Comparison of Auto-Generated Contours on Virtual Monoenergetic Images Across Multiple Energy Levels

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PURPOSE

To assess the effect of virtual monoenergetic image (VMI) energy variation (50-160keV) on the accuracy of auto-generated contours using commercial auto contouring software.

METHODS AND MATERIALS

An anthropomorphic thorax phantom (CIRS) was scanned using both conventional single-energy CT (SECT) at 120 kVp and dual-energy CT (DECT) on a SOMATOM go.Open Pro scanner (Siemens Healthineers, Erlangen, Germany). DECT acquisitions were performed sequentially at 80 and 140 kVp and reconstructed into corresponding VMI series with 10 keV intervals ranging from 50 to 160 keV. Air calibration was performed on the same day prior to image acquisition.

SECT and DECT scans were performed under identical acquisition conditions , with the phantom maintained in the same position for both scans. All images were reconstructed using a medium kernel (Q40), a 2-mm slice thickness, and sinogram-affirmed iterative reconstruction (SAFIRE) at strength level 3.

Auto-contouring was performed using AutoContour® (Radformation, New York, NY, USA) , generating contours for the left lung, right lung, heart, and spinal canal on all reconstructed VMI series. Manual contours for the same structures were delineated by a medical physicist for SECT series to serve as the reference standard . Contour agreement was quantified using the Dice similarity coefficient (DSC). , defined as follows:

$$\mathrm{DSC(E)_{Mono}} = \frac{2|\mathrm{A(E)_{mono}} \cap \mathrm{B(120\ Kvp)_{SECT}}|}{|\mathrm{A(E)_{mono}}| + |\mathrm{B(120\ Kvp)_{SECT}}|} \times 100$$

where $\mathrm{A(E)_{mono}}$ represents the auto-generated contour for a given organ on the virtual monoenergetic image at energy E, and $\mathrm{B(120\ Kvp)_{SECT}}$ represents the corresponding manual contour (reference standard / ground truth) on the 120-kVp SECT image.

RESULTS

Across the evaluated energy range, DSC variation, expressed as ΔDSC (max–min), was organ dependent but generally demonstrated little sensitivity to energy variation (maximum ΔDSC < 4%). The ΔDSC for the left lung, right lung, heart, and spinal canal was approximately 2.4%, 3.9%, 1.9%, and 2.5%, respectively.

The results are summarized in Table 1 and illustrated in Figure 1. Figure 1 shows DSC vs. VMI energy and Table 1 shows DSC variation (ΔDSC).

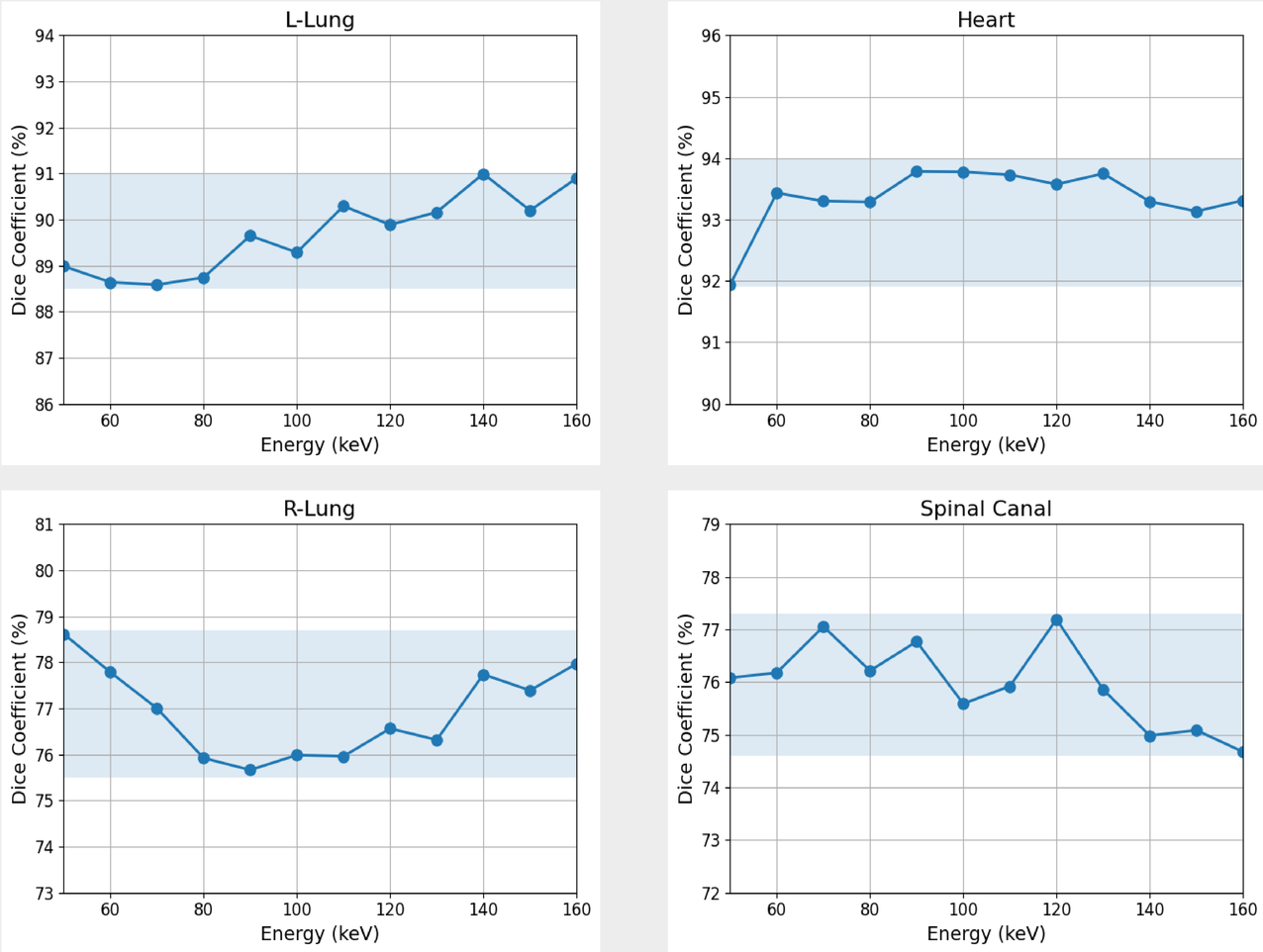

Figure 1 . Dice similarity coefficient (DSC) for auto-generated contours of the left lung (L-Lung), right lung (R-Lung), heart, and spinal canal on virtual monoenergetic images across an energy range of 50–160 keV. Shaded regions indicate the variation in Dice performance for each structure over the studied energy range. Data points represent Dice values at each energy level .

Table 1. Dice Similarity Coefficient (DSC) Variation Across VMI Energy Levels (50–160 keV)

Organ	Min DSC (%)	Energy (keV)	Max DSC (%)	Energy (keV)	ΔDSC (Max–Min) (%)	Energy Dependence
Left Lung	88.6	70	91.0	140	2.4	Moderate (↑ with energy)
Right Lung	75.7	90	78.6	50	3.9	Highest variation
Heart	91.9	50	93.8	90	1.9	Lowest variation
Spinal Canal	74.7	160	77.2	120	2.5	Moderate, non-monotonic

CONCLUSIONS

The limited ΔDSC observed across all evaluated organs indicates that auto-generated contours are minimally affected by VMI energy, supporting the use of a wide range of VMI energies without compromising contour accuracy.

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