

Lesion detection performance in an anthropomorphic chest phantom: comparative analysis of low-dose CT data on two hybrid imaging systems.

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INTRODUCTION

- Multimodality environment.
- Requirement for greater understanding of the imaging technologies used, the limitations of these technologies, and how to best interpret the results.
- Dose optimization.
- Introduction of new techniques.
- Current practice and Best practice.

INTRODUCTION

- Incidental findings, in low-dose CT images obtained as part of the hybrid imaging process, are an increasing phenomenon with advancing CT technology.
- Resultant ethical and medico-legal dilemmas.
- Understanding limitations of these procedures important when reporting images and recommending follow-up.
- Free-response observer performance study was used to evaluate lesion detection in low-dose CT images obtained during attenuation correction acquisitions for myocardial perfusion imaging, on two hybrid imaging systems.

PROCESS













- CTAC acquisitions on GE Infinia Hawkeye 4 and Siemens Symbia T6 (situated side by side + diagnostic CT).
- Anthropomorphic chest phantom with simulated tumour lesions of varying densities and sizes.
- Manufacturer's low-dose CT settings for attenuation correction of myocardial perfusion images.
- JAFROC analysis.
- Relate lesion detection data back to the clinical setting on the specific equipment used in this research.

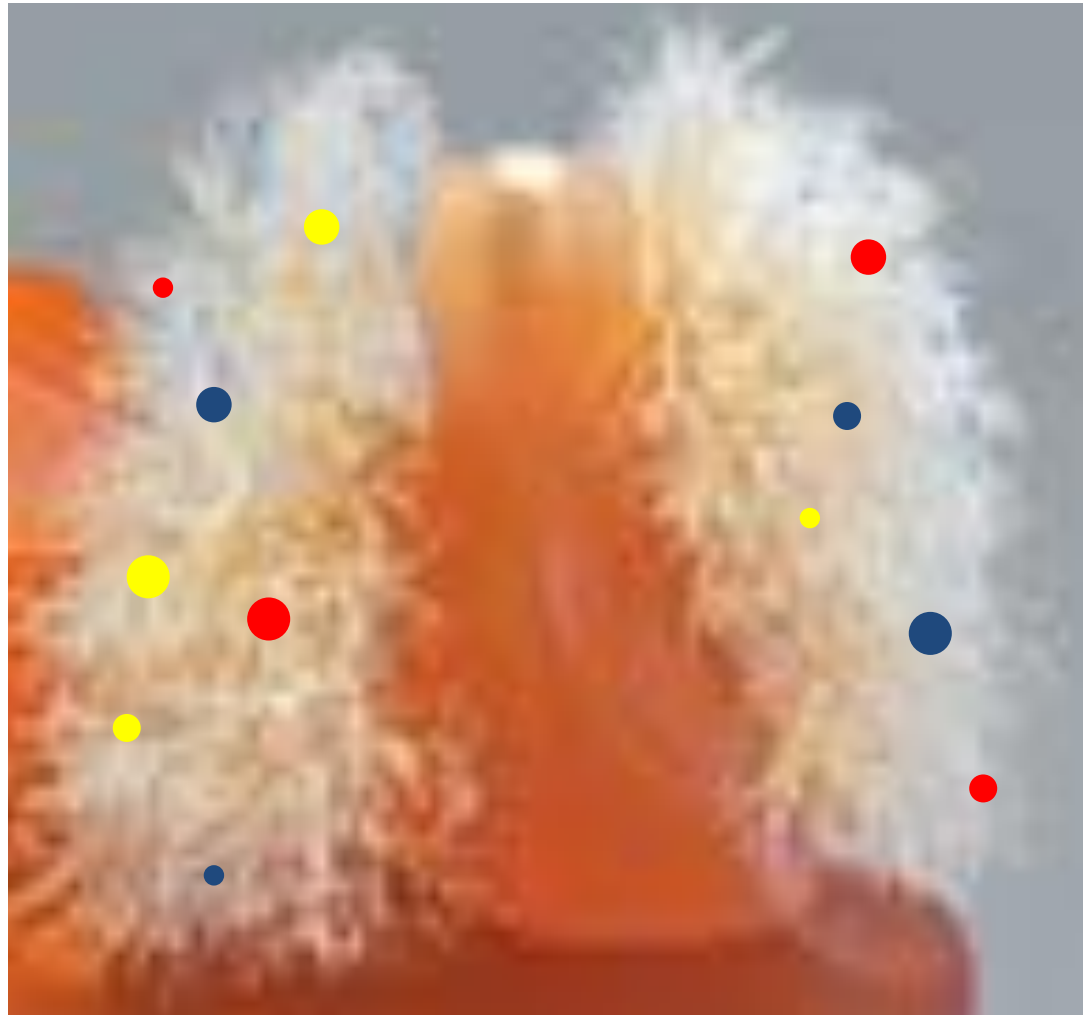
ANTHROPOMORPHIC PHANTOM



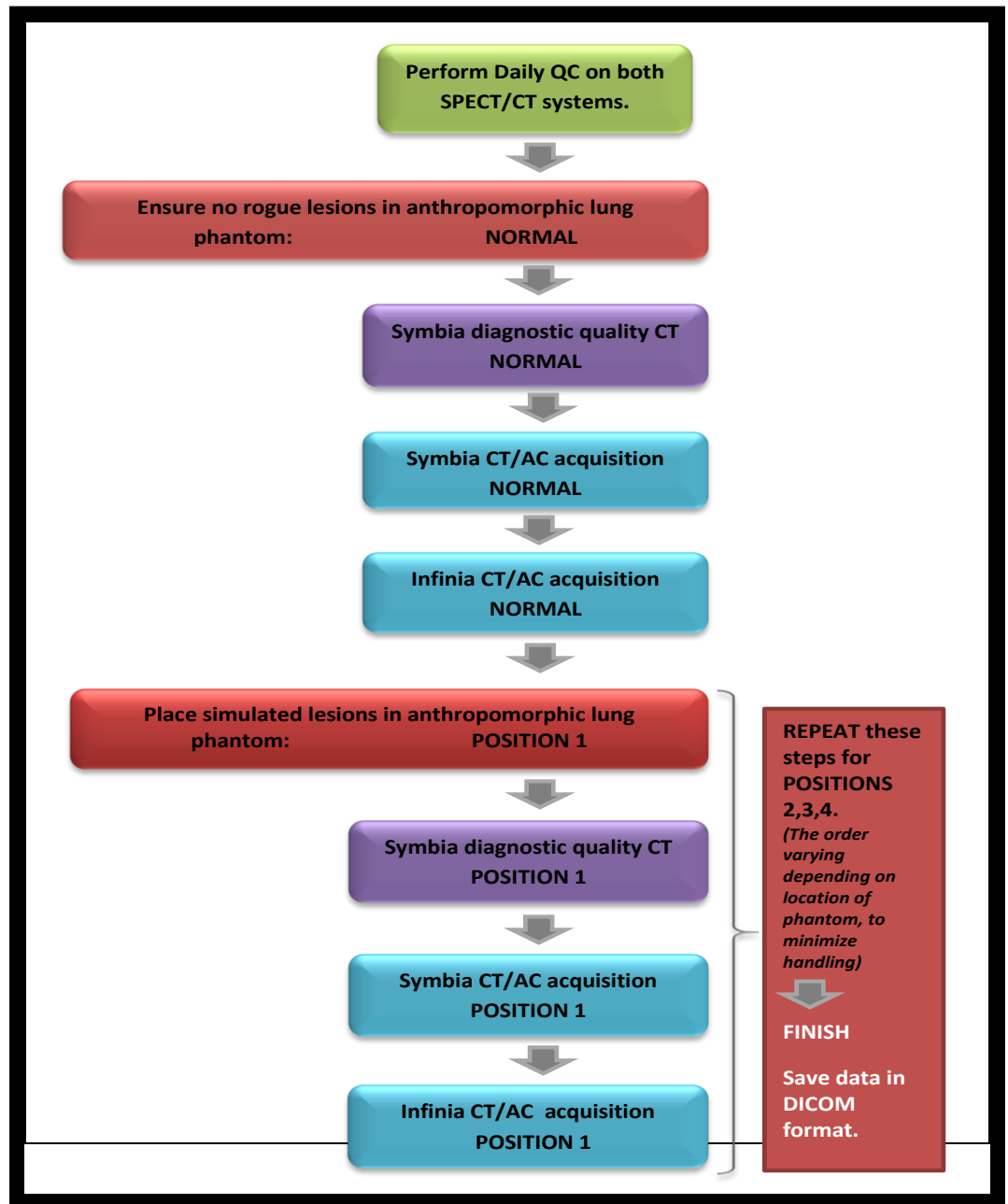
Multipurpose Chest Phantom N1
"LUNGMAN"

LESION PLACEMENT

Size (mm): <i>diameter</i>	HU +100	HU -630	HU - 800
5			
8			
10			
12			



WORKFLOW



QUALITY CONTROL and DIAGNOSTIC CT

- ‘Setting the scene’.
- Established correct operation of the equipment.
- Imaging for any rogue lesions prior to placing any simulated tumour lesions.
- Diagnostic quality CT images to be used to establish “truth” data for low dose CT images.

CT/AC INFINIA HAWKEYE 4



CT/AC SYMBIA T6



SIEMENS

Siemens Healthcare
Diagnostics

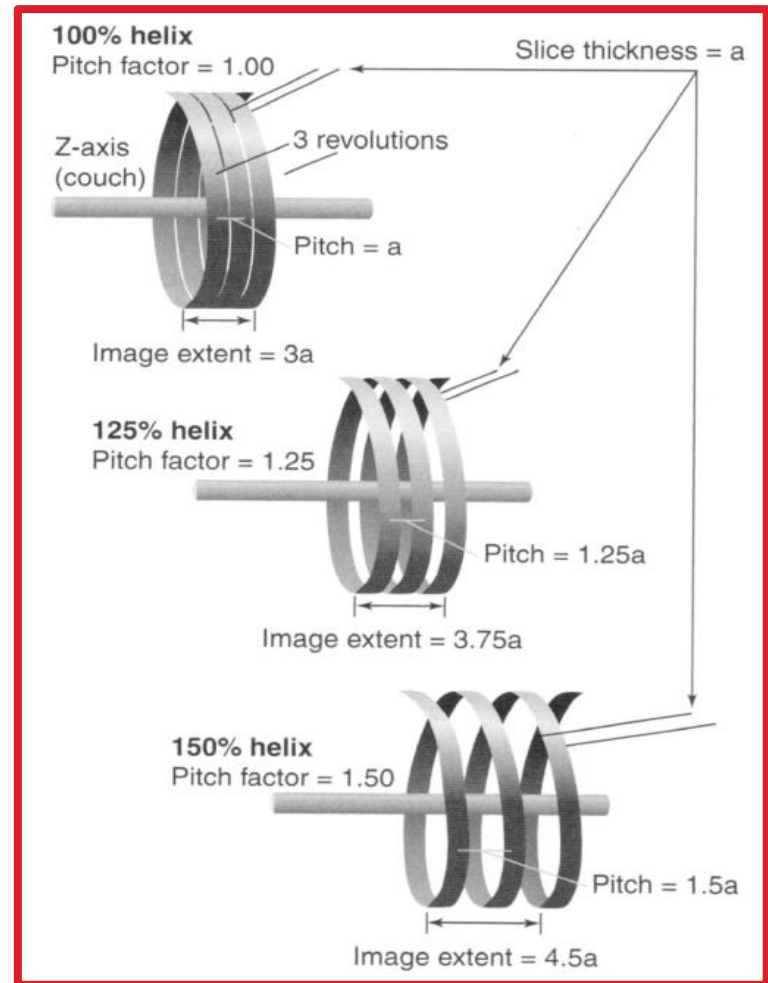
ACQUISITION SETTINGS USED FOR CT/AC

<i>SPECT/CT system</i>	<i>kVp</i>	<i>Eff. mAs</i>	<i>Pitch</i>	<i>Slice configuration</i>	<i>Matrix size</i>	<i>Scan FOV (mm)</i>	<i>Display FOV (mm)</i>	<i>Pixel size (mm)</i>	<i>Rotation time</i>	<i>Reconstruction Kernels</i>
Symbia T6	130	13.8	1.0	6 x 3 mm	512 x 512	500	282	0.55	0.6 secs	B08s, B30s, B60s
Hawkeye 4	140	23.7	1.9	4 x 5 mm	256 x 256	565	435	1.70	Velocity = 2.0 rpm	Defined

PITCH

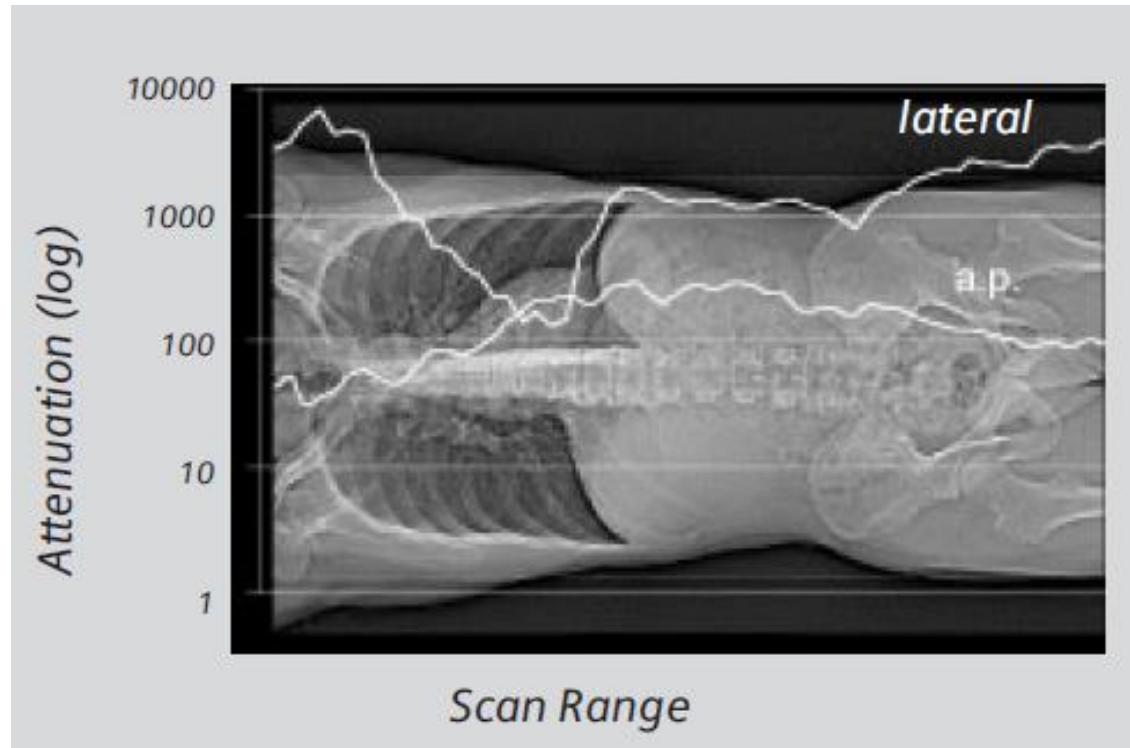
Increasing pitch increases interspaces between helical paths.

Seeram, E. (2009). *Computed Tomography – Physical Principles, Clinical Applications, and Quality Control*. (3rd ed.) St Louis, US: Saunders Elsevier. p.260 [Figure 11-21].



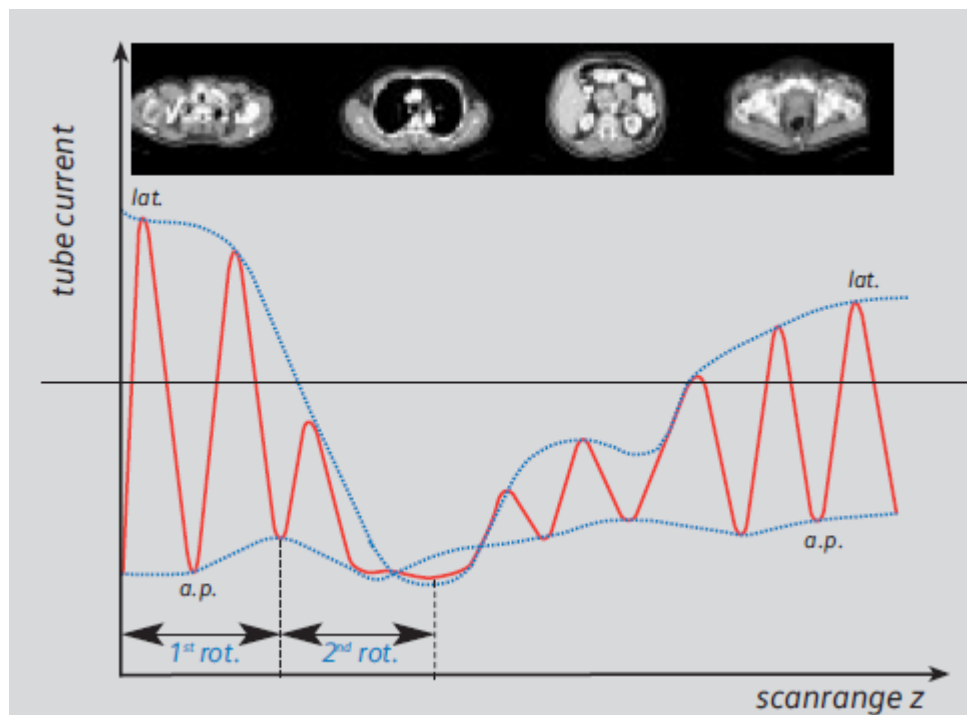
DOSE MODULATION

Care Dose4D: Example of a lateral and a.p. attenuation profile evaluated from an a.p. Topogram.



Siemens. *SOMATOM Emotion Application Guide*.
[Product information C2-019.630.01.01.02].

DOSE MODULATION



Care Dose4D: Example of a dose modulation profile where high tube current and strong modulation are seen in the shoulder and pelvis, and lower tube current and low modulation are seen in the abdomen and thorax. The dotted lines represent the min. and max. tube current at the corresponding table position and result from the attenuation profile of the Topogram.

Siemens. *SOMATOM Emotion Application Guide*.
[Product information C2-019.630.01.01.02].

RECONSTRUCTION ALGORITHMS

Kernel names: Kernel names have 4 positions. Example: B31s.

Pos.1: kernel type (B=body, C=child head, H=head, U=ultra high resolution, S=special kernel, T=topo. In former times: A=abdomen, L=lung,p=petrousbone)

Pos. 2: resolution (1,...,9. Higher number -> higher resolution)

Pos. 3: version (0,...,9)

Pos. 4: scan mode eg. f=fast, s=standard , h=highres, u=ultrahighres

- B08s is a special kernel for SPECT AC.
- B30s is a standard kernel
- B60s is a sharper kernel that is used for thorax (cervical spine, shoulders, extremities)

SIEMENS

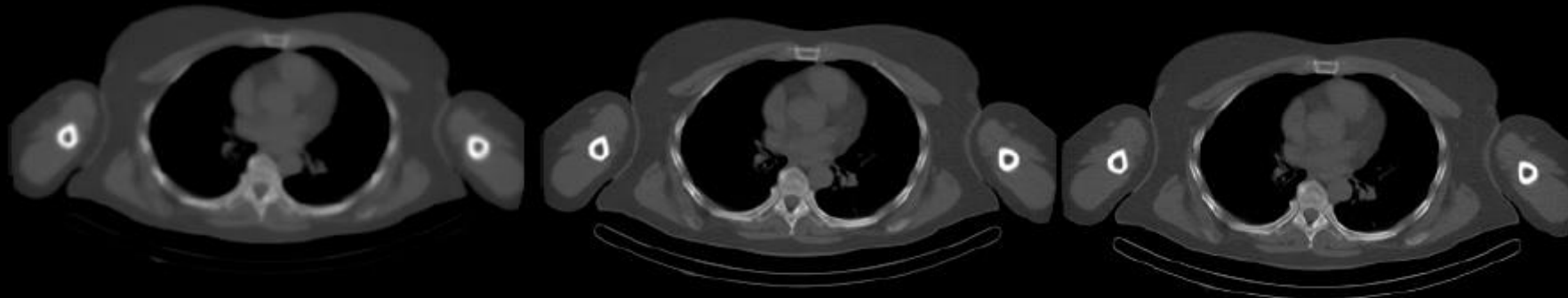
Symbia

Bone Window

B08s

B30s

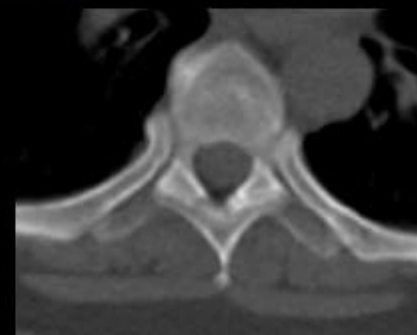
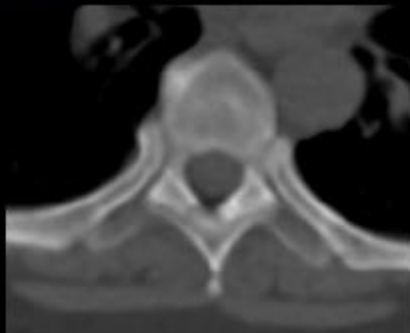
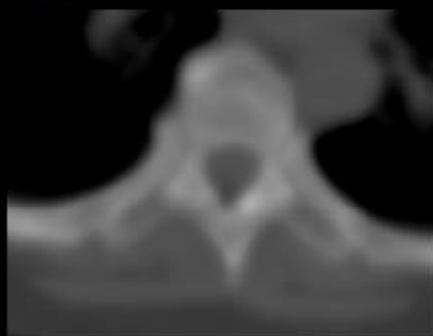
B60s



B08s

B30s

B60s



Symbia T – CT Reconstruction Kernels

CT Low – Dose CT for attenuation correction and anatomical localization (19 mAs, 140 kV)
Reconstruction with 3 different kernels

PATIENT (PHANTOM) DOSE INFORMATION

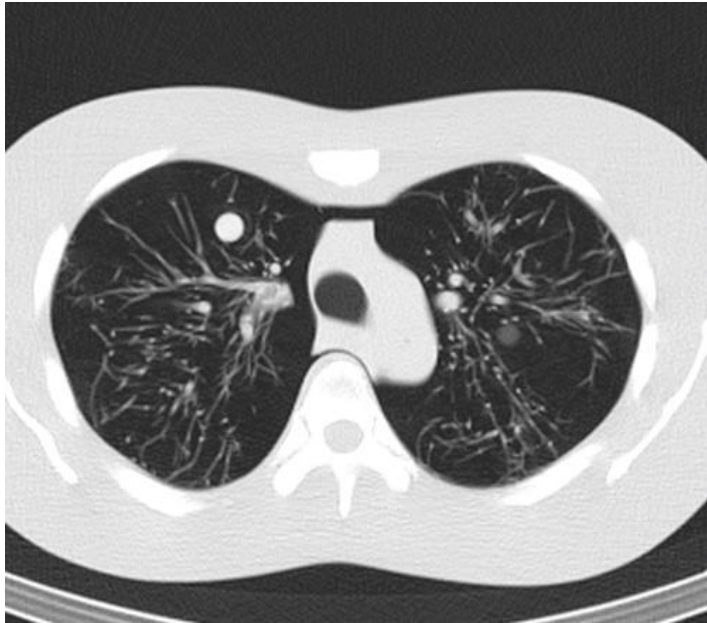
	CTDIvol (mGy)	Range (cm)	Number of slices	DLP (mGy.cm)	Exposure time (secs)
Normal	2.38	41 - 78	87	97	324
Positions 1-4	2.38	41 - 79	87	97	324

CT Dose Information (Image Acquisition – Infinia Hawkeye 4)

	reference effective mAs	delivered effective mAs	CTDIvol (mGy)	DLP (mGy.cm)
Normal	13	13	1.47	43
Position1	13	13	1.47	44
Position2	13	13	1.47	44
Position3	13	13	1.47	44
Position4	13	13	1.47	45

CT Dose Information (Image Acquisition - Symbia T6)

IMAGE PROCESSING



Symbia T6



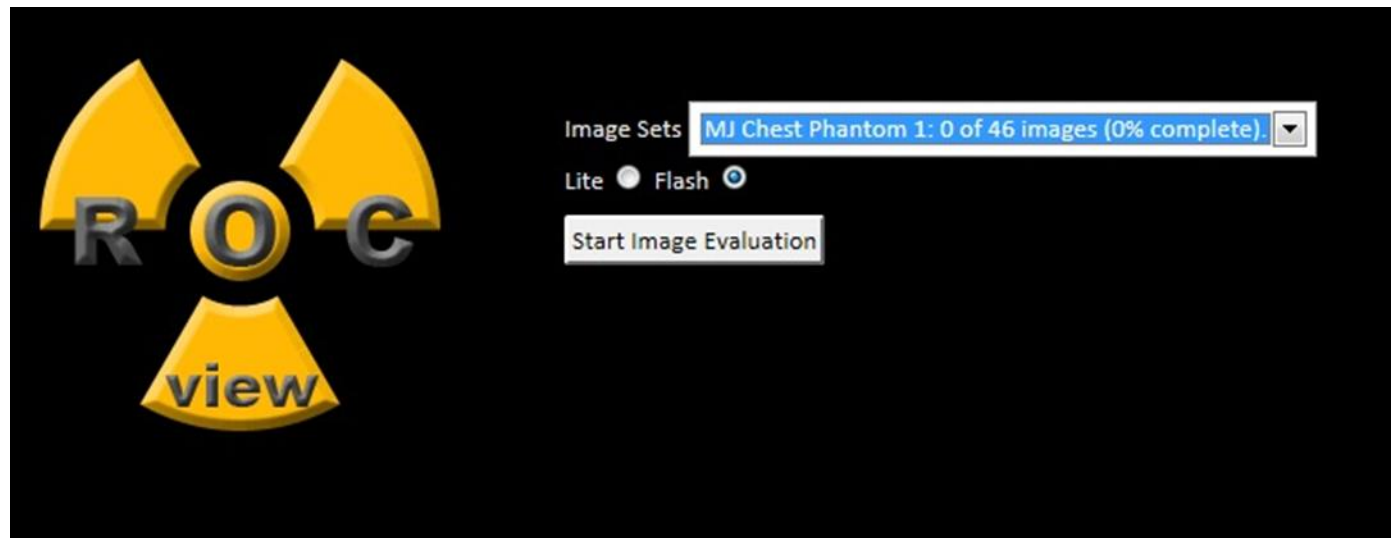
Infinia Hawkeye 4

ROCView PARTICIPATION

- Ethics
- Image viewing facilities
- Diversity of observers
- Adequate numbers of participants
- Number of images to be evaluated
- Observer training
- Minimize effects of observer variability
- Statistical power of the analysis

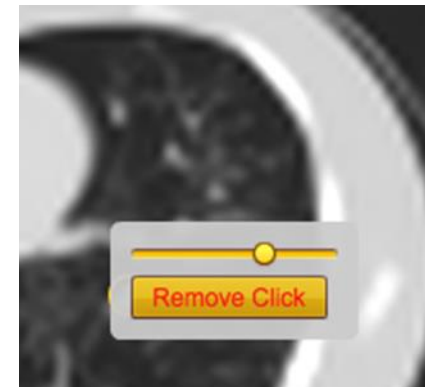
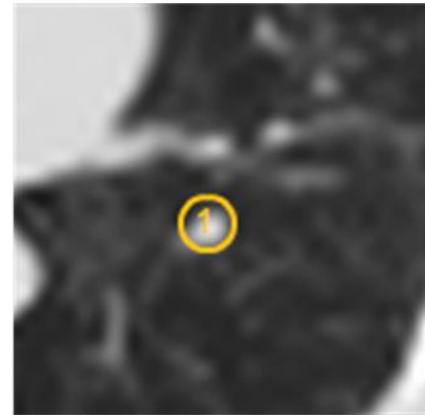
ROCView ANALYSIS

- www.rocview.net
- Web-based image display and response capture software (Created by John Thompson)
- Login and password



IF YOU THINK YOU SEE A LESION

- Mark it by placing the cross-hairs over the lesion and left click the mouse button
- A yellow marker with a number will show where you have marked
- Then score your confidence using the slider bar, or remove your mark if you have made a mistake
 - Left of bar is low confidence
 - Right of bar is high confidence
- Repeat this process for each simulated lesion
- The position of the marker can be moved, the slider adjusted and clicks removed, only while still on a particular image

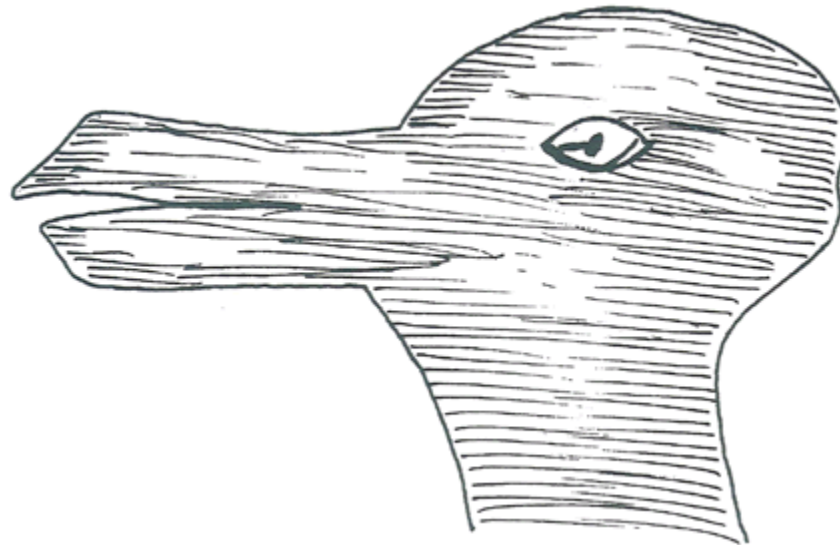


VISUAL PERCEPTION

- Vision & perception : visual signals & what we actually see.
- Radiography : 2-dimensional; contours; dominant visual mechanism
- Satisfaction of search : detection of one lesion interfering with the detection of another.
- Conspicuity : standing out from the crowd.
- Human visual system adaptation to noise.
- Multistability : pleurality of perception.

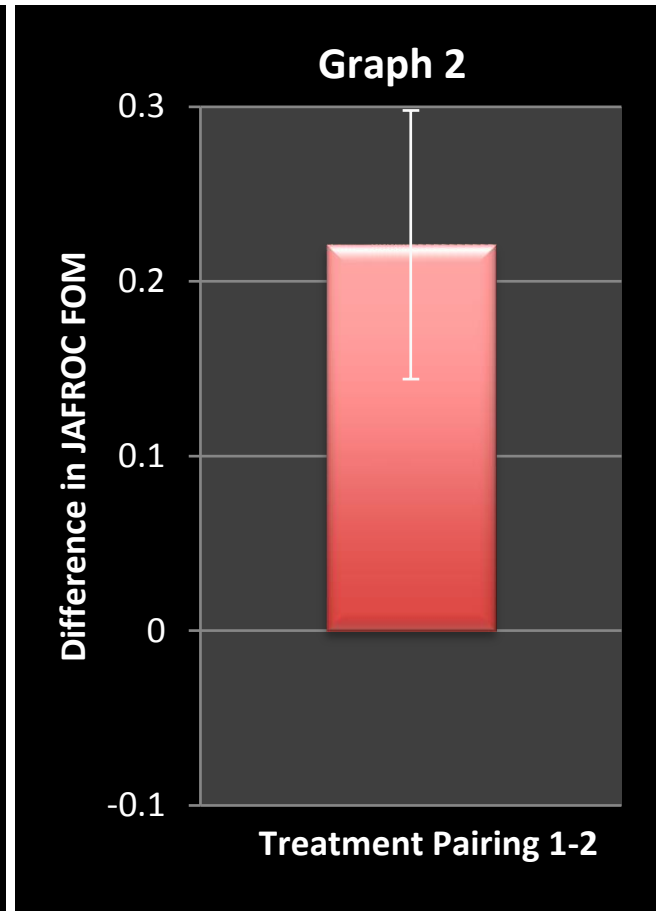
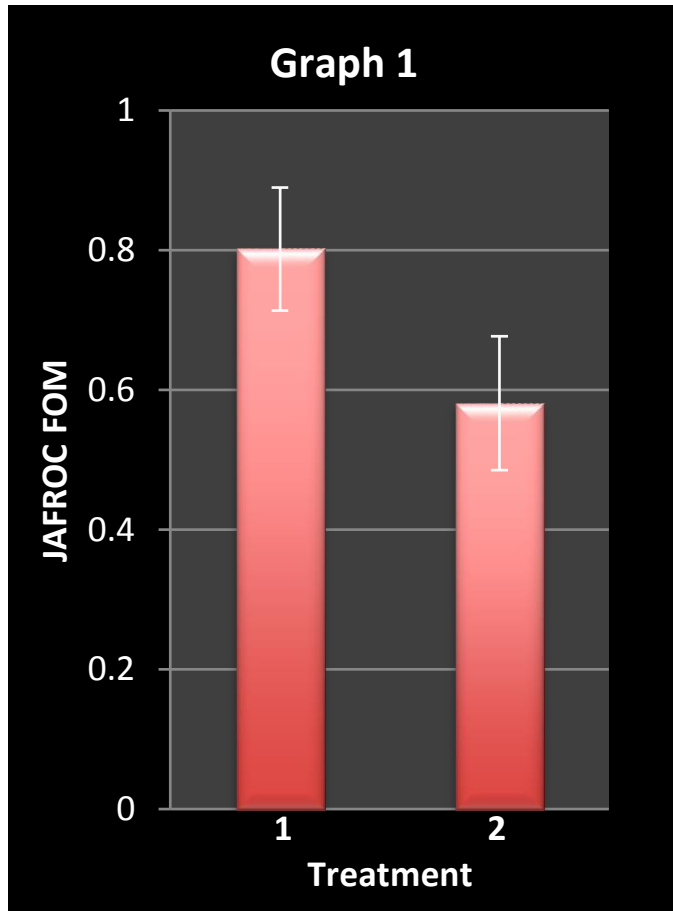
VISUAL PERCEPTION

Multistability:



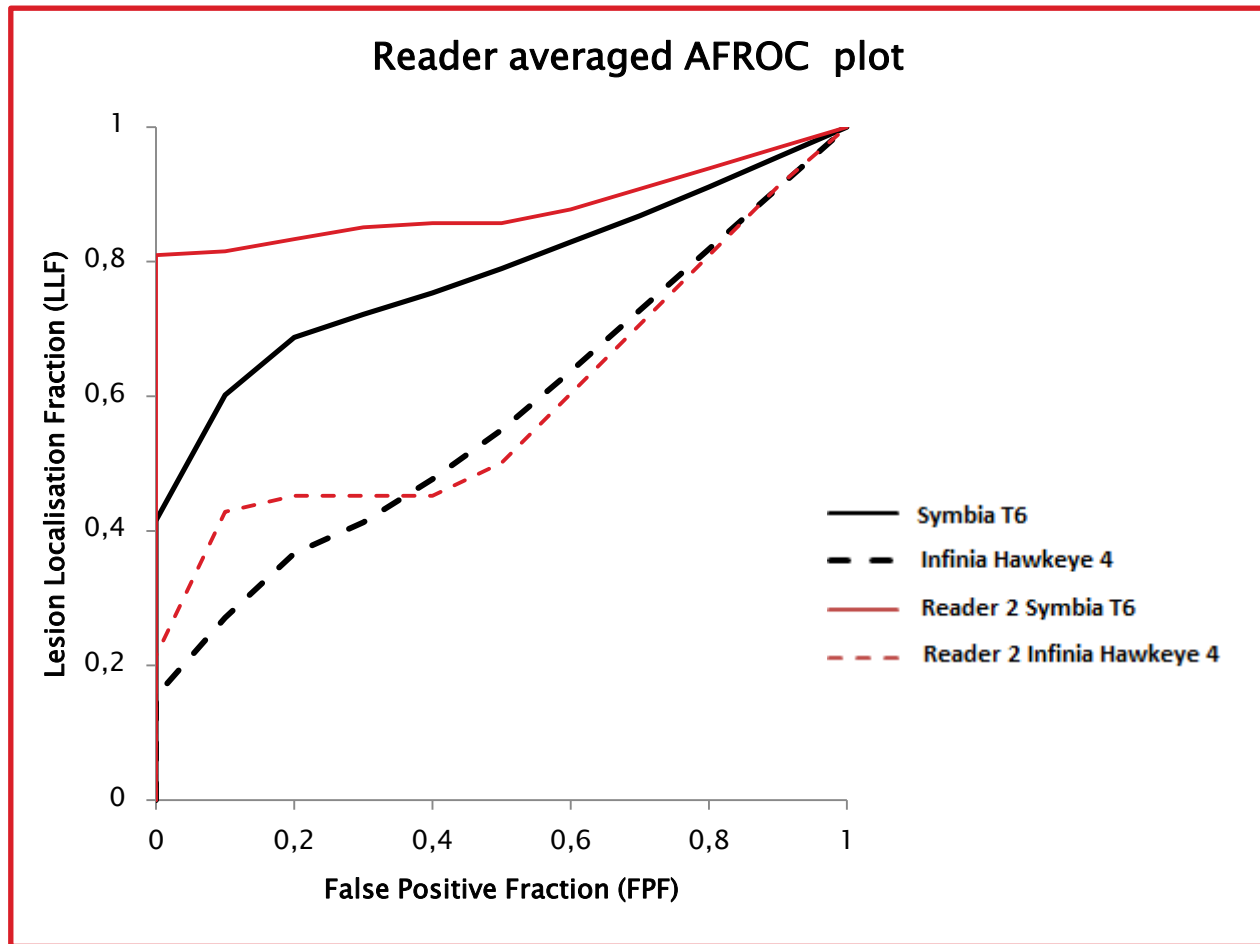
JAFROC ANALYSIS

- FOM (Figure of Merit) : for the perfect observer the JAFROC FOM would be 'unity' ie. 1
- Symbia T6 = 0.810 (95% CI : 0.781 , 0.839)
- Infinia Hawkeye 4 = 0.599
(95% CI : 0.568 , 0.631)
- p-value < 0.0001 significant result $p < 0.05$
- F statistic = 224.1 Critical value ($\alpha = 0.05$) $F(1,21) = 4.3248$



Graph 1 showing JAFROC *reader-averaged* FOM with 95% confidence intervals for both imaging systems; **Graph 2** showing the inter-treatment difference in JAFROC *reader-averaged* FOM between the two imaging systems.

AFROC Plot



LESION DETECTION

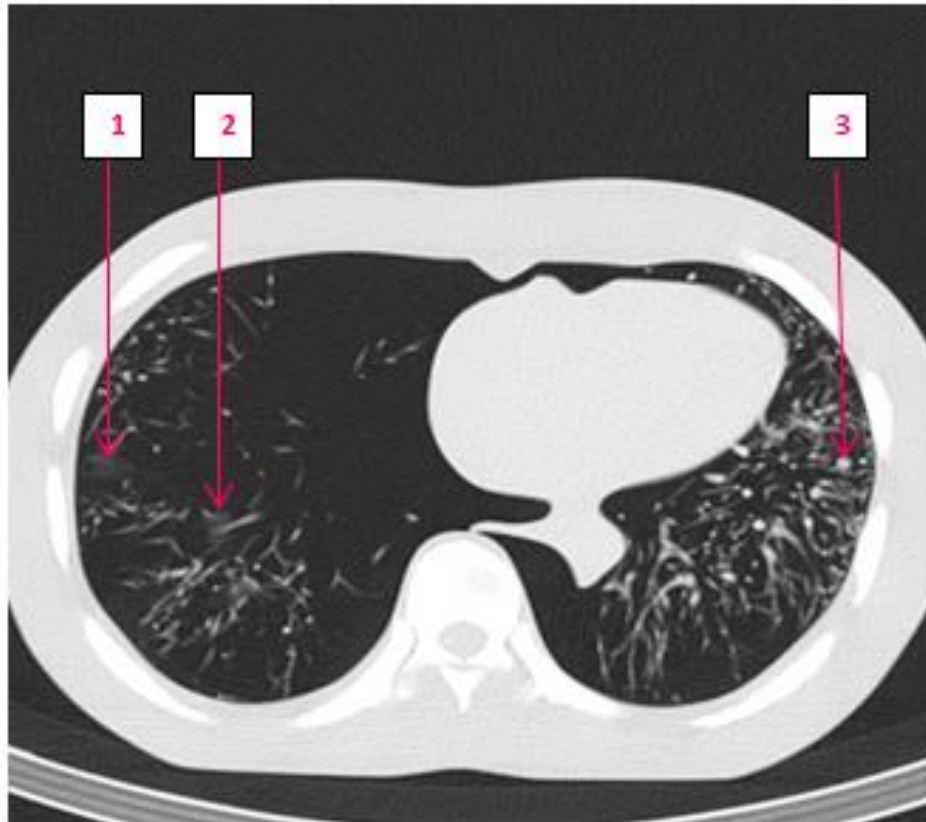
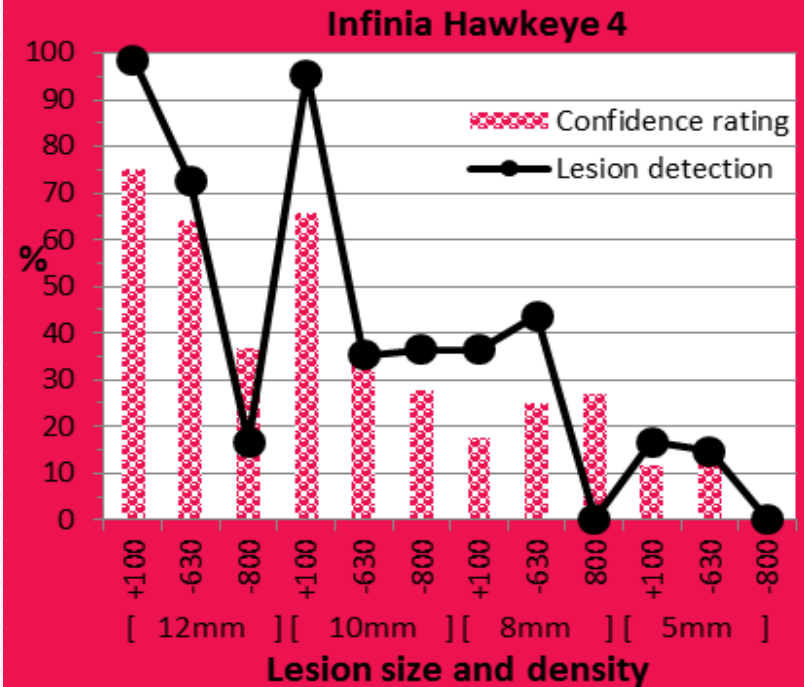
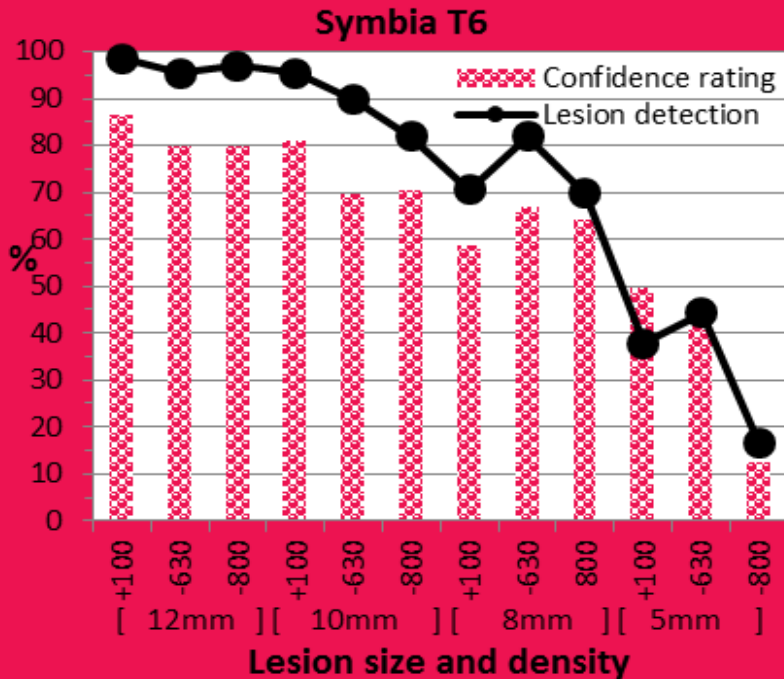


Figure 21: Case 8 (Symbia T6) demonstrates partial volume effects and complexity of surrounding structures. Lesions 1&2 show partial volume effects and lesion 3 is almost lost amidst its surroundings.

LESION DETECTION

Symbia T6

Infinia Hawkeye 4



Symbia T6 lesion detection data expressed as a percentage. Series 1 = number of readers that detected the lesion averaged over cases. Series 2 = overall average TP confidence. X-axis indicators correspond to lesion size and density ranging from largest to smallest (mm) and greatest to lowest density (HU) for each size.

Infinia Hawkeye 4 lesion detection data expressed as a percentage. Series 1 = number of readers that detected the lesion averaged over cases. Series 2 = overall average TP confidence. X-axis indicators correspond to lesion size and density ranging from largest to smallest (mm) and greatest to lowest density (HU) for each size.

DISCUSSION

- Limitations + advantages of phantom work.
- Equipment limitations.
- Lesion detection (size, location, density, shape)
- Visual perception + lesion visibility.
- JAFROC analysis → weighted JAFROC
- Reconstruction algorithms.
- ‘Incidentalomas’ – to report or not to report?
- Interpretation of research findings within the clinical context, specific to the equipment.
- Future research.

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Your
Work**

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Lesion Detection Performance: Comparative Analysis of Low-Dose CT Data of the Chest on Two Hybrid Imaging Systems

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Incidental findings on low-dose CT images obtained during hybrid imaging are an increasing phenomenon as CT technology advances. Understanding the diagnostic value of incidental findings along with the technical limitations is important when reporting image results and recommending follow-up, which may result in an additional radiation dose from further diagnostic imaging and an increase in patient anxiety. This study assessed lesions incidentally detected on CT images acquired for attenuation correction on two SPECT/CT systems. **Methods:** An anthropomorphic chest phantom containing simulated lesions of varying size and density was imaged on an Infinia Hawkeye 4 and a Symbia T6 using the low-dose CT settings applied for attenuation correction acquisitions in myocardial perfusion imaging. Twenty-two interpreters assessed 48 images from each SPECT/CT system (15 normal images and 31 abnormal images; 41 lesions). Data were evaluated using a jackknife alternative free-response receiver-operating-characteristic analysis (JAFROC). **Results:** JAFROC analysis showed a significant difference ($P < 0.0001$) in lesion detection, with the figures of merit being 0.599 (95% confidence interval, 0.568, 0.631) and 0.810 (95% confidence interval, 0.781, 0.839) for the Infinia Hawkeye 4 and Symbia T6, respectively. Lesion detection on the Infinia Hawkeye 4 was generally limited to larger, higher-density lesions. The Symbia T6 allowed improved detection rates for mid-sized lesions and some lower-density lesions. However, interpreters struggled to detect small (5 mm) lesions on both image sets, irrespective of density. **Conclusion:** Lesion detection is more reliable on low-dose CT images from the Symbia T6 than from the Infinia Hawkeye 4. This phantom-based study gives an indication of potential lesion detection in the clinical context as shown by two commonly used SPECT/CT systems, which may assist the clinician in determining whether further diagnostic imaging is justified.

Key Words: JAFROC; observer performance; low-dose CT; CTAC; incidental findings

**J Nucl Med Technol 2015; 43:47–52
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The need for the research performed in this study came about with the advent of hybrid SPECT/CT technology and the subsequent phenomenon of incidental findings on the low-dose CT images acquired for attenuation correction (CTAC) for myocardial perfusion imaging (MPI). Attenuation correction of the SPECT data obtained in MPI acquisitions is needed because attenuation of soft tissue in the chest musculature, breasts, and sometimes diaphragm may cause artifacts resembling perfusion defects, which vary with each patient (1). The current use of low-dose CT for this purpose produces image data that are then converted into an attenuation correction map, which is subsequently applied to the SPECT data to produce more accurate images with increased specificity and improved diagnostic performance (2,3).

The existence of the CT information and the extent of its use in the detection of incidental pathology have become controversial, with discussions on ethical issues and concern about the added radiation dose in resultant follow-up examinations (4,5). Those reporting the imaging results need to understand the technical limitations of the images, which may influence the confidence level on which any recommendations for further examinations are based (6,7). Incidental findings have been referred to as “unsought information generated in the seeking of the information one desires” (8). Although such information can be beneficial, it can also be of detriment to the patient (as can a false-positive report) by causing increased anxiety, excessive diagnostic intervention, and extra cost (4). If reported or not reported, incidental findings, or “incidentalomas,” can also lead to medicolegal dilemmas (9). Whatever one’s perspective, the reality is that low-dose CT images now have the potential to produce incidental findings, especially with

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Thank you

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