Contrast Thresholds for Detection of Various Iodine Concentrations in Subtraction CT and Dual Energy CT Systems

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INTRODUCTION:

Dual energy CT (DECT) and subtraction CT (SCT) provide more accurate information for clinical evaluation of vascular disease. Iodine can be utilized as an imaging biomarker to differentiate between benign cysts and malignant lesions in the liver, kidney, and pancreas, as well as to define tumor extent and treatment response[1-3].

Iodine map (IM) images in DECT display the distribution of iodinated contrast agents in the body, offering local perfusion information and quantification of iodine, useful for characterizing different kinds of lesions[1].

Alternatively, SCT subtracts an unenhanced scan from a contrast-enhanced scan, it can also generate IM images, and may be an attractive alternative to DECT due to the lack of need for additional hardware.

The adequate enhancement of vessels is the basic requirement for the diagnosis of artery stenosis and plaques, which is dependent on the concentration of the iodinated contrast agent[2-4].

It is imperative to know the lower limits of detection of DECT and SCT systems to balance image quality, contrast dose and radiation dose to optimize CT protocols.

AIM:

To estimate the minimum iodine concentrations detectable in simulated vessels of various diameters for SCT and DECT systems.

Figure 1 : Modification of the Gammex phantom with simulated vessels with varying diameters and iodine concentrations scanned with Canon's Aquilion ONE Genesis Edition

METHODS:

Tubes (Diameters: 1 mm, 3 mm, 5mm) were filled with a variety of iodine concentrations (Range: 0 - 20 mg/mL), placed in the center of 28-mm cylindrical rods and surrounded with water. Rods with and without tubes were placed in a 20-cm cylindrical solid-water phantom to simulate administration of iodine in blood vessels.

The phantom was scanned with clinical SCT and DECT head protocols to assess the detection of minimum iodine concentrations in both systems.

The SCT and DECT images were evaluated quantitatively with a Matlab script to extract regions of interest (ROIs) of each simulated vessel.

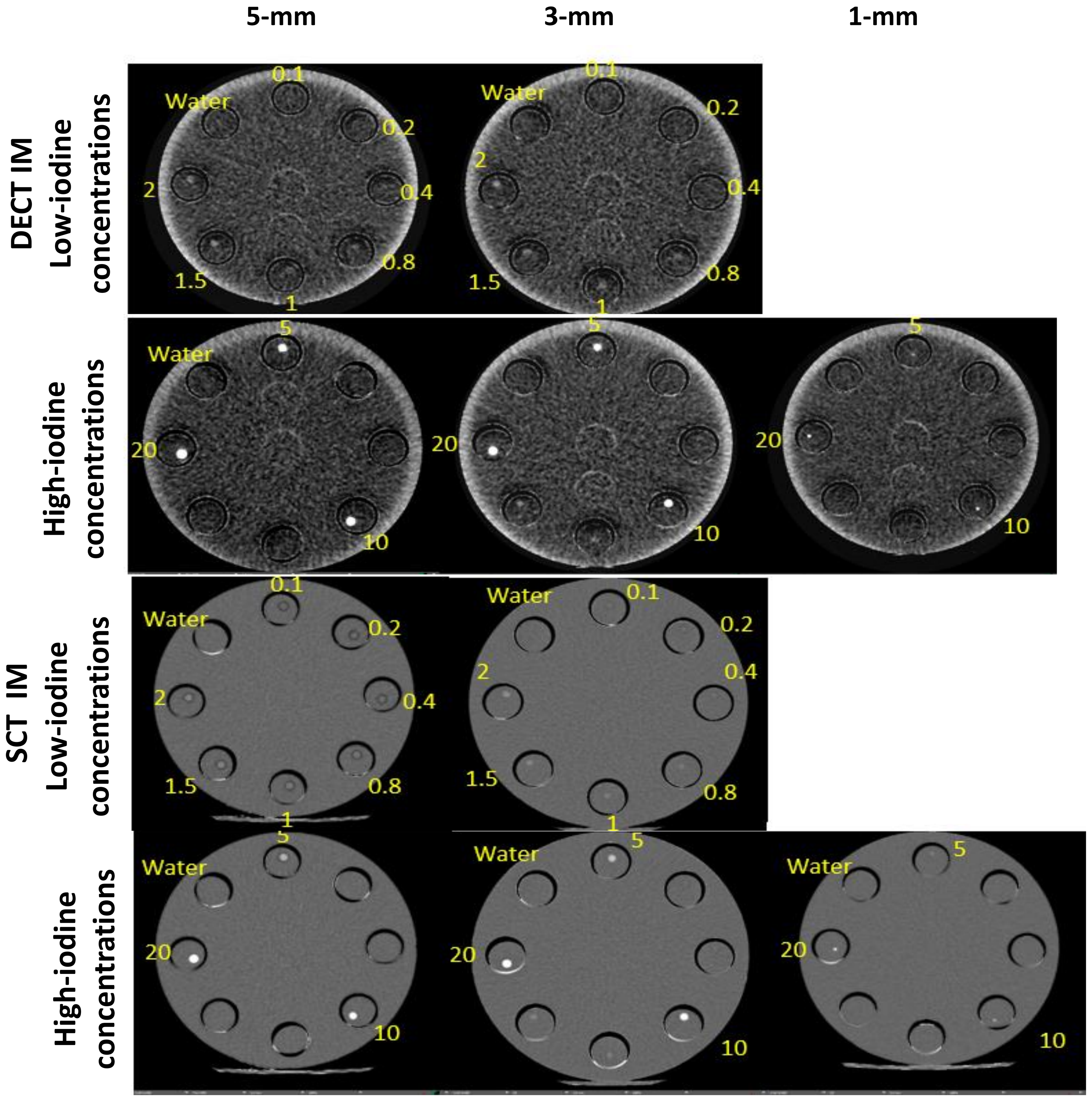

Figure 2: DECT and SCT images of IM in variety of tube diameters (5, 3, 1 mm) and iodine concentrations in mg/mL (overlaid in yellow text on the images)

Table 1: Detectability of minimum iodine concentration calculated with Limit of Detectability and SNR $_{Rose}$ criteria

Systems	Tube Diameter (mm)	LOB_{signal} (HU)	LOD_{signal} (HU)	LOD_{signal} (mg/mL)	Corresponding Detectable Iodine Concentration (mg/mL)	SNR $_{Rose}$	CNR	Corresponding Detectable Iodine Concentration (mg/mL)
	5	4.93	9.87	0.32	0.4	6.27	1.21	0.4
SCT	3	7.36	14.73	0.67	0.8	8.44	2.67	0.8
	1	6.98	45.98	7.33	10.0	29.05	14.50	10.0
	5	23.21	26.90	0.87	1.0	6.23	1.20	1.0
DECT	3	41.21	50.15	1.76	2.0	6.57	3.48	2.0
	1	43.29	63.05	10.00	10	8.77	4.38	10

RESULTS:

Both detectability methods agreed, and determined the minimum detectable iodine concentration to be 0.4 mg/mL in the 5-mm diameter vessel for SCT. The minimum detectable concentration in the 5-mm vessel with DECT was 1 mg/mL. The 3-mm vessel had a minimum detectable concentration of 0.8 mg/mL for SCT and 2 mg/mL for DECT. Lastly, the minimum detectable iodine concentration for the 1-mm vessel was 10 mg/mL for SCT and 10 mg/mL for DECT.

CONCLUSION:

SCT showed the capability to detect lower iodine concentrations compared to DECT. Contrast thresholds varied for vessels of different diameters and the smaller vessels required a higher iodine concentration for detection. Based on this knowledge, radiologists can modify their protocols to increase contrast enhancement.

DISCUSSION:

In this study, we found that SCT had superior detectability and CNR compared to DECT. Also, discrimination of details smaller than 5 mm was possible at lower iodine concentrations in SCT as compared to DECT. From the detectability data it is evident that SCT images can be obtained at a lower dose level and have the same results as DECT. However, SCT is only useful for clinical applications that utilize administered contrast agents, and not useful for differentiating materials in the body such as bone, calcifications, and blood. Since the scanner we investigated in this study does not provide iodine concentration (mg/mL), but rather CT numbers (HU), it was vital to create a conversion factor that allows the user to convert a CT number to a concentration of iodine in the IM.

Potential uses of the conversion factor may include iodine uptake measurements in clinical patient data for quantitative imaging. Assessment of the quantitative data using the Rose criteria and Limit of detectability methods could aid researchers in quantification of limiting iodine concentrations in mg/mL for scanners that do not have the capability of displaying quantification of iodine. This will guide radiologists in case they need to increase the contrast dose for detection of smaller vessels.

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