Impact of Dose on 3D Volumetric Scout Scan Water Equivalent Diameter Determination

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INTRODUCTION

- Canon Healthcare Systems USA has recently introduced a volumetric planning scan, known as the 3D Landmark (3D_LM), designed to support automatic exposure control (AEC), automated anatomical landmark detection for scan planning, patient positioning, and bolus tracking region of interest placement.
- The 3D_LM (Figure 1) has facilitated planning of scan ranges for technologists especially at the base of the lungs which can be clipped when planning on a traditional AP or Lateral projection image.
- The 3D_LM acquisition uses silver beam filtration which attenuates the lower energy spectrum of the x-ray beam allowing for substantial reductions in patient dose.
- The purpose of this study is to quantify the effect of radiation dose on the accuracy of water equivalent diameter (WED) measurements derived from the 3D Landmark scan.

METHODS AND MATERIALS

- A Sun Nuclear Mercury 4.0 phantom containing multiple sections of varying diameters (10 -36 cm) was scanned on a Canon Aquilion One Insight.
- All scan and reconstruction parameters are fixed within the 3D_LM acquisition except for tube current.
- The 3D_LM is acquired with a pitch 1.39, 40 mm collimation, 0.5 s rotation, 120 kV, and silver beam filtration.
- The phantom was scanned at tube currents corresponding to CTDIvol values ranging from the minimum 0.1 mGy (10 mA) to the maximum 3.2 mGy (700 mA) as seen in figure 2.
- A reference scan without silver filtration was acquired with a pitch of 0.81, 50 mm collimation, 1.0 s rotation and 41.9 mGy CTDIvol.
- The 3D_LM was reconstructed with 50 cm FOV, Body kernel, 1mm slice thickness while the reference used Body+ BHC kernel with AICE L2 DL.
- WED was measured in each image slice and compared across dose levels.
- CT number accuracy was measured in the sensitometry inserts as well as noise in the uniform sections.
- Microsoft Copilot was used in data analysis and preparation of this poster

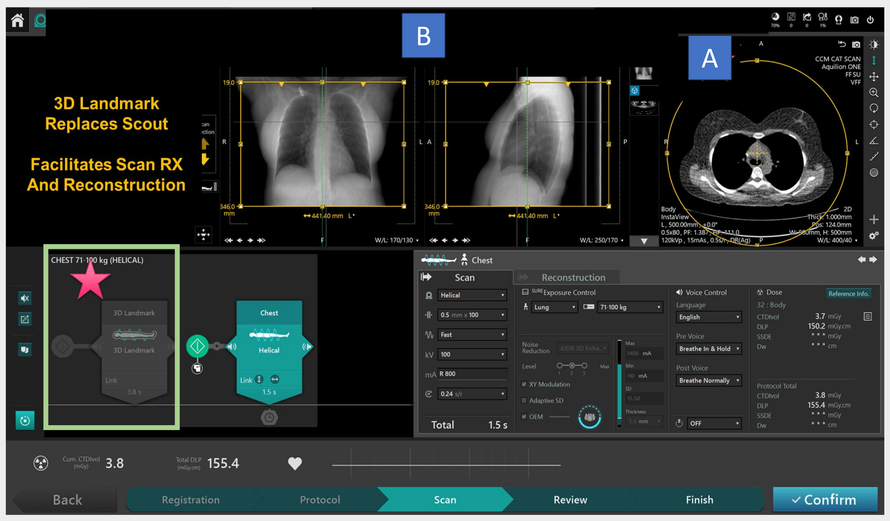


Figure 1. Interface of the Canon Insight. A) The 3D_LM axial images are shown in the upper right of the interface. B) AP and Lateral Projection images are created from the 3D_LM. The technologists can more accurately prescribe the scan range through better visualization of the base of the lungs. In addition, the volumetric scan provides better visualization of any patient mispositioning in the AP or lateral positioning. Any lateral or AP shifts that are needed can be applied to the table from the control console.

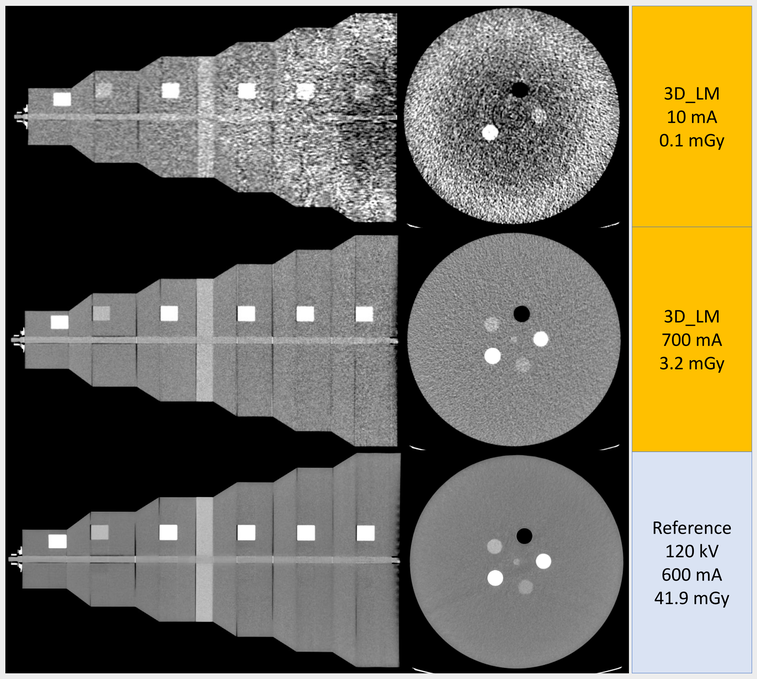


Figure 2. Mercury Phantom Coronal Images,(left column) and axial images (middle column) of the 36 cm diameter section. The top row is the 3D_LM dose with the lowest possible mA (10 mA), the middle with the highest(700 mA), and the reference scan with the highest dose.

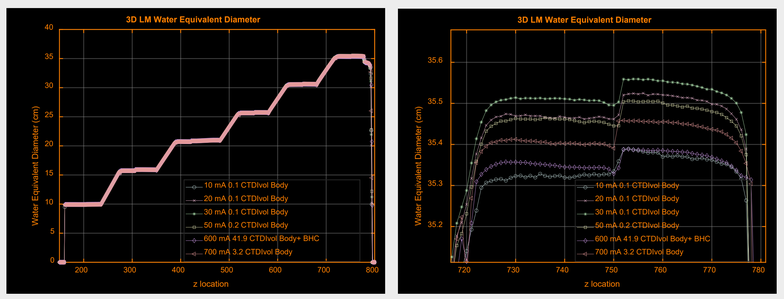


Figure 3. Plot of water Equivalent diameter over the entire Mercury phantom(left), and over the largest section of the phantom for the entire range of 3D_LM doses acquired as well as the reference scan. This demonstrates that there is little variation between the acquisitions across the entire dose ranges acquired.

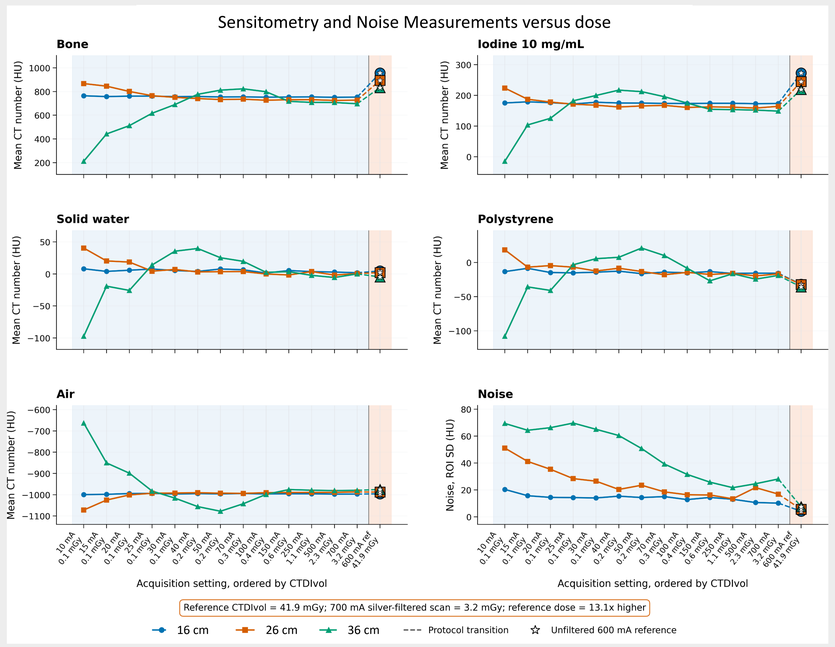


Figure 4. Effect of acquisition protocol and phantom diameter on CT-number measurements and image noise. Mean CT numbers for bone, iodine (10 mg/mL), solid water, polystyrene, and air are presented for the 16-, 26-, and 36-cm diameter sensitometry sections. Image noise, defined as the mean within-ROI standard deviation, is shown for the corresponding uniform sections. Circles, squares, and triangles represent the 16-, 26-, and 36-cm diameter sections, respectively. Solid lines and filled markers represent silver-filtered 3D_LM acquisitions from 10 to 700 mA, corresponding to CTDIvol values from 0.1 to 3.2 mGy. Star overlays represent the unfiltered 600 mA reference acquisition with a CTDIvol of 41.9 mGy. Dashed lines indicate the transition from the silver-filtered series to the unfiltered reference.

RESULTS

- WED remained highly stable across the phantom (figure 3). Differences were less than 3 mm across all sections and dose levels.
- WED stability was maintained despite severe image degradation at the lowest doses.
- CT-number accuracy depended on dose and phantom thickness
- As seen in figure 4, the CT numbers were most stable in the small diameter sections and progressively degraded as the diameter increased.
- Across all dose levels, in the largest section (36 cm), the greatest CT-number variation was observed for bone (212 to 833 HU; 621-HU range), followed by air (−1,078 to −663 HU; 415-HU range), iodine (−14 to 219 HU; 234-HU range), solid water (−97 to 40 HU; 137-HU range), and polystyrene (−108 to 21 HU; 129-HU range).
- In comparison, in the 16-cm section, CT-number variation was greatest for bone (205 HU) and iodine (101 HU), while polystyrene (23 HU), solid water (7 HU), and air (6 HU) were substantially more stable.
- As expected, image noise increased with phantom diameter and decreasing dose.
- Increasing CTDIvol generally improved CT-number stability and reduced image noise, but diameter-dependent differences remained.

DISCUSSION

- The stability of WED across phantom diameters and dose levels suggests that the volumetric planning scan retained sufficient information for patient-size estimation, even when the images were not suitable for quantitative CT-number assessment.
- Increasing phantom diameter resulted in greater noise and CT-number variability, with the largest changes observed in the 36-cm section.
- Increasing CTDIvol improved quantitative performance, but did not fully eliminate the differences among phantom diameters.
- These findings indicate that acceptable WED performance does not necessarily imply acceptable diagnostic image quality or quantitative CT-number accuracy.

CONCLUSION

- Despite substantial degradation of image quality and sensitometry quantitative accuracy at very low doses, WED measurements derived from the 3D_LM volumetric planning scan remained robust across a wide dose ranges and sizes.
- These results suggest that low dose volumetric scouts with silver filtration can reliably support patient size assessment for AEC.
- Future work will evaluate this larger patient sizes as well as the impact of mispositioning of the phantom laterally and vertically.