Lymphoscintigraphy and Radiopharmaceutical Safety

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Outline
• Review Sentinel node concept
• Procedure
  • Nuclear medicine perspective
    • Radiopharmaceuticals
    • Probes
    • Injection techniques/locations
  • Lymphoscintigraphy
• Melanoma/Breast cancer examples
• Radiation Safety
• Area for further clarification

Sentinel Lymph Node Mapping

• Late 1980’s Morton (surgeon) & Cochran (pathologist) proposed concept of lymph node mapping with sentinel lymph node biopsy.

Definitions
• Sentinel lymph node: The first lymph node(s) in a lymph node basin to receive lymphatic drainage from a tumor
  • Often there is direct drainage from the tumor to more than 1 lymph node within a regional lymph node basin.
• Lymphoscintigraphy: Imaging pathways of lymphatic flow and lymph nodes after injection of a radiopharmaceutical that is absorbed by the lymphatics

Sentinel Node Concept

![Sentinel Node Concept Diagram]
**Sentinel Node Concept**

- Tumor
- SN
- Non-SN
- "SN"
- 2nd
- 3rd

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**Other definitions of Sentinel Node**

- Closest node to the primary lesion
- First node detected on lymphoscintigraphy
- Node with highest count rate
- Node with count rate 3-5X higher than background
- Blue Node
Lymphoscintigraphy

- Imaging pathways of lymphatic flow and lymph nodes after injection of a radiopharmaceutical
- Performed with standard gamma camera
Lymphoscintigraphy

- Ideal Radiopharmaceutical
  - 100% migration from injection site
  - 100% retention within sentinel node

Lymphoscintigraphy

- Radiopharmaceuticals
  - Tc-99m Sulfur colloid 10-1000 nm
  - Filtered Tc-99m Sulfur colloid 10-50 nm
  - Tc-99m Antinomy colloid 5-20 nm
  - Tc-99m Human serum albumin 2-3 nm
Lymphoscintigraphy - Breast Cancer

• There are no dietary or medication restrictions for the procedure. Patients should follow preoperative restrictions if the procedure is performed on the same day as scheduled surgery.

• 1-2 mCi of Tc-99m Filter sulfur colloid

Lymphoscintigraphy - Breast cancer Why bother?

• Lymphatic drainage for the breast is not clinically predictable
• Imaging is needed to confidently identify the location and number of SLN(s)
• Smaller incision, faster procedure

Variability of Breast Lymphatic drainage

• 92% of medial quadrant lesion drain into the axilla
• 25% of outer quadrant lesions drain into internal mammary nodes
• 45% of patients demonstrate breast lymphatic drainage across the midline

Lymphoscintigraphy Breast Cancer

• Routes of administration

![Routes of administration](image)
Sentinel Node Biopsy: Standard or Investigational?

- Use of SNB increased from 8% (1997) to 58% (late 2000).
- There are several extensive, randomized NCI trials comparing SNB and Axillary Node Dissection, 1999-2007.
- There is debate on whether surgeons should wait for those trial results before using SNB routinely.
<table>
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<tr>
<th>Melanoma</th>
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<tr>
<td>• Elective lymph node dissection (ELND) of the lymphatic bed believed most likely to drain the primary tumor site (based on Sappey's classic anatomic description of cutaneous lymphatic flow) was used as part of the staging procedure for melanoma.</td>
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<td>• The sentinel lymph node excisional biopsy is a simple procedure and not associated with significant morbidity.</td>
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<tr>
<td>• Provides accurate information about lymphatic drainage patterns.</td>
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<td>• Sentinel node localization and excision using radionuclide methods are performed in patients with:</td>
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<tr>
<td>• Intermediate stage primary melanoma (Breslow 0.76 mm–4.0 mm).</td>
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<tr>
<td>• No clinical evidence of nodal involvement</td>
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<tr>
<td>• No clinical evidence of distant tumor spread</td>
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<td>• Exclusions may include patients with:</td>
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<td>• Extensive previous surgery in the region of the primary tumor site or targeted lymph node bed.</td>
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<td>• Patients with known metastases.</td>
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<td>• Society of Nuclear Medicine Procedure Guideline for Lymphoscintigraphy and the Use of Intraoperative Gamma Probe for Sentinel Lymph Node Localization in Melanoma of Intermediate Thickness</td>
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| ![Procedure](image) |
Procedure - Melanoma

- If surgery is to be performed using the intraoperative gamma probe to assist in finding the sentinel node, the tracer must be injected approximately 0.5–3 hr before surgery.
- 0.2-0.4 mL containing at least 17 MBq Tc-99m sulfur colloid, filtered (0.22µ millipore filter), is administered.
- 2- 4 peritumoral intradermal injections
  - within 1 cm from the melanoma or the excisional biopsy site at which the melanoma was located.

Injectionsshould surround the lesion or biopsy site to best sample lymphatic drainage in all directions. (Exception- primary cutaneous melanoma in the head or neck)

- Gentle finger massage should be considered at each injection site to promote uptake of the tracer into lymphatic channels and lymphatic flow.
- The injection site should be covered with a bandaid to prevent leakage of activity through the needle puncture site.

Image Acquisition

- Sequential or continuous imaging begins immediately after completion of injections and continues for 30–60 minutes.
- For trunk lesions, images of both axillary and inguinal regions should be obtained.
- Lateral or oblique views are often helpful.

For extremity lesions, the knee or elbow regions should be included in the field of view on dynamic and static images to detect “in-transit” or intercalated lymph nodes, which are sentinel lymph nodes.

In-transit Node

- Initial
- 30 minute delay
Image Interpretation

- Sentinel lymph node is the first to receive drainage from the tumor site.
- When drainage to more than 1 anatomic region is seen (e.g., axilla and inguinal), each of those regions must have at least 1 sentinel lymph node.
- Intraoperative probe criteria- A sentinel lymph node usually has at least 10 times the background counts

Radiation safety

- Exposures from these procedures are sufficiently low that badging is not essential
- Radiation dose to the hands of the surgeon has been estimated to be 5–94 μSv per patient
- At an altitude of 30,000 feet, the dose rate was about 4 μSv per hour at the latitudes of North America and Western Europe

Radiation safety

- Radiation doses to pathology personnel who handle the radioactive sentinel node and primary tumor specimen for a limited period would be no greater than that received by the surgeon.
- Therefore, the histological specimen can be processed without delay, and patient care is not compromised.
Radiation Safety - Patient

- Deterministic effects (e.g., local skin necrosis) are not a concern for Tc-99m-labeled radiopharmaceuticals.

- Effective doses:
  - Lymphoscintigraphy: 0.05-0.1 mSv
  - CT Head: 2.0 mSv
  - CT Chest: 8.0 mSv
  - CT Abdomen: 10.0 mSv
  - Angioplasty: 7.5 - 55.0 mSv

Problems

- Standardization of injection technique (breast carcinoma)
- False negative rate or skip rate
- More extensive histological evaluation
  - IHC stains, RT-PRC

The Sentinel Node Concept

- Success story
  - The SLN Concept originated with surgeons
  - Popularized by surgeons
  - Radionuclide Imaging and Intraoperative Probe detection for SLN introduced by a surgeon
  - Validated by surgeons