Some Remarks on Technology Development for SLN Procedures

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beyond melanoma and breast cancer
prostate cancer, esophageal cancer, gastric cancer
colorectal cancer, head & neck cancer, …

Commercial Intraoperative Gamma Counting Probes

approximately a dozen vendors
Gammasonics Institute for Medical Research Pty, Ltd
Gamma Probe PC
www.gammasonics.com/

IntraMedical Imaging, LLC
Node Seeker 800
www.intra-medical.com/

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Radiation Monitoring Devices (RMD)
Navigator
www.rmdinc.com/

Silicon Sensor International AG
SIS-PET Probe System
www.silicon-sensor.com/
Commercial Relatively Small FOV Gamma Cameras—critical dimensions 15-25cm

<table>
<thead>
<tr>
<th>Camera Model</th>
<th>Manufacturer</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>CapIMAGE</td>
<td>CII (Capintec, Inc)</td>
<td><a href="http://www.capintec.com">www.capintec.com</a></td>
</tr>
<tr>
<td>2020tc Imager</td>
<td>Digirad Corp</td>
<td><a href="http://www.digirad.com/">www.digirad.com/</a></td>
</tr>
<tr>
<td>Dilon 6800 Gamma Camera</td>
<td>Dilon Technologies</td>
<td><a href="http://www.dilon.com/">www.dilon.com/</a></td>
</tr>
<tr>
<td>Gamma CAM/OR</td>
<td>Gamma Medica-Ideas, Inc</td>
<td><a href="http://www.gm-ideas.com/">www.gm-ideas.com/</a></td>
</tr>
<tr>
<td>T-Quest Mobile Gamma Camera</td>
<td>MEDX, Inc</td>
<td><a href="http://www.medx-inc.com/">www.medx-inc.com/</a></td>
</tr>
<tr>
<td>SD-X 37 IV – SCINTRON VI</td>
<td>MiE (Medical Imaging Electronics)</td>
<td><a href="http://www.miegermany.de/">www.miegermany.de/</a></td>
</tr>
</tbody>
</table>

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Slides are not to be reproduced without permission of author.
Intraoperative Imaging (is not new)

FIG. 1. Gamma-camera operating table with TV monitor.


70-80s

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“The Old Ones” Probes (1948)
Intraoperative gamma imaging of axillary sentinel lymph nodes in breast cancer patients

Aarsvold JN, Greene CM, Mintzer RA, Grant SF, Styblo TM, Alazraki NP, Patt BE, Carvaglia GM, Li J, Iwanczyk JS

Atlanta Veterans Affairs Medical Center
Emory University
Georgia Institute of Technology
Gamma Medica Inc.

Physica Medica, 2006, 21(Supplement 1):76-79

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Relatively small FOV

Gamma CAM/OR
Gamma Medica, Inc.
Northridge, CA

12.5 cm x 12.5 cm FOV
56x56 array of NaI(Tl) crystals
5x5 array of 1”x1” PSPMTs
LEHR collimator (135 cpm/µCi)
Task

Is the task, for example, survey imaging or spot imaging or ...?
Small FOV Camera (in sterile field)

Purpose:

to survey all regions with “relevant” nodes.
If possible,

**task:**
- locate all SLNs
- axillary
- extra-axillary (IM, etc.)

**tools:**
- preop imaging (large FOV)
- preop counting (probe)
- intraop counting (probe)
- intraop visualization (dye)
This study

Branch 1 (probe/dye):
  intraop counting (probe)
  intraop visualization (dye)

Branch 2 (camera/probe/dye):
  intraop counting (probe)
  intraop visualization (dye)
  &
  intraop imaging (relatively small FOV)
This study (some details)

Subjects:
branch 1: 8 patients
branch 2: 8 patients

Very experienced team
nuclear medicine personnel
surgeon
pathologist
more details

Care Wise
C-Trak probe

Gamma Medica
GammaCAM/OR gamma camera
Surgeon BLINDED to preop images until she indicates end of foci removal.
Example case

59 yo female; A cup; R breast @ 3:00; lobular carcinoma in situ

- Axillary
- Internal mammary

Radioactive foci located via external counting w/ counting probe
Example case

59 yo female; A cup; R breast @ 3:00; lobular carcinoma in situ

Axillary

Internal mammary

Pre-incision
Example case

59 yo female; A cup; R breast @ 3:00; lobular carcinoma in situ

axillary
5 specimens removed

internal mammary
0 specimens removed

pre-incision
post-incision
post-lumpectomy
Example case

59 yo female; A cup;
R breast @ 3:00;
lobular carcinoma in situ

ant 20 min
rao 25 min
r lat 30 min
GE 500 camera
Specimen imaging
<table>
<thead>
<tr>
<th>Specimen ID</th>
<th>post-ex cts (10s) (probe)</th>
<th>activity (nCi)</th>
<th>specimen/injected activity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(SLNax)</td>
<td>7958</td>
<td>3740</td>
<td>1.46</td>
</tr>
<tr>
<td>2(SLNax)</td>
<td>1262</td>
<td>376</td>
<td>0.15</td>
</tr>
<tr>
<td>3(secLNax)</td>
<td>3190</td>
<td>459</td>
<td>0.18</td>
</tr>
<tr>
<td>4(secLNax)</td>
<td>829</td>
<td>267</td>
<td>0.11</td>
</tr>
<tr>
<td>5(secLNax)</td>
<td>2085</td>
<td>300</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Results

Preop imaging:
focus or foci visualized in 16/16

Intraop external counting:
focus or foci detected in 15/16
[mean time to detection = 1.5 min]
Results

**Camera/probe/dye**

- Hot and/or blue nodes removed from 8/8 patients [mean = 28 min (n=8), range 16 to 47 min]
- Intraop imaging: focus or foci visualized in 6/8 patients
  - One focus adjacent to injection site—visualized only on preop time-course images
  - One node contained 40 nCi (~0.015% injected dose)

**Probe/dye**

- Hot and/or blue nodes removed from 7/8 patients [mean = 19 min (n=7), range 7 to 29 min]
Results

**Camera/probe/dye**

hot and/or blue nodes removed from 8/8 patients  
[mean = 28 min (n=8), range 16 to 47 min]

How long to image?  
Anyone can find the “hot” nodes.  
The critical ones are those with limited uptake but detectable cancer.  

Based on preop time course images  
one node contained 40 nCi (~0.015% injected dose)

**Probe/dye**

hot and/or blue nodes removed from 7/8 patients  
[mean = 19 min (n=7), range 7 to 29 min]

Issue was probably timing
This was a narrow “early experience” study pursued in the context of protocols w/ intraop probe/dye but w/o preop imaging. The study used a 12.5 cm x 12.5 cm FOV camera w/ a LEHR collimator and included participation of a very experienced SLN breast cancer surgeon.

The primary conclusion of the study is the use of an intraop camera in this context will not shorten on average SLN biopsy procedures performed by experienced surgeons.

Intraop imaging may be useful in some contexts. The use of such technology may provide surgeons with information that results in higher confidence regarding procedure success. Additional structured studies are needed to address such.

Gratefully acknowledged are research funds through DOD-BC011239 and NCRR-2R44RR15157.
SHGC (Small High-resolution Gamma Camera)


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<tr>
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<tr>
<td>eZ-Scope</td>
<td>eV PRODUCTS</td>
<td><a href="http://www.evproducts.com/">www.evproducts.com/</a></td>
</tr>
<tr>
<td>Minicam II</td>
<td>Eurorad SA</td>
<td><a href="http://www.eurorad.com/">www.eurorad.com/</a></td>
</tr>
<tr>
<td>IP Guardian II</td>
<td>LI TECH (Life Imaging Technologies)</td>
<td><a href="http://www.li-tech.it/">www.li-tech.it/</a></td>
</tr>
<tr>
<td>Acrorad</td>
<td></td>
<td><a href="http://www.acrorad.co.jp/">www.acrorad.co.jp/</a></td>
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<td>Biospace Lab</td>
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<td>Oy Ajat, Ltd</td>
<td></td>
<td><a href="http://www.ajat.fi/">www.ajat.fi/</a></td>
</tr>
<tr>
<td>TeraRecon, Inc</td>
<td></td>
<td><a href="http://www.terarecon.com/">www.terarecon.com/</a></td>
</tr>
</tbody>
</table>
eZ-SCOPE

Minicam II

MGC 500

Sentinella

IP Guardian II is not pictured.
Place of a hand-held gamma camera (POCI) in the breast cancer sentinel node biopsy.

A hand-held imaging probe for radio-guided surgery: physical performance and preliminary clinical experience.
High-resolution, hand-held camera for sentinel-node detection.


Simplified technique of radioguided occult lesion localization (ROLL) plus sentinel lymph node biopsy (SNOLL) in breast carcinoma.

Lavoué V, Nos C, Clough KB, Baghaie F, Zerbib E, Poulet B, Lefrère Belda MA, Ducellier A, Lecuru F.


**Figure 1A:**
The portable gamma camera (Sentinella) and placing of an I125 seed on the top of the laparoscopic probe.

Figures 1B & 1C:
The portable gamma camera during operation. The camera is placed behind the patient’s head. The nuclear medicine physician can use his/her own screen to operate the camera and guide the surgeon.

**Figure 1D:**
One screen of the portable gamma camera system showing matching of the sentinel node signal (99mTc) and the 125I seed pointer (yellow circle) signal: exact location of the SN by the surgeons probe.

**Figure 2:**
Screen of the portable gamma camera, showing comparison of two situations. On the first (left) view, we see only the 99mTc-signal (the location of a sentinel node). On the second (right) view, we see that the surgeon has found the exact location of the SN, because the yellow circle (125I seed used as pointer) matches with the previously found SN-signal.