Development of Patient Height-Specific 3D Age-Scaling Factors to Generate DICOM Computational Phantoms for Retrospective Late-Effects Studies

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Introduction

Purpose

For late-effects studies, we use 3D age-scaling factors (ASFs) to scale our in-house DICOM computational phantom to patients' ages at the time of radiation therapy (RT); each body region is uniquely scaled to account for non-uniform growth[1,2].

Since these ASFs are based on 50th percentile height data and do not consider patient variations at each age, our *goal* was to generate additional ASFs to account for individuals in different height percentiles. The new ASFs correspond to U.S. population (male-based) heights reported by Center for Disease Control and Prevention (CDC).

Specific Aims

1. Generate 3D ASFs (CDC-ASFs) of head, neck and trunk corresponding to CDC reported 5th, 25th, 50th, 75th and 95th percentile heights for ages 1, 3, 5, 10, 15, and 18 years old.
2. Scale DICOM phantom organs (heart, liver, and colon) using the CDC-ASFs.

Methods

Step 1: Obtain data

ASFs from DICOM phantom | Heights of DICOM phantoms | CDC reported percentile specific heights

Step 2: Calculate multiplication factor (MF)

$$MF = \frac{\text{CDC reported height}}{\text{DICOM phantom height}}$$

Step 3: Calculate CDC-ASF

CDC-ASF = MF x ASFs

Performed for all ages and body regions in all three directions

Step 4: Calculate organ volumes

Organs are scaled using CDC-ASFs

Volumes are calculated in RayStation TPS

Results

Key Results

- We developed 450 CDC-ASFs from CDC reported percentile heights for each body region for ages 1, 3, 5, 10, 15, and 18 years.
  - In general, the 25th and 50th percentile CDC-ASFs were well representative of our original ASFs.

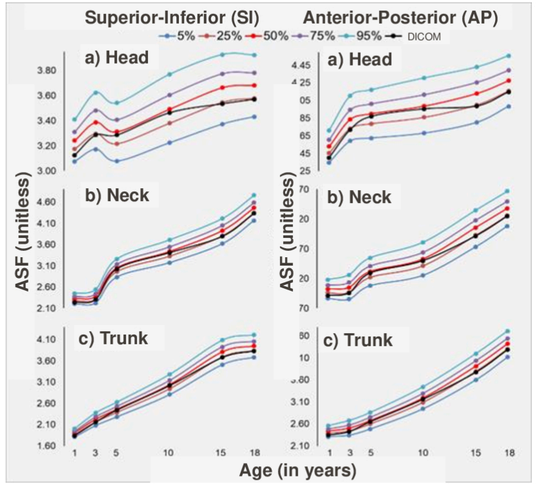

Figure 1: Evolution of ASFs as a function of age and percentile heights for different ages. The original ASFs are closer to 25th and 50th percentile data. Similar trends were found in right-left direction and for legs and arms in all three directions

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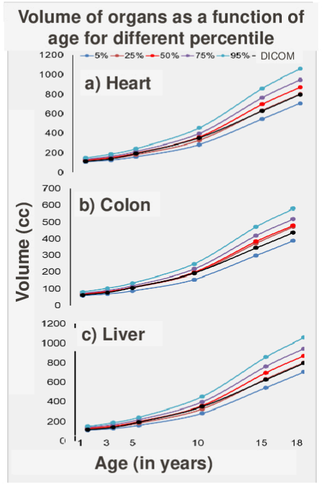

Figure 2: Volume of heart, colon, and liver as a function of age and percentile ASFs. All three organs show the same trend because they follow the ASFs of the trunk

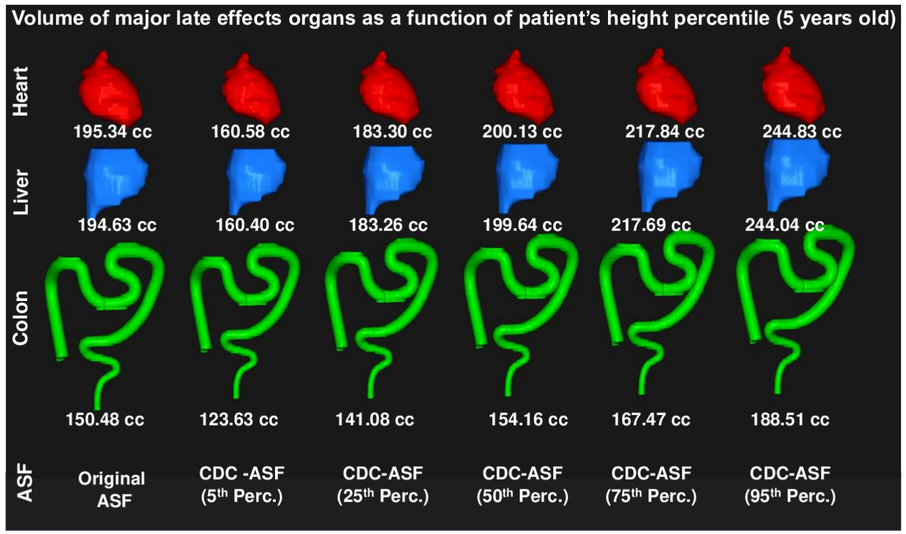

Figure 3: Change in the volume (volume is shown in white) of heart, liver, and colon as function of percentile based ASF is shown for 5-year-old. Here, original stands for 5-year-old organs that were generated using our original ASFs. The data for all three organs lies in between 25th and 50th percentile volumes

Discussion and Conclusion

We generated and validated the ASFs from the percentile heights reported by CDC for each body regions, which can be used to generate patient's height specific phantoms.

Maximum differences were found for –

- 5th and 95th percentile of head and neck in AP direction
- Volume of heart (350cc), colon (192cc), and liver (350cc) at the age of 18.

References

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