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Utilization of High kV Lumbar Examination Technique in Determination of Entrance Surface Dose (ESD)

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ABSTRACT

Entrance Surface Dose (ESD) is one of the units of quantity used in diagnostics to express the radiation dose received by the object (phantom or patient) measured at the centre of the main beam on the surface of the phantom or patient (UNSCEAR, 2010). According to Bushong (2008), the high kV technique states that to get the same optical density, with an increase in tube voltage (kV) of 15%, a 50% decrease in the mAs value is required. This study aims to calculate the ESD value if applied in the use of the high kV technique in lumbar irradiation using the Cobia Smart R/F measuring instrument. In this study, the authors applied the high kV technique using 65 kV and 16 mAs, 75 kV and 8 mAs, and 85 kV and 4 mAs. The dose value measured in the Cobia Smart R/F tool is then entered into the formula to calculate the Entrance Surface Dose (ESD) value. The results showed that the Entrance Surface Dose (ESD) produced at 65 kV, 75 kV, and 85 kV, respectively, were: 1.3597 mGy, 0.9728 mGy, and 0.7055 mGy. From the Diagnostic Reference Level (DRL) data released by BAPETEN in 2020, it is known that the DRL value for the Lumbar AP examination is 1.8 mGy. In this case, the high kV technique can minimize the dose to the examined object.

Keywords:
Entrance Surface Dose (ESD), high KV, lumbar

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1. INTRODUCTION

An increasing interest in diagnostic imaging examinations leads to increased safety, especially at radiation doses. This is related to the effects that can be caused by ionizing radiation, namely the deterministic effect and the stochastic effect[1]. The Lumbar is one of the radiology examinations, usually done with several projections. Therefore, protection and justification are needed to prevent recurrence and reduce radiation dose. Because the object in the lumbar radiograph is quite thick, it will require a high exposure factor, especially tube voltage (kV). The higher the exposure factor is set, the number of x-rays will also increase, in this case, the radiation dose.

The high kV technique is an examination of body organs by increasing one of the radiation parameters, namely the tube voltage value (kVp2), by compensating for the decrease in the tube load value (mAs2) from standard irradiation parameters in the form of initial tube voltage (kVp) and initial tube load (mAs1) to produce almost the same image density[2][3]. The same optical density can be obtained with an increase in tube voltage (kV) of 15%. It requires a decrease in the value of mAs by as much as 50%[4][5].

Entrance Surface Dose (ESD) is one of the units of quantity used in diagnostics to express the radiation dose received by the radiation object (phantom or patient) measured at the centre of the main beam on the surface of the phantom or patient [4][6]. The dosimetry protocol in the IAEA Technical Report Series No. 457 explains that ESD in patients can be determined by measuring water kerma with the indirect method during the examination using a calibrated kVp meter[7].

The author will determine the Entrance Surface Dose (ESD) in this study by measuring Incident Air Kerma (INAK). The INAK value will be obtained from the measurement results, which is then used to calculate the ESD dose. This study was combined with the high kV technique. The high kVp technique is a well-known and widely documented method of reducing the patient's radiation dose.

2. METHOD

The type of research in this research plan is quantitative with an experimental approach. This study aims to determine the dose of ESD using the Cobia Smart R/F device, which was performed on a lumbar examination using the high kV technique. The variations of kV and mAs used are 65 kV and 16 mAs; 75 kV and 8 mAs; 86 kV and 4 mAs. The dose measurement tool uses the Cobia Smart R/F. The measured dose value will then be converted to the ESD value, multiplying it by the BSF (1.35).

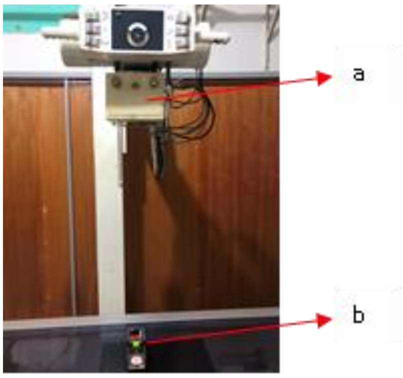
Entrance Surface Dose (ESD) is one of the units of quantity used in diagnostics to express the radiation dose received by the radiation object (phantom or patient) measured at the centre of the main beam on the surface of the phantom or patient[8]. The dosimetry protocol in the IAEA Technical Report Series No. 457 explains that ESD in patients can be determined by measuring water kerma with the indirect method during the examination using a calibrated kVp meter[9][7]. The following formula can calculate ESD:

$$ESD = {}_{n}K_{a}\,(U, F) \times (100\ cm/\ FSD)^{2} \times P_{it} \times BSF \quad (1)$$

The information on the formula symbols is: FSD is Focus to Surface Distance (cm); Pit is tube current (mAs); and BSF is the radiation scattering factor.

3. RESULTS AND DISCUSSION

The procedure begins by positioning the Cobia Smart R/F measuring instrument above the bucky table, with the instrument in the On condition, as shown in figure 1. The central point is directed to the middle of the Cobia Smart R/F measuring point. The irradiation area (collimation) is set as wide as the measuring instrument. Radiation or exposure is carried out in 3 (three) stages using different exposure factors. Each step is repeated in 3 (three) measurements.



Information:
a. X-Ray Tube
b. Cobia Measuring Instrument

Figure 1. Dose Measurement Position Using Cobia Smart

The following is Table 1, which contains measurement data using the Cobia Smart R/F. The selection of tube voltage and tube current at the beginning is 65 kV and 16 mAs. This is adjusted to the exposure factor used in examining lumbar radiographs. Then by using the 15% rule in the high kV technique, the tube voltage is increased by 15% while the tube current value is halved so that the further exposure factors used in this study were 75 kV and 8 mAs and 85 kV and 4 mAs.

Table 1. Measurable INF Dose from the Cobia Smart R/F Tool

Exposure Factors			**Measured INAK Dose Value**
Voltage (kV)	Current (mA)	Time (second)	Average (µGy)
65	100	0.16	100.72
75	100	0.08	72.06
85	100	0.04	52.26

The value of the INAK dose was then multiplied by the BSF to obtain the Entrance Sureface Dose (ESD) (shown in table 2). The units used are still in Gy units. The difference in the dose value between the 65 and 75 kV tube voltages is 28.46%. In comparison, the difference in the dose value between the 75 and 85 kV tube voltages is 48.11%.

Table 2. Calculation of Entrance Sureface Dose (ESD)

Voltage (kV)	**Current (mA)**	**Time (second)**	**INAK Value (µGy)**	**ESD Value (µGy)**	**Dosage Percentage Difference**
65	100	0.16	100,72	135,97	0,00
75	100	0.08	72,06	97,28	28,46
85	100	0.04	52,26	70,55	48,11

The following Figure 1 is a graph of the Entrance Sureface Dose value according to table 2. The graph shows that the higher the kV value followed by a decrease in the mAs value, the lower the INAK and ESD dose values.

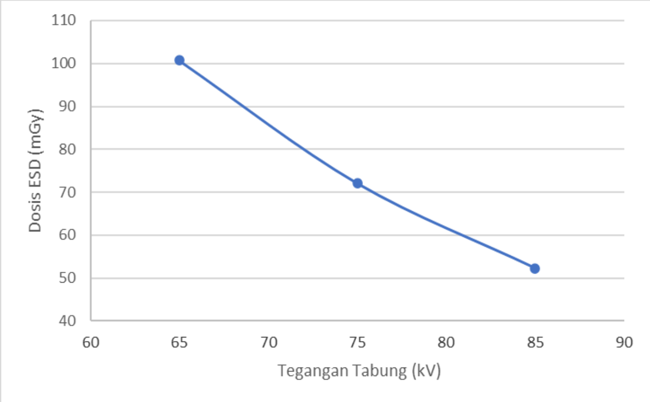


Figure 2. Graph of Entrance Surface Dose

The high kV technique is an examination of body organs by increasing one of the radiation parameters, namely the tube voltage value (kVp2), by compensating for the decrease in the tube load value (mAs2) from standard irradiation parameters in the form of initial tube voltage (kVp) and initial tube load (mAs1) to produce nearly the same image density. According to Bushong (2008), it is stated that to get the same optical density, with an increase in tube voltage (kV) of 15%, a 50% decrease in the mAs value is required. The high kV technique can be applied, one of which is the lumbar examination. Examination of the lumbar vertebrae requires a fairly high exposure factor because the object to be passed by x-rays has a high density. This study aims to determine the value of the Entrance Sureface Dose when applied to the high kV technique, whose exposure factor range can be used to examine the vertebrae lumbar.

Entrance Sureface Dose (ESD) is the kerma in the air that comes from x-ray irradiation measured at the center of the beam in the middle of the patient's position or phantom, taking into account the scattered radiation that occurs from the object or phantom. The ESD value can be calculated using the Incident Air Kerma (INAK) value[10]. INAK is kerma in the air from x-ray irradiation measured at the x-ray centre in the middle of the patient's position or phantom. This dose only takes into account the radiation that occurs to the patient, without taking into account the back-scattered factor. The units are in J/kg, or commonly referred to as Gray (Gy).

In this study, the value of INAK on irradiation with the high kV technique was measured using the Cobia Smart R/F tool. This measuring instrument is a digital kV and dosemeter, so it can be used to measure the dose and kV output. The results showed that the higher the kV value (15% increase), followed by a decrease in mAs, the smaller the INAK and Entrance Sureface Dose values. Each 15% kV increase will result in a dose reduction of approximately 24–28%.

From the Diagnostic Reference Level (DRL) data released by BAPETEN in 2020, it is known that the DRL value for the Lumbar AP examination is 1.8 mGy. When compared with the measurement results in this study, namely: 1.3597 mGy, 0.9728 mGy, and 0.7055 mGy (the Gy unit of measurement has been converted into mGy), the resulting dose is still below the DRL value issued by Bapeten, especially in the use of the high kV technique. The resulting dose is much lower than the use of standard exposure factors.

Therefore, if you want to reduce the radiation dose to the object you are examining, you can use a higher tube voltage (kV) followed by a reduction in the mAs value. However, using the high kV technique also has a drawback: it will place a heavy load on the aircraft. Suppose the number of inspections is large enough, and the equipment use age is also relatively long. In that case, the use of the high kV technique should be considered so that the condition of the equipment can be more durable and minimize the damage that the excessively high load may cause.

This study still has shortcomings, namely limited exposure factors (only using 65 kV, 75 kV, and 85 kV tube voltages). This is due to the limited capability of the x-ray machine used. So it is still possible to conduct further research on using high kV techniques in determining the Entrance Sureface Dose (ESD) dose.

4. CONCLUSION

Using the high kV technique with the 15% rule can reduce the Entrance Skin Dose (ESD) dose value by 24-28%. The higher the tube voltage (kV) used, followed by a decrease in tube current and exposure time (mAs), the smaller the ESD value. In this study, only three exposure factors were used. This was due to the limited capability of the x-ray machine used. Thus, this research can still be continued by increasing the range of exposure factors or adding other variables.

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