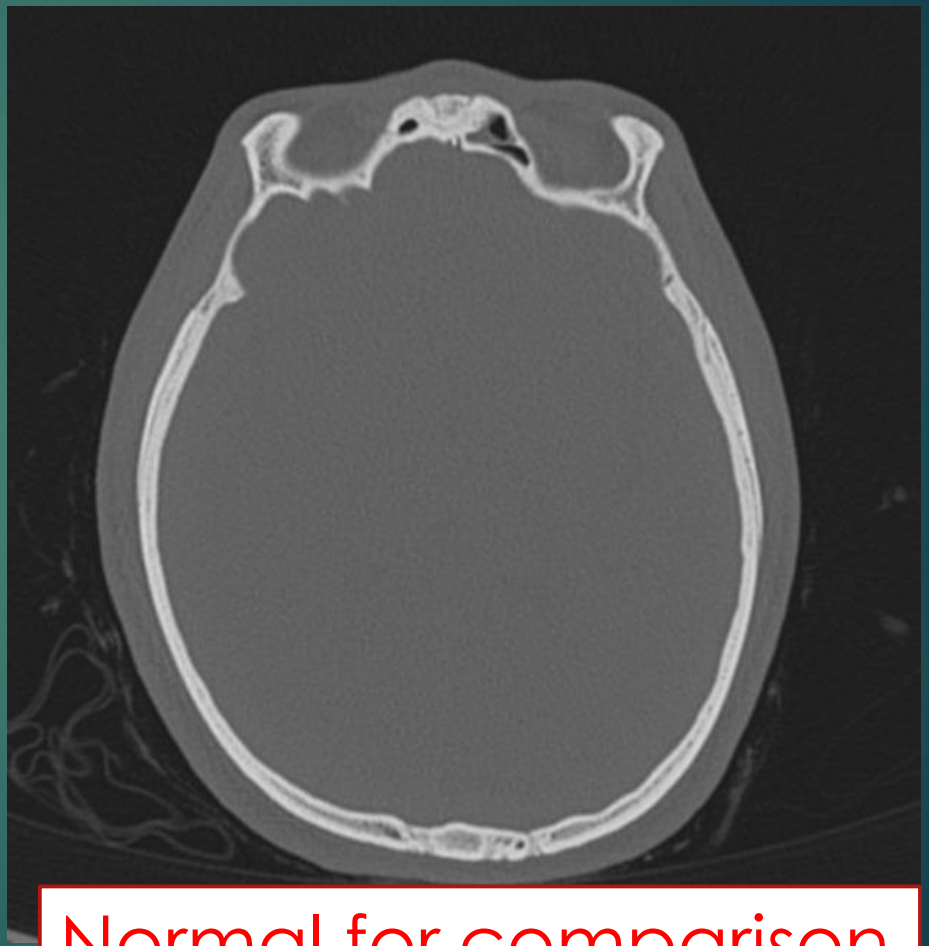
AJR

Severe chronic anemia

Normal for comparison

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



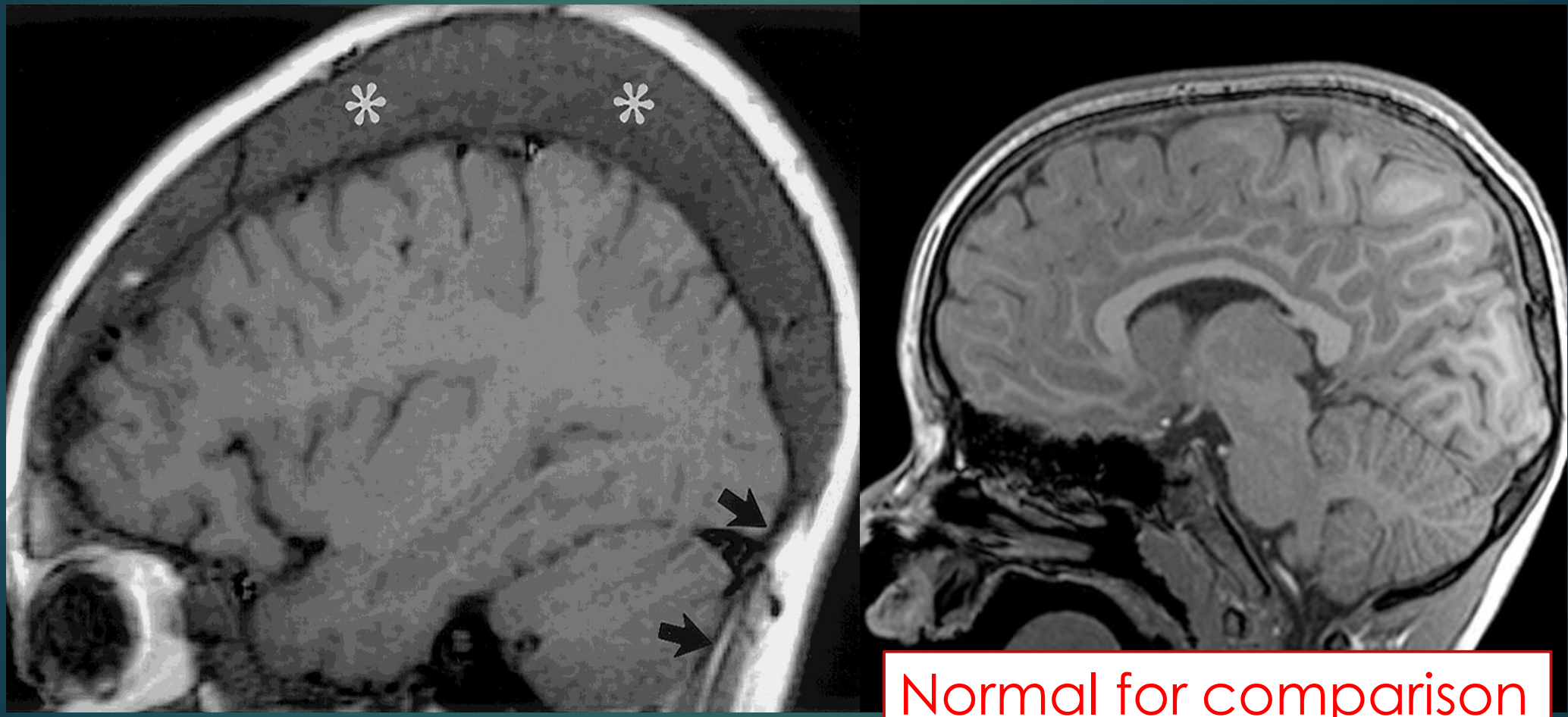


Normal for comparison

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

RadioGraphics

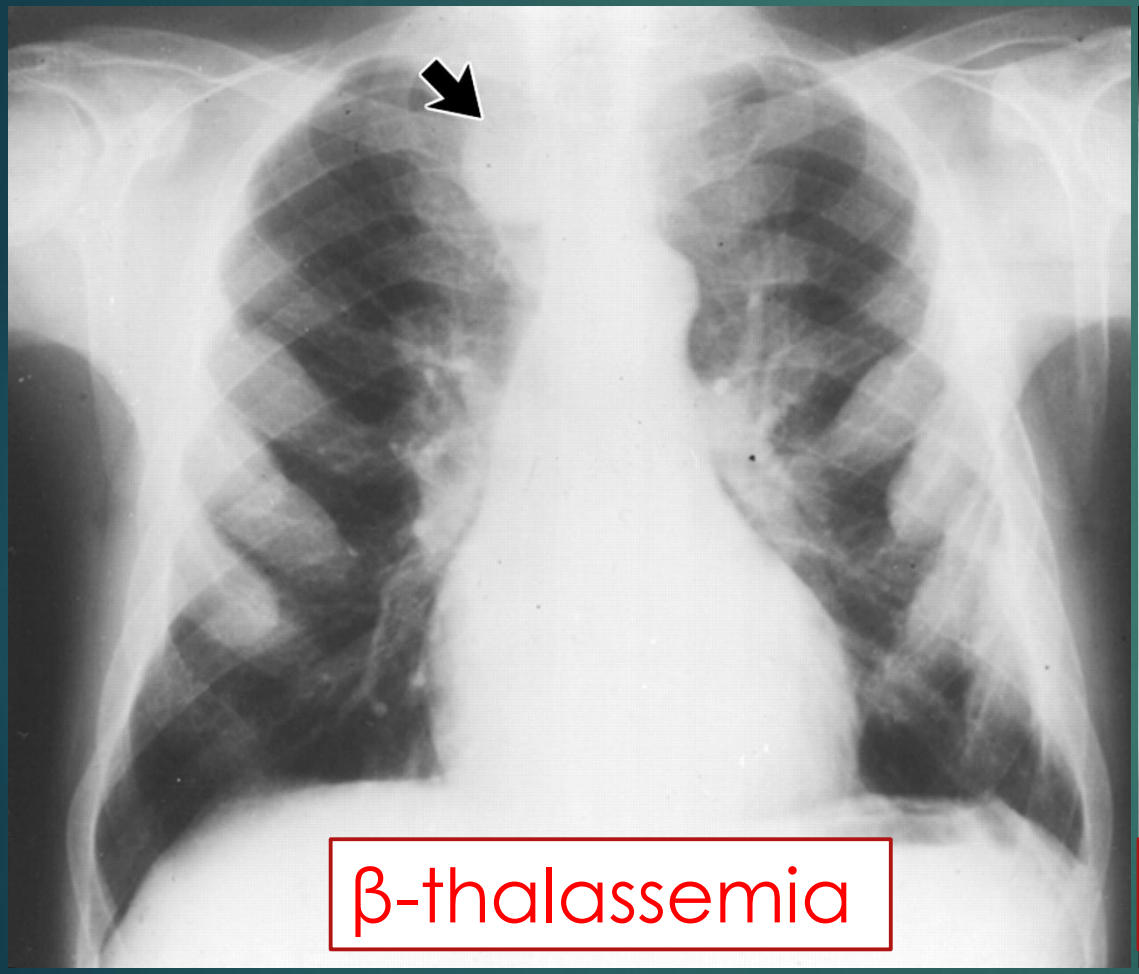
Sagittal MRI of brain (right) shows diploic space widening representing red marrow (*). Note spared occipital bone (arrows), which has no marrow elements

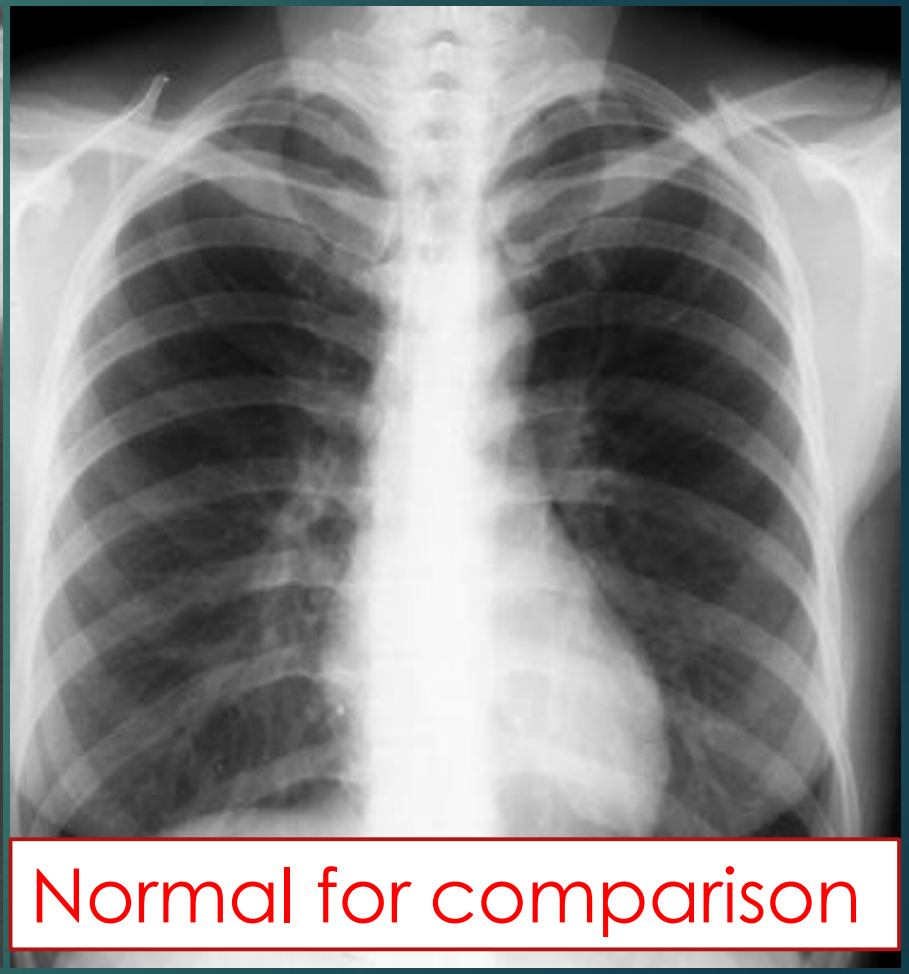


Lonergan G J et al. Radiographics 2001;21:971-994

RadioGraphics

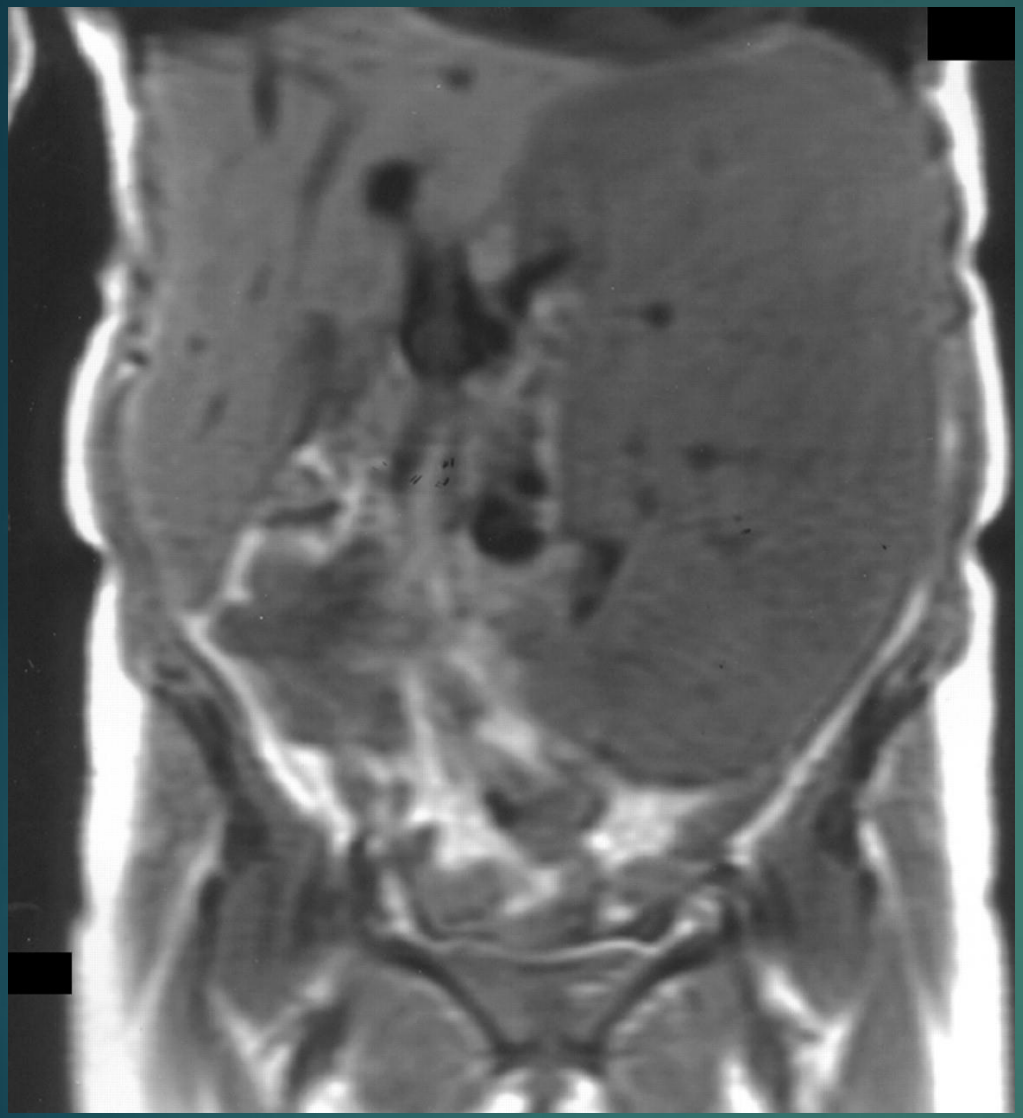
25-year-old man with β-thalassemia.
PA radiograph of chest (left) shows diffuse expansion of ribs and right upper paraspinal thoracic mass (arrow) compatible with extramedullary hemopoiesis.





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

AJR



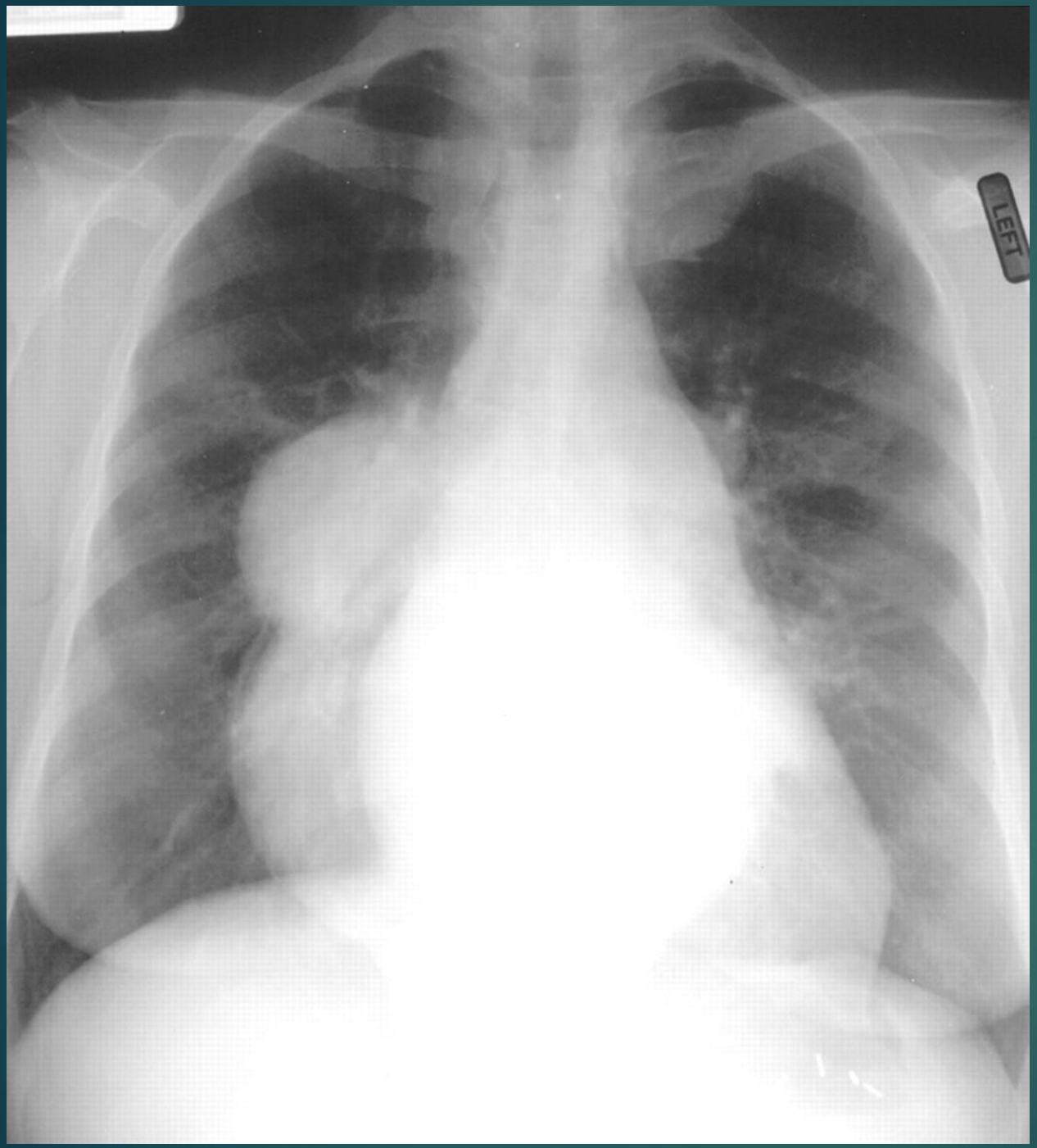
51-year-old woman with myelofibrosis.

Coronal T1-weighted MR image shows massively enlarged spleen

Splenic biopsy was followed by splenectomy

Pathologic examination revealed extramedullary hematopoiesis

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



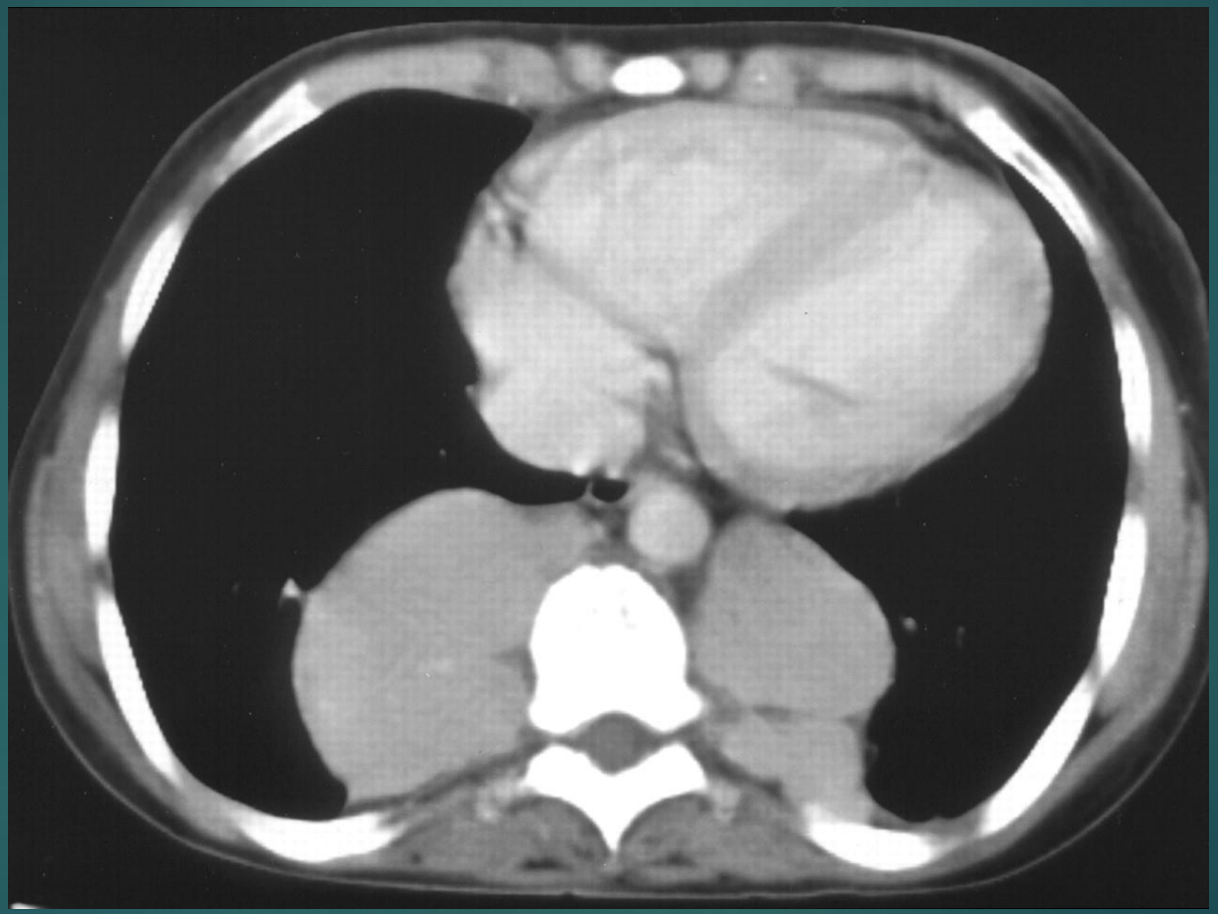
23-year-old woman with history of thalassemia and known extramedullary hemopoiesis

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

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

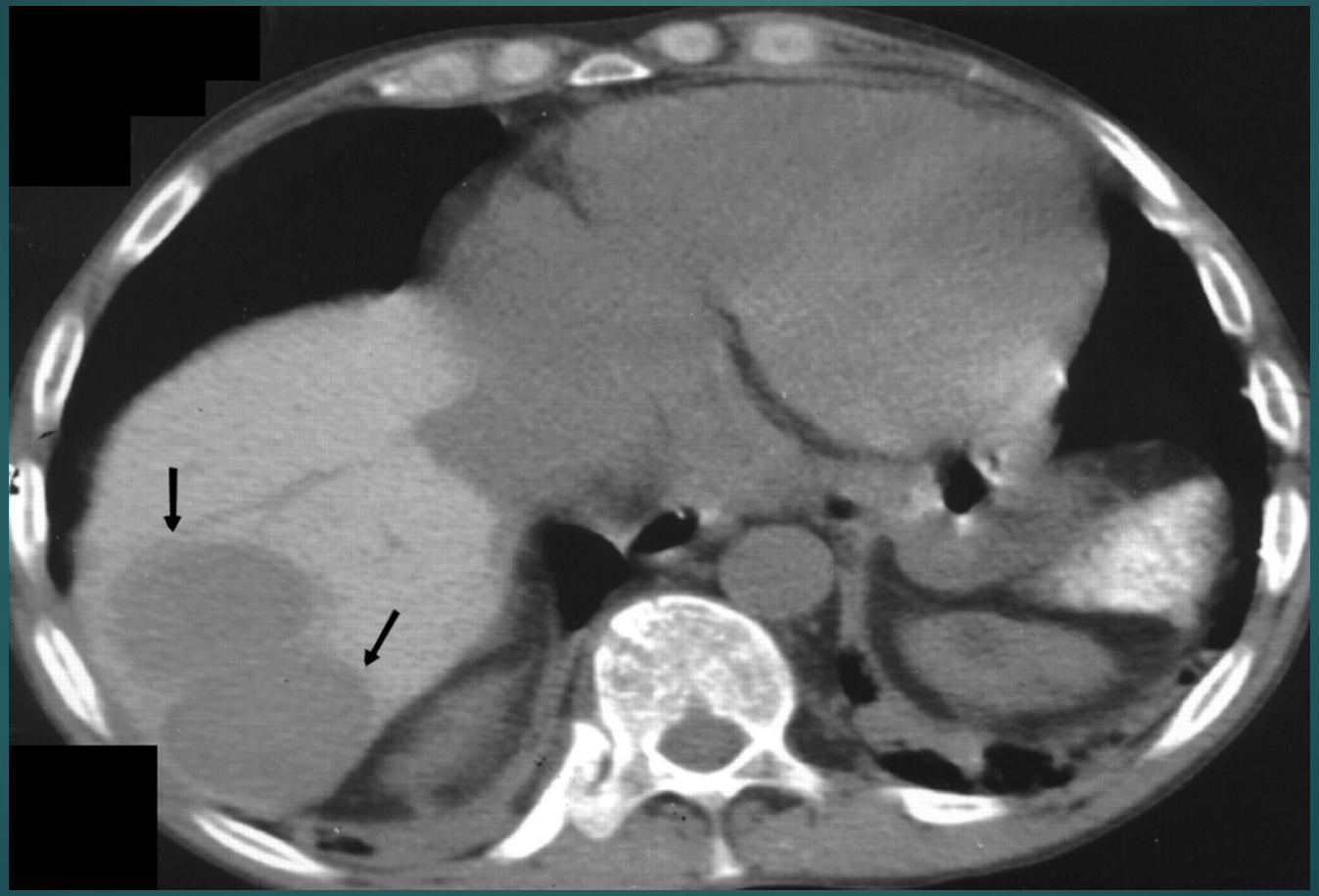
AJR

23-year-old woman with history of thalassemia and known extramedullary hemopoiesis. Axial contrast-enhanced CT scan through chest shows uniformly enhancing paraspinal hemopoietic masses with no bony erosion.



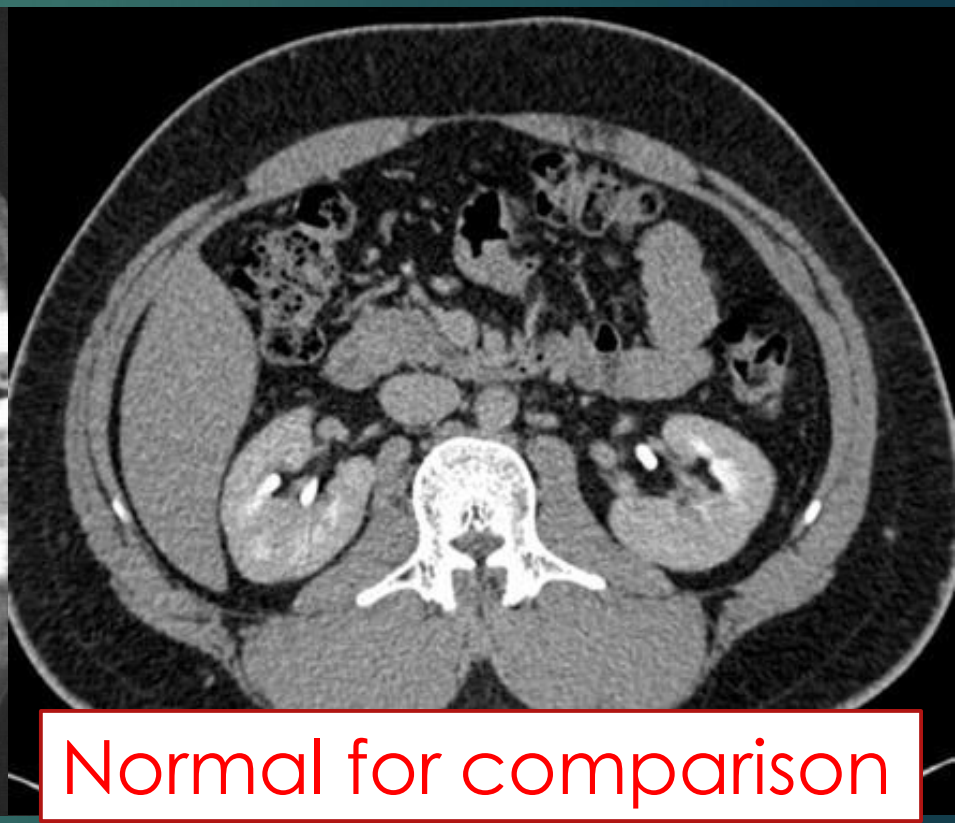
Georgiades C S et al. AJR 2002;179:1239-1243

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



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

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



Normal for comparison

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

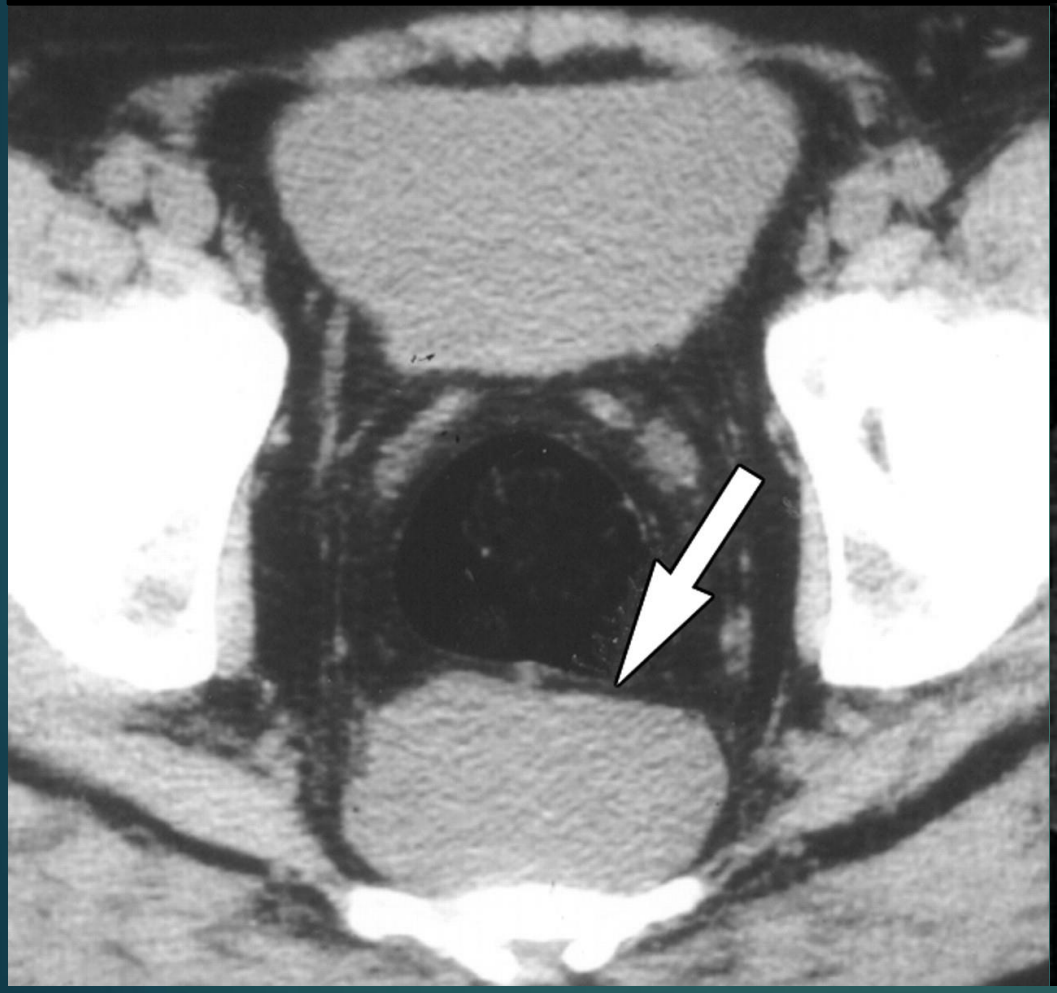
AJR

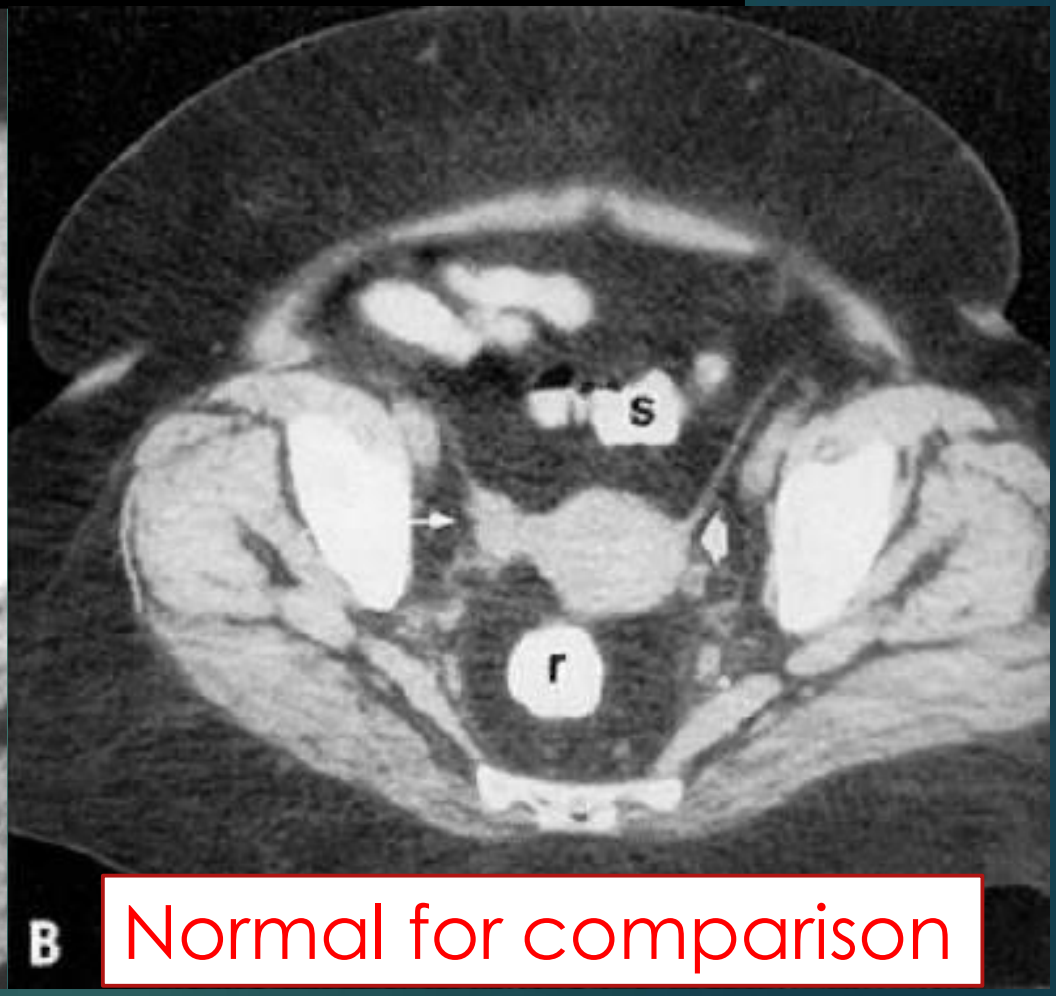
48-year-old man with hemolytic anemia and myelofibrosis

Axial CT scan through pelvis shows

well-marginated presacral soft-tissue mass (arrow) with no bony erosion

Biopsy (not often needed) showed extramedullary hematopoiesis





Normal for comparison

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

AJR

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)*

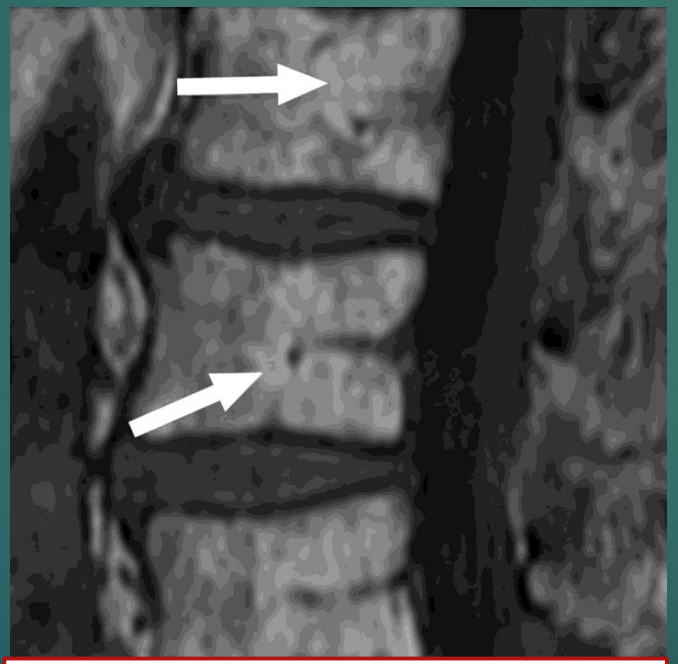
Lonergan G J et al. Radiographics 2001;21:971-994

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



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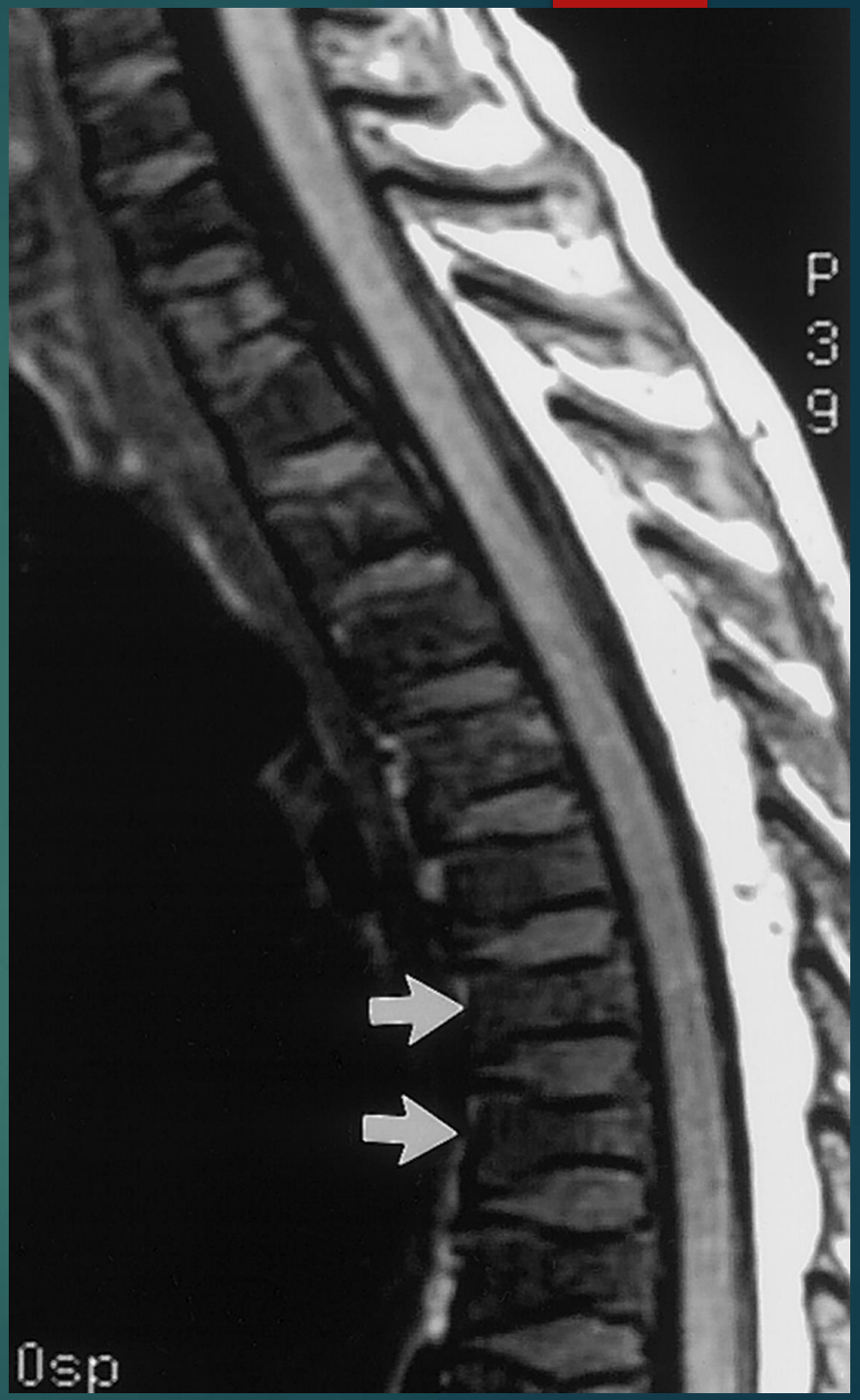
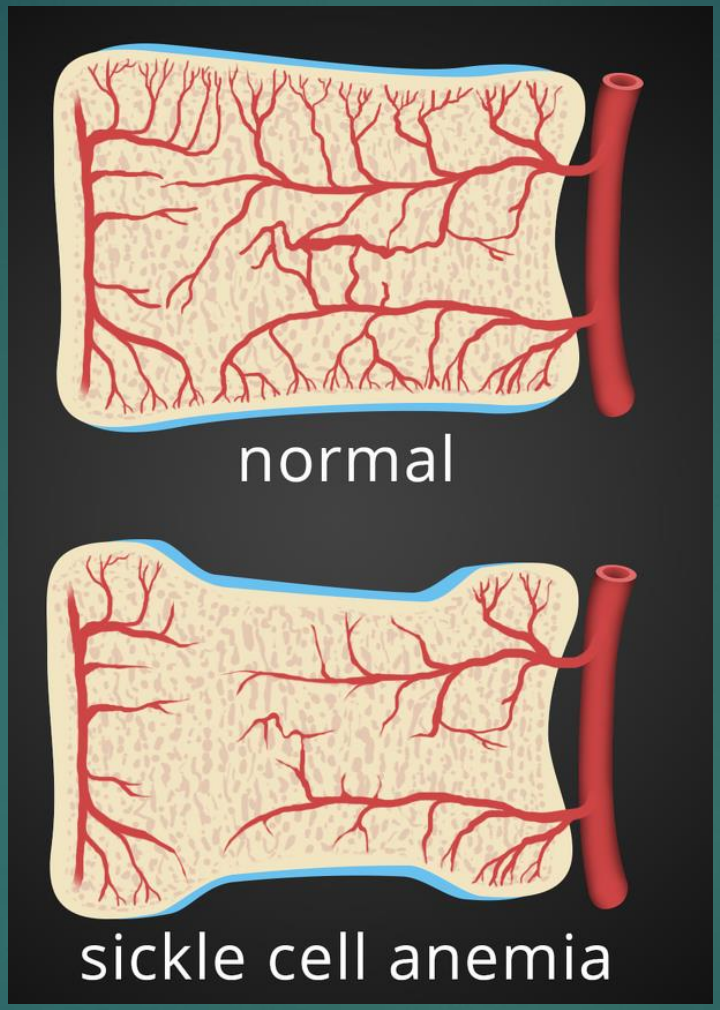


Lonergan G J et al. Radiographics 2001;21:971-994

RadioGraphics


normal
sickle cell anemia

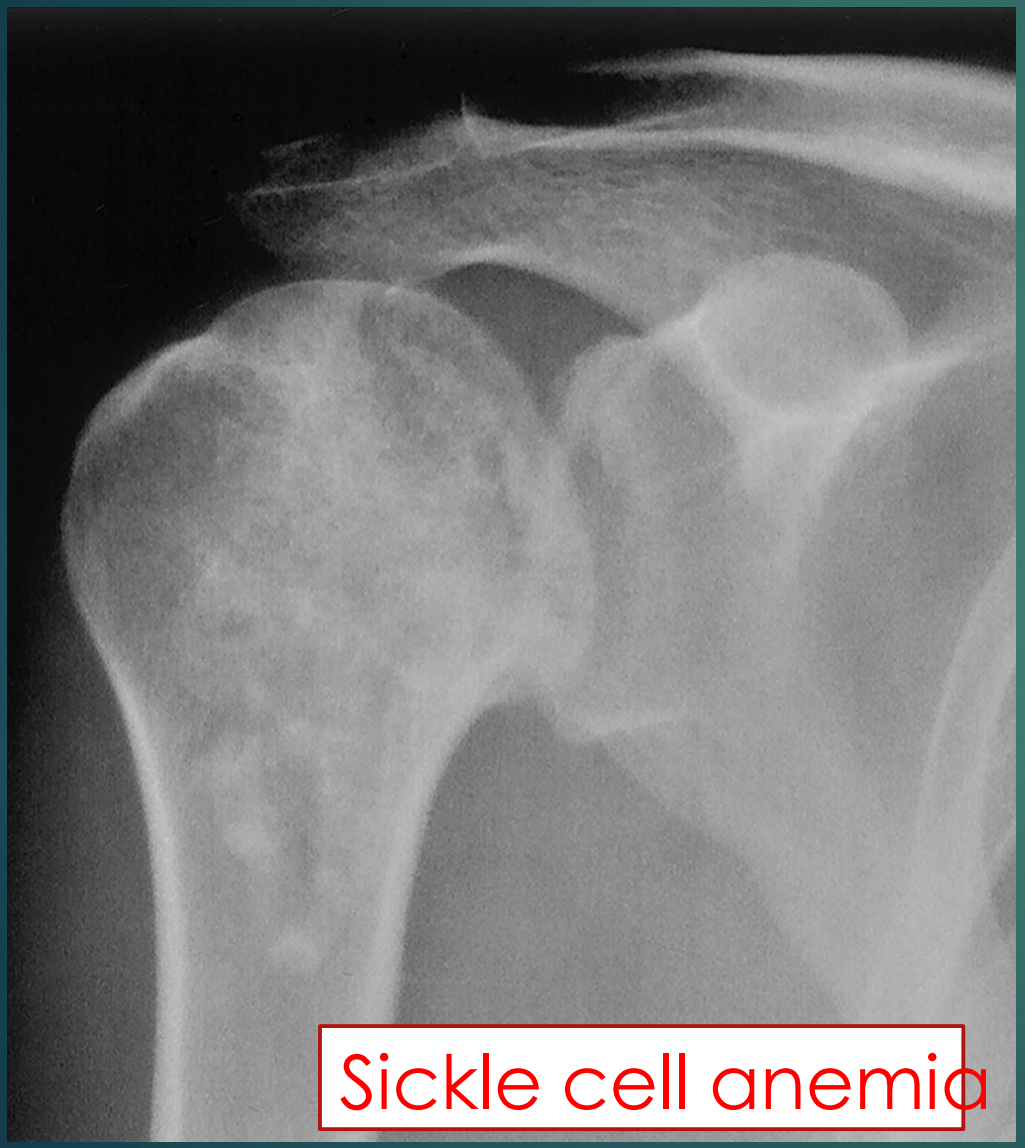
Bone infarcts typically occur in the medullary cavities and epiphyses

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

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

RadioGraphics

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



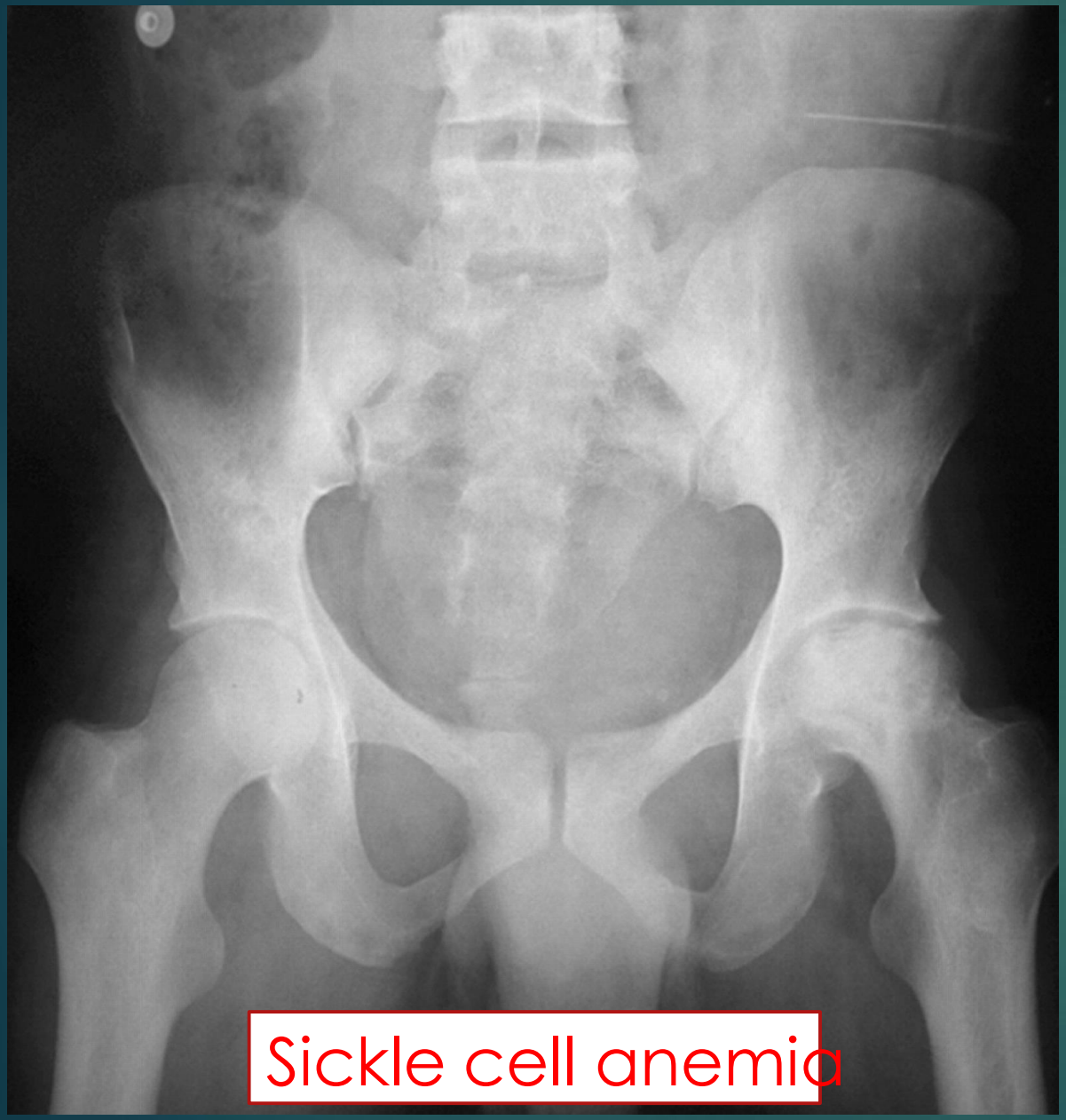
Sickle cell anemia

Normal for comparison

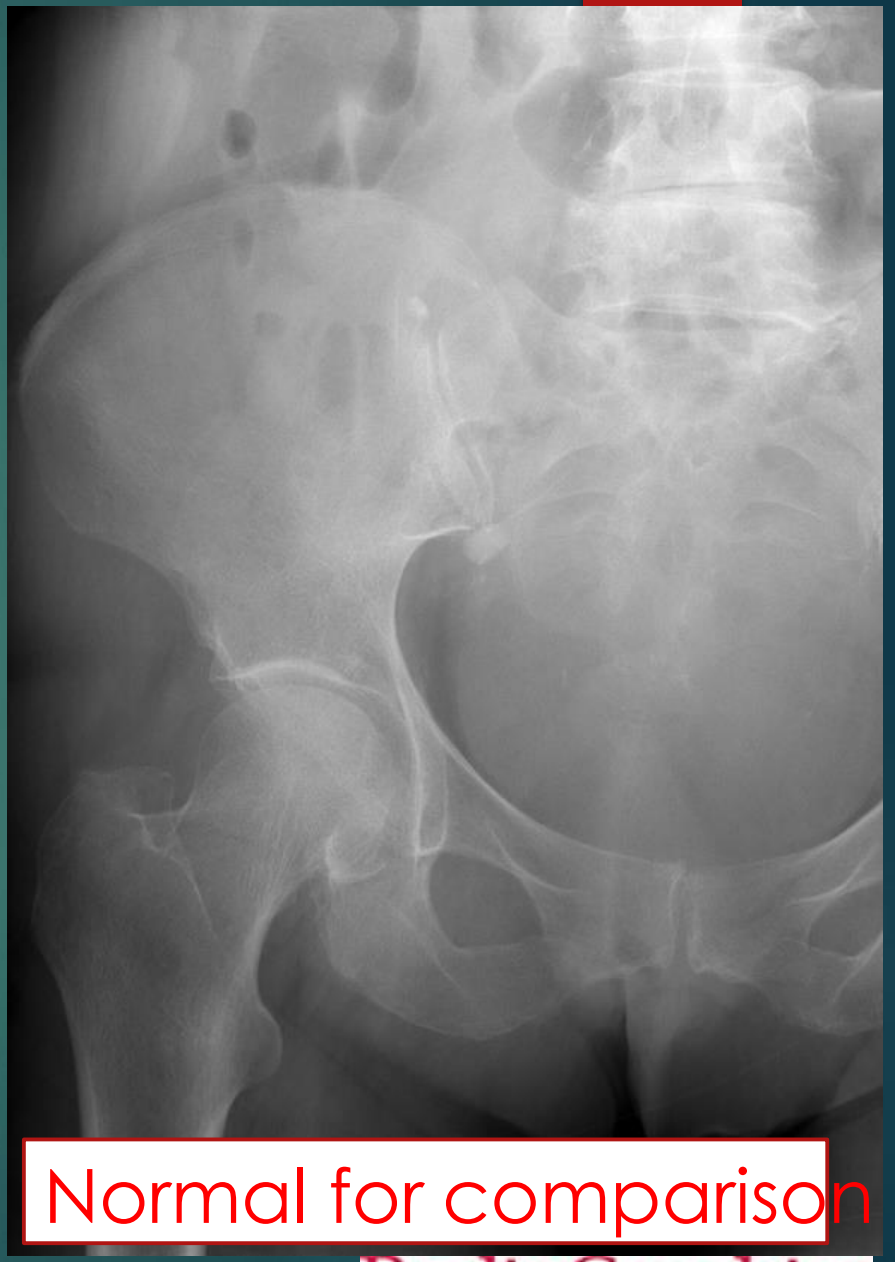
Lonergan G J et al. Radiographics 2001;21:971-994

RadioGraphics

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



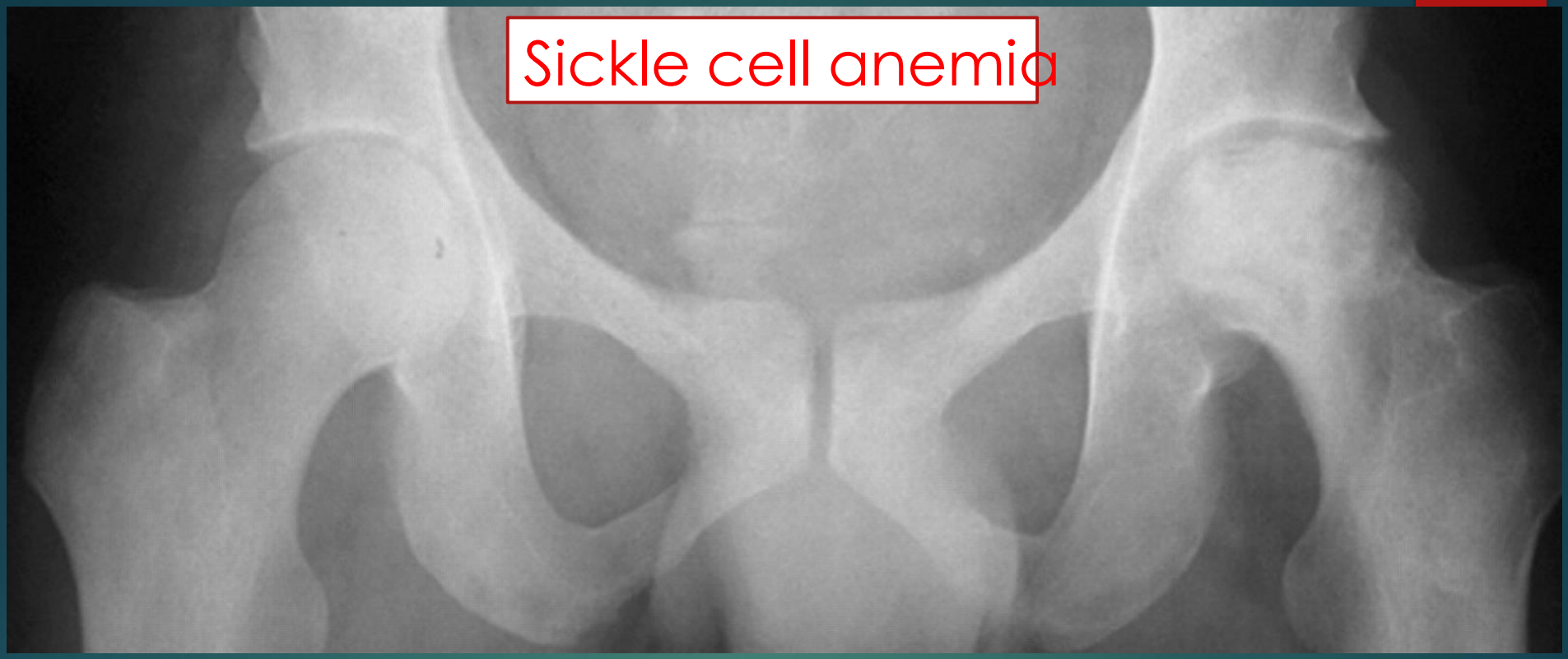
Sickle cell anemia

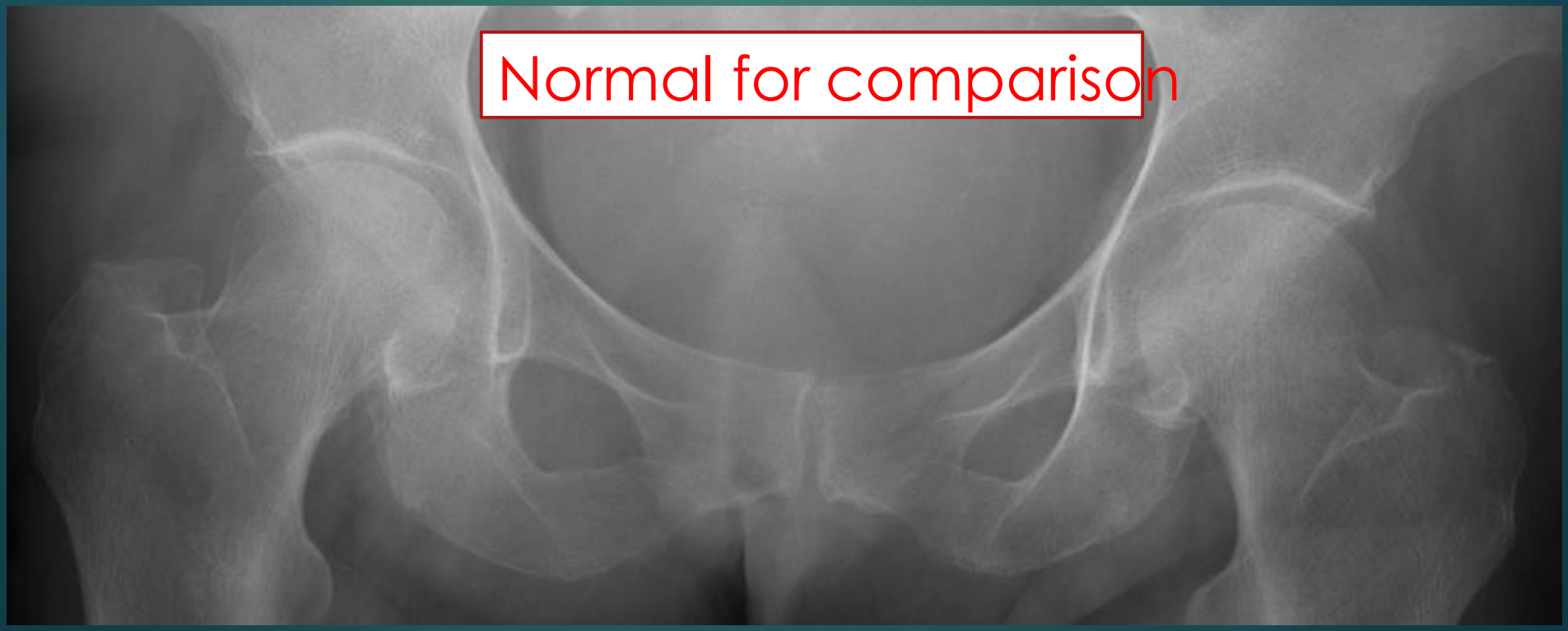


Normal for comparison

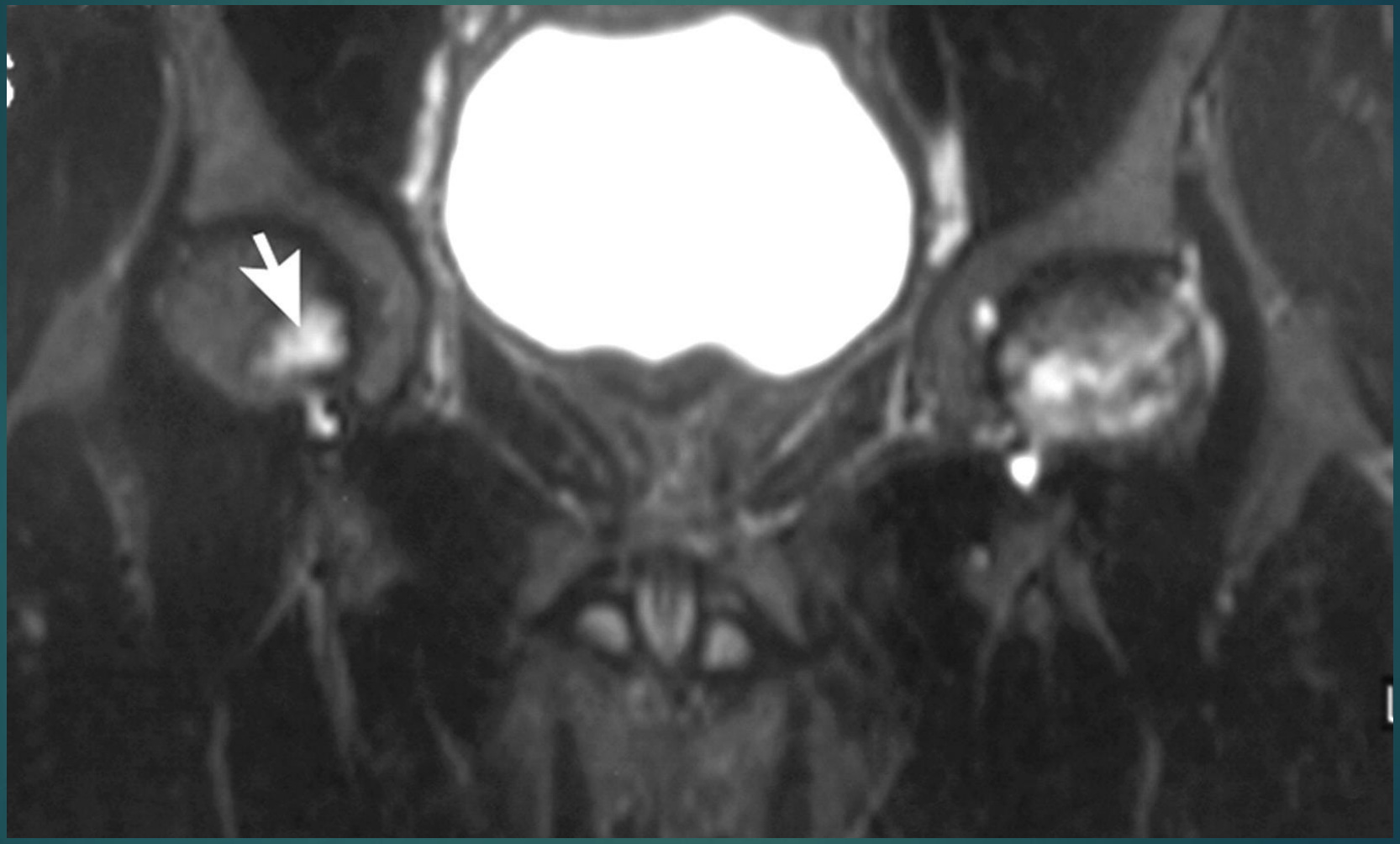
Ejindu V C et al. Radiographics 2007;27:1005-1021

RadioGraphics


Sickle cell anemia


Normal for comparison

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



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

RadioGraphics

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

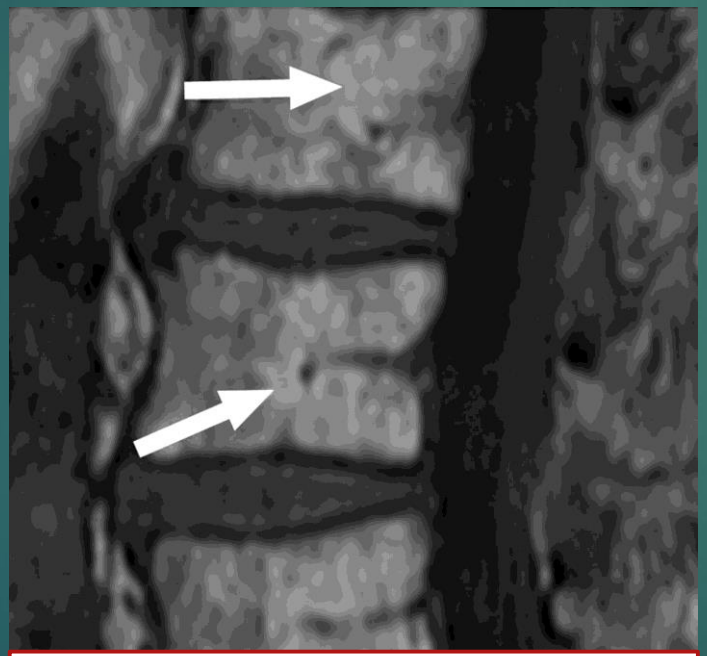
Normal for comparison

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

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

RadioGraphics

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

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 lower tibial shaft and diffuse periostitis of the lower diaphysis

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

RadioGraphics

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

MRI findings of

- Cortical defects in bone
- Adjacent fluid collections in soft tissue
- Bone marrow enhancement

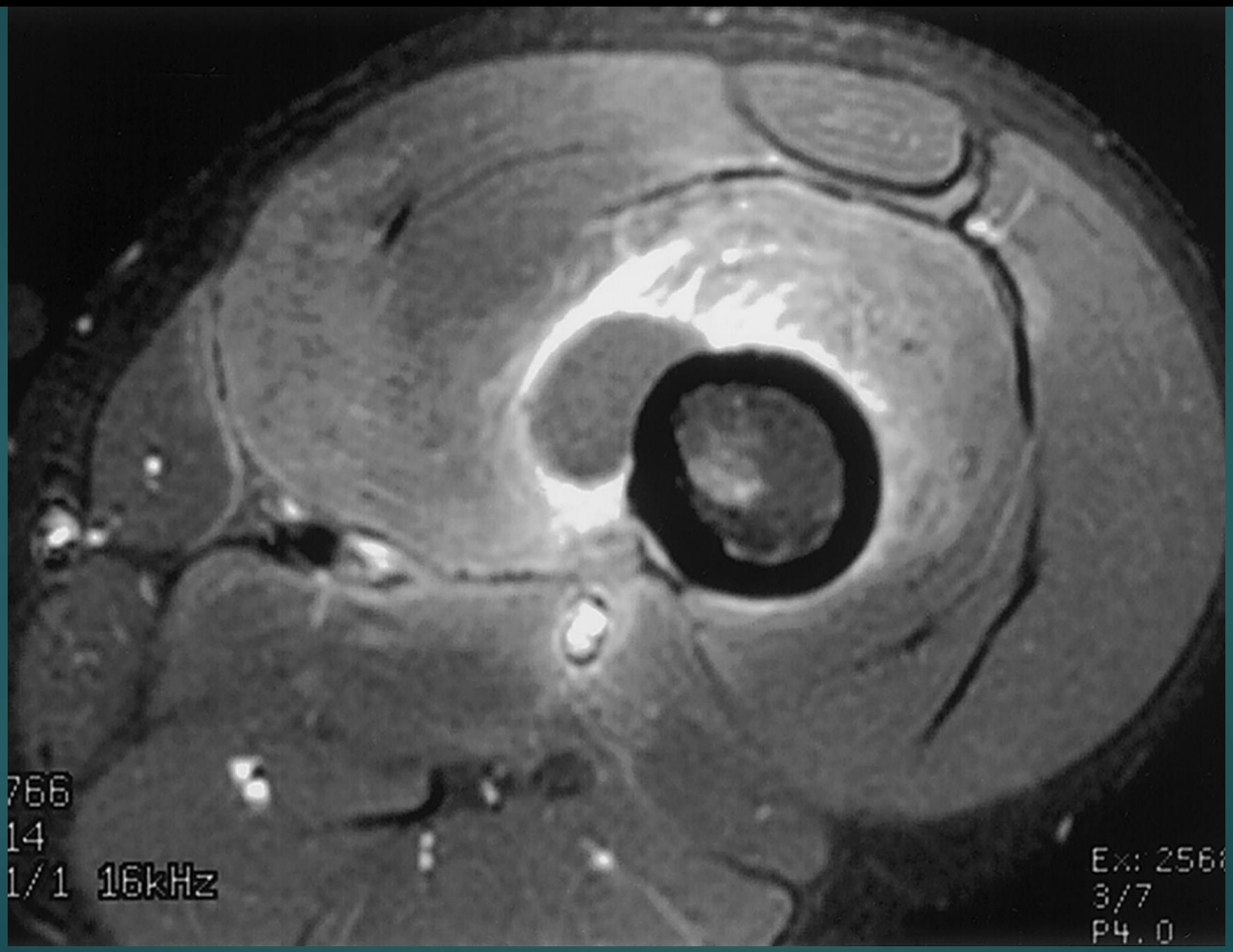
are highly suggestive of infection

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

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

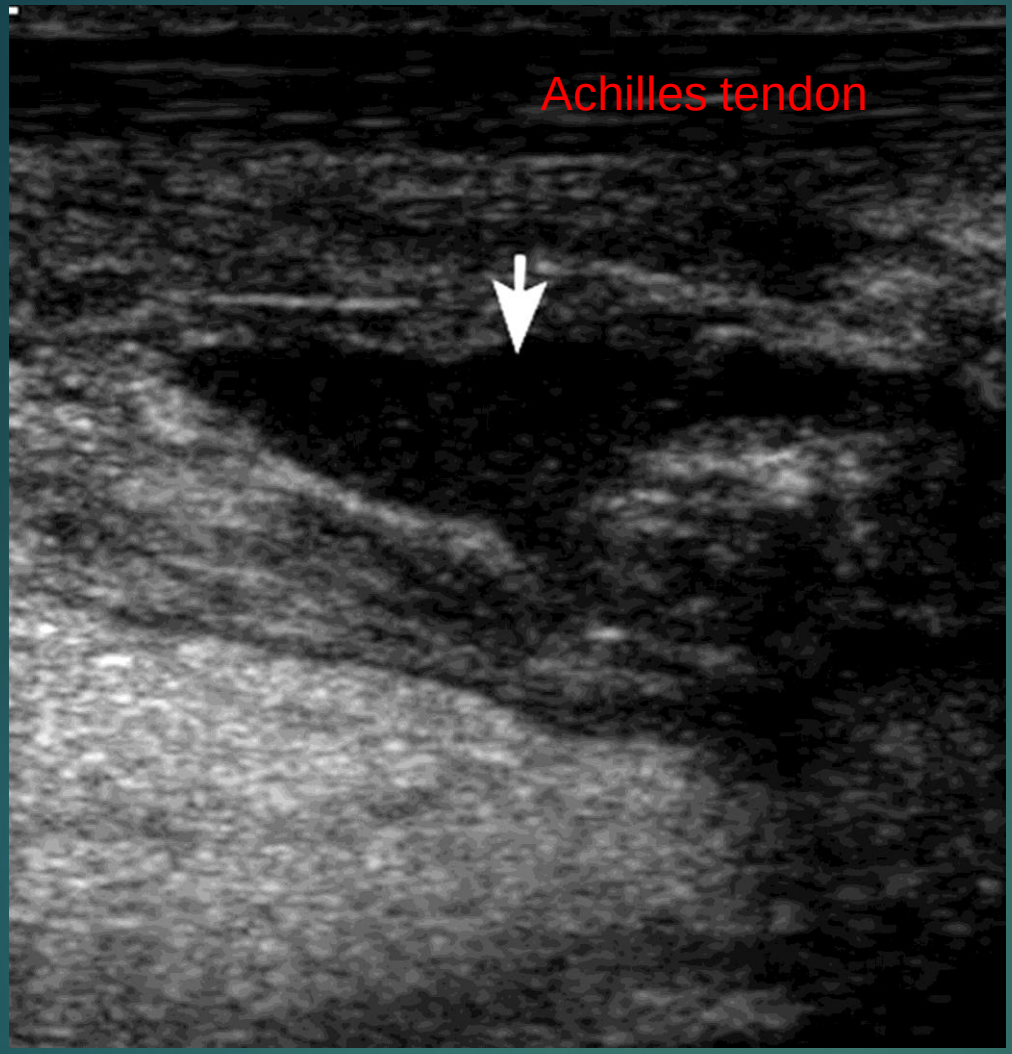
RadioGraphics

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



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

RadioGraphics

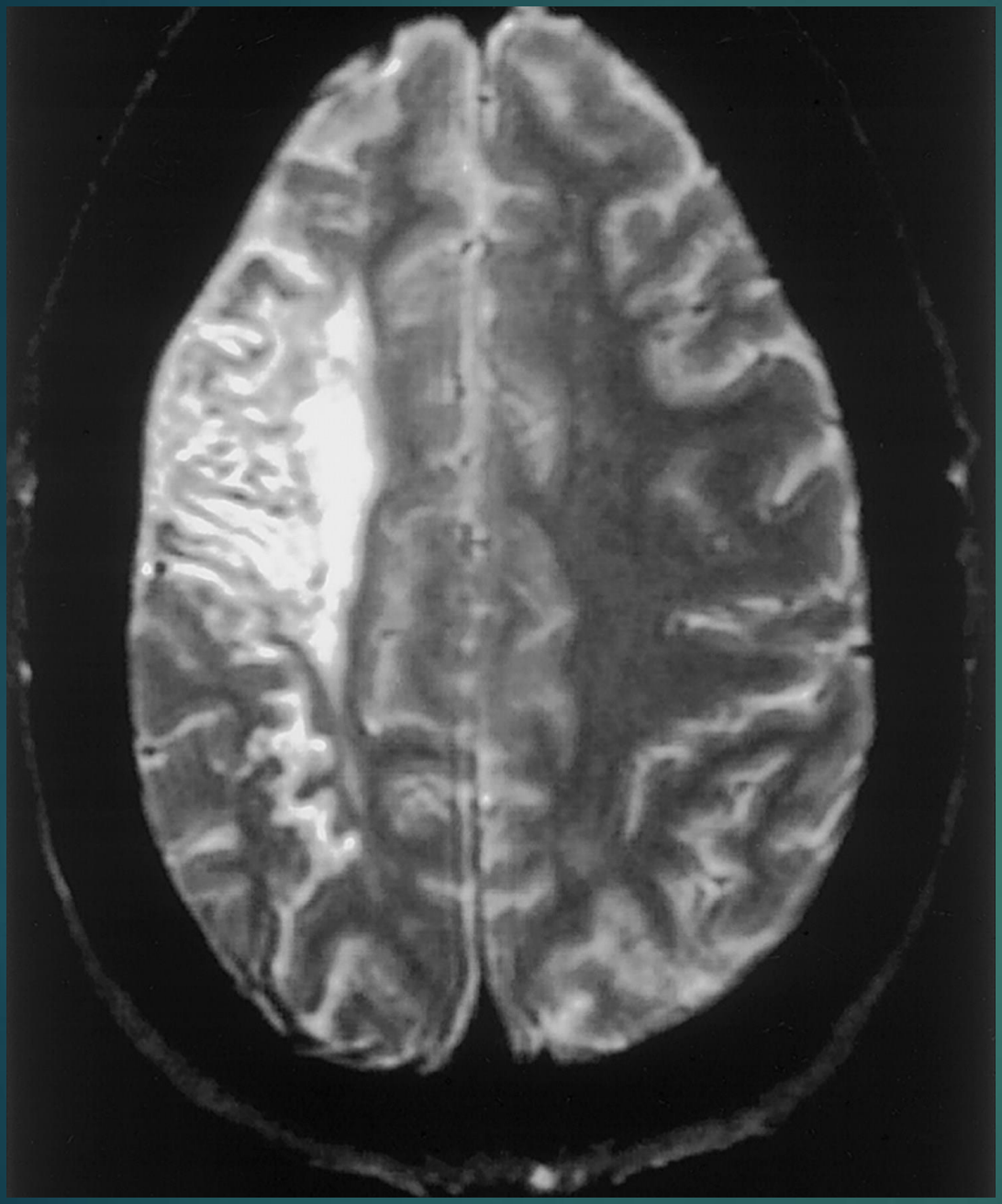


Soft-tissue infection in a 52-year-old man with homozygous sickle cell disease.

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

RadioGraphics



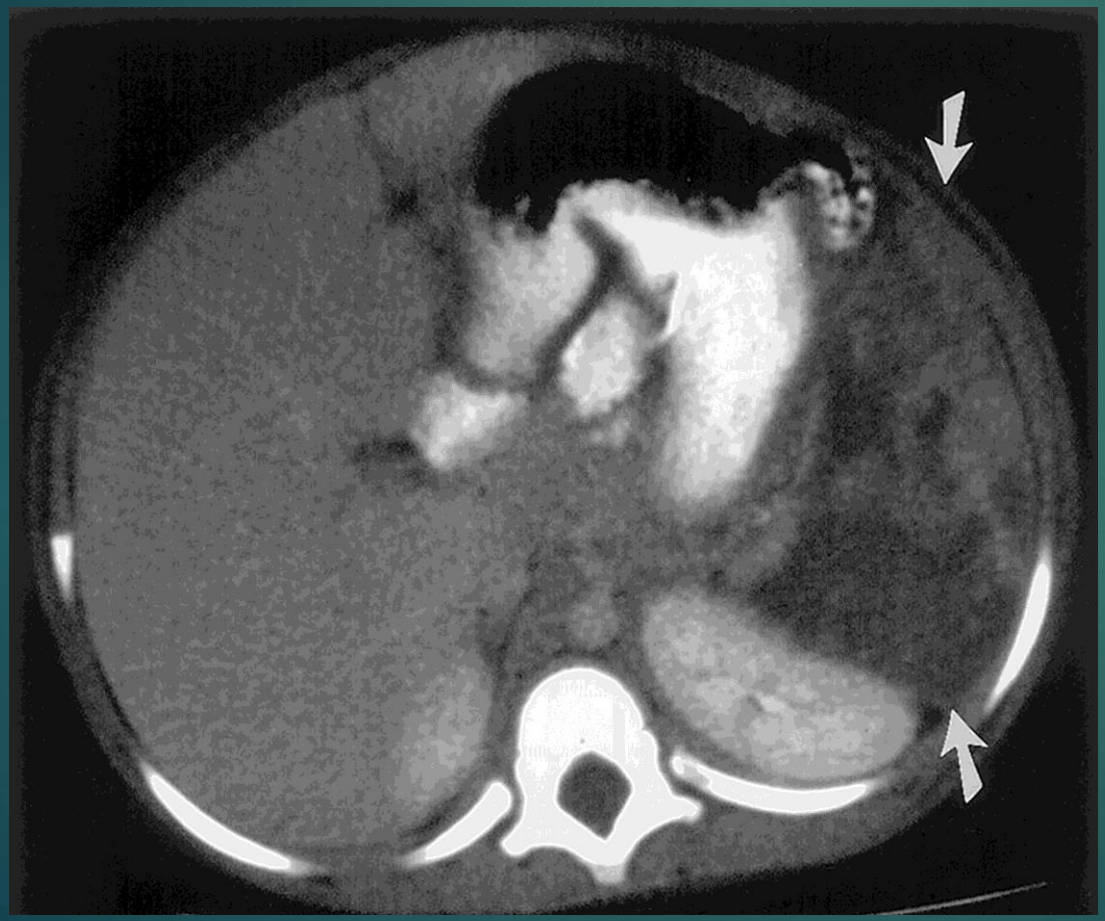
Chronic infarct in a 19-year-old patient with SCA and longstanding mild left sided weakness

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

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

RadioGraphics

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



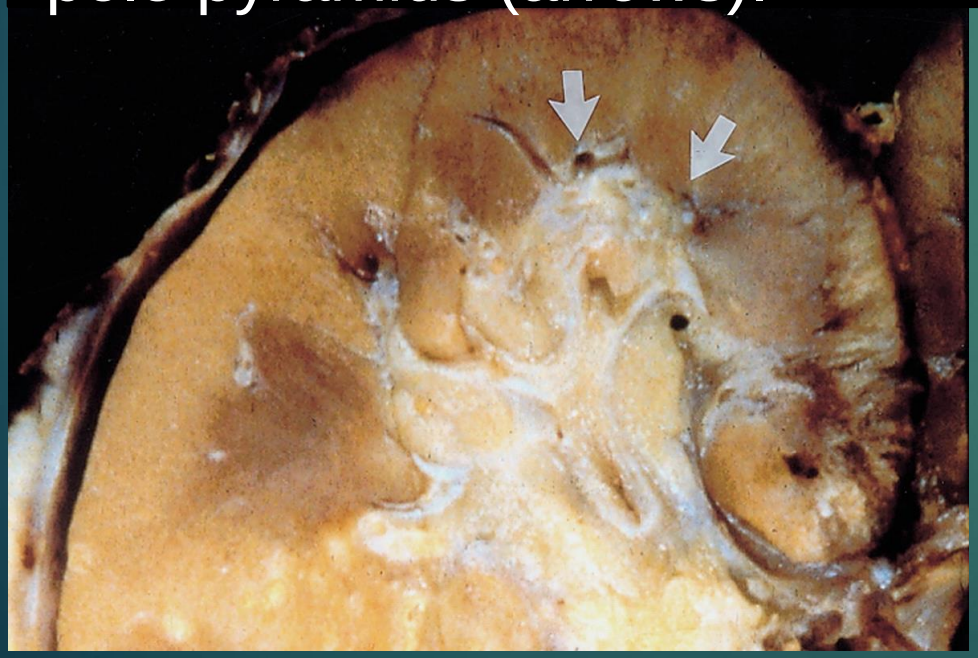
Lonergan G J et al. Radiographics 2001;21:971-994

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).



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

RadioGraphics

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

Hodgkin's Disease

- Lymphocytic predominance
- Mixed cellularity
- Lymphocytic depletion
- Nodular sclerosis - the most common

Non Hodgkin's Lymphoma

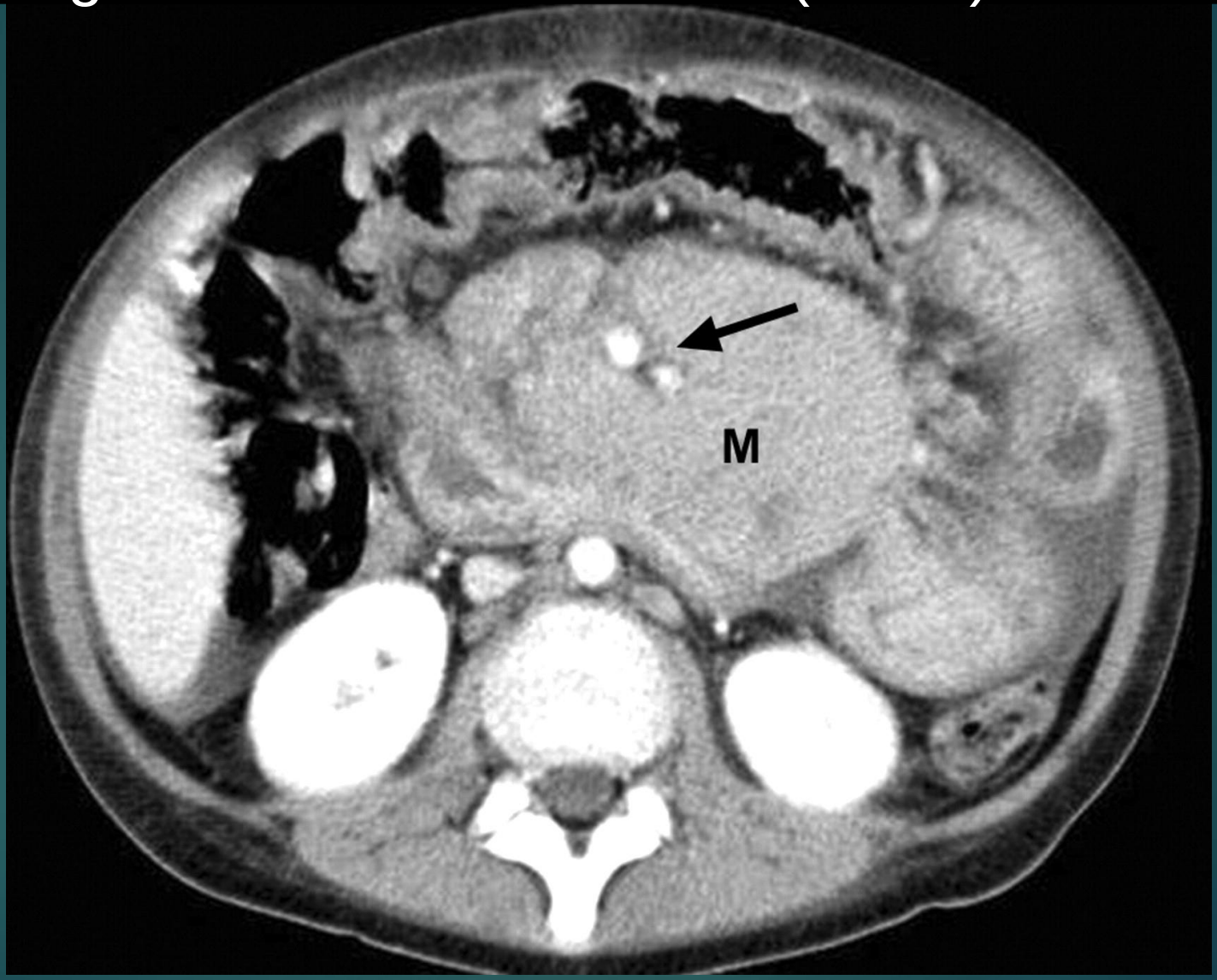
- Burkitt lymphoma (jaw and abdomen)
- Burkitt-like lymphomas (abdomen and nodes)
- Large B-cell lymphomas (abdomen and nodes)
- Lymphoblastic lymphoma (Mediastinum, nodes, bone marrow)
- Anaplastic large cell lymphoma (Nodes, skin, soft tissue, bone)
- Other peripheral T-cell lymphomas
- MALT lymphoma

Lymphoma can present as mass anywhere in the body

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

RadioGraphics

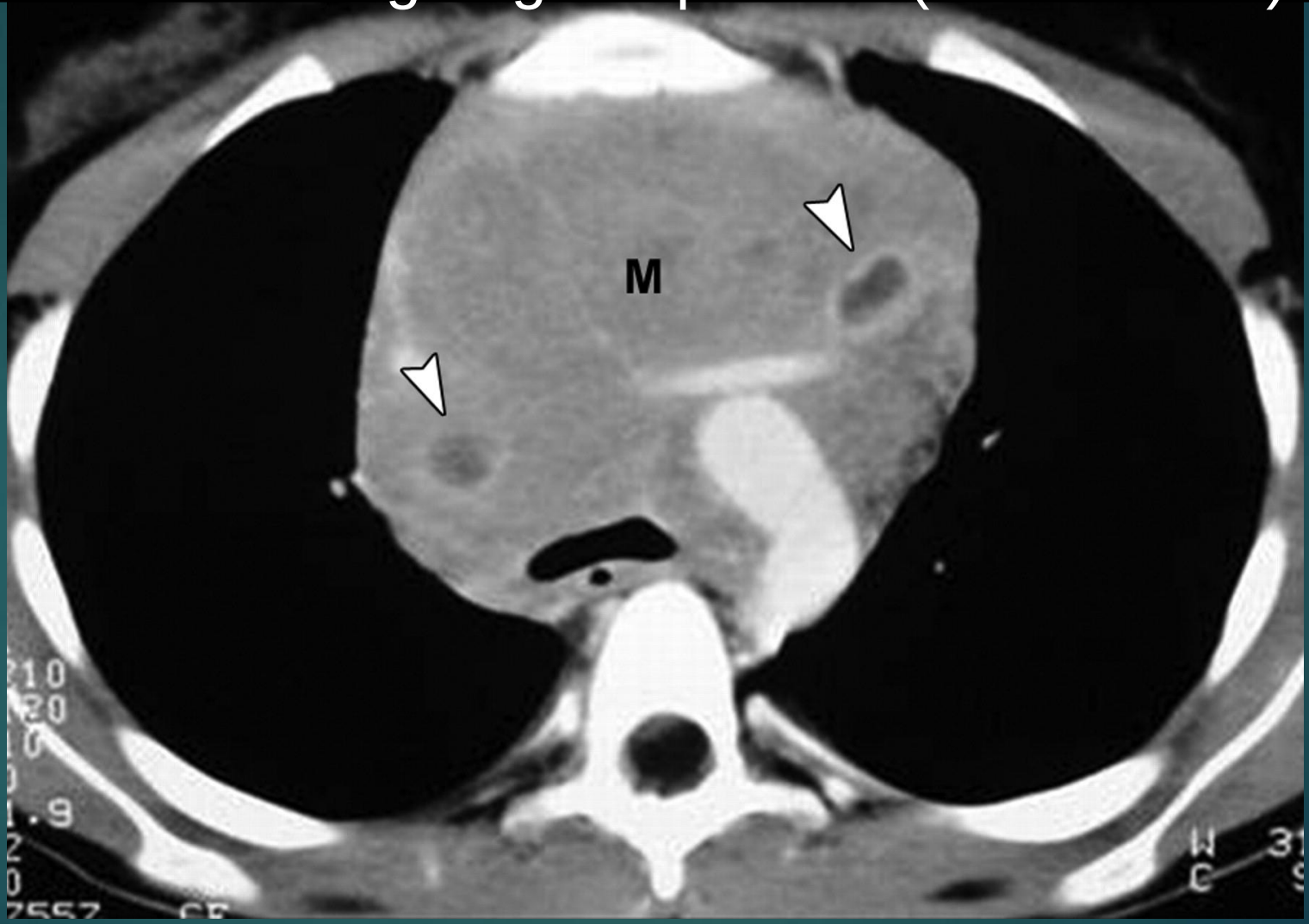
NHL in an 11-year-old boy.
Axial CT scan shows a large lymphomatous mass (M) encasing the mesenteric vessels (arrow)



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

RadioGraphics

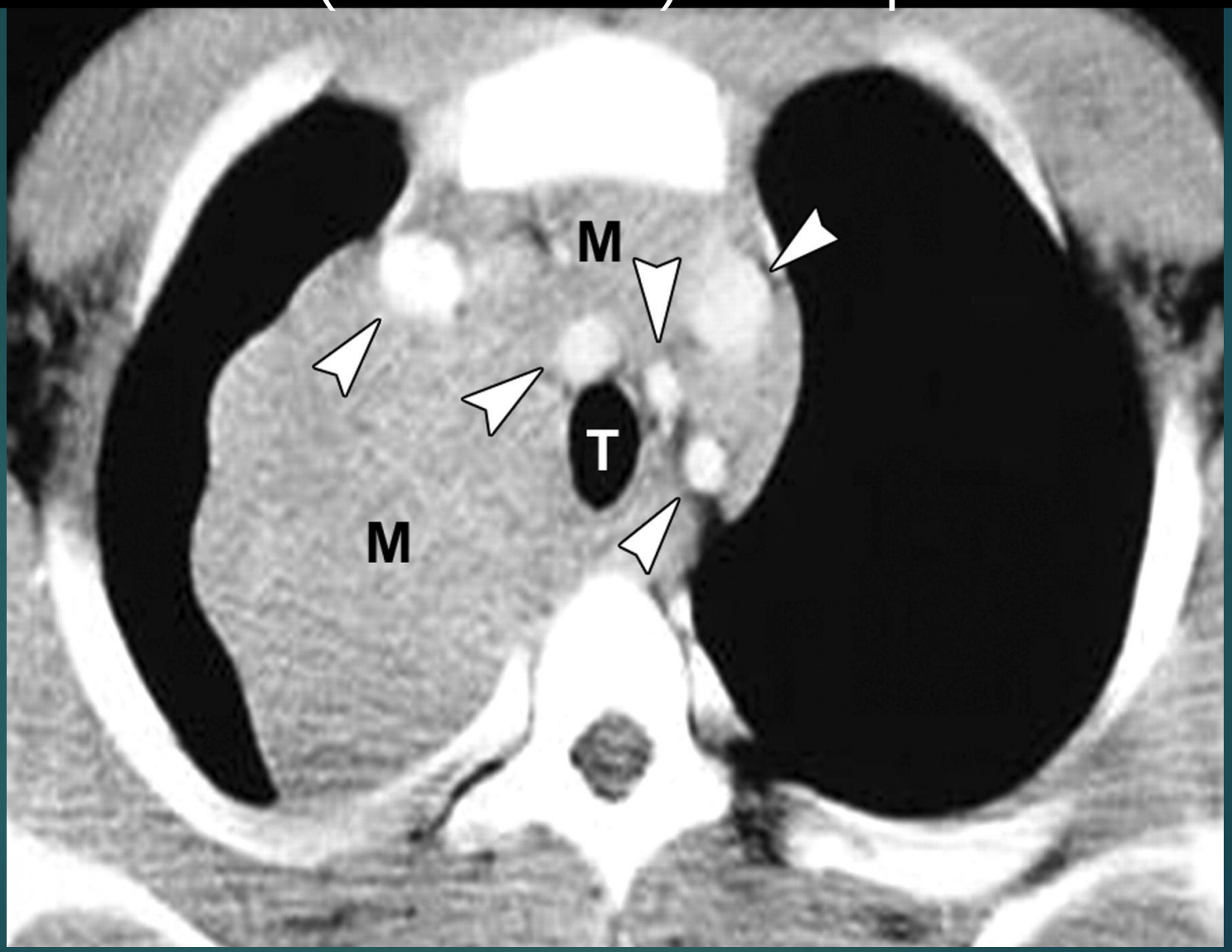
NHL in a 14-year-old boy. Contrast-enhanced CT scan shows a large anterior mediastinal mass (M) that originates from thymus. A few cysts with central low attenuation and a peripheral enhancing ring are present (arrowheads).



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

RadioGraphics

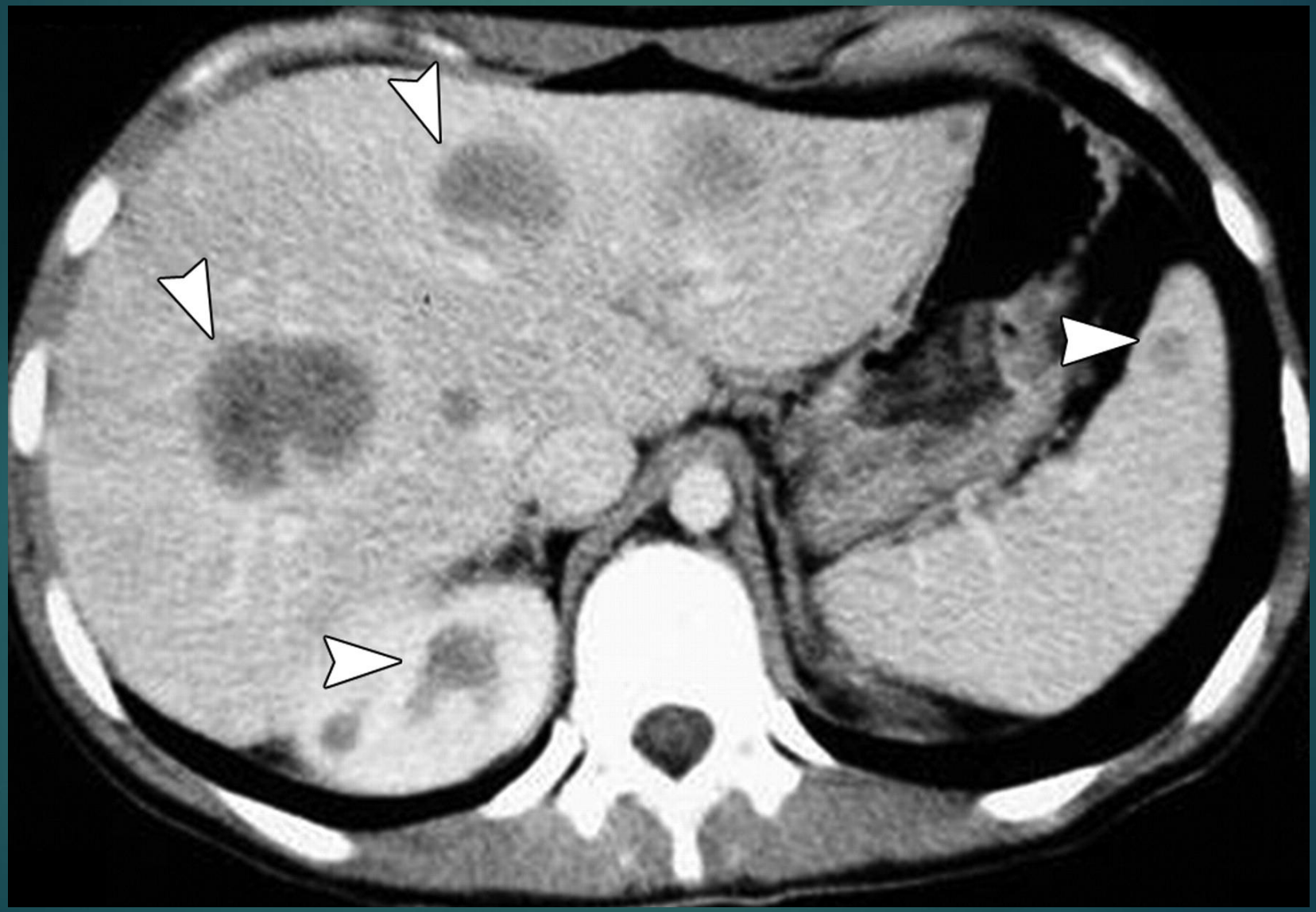
HD in a 17-year-old boy. Contrast-enhanced CT scan shows a large mediastinal mass (M). Trachea (T) is compressed, and great vessels (arrowheads) are displaced



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.



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

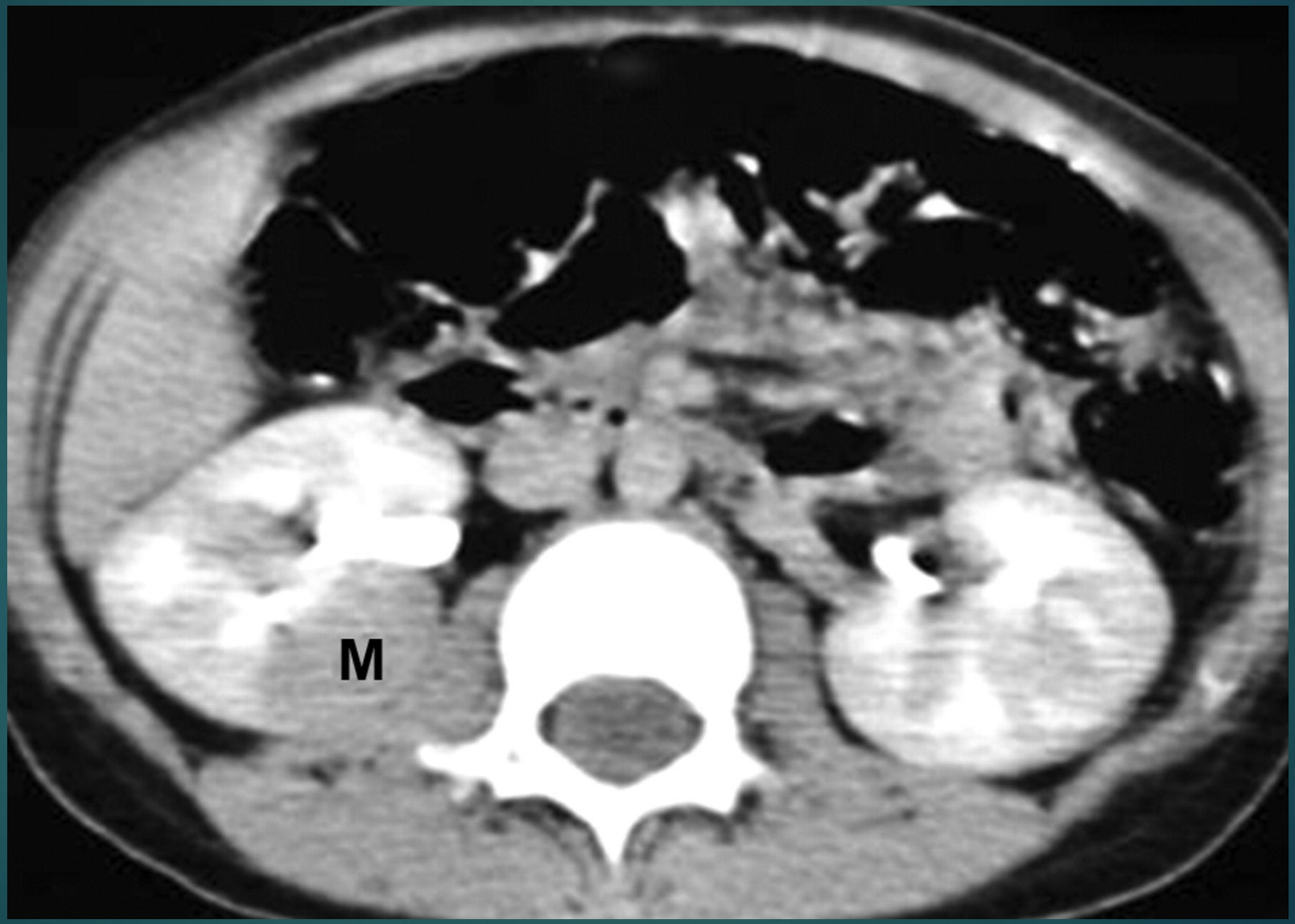
RadioGraphics

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

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

RadioGraphics

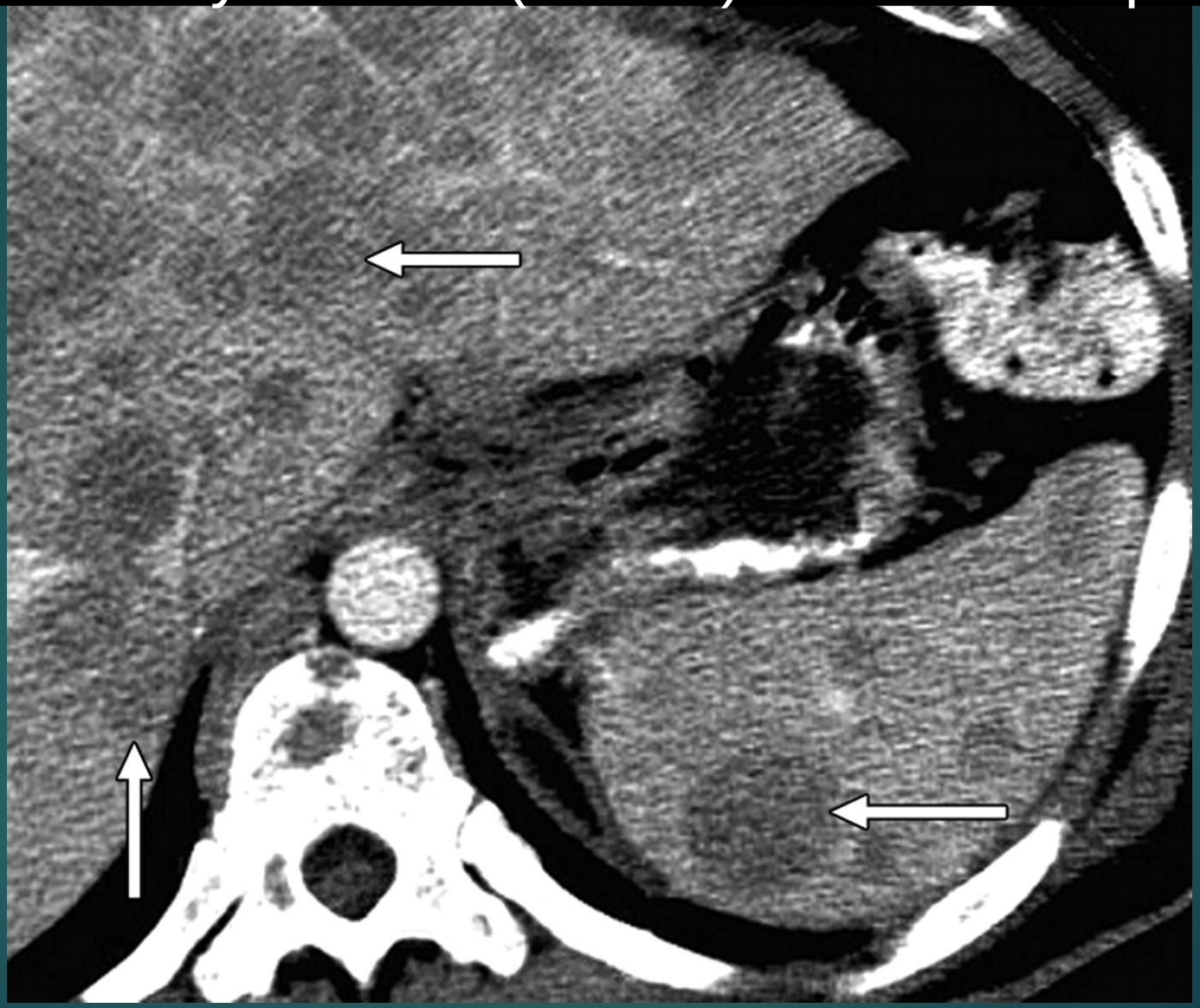
NHL in a 14-year-old boy. Contrast-enhanced CT scan shows single well-defined, low density mass (M) in right kidney



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

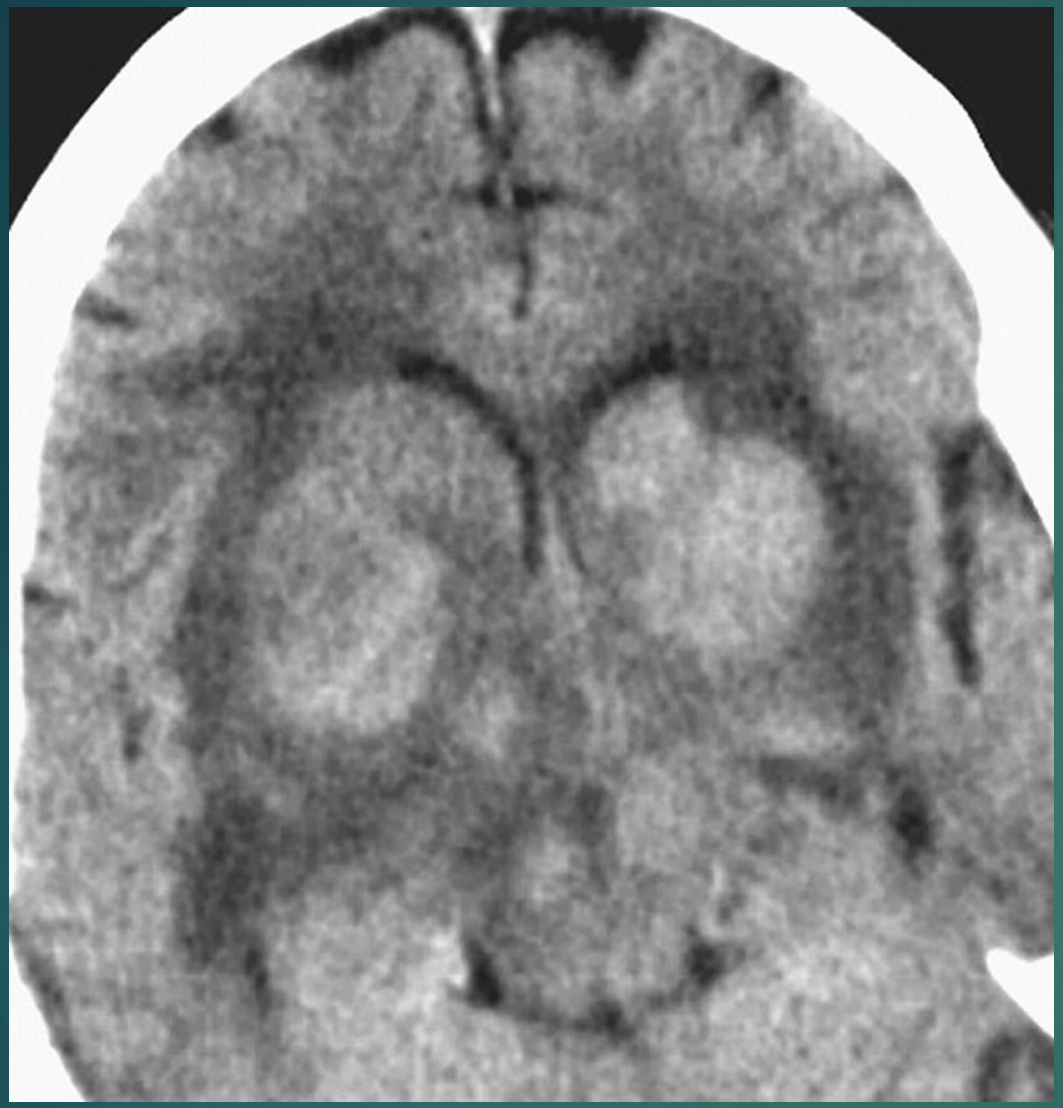
RadioGraphics

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

RadioGraphics

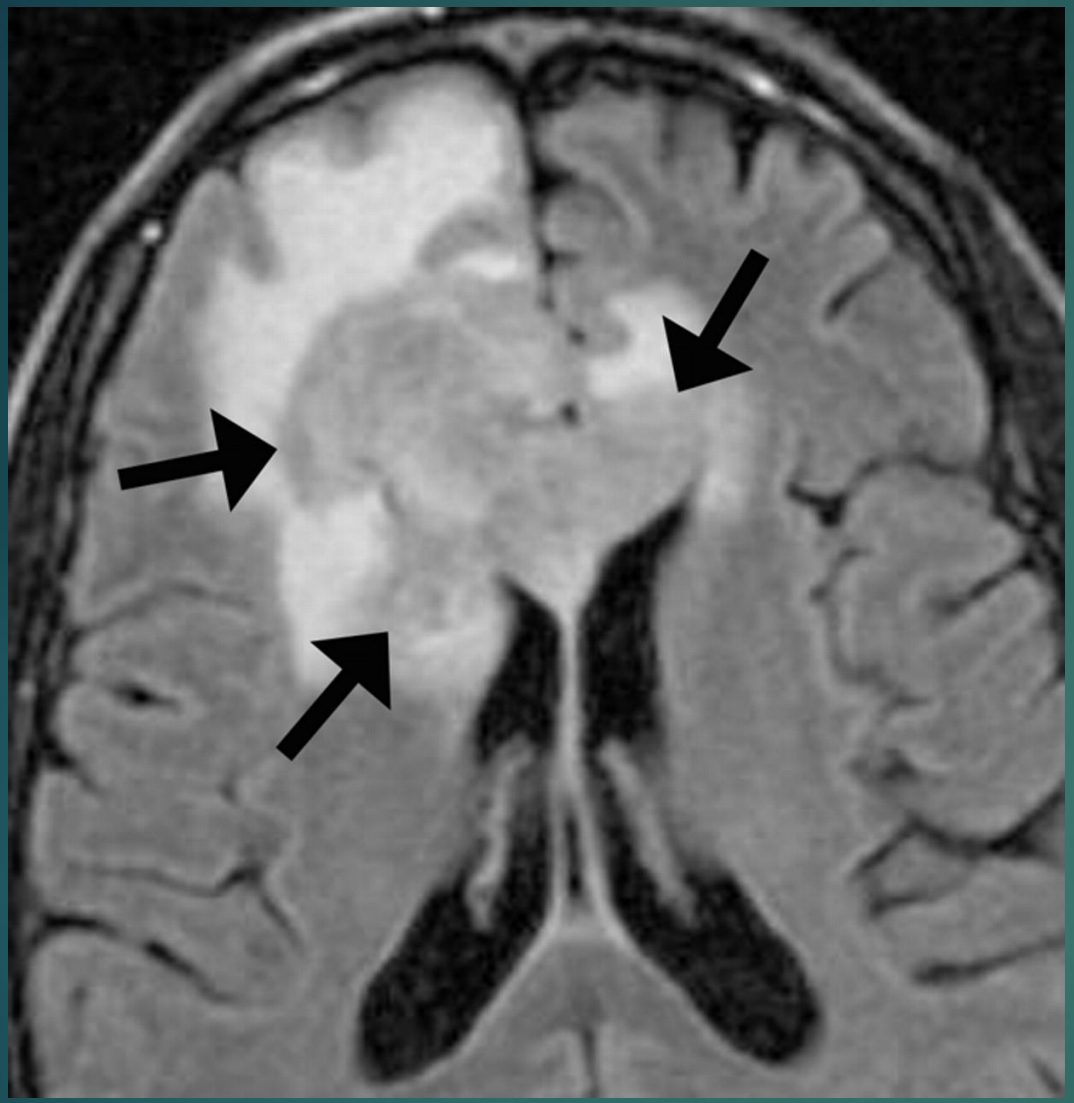


72-year-old immunocompetent woman with primary CNS non-Hodgkin's B-cell lymphoma

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

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

AJR



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).

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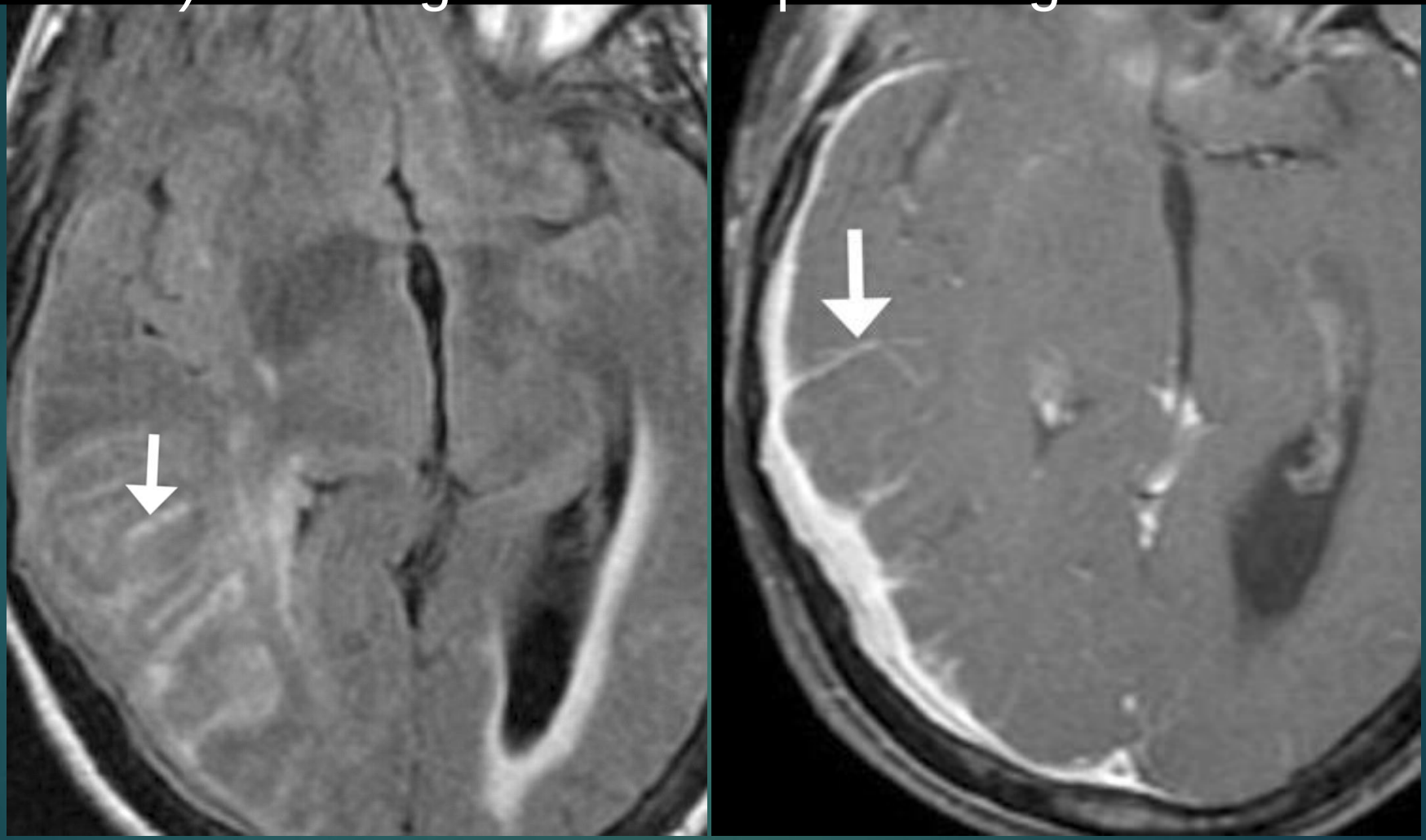
63-year-old woman with primary meningeal lymphoma
Axial FLAIR (left) and post contrast T1 weighted (right) MR images show hyperintensity and enhancement (arrows) involving sulci and leptomeninges



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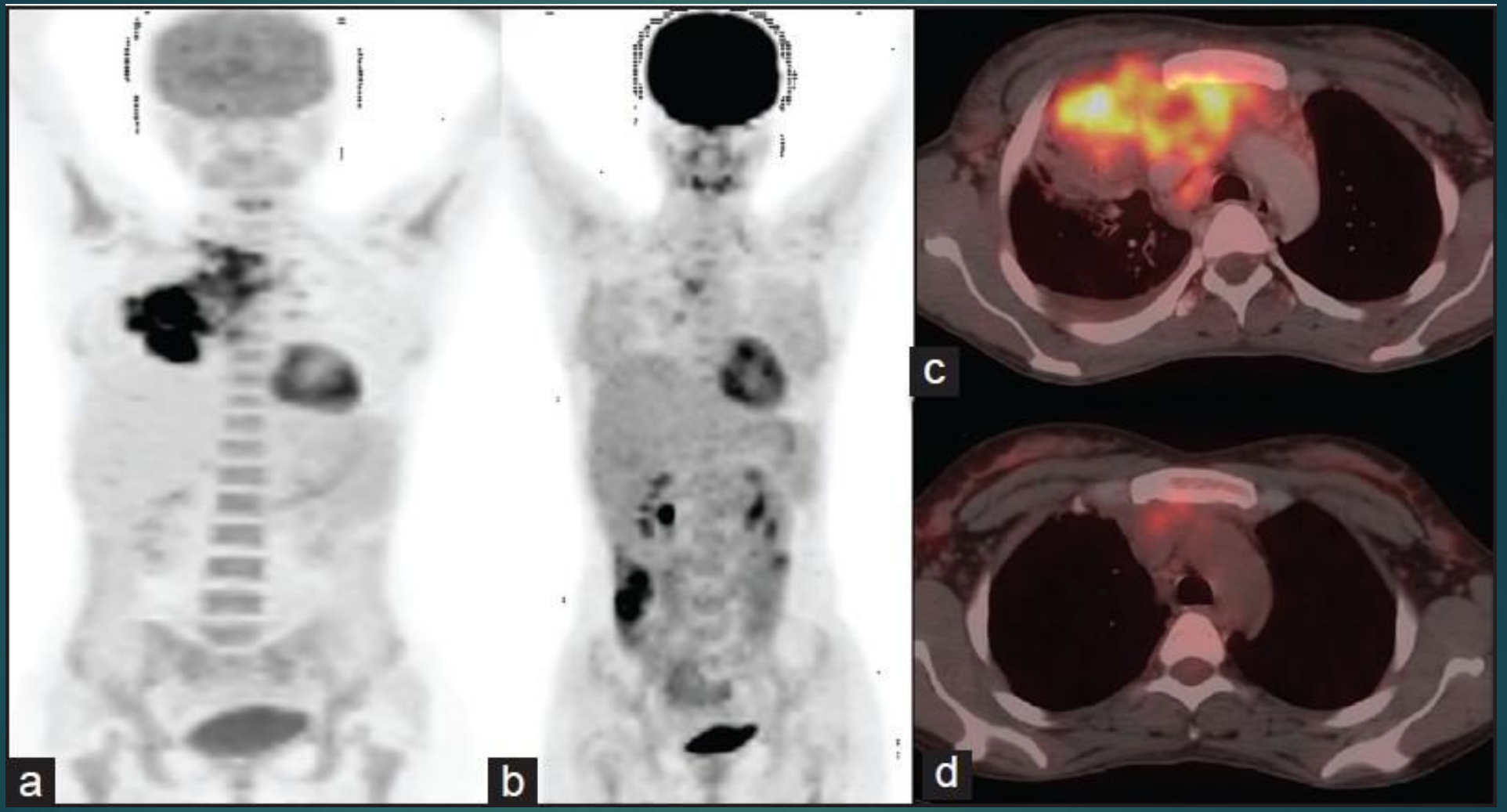
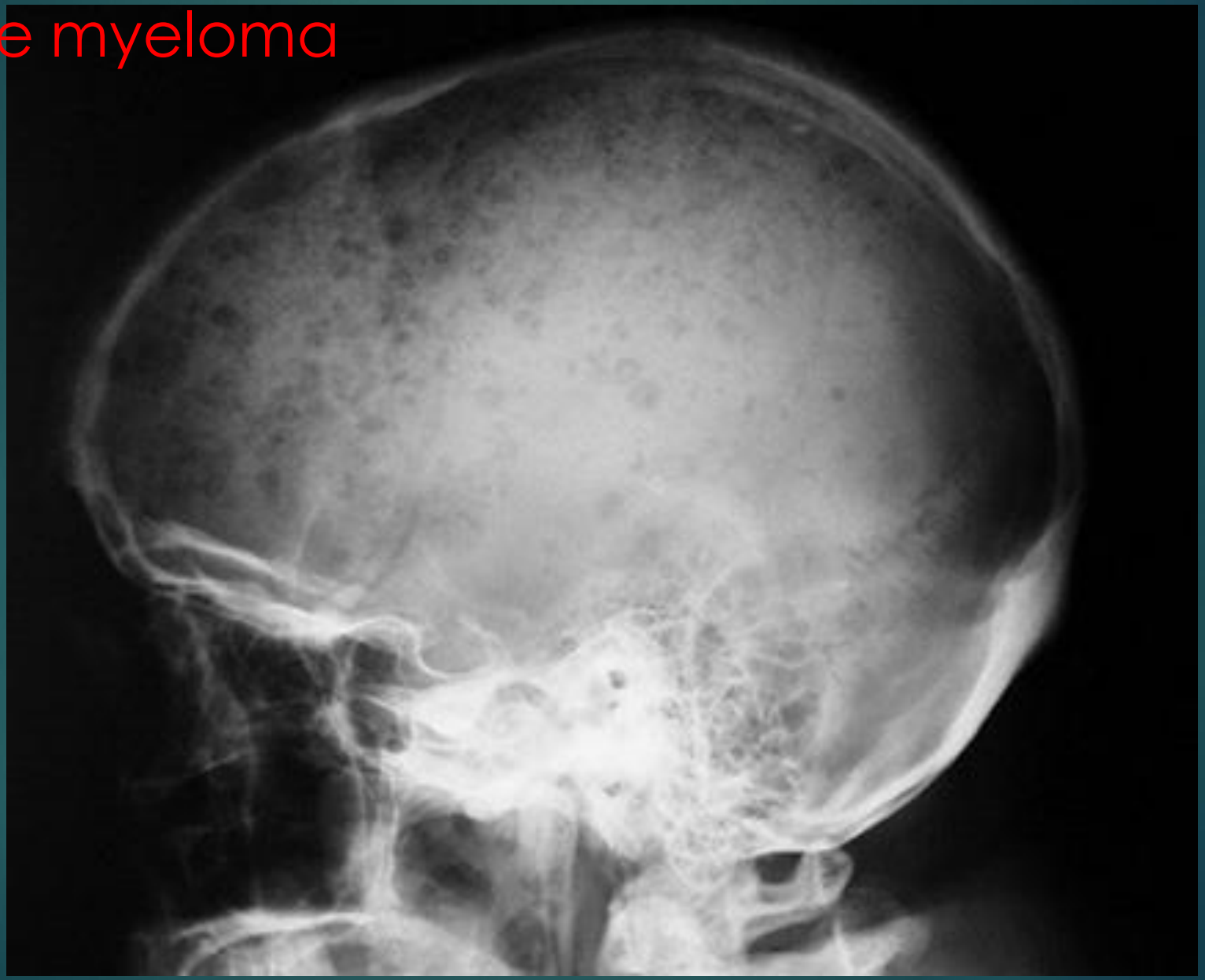
PET-CT scan is the gold standard imaging modality to diagnose and F/U Therapy of lymphoma

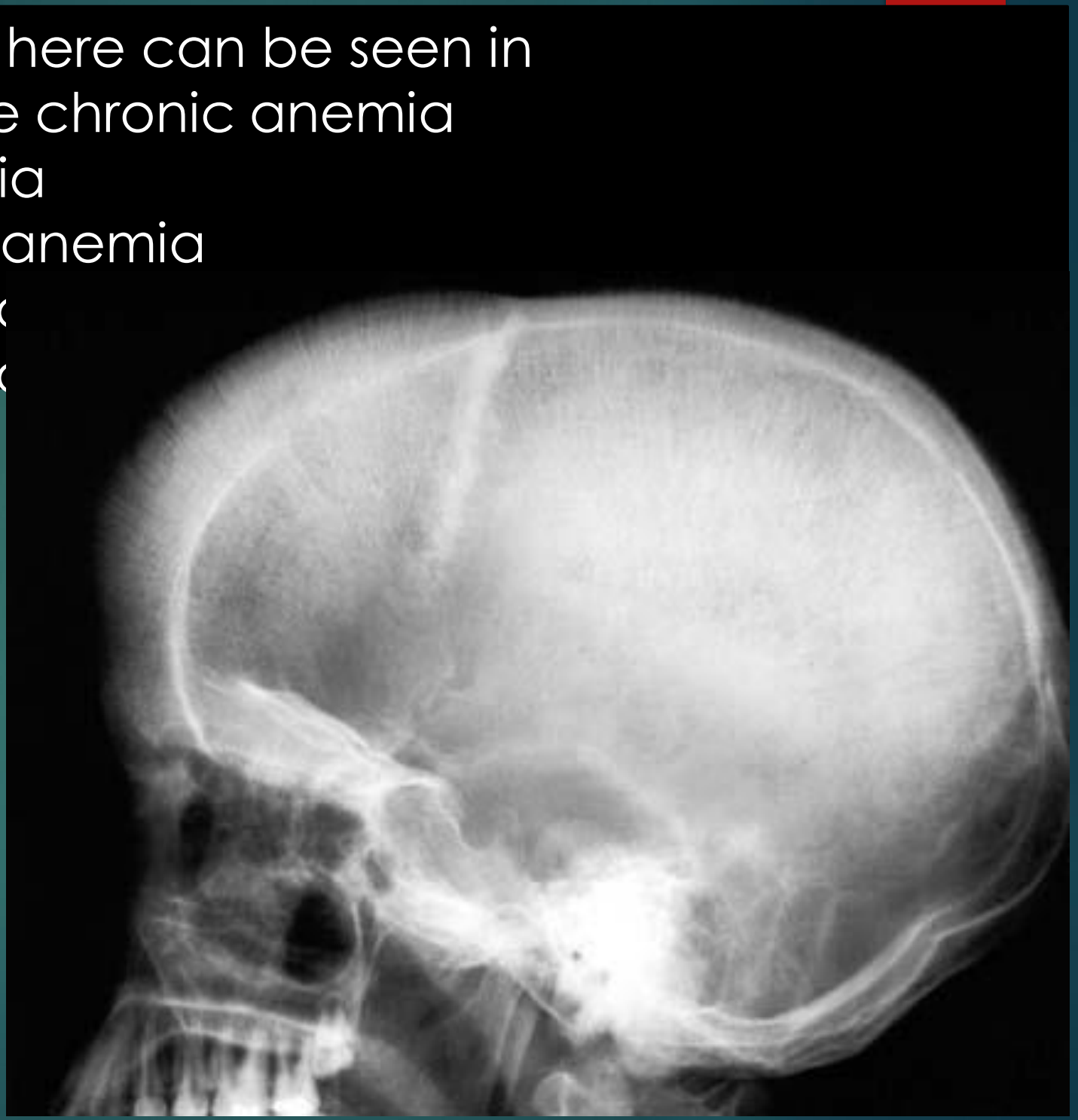


Lateral skull radiograph showing multiple very sharply outlined (punched out) lytic lesions of multiple myeloma



Findings shown here can be seen in

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



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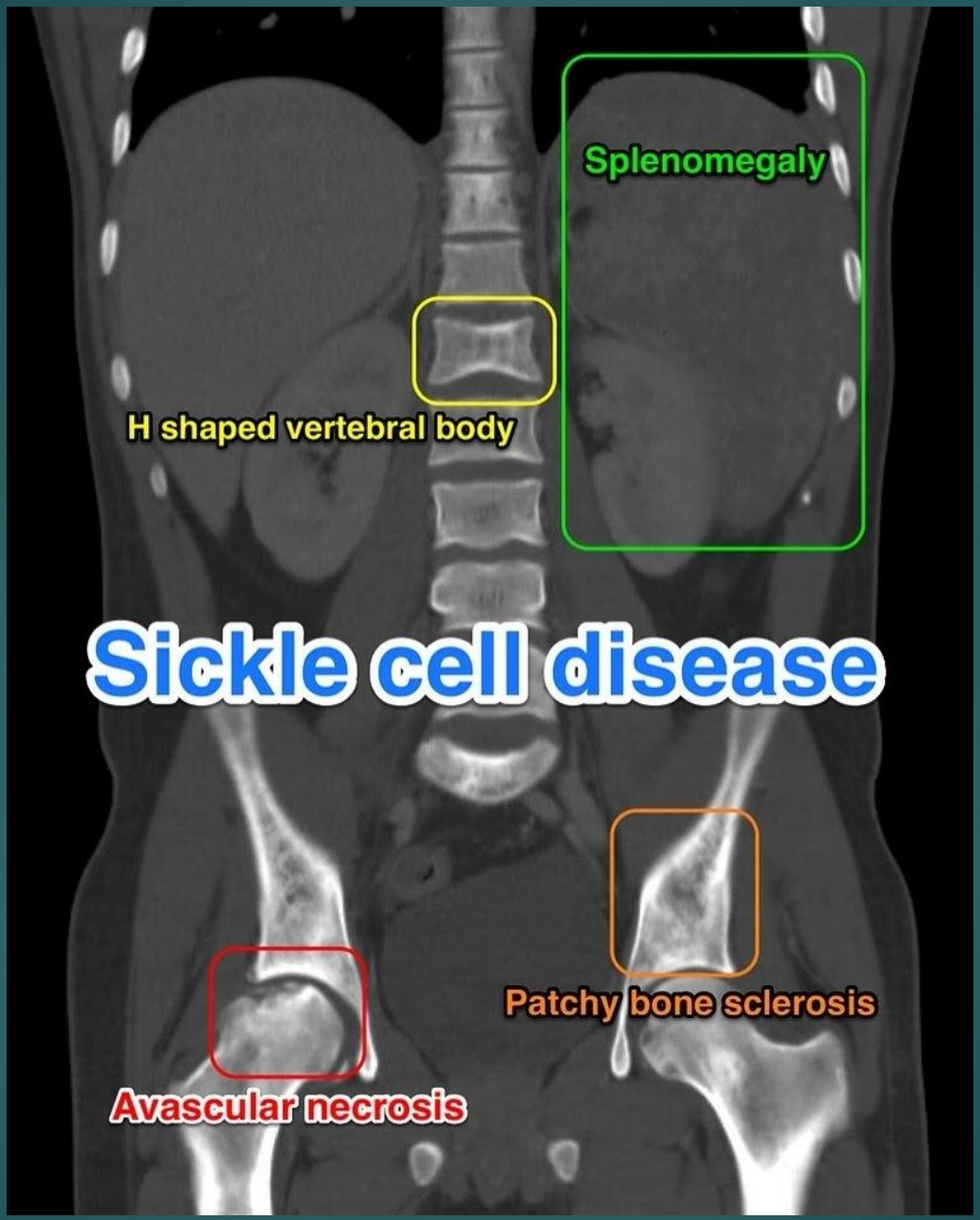
Splenomegaly
H shaped vertebral body
Sickle cell disease
Patchy bone sclerosis
Avascular necrosis

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 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.

THANKS