Plenary Session IV: Hybrid Imaging and Other Imaging Techniques in Pediatrics:

Other Imaging Modalities in Pediatric Cancer

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Modalities for Imaging Children with Cancer

- Ultrasound
- Radiography
- MRI
- SPECT/CT
- PET/CT
- PET/MRI

DOSE

INCREASING

COMPLEXITY
Objectives

At the end of this presentation you will be able to identify:

- correlative imaging modalities used for diagnosis and management of children with cancer
- Use of SPECT/CT in pediatric oncology
- Use of PET Probe in pediatric oncology
- Novel use of F-DOPA
- PET/MRI
Child with previously resected Wilms' tumor for routine follow-up surveillance ultrasound examination
Recurrent Metastatic Wilms'
2 year old with enlarging abdomen

US with doppler

POST Gad COR T1 MRI
FDG PET CT in nephroblastomatosis with focal Wilms’ tumor
PET/CT at BCCH

- No separate attenuation correction scan
- PET CT as initial cross-sectional imaging study for child presenting with presumed lymphoma, sarcoma, solid organ non-renal tumor
- Contrast enhanced CT used for attenuation correction for PET
- Vertex to toe true whole body imaging
- “One Stop Shop”
7 year old male presented with left facial mass after incidental trauma 3-4 months ago

Presumed diagnosis = rhabdomyosarcoma

Ultrasound-solid mass

MRI left maxillary mass with bone and soft tissue involvement and adjacent lymph nodes

To PET/CT
Dx=Neuroblastoma

- This patient has both a left maxillary mass but also note the right adrenal calcified mass and multiple bony lesions
Dx=Neuroblastoma

- This patient has both a left maxillary mass but also note the right adrenal calcified mass and multiple bony lesions.
Neuroblastoma Epidemiology

- ~8 children per million per year under 15 years
- Most common extracranial solid tumor of childhood
- More than 95% of cases diagnosed <10 years
- 3rd leading cause of childhood cancer mortality
EFS by Neuroblastoma Risk Group

EFS Rate (%)

Years Since Enrollment

n=2621; p<0.0001
Pediatric I-123 mIUG SPECT/CT Indications

- Staging / restaging / metastatic workup
- Response assessment
- Biopsy site planning
- End of therapy baseline
- Confirmation of discrepant findings on other studies
SPECT/CT and I-123 mIBG Scintigraphy

- Pediatric cooperative group protocols require mIBG scintigraphy for staging and response assessment and Curie score

- Most children with neuroblastoma will have CT evaluation and some depending on site of tumor (ie spinal involvement) will get additional MR

- Since 2007 with arrival of SPECT/CT gamma camera it was decided where possible to perform single optimized post contrast enhanced CT scan with I-123 mIBG SPECT for staging, restaging, response assessment in children with neuroblastoma

- “One stop shop”
<table>
<thead>
<tr>
<th>Methods: SPECT Parameters</th>
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<tbody>
<tr>
<td>Injected dose</td>
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<td>SPECT acquisition</td>
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<tr>
<td>SPECT reconstruction</td>
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<td>Resolution recovery program for SPECT</td>
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## Methods: CT Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>CT slices</td>
<td>6 with high resolution package</td>
</tr>
<tr>
<td>Scout acquisition</td>
<td>80 kVp</td>
</tr>
<tr>
<td>CT scan acquisition</td>
<td>per pediatric CT protocol; kVp range usually 80-110 kVp</td>
</tr>
<tr>
<td>CT dose Modulation</td>
<td>applied</td>
</tr>
<tr>
<td>Contrast administration</td>
<td>contrast dose 2ml/kg up to maximum of 100 ml non-ionic contrast</td>
</tr>
<tr>
<td>Phase of opacification</td>
<td>Portal venous; inject over 45 seconds scan at 65-70 seconds</td>
</tr>
<tr>
<td>Acquisition slice thickness</td>
<td>2.5mm slice thickness overlapping cuts; pitch 0.6</td>
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<tr>
<td>Attenuation correction</td>
<td>CT utilized</td>
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<tr>
<td>Scan reconstruction</td>
<td>soft tissue, bone, and lung reconstructions in 3mm slice thickness for axial scans; coronal and sagittal reconstruction</td>
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Sedation

- No routine sedation but individualized by patient at time of booking

- All sedation performed by anesthesiologist to include conscious sedation and general anesthesia with monitoring during scan and recovery

- Sedation for imaging at 24 hours to include planar and SPECT-CT
Results

- Optimized IV contrast enhanced SPECT/CT utilized for staging evaluation only with no additional imaging in 40% children
Results—"value-added" lesions

- Progressive disease
- Psoas muscle disease
- Retroperitoneal disease
- Solitary metastatic bone disease
- Thoracic nodal disease
- Intraspinal extent
Stand alone CT at diagnosis

CTDI vol = 5.3
DLP = 211.9

Follow-up CT from SPECT/CT

CTDI vol = 3.6
DLP = 102

Optimized SPECT/CT = lower dose
4 year old this SPECT/CT study was the only staging evaluation with scan findings compatible with Stage 4 neuroblastoma
Solitary bone metastasis
Multiple bone mets and intraspinal extent in this patient with progressive disease
off treatment follow-up study for neuroblastoma; thyroid ultrasound showed a neck mass

additional metastasis to the right psoas

metastasis to the left neck
• Infant with opsoclonus- myoclonus for screening for neuroblastoma
MR/SPECT mIBG FUSION

Biopsy proven neuroblastoma stage 1
3 day old with antenatal mass RUQ
ANT POST
AT DIAGNOSIS
13 day old with mass

24 HOUR I-123 mIBG

ANT

POST

6 WEEKS POST SURGERY
I-123 mIBG SPECT/CT at 6 weeks
MR at diagnosis
Conclusions

• Optimized post IV contrast enhanced diagnostic CT performed as co-registered SPECT-CT with I-123 mIBG provides 30% additional information

• This allows for improved diagnostic accuracy for staging, response assessment, and re-staging in children with neuroblastoma

• A single co-registered optimized diagnostic study reduces radiation exposure and number of individual studies performed on these children
I-123 mIBG SPECT/CT at BCCH

- SPECT/CT for staging at diagnosis or relapse regardless of other cross-sectional imaging

- Image fusion to MR even if SPECT/CT performed
IMAGE FUSION
OBJECTIVES

1. CO-LOCALIZATION
2. ADDED DIAGNOSTIC BENEFIT
3. DECREASE IN EXAMINATION TIME
16 year old female with previously resected papillary thyroid ca and post surgical I-131 therapy done elsewhere. Now presents for evaluation of possible neck node seen on ultrasound. post recombinant TSH stimulated wholebody I-123 scan. Thyroglobulin is normal.
□ Two small lymph nodes resected with help of gamma probe
□ No tumor found
15 year old with hypertension and flushing
Presents with recurrent symptoms 6 years later
18F-DOPA PET/CT again identifies multiple lesions
- Two newborns with hyperinsulinemic hypoglycemia of infancy - 18-F-DOPA scan
Whole Body MRI in Pediatric Oncology

- Lack of ionizing radiation
- MRI used for evaluating many pediatric solid tumors
- Screening technique for cancer genetic predisposition


Total Body MRI-DWIBS

diffusion weighted whole body imaging with background body signal suppression

Y. Sakura et al
http://dx.doi.org/10.1594/ecr2012/C-082
PET/MRI in Pediatrics

CHALLENGES

- Length of time for examination and sedation
- Still need CT lungs for sarcoma
- May still need low dose CT for proper attenuation correction for bone vs soft tissue

OPPORTUNITIES

- Decrease in radiation dose
- Optimized protocol may achieve dose as low as 1 mSv
- Reduce injected PET radiotracer and image as long as MRI study
- Value in sarcoma /soft tissue tumors and CNS tumors where MRI is already routine

- “all discussants agreed that they would gladly shift all of their paediatric PET/CT studies to PET/MRI if they were able to.”

Total Body PET/MRI in 14 year old with NHL

A-D Dixon Sequence MRI  
E-μmap F-PET G-STIR H-DWI I-J STIR K-T2 SE

Published in: Jürgen F. Schäfer; Sergios Gatidis; Holger Schmidt; Brigitte Gückel; Ilja Bezrukov; Christina A. Pfannenberg; Matthias Reimold; Martin Ebinger; Jörg Fuchs; Claus D. Claussen; Nina F. Schwenzer; Radiology 2014, 273, 220-231. 2014 by the Radiological Society of North America, Inc. Radiology, http://pubs.rsna.org/doi/abs/10.1148/radiol.14131732
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INCREASE

DOSE COMPLEXITY UTILIZATION
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