UNIVERSITI PUTRA MALAYSIA

MINIMIZATION OF ENTRANCE SURFACE DOSE AND CRITICAL ORGAN DOSE FOR MEDICAL RADIOGRAPHY USING OPTIMIZATION PROCEDURES

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MASTER OF SCIENCE

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By

LOTF ALI MEHDIPOUR NASAB RABOR

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science.

February 2010

This thesis dedicates to

My dear wife (NAHID),

My parents, my brothers, my sisters,

And

My dear niece (Sahar)

Abstract of thesis presented to the Senate of Universiti Putra Malaysia, in fulfillment of the Requirement for the degree of Master of Science

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LOTF ALI MEHDIPOUR NASSAB RABOR

February 2010

Chairman : Professor Dr. Elias Bin Saion, PhD

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In hospitals, clinics, nursing homes, and medical laboratories, diagnostic radiography is extensively used to view internal structures of a patient and to aid radiologists and doctors diagnose and treat illness and injury. The most common medical radiography is by passing x-rays through the body and captures the image of the patient by means of a sensitized film. This radiographic procedure must feature the system of dose optimization and limitation known as the practice of ALARA (as low as reasonably achievable) recommended by the International Commission on Radiological Protection. The measurements of the entrance surface dose (ESD) and the critical organ dose (COD) in common medical radiography are very important to ensure the dose limit received by the patient in a single radiographic exposure must fulfill the ALARA principle. The most useful way to evaluate ESD is either by indirect measurement on a phantom using an ionization chamber or thermo luminescent dosimeter (TLD) or using calculation based on mathematical model.

In this work, the ESD values measured by the indirect method on RANDO phantom using ionization chamber and by direct method on volunteer patients using TLD. The ESD values of X-ray examinations on chest posterior-anterior (PA) and lateral (lat), skull PA and lat, cervical spine anterior-posterior (AP) and lat, thoracic spine AP and lat, lumbosacral spine AP and lat, abdomen AP, and pelvis AP were found to be 0.15, 0.75, 1.82, 1.16, 0.70, 0.73, 3.6, 5.40, 4.74, 11.7, 4.55, and 3.26 mGy respectively. The IAEA (1996) ESD values are 0.4, 1.5, 5, 3, -, -, 7, 20, 10, 30, 10, and 10 mGy respectively and the NRPB (2000) values are 0.2, 1, 3, 1.6, -, -, 3.5, 10, 6, 14, 6, and 4 mGy respectively. Patients weighting between 65 to 75 kg, from two hospitals in Iran were volunteered to be placed with TLD 100 (LiF) chips during X-ray examinations on chest, skull, cervical, thoracic, lumbar, abdomen, and pelvis to measure the ESD values. For each radiographic procedure 10 patients were selected and in one sachet three TLD chips were used. The measured ESD values on RANDO phantom and patients were compared with the guidance levels provided by the International Atomic Energy Agency (IAEA) and the National Radiological Protection Board (NRPB).

For the indirect measurement of COD values, RANDO phantom and TLDs were used during ESD X-ray measurements. The COD values measured on chest PA for lens, thyroid, and testis were 0.11, 0.12, 0.09 mGy respectively, on chest lat for lens, thyroid and testis were 0.12, 0.14, 0.1 mGy respectively, on skull PA for lens, thyroid and testis were 0.20, 0.19, 0.13 mGy respectively, on skull lat for lens, thyroid and testis were 0.90, 0.20, 0.15 mGy respectively, on cervical spine AP for lens, thyroid and testis were 0.24, 0.67, 0.20 mGy respectively, on cervical spine lat for lens, thyroid and testis were 0.19, 0.62, 0.17 mGy respectively, on thoracic AP

for lens, thyroid and testis were 0.20, 0.68, 0.18 mGy respectively, on thoracic spine lat for lens thyroid and testis were 0.21, 0.25, 0.20 mGy respectively, on lumbosacral spine AP for lens thyroid and testis were 0.24, 0.27, 1.37 mGy respectively, on lumbosacral spine lat for lens thyroid and testis were 0.22, 0.24, 0.40 mGy respectively, on abdomen AP for lens thyroid and testis were 0.23, 0.24, 1.89 mGy respectively, and on pelvis AP for lens thyroid and testis were 0.24, 0.26, 1.23 mGy respectively. In this study the level of stochastic effect of X-rays in diagnostic radiology was lowered in comparison with the guidance levels of IAEA and NRPB. These results enable us to propose the COD values for common general radiography procedures.

Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

MENGURANGKAN DOS PERMUKAAN SINAR DATANG DAN DOS ORGAN KRITIKAL UNTUK KEGUNAAN RADIOGRAfI PERUBATAN MENGUNAKAN KAEDAH PENGOPTIMUMAN

Oleh

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Di hospital, klinik, rumah pemulihan dan makmal perubatan, radiograf dianostik kerap digunakan untuk melihat struktur dalaman seorang pesakit dan bertujuan membantu pakar radiologi dan doktor melakukan diagnostik dan merawat penyakit dan kecederaan. Lazimnya radiografi penibutan adalah diperolehi dengan menyinarkan sinar-X menembusi jasad dan merekodkan imej pesakit dengan sekeping filem. Prosedur radiograf perlu menyatakan system pengoptimum dan penghadan dos dikenali sebagai ALARA (serendah mungkin yang boleh dicapai) yang disyorkan oleh Badan Antarabangsa mengenai Perlindungan Sinaran. Pengukuran dos permukaan sinar datang (ESD) dan dos organ kritikal (COD) dalam amalan biasa radiograf perubatan adalah amat penting untuk memastikan had dos yang diterima oleh pesakit dalam pendedahan radiograf tunggal perlu memenuhi prinsip ALARA.lazimny cara paling utama untuk menentukan ESD adalah samada melalui pengukaran terus keatas fentom menggunakan kebuk pengionan atau

dosimeter termopendarcahaya (TLD) atau dengan menggunakan pengiraan berdasarkan model matematik.

Dalam kajian ini, ESD diukur dengan kaedah tak terus menggunakan fentom Rando dan kebuk pengionan dan dengan kaedah terus menggunakan pesakit dan pengesan TLD. Nilai ESD bagi pemerikasaan bagi torkas posterior-anterior (PA) dan lateral (lat), tengkorak PA dan lat, spina servikal anterior-posterior (AP) dan lat, spina torkas AP and lat, spina lumbosakral AP and lat, abdomen AP, and pelvis AP mempunyai nilai masing-masing 0.15, 0.75, 1.82, 1.16, 0.70, 0.73, 3.6, 5.40, 4.74, 11.7, 4.55, dan 3.26 mGy. Nilai ESD bagi IAEA (1996) 0.4, 1.5, 5, 3, -, -, 7, 20, 10, 30, 10, dan. 10 mGy manakala nilai untuk NRPB (2000) ialah 0.2, 1, 3, 1.6, -, -, 3.5, 10, 6, 14, 6, dan 4 mGy. Bagi keadah terus, pesakit-pesakit yang beratnya diantara 65 dan 75 kg yang mendapat rawatan daripada dua hospital telah secara sukalera diletakkan cip TLD 100 (LiF) semasa pemeriksaan sinar-X dada, tengkorak, servikal, torkas, lumbar, abdomen, and pelvis to mengukur nilai ESD berkaitan. Untuk setiap kaedah radiograf sebanyak 10 pesakit telah dipilih dan tiga cip TLD diletakkan dalam setiap lokasi pengesan. Nilai-nilai ESD yang diukur dengan menggunakan fentom RANDO dan pesakit telah dibandingkan dengan paras dos yang dicadangkan oleh Agensi Tenaga Atom Antarabansa (IAEA) dan Badan Perlindungan Sinaran kebangsaan (NRPB).

Untuk mengukur nilai COD secara tak terus, fantom RANDO dan pengesan TLD telah digunakan. Nilai COD yang diukur semasa pemeriksaan sinar-X dada PA untuk kanta, kelenjar tiroid, dan testis adalah masing-masing 0.11, 0.12, 0.09 mGy, peperikasaan dada lat untuk kanta, kelenjar tiroid, dan testis adalah masing-masing 0.12, 0.14, 0.1 mGy, pemeriksaan tengkorak PA untuk kanta, kelenjar tiroid and testis adalah masing-masing 0.20, 0.19, 0.13 mGy, pemeriksaan tengkorak lat untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.90, 0.20, 0.15 mGy, pemeriksaan spina servikal AP untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.24, 0.67, 0.20 mGy, pemeriksaan spina servikal lat untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.19, 0.62, 0.17 mGy, pemeriksaan spina torkas AP untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.20, 0.68, 0.18 mGy, pemeriksaan spina torkas lat untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.21, 0.25, 0.20 mGy, pemeriksaan spina on lumbosacral spine x-ray AP for lens thyroid and testis adalah masing-masing 0.24, 0.27, 1.37 mGy, pemeriksaan spina lumbosakral lat untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.22, 0.24, 0.40 mGy, pemeriksaan abdomen AP untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.23, 0.24, 1.89 mGy, dan pemeriksaan pelvis AP untuk kanta, kelenjar tiroid dan testis adalah masing-masing 0.24, 0.26, 1.23 mGy. Dalam kajian ini paras kesan stokastik sinar-X dalam radiology adalah lebih rendah berbanding dengan paras panduan oleh IAEA dan NRPB. Keputusan kajian ini membolehkan kita mencadangkan nilai COD bagi prosedur radiografi am biasa.

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"Open your heart eye, to see the ghost
You will see any invisible thing
If you split the heart of any particle,
You will see a sun within it,,

At the end of this step of my graduate period has allowed for a bit of reflection, and the many people who have contributed to both my work, and my life during of this period of time.

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Lotf Ali Mehdipour
2010

I certify that a Thesis Examination Committee has met on 11.2.2010 to conduct the final examination of Lotf Ali Mehdipour nassab rabor on his Master thesis entitled "Minimization of entrance surface dose and critical organ dose for medical radiography using optimization procedures"in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at University Putra Malaysia or at any other institution.

(Signature)

LOTF ALI MEHDIPOUR NASSAB RABOR

2010

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LIST OF ABBREVIATIONS

ALARA	As Low As Reasonably Achievable
AP	Anterior - Posterior
BG	Back ground radiation
CF	Calibration Factor
COD	Critical Organ Dose
Cm	Centimeter
CPS	Cycle per second
DNA	Deoxyribonucleic Acid
DRL	Diagnostic Reference Level
ESD	Entrance Surface Dose
HVL	Half Value Layer
HZ	Hertz
IAEA	International Atomic Energy Agency
ICRP	International commission of Radiation Protection
KERMA	Kinetic Energy Released in Material
Kev	Kiloelectron volt
Kpa	Kilopascal
kVp	Kilovolt peak
Lat	Lateral
LiF	Lithium Florid
mAs	milliampere second
mbar	millibar
MDD	minimum Detectable Dose

mGy	milligray
MINT	Malaysian Institute of Nuclear research Technology
MM	millimeter
mR	milliroentgen
NC	nanocoulomb
PA	Posterior - Anterior
Rad	Radiation Absorbed Dose
RPM	Round per minute
SID	Source Image Distance
SSDL	Secondary Standard Dose Laboratory
TLD	Thermo Luminescent Dosimeter
UK	United Kingdom
USA	United State of America
µGy	microgray
◦C	degree centigrade
◦F	degree fahrenheit

CHAPTER 1

INTRODUCTION

1.1 General introduction

X-ray was discovered in the 1895 by Wilhelm Conrad Roentgen by accident. He spent several weeks working in his laboratory to investigate the properties of X-rays and noticed that when he placed his hand between his energized tube and the barium platinocyanide-coated paper, he could see the bones of his hand glow on the paper with the fluoroscopic image moving as he moved his hand. He also produced a static radiograph of his wife's hand using this new radiation (Alexi A, 1995). This was the first radiograph of the world and has become an important step in physics and medicine. He proceeded to study them so thoroughly that within a very short period of time, he had identified the properties of X-rays that we recognized today.

In medical diagnostic radiology, X-ray creates images help diagnose the patient's medical conditions. The quality of the images produced depends partly on how much radiation is used, which is under the direct control of radiographers and radiologists. To produce a quality X-ray image, the amount of radiation transverse the patient depends on various factors such as type of examination, patient's physical characteristics, and condition of pathology to be imaged and several factors related to instrumentation. One of the major goals of medical radiography is to minimize radiation dose to the patient without compromising the image quality needed to produce an accurate diagnosis (Seeram, and Patrick., 2006). This is the subject of the present study.

1.2 Significance of study

The basic principles of radiological protection as suggested by the International Commission of Radiological Protection (ICRP) are justification of the practice and optimization of protection. Justification is the first step in radiological protection, which has been accepted that, diagnostic exposure is justifiable only when there is a valid clinical indication, no matter how good the imaging performance may be, that every examination must result in a net benefit to the patient (IAEA, 2004). In the area of optimization in diagnostic radiology there is considerable scope for reducing dose without loss of diagnostic information, but the extent to which the measures available are used varies widely. The optimization of protection in diagnostic radiology does not necessarily mean the reduction of doses to the patient. It is paramount that the image obtained contains the diagnostic information as intended (IAEA, 2004).

The need to optimize the protection of patients results from the fact that medical exposures are by far the largest source of exposition of artificial origin. Diagnostic