AN ANTHROPOMETRIC APPROACH TO ASSIGNING REFERENCE PHANTOMS TO INDIVIDUAL PATIENTS FOR MEDICAL ORGAN DOSE RECONSTRUCTION

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In traditional dose reconstruction studies of patients undergoing diagnostic imaging or interventional procedures, organ absorbed doses are typically assessed via Monte Carlo computer simulations using whole-body anthropomorphic computational phantoms. These phantoms are in turn developed via 3D surface equation representations of the internal organ anatomy and outer body contour (e.g., stylized phantoms) or from segmented 3D images sets from CT or MR scans (e.g., voxel phantoms). In either case, phantoms sets have traditionally been tied to reference values for age-dependent body masses, body heights, and organ masses specified by the International Commission on Radiological Protection (ICRP). ICRP reference ages are specified for the newborn, 1-year, 5-year, 10-year, and 15-year child, where only the latter age is gender specific for all organs and body size. When assigning a given computational phantom to an individual patient in a medical dose reconstruction study, the traditional method has been to use the patient's age as the sole criteria for matching phantom to patient. However, the ICRP reference children are taken to be roughly at the 50th percentile by weight and height, and thus anatomical discrepancies will exist when matching reference phantom to non-50th percentile patients. Even if total patient weight is used to match phantom to patient, discrepancies in internal organ volumes will still persist due to the presence of higher or lower amounts of subcutaneous fat irrespective of internal organ anatomy. **Methods:** The goal of the present study was to explore the use of other anthropometric parameters – trunk height or body cavity volume – as a replacement of either patient age or patient body weight as the means to which computational phantoms are assigned to individual patients in dosimetry assessments. Various abdominal and thoracic organs were segmented and organ volumes obtained from chest-abdominal-pelvic (CAP) computed tomography (CT) image sets from 38 pediatric patients ranging in age from 2 months to 15 years. The organs segmented included the skeleton, heart, kidneys, liver, lungs, and spleen. For each organ, best fit trend lines and 95th percentile confidence intervals were established as a function of patient age, trunk volume, trunk mass, trunk height, and three variations of effective thoracic-abdominal cavity volume, where the later is based on trunk height and possibly a circumferential or areal measurement in the upper chest of the CT image set. **Results and Discussion:** When matching phantom to patient based upon age, residual uncertainties in organ volumes ranged from 53% (lungs) to 33% (kidneys), and when trunk mass was used, these uncertainties ranged from 56% (spleen) to 32% (liver). When trunk height is used as the matching parameter, residual uncertainties in organ volumes were reduced to between 21 to 29% for all organs except the spleen (40%). In the case of the lungs and skeleton, the 2-fold reduction in organ volume uncertainties was seen in moving from patient age to trunk height – a parameter easily measured in the clinic. When thoracic-abdominal cavity volumes were used, residual uncertainties were lowered further to a range of between 14 to 20% for all organ except the spleen, which remained at around 40%. **Conclusion:** The results of this study suggest that a more anthropometric pairing of computational phantom to individual patient based on simple measurements of trunk height and possibly upper chest area or circumference (where influences of subcutaneous fat are minimized) can lead to significant reductions in organ volume uncertainties: ranges of 40-50% (based on patient age) to between 15-20% (based on body cavity volumes estimated from trunk height). An expanded series of NURBS-based pediatric phantoms are being created at UF to allow application of this new approach in fluoroscopy, CT, and radiotherapy dose assessments.