Individual optimisation of contrast media application and radiation dose in computed tomographic angiography

9.1
Summary

This thesis addressed several topics on individual optimisation of contrast media (CM) volume and radiation dose for different CT angiography (CTA) examinations. The overall focus of this research was to maintain diagnostic image quality in CTA while using iodinated CM and radiation dose in a more efficient way for the individual patient.

In **Chapter 2** the relationship between CM concentration and viscosity was described. The results show that the viscosity of CM lower with lower concentrations of iodine (240mgI/ml and 300mgI/ml) was significantly lower compared to CM with higher concentrations of iodine (370mgI/ml and 400mgI/ml). Furthermore, pre-heating CM to body temperature drastically decreased the viscosity of CM. In addition, the influence of different viscosity levels was investigated in circulation phantom, where CM was injection at different temperatures (20 – 37˚C). From these experiments, we could conclude that the injection pressure significantly decreased while using lower concentrated CM and, moreover, when injecting these concentrations at body temperature. Therefore, standardised pre-heating should be a prerequisite for clinical CM administration.

In **Chapter 3** the potential for automated kVp-selection to reduce the radiation dose during CTA using different concentrated CM – normalised to an identical iodine delivery rate (IDR; [gI/s]) – was explored using a circulation phantom. The results showed that automated tube current modulation can result in radiation dose reduction up to 53% and automated tube voltage selection up to 77%, if human subjects approximate the dimensions and therefore the attenuation values of the phantom used in the experiment. Furthermore, Dose reduction was – as expected – independent of the CM concentration applied at normalised IDR.

In **Chapter 4** the influence of scan parameters – especially tube voltage [kVp] settings – on intravascular enhancement in coronary CTA (CCTA) was investigated. A circulation phantom was used to systematically investigate how IDR and CM volume could be adapted to a particular kVp setting in order to remain optimal enhancement levels in the coronary arteries. These primary results were then also tested in sixty patients referred for CCTA. In a circulation phantom, lower kVp settings allowed a substantial reduction in CM volume - up to 56% at 70kVp - whilst maintaining diagnostically sufficient attenuation within the target vessels. Furthermore, initial results in patients confirmed this finding at 100kVp using 12% reduction of CM volume in CCTA.

In **Chapter 5** the effect on image quality when using body weight adapted injections was studied in patients referred for CT pulmonary angiography (CTPA). The use of individualised CM protocols provided diagnostic and robust enhancement in emergency CTPA, as well as a substantial CM volume reduction in lower weight patients compared to a fixed CM protocol. Moreover, greater consistency of vascular enhancement

values – indicating a more reliable protocol – was observed throughout the patients who received body weight adapted injections, whereas the scans for patients who received fixed injections showed a steady decline in attenuation with increasing body weight.

In **Chapter 6** the role of individual adaptation of both injection and scan protocols based on patient's body mass index (BMI) was elaborated in patients referred for pre-TAVI CT examination. As these patients frequently suffer from an impaired renal function, the possibility of reducing CM volume while using lower kVp settings was investigated. The use of low kVp (80kVp and 70kVp) scan protocols allowed for substantial reduction in CM volume as compared to common high volume injection protocols for pre-TAVI CT examinations. Sufficient image quality was maintained for the evaluation of the aortic root and peripheral access site despite a CM volume reduction of 34-67%.

In **Chapter 7** the possibility of reducing radiation dose exposure and CM volume was studied in patients referred for the evaluation of the aorta, as aortic CTA is associated with frequent follow-up over time, which implies high cumulative radiation dose and iodinated CM volume for these patients. It turned out that individualised CTA protocols based on the BMI of the patient are favourable for CTA of the whole aorta in routine clinical practice. Iterative reconstruction algorithms resulted in 23-57% less radiation in combination with 55-63% less contrast volume when compared to standard CT protocols.