Enhanced Techniques to Increase the Utility of Radioiodine Imaging in Patients with Differentiated Thyroid Cancer

Online session sponsored by Jubilant Radiopharma

The Society of Nuclear Medicine and Molecular Imaging (SNMMI)’s Verification Of Involvement in Continuing Education (VOICE) has approved this enduring activity for 1.00 CEHs (Continuing Education Hours), for ARRT Category A credit.
Session originally presented by:

Douglas Van Nostrand, MD, FACP, FACNM
Director, Nuclear Medicine Research
MedStar Health Research Institute and Washington Hospital Center
Professor of Medicine, Georgetown University School of Medicine
Washington, D.C.
Objectives

1. To list multiple techniques to help improve the quality of the radioiodine images for patients with differentiated thyroid cancer

2. To describe how those techniques improve the quality of radioiodine imaging

3. To discuss the evidence based literature demonstrating the value of pre-therapy radioiodine staging scans
Image interpretation is only as good as the **quality of the images obtained**

**Successful patient treatment** and outcomes are **directly related to the quality of the images** and interpretation

A rarely, if ever, spoken factor is the role the technologist plays in imaging and how important it is

In the following slides, we will list and detail several techniques that will increase the quality of thyroid imaging
Both Images are from the same patient
• What technique was used to produce the second image?

Image A

Image B
Both Images are from the same patient
• What technique was used to produce the second image?

A spot (planar) image can be superior to a whole body zoomed image (A). We can now identify 4 different foci on the spot image (B).
A radioactive source emits gamma ray photons in all directions. The collimator conveys only those photons traveling directly along the long axis of each hole. Photons emitted in other directions are absorbed by the septa (wall) between the holes.

A planar view with increased time will ensure that more data will be collected from photons directed to the crystal.
The star artifact represents marked streaking in an area with intense radionucleotide emission. The streaking goes in multiple directions and resembles a multi-pointed star.

It can happen from the penetration of photons through the septae of the collimator either due to a very large flux of photons or due to high energy photons.
What technique can we use to avoid a star artifact?

On I-131 scans, the star artifact is most likely due to the high energy photons.

Using a pinhole collimator will definitely increase the resolution of the image as seen in B.
Technique 1 and 2

Spot images: parallel hole collimator & pinhole collimator

Parallel hole collimator

Pinhole collimator

Image A: WB Zoomed
Image B: Spot (planar)
Image C: Pinhole
The aperture of the pinhole collimator insert is important: the smaller the aperture, the better the resolution.
Pinhole collimator images: overview of trade offs

- Pinholes are largely used for imaging only small objects
- Longer acquisition times

But they are worth it!
Pinhole collimator image references


Technique 3

Same patient: What technique was used to produce the second image?

Image A

Image B
Technique 3

Same patient: What technique was used to produce the second image? Answer: delayed imaging

The Target/Bkg ratio keeps increasing, because the background frequently clears faster than the target.
Technique 4

Same images as before, but different technique: what is it?

Image A

Image B
Technique 4

Same images as before, but different technique: was is it?

![Image A](image_a.png) ![Image B](image_b.png)

Longer acquisition time: image B was acquired for twice as Long as image A.
Technique 4

Longer acquisition time

No magic here; you may already know the secret: it’s all about counting statistics!!!
Technique 5

Same views: what technique was used?

Series A

Series B
Technique 5

Same views: Modify image display by adjusting brightness and contrast.

Series A

Series B
Technique 6

Suspicious hot spot on whole body and planar images.
Technique 6

Suspicious hot spot on whole body and planar images. Repeat images: what was done?
Obtain specific patient history

- If there is a focal hot spot, talk or examine the patient
- One only has to ask, inspect, and, if necessary, take an additional modified view to confirm

In this particular case, the patient had an artificial eye that probably got contaminated by sweaty fingers... the eye was removed and the images repeated: the suspicious hot spot disappeared!
Technique 6 (good practice)

Obtain specific patient history

Another example of a suspicious hot spot: this time it was contaminated dentures...
The last technique, and perhaps ONE OF THE MOST IMPORTANT:

SPECT-CT
Technique 7

SPECT-CT

Technique 7

SPECT-CT

• Multiple views (tomographic images)

• Improved contrast resolution

• Localization of activity in reference to anatomical structures

• Improved differentiation of lesion activity (pathology) versus normal activity (physiology)

• Increased specificity
Technique 7

SPECT-CT

The following slides summarize many of the publications demonstrating the utility of I-131 SPECT-CT imaging.
Value of $^{131}$I SPECT/CT for the evaluation of differentiated thyroid cancer: a systematic review of the literature

Yan-Li Xue · Zhong-Ling Qiu · Hong-Jun Song · Quan-Yong Luo

Ref: Xue, EJNMMI 2013;40:768-78
Technique 7

SPECT-CT: the right column displays by which percentage SPECT-CT clarified the indeterminate cases; altered the staging or the management; and/or the outcomes for the patient.

<table>
<thead>
<tr>
<th>Author</th>
<th>Reference</th>
<th>Altered staging, indeterminates, management, and/or outcomes</th>
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</thead>
<tbody>
<tr>
<td>Aide</td>
<td>J Clin Endocrinol Metab 2009; 94:2075-2084.</td>
<td>22%</td>
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<tr>
<td>Barwick</td>
<td>Eur J Endocrinol 2010; 162:1131-1139.</td>
<td>42%</td>
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<tr>
<td>Ciappuccini</td>
<td>Eur J Endocrinol 2011; 164:961-969.</td>
<td>Sole prognostic variable</td>
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<td>Geerlings</td>
<td>Nuc Med Comm 2010; 31:417-422.</td>
<td>27%</td>
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<tr>
<td>Grewal</td>
<td>J Nucl Med 2010; 51:1361-1367.</td>
<td>20%</td>
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<tr>
<td>Kohlfuerest</td>
<td>Eur JNMMI 2009;36:886-893.</td>
<td>36%</td>
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<tr>
<td>Maruoka</td>
<td>Radiology 2012;265:902-909.</td>
<td>22%</td>
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<tr>
<td>Mustafa</td>
<td>Eur JNMMI 2010;37:1462-1466.</td>
<td>25%</td>
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<tr>
<td>Ruf</td>
<td>Nuc Med Comm 2004;25:1177-1182.</td>
<td>25%</td>
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<tr>
<td>Schmidt</td>
<td>J Nucl Med 2009;50:18-23.</td>
<td>35%</td>
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Technique 7

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<td>Spanu</td>
<td>JNMMI 2009;50:184-190.</td>
<td>36%</td>
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<tr>
<td>Tharp</td>
<td>Eur J Nucl Med Mol Imaging 2004;31:1435-1442.</td>
<td>41%</td>
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<tr>
<td>Wang</td>
<td>Clinical Imaging 2009;33:49-54.</td>
<td>23%</td>
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<tr>
<td>Yamamato</td>
<td>J Nucl Med 2003;44:1905-1910.</td>
<td>88%</td>
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<tr>
<td>Avram</td>
<td>JCEM 2015. 100; 1895-1902</td>
<td>29%</td>
</tr>
</tbody>
</table>
The Future / Research advancements

- Development of drugs called MEK inhibitors* (e.g. selumetinib, dabrafenib, trametinib)

- These agents can re-establish I-131 uptake in patients whose cancer no longer takes up I-131

- This in turn can allow the patient to be treated again with I-131

*A MEK inhibitor is a chemical or drug that inhibits the mitogen-activated protein kinase enzymes MEK1 and/or MEK2. They can be used to affect the MAPK/ERK pathway which is often overactive in some cancers.

Ref.: Ho AL, et al. NEJM 2013;368:623-632
The Future / Research advancements

Baseline fused $^{124}$I PET and CT scan

Several sites of lung metastases identified

Fused $^{124}$I PET and CT scan after selumetinib

Many more sites of lung metastases are present
Utility of Pre-therapy Staging Scans
Utility of Pre-therapy Staging Scans

According to the 2015 ATA Guidelines a Pre-therapy Radioiodine Staging Scan would be useful:

• “When the results may alter the decision to treat or the [amount of prescribed] activity of RAI that is to be administered, and

• When the extent of the thyroid remnant or residual disease cannot be accurately ascertained from surgical report or neck ultrasonography.”

Ref: Final 2015 ATA Guidelines
Utility of Pre-therapy Staging Scans

According to the 2015 ATA Guidelines a Pre-therapy Radioiodine Staging Scan:

• “... has been reported to yield information that could alter clinical management... in 25 to 53% of patients.”

• Could be useful when there is concern for stunning with I-131

• May enhance identification and localization of uptake foci when used with concomitant SPECT-CT

Ref: Final 2015 ATA Guidelines
A pre-therapy radioiodine staging scan:

- Is performed using I-123 or low activity I -131 (1 to 3 mCi)
- Is optimally followed within 72 h with the therapeutic activity
Utility of Pre-therapy Staging Scans

Ref: Chen MK, et al., Thyroid 2012;22:304

Retrospective study

• 122 patients
• Pre-therapy radioiodine staging scans (no SPECT)
• I-123 scans
• Images performed 24 hours after administration
• Whole body images and anterior “spot images”
Utility of Pre-therapy Staging Scans

Ref: Chen MK, et al., Thyroid 2012;22:304

The pre-therapy radioiodine scan:

- Provided additional critical information in 25% of the cases

- Provided additional information in 50% of cases demonstrating > 3% uptake with midline lymph nodes
Utility of Pre-therapy Staging Scans

Ref: Van Nostrand D, et al., Thyroid 2009;19:849

Retrospective study

• 355 patients
• Pre-therapy radioiodine staging scans (no SPECT)
• I-123 scans
• Images performed 24 hours after administration using the seven techniques discussed previously
Utility of Pre-therapy Staging Scans

Ref: Van Nostrand D, et al., Thyroid 2009;19:849

• Pre-therapy radio-iodine staging scan provided additional critical information in 29% of the cases
List several techniques that will increase the quality of thyroid imaging

1. Spot (planar) images
2. Pinhole images
3. Delayed imaging (even when using I-123)
4. Longer acquisition time
5. Alter contrast and brightness of display
6. Obtain specific history from patient
7. SPECT-CT
Special thanks to the Staff of the Washington Hospital Center, Division of Nuclear Medicine