BLOOD

CELLS
- RBCs
- WBCs
- Platelets

PLASMA
BLOOD

CELLS

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

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- **RBCs**
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  - Anemia
  - Thalassemia
  - Others – nutritional, hemolysis etc.
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- **WBCs**
  - Leukemia
  - Lymphoma
  - Multiple myeloma

- **Platelets**

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  - Others – nutritional, hemolysis etc.
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- WBCs
  - Lymphoma
  - Leukemia
  - Multiple myeloma

- Platelets
  - Bleeding / clotting disorders

PLASMA
ANEMIA

Reactive increase in red bone marrow

New marrow areas in potential organs

Transfusions
Iron overload

SCA

Infections

Infarcts

Pneumonias, Osteomyelitis

Spleen, Kidneys, Brain, Bones

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

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

Increased CT density (brightness) and changes in MRI signal of liver & spleen
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)
Severe chronic anemia

Normal for comparison
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.

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.
51-year-old woman with myelofibrosis.

Coronal T1-weighted MR image shows massively enlarged spleen.

Splenectomy was followed by splenectomy.

Pathologic examination revealed extramedullary hematopoiesis.
23-year-old woman with history of thalassemia and known extramedullary hemopoiesis

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

H-shaped vertebrae (arrows in right image) due to osteonecrosis of vertebral endplates

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.
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
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.
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.
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.

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.
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.
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.

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.
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
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
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).
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.
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**
NHL in an 11-year-old boy. Axial CT scan shows a 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 and a peripheral enhancing ring are present (arrowheads).
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.
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.
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 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.
PET-CT scan is the gold standard imaging modality to diagnose and F/U 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. Lymphoma
5. Lymphoma
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**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

**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