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Estimation of clinical dose distributions for breast and lung cancer radiotherapy treatments

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i Hjärtats aula, Vita Stråket 13 SU/Sahlgrenska, Göteborg, den 1 december 2016, klockan 09.00

av Emma Hedin

Fakultetsopponent:
Tom Knöös, Professor
Lunds Universitet, Sverige

Avhandlingen baseras på följande delarbeten

I. Hedin, E. and Bäck, A. *Influence of different dose calculation algorithms on the estimate of NTCP for lung complications.* Journal of applied clinical medical physics 2013; 14(5): 127–139.

II. Hedin, E., Chakarova, R. and Bäck, A. *From AAA to Acuros XB for lung cancer SBRT.* Submitted

III. Hedin, E., Bäck, A. and Chakarova, R. *Jaw position uncertainty and adjacent fields in breast cancer radiotherapy.* Journal of applied clinical medical physics 2015; 16(6):240-251

IV. Hedin, E., Bäck, A. and Chakarova, R. *From AAA to Acuros XB for breast cancer treatment planning: Implications for dose to lung tissue.* Submitted

SAHLGRENSKA AKADEMIN
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Estimation of clinical dose distributions for breast and lung cancer radiotherapy treatments

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Abstract

The overall aim of this thesis was to investigate the uncertainties in the dose distribution determined at the treatment planning stage. The work has been based on the main hypothesis that the way of determining dose at the stage of treatment planning can be improved to such an extent that it affects the risk-benefit assessment. Photon beam treatments of breast and lung cancer were considered, i.e. treatments that are delivered to a region of the body that includes lung tissue. Density inhomogenities are a challenge for the clinical dose calculation algorithms (DCAs). Another challenge for the loco-regional breast cancer treatments are the adjacent fields where the jaw positioning uncertainty may influence the uniformity of the dose distribution.

Different clinical DCAs were compared regarding their ability to calculate dose to lung (organ at risk). The differences were quantified in terms of normal tissue complication probabilities (NTCP) in Paper I. This study showed that the uncertainties in clinical DCAs can be of the same magnitude as the uncertainties of published NTCP model parameters. Adjusted NTCP model parameters were retrieved to avoid introduction of this additional uncertainty. The performance of clinical DCAs regarding calculation of target dose for the case of stereotactic (small fields) lung cancer treatments was compared to Monte Carlo (MC) calculations in Paper II. The principle-based DCA Acuros XB (Varian, Eclipse) was found to comply better with MC than the pencil-beam based analytical anisotropic algorithm (AAA) included in the study. The clinical impact of the transition from the AAA to Acuros XB was discussed. In paper III and IV breast cancer treatments were studied. The impact of jaw positioning uncertainty on the dose distribution in the case of adjacent fields was investigated in paper III. The effect on lung tissue was small whereas hotspots were found in soft tissue with unknown risks for plexus brachialis. In paper IV the performance of different clinical dose calculation algorithms in lung tissue with low density due to the breathing adaptive technique of deep inspiration breath hold (DIBH) was investigated. The clinical impact of the transition from AAA to Acuros XB was discussed. Acuros XB was compared to MC for the lowest lung density identified and the reliability of the Acuros XB calculation was confirmed. The clinical impact of the transition from AAA to Acuros XB was quantified for dose planning criteria based on different lung DVH parameters.

Keywords: External radiation therapy, breast cancer, lung cancer, clinical dose calculation algorithms, Monte Carlo, NTCP, dose planning criteria

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