A Child Who Refused to Walk: A Radiologic Work-up

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TG’s Story
A Child who Refused to Walk

- TG is a 16 month-old female with no significant past medical history who is brought to her primary care physician for refusal to walk.
- She began walking without difficulty at 13 months of age.
- Two weeks ago, she began crawling and refusing to bear weight when her parents stood her up.
A Child who Refused to Walk

• On further questioning, her parents have noted that she is slightly irritable and pale.
• Her parents deny known trauma.
• They deny fever or rash.
• The rest of the Review of Symptoms is negative.

• On physical, she is in no acute distress. She is afebrile at 36.3, HR 126, RR 28.
• She has no focal tenderness.
• Tone is normal, reflexes present bilaterally.
• Lower extremity examination showed muscular weakness
• She refused to walk.
Choosing the Initial Study
Which Radiologic Study would you Order?

- First, let’s consider a differential diagnosis to provide a framework for ordering studies.
DDx of a child who limps or refuses to walk– by System

- **Infectious**
  - Septic Arthritis
  - Osteomyelitis
  - Diskitis
  - TB (Potts disease)

- **Trauma**
  - Sprains, strains, contusions
  - Fractures
    - Toddler’s fracture
    - Stress fracture
    - Child abuse

- **Acquired**
  - Legg-Calve Perthes Disease
  - SCFE

- **Rheumatologic**
  - JRA
  - Henloch-Schonelin Purpura

- **Tumor**
  - Benign- ie Osteoid Osteoma
  - Malignant
    - Osteogenic Sarcoma
    - Ewing Sarcoma
    - Leukemia
    - Spinal Cord Tumor
    - Metastatic Neuroblastoma

- **Endocrine**
  - Hyperparathyroidism
  - Vitamin D deficiency

- **Neurological**
  - Cerebral Palsy
  - CNS or Spinal cord tumor
  - Meningitis
DDx of a child who limps or refuses to walk– by Age

**Toddler (1-3 years)**
- Infection
- Occult Trauma
- Tumor
- Developmental dysplasia of the hip

**Childhood (4-10 years)**
- Infection
- Transient Synovitis of the Hip
- Legg-Calve-Perthe Disease
- Juvenile Arthritis
- Trauma
- Tumor

**Adolescence (11+ years)**
- Trauma
- Juvenile Arthritis
- Tumor
- SCFE

Which Test Would You Choose for TG?

- A. Plain films
- B. Bone Scan
- C. CT
- D. Ultrasound
- E. MRI
Plain Films of the Hip

TG’s films were read as normal in outside clinic, ruling out any obvious bony abnormalities. This actually a film of a 9 year-old girl. TG’s films were not available.

She was referred to the Emergency Department.

http://www.up.ac.za/academic/medicine/anatomy/current/x/039ol6.html
The Hospital Work-up
TG’s Spinal MRI

Concerned for a primary neurologic process, TG’s doctors ordered an MRI of the brain and spine. Her brain scan was negative. A T1-weighted image is below:

Diffuse mild heterogeneous signal of marrow throughout the spine.

Bi-concave T4 and T5

Disk Spaces intact: No focal Neuro abnormalities

Courtesy of Children’s Hospital Boston
TG’s Spinal MRI: Interpreting the Findings

1) Mildly Heterogeneous Bone Marrow
   Marrow should be homogenous, except during conversion of red marrow to yellow marrow that occurs throughout childhood.
   Could represent a systemic disorder:
   - proliferation of abnormal leukocytes, as in leukemia
   - infiltration in metastatic disease, as in Neuroblastoma
   - hyperplasia of normal cells, as in Sickle Cell Anemia
   - marrow packing, as in Gaucher disease

2) Biconcave or “Fish” Vertebrae
   These are indicative of decreased bone mass and repetitive trauma.
   The disks herniate into the vertebral bodies, causing endplate compression fractures.

A Lumbar Plain Film was ordered to further characterize the bony findings.
TG’s Lumbar Spine Study

Diffuse Osteopenia

Height loss of vertebral bodies

Courtesy of Children’s Hospital Boston
TG and a 1 year-old child with pneumonia. Compare the density of the spine and the height of the vertebrae.
A New Differential: Biconcave Vertebrae

Fish Vertebrae = Decreased Bone Mass

<table>
<thead>
<tr>
<th>Common</th>
<th>Uncommon</th>
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<tbody>
<tr>
<td>- Osteopenia</td>
<td>- Gaucher’s, Niemann-Pick</td>
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<tr>
<td>- Inherited Anemias</td>
<td>- Acromegaly</td>
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<tr>
<td>- Steroid Therapy</td>
<td>- Osteogenesis imperfecta</td>
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<tr>
<td>- Cushing’s</td>
<td>- Leukemia, Lymphoma</td>
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<tr>
<td>- Hyper-parathyroidism</td>
<td>- Hyperthyroidism</td>
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<tr>
<td>- Multiple Myeloma</td>
<td></td>
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<tr>
<td>- Metastatic Disease</td>
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TG: The work-up continues…

- 3 weeks later, TG returned to Endocrine Clinic with a Calcium of 13.4 (high).
- She is still refusing to walk.
- She is re-admitted to the hospital.
- A bone scan is ordered.
TG’s Bone Scan

No focal Abnormalities

No focal uptake in the spine
TG: A Brief Review

19 month-old female now with 6 weeks of refusal to walk.

• **Plain films of Hips**: Normal

• **MRI of spine**: diffusely heterogeneous bone marrow. Biconcave vertebrae. No focal neuro abnormalities.

• **Lumbar x ray**: diffuse osteopenia, height loss of multiple vertebrae.

• **Bone scan**: No focal abnormalities.
The Diagnosis
Acute Lymphoblastic Leukemia

TG underwent a Bone Marrow biopsy which revealed pre B-cell ALL

- ALL is most common childhood malignancy
- 2500 to 3500 new cases of ALL are diagnosed in children in the US each year
- Peak incidence: 2-5 years of age, in boys more than girls
- Current 5-year survival rate of approximately 78 percent

Clinical Presentation of ALL

Symptoms are non-specific!

- Intense bone pain unresponsive to analgesics (21-33%)
- Petichiae/ purpura/ bleeding (50%)
- Lethargy, Pallor
- +/- Fever
- Lymphadenopathy, Splenomegaly, Hepatomegaly (50%)
- Endocrine abnormalities:
  - Hypercalcemia
  - High uric acid

Radiologic Findings in Leukemia
Common Presenting Findings In Leukemia

43% of leukemias present with radiographic findings

- **Bony Changes**
  - diffuse osteopenia (90% of children with ALL)
  - Most lesions occur in femur, ilium, spine, humerus, and tibia
  - “Leukemic Lines” - (24% in ALL)
  - Moth-eaten lesions of bone
  - Biconcave vertebrae or compression fractures

- **Soft Tissue Changes**
  - Lymphadenopathy
  - Mediastinal Mass
  - Splenomegaly
  - CNS involvement (<5% of children with ALL)

- **Bone Marrow Changes**
  - Diffusely heterogenous changes on MRI


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Radiographic Findings in Leukemia: Overview of Vertebral lesions

**Anterior Lesions = Malignant**
- Lymphoma
- Hodgkin’s Lymphoma
- Myeloma
- Ewing’s
- Osteosarcoma
- Chondrosarcoma
- Metastasis

**Exceptions:**
- Hemangioma
- Langerhans-cell Granuloma
- Fibrous Dysplasia

**Posterior Lesions = Benign**
- Osteoblastoma
- Osteoid Osteoma
- Aneurysmal Bone Cyst
- Osteochondroma
- Chondromyxoid Fibroma

Radiologic Findings: “Leukemic Lines”

- **Leukemic Lines** are lucent lines in metaphyses of peripheral bones.

- Most commonly found in the knee or proximal humerus of children
- Narrow and sharply defined lines—likely represent submetaphyseal osteoporosis
- Broad and poorly demarcated lines—likely represent leukemic infiltration of bone
Radiologic Findings: “Leukemic Lines”

Can you spot the Leukemic lines in this 8-year old with ALL?

Broad, irregular lucencies typical of leukemic infiltration.

These are commonly associated with focal tenderness.

Status post chemotherapy, the lucencies resolved.

Radiologic Findings: Infiltration of Long Bones

- Acute Lymphoblastic Leukemia
- Moth Eaten Pattern and scattered lytic lesions throughout both distal ulna and radius.
- These represent leukemic infiltration

States LJ. Imaging of Metabolic Bone Disease and Marrow Disorders in Children. *Rad Clinic North Am.* 39: 4
Radiologic Findings: Infiltration of Long Bones

Lymphoblastic Leukemia. Bone destruction and laminated periosteal reaction.

CT scan shows infiltration and destruction of the cortex and medulla.

Radiographic Findings: CNS Involvement

MRI with contrast shows a rare mass at the base of the skull in a patient with ALL.

What else is involved?

Meninges also enhance, suggesting involvement

Para-nasal sinuses

Radiologic Findings in Leukemia: Lung Involvement

Thymic infiltration in T-Cell Lymphoblastic leukemia causing mediastinal shift and a large pleural effusion.

Radiologic Findings in Leukemia: Lung Involvement

- Multiple rounded nodules can be findings of presenting or relapsing leukemia.
Sequelae of ALL

- **Osteoporosis**: can lead to pathologic fracture, loss of height.

- **Relapse**: In over 50% of children who relapse, involvement tends to spread to CNS, testes, and kidneys.

- **Secondary Cancer**: 2-3% of childhood survivors of ALL develop secondary cancers, usually a brain or hematologic cancer.

Radiographic Findings in Leukemia: Testicular Involvement at Relapse

• This child with prior ALL presented with painless, unilateral swelling of the testes.

• Ultrasound of right testicle shows marked enlargement and hypoechoic signal.

• The left testicle is normal.

Radiologic Follow-up

• At presentation:
  – Patients receive routine chest x ray.
  – Some doctors suggest baseline CT scan or MR imaging of the CNS, since up to 30% of newly-diagnosed patients have findings, though of unknown significance.

• Follow-up:
  – Patients with T-cell ALL receive periodic chest X rays because of risk of mediastinal relapse.
  – Imaging with MR after therapy is challenging because of the similarity of regeneration of red marrow and residual disease.

Summary

• The differential diagnosis of a child with a limp or a child who refuses to walk is broad.
• Up to a third of children with acute leukemia present with intense bone pain.
• Leukemia can have a wide range of radiologic findings at presentation.
• Some common findings are bony changes such as diffuse osteopenia and leukemic lines.
Conclusions

• When evaluating a child with a limp, consideration of a broad differential and the limitations in radiological imaging modalities is essential to an effective work-up.

• Radiologic evaluation with multiple modalities is critical in narrowing the differential.

• Familiarity of the presenting radiological findings of leukemia should be a goal of radiologists and clinicians alike.
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References