Australian Journal of Basic and Applied Sciences, 7(7): 383-387, 2013
ISSN 1991-8178

Factors Affecting Backscattered Radiation Dose During Diagnostic X-Ray Examination

[1]Abdullah T. Naji, [2]Mohamad S. Jaafar

[1,2]School of Physics, Universiti Sains Malaysia, Pulau Pinang, Malaysia

Abstract: The purpose of this study was to assess the effect of some factors on reducing backscattered radiation in an X-ray room during diagnostic examinations. The materials include X-ray machine as a source for radiation which is directed normally on the phantom. The backscattered radiation was measured by using ion chamber. The measurements were recorded at different field sizes of X-ray beam, different applied voltages ranged between 60 kVp and 130 kVp which are used for diagnostic examinations, different tube currents ranged from 320 mA to 500 mA, and different distances between the X-ray source and the exposured target surface. The results indicate a number of factors determine the backscattered radiation due to a medical diagnostic X-ray procedure, namely applied voltage, tube current, exposure time, and source of X-rays to surface distance (SSD). Therefore, the reduction of beckscattered radiation can be obtained by the reducing the applied voltage potential, tube current, exposure time, field size of X-ray beam, and increasing the distance between the X-ray source and the surface of the target.

Key words: Factors**,** Reduction, Backscattered Radiation, X-ray, Diagnostic.

INTRODUCTION

Over the past years, a wide debate has been developed on the effects of possible health of exposure to electromagnetic field. At the same time, concern has been increasing on human health (Grandolfo, 2009). Ionizing radiation exposure produces a long term health risk both directly or indirectly (free radical interaction) causing damage to cellular DNA, producing oxidized bases bulky DNA adducts, and DNA strand breaks (Foffa, 2009).

Scattering is one of the possible interactions of X-rays. In the classical description of X-ray scattering, the incoming wave interacts with the electrons which start oscillating and radiating with the wavelength of the incident radiation. It can be shown that this description is valid for electrons bound to the atom when the energy of the incident beam is far from the absorption edges of the material (Díaz, 2006).

Backscattered radiation contributes to a large portion of scattered radiation which is the main source of exposure to radiation workers in an X-ray room (Abdul-Majid *et al*., 2005). Although, scattered radiation can never be completely eliminated, a number of methods are available to reduce its effect, and the reducing the effect of scattered radiation has been achieved through the use of scatter absorbing grids (Gray & Princehorn, 2004).

The problem of radiation load on the medical personnel during radiographic and radiological operations is very urgent because of the position of the workers and patient related to the radiation source, the long time of X-ray exposure (Naryshkin, 2007).

The harmful effects of overexposure to ionizing radiation were seen almost immediately after the discovery of X-ray and its introduction into medicine. The incidence rate of cancer and other harmful effects among users of radiation was relatively high. This change in the hazards of radiation work from relatively hazardous to safer standards by (ICRP) International Commission on Radiological Protection (Cember & Johnson, 2009). The reduction of backscattered radiation is desirable to protect the patient and workers in an X-ray room from unnecessary radiation exposure (Nicholas, 2006).

Equipments:

The equipments used in this experiment include an X-ray machine, ion chamber, and fabricated iron steel grid.

X-ray Machine:

The X-ray machine consists of major components. The major components of an X-ray generator are X-ray tube, high voltage generator, control console, and cooling system.

Ion Chamber:

The ion chamber used for the measurement of backscattered X-ray photons includes model Exradin A10 which is used with electrometer to measure dose, charge, and current.

Corresponding Author: Abdullah T. Naji, School of Physics, Universiti Sains Malaysia, Pulau Pinang, Malaysia
E-mail: ataher8383@yahoo.com, msj@usm.my

Electrometer Max 4000:

The Ion Chamber was used with a Dosimeter Model MAX 4000 which automatically detects the start and stop of radiation exposure by measuring the current crossing predetermined limit thresholds.

Experimental Procedures:

Backscattered radiation doses were measured at different field size of the X-ray beam and different applied voltage ranged (60 kVp to 130 kVp). For examining effect of exposure time on backscattered radiation dose, the results were recorded at different exposure time ranged (0.04 to 0.4 sec). In addition, the results were recorded at an angle of scattering of 160^o with the incident X-ray beam with 80 cm distance from the target material, one meter distance between the X-ray machine source and the target surface (SSD), and 10 × 10 cm^2 field size.

For examining the effect of the current on backscattered radiation dose, different currents ranged from 320 to 500 mA were used. The results have recorded at an angle of scattering of 160^o with the incident X-ray beam, 80 cm distance from the target material, one meter distance between the X-ray machine source and the target material, and 10 × 10 cm^2 field size.

To examine the effect of the distance between the X-ray source and surface of the target (Phantom) SSD on backscattered radiation dose, the results have been recorded at different distances between the X-ray source and the target material. The detector is placed at an angle 160^o with the incident X-ray beam with 80 cm distance from the target material, and 10 × 10 cm^2 field size.

RESULTS AND DISCUSSION

Comparing of Total Doses with Different Field Size:

The relationship between the field size of the X-ray beam and total dose of Back scattered radiation dose was studied at 180^o scattering angle with the incident X-ray beam, and 100 cm distance between the X-ray machine source and the surface of the target material at different field size of the X-ray beam. Due to the high effect of applied voltage (kVp) on the dose scale at different field size, the graph clearly shows the relationship between the field size for each kVp and the total dose

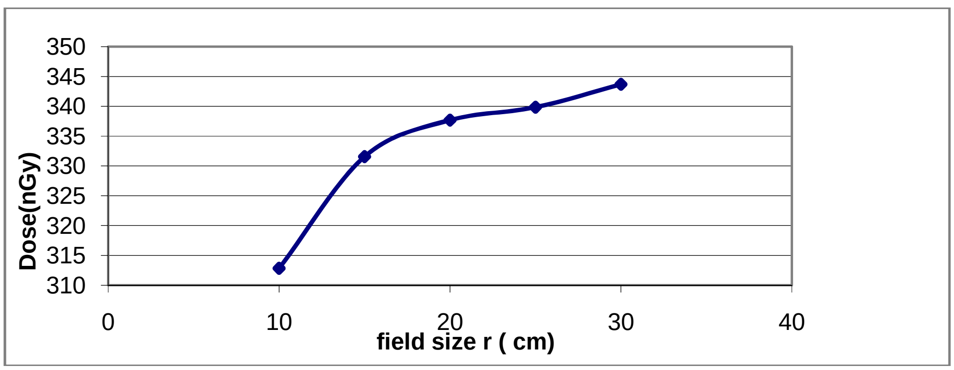

Fig. 1: Effect of the field size on the total dose at 60 kVp

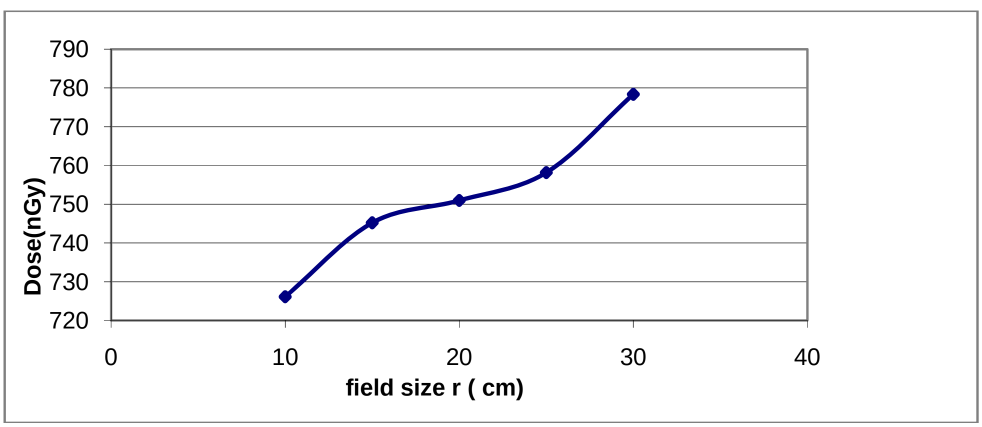

Fig. 2: Effect of the field size on the total dose at 130 kVp

The previous Figures 1 and 2 are describe the backscattered radiation as a function of the field size. They indicate that, the total dose of X-ray is proportional to the field size of the X-ray beam. The transmission factor increases with increasing the field size due to the increasing in the number of photons in the irradiation area, and consequently increasing the probability of scattering. For relatively high kVp, we can see fewer differences between the different field sizes. The backscattered radiation dose increases rapidly with increasing tube voltage (kVp).

Effect of Applied Voltage on Backscattered Radiation Dose:

The effect of applied voltage on backscattered radiation dose was studied for different field sizes at 180^o angle with incident beam, 0.4 sec exposure time, and 320 mA current.

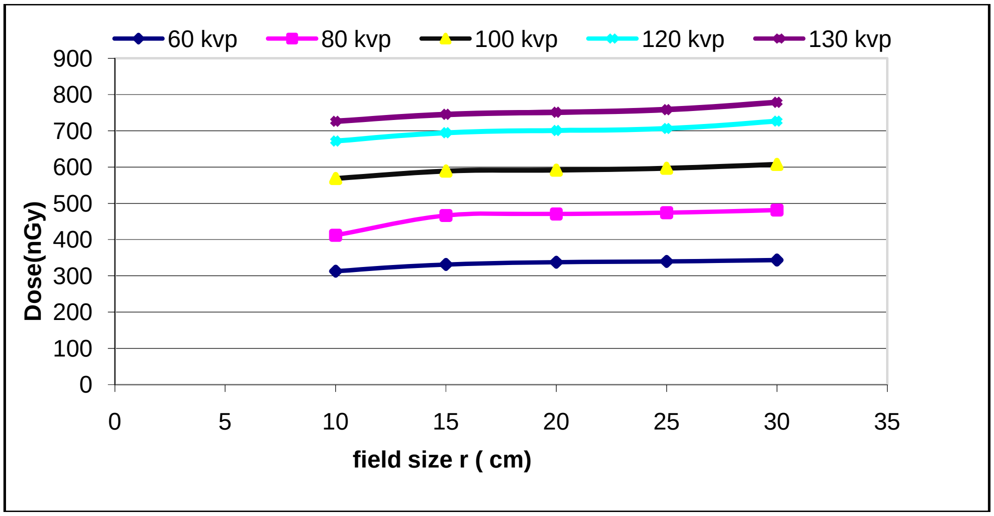

Fig. 3: Effect of the field size on the total dose for different kVp,

Fig. 3 shows that, the effect of applied voltage (kVp) on the total dose due to the X-ray beam energy is characterized by the applied voltage peak kilovoltage (kVp). The magnitude of this effect is directly related to photons energy. Thus, the reduction of the tube voltage and minimize the field size of X-ray beam will decrease the output of the X-ray tube that reduce the radiation and backscattered radiation dose.

Effect of Exposure Time on Backscattered Radiation Dose:

This part concerns the most common reason that affect backscattered radiation dose. the results were recorded for different exposure time at 10×10 cm^2 field size, current = 320 mA, and θ= 160^o.

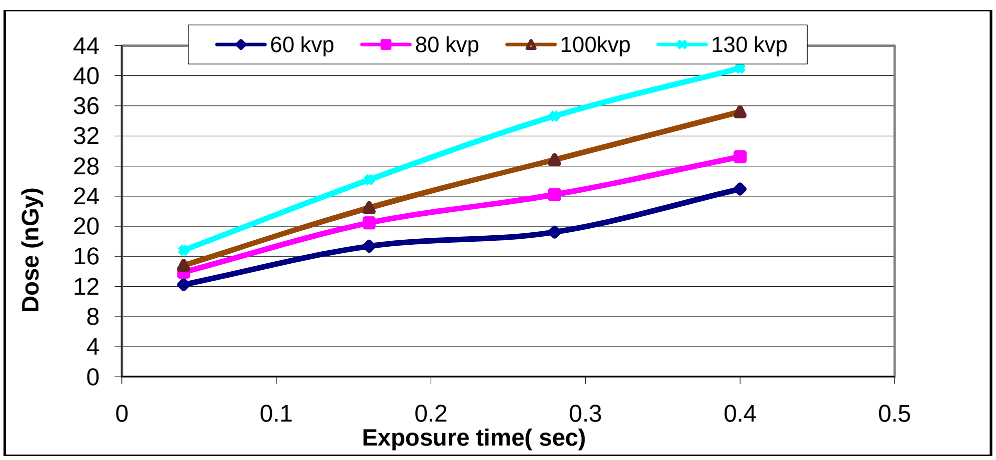

Fig. 4: Backscattered radiation dose of X- ray at different exposure time

The results were recorded for different exposure time ranged from 0.04 sec to 0.4 sec. Fig. 4 shows the relationship between the backscattered radiation dose and exposure time particularly at high applied voltage. When the exposure time is increased, the number of photons generated is increased so that the number of scattered photons is increased. As the backscattered radiation dose is proportional to the exposure time, radiation dose is directly affected by the scan or exposure time, good management of procedure time is crucial for minimizing the personnel radiation dose, due to the exposure time is directly proportional to the amount of ionized radiation, so the reduction in back-scattered radiation dose increases with reducing exposure time.

Effect of Tube Current on Backscattered Radiation Dose:

The used different X-ray tube current ranged between 320 and 500 mA. The results were recorded at an angle of scattering of 160^o with the incident X-ray beam with 80 cm distance from the target material, one meter distance between X-ray machine source and surface of target material, at 1 cm spacing between strips, 10 × 10 cm^2 field size, t = 0.1sec, θ = 160^o.

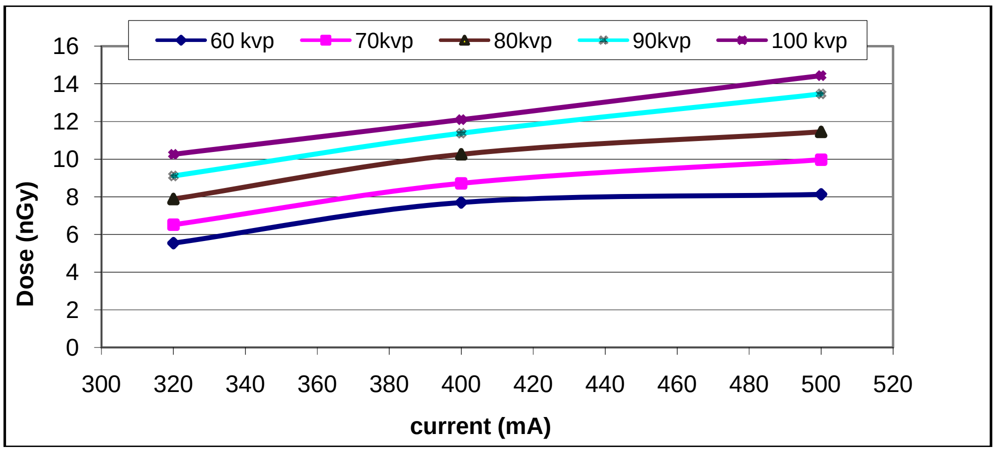

Fig. 5: Backscattered radiation dose of X- ray at different current

Fig. 5 shows that the highest backscattered radiation dose at high current of X-ray tube. In addition, there is a clear relationship between the backscattered radiation dose and the tube current mA, back scattered radiation exposure, and proportional dose to X-ray tube current. Therefore, the most effective way to reduce radiation exposure to both the patient and workers during diagnostic procedures is to reduce the tube current. Reducing in the tube current may lead to the reduction in the backscattered dose which, in turn, results in the radiation dose that is directly affected by the product of tube current.

Effect of the Distance between the X-ray Source and the Surface of the Target (SSD) on the Backscattered Radiation Dose:

This part has concerned with the effect of the distance between the X-ray source and the target surface on the backscattered radiation dose. The results were recorded for different distances between the X-ray source and the target surface- the source (of X-rays)-to-surface distance (SSD). The detector is placed at an angle 160^o with the incident X-ray beam with 80 cm distance from the target material

Fig. 6 shows that the distances between the X-ray source and the surface of exposure target SSD can also affect worker dose for a given individual. The SSD will be determined largely by his or her body's thickness and the accuracy of the exposure position. Normally, the estimated variation in SSD is no more than a few centimeters. On the basis of the inverse square law since increasing the distance decreases the radiation field intensity, we showed that backscatter radiation dose decrease with increasing SSD particularly for high applied voltage. The reduction in back-scattered radiation dose increases with increasing distances between the X-ray source and the surface of the phantom or exposure target.

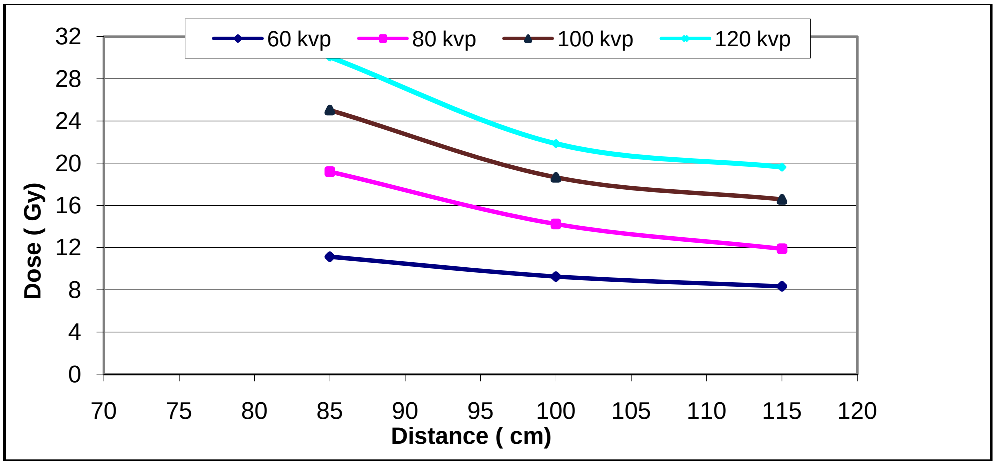

Fig. 6: Backscattered radiation dose of X- ray at different SSD

Conclusion:

During diagnostic examinations, a number of factors increase the exposure of the worker to X-rays and the accompanying absorbed dose he or she receives. The backscattered radiation dose depends not only on the applied potential voltage and tube current, but also on the exposure time, field size, and the distance between the X-ray source and the target surface. The back scattered radiation dose in an X-ray room was measured and the results indicate that the total dose of X-ray is proportional to the field size of X-ray beam and applied voltage (kVp). This means the increase in the field size of X-ray beam gives more incident and backscattered doses. Also, the results show that the backscattered radiation dose is proportional to exposure time and X-ray tube current respectively. However, the back-scattered radiation dose decreases with increasing the distance between the X-ray source and the surface of target.

REFERENCES

ABDUL-MAJID, S., A. KINSARA, A. ALMASOUMI, & M. KALLOTHODY, 2005. Reduction of Backscattered Radiation in Enclosure X-ray Radiography, pp: 27-30.

CEMBER, H. & T.E. JOHNSON, 2009. Introduction to Health Physics, 4th ed., New York: McGraw-Hill Medical.

DÍAZ, A., 2006. X-Ray Scattering Studies of Ordering Phenomena in Colloids Confined in Microcavity Arrays. PhD., Univ. Oviedo, Switzerland.

FOFFA, I., M. CRESCI, & M.G. ANDREASSI, 2009. Health Risk and Biological Effects of Cardiac Ionizing imaging: From Epidemiology to Genes. International Journal of Environmental Research and Public Health, 6: 1882-1893.

GRANDOLFO, M., 2009. Worldwide Standards on Exposure to Electromagnetic Fields: an Overview. The Environmentalist, 29: 109-117.

GRAY, J E. & J.A. PRINCEHORN, 2004. HTC™ Grids Improve Mammography Contrast. Mayo Medical School.

NARYSHKIN, S., 2007. On Methods for Assessing Radiation Load on Medical Personnel During an Endourologic Intervention. Biomedical Engineering, 41: 228-231.

NICHOLAS, J., 2006. Principle of Patient Radiation Protection [Online]. Available: www. ceessential.net [Accessed 04-03-2013].