Rhabdomyosarcoma and Other Soft Tissue Sarcomas

Beth McCarville, MD
Department of Radiological Sciences
St. Jude Children’s Research Hospital
Memphis, TN
Overview

- Rhabdomyosarcomas (RMS) and non-rhabdomyosarcoma soft tissue sarcomas (NRSTS)
  - Background
  - Role of PET-CT

- Limitations/pitfalls of PET/CT in assessing pediatric ST sarcomas
Soft Tissue Sarcomas of Childhood

- **Rhabdomyosarcoma**
  - 3rd most common extra-cranial, malignant solid tumor
  - ~ 40% of all ST sarcomas

- **Non-rhabdomyosarcoma soft tissue sarcomas (NRSTS)**
  - More common > 15 yr
Rhabdomyosarcoma (RMS)

- Arises from primitive mesenchymal cells, can occur in virtually all tissues except bone
- Highly heterogeneous biological behavior comprising several histologic subtypes
From: Principles and Practice of Pediatric Oncology, 5th Ed., Editors; Pizzo and Poplack
RMS Pearls

- Distinctive features regarding patient age, primary site, histology
  - Orbit tumors usually embryonal
  - Extremity tumors usually alveolar
  - Botryoid variant arises in bladder and vagina of young children
Clinical Features of RMS

- Non-metastatic disease ~ 86% survival
- 14% have metastatic disease at diagnosis
- Metastatic disease = poor outcome (~20% survival)
- Metastasizes to
  - Lung (36%)
  - Bone marrow (22%)
  - Bone (7%)
  - Local-regional lymph nodes (up to 20%)
# RMS classified by risk of treatment failure

<table>
<thead>
<tr>
<th>Risk of treatment failure</th>
<th>Clinical group</th>
<th>TNM stage</th>
<th>Tumor histology</th>
<th>Patient’s age at presentation</th>
<th>Tumor site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>I/II</td>
<td>2/3</td>
<td>Embryonal, botryoid or spindle variant</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td></td>
<td>I-III</td>
<td>1</td>
<td>any</td>
<td>any</td>
<td>favorable</td>
</tr>
<tr>
<td>Intermediate</td>
<td>I-III</td>
<td>1-3</td>
<td>Alveolar</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>2/3</td>
<td>Embryonal, botryoid or spindle variant</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>4</td>
<td>Embryonal, botryoid or spindle variant</td>
<td>&lt; 10 years</td>
<td>any</td>
</tr>
<tr>
<td>High</td>
<td>IV</td>
<td>4</td>
<td>Alveolar</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td></td>
<td>I-III</td>
<td>1-3</td>
<td>Embryonal, botryoid or spindle variant</td>
<td>≥ 10 years</td>
<td>any</td>
</tr>
</tbody>
</table>
Non-rhabdomyosarcoma Soft Tissue Sarcomas (NRSTS) of Childhood

- Rare and heterogenous group of tumors
- Mesenchymal origin
- Differences in biology and natural history in *infants/young children* compared to adults
  - Infantile fibrosarcoma
  - Infantile hemangiopericytoma
Histologies

- Malignant peripheral nerve sheath tumor
- Malignant fibrous histiocytoma
- Leiomyosarcoma
- Fibrosarcoma
- Hemangiopericytoma
- Alveolar soft part sarcoma
- Epithelioid sarcoma
Primary Sites

Surgically resected

Unresected or metastatic

Spunt et al., JCO 1999;17:1219

Pappo et al. Med Ped Onc 1999;33:76
Outcome of Patients with NRSTSs

- 20% of patients with tumors completely resected recur
  - Local recurrences predicted by
    - Microscopic positive margins
    - Lack of radiation therapy
    - Tumor size > 5 cm
    - Intra-abdominal primary site
  - Distant recurrences predicted by
    - Tumor size > 5 cm
    - Invasiveness
    - High histologic grade

Spunt et al. JCO 1999;17:3697-3705
NRSTS Metastatic Sites

- Lung
- Bone
- Liver
- Mesentery
- Lymph nodes rarely
Diagnostic Imaging of Soft Tissue Sarcomas

- Crucial to assigning risk-based therapy
- MRI
  - Tumor origin
  - Size
  - Local invasion
  - Nodal spread
- Chest CT: Pulmonary metastases
- Tc\textsuperscript{99m} bone scan: Bone metastases
Role of PET-CT in RMS and NRSTS

- No large clinical trials in pediatric STS
- Diagnosis: Identifying unknown primary site
- Staging: Detecting distant metastases
- Monitoring response to therapy
- Re-staging: Detecting recurrences
- Scan skull vertex to toes!
Diagnosis
Identifying an Unknown Primary

- Metastatic disease with unknown primary
  - 4% of rhabdomyosarcomas
  - 3-5% all cancers

- Diagnostic work-up
  - Guided by clinical suspicion and pathology of metastatic disease
  - Traditionally requires multiple imaging examinations
11 yo girl with anemia and adenopathy: Rule-out lymphoma

McCarville et al. AJR 2005:184:1293-1304
MRI of the primary alveolar RMS
Unsuspected soft-tissue metastasis
Unsuspected breast metastases
Staging
5 yo boy, parapharyngeal embryonal RMS
Baseline PET-CT
Marrow disease confirmed by MRI and biopsy
19 yo girl, malignant peripheral nerve sheath tumor

McCarville et al. AJR 2005:184:1293-1304
Negative bone scan
PET-CT shows unsuspected bone metastasis and inguinal nodes
Died of progressive disease
PET/CT as a Subjective Assessment of ST Sarcoma Response to Therapy
Follow-up 25 weeks of chemotherapy for alveolar RMS
17 yo, girl with alveolar RMS

At Recurrence  
After Bone Marrow Transplant

McClave et al. AJR 2005:184:1293-1304
6 yo boy with non-metastatic alveolar RMS

McCarville et al. AJR 2005:184:1293-1304
After surgical resection margins negative
Monitoring for Tumor Recurrence

- Children with sarcomas followed for 3-5 years
- Likelihood of recurrence depends on tumor histology and biology
- Approximately 25-35% recurrence rate
- Most recurrences occur at distant sites
16 yo girl with alveolar RMS being evaluated for bone marrow transplant

McCarville et al. AJR 2005:184:1293-1304
18 yo girl with treated metastatic alveolar RMS
Pancreas metastasis overlooked on diagnostic CT 1 week earlier
Recurrent alveolar RMS
Unsuspected pancreas metastasis
Limitations/Pitfalls
Assessment of Nodal Disease
19 yo, 4 years after leiomyosarcoma resected from left thigh.
“Cyst” FDG avid
Biopsy proven recurrence
19 yo, girl with embryonal RMS
Retroperitoneal node FDG negative and biopsy negative for tumor
Biopsy proven benign follicular hyperplasia
Benign Fibro-Osseous Lesions
Mild FDG Uptake

Goodin et al. AJR 2006; 187:1124–1128
Moderate FDG Uptake
Intense FDG Uptake

MIP PET image
Comparison with Bone Scan

- 5 patients with NOF or FCD
  - 4 no uptake on bone scan
  - 2 - moderate FDG uptake
  - 2 - mild FDG uptake
  - 1 mild uptake on bone scan
  - moderate FDG uptake
Bone Scan vs PET

PET MIP Image

Bone Scan

Slides are not to be reproduced without permission of author.
Summary

- PET/CT is a powerful imaging modality
- Offers information regarding solid tumor staging and recurrence
- May be more sensitive than bone scan for detection of marrow metastases
- May have limited specificity in nodal disease
- Requires rigorous clinical trials to validate appropriate role