Systematic errors in respiratory gating due to intrafraction deformations of the liver

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This article shows the limitations of respiratory gating due to intrafraction deformations of the right liver lobe. The variability of organ shape and motion over tens of minutes was taken into account for this evaluation, which closes the gap between short-term analysis of a few regular cycles, as it is possible with 4DCT, and long-term analysis of interfraction motion. Time resolved MR volumes (41) MR sequences) were reconstructed for 12 volunteers and subsequent non-rigid registration provided estimates of the 3D trajectories of points within the liver over time. The full motion during free breathing and its distribution over the liver were quantified and respiratory gating was simulated to determine the gating accuracy for different gating signals, duty cycles, and different intervals between patient setup and treatment. Gating effectively compensated for the respiratory motion within short sequences (3 min), but deformations, mainly in the anterior inferior part (Couinaud segments IVb and V), led to systematic deviations from the setup position of more than 5 min in 7 of 12 subjects after 20 min. We conclude that measurements over a few breathing cycles should not be used as a proof of accurate reproducibility of motion, not even within the same fraction, if it is longer than a few minutes. Although the diaphragm shows the largest magnitude of motion, it should not be used to assess the gating accuracy over the entire liver because the reproducibility is typically much more limited in inferior parts. Simple gating signals, such as the trajectory of skin motion, can detect the exhalation phase, but do not allow for an absolute localization of the complete liver over longer periods because the drift of these signals does not necessarily correlate with the internal drift. (c) 2007 American Association of Physicists in Medicine.
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