Optimizing Dual-Energy CT Contrast Timing and Virtual Monochromatic Energy to Maximize Brain Metastasis Conspicuity

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Background

- Brain metastases (BM) have been reported to occur in up to 40% of patients with cancer.
- At present, gadolinium-enhanced MRI is considered to be the imaging technique of choice in patients suspected of BM; however, CT is cheaper, more widely available, and does not suffer from geometric distortion as seen with MR imaging.
- Prior studies have shown superior conspicuity of brain malignancy with delayed imaging times.
- We sought to optimize CT parameters for BM conspicuity in a prospective trial.

Hypothesis

- **Earlier contrast timing and higher virtual monochromatic energies will demonstrate greater metastasis conspicuity compared to later time points and lower energies.**

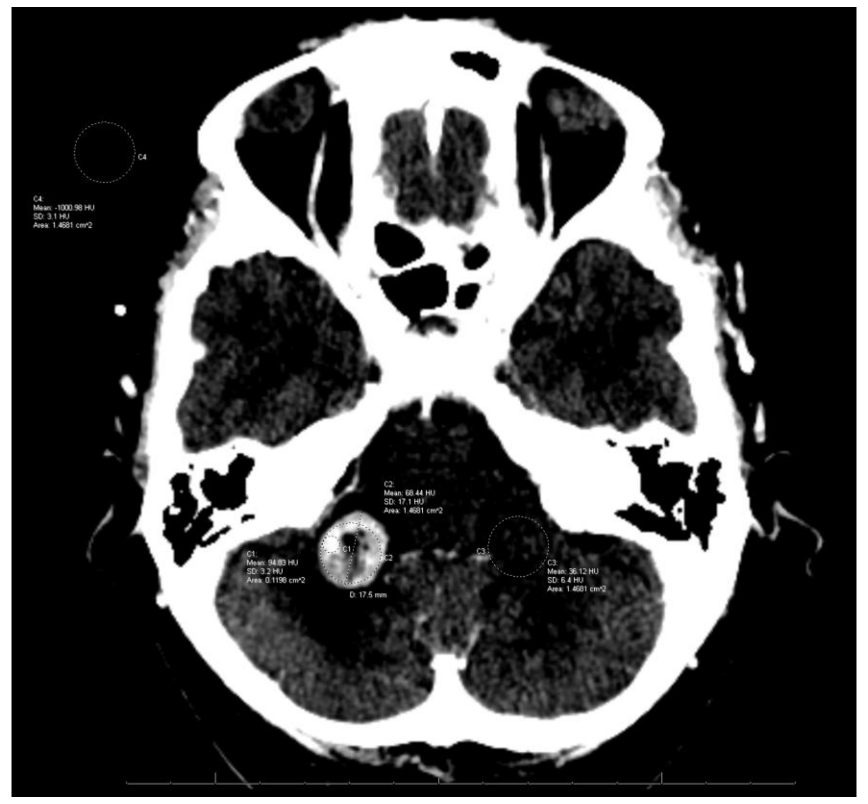
Methods

Patient Selection and DECT

- Twenty-three patients (12 women, 58.4±14.6 years) with 4.4±2.5 BM were scanned on a DECT scanner (Somatom Force, Siemens, Malvern, USA) at 90 seconds, 5 minutes, 10 minutes, and 20 minutes following the injection of 123±8.0 ml of iohexol (GE Healthcare, Chicago, USA). The primary cancer was melanoma (7), lung (7), breast (5), genitourinary (3), and gastrointestinal (1).

Optimizing Dual-Energy CT Contrast Timing

- Using 4 mm axial QC images, a circular ROI was drawn on the BM with the largest cross-sectional diameter. BM with necrosis had an ROI placed to cover the area of maximal enhancement (“hot-spots”) while avoiding tissue outside of the BM and the necrotic (non-enhancing) region. A circular ROI was also placed in the contralateral normal-appearing brain (NAB) as well as in the air for “noise” measurements.
- This was obtained at **each imaging time point**. For lesions with necrosis, the “hot spot” was used for SNR/CNR. A single-tail Students T-test was used for comparative statistics.



Methods (continued)

Optimizing Dual-Energy CT Virtual Monochromatic Energy

- DE virtual monochromatic reconstructed (VMR) images were created using Syngo (Siemens, Malvern, USA). Using the **optimal time point** determined from the first objective, ROI were placed as previously mentioned in both lesion and NAB. The HU were recorded for each energy between 40 and 190 keV. VMR lesion and NAB data were used to calculate SNR and CNR at each energy.

Results

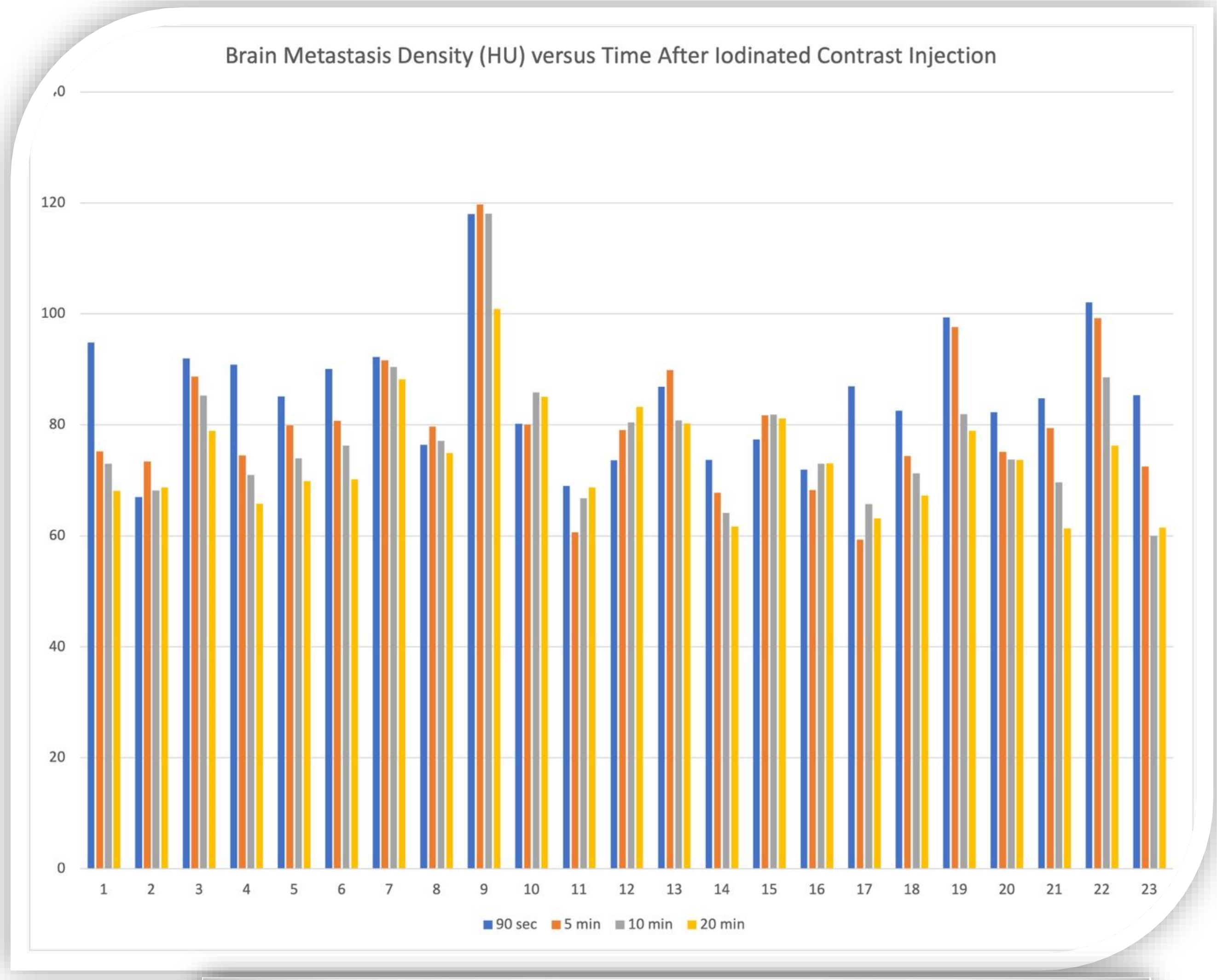


Figure 1. BM density (HU) of the twenty-three patients at four different post-contrast time points (90 seconds, 5 minutes, 10 minutes, and 20 minutes).

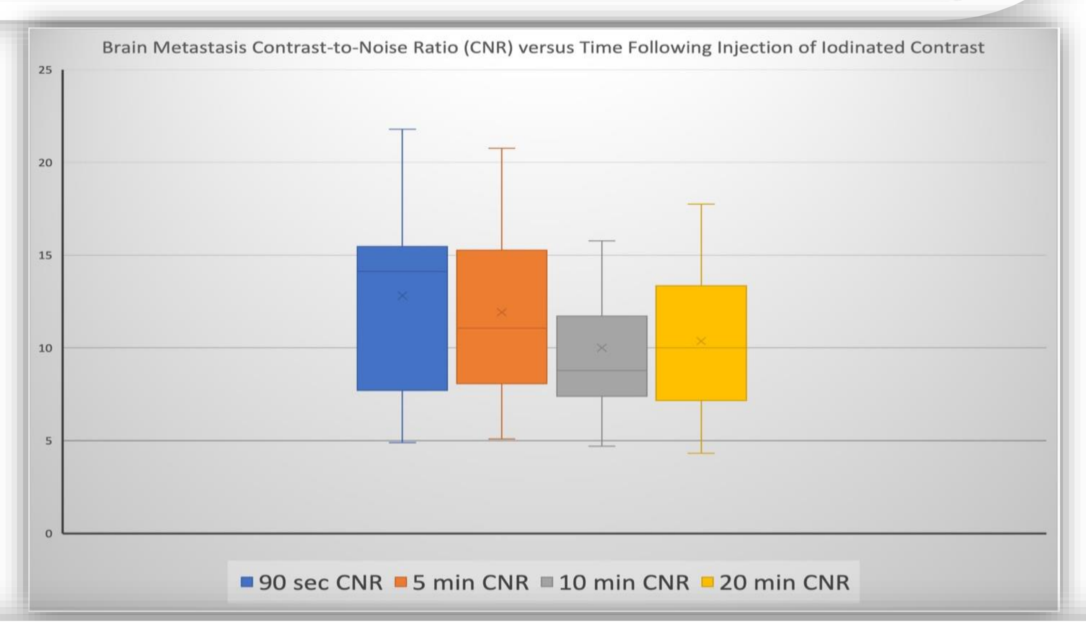


Figure 2. Pooled BM Contrast-to-Noise ratios (CNR) for the four different post-contrast time points. A box plot clearly displays greater CNR at lower post-contrast time points.

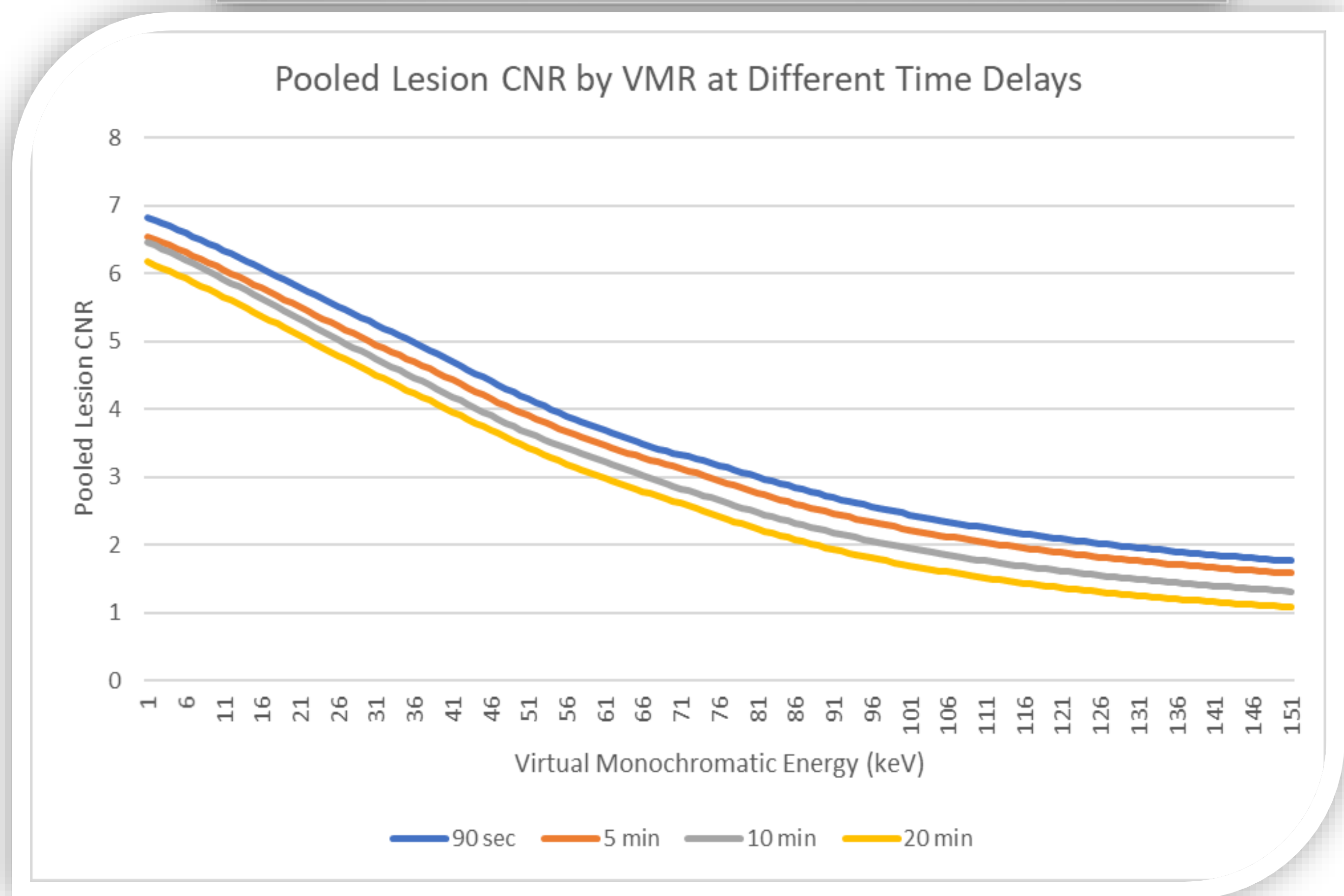


Figure 3. Pooled BM Contrast-to-Noise ratios (CNR) represented at the spectrum of virtual monochromatic energies used (40-190 keV), along with their respective time delays.

Results (continued)

- At 90 sec, the mean BM HU was 85.3±12.0, SNR 27.0±10.0, CNR 12.8±4.7. (Figure 1) At 5 min, the mean BM HU was 80.4±13.3, SNR 25.3±10.5, CNR 11.9±5.9. At 10 min, the mean BM HU was 77.2±12.0, SNR 22.5±6.7, CNR 10.0±3.5. At 20 min, the mean BM HU was 74.0±9.8, SNR 23.4±7.1, CNR 10.4±3.7.
- CNR was greatest at 90 sec, and this difference was statistically significant ($P < 0.05$) compared to 10 and 20 min. CNR at 5 min was also statistically significantly greater than later time points ($P < 0.05$).
- A negative linear relationship was observed between SNR/CNR and keV, with lower VMR energies resulting in the highest SNR and CNR, and higher VMR showing the lowest SNR and CNR (see Figure 3).

Conclusions

- Despite prior reports demonstrating greater conspicuity for brain malignancy using later time points, our results show that earlier time points show objectively greater conspicuity.
- Although lower energies result in higher VMR noise, the increased iodine conspicuity at lower energies resulted in the highest SNR/CNR at lower VMR.
- Additional work remains to verify that earlier times and lower VMR energies lead to a difference in radiologist detection rate and confidence.

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