Radiation Dose Management of Pregnant Patients, Pregnant Staff and Paediatric Patients Diagnostic and Interventional Radiology

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Publisher: Institute of Physics Publishing Temple Circus, Bristol BS1 6HG UK (An IPEM-IOP Series in Physics and Engineering in Medicine and Biology)
Year of publication: 2020 e-book
Number of pages: 239
ISBN: 978-0-7503-1317-9 (ebook)
Edition: First 2019

This book, a unique in its kind, deals with in-depth information on radiation dose management of pregnant patients, pregnant staff, and pediatric patients in diagnostic and interventional radiology. This book has been edited by John Damilakis and apart from John Damilakis, there are other contributors, namely, A Papadakis, K Perisinakis, J Stratakis, and V Tsapaki.

This book, provides very useful knowledge about the practical use of radiation dosimetry, estimation of radiation-induced risk and for further management to limit radiation doses to pregnant patients, pregnant staff, and pediatric patients undergoing diagnostic interventional radiological procedures and computed tomography (CT) examinations. The book has 239 pages and has been divided into eight chapters ranging from medical dosimetry, biological effect of exposure to ionizing radiation during gestation and childhood, parameters that influence the conceptus and pediatric doses, method to calculate the doses to the conceptus and the pediatric patient, and strategies to optimize examination performed on pregnant and pediatric patients in order to limit radiation doses. This book will be a useful resource for medical physicists, diagnostic radiologists, interventional radiologists, and other physicians performing fluoroscopy-guided procedures, radiographers, gynecologists, obstetricians, and pediatricians.

Chapter 1: This chapter is contributed by John Stratakis and Antonios Papadakis and deals with the description of dosimetry concerning with radiation dose measurement in a specially designed phantoms using TLDs/OSLDs MOSFET and other passive solid-state dosimeters. The later section of this chapter explains about computational phantoms simulating pregnancy and children, especially based on Monte Carlo simulations. Using these methods, one can estimate conceptus and pediatric doses based on Monte Carlo radiation transport code and other commercially available computational dosimetry software such as PCXMC, ImpactMC, and CoDE.

Chapter 2: This chapter is contributed by Kostas Perisinakis and Virginia Tsapaki and deals with the biological effects of exposure to ionizing radiation during gestation and childhood. The first part of this chapter deals with the biological effect to conceptus from radiation in which it explains the concepts about the menstrual cycle, conception and fetal development, radiation effects following in utero exposure to ionizing radiation, such as lethality, growth retardation, congenital malformations/teratogenesis, mental retardation, cancer induction, genetic effect, and no deleterious effect. It also deals with the sensitivity of developing concepts about conceptus exposure during the preimplantation period, organogenesis, and during the fetal period including methods to estimate the probability for radiation-induced deleterious effects following in utero exposure. The later part of this chapter deals with the biological effects in children from ionizing radiation, their mechanism, physiological characteristics of the pediatric patient and adults, and then most prominent radiation-induced cancers in children. At the end, the chapter deals with the latest data published in the diagnostic imaging and cancer risk such as BEIR VII Report 2006, UNSCEAR 2013, and some recently published articles.

Chapter 3: Contributors are Perisinakis Kostas and Papadakis Antonis. The chapter deals with the parameters that influence radiation dose to the conceptus and pediatric patient radiation dose from radiodiagnostic procedures. First, it explains in detail about the parameters such as Kilo Voltage Peak (kVp), mAs, Automatic Exposure (AEC), tube to patient and tube to detector distance field size, projections, filtration and antiscatter
grids, and detector technology (in digital radiography). In addition to these, it explains dose rate (in fluoroscopy), beam on time (in fluoroscopy), and entrance exposure rate to the detector influencing the conceptus and pediatric doses in digital radiography and fluoroscopy, respectively. It discusses how dose descriptors such as patient skin entrance exposure rate and DAP vary with the parameters as mentioned above and also on the location of conceptus relative to the X-ray beam, anatomic characteristics of the pregnant patient that affects conceptus dose, and the effect of pediatric patient’s size. Second, it discusses the exposure parameters such as mAs, kVp, beam collimation, pitch, CT beam filtration, automatic tube current modulation, patient size, and imaged volume length along the z-axis, which affect radiation dose to the conceptus or children exposed during a CT examination.

Chapter 4: Contributors for this chapter are Damilakis and V Tsapaki and the chapter deals with the amount of dose absorbed by the conceptus and pediatric patients from diagnostic and interventional radiology.

This chapter is divided into two main parts. First, information is provided about the amount of radiation dose absorbed by the conceptus and radiation-induced risks associated with the radiographic examination, fluoroscopy-associated and fluoroscopically guided procedures performed, DEXA, and CT examination on a pregnant patient. The second part deals with pediatric radiation doses and radiation-induced risks associated with digital radiography, fluoroscopy, interventional procedures, and CT examination. The authors have quoted all the latest relevant published articles concerning with the doses and associated risk in pregnant patients and pediatric patients undergoing diagnostic and interventional procedures including CT examination.

Chapter 5: Contributors are J Damilakis and V Tsapaki and the chapter deals with the methods to calculate conceptus and pediatric dose. It explains the methodologies published in the literature by researchers to calculate conceptus and pediatric doses from radiographic, fluoroscopy examination including fluoroscopic-guided procedures and CT examination. In the beginning, the authors have quoted numerous published articles to calculate conceptus dose from digital radiography and fluoroscopic procedures using air kerma, dose area product, and one study which generated conceptus dose data using Monte Carlo simulation. The authors have explained numerous examples to calculate conceptus dose in CT examination using CTDI and normalized conceptus dose during early pregnancy, second and third trimesters of gestation. It also illustrates about Conceptus Dose Estimation (CoDE) software uploaded at http://embryodose.med.uoc.gr/code/and its use is free of charge. The second part of the chapter deals with methods to calculate pediatric dose in diagnostic and international procedures including CT examinations. The authors have meticulously illustrated how doses can be estimated with numerous examples through which medical physicists can easily calculate conceptus doses (for the pregnant patient) in radiography, fluoroscopy, and CT examination and also for calculating pediatric doses in these procedures.

Chapter 6 and Chapter 7 deal with the optimization of radiological examinations performed on pregnant patients (Chapter 6) and on pediatric patients (Chapter 7). Chapter 6 deals with the radiation protection approach for imaging the female patient, practical action for optimizing conceptus dose in radiographic examinations, fluoroscopy procedures performed on pregnant patients, and ways to limit conceptus doses. It emphasizes on the importance of dose monitoring during these procedures. It also deals with optimizing CT examinations of pregnant patients and particularly gives recommendations for the radiologists and the operators during CT examinations to limit the radiation dose to the conceptus. Chapter 7 deals with the optimization of radiographic, fluoroscopic, and CT examinations performed on the pediatric patients. The authors have illustrated in detail about the importance of assessment of doses before examination and better work practice to be adopted for optimizing radiation dose to the pediatric group including the adaptation of iterative reconstruction algorithms which can reduce radiation dose by 40%–80%.

The authors have also mentioned about the hybrid iterative reconstruction methods that blend filtered back projection and iterative reconstruction. Such hybrid methods have been introduced into the market to increase the speed of image reconstruction to leave the clinical workflow unaffected and to limit the radiation dose at the same time. The chapter also enumerates the published dose reference levels and dose management software.

Chapter 8 deals with the radiation dose management, in terms of organization and coordination, of pregnant patients and pregnant staff (who participate in fluoroscopically guided interventional procedures). This chapter identifies the need of justification of the examination, dose anticipation and estimation of radiogenic risk, communication between the medical physicist and the referring physician and/or the radiologist, communication with the patient and her relatives, and dose optimization protocols for intentional exposure of pregnant patients and also with accidental exposure to the pregnant patients. For instance, it clearly states that the risk of excess childhood fatal cancer is 0.06%/Sv. For an X-ray examination with a 10 mGy dose to the conceptus, there is a very small increase in the probability of fatal cancer. As there is a low probability of radiation-induced cancer for the low dose, abortion should not be considered if the dose to the unborn child is lower than 100 mGy. However, when the conceptus dose is above 100 mGy, deterministic effects are likely to be observed and, for this reason, abortion might be considered especially if the exposure takes place during the first trimester. The later part of this chapter deals with the management of radiation dose for pregnant employees. It describes that the important elements of a dose management program for pregnant personnel after declaration of pregnancy for
further evaluation of the working conditions of the pregnant workers, anticipation of the conceptus dose, estimation of the workload, and dose monitoring.

**SUMMARY**

The list of references supporting the studies carried out in the respective fields has been covered extensively at the end of each chapter. Readers of this book can get more in-depth information from the quoted references. This book has also given the names of numerous software, mainly based on Monte Carlo simulation techniques, and can be downloaded elsewhere. The usage of high-dose interventional procedures and CT examination in the pregnant patient is limited, but CT examination in children is rapidly increasing; hence, an extensive elaboration on radiation dose measurement in pregnant patient and the pediatric patient group was needed. The author has given lots of illustrative problems and their solutions. There are certain repetitions of exposure parameters and risk assessment in each individual procedure. In my opinion, combining Chapter 6 and Chapter 7 could have given some scope to reduce the number of pages of the book.

I strongly recommend medical physicist and radiologist to read this book if one is interested in knowing various aspects of conceptus dose and pediatric doses in diagnostic radiological examinations.