International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-6, Issue-2, October 2016

Radiation Exposure Factors Affecting on the Capability of Anti-scattered X-ray Grid in Reducing Backscattered Radiation

Abdullah Taher Naji, Mohamad Suhaimi Jaafar

Abstract— **This study aims to evaluate the effect of some exposure parameters on backscattered radiation dose to elucidate the backscattered radiation reduction capabilities of fabricated grids under different exposure sittings such as exposure intensity (mAs), exposed area (field size), dosimeter position (backscattering angle), and distance between x-ray source and imaged object surface (SSD). The results showed that, the effectiveness of fabricated anti-scatter grids in reducing backscattered radiation is dependent the radiation exposure parameters. The fabricated anti-scatter grids show the best attenuation capabilities at relatively low exposure intensity, small field size, small backscatter angle, and long SSD.**

Index Terms - anti-scattered X-ray grid, exposure factors, reducing backscattered radiation.

I. INTRODUCTION

Radiography is a vital and frequently utilized diagnostic tool in medicine, and is considered the most valuable imaging modality for examining bone fractures and other related abnormalities [1], [2]. On the other hand, medical X-ray is one of the largest artificial sources of radiation exposure to patients, workers, and the general populace, hence there exists the problem of safely delivering radiation dose when imaging biological tissues [2], [3]. This problem is caused from incorrect use of X-ray imaging equipment and from the radiation exposure to patient much more than required [4]. Backscattered radiation is defined as a secondary radiation deflected with scattering angle more than 90^{o} from the primary radiation [5]. Hence, backscattered photons refer to the part of scattered radiation that reflects back toward the source of radiation. Backscattered radiation is an important portion of scattered radiation which can cause harm to the patients and workers in an X-ray room if their exposure exceeds the permissible value [6], [7].

When attenuated photons transmit through an exposed target and collide with patient's table or wall bucky, some of the backscattered photons reach the film screen or detectors, possibly affecting the imaging system and initiating the presence of redundant radiation dose in the X-ray room. Therefore, scattered radiation photons (whether side scattered or backscattered) are constantly taken into consideration when producing a radiograph due to its effect on the image quality and exposure of medical personnel to the X-ray [8], [9].

Abdullah Taher Naji, Medical Physics Department, School of Physics, Universiti Sains Malaysia (USM), Pulau Pinang, Malaysia, Mobile No.: 0060183948297

Mohamad Suhaimi Jaafar, Medical Physics Department, School of Physics, Universiti Sains Malaysia (USM), Pulau Pinang, Malaysia, Mobile No.: 0060194785418

The reduction of backscattered radiation can be accomplished by appropriate selection of a material to line the walls on which the primary radiation is incident and by designing a beam catcher that is capable of absorbing significant portion of the scattered radiation [10].

II. EXPERIMENTAL

A. Materials

The experiments of this study involved utilizing a number of equipments and accessories. The list of these instruments includes general radiography system, different anti-scattered x-ray grids constructed from different materials (iron steel and aluminium) with different geometrical design (crossed and linear), different ionization chambers and electrometers, holders, radiographic phantom.

B. Methods

The effectiveness of fabricated anti-scatter grids in reducing backscattered radiation were evaluated by measuring the backscattered dose with and without using fabricated grids under film cassette. The backscattered radiation doses were measured using different dosimeters (ionization chambers). The measurements were carried out with different exposure parameters (radiation intensities, field sizes, SSD, and backscatter angles) to evaluate the effect of these exposure parameters on resultant backscattered radiation measurements as well as on the effectiveness of fabricated anti-scattered grids. Figure 1 shows the experiments settings to measure backscattered radiation doses and illustrates the main components of the experiments including X-ray unit, anti-scattered x-ray grid, ionization chamber, electrometer, and phantom.

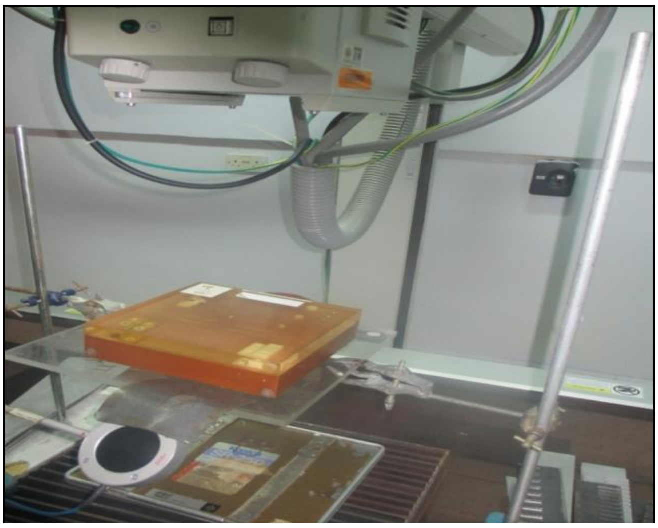

Figure 1: Measurement of backscattered radiation

III. Results and Discussion

A. The effectiveness of anti-scatter grids at different radiation exposure intensities

The effect of mAs on backscattered dose at relatively moderate x-ray energy (70 kVp) was investigated. Also, the capabilities of fabricated anti-scatter grids in reducing backscattered radiation dose at different mAs were estimated. The data was obtained at different exposure intensities (relatively low and high mAs). The dosimeters were positioned at a backscattered angle of 135^o; the SSD was fixed at 85 cm. The anti-scatter grids reduced the backscattered radiation for both mAs. A comparison between backscattered radiation doses at different mAs, with and without using anti-scatter grid is shown in Figure 2.

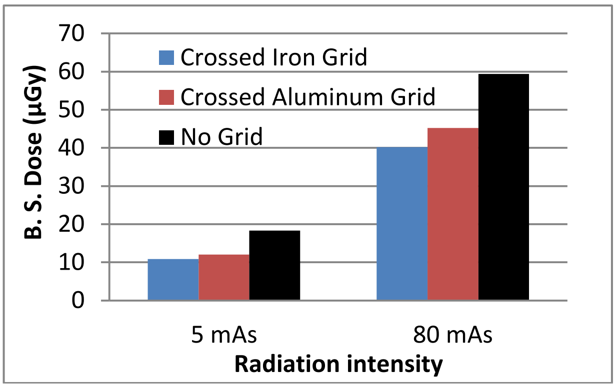

Figure2: Backscattered dose at different radiation intensities

The capability of different anti-scatter grids was evaluated at various mAs. To evaluate the effectiveness of different anti-scatter grids in reducing backscattering radiation; the reduction percentages of backscattered radiation doses are calculated. Figure 3 showed the percentages of backscattered radiation reduction for the two types of anti-scatter grid at various exposure intensities (mAs). Both anti-scatter grids reduced backscattered radiation for various radiation exposure intensities particularly at low exposure intensity (5 mAs). Both anti-scatter grids reduced backscattered radiation at different (mAs) particularly at low mAs due to the statistical nature of recorded doses at low mAs. In addition, the crossed iron grid presented the best capability of reducing backscattered radiation for both mAs compared to crossed aluminium grid due to that iron produces less backscattered radiation.

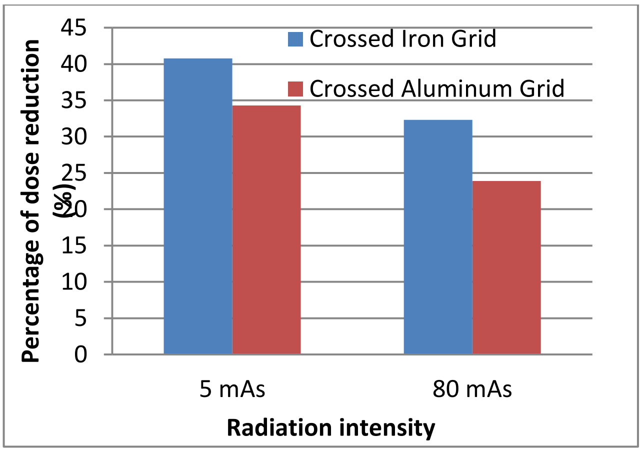

Figure 3: Effectiveness of anti-scatter grids at different mAs.

B. Effect of dosimeter position (backscatter angle) on recorded backscattered dose

The effect of dosimeter position on the recorded backscattered radiation dose was evaluated. The backscattered radiation doses were measured at different backscatter angles between incident and backscattered X-ray beam. The tube applied voltage of the X-ray tube was fixed at 70 kVp for all readings. The readings were obtained for each backscatter angle with and without anti-scatter grid.

The measurements of backscattered radiation dose as a function of backscatter angles between incident and backscattered radiation are shown in Figure 4. The effects of anti-scatter grids on the reduction of backscattered radiation with different backscatter angles were analyzed by comparing the recorded doses with and without using anti-scatter grids. The result shows clearly the relationship between the recorded backscattered radiation doses and the position of dosimeter (backscatter angle). Higher backscattered radiation doses were recorded at 160^o backscattered angle with incident beam while lower backscattered radiation doses were recorded at 90^o angle with central ray of incident beam. The higher backscattered radiation doses which recorded at 160^o can be attributed to the higher volume of backscattered photons that reach to the ionization chamber flat position at this angle, and vice versa (less recorded backscattered dose obtained at 90^o angle between incident and backscattered radiation). This result is in consistent with the Binger's study [11], who similarly reported the dependence of backscattered dose on the angle between central beam axis and scattering material position.

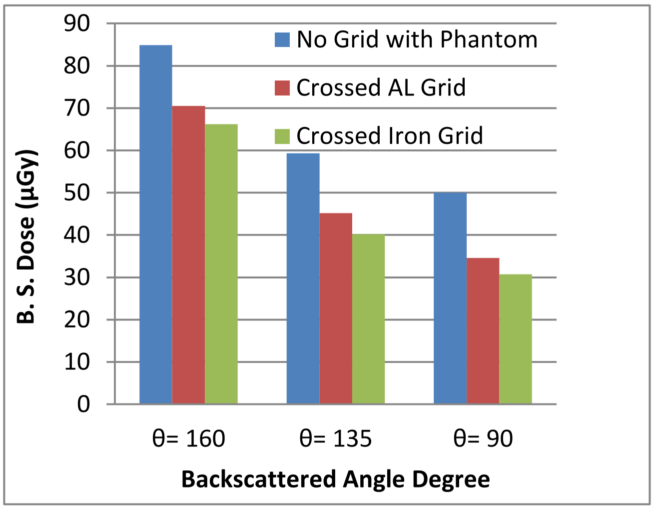

Figure 4: Backscattered radiation dose at different backscatter angles

The dosimeter reading is expressed as incident backscattered photons per unit area of ionization chamber flat because the flounces of backscattered photons depend on backscatter angle and ion chamber position. Thus, at higher backscattered angle, the dosimeter records more backscattered dose.

To determine the capability of different anti-scatter grids in reducing backscattered photons with different backscatter angles (dosimeter positions); the percentages of backscattered radiation doses reduction were calculated and shown in Figure 5. Both grids were most effective in reducing backscattered radiation at backscattered angle of 90^o, given that most of the scattered photons reached to this position remains trapped by strips of anti-scatter grids due to the height and thickness of grid strips. The crossed iron steel grid displayed the best capability in reducing backscattered radiation photons at the various backscattered angles.

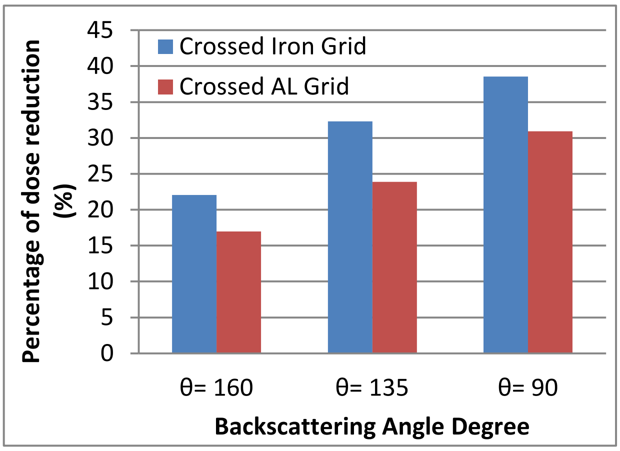

Figure 5: Capability of grids in reducing photons with different Backscattering angles

C. Effect of X-ray field size on recorded backscattered dose

The effectiveness of anti-scatter grids at different field sizes or exposed areas was evaluated. The backscattered radiation doses were measured at different field sizes of incident X-ray with an X-ray tube voltage of 90 kVp and relatively short SSD. Backscattered radiation doses were recorded with and without using anti-scatter grids for each field size.

It is evident from Figure 6 that backscattered radiation dose is directly proportional to the field size of incident radiation (exposed area). This result is consistent with the by Bushberg's study [12], who reported that scattered radiation is proportional to the field size of incident X-ray. In addition, [13] reported that skin dose increased as the field size increased. Whereas [14] reported that backscattered factor depends on the irradiated area of the phantom, and the intensity of backscattered radiation increases rapidly with increase in field size as a result of increasing in the number of incident photons on the exposed target.

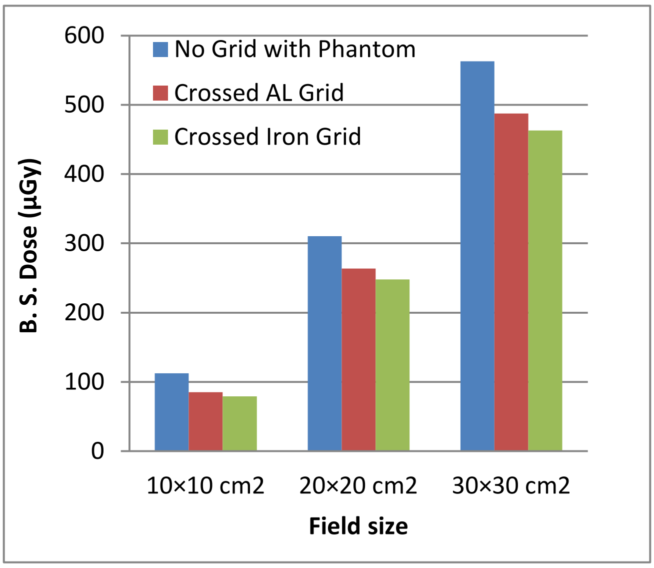

Figure 6: Backscattered radiation dose at different field size.

Both anti-scatter grids presented capabilities in reducing backscattered dose with different field sizes. The effect of anti-backscattered radiation grids on the attenuation of backscattered radiation reflected from different exposed areas is shown in Figure 7. The capabilities of the anti-scatter grids are expressed as a function of field size (exposed area). For both anti-scatter grids, the backscattered dose reduction percentages for small field size are much greater than percentages for large field size. This disparity can be attributed to the statistical nature of backscattered dose measurements (dose quantities and ratio of doses change), as well as the dependence of backscattered photons number on exposed area, which affects the distribution of backscattered radiation. These results are consistent with [15], who reported that the amount of scattered radiation that reaches a film increases with increase in the exposed volume of tissue to the X-ray. For all exposed areas, crossed iron steel grid proved the most effective in reducing backscattered radiation dose compared to crossed aluminium grid due to the trapping capability of the grid material.

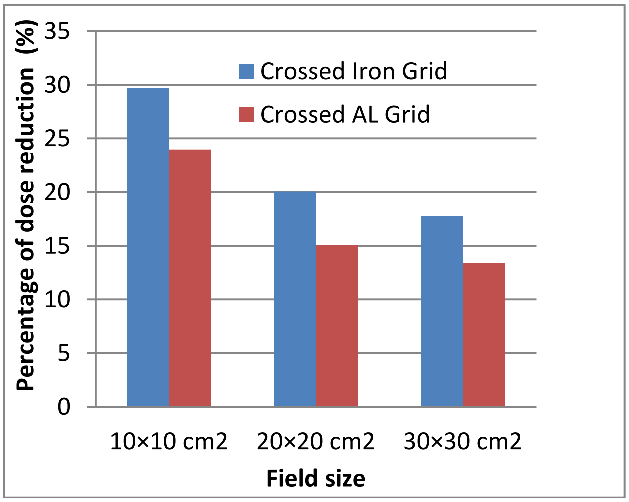

Figure 7: The effectiveness of anti-scatter grids at different exposed area

D. Effect of distance between X-ray source and imaged object surface (SSD) on backscattered radiation doses

The effect of the distance between X-ray source and the surface of imaged object (Phantom) on backscattered radiation dose quantity and on the effectiveness of anti-scatter grids was evaluated. Backscattered radiation doses were measured with and without using anti-scatter grids at different SSD. The dosimeters were fixed at 160^{o} backscatter angle with the incident X-ray beam. The X-ray voltage and exposure intensity were fixed at 90 kVp and 80 mAs, respectively, for all setups. The relation between SSD and backscattered radiation is illustrated in Figure 8, which also presents the effectiveness of anti-scatter grids at various SSD. Based on the inverse square law, the increase of SSD reduced incident radiation intensity, which in turn reduced the backscattered radiation. Higher backscattered radiation doses were obtained at short SSD and vice versa. This deduction is consistent with studies by [16], who reported that changes in SSD or the position of X-ray device affect the overall radiation exposure dose delivered to patients and operators. In addition, [17] reported that X-ray quantity can be reduced by increasing the distance from X-ray source and target because X-ray intensity varies inversely with the square of the distance from the X-ray tube. As a result, the reduction of primary photons number by increasing SSD causes less backscattering photons.

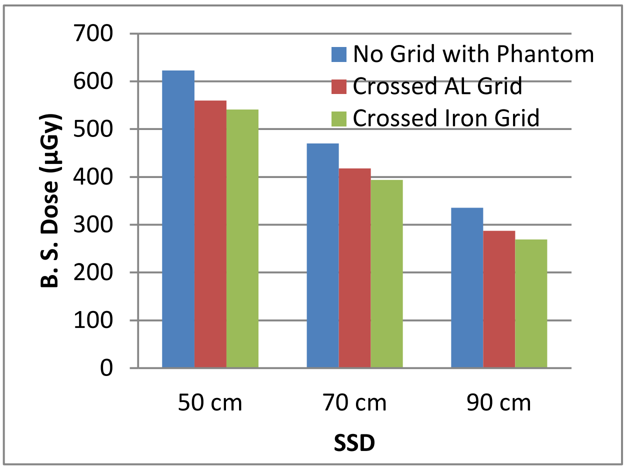

Figure 8: Backscattered radiation dose at different distance from X-ray source

Less backscattered radiation doses were obtained using anti-scatter grids as shown in Figure 8. The percentages of backscattered radiation reduction from the use of anti-scatter grids at different SSD were calculated and illustrated in Figure 9. Both grids proved capable of trapping backscattered radiation dose for all distances. The highest radiation reduction for both grids was obtained at long distance SSD. The crossed iron steel grid showed better reduction of backscattering radiation at all distances (SSD) because of the density and radiation attenuation capability of iron.

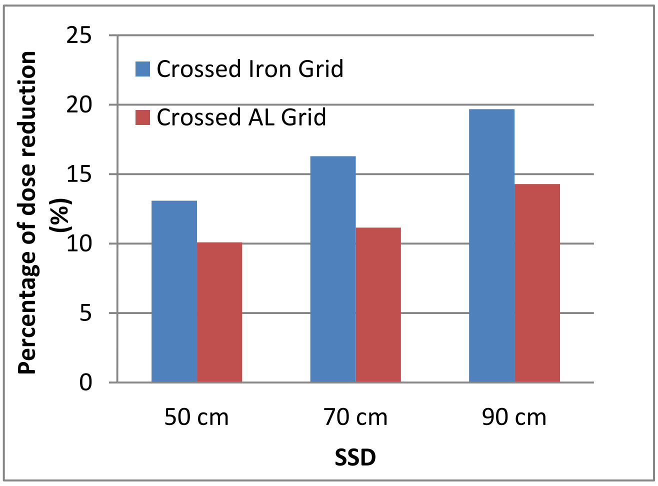

Figure 9: Effectiveness of anti-scatter grids at different SSD

Collectively, the reduction percentage of backscattered radiation due to using anti-scattered grid is affected by several exposure parameters such as exposure intensity (mAs), the distance from X-ray source (SSD), and exposed area.

IV. Conclusion

Reduction of back scattered radiation in an X-ray room is needed in order to protect patients, medical personnel, and general public from redundant radiation dose and to enhance X-ray image quality. The capability of materials in attenuating of X-ray is also dependent on many factors such as material density, components, atomic number, and exposure parameters (mAs, backscattering angle, field size, SSD). Therefore, the reduction of backscattered radiation dose can be obtained by adequate changes of exposure parameters. The results of this study can be applied to develop guidelines for the reduction of backscattered radiation using anti-scatter grids.

References

[1] Mohanta, K. and V. Khanaa, An Efficient Contrast Enhancement of Medical X-Ray Images–Adaptive Region Growing Approach. International Journal of Engineering and Computer Science, 2013. 2(2): p. 208-212.

[2] Mittone, A., Development of X-ray phase-contrast imaging techniques for medical diagnostics: towards clinical application. 2015, München, Ludwig-Maximilians-Universität, PhD Thesis.

[3] Foffa, I., M. Cresci, and M.G. Andreassi, Health risk and biological effects of cardiac ionising imaging: from epidemiology to genes. International journal of environmental research and public health, 2009. 6(6): p. 1882-1893.

[4] Sezdi, M., Dose optimization for the quality control tests of X-ray equipment, Modern Approaches To Quality Control. 2011: INTECH Open Access Publisher, Available from: http://www.intechopen.com/books/modern-approaches-to-quality-control/dose-optimization-for-the-quality-control-tests-of-x-ray-equipment.

[5] Farlex, Medical Dictionary for the Dental Professions, in Available at Website:http:// medical dictionary. thefreedictionary.com /backscatter+radiation "> backscatter radiation. 2012.

[6] Engel-Hills, P., Radiation protection in medical imaging. Radiography, 2006. 12(2): p. 153-160.

[7] Tsapaki, V., Tsalafoutas, I. Radiation doses to patients undergoing standard radiographic examinations: a comparison between two methods. The British Journal of Radiology, 2014. 80: p. 107-112.

[8] JAENISCH, G.-R., U. EWERT, and M. JECHOW, Scatter radiation in radiography. 2010, Federal Institute for Materials Research and Testing, Berlin, Germany.

[9] Neugschwandtner, K., et al., Evaluation of radiation exposure in interventional radiology (IR) using active personal dosimeters (APD), in Radiation Protection and Health Proceedings, Radiation Protection and Dosimetry. 2015, IAEA.

[10] Abdul-Majid, S., Kinsara, S., A. Reduction of Backscattered Radiation in Enclosure X-ray Radiography. in 3rd Middle East Nondestructive Testing Conference and Exhibition. 2005.

[11] Binger, T., et al., Dose inhomogeneities on surfaces of different dental implants during irradiation with high-energy photons. Dentomaxillofacial Radiology, 2014.

[12] Bushberg, J.T. and J.M. Boone, The essential physics of medical imaging, Third edition. Third edition ed. 2012: Lippincott Williams & Wilkins.

[13] Yadav, G., R. Yadav, and A. Kumar, Skin dose estimation for various beam modifiers and source-to-surface distances for 6MV photons. Journal of Medical Physics, 2009. 34(2): p. 87-92.

[14] Camargo-Mendoza, R.E.,. Poletti, E., M.., Measurement of some dosimetric parameters for two mammography systems using thermoluminescent dosimetry. Radiation Measurements, 2011. 46(12): p. 2086-2089.

[15] Hendee, W.R. and E.R. Ritenour, Medical imaging physics. 2003: John Wiley & Sons.

[16] Wagner, L.K., B.R. Archer, and A.M. Cohen, Management of patient skin dose in fluoroscopically guided interventional procedures. Journal of Vascular and Interventional Radiology, 2000. 11(1): p. 25-33.

[17] Bushong, S.C., Radiologic science for technologists: physics, biology, and protection, 10th edition, ISBN 978-0-323-08135-1. 10th edition ed. 2013: Elsevier Health Sciences.