PVC AS A POTENTIAL FILTER MATERIAL FOR IONISING RADIATION

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ABSTRACT

Aluminum (Al) is a standard material that has been used as a filter for ionising radiation however for polyvinyl chloride (PVC) there is no solid evidence to support but has been recommended. PVC has been selected as a potential filter material due to it being a long lasting constructing material and very durable, which can be used in a variety of applications. The purpose of this study was to observe the effect of PVC on entrance surface dose (ESD) values as compared to the standard X-ray filter of Al. The effect of varying thickness of the materials and difference exposure settings were observed and compared to each other. From this study, the percentage difference for both PVC and Al thickness is less than ± 25.00 % shows that PVC has a potential to be used as one of the filter materials due to its ability to reduce the ESD value.

INTRODUCTION

In the field of radiographic imaging, X-radiation (X-rays) is used to visualise the image of the part of interest in the human body. X-rays is an ionising radiation

that can interact with atoms in material, which changed and ionised the atom or structure by removing the tightly bound electron from the outer shell (WHO, 2015). The ionising radiation can be filtered using a certain type of materials.

Filter can be defined as an object or material that is made to differentiate the ionising radiation energy (Carlton et al., 2006). The distance of the filter material from the ionisation radiation can affect the attenuation rate of the ionising radiation. The longer the distance of the ionising radiation to the filter, the lower the energy of the ionising radiation can pass through the filter. Aluminium (Al) has been being used in the radiographic imaging field as a filter material for the X-ray beam radiation exposure reduction (Trout et al., 1952), also considered as a standard and most commonly used as filter material (Carlton et al., 2006). Besides Al, there are several materials that being suggested to be used as a filter such as ytterbium (Yb), tantalum (Ta) and lead (Pb) (Ohshita et al., 2007), including the polyvinyl chloride (PVC) (Junet et al., 2014).

PVC has been selected as a potential filter material due to it is a long lasting constructing material and very durable, which can be used in a variety of application (BPF, 2015) and it has been commonly used in many application and the behavior of PVC is studied with ionising radiation (Labed et al., 2013). There are many journals and books that have mentioned Al as the filter material, but for PVC, it does not have sufficient evidence that can support it being used as a filter material.

In this paper, a comparison between PVC and Al as a filter material has been studied. This is to observe the effect of PVC as a filter material for radiation exposure reduction. The result shown by the PVC will be compared with the Al as it is a well-known material as a filter [2, 3].

MATERIALS AND METHODS

Materials

The materials used for this study were Al and PVC pipe pressure rating Class E (PN 25) flat sheets. Due to PVC flat sheets not being available in the market, the PVC pipe was converted to PVC sheet manually. The PVC pipe was put inside an aluminium container and then it was heated using a blower for about 10 minutes. The PVC pipe was cut to half and then reheated back with the hair blower for another 10 minutes. After the PVC was soft enough, the PVC pipe was pressed until it became a flat sheet.

The Al and PVC sheets consisted of four different thickness which were 1.5 mm, 2.0 mm, 2.5 mm and 3.0 mm was cut in a shape of square (11.5cm x 11.5cm).

Methods

This research was done in the Diagnostic Imaging and Radiotherapy Department at International Islamic University Malaysia (IIUM), Kuantan, Pahang, Malaysia. The X-ray machine that was used to replace ionising radiation sources is Siemens POLYDOROS IT 80 and radiation dosimeter that being used to detect radiation dose is Radcal model 9095 with 10X9-60E ion chamber.

This study was conducted by using fixed values of exposure factors. The peak kilovoltage (kVp) being applied is 40 kVp, 5 milliampere-second (mAs). The lowest value of kVp that X-rays machine system can give is 40 kVp which was the reason for the selection of the lowest value of kVp for this research.

The 10X9-60E ion chamber was placed top of the table bucky and being held with tape to avoid the ion chamber from moving from its original place. The center of the X-ray tube must be placed at the center of the ion camber. The filter material flat sheets were put on top of the ion chamber. The Radcal 9095 reading was set to auto dose which can provide the total-dose measurement. The entrance surface dose (ESD) reading was taken three times and averaged to avoid any parallax error. Then, filter materials were changed from one thickness to another. The material was changed from PVC to Al and the experiment was repeated again using different thickness of filter materials flat sheet.

RESULTS AND DISCUSSION

Experimental results of the findings are shown in Figure 1. The control mean ESD value is 63.50 μGy with no filter material being applied.

In Figure 1 the pattern shows that the mean ESD values are decreased as the thickness of the Al and PVC are increased. As shown in the graph, for lowest Al thickness uses (1.5mm), the mean ESD value is 35.7 μGy and for the highest Al thickness (3.0 mm), the mean ESD reading is 20.92 μGy. Meanwhile, for lowest PVC thickness uses (1.5mm), the mean ESD value is 37.02 μGy and for the highest PVC thickness (3.0 mm), the mean ESD reading is 25.03 μGy. These mean ESD values show that it is respectively lessened from the control value of 63.50 μGy.

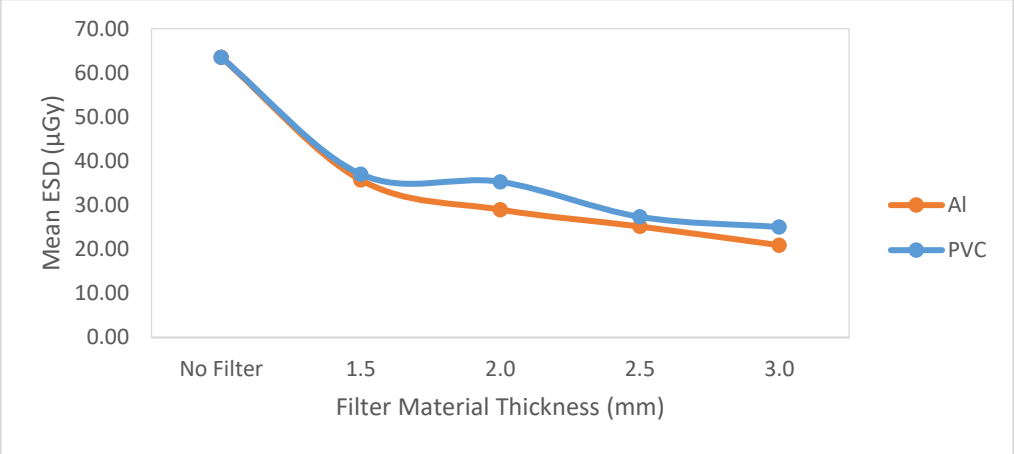

Figure 1. Graph shows means entrance surface dose (ESD) values versus increment in filter material thickness

The Figure 2 illustrates the ESD value for PVC thickness of 1.5 mm is 37.02 µGy, the ESD value for Al thickness of 1.5 mm is 35.7 µGy. The percentage difference for the materials is ± 3.7%. When the PVC and Al thickness is increased to 2.0 mm, the ESD value for PVC is reduced to 35.3 µGy, while for Al is 28.99 µG. The percentage difference for PVC and Al thickness of 2.0 mm is ± 21.77%. At PVC and Al thickness of 2.5 mm, the ESD value for PVC is 27.36 µGy and Al is 25.16 µGy. For PVC and Al thickness of 2.5mm, the percentage difference is ± 8.74%. Lastly, the ESD value for PVC and Al thickness of 3.0 mm are 25.03 µGy for PVC and 20.92 µGy for Al respectively. The percentage difference for both PVC and Al thickness of 3.0 mm is ± 19.65 %.

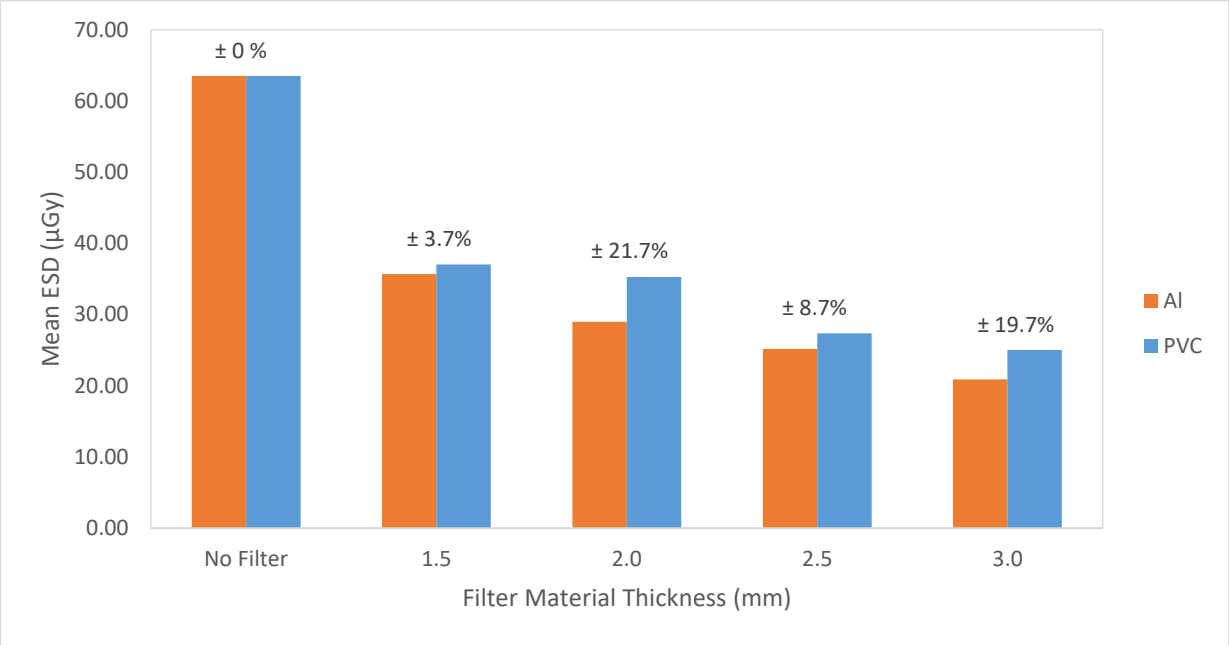

Figure 2. Graph shows the percentage difference between Al and PVC filter with the equal thickness

Compared the control mean ESD value and the results collected for different materials and thickness, there is significant decrease in mean ESD values when the thickness of the Al and PVC are increased. The thickness of the materials is one of the factors that can affect the rate of attenuation and higher thickness will result in more ionising radiation to be absorbed by materials (Mcketty, 1998). The highest thickness of Al and PVC is able to reduce the ESD value more than the lowest thickness of Al and PVC. As the thickness of the Al and PVC were increased, the

attenuation rate of ionising radiation will increase and the ESD value will decrease. Therefore, energy that is being detected by the ionising chamber will be lowered as the incidence photon energy is being filtered.

CONCLUSION

In conclusion, it can be suggested that the Al have higher ability to reduce the ESD value compared to the PVC. Higher atomic number of the materials can result in higher rate of attenuation (Mcketty, 1998). The results obtained from this study have suggested that PVC also can be used to reduce the ESD value. However, Al has higher ability to reduce the ESD value as compared to the PVC. From the data above, the percentage difference for both PVC and Al thickness for all thickness is less than ± 25.00 %. Therefore, it can be suggested that PVC has a potential characteristic to be used as a filter material for ionising radiation similar to Al material.

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