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General Radiographic Patient Dose Monitoring Using Conformity Test Data

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Abstract

Currently, the Nuclear Energy Supervisory Agency (BAPETEN) is actively guiding users or license holders related to patient protection against radiation hazards or often referred to as radiation protection and safety on medical exposure. Protection against medical exposure became a big issue when the mandatory compliance test on X-ray equipment for diagnostic and interventional radiology was introduced. In addition, license holders through their medical practitioners are also required to use the level of medical exposure guidelines. While PERKA BAPETEN No. 9, 2011 concerning the Suitability Test of Diagnostic and Interventional Radiology X-Ray device, states that one of the test parameters that directly affect the patient's radiation dose and determine the feasibility of operating the X-Ray device to the patient is information on the dose or rate of radiation dose received by the patient. Monitoring doses with Entrance Surface Air Kerma (ESAK) or what is often referred to as ESD (entrance surface dose) using suitability conformity test data starting from 50, 60,70,80,90 and 100 kVp with 20 mAs at SID 100 meters. The results of the research on the value of ESAK was 0.049 mGy, an ESAK value that still met the national I-DRL value from BAPETEN Regulation No. 1211/K/V/2021.

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1 Introduction

The X-ray machine is a device used to perform medical diagnoses using X-rays. The beam emitted from the tube is directed at the body part to be diagnosed. The X-ray beam will penetrate the body part and will be captured by the film so that an image will be formed of the irradiated body part (Sutapa et al., 2018; Wilks, 1987). Before operating the X-ray machine, it is necessary to set the parameters to get the desired X-ray. These parameters are voltage (kV), tube current (mA), and exposure time (s) (Adler et al., 1992; Akhadi, 2000). Tube voltage on X-ray equipment is one of the factors that can be controlled to reduce scattered radiation and reduce the patient's dose of radiation hazards or in the regulatory language is radiation protection and safety in medical exposure used in radiodiagnosis (Vassileva, 2004). Protection against medical exposure became a big issue when the mandatory compliance test on X-ray equipment for diagnostic and interventional radiology was introduced (Sikumbang, 2018; Susilo & Setiowati, 2012). In addition, licensees through their medical practitioners are also required to use the level of medical exposure guidelines when performing diagnostic and interventional radiology procedures. In PP No. 33, 2007 Articles 39 and 40 stipulate that medical practitioners are required to use medical exposure guidelines to optimize patient protection and to ensure that medical exposure guidelines are complied with (Horner & Devlin, 1998; Sherrick et al., 1994). The Guidance Level is the guiding value that should be achieved through the implementation of medical activities with tested methods. Guidance values for diagnostic radiology activities are expressed in dose values or dose rates. While PERKA BAPETEN No. 9 of 2011 concerning the Suitability Test of Diagnostic and Interventional Radiology X-Ray device, states that one of the test parameters that directly affect the patient's radiation dose and determine the feasibility of operating the X-Ray device to the patient is information on the dose or rate of radiation dose received by the patient (Suryatika et al., 2019; Putra et al., 2020).

2 Research Methods

The research was conducted at the Radiology Unit of the Kasih Ibu Hospital Kedonganan. Meanwhile, data analysis was carried out at the Biophysics and Medical Physics Laboratory at Bukit Jimbaran Campus. The tools used in this study were X-ray aircraft, CR (Computer Radiography), Lux meter, Humidity meter, thermometer, patient medical records, and conformity test data (Yoo et al., 2013; Ribeiro & Yoshimura, 2008). Patient identification information that is needed other than age group is gender and weight. Each type of examination requires data of at least 10 patients for each type of examination that is infrequent or infrequent and 20 patients for each type of examination that is frequent or multiple (Suandayani et al., 2020). If the facility can estimate the patient's workload per type of examination for each modality, then the number of patient samples required is at least 30% of the workload. In this research, an X-ray machine was used with voltage variations ranging from 50, 60, 70, 80, 90, and 100 kVp, the tube current was set to 200 mA and the SID was 100 cm. Medical record data were taken for thorax examination because this examination most often occurs in radiology units and conformity test data (Rusmanto, 2016).

3 Results and Discussions

The research data used is the conformity test data for X-ray device Kasih Ibu Hospital, Kedonganan, Badung, Bali. Information on radiation output dose data such as field area 20 cm × 20 cm, tube current 200 mA, setting time 0.1 s, SID 100, and average patient thickness (tp) for PA projection of 23 cm (Costa & Pelegrino, 2014; Porto et al., 2014). With the test data for the suitability of the X-ray tube voltage, it is possible to determine the dose in Gy and the radiation output in Gy/mAs which is exemplified as follows:

$$D(mR) = \frac{P\ mAs\ (kV)^2}{r^2}$$

Where:

D : Exposure dose in mR
P : X-ray machine factor (P = 15)
mA : X-ray tube current
kV : X-ray tube voltage

r : SID, distance from source to detector in cm

For a voltage that is set to 50 kV and the measured voltage is 48.90 kV, the exposure dose can be determined as follows:

$$D(mR) = \frac{15 \times 20(48{,}90)^2}{100^2}$$
$$= 74{,}6 \text{ mR}$$

Next, the unit conversion is carried out from the dose in mR to the dose in Gy as shown below:

$$1mR = 10^{-3}R, \quad where\ 1R = 0{,}87\ rad$$
$$= 10^{-3} \times 0{,}87\ rad, \quad where\ 1rad = 10^{-2}Gy$$
$$= 0{,}87 \times 10^{-5}Gy$$
$$= 87\mu Gy$$

So that:

$$74{,}6\ mR = 74{,}6 \times 87\mu Gy$$
$$= 6490\mu Gy$$

And the radiation output is 6490 Gy/20 mAs = 324.5 Gy/mAs, other data can be shown in Table 1.

Table 1
X-Ray tube voltage conformity test data

No.	kV seting	kV measured	% Eror	mAs	Dose (µGy)	Radiation output (µGy/mAs)
1	50	48,90	2,20%	20	6490	324,5
2	60	59,25	1,25%	20	8810	440,5
3	70	67,98	2,89%	20	10360	518,0
4	80	77,68	2,90%	20	11970	598,5
5	90	85,82	4,64%	20	13890	694,5
6	100	98,80	1,20%	20	16010	800,5

Where the percentage error (% error) can be determined using the following equation:

$$\%Eror = \left[\frac{Setting\ voltage - Measured\ voltage}{Seting\ voltage}\right] \times 100\%$$

Referencing the graph from Table 1 can be shown in the following Figure:

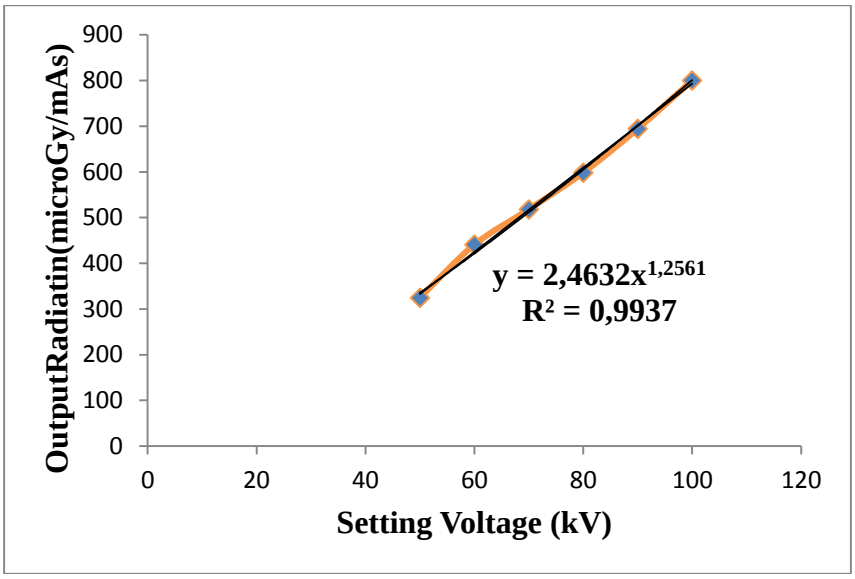

Figure 1 Graph of X-ray tube voltage accuracy conformity test

The quadratic line equation obtained in Figure 1 is the INAK value of the equation:

$$ESAK = INAK \times \left(\frac{100}{FSD}\right)^2 \times mAs$$
$$= 2{,}084kV^{1{,}2845} \times \left(\frac{100}{FSD}\right)^2 \times mAs$$

Where:

FSD : FFD – tp – d
FFD : Focus distance to film = 130 cm
d : Distance between detector and holder detector = 5 cm
FSD : 130 cm – 25 cm – 5 cm = 102 cm

Thus, ESAK can be calculated as follows:

$$ESAK = (2{,}084)^{1{,}2845} \times (\frac{100}{102})^2 \times 20$$
$$= 49{,}357\mu Gy = 0{,}049\, mGy$$

The ESAK value can be used to determine the amount of exposure dose which refers to the national I-DRL value, as stated in the Decree of the Head of BAPETEN No. 1211/K/V/2021 concerning the Determination of Indonesian Diagnostic Reference Level Values for X-ray Ct Scan and General Radiography Modalities (Ratnawati et al., 2019; Winkler, 1976). Where in this decision the ESAK value for Chast PA is 0.4 mGy, so the ESAK value in this study still meets the national I-DRL value (Proost & Meijer, 1992; Bonello et al., 2009). The method of implementation and the results of this study are following the statement that patient dose information can be estimated if each diagnostic X-ray machine has 2 important components, namely radiation output data and irradiation recordings containing information on technical parameters, which was conveyed, in Implementation Level Guide to Medical Exposure and X-Ray Aircraft Suitability Tests Related to Dosage Information or Radiation Dose Rates Received by Patients. From this local DRL value, it can be implemented by one way of pasting the radiation output data near the Radiology operator room at the Sanjiwani Gianyar General Hospital and can be used within the next 1-2 years (Susanto, 2018).

4 Conclusion

The conclusion of this study is that dose monitoring with ESAK or often referred to as ESD using conformity test data has been determined to be 0.049 mGy, which is the local DRL value of the Sanjiwani General Hospital Gianyar and according to the national I-DRL value from BAPETEN Regulation No. 1211/K/V/2021 (Gabbert et al., 2007; de Oliveira & Lourenço, 2021).

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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