International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

ISSN:2347-6567

IJAMSCR |Volume 7 | Issue 4 | Oct - Dec - 2019
www.ijamscr.com

Research article *Medical research*

Dose rate optimization and image quality based relations source image distance (SID) and diagonal flat detector (FD) on catheterization laboratory

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ABSTRACT

Interventional Radiology (IR) experiencing very rapid development, this procedure is widely used both in adults and children even in patients with contra indications for surgery. However, this procedure is associated with high radiation risk. This study aims to determine the dose rate optimization and image quality based on the relationship of Source Image Distance (SID) and Diagonal Flat Detector (FD) on catheterizatio n laboratory. The study used 25 cm thick PMMA phantom. From the research , an analysis is carried out to determine the dose optimization and image quality. Doses rate are measured using a solid state detector while image quality studies are shown with spatial resolution through the Modulation Transfer Function (MTF) analysis. The results showed that the smallest SID was 90 cm, dose rate was 0.119 mGy/s, while the largest SID was 120 cm, dose rate was 0.243 mGy /s, while the diagonal FD variation showed the largest dose rate at FD 15 cm, namely 0.263 mGy/s and the smallest dose rate at 48 cm FD is 0.109 mGy/s. Analysis on the image shows that the largest spatial resolution was found at SID 105 cm with MTF of 2.69 lp/mm, in diagonal variations FD the largest MTF value was at FD 27 cm with MTF 2.77 lp/mm, so dose optimization and quality optimization The image is shown at SID 105 cm and diagonal FD 27 cm because in these conditions we get a good image quality with a small dose rate.

Keywords: Dose rate, Image quality, Source Image Distance, Diagonal Flat Detector, Modulation Transfer Function

INTRODUCTION

Studies have suggested that catheterization laboratory account for the largest dose of radiation in interventional radiology compared to other x-ray examination modalities. Interventional radiology and interventional cardiology account for a significant proportion of the population collective doses from medical exposure [1]. Interventional fluoroscopy can provide more radiation to the patient's skin during the interventional procedure than most radiation therapies in one treatment [2]. The radiation dose from interventional procedures using fluoroscopy is the highest [3].

Interventional procedures are only about 12% of all radiological procedures but contribute to about 48% of the total collective dose in adult cardiac patients [3]. Flat detector (FD) technology for digital X-ray imaging was first introduced in the late 1990s [4]. The new FD system has seven FOV (Field of View) available from 15 to 48 cm [5]. The advantages of this system are its large dynamic range, high sensitivity to X-rays, distortion-free images and good contrast [6]. Since then this new technology has been set to become the main standard in digital X-ray imaging replacing the combination of analog film screens and digital phosphorus storage systems [4]. During the admission test and commissioning process it is not possible to evaluate all procedures to choose the appropriate initial settings.

The compromise was adopted by the manufacturer to choose an arrangement that had been tested by other hospitals [7]. Studies have been carried out, Simon et al. [7] analyzing the relationship between image quality and air kerma carried out on FD systems in interventional radiology. Pantos et. al [1] conveyed that the radiation dose of patients in IR procedures can be assessed either by measurements in clinical practice or measurements using phantom. Vano et al. [8] examined the Entrance surface of kerma water (ESAK) in phantoms with a thickness of 20 cm, the ESAK values for fluoroscopic mode ranged from 7.1 to 121.7 mGy while for cine mode ranged from 63 to 400 mGy.

Quality in medical field X-ray imaging depends on the characteristics of X-ray photons produced by X-ray tubes, detection of X-ray photons by detectors and image processing. Endovascular intervention procedures are usually performed with fluoroscopy C arm. In this procedure, the image must be of high quality [9]. Spatial resolution is the ability to distinguish objects that are located close together in an image. Modulation transfer function is an objective way to determine the characteristics of spatial resolution [10].

Material and Method

The study used a fluoroscopic for catheterization laboratory with c arm rotation. The measuring instrument used is a solid state detector with radiographic and fluoroscopic sensors, phantom of polymethyl methacrylate (PMMA) thickness of 25 cm. The study was conducted by placing phantom on the examination table with x-ray tube under the examination table. Then do research with a variety of source image detector (SID) totaling 90 cm, 95 cm, 100 cm, 105 cm, 110 cm, 115 cm and 120 cm, with the distance of the radiation source to a fixed object. The study continued with diagonal flat detector (FD) variations of 15 cm, 19 cm, 22 cm, 27 cm, 31 cm, 37 cm, 42 cm and 48 cm. The results of the study were then analyzed for the dose rate and the spatial resolution value shown by the modulation transfer function, from this result an optimization of dosage and image is obtained. Research scheme as shown in Figure 1.

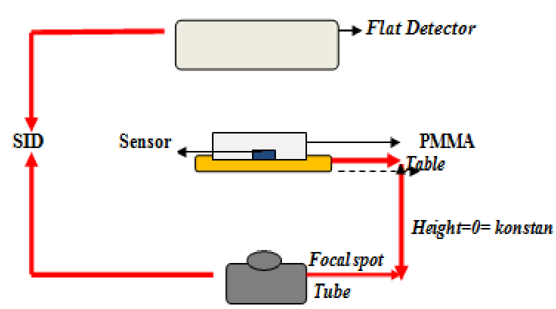

Figure 1. Research schematic

Result and Discussion

The results of research on dose rate optimization and image quality based on the source image distance (SID) and diagonal flat detector (FD) relationship on catheterization laboratory are shown in figure 2 (a) and (b).

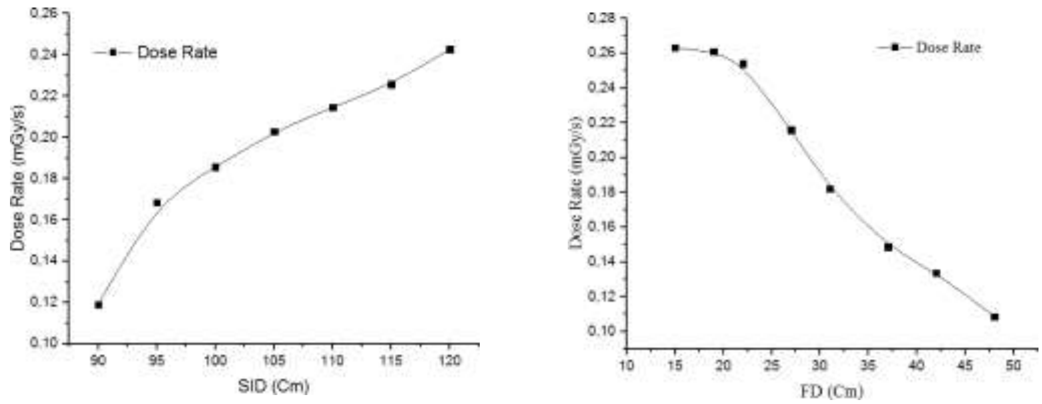

Figure 2 (a) SID vs Dose Rate (b) Diagonal FD vs Dose Rate

Figure 2 (a) shows a graph of the function between SID versus dose rate. It can be seen that the dose rate increases with increasing SID. The smallest dose rate is 0.119 mGy/s at 90 cm SID and the largest dose rate is 0.243 mGy/s at 120 cm SID. The increase in dose rate is due to the amount of scattering that is caught by the detector increases with increasing SID.

Figure 2 (b) shows a graph of the function between the diagonal FD versus dose rate. It can be seen that dose rate decreases with increasing FD. The smallest dose is 0.109 mGy/s at FD 48 cm and the largest dose is 0.263 mGy/s at FD 15 cm. This is because the area of the field is constant while the diagonal FD increases, so as the FD increases the amount of radiation scattering can be received by the detector. Spatial resolution research using the Modulation Transfer Function (MTF) obtained results as shown in Figure 3 (a) and (b).

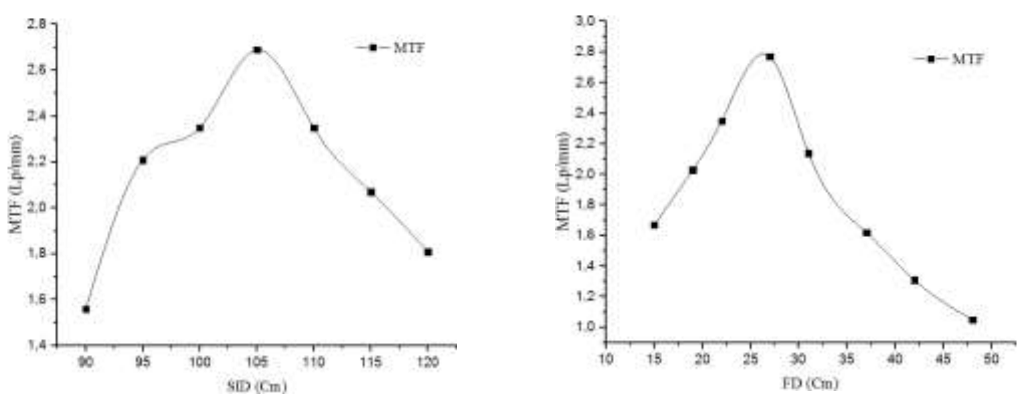

Figure 3 (a) SID vs Spatial Resolution (b) Diagonal FD vs Spatial Resolution

Figure 3 (a) Shows a graph of the function between SID versus spatial resolution. It can be seen that in the SID variation, the MTF value is between 1.56 lp / mm to 2.69 lp / mm, with the peak of the MTF at 105 cm SID. So it can be said that the largest spatial resolution is at SID 105 cm. This happens because the digital exposure factor adjustment will adjust to the translucency of the object, the magnification factor that can cause motion blur and the detector efficiency.

Figure 3 (b) Shows the FD diagonal variation, the MTF value is between 1.05 lp / mm to 2.77 lp / mm, with the peak of the MTF diagonal FD 27 cm. This happens because magnification can reduce spatial resolution, digitizing exposure factor settings and detector efficiency.

If the spatial resolution is related to the average dose value received to the patient, it can be shown in Figures 4 (a) and 4 (b).

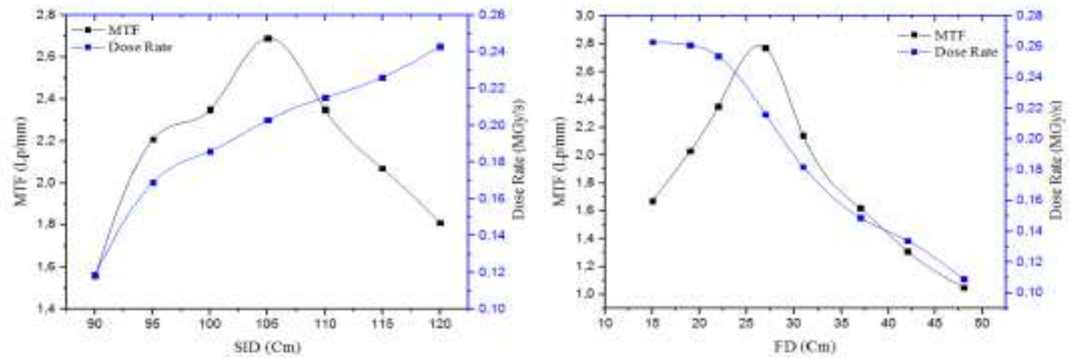

Figure 4 (a) SID vs MTF (b) Diagonal FD vs MTF

CONCLUSION

The dose rate increases with increasing SID, whereas the greater the diagonal FD the smaller the dose rate. The image optimization is SID 105 cm and diagonal FD 27 cm. When connected between SID vs diagonal FD with dose rate and optimization of image quality, the SID 105 and diagonal FD 27 cm are the optimization of dose rate and image quality on cateterization laboratory.

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How to cite this article: Supriyati, Wahyu Setia Budi and Heri Sutanto. Dose rate optimization and image quality based relations source image distance (SID) and diagonal flat detector (FD) on catheterization laboratory. Int J of Allied Med Sci and Clin Res 2019; 7(4): 1321-1324.
Source of Support: Nil. **Conflict of Interest:** None declared.