Use of Virtual Dose Reconstruction for Optimization of ^{89}Zr-Df-IAB2M Administered Activity in the Detection of Metastatic Prostate Cancer by PET/CT

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Objectives

When developing novel PET agents, such as ^{89}Zr-Df-IAB2M for metastatic prostate cancer detection, it is important to minimize patient radiation exposure while maintaining image quality. We performed an investigation of whether administered radioactivity could be reduced without compromising diagnostic utility. Our approach used virtual dose reconstructions of PET data from a standard radionuclide dose scanned in list-mode. In particular, we reconstructed images at virtual doses of 1.25 and 2.5 mCi and compared these with the original 5.0 mCi images to determine the lowest useful diagnostic dose of ^{89}Zr-Df-IAB2M.

Methods

Ten subjects with progressive, histologically confirmed prostate cancer were administered 5.0 mCi of ^{89}Zr-Df-IAB2M at a total IAB2M protein dose of either 10 (n=5) or 20 (n=5) mg. Whole body ^{89}Zr-Df-IAB2M PET scans were acquired at 48 and 96-120 h post injection on a GE Discovery STE (3D mode, 3-7 min per bed position, iterative reconstruction, low dose CTAC). PET scans were acquired in list-mode, allowing retrospective data rebinning and image reconstruction to obtain "virtual dose-equivalent" scans at 1.25 mCi, and 2.5 mCi. Scans were then evaluated by a central reader to quantify lesion detection and image quality. Quality was scored on a scale of 0 to 4 with 0=unacceptable, 1=poor but acceptable, 2=fair, 3=good, and 4=Excellent.

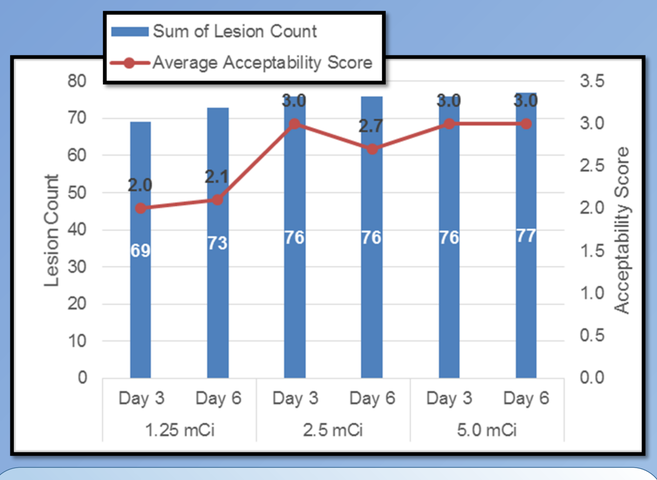

Figure 2: The effects of virtual dose on lesion count (blue bars) and image quality (red line) at each time point and dose reconstruction. The numbers in white represent the total lesion count while the numbers in black are the average scan quality rating by the reader.

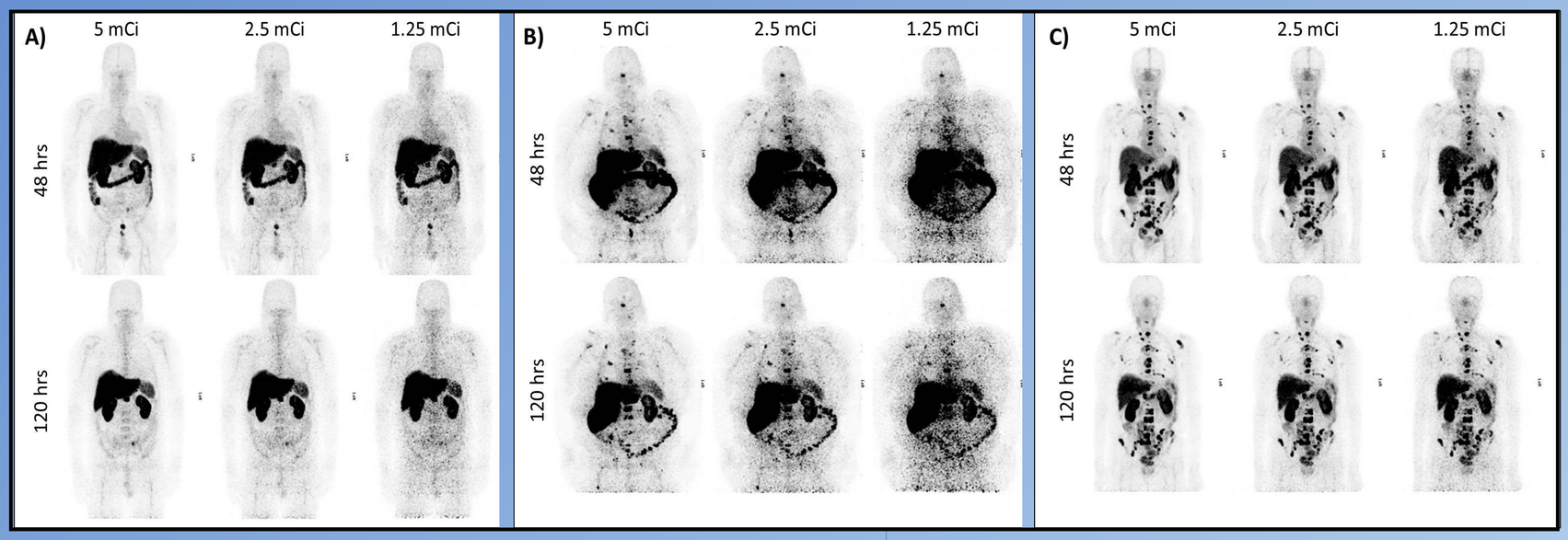

Figure 1: Original 5 mCi reconstructions and 2.5 mCi and 1.25 mCi virtual dose reconstructions for 3 subjects at 48 and 120 hours for: A) Subject 23, BMI = 29.9, PSA = 3.07 ng/mL. Note this subject had no discernable tumors. B) Subject 25, BMI = 48.7, PSA = 6.6 ng/mL. C) Subject 29, BMI = 23.8, PSA 13.12 mg/mL.. There is noticeable image degradation in subject 25 shown in B) for the 1.25 mCi reconstructions.

Results

Figure 1 shows examples of scans reconstructed at the different dose equivalents for three subjects. In general, the 2.5 mCi virtual dose yielded similar image quality and equivalent lesion detection to the 5.0 mCi data, whereas the 1.25 mCi virtual dose showed degradation in image quality with fewer lesions visualized.

Figure 2 shows the total lesion detected and the quality or acceptability scores for each reconstruction. For the 10 patients studied, total lesion detection at 48 and 96-120 h respectively was 76 and 77 for 5.0 mCi, 76 and 76 for 2.5 mCi, and 69 and 73 for 1.25 mCi. There were effectively no differences in reader rated image quality between the 2.5 mCi and 5.0 mCi scans but there was a reduction in image quality for the 1.25 mCi scans.

Figure 3 shows the bone and lymph node lesion counts for each reconstruction. The total bone lesion counts were 70 and 71 for 5.0 mCi at 48 and 96-120 h respectively, 70 and 70 for 2.5 mCi and 63 and 67 for 1.25 mCi. Six lymph nodes were identified on the 5.0 mCi scans and at all virtual dose scans and time points indicating equivalence for this small sample of lesions.

Analysis of the 10 and 20 mg cohorts separately indicated similar trends.

Conclusion

Virtual dose reconstruction provides a novel and effective way to assess the diagnostic merits of different radioactive doses using a minimal number of subjects. For ^{89}Zr-Df-IAb2M, the 2.5 mCi dose demonstrated diagnostic equivalence and sustained image quality in comparison to the original 5.0 mCi dose while the 1.25 mCi dose showed a noticeable deterioration in tumor identification. Hence, a 2.5 mCi dose has been selected for future clinical studies.

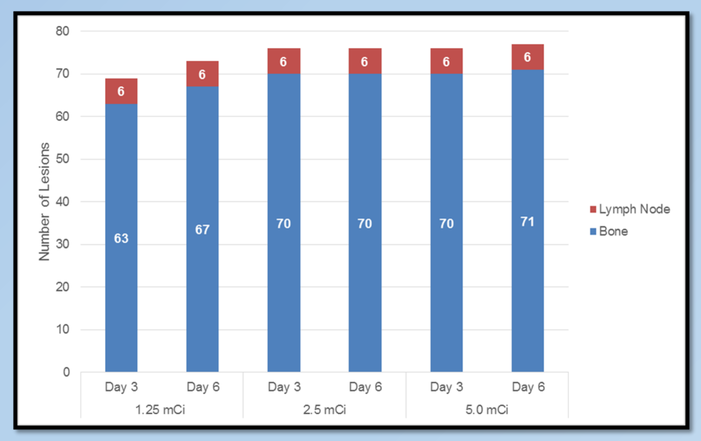

Figure 3: Total lesion count at each reconstruction for lymph nodes (red) and bone lesions (blue).

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