Optimization of image acquisition parameters in chest tomosynthesis

Experimental studies on pulmonary nodule assessment and perceived image quality

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i *Ivan Östholm*, Medicinaregatan 13, den 13 januari 2017, klockan 9.00

av

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Avhandlingen baseras på följande delarbeten:

I.   Söderman, C., Asplund, S., Allansdotter Johnsson, Å., Vikgren, J., Rossi Norrlund, R., Molnar, D., Svalkvist, A., Månsson, L.G., Båth, M. *Image quality dependency on system configuration and tube voltage in chest tomosynthesis – A visual grading study using an anthropomorphic chest phantom.* Medical Physics 2015 Mar;42(3):1200-1212.

II.   Söderman, C., Allansdotter Johnsson, Å., Vikgren, J., Rossi Norrlund, R., Molnar, D., Svalkvist, A., Månsson, L.G., Båth, M. *Evaluation of accuracy and precision of manual size measurements in chest tomosynthesis using simulated pulmonary nodules*. Academic Radiology 2015 Apr;22(4):496-504.

III.   Söderman C., Allansdotter Johnsson Å., Vikgren J., Rossi Norrlund R., Molnar D., Svalkvist A., Månsson L.G., Båth M. *Effect of radiation dose level on accuracy and precision of manual size measurements in chest tomosynthesis evaluated using simulated pulmonary nodules*. Radiation Protection Dosimetry 2016 Jun;169(1-4):199-203.

IV.   Söderman C., Allansdotter Johnsson Å., Vikgren J., Rossi Norrlund R., Molnar D., Svalkvist A., Månsson L.G., Båth M. *Influence of the in-plane artefact in chest tomosynthesis on pulmonary nodule size measurements*. Radiation Protection Dosimetry 2016 Jun;169(1-4):188-198.

V.   Söderman C., Allansdotter Johnsson Å., Vikgren J., Rossi Norrlund R., Molnar D., Mirzai, M., Svalkvist A., Månsson L.G., Båth M. *Detection of pulmonary growth with chest tomosynthesis: a human observer study using simulated nodules and simulated dose reduction*. Submitted

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ABSTRACT

Chest tomosynthesis refers to the technique of acquiring a number of discrete projection images within a limited angular range around the patient. These projection images are then used to reconstruct section images of the chest. Chest tomosynthesis might be a suitable alternative to CT in follow up of pulmonary nodules, which involves nodule size characterization and detection of nodule growth over time. Tomosynthesis section images will contain artifacts due to the limited angular interval of the scan. For example, an in-plane artifact appears as darker areas around nodule borders. There is a need for evaluating the influence of different parameters of a tomosynthesis examination on the resulting section images. The overall aim of this thesis was to find optimal image acquisition parameters in chest tomosynthesis, both in terms of perceived image quality and pulmonary nodule size assessment. In addition, it aims at contributing to a general evaluation of chest tomosynthesis in the task of follow up of nodules, and it includes an evaluation of the effect of the in-plane artifact on nodule size assessment.

Methods including participation of radiologists were used. A visual grading study was performed using an anthropomorphic phantom in order to find the optimal image acquisition parameters regarding perceived image quality. In order to evaluate the quality of the images in terms of nodule measurement accuracy and precision, as well as to evaluate the possibility to detect nodule size change over time, the radiologists measured and visually evaluated the size of simulated pulmonary nodules inserted into clinical chest tomosynthesis images.

With the specific imaging system used, and at the standard dose level, potential benefits for perceived image quality of increasing the dose per projection image do not fully compensate for the negative effects of an accompanying reduction in the number of acquired projection images. Regarding nodule size measurements, the results suggest high measurement accuracy and precision with chest tomosynthesis, and that a reduction of up to 50% of the standard dose level for the imaging system used may be possible without reducing the measurement accuracy and precision. A minor negative effect on nodule measurement accuracy due to the presence of the in-plane artifact was found. Results suggest that chest tomosynthesis is a promising imaging modality for detection of pulmonary nodule growth. However, the possibility to detect growth may decrease with decreasing nodule sizes and dose level. Mismatch in nodule position relative to the reconstructed image planes between two consecutive chest tomosynthesis examinations can also hamper the detection.

In a future perspective, the results presented in this thesis should be confirmed using clinical chest tomosynthesis images including real pulmonary nodules.

Keywords: Chest radiology, chest tomosynthesis, pulmonary nodule, phantoms, hybrid images