CHAPTER 7

Concluding remarks
In the Academic Medical Center ‘AMC’ in Amsterdam, interventional cardiologists and radiologists use ionizing radiation for fluoroscopy-guided procedures. During the years, radiation exposure of interventional specialists has steadily increased, related to the increasing demand for interventional procedures. For a number of interventional cardiologists and radiologists the doses measured exceeded 20 mSv (limit for effective dose). If the radiation exposure keeps rising, chances to develop fatal tumors (stochastic effects) increase proportionally. Additionally, interventional cardiologists and radiologists will develop somatic effects like cataract (deterministic effects) if threshold doses remain exceeded. As a consequence, it is worthwhile to study the radiation exposure of interventional cardiologists radiologists in the hospital.

The studies described in this thesis lead to the following conclusions:

1. To monitor the radiation exposure of interventional cardiologists and radiologists, a single personal dosemeter can be used. This personal dosemeter must be placed outside the lead apron, on a predetermined position.

2. The settings of X-ray equipment must be standardized, to limit radiation exposure of patients and interventional cardiologists.

1. Monitoring of radiation exposure of interventional radiologists and cardiologists

The results of this thesis show that, by using a single personal dosemeter, radiation exposure of interventional cardiologists and radiologists can be monitored adequately. The dose inside the lead apron can be estimated from the dose measured outside the lead apron. However, if the dose is measured inside the lead apron, an accurate estimation of the dose outside the lead apron cannot always be provided. In other words, this implies that radiation exposure of interventional specialists cannot be adequately monitored by means of a single dosemeter worn inside the lead apron. If doses measured outside the lead apron are below 0.25 mSv/4-weeks, doses inside the lead apron are below the measurement threshold. If this is the case, the radiation exposure of interventional specialists will be underestimated. Moreover, the doses measured are also influenced by the position of the dosemeter. For this reason it is important to place the personal dosemeter on a predetermined, fixed position. The
position of the personal dosemeter placed outside of the lead apron is dependent on the method used to estimate the effective dose. For example, a personal dosemeter placed on the left sleeve requires a higher correction factor compared to a personal dosemeter placed on the collar.

If double dosimetry is applied, the effective dose can be estimated with an algorithm. The method used to estimate the effective dose when single dosimetry is applied, results in higher estimates of the effective dose compared to the method for double dosimetry. The methods for double dosimetry either lead to an overestimation or to an underestimation of the effective dose, whereas the method for single dosimetry results in an overestimation. Thus, from the perspective of radiation protection, the method for single dosimetry is preferred to the methods for double dosimetry, because radiation exposure of the interventional specialists will never be underestimated.

Within the European Member States, there does not exist any harmonization with respect to the amount and position of the personal dosemeters for interventional specialists. In most of the Member States, interventional specialists use a single personal dosemeter placed either inside or outside the lead apron. In only a limited number of countries it is common to use two dosemeters: one outside and one inside the lead apron. This study revealed that a single personal dosemeter worn outside the lead apron allows the estimation of radiation exposure of interventional specialist. This provides valuable information that aids the discussion concerning the position of the personal dosemeter for interventional specialists in the AMC, as well as for interventional specialist in other departments, hospitals and European Member States.

2. Limitation of the radiation exposure of patients and interventional cardiologists

In this thesis, the differences in radiation exposure among interventional cardiologists during fluoroscopy-guided procedures are examined. This was essential, as the radiation exposure of interventional specialists could not only be explained by differences in amount of procedures performed and the complexity of procedures. It is more likely that the radiation exposure of cardiologists is influenced by their preferences for specific radiation-equipment settings such as dose mode settings, field size and frequency of use of the cine mode. As the exposure of cardiologists is
dependent on their personal preferences, standardization of these variables may lead to a reduction of radiation exposure of cardiologists.

In order to optimize the radiation exposure of interventional specialists, the use of shielding materials as well as the preferred settings must be considered continuously. For this reason, protective measures as well as optimal use of preference settings must be subject of a continuous education program for interventional specialists. Therefore it is important to conduct further investigations in order to determine to what extend variables such as the use of the cine mode and the three different fluoroscopy modes, the position of the X-ray tube, the use of different shielding devices, the height of the table, the distance between patient and image intensifier as well as the position of the cardiologists during the procedures, influence the exposure of cardiologists.

The study of this thesis was performed by employees of the department of radiation protection at the AMC. The primary task of this department is to set up guidelines for radiation protection, to develop and maintain a quality system for the safe use of ionizing radiation within the AMC, and to supervise the use of ionizing radiation in order to keep doses and accompanying risks as low as reasonably achievable (ALARA). Scientific research as presented in this thesis is considered a primary task by neither the institute nor the Dutch government that captures the tasks of a department of radiation protection through licensing and legislation. Nevertheless, the research presented in this thesis is an example of what can be established with data obtained from monitoring programs in combination with medical data. In general, radiation protection guidelines within institutions are based on recommendations of the ICRP, which are subsequently implemented in the European and Dutch legislation. These recommendations are often based on small pilot research projects carried out within well-described circumstances in a limited number of institutions, or such recommendations are sometimes based on common sense. A similar situation applies for modifications of recommendations and the legislation. Collecting data of one’s own institution to conduct scientific research, does not only render possibilities to improve radiation safety within the own institution, but it will also contribute to the improvement of radiation protection recommendations, guidelines and standards.
This study used data regarding radiation exposure of intervention cardiologists and radiologists from procedures performed between 1999-2008. In addition, data regarding radiation exposure of patients from diagnostic and therapeutic procedures between 2004-2008 were used in this study. During the latter study period, more than 10000 procedures were performed at the AMC Heartcenter. Several other authors have published results on radiation exposure of interventional cardiologists, radiologists and patients as well. However, the results in those studies are often based on smaller numbers of observations or lower number numbers of patients compared to the data in this thesis. Moreover, radiation exposure of interventional specialists in this thesis was measured at a predetermined position outside and inside the lead apron. The findings of this thesis therefore resulted in an important scientific contribution to the existing knowledge on radiation exposure of interventional specialists and patients from fluoroscopy-guided procedures.