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15% kVp Rule Effect on CR Exposure Index: An Initial Phantom Study

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ABSTRACT

In using the Computed Radiography (CR), radiographers usually carry out abdomen examinations with different exposure factors without any definite reference or standard, by setting higher kV and higher mAs. Without realizing it, this will certainly affect the Exposure Index as a dose indicator indirectly on Computer Radiography. It is necessary to have an appropriate standard for calculating the exposure factor to control the Exposure Index value in order to produce Exposure Index / within a safe range. This research was conducted using descriptive quantitative methods at the Bali ATRO Laboratory which was conducted in April 2020. The sample in this study was a water phantom which is equivalent to the abdominal organs of a normal person. From the results of research and data analysis, it can be concluded that in First variation 1 with 77 kV and 8 mAs show 332.4 average exposure index, in the second variation with 89 kV and 4 mAs, the average exposure index was 313.6, and the third variation with 65 kV and 16 obtained 335.6 average exposure index. From the results obtained, it allows flexibility in the use of combinations of exposure factors as needed. 15% increased kVp variation can be used for taking action on non-cooperative patients which can help minimize unsharpness and repetition caused by patient movement. 15% reduced kVp is good for extremities and certain examinations that require optimal detail.

Keywords: *Exposure* Factor, Exposure Index, Computed Radiography, Water Phantom, 15% kVp Technique.

INTRODUCTION

In the era of computer technology and digital data, computer-based radiographic examination techniques have been developed with the aim of producing higher quality radiographs. Computed Radiography technology was introduced by Fuji film Medical Systems in 1980. Most radiographic examinations currently use digital technology for image readers and image processing modality Computed Radiography (CR). The use of CR is more advantageous than film-screen with faster acquisition and image processing, wider dynamic range, easy brightness-contrast adjustment, and electronic cropping. CR will produce an image with an exposure index as feedback for a radiographer [1].

Although the post processing is carried out using a computer system, the CR system still requires an image acquisition process with X-rays resulting from a combination of exposure factors as in conventional radiography. The exposure factor consists of voltage in kV (kilo Volts), current in mA (milli Ampere) and time in s (second). kV is the unit of potential difference exerted between the cathode and anode in an X-ray tube. The voltage will determine the quality of the X-ray. mA is a unit of tube current, and s is a unit of irradiation time. mAs will determine the quantity of x-rays [2].

In its application there are several techniques of setting the exposure factor that can be used to produce optimal image quality. The technique includes the 10 kV rule and the 15% kVp rule. The 15% kVp rule is a rule that states that increasing the voltage by 15%, and changing the value of mAs by reducing it to half of the initial exposure factor, while lowering 15% of the voltage means changing the value of mAs to be double the initial exposure factor [3]. Using the 15% rule will always change the contrast of the image. In order to maintain the density of the image, it is necessary to adjust the components of other exposure factors (tube current and exposure time). Adjustments were made using the doubling mAs technique when applying a 15% reduced voltage and half mAs when applying a 15% increased voltage. The use of the 15% rule would be more appropriate to use in the 60-100 kV voltage range. With reference to the voltages range, the 15% rule is more accurately applied to abdominal examinations with a thickness of 20 cm [4].

Abdominal radiography is still the most frequently performed radiological examination as an initial procedure in evaluating abdominal pathology. Abdominal radiographs play a very important role in diagnosing pathology in the form of obstruction, perforation, and urinary calculus. Although some of its functions have been replaced by ultrasound examination, abdominal radiography cannot be completely replaced, it is proven that 72.5% of cases of pathological examination of the abdomen still use abdominal radiography [5].

With a thickness value that is greater than other organs which implies the use of a higher exposure factor, it is mandatory to use a grid in its implementation. This is due to the increased scatter of radiation in the patient's organs which are thicker and in a larger field size [6]. In abdominal examination, in addition to the need for accuracy in the selection of exposure factors for optimal image quality, it is also necessary to use additional grids to support the image quality of the abdominal radiograph. In using the grid, an appropriate combination of kV & mAs is needed because there is an increase in the thickness of the grid.

The combination of voltage adjustment (kV and current-time (mAs)) is expected to provide the same exposure to the abdominal organs being examined. This can be accommodated by referring to the Exposure Index. In the CR system, the Exposure Index is an indirect indicator that can be used as a reference. The amount of exposure received by the patient Exposure Index is the median pixel level noise in an image. When the median pixel is too low, it means that there is too much noise in an image, whereas if the pixel is too high, it indicates overexposure to the patient. It should be noted that the exposure index is not the radiation level received by the patient, but the radiation level reaching the detector. However, when the radiation level reaching the detector is of high value, it can be indicated as high radiation received by the patient, so it can be used as feedback for the radiographer whether the exposure factor used is too high or low [7].

As described above regarding Optimizing Exposure Factors for Exposure Index on abdominal objects using the 15% kVp technique, where previously the authors observed in 3 hospitals that many radiographers performed abdominal examinations using different exposure factors without any definite reference or standard, by setting both higher kV and higher mAs. It is necessary to have an appropriate standard for calculating the exposure factor to control the Exposure Index value in order to produce Exposure Index within a safe range. In this study, the authors want to use the 15% kVp technique because the authors see that some previous studies mostly used the 15% kVp technique, but no researchers have used the exposure index value as the value observed.

This Study was used 3 Variation of combinated exposure Factors, first variation uses the standard exposure factor for abdominal examination found in the manual book at the ATRO Bali laboratory with 77 kV and 8 mAs, second variation uses the exposure factor with a 15% increased kVp technique with a combination a half mAs: 89 kV and 4 mAs, and the last variation, which reduces 15% kVp with a combination of 2x mAs: 65 kV and 16 mAs. The author will use control variables to reduce bias in the study which includes grid, 100 cm FFD, central point, the same collimation on a gallon phantom object filled with water according to the thickness of the abdomen which is equivalent to the abdomen of a normal person who has an average thickness (21 cm).

METHOD

This research is descriptive quantitative research. This research was conducted by varying the exposure factor to determine the Exposure Index using the 15% kVp technique on abdominal objects (water phantom) at the ATRO Bali Laboratory.

Data analysis starts from collecting data in the form of the exposure index of each scanned IP with predetermined Exposure Factor Variations (I: 77 kV, 8 mAs, II: 89 kV, 4 mAs and III: 65 kV, 16 mAs). Exposure index was recorded, tabulated and processed using Excel to determine changes in the exposure index in the variation of exposure factors and to get the optimal exposure factor within an exposure index.

RESULT AND DISCUSSION

Research on Optimizing Exposure Index on Abdominal Objects with the 15% kVp at the ATRO Bali laboratory was carried out in 2 stages, the first stage was data collection regarding the Optimization of Exposure Factors to Exposure Index and the second stage was recording the Exposure Index shown on the image console Computed Radiography (CR). The results of the Exposure Index for each Variation of Exposure Factors used can be shown in the table below.

Table 1: Measurement Results of Exposure Index

Number of Exposure	Exposure Index		
	1st Variation	2nd Variation	3rd Variation
1	335	318	338
2	355	305	371
3	325	314	330
4	316	313	360
5	331	318	346
Average	332.4	313.6	349

The table above shows the results of the Exposure Index on Variation of Exposure Factors using the 15% kVp Technique on Abdominal Objects at ATRO Bali Laboratory. In the use of variations of standard exposure factors using 77 kV and 8 mAs, the results obtained an average exposure index of 332.4 with each exposure value, namely I(335), II(355), III(325), IV(316), V(331). In the second variation using the exposure factor with a 15% kVp increase technique with a combination of decreasing half mAs to 89 kV and 4 mAs, the average exposure index 313.6 with the respective exposure values I(318), II(305), III(314), IV(313), V(318). As well as the third variation using the exposure factor with a technique of reducing 15% kVp with a combination of 2x mAs increases to 65 kV and 16, the results obtained are the average exposure index of 349 with each exposure value I(338), II(371), III(330), IV(360), V(346).

The results of the Optimization of Exposure Factor Variations to produce an Exposure Index within the safe range of the 3 variations of the exposure factors used can be seen in Fig 1.

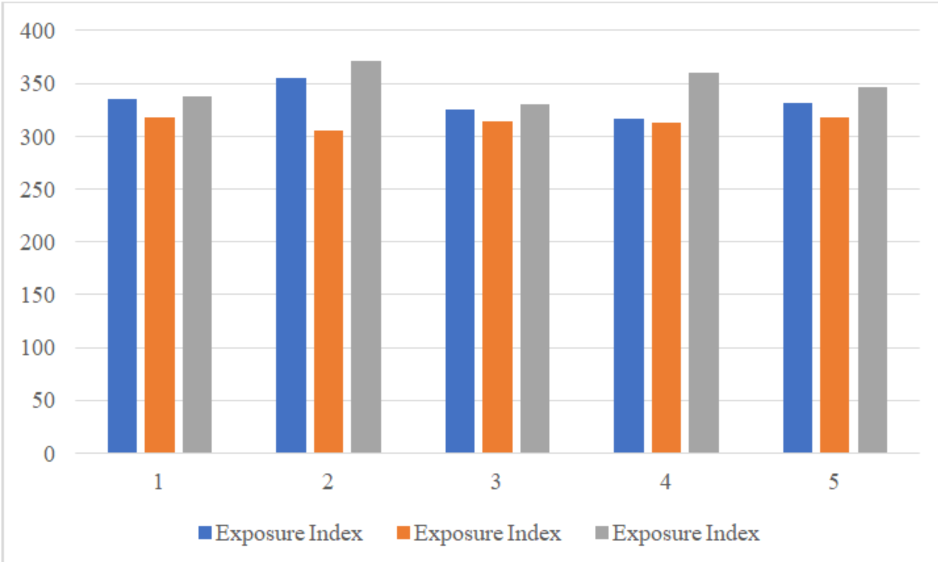

Fig 1: Exposure Index Distributions in 3 Variation in 15% kVp Rule

From the graph above, it can be seen that the lowest exposure index was shown in the second variation with a 15% increased kVp technique and a combination of a half mAs (89 kV and 4 mAs), but each variation of the exposure factor used wass still have a safe range and have their respective advantages in the accuracy of use as expected, such as the selection of a 15% increased kVp variation which uses high tube voltages to be appropriate for taking action on non-cooperative patients which can help minimize unsharpness and repetition caused by patient movement. As well as in this 15% kVp reduction, it is used for both extremity examinations and certain examinations that require optimal detail.

In a previous study regarding the Effect of High kVp Use on Radiation Dose and Radiographic Image Quality in Lumbar Lateral Examination Using a Grid, it was said that the use of the high kV technique is a technique that prioritizes very low exposure times. This technique is very effective for controlling the sharpness due to the movement of the object that is not accidental and causes the image to become blurry [7,8]. The connection with this study is the use of the second variation of exposure factor by using the 15% kVp increase technique with a combination of half mAs was good for non-cooperative patients which can help minimize unsharpness and repetition caused by patient movement.

The use of the third variation of the exposure factor, which uses the exposure factor with the technique of reducing 15% kVp with a combination of 2x mAs (65 kV and 16) is used for both extremity examinations and certain examinations that require optimal detail. We can observe the results of Sartinah's research where it can be seen that the exposure value at a decrease of 15% kVp show the highest contrast value at 8 mm thickness step wedge, equivalent to mammae tissue (on mammography examination using an imaging plate), brain tissue (on normal adult head CT scan examination) [4].

In the results of previous studies regarding the Effect of the 15% kVp Rule on Computed Radiography on Signal to Noise Ratio at the Bali ATRO Laboratory, it was found that the application of the 15% kVp reduction variation was used to improve digital image quality, especially SNR. Which can be related to the author's research. The selection of the 3rd variation using a 15% kVp reduction technique with a combination of 2x mAs increases to 65 kV and 16, which is good for higher digital image quality, especially SNR. It was explained in a previous study that the application of a 15% increased kVp which reduces the mAs value by half results in the quality of digital images, especially SNR, being reduced due to a decrease in X-ray intensity, but this can reduce the dose received by the object. While a 15% decrease in kVp which increases the mAs used to double from the original means increasing the SNR value of the digital image due to an increase in X-ray intensity, it also gives higher radiation dose that can be received by the object [9].

CONCLUSION

EI value on the variation of exposure factors Using the 15% kVp technique on abdominal objects at ATRO Bali Laboratory show different average Exposure Index (EI), 332.4 in First Variation, 313.6 in the Second variation, and the third variation show 335.6 of EI. The optimal EI was shown in the second variation with a 15% increased kVp with a combination of half mAs (89 kV and 4 mAs).

Suggestion

With the EI results shown in related studies, the researcher suggests the use of exposure factor variations must be adjusted to the needs of diagnosis and the patient's condition to obtain optimal radiographs.

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