The quantification of renal and diaphragmatic interfraction motion in children
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Purpose/Objective: Knowledge of organ motion in children is of high importance for an adequate definition of the margin to create the PTV. An inadequate PTV definition can result in insufficient tumor coverage or adverse events due to unnecessary irradiated surrounding healthy tissue. Especially for children, avoiding the risk of late toxicity is pertinent. The size of the margin is proportional to the magnitude of organ motion and is extensively studied for adults. Quantitative data for organ motion in children is scarce. Consequently, margins in children are generally based on adults and are presumably too large. The effects of age or height on interfraction motion are unknown. The aim of this pilot study is to quantify renal and diaphragmatic interfraction motion in children during radiotherapy.

Materials and Methods: This retrospective study consisted of 21 patients at a mean age of 12 years (range 3-18 years) with a mean height of 1.50 m (range 1.10 – 1.80 m), treated at our institute between 2006 and 2014, for whom for setup correction routinely acquired evaluable images of the abdomen and thorax were available. This amounted to a total of 21 reference CT (refCT) scans and 206 Cone Beam CT (CBCT) scans, with a minimum of 5 CBCTs per patient. Image analysis utilized XVI software for a two-step rigid alignment of each CBCT to its refCT. First, the bony anatomy was aligned. Subsequently, the kidneys and diaphragm were aligned separately. The result yields a translational vector: the interfractional deviation assessed in the cranio-caudal (CC), anterior-posterior (AP) and left-right (LR) directions, with exception for the diaphragm where only CC direction was measured. To enable comparison with the literature in adults (Wysocka et al., IJROBP, 2010), interfraction motion was quantified in medians of absolute deviations in each direction across all organs at all fractions and was tested with the one-sample Wilcoxon signed rank test. Correlation between the translational vector of the motion magnitude and age and height was analyzed. Also, the SD of the random (σ) and the systematic error (Σ) was determined.

Results: The largest motions occur in the CC direction. Interfraction motion of the kidneys and diaphragm in children and adults were significantly different (p<0.05), with a smaller deviation in children than in adults (Figure 1), with exception in the LR direction of the left kidney. Our analysis showed no correlation between motion magnitude and age and height. Table 1 shows the SD of the random and systematic errors.

Conclusions: Our results show that renal and diaphragmatic interfraction motion in children is smaller compared to literature data in adults. No correlation between motion magnitude and age or height was found. This needs to be further elaborated to estimate a child-specific margin definition based on random and systematic errors and to investigate if an approach based on individualized tailored margins is more appropriate to minimize healthy tissue exposure and to reduce the risk of adverse events in children.