SPECT/CT: Oncologic Applications
Part 1 - Neuroblastoma

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Disclosures

• No financial disclosures
• $^{131}$I-MIBG therapy is performed as part of research protocols and is not FDA approved
Objectives

Brief literature review

Overview of SPECT/CT technique

Clinical applications of SPECT/CT
  • physiologic versus pathologic uptake
  • staging and follow-up
$^{123}$I-MIBG in Neuroblastoma

First line functional imaging agent

Utilizes catecholamine reuptake system

Highly sensitive and specific
  • sensitivity 85-100%
  • specificity > 90%

Uptake in > 90% of neuroblastomas
123I-MIBG SPECT

- increases accuracy and sensitivity
- allows better correlation with CT/MR

\[ ^{123} \text{I-MIBG SPECT/CT} \]

- increasing use as more sites acquire hybrid imaging systems
$^{123}$I-MIBG SPECT/CT

Patient selection
• most patients, unless SPECT clearly negative

Limit CT extent
• generally include abdomen +/- pelvis
• site of primary tumor
\(^{123}\)I-MIBG SPECT/CT

SPECT acquisition:
- medium energy collimation
- 25 – 30 seconds / stop, 64 stops

CT acquisition:
- appropriate pediatric reduced dose techniques
- +/- IV contrast
$^{123}$I-MIBG SPECT/CT in Neuroblastoma: The Literature


**Added value of SPECT/CT for correlation of MIBG scintigraphy and diagnostic CT in neuroblastoma and pheochromocytoma.**


Department of Radiology, Hadassah-Hebrew University Medical Center, Jerusalem, Israel.


**Comparison of diagnostic value of I-123 MIBG and high-dose I-131 MIBG scintigraphy including incremental value of SPECT/CT over planar image in patients with malignant pheochromocytoma/paraganglioma and neuroblastoma.**

Fukuoka M, Taki J, Mochizuki T, Kinuya S.

Department of Nuclear Medicine, Kanazawa University Hospital, Kanazawa, Japan.
$^{123}$I-MIBG SPECT/CT

Rozovsky et al. AJR 2008.

- 11 scans in 8 neuroblastoma patients
- Correlating diagnostic CT with SPECT/CT
  - increased diagnostic certainty
  - eliminated equivocal readings
123I-MIBG SPECT/CT


• 11 scans in 8 neuroblastoma patients

• Addition of SPECT/CT
  – increased lesion detection, especially near sites of physiology uptake
  – improved anatomic localization
<table>
<thead>
<tr>
<th>ABSTRACTS</th>
<th># of patients</th>
<th># of scans</th>
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<tbody>
<tr>
<td>Sharp and Gelfand</td>
<td>J Nucl Med 2009</td>
<td>23</td>
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<tr>
<td>Liu and Zhuang</td>
<td>J Nucl Med 2013</td>
<td>33</td>
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<td>Nadel</td>
<td>J Nucl Med 2014</td>
<td>44</td>
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$^{123}$I-MIBG SPECT/CT

Improves diagnostic accuracy and confidence in interpretation

Improves anatomic localization

Differentiates sites of physiologic and pathologic uptake
Clinical Applications: Physiologic versus Pathologic
$^{123}$I-MIBG

Physiologic Distribution

- salivary glands
- nasal mucosa
- myocardium
- liver
- bowel
- kidneys/bladder
- adrenal gland
- lungs
- brown fat
- thyroid (blocked with SSKI)
$^{123}\text{I-ΜΙBG}$

Physiologic Distribution

- salivary glands
- nasal mucosa
- myocardium
- liver
- bowel
- kidneys/bladder
- adrenal gland
- lungs
- brown fat
- thyroid (blocked with SSKI)
Left Retroperitoneal Uptake

Patient 1

Patient 2

Patient 3

Physiologic Renal Activity

Coronal SPECT

Axial SPECT/CT

Physiologic Adrenal Activity

T12 Pedicle Metastasis

$^{123}$I-MIBG

Physiologic Distribution

- salivary glands
- nasal mucosa
- myocardium
- liver
- bowel
- kidneys/bladder
- adrenal gland
- lungs
- brown fat
- thyroid (blocked with SSKI)
Physiologic Liver Uptake

Left lobe uptake > right lobe uptake

Often heterogeneous on SPECT

Liver foci should be interpreted with caution
• correlation with diagnostic CT/MR often helpful

Physiologic Liver Uptake

Liver Metastasis

$^{123}$I-MIBG

Physiologic Distribution

- salivary glands
- nasal mucosa
- myocardium
- liver
- bowel
- kidneys/bladder
- adrenal gland
- lungs
- brown fat
- thyroid (blocked with SSKI)

Normal $^{123}$I-MIBG Scan
Physiologic Lung Uptake

Diffuse low level uptake at 24 hours

Focal uptake may occur in areas of atelectasis or pneumonia

Lung Metastasis
Rare – 3% of patients at diagnosis
Unfavorable metastatic site
Seen with widely metastatic disease
Three patterns – direct extension, hematogenous, and lymphangitic

Towbin and Gruppo. AJR 1982;138:75-78.
Clinical Applications: Staging and Follow-up
$^{123}$I-MIBG Imaging

At diagnosis/initial staging

- document MIBG avidity of primary tumor
  - impact on follow-up imaging choices
  - establish eligibility for $^{131}$I-MIBG therapy

- identify metastatic sites

MIBG

Non-avid tumors in < 10%

• some non-avid at diagnosis
• others become non-avid during therapy
• patients can have both MIBG avid and non-avid disease sites

MIBG versus FDG

FDG most useful

- in tumors that fail to or weakly accumulate MIBG
- when MIBG shows less disease than suspected clinically or by CT/MR

MIBG versus FDG

Melzer et al. studied patients with
- MIBG negative tumors
- discrepancies between MIBG scans and anatomic imaging or clinical findings

FDG more sensitive (78% vs 50%) and specific (92% vs 75%) than MIBG

Reviewing both FDG and MIBG scans gave the highest sensitivity (85%)

$^{123}$I-MIBG Imaging

At diagnosis/initial staging

- document MIBG avidity of primary tumor
- identify metastatic sites

$^{123}$I-MIBG Imaging

During/after therapy

- provides functional evidence of residual tumor
- most sensitive method to evaluate for residual disease and unsuspected relapse

High Risk Disease

Recurrent metastatic disease during maintenance therapy

• bone marrow or bone recurrence in 30-40% up to 3 years after BMT
Disease Surveillance

Goal

• detection of recurrent disease at small tumor burdens

$^{123}$I-MIBG has high sensitivity for bone and bone marrow disease
Summary

MIBG is the primary functional imaging agent for neuroblastoma assessment.

SPECT/CT useful at diagnosis and follow-up

- improves confidence in interpretation and diagnostic accuracy
- improves anatomic localization
- differentiates physiologic from pathologic uptake