Indonesian Physical Review
Volume 5 Issue 2, May 2022
P-ISSN: 2615-1278, E-ISSN: 2614-7904

# Analysis of the Signal to Noise Ratio in Use of 15% kVp Rule Method in the Radiography Examination Supine AP Chest

**Shinta Gunawati Sutoro[1], Muhammad Irsal[12], Tri Asih Budiati[3], Andri Yansyah[4], Shofiyah Hasna Faradila[1]**

[1]*Department of Diagnostic Imaging and Radiotherapy, Health Polytechnic of Jakarta 2. Indonesia. E-mail: shinta.gunawati@poltekkesjkt2.ac.id*
[2]*Center of Excellence for Science and Technology, Health Polytechnic of Jakarta 2. Indonesia. E-mail: muhammad.irsal@poltekkesjkt2.ac.id*
[3]*Department of Radiology, Pertamina Center Hospital, Indonesia*
[4]*Global Promedika Services, Indonesia*

**ARTICLE INFO**

***Article History :***
*Received:09-02-2022*
*Revised:26-04-2022*
*Accepted: 11-05-2022*

***Keywords:***
*Signal to Noise Ratio; 15% kV Rule Method; Supine AP Chest*

***How To Cite :***
*Shinta, G. S., Irsal M., Budiati T.A., Yansyah A., Shofiyah H,F. (2022). Analysis of the Signal to Noise Ratio in Use 15% kV Rule Method in the Radiography Examination Supine AP Chest. Indonesian Physical Review, 5(2), 107-115*

***DOI :***
*https://doi.org/10.29303/ipr.v5i2.141*

**ABSTRACT**

*The exposure factor is one of the important parameters in optimizing the radiographic examination. This study aimed to analyze the value of the Signal To Noise Ratio (SNR) against the use of the 15% kV rule method in the examination of Chest AP Supine. Descriptive quantitative research method conducted in the laboratory of the Department of diagnostic imaging and radiotherapy, Health Polytechnic of the Ministry of Health, Jakarta 2, using computer radiography, X-rays, piranha radiation detectors, and anthropomorphic phantoms, with statistical analysis of the Pearson test to determine the level of relationship between SNR and Exposure Index (EI). Against the 15% kV rule method, then the one-way ANOVA test to determine the effect of the 15% method on changes in value. The results of the Pearson test obtained a p-value of 0.820 with a strong relationship between SNR and EI against the 15% kV method. Therefore, using an exposure factor of 15% kV rule method makes it possible to control the SNR and EI values. The one way ANOVA test has a p-value of 0.943, so there is no significant difference in the SNR value to changes in the exposure factor with the 15% kV rule method so that the optimization of the exposure factor with the 15% kV rule method can reduce the radiation dose while maintaining the image quality radiographic.*



## Introduction

Computed radiography (CR) is a radiographic image process using barium fluoro halide that stores X-ray energy [1]. The CR imaging significantly impacts the radiographic image quality and causes a reduction in the radiation dose. However, when it is shown that the radiation dose increases due to an understanding of the dynamic range, this increase in radiation dose is called "dose creep". It is a phenomenon where the selection of exposure factors increases the radiation dose to produce a higher signal-to-noise ratio (SNR) [2-3]. In addition, the research results on radiation doses in recent years have increased for medical exposure; this causes the risk of stochastic and deterministic effects [4-5]. The loss of radiation effects due to radiation dose optimization measures are needed by considering radiation dose and improving image quality [6-7]; therefore, optimization efforts are needed in radiographic examination [8-9]. To optimize CR imaging, unlike conventional radiographic imaging. CR images are not dependent on radiation exposure because the image acquisition process requires an assessment between image quality and radiation dose [10-11]. The 15% kV method changes the tube voltage parameter with an increase of 15% from the standard tube voltage value accompanied by a decrease in the tube current parameter to half of the standard value. It can maintain the quality of radiographic images, especially radiographic examinations that require optimal radiographic contrast, but it can also provide benefits by reducing patient doses so that optimization efforts can be made to patients [12].

Radiographers sometimes have problems determining the optimal exposure factor, the tendency to choose a fairly large exposure factor to increase image quality. In contrast, a low exposure factor can cause noise or decrease the quality of the radiographic image. The CR system provides recommendations for exposure indicator values used to obtain optimal image quality or called the Exposure index (EI) [13-15]. EI can be used as an indicator to obtain an optimal radiographic image with the lowest possible radiation dose [16-17]. EI is proportional to radiation exposure; EI is also used to calculate the deviation index (DI) value to provide optimal radiation exposure [18]. One of the radiographic image quality parameters is the signal-to-noise ratio (SNR); with the greater the SNR value, it can be ascertained that the quality of the radiographic image can be improved.

In some cases, for clinicians in the field, there is a radiographer's error in selecting exposure factors; the shape of the radiographic image causes this. With the patient's body size, CR image processing, and work experience as a radiographer, this study will analyze the SNR against the 15% kV rule in the examination of Chest AP Supine. In addition, it will analyze the relationship between SNR and EI, which serves as a guide for exposure indicators to optimize image quality [19-21].

## Experimental Method

The research method is descriptive and quantitative. The research was carried out in the diagnostic imaging and radiotherapy laboratory, Health Polytechnic of the Ministry of Health, Jakarta 2. It was carried out from February to July 2021. The equipment used in this study was computer radiography, Fujifilm FCR Prima T2 brand, X-ray machine, GE multipurpose 500 mA, radiation detector, and anthropomorphic phantom are shown in Figure 1.

**Figure 1.** Computer radiography and X-ray equipment

Research started by ensuring that CR can be used in this research by testing dark noise and laser beam function. After selecting the exposure factor using the 15% kV rule method, the standard kV will be varied for 2nd exposure increased and lowered. Then the phantom will be positioned according to the procedure for examining a supine chest AP radiograph. After the CR cassette has been processed on the CR reader, the signal-to-noise ratio value will be measured using the image-j software. Then the region of interest (ROI) will be carried out on several AP supine chest anatomical criteria, as shown in Table 1. Statistical analysis using SPSS version 26 to determine the level of relationship between SNR and EI to changes in exposure factors of the 15% kV rule method using the Pearson test with a correlation coefficient of 0.00-0.25, the level of the relationship is weak, 0.26-0.50 the level of the relationship is sufficient, 0, 51-0.75 strong relationship level 0.76-0.99. very strong relationship level 1 level of the perfect relationship. In addition, an analysis was carried out to determine the effect of the 15% rule method on changes in the SNR value with the one-way ANOVA test.

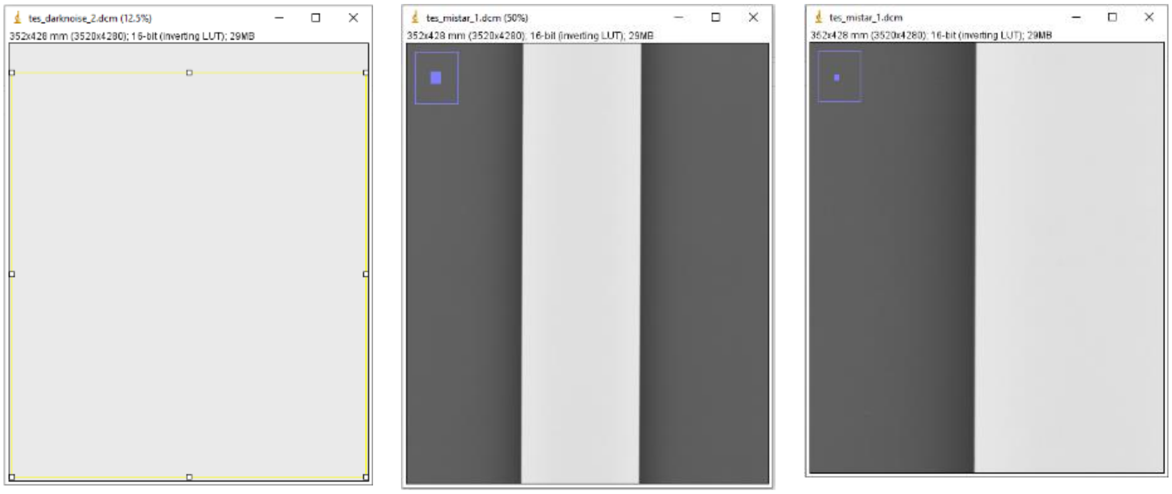
$$SNR = \frac{Mean_o}{Std\ dev_o} \tag{1}$$

**Table 1.** Research parameters

| **AP supine procedure** | | **Exposure factors** | | **Anatomy** |
|---|---|---|---|---|
| **Centre ray** | Vertical | ↑15% kV-2nd | 85kV 2,5mAs | Coste |
| **Centre point** | Thoracal to 7nd | ↑ 15% kV-1st | 75kV 5mAs | Lung |
| **Focus Image Distance** | 100 cm | kV standard | 65kV 10mAs | Heart |
| **Caset** | 35 cm x 45 cm | ↓15% kV-1st | 55kV 20mAs | Thoracal |
| **Image processing** | Computed radiography | ↓15% kV-2nd | 45kV 40mAs | Diaphragm |

## Result and Discussion

Before taking radiographic image data, all equipment in this study was reliable. One of them is to ensure the reliability of CR by testing the dark noise and laser beam function, with the results shown in Figure 2 and Table 2. The laser beam function was evaluated visually by observing 50% and 100% enlarged images. Based on the AAPM report on Quality Control CR, the dark noise and the laser beam function test result indicate that the CR system used in this study is feasible and reliable [22].




a) Dark noise b) Image Magnified 50% c) Image Magnified 100%

**Figure 2.** Dark noise and laser beam function test

**Table 2.** Dark noise test

| Area (mm) | Mean | Std Dev | Median | Min | Max |
|---|---|---|---|---|---|
| 142053.76 | 333 | 0.009 | 333 | 333 | 344 |

Then a supine AP chest radiography examination procedure was carried out with an exposure factor using the 15% kV rule method; the image results are shown in Figure 3. From the image results, SNR measurements were then carried out with anatomical region of interest (ROI), which became the image quality criteria for the supine AP chest examination, namely coste, lungs, heart, thoracal, and diaphragm. The measurement results of the SNR value are shown in Table 3.

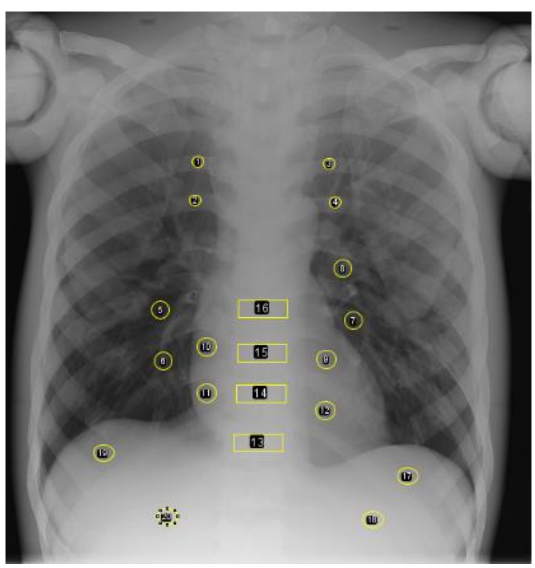


**Figure 3.** AP chest radiograph and anatomical ROI

**Table 3.** SNR values

| Experiment | Anatomical image | | | | |
|---|---|---|---|---|---|
| | Coste | Lung | Heart | Thoracal | Diaphragm |
| ↑15% kV-2nd | 54.6 ± 17.6 | 63.3 ± 22.1 | 29.5 ± 14.5 | 37.2 ± 7.8 | 24.3 ± 5 |
| ↑ 15% kV-1st | 48.2 ± 50.9 | 45 ± 56.3 | 16.8 ± 17.7 | 37.1 ± 43.2 | 24.5 ± 20.5 |
| kV standard | 66.8 ± 32 | 40.1 ± 53.6 | 15.8 ± 15.2 | 38.2 ± 41.1 | 23.9 ± 22.8 |
| ↓15% kv-1st | 58.9 ± 30.8 | 51.3 ± 37.3 | 17.4 ± 17.7 | 46.7 ± 46.8 | 24.8 ± 21.7 |
| ↓15% kV-2nd | 58.9 ±16.1 | 59.9 ±25.9 | 29.3 ± 15.6 | 39.8 ± 8.5 | 24.2 ± 5.3 |

The SNR results show that the average value of the highest SNR on exposure factors is 45kV 40mAs and 85kV 2.5mAs. While the lowest SNR value is at 55kV 20mAs exposure factor. In addition, these results also provide information that there is no significant difference in the SNR value between the variations in the exposure factor using the 15% kV rule method. Then the results of the SNR will be further analyzed regarding the effect of exposure on image quality parameters in the 15% kV rule method. The exposure index can be used to indicate radiation exposure received at the radiographic examination. The exposure index can show underexposure, optimal, and overexposure. Based on research, the exposure index can be used as an optimization indicator to reduce radiation exposure received by patients [23-24].

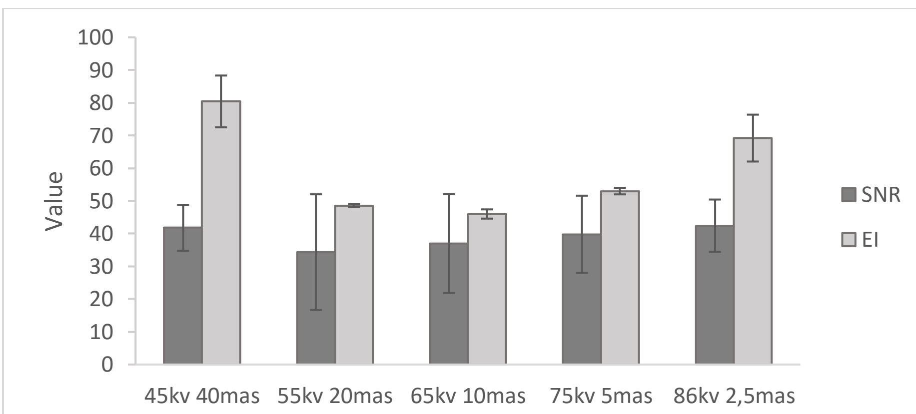



**Figure 4.** Comparison of exposure index to SNR

Figure 4. shows a change in the exposure index value against the 15% kV rule method, with the highest exposure index values at exposure factors of 45kV 40 mAs and 85kV 2.5 mAs. While the lowest EI value at 55kV 20mAs exposure factor. These results also show a pattern of SNR and EI values that are similar in the use of the 15% kV rule method when the exposure is increased or decreased. Then from the EI results, it can be shown that the selection of exposure factors can be optimized to reduce radiation exposure because the Fujifilm exposure index shows the inverse of the EI value to radiation exposure. Where the increasing EI value, it is certain that the radiation exposure will be smaller, while the smaller the EI value, it is certain that the greater the radiation exposure received [18, 25].

The Pearson test was carried out to determine the level of relationship between SNR and EI using the exposure factor of the 15% kV rule method, as shown in Table 4. From the results of the Pearson test, a p-value of 0.820 was obtained with a strong relationship level. Therefore, the use of the exposure factor of the 15% kV rule method can control the SNR and EI values, but the EI values in some CR vendors have different EI values for radiation exposure received by the CR system, so for different CR vendors this result may change. In research, the CR system used has an inverse response to radiation exposure. It can make it easier for radiographers and medical physicists to assess image quality by looking at the EI value. Overexposure, optimal, and very much overexposure, where the SNR increases, the image quality will increase, while the image quality will decrease by decreasing the SNR value.

**Table 4.** Pearson's test between SNR and EI the 15% kV rule method

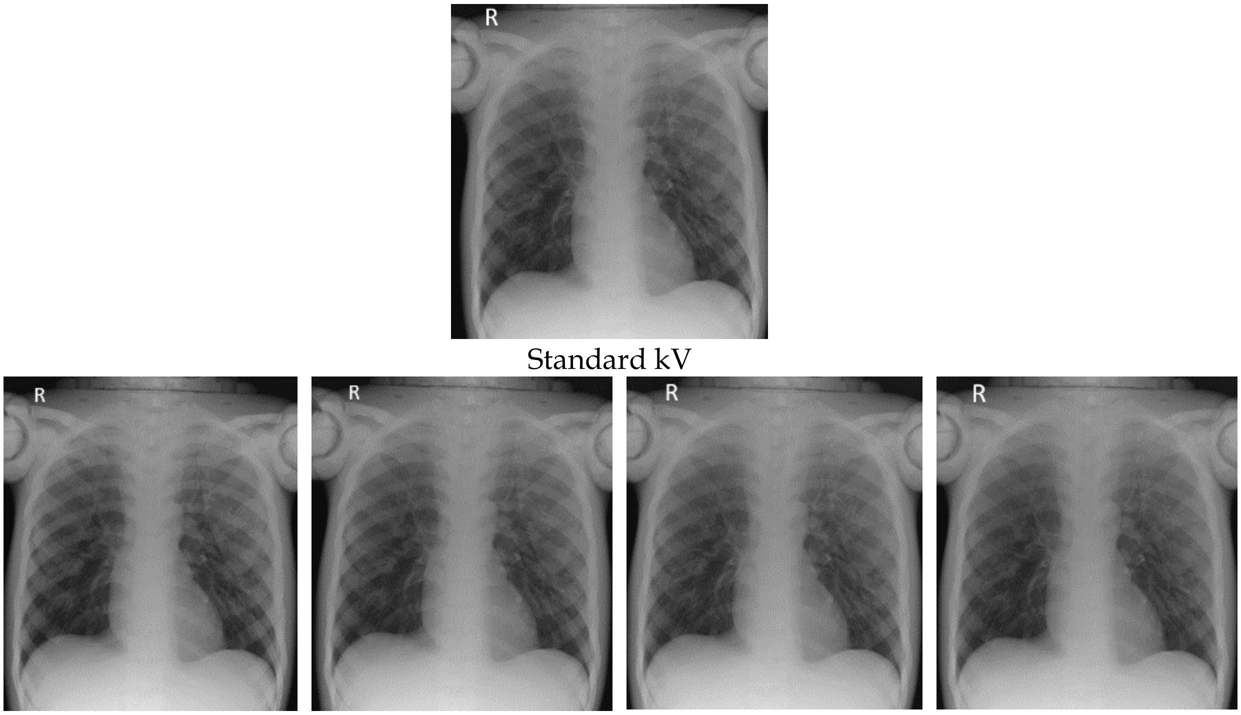
| Parameters | Mean | Coefficient correlation |
|---|---|---|
| SNR | 39.05 ± 3.39 | 0.820 |
| EI | 59.44 ± 14.78 | |

The one-way ANOVA test was carried out to determine the effect of changes in the exposure factor of the 15% kV rule method on changes in the SNR value shown in Table 4. From the results, it was found that the p-value was 0.943. Therefore, there was no significant difference in the SNR value to changes in the exposure factor using the 15% kV rule method. This is due to the use of exposure factors where every increase and decrease in kV is always compensated by changes in the increase and decrease in the value of mAs, therefore the value causes the SNR value to tend to be the same for all variations of the exposure factor of the 15% kV rule method.

**Table 5.** One-way ANOVA SNR test of the 15% kV rule method

| Experiment | Mean | P –value |
|---|---|---|
| ↑15% kV-2nd | 41.78 ± 16.61 | 0.943 |
| ↑ 15% kV-1st | 34.32 ± 13.39 | |
| kV standard | 36.96 ± 19.49 | |
| ↓15% kV-1st | 39.80 ± 17.92 | |
| ↓15% kV-2nd | 42.42 ± 16.49 | |

Figure 5. the image results based on radiographic image observations show visuals that tend to be the same. There is no significant difference, but further studies still need to use visual grading analysis to determine the subjective level of image quality. This study shows that optimization of radiographic examination can be carried out using the 15% kV rule method to reduce the radiation dose and maintain the image quality radiographic.



Standard kV

↑15% kV-2nd ↑ 15% kV-1st ↓15% kV-1st ↓15% kV-2nd

**Figure 5.** Radiographic image of 15% kV rule method

## Conclusion

The SNR and EI values show that the highest values are at exposure factors of 45kV 40mAs and 85kV 2.5mAs. At the same time, the lowest SNR value is at 55kV 20mAs exposure factor. From the results of the Pearson test, a p-value of 0.820 was obtained with the level of a strong relationship between SNR and EI against the 15% kV method. While in the one way ANOVA test, the p-value is 0.943, so there is no significant difference in the SNR value to changes in the exposure factor using the 15% kV rule method, so the optimization of the exposure factor using the 15% kV rule method can reduce the radiation dose while maintaining image quality radiographic.

## References


[1] Compagnone, G.; Pagan, L.; Baleni, M. C.; Calzolaio, F. L.; Barozzi, L.; Bergamini, C. (2008). Patient dose in digital projection radiography. , 129(1), 135-137. doi:10.1093/rpd/ncn013

[2] Mc Fadden, S.; Roding, T.; de Vries, G.; Benwell, M.; Bijwaard, H.; Scheurleer, J. (2017). Digital imaging and radiographic practise in diagnostic radiography: An overview of current knowledge and practice in Europe. Radiography. S1078817417301712–. doi:10.1016/j.radi.2017.11.004

[3] Sandborg, Michael; Tingberg, Anders; Ullman, Gustaf; Dance, David R.; Alm Carlsson, Gudrun (2006). Comparison of clinical and physical measures of image quality in chest and pelvis computed radiography at different tube voltages. *Medical Physics*, 33(11), 4169–. doi:10.1118/1.2362871

[4] Chan, C.T.P.; Fung, K.K.L. (2015). Dose optimization in pelvic radiography by air gap method on CR and DR systems – A phantom study. *Radiography,* 21(3), 214–223. doi:10.1016/j.radi.2014.11.005

[5] Kyprianou, Iacovos S.; Ganguly, Arundhuti; Rudin, Stephen; Bednarek, Daniel R.; Gallas, Brandon D.; Myers, Kyle J.; Eckstein, Miguel P.; Jiang, Yulei (2005). SPIE Proceedings [SPIE Medical Imaging - San Diego, CA (Saturday 12 February 2005)] Medical Imaging 2005: Image Perception, Observer Performance, and Technology Assessment - Efficiency of the human observer compared to an ideal observer based on a generalized NEQ which incorporates scatter and geometric unsharpness: evaluation with a 2AFC experiment. 5749, 251–262. doi:10.1117/12.595870

[6] Ekpo, Ernest U.; Hoban, Alishja C.; McEntee, Mark F. (2014). Optimisation of direct digital chest radiography using Cu filtration. *Radiography.* 20(4), 346–350. doi:10.1016/j.radi.2014.07.001

[7] Zhonghua Sun; Chenghsun Lin; YeuSheng Tyan; Kwan-Hoong Ng (2012). Optimization of chest radiographic imaging parameters: a comparison of image quality and entrance skin dose for digital chest radiography systems. 36(4). doi:10.1016/j.clinimag.2011.09.006

[8] Metaxas, Vasileios I; Messaris, Gerasimos A; Lekatou, Aristea N; Petsas, Theodore G; Panayiotakis, George S (2018). Patient Dose In Digital Radiography Utilising Bmi Classification. Radiation Protection Dosimetry, doi:10.1093/rpd/ncy194

[9] Roch, Patrice; Célier, David; Dessaud, Cécile; Etard, Cécile (2018). Using diagnostic reference levels to evaluate the improvement of patient dose optimisation and the influence of recent technologies in radiography and computed tomography. *European Journal of Radiology*, 98, 68–74. doi:10.1016/j.ejrad.2017.11.002

[10] N.O. Egbe; B. Heaton; P.F. Sharp (2010). A simple phantom study of the effects of dose reduction (by kVp increment) below current dose levels on CR chest image quality. , 16(4), 327–332. doi:10.1016/j.radi.2010.05.004

[11] Busch, H.P. (2000). Need for New Optimisation Strategies in CR and Direct Digital Radiography. Radiation Protection Dosimetry, 90(1), 31–33. doi:10.1093/oxfordjournals.rpd.a033139

[12] Fauber, T. (2016). Image Formation and Radiographic Quality. In Radiographic Imaging and Exposure. Elsevier Inc.

[13] Nicholas Bond (1999). Optimization of image quality and patient exposure in chest radiography. 5(1), 29–31. doi:10.1016/s1078-8174(99)90006-8

[14] Gibson, D. J., & Davidson, R. A. (2012). Exposure Creep in Computed Radiography. *Academic Radiology,* 19(4), 458–462. doi:10.1016/j.acra.2011.12.003

[15] Egbe, N. O., Heaton, B., & Sharp, P. F. (2010). Application of a simple phantom in assessing the effects of dose reduction on image quality in chest radiography. *Radiography,* 16(2), 108–114. doi:10.1016/j.radi.2009.09.007

[16] Dalah, E. Z. (2019). Quantifying dose-creep for Skull and chest radiography using dose area product and entrance surface dose: Phantom study. *Radiation Physics and Chemistry.* doi:10.1016/j.radphyschem.201903.035

[17] Seeram, E., Davidson, R., Bushong, S., & Swan, H. (2013). Radiation dose optimization research: Exposure technique approaches in CR imaging – A literature review. *Radiography,* 19(4), 331–338. doi:10.1016/j.radi.2013.07.005

[18] Seeram, E. (2014). The New Exposure Indicator for Digital Radiography. *Journal of Medical Imaging and Radiation Sciences,* 45(2), 144–158. doi:10.1016/j.jmir.2014.02.004

[19] Hinojos-Armendáriz, V. I., Mejía-Rosales, S. J., & Franco-Cabrera, M. C. (2018). Optimisation of radiation dose and image quality in mobile neonatal chest radiography. *Radiography*, 24(2), 104–109. doi:10.1016/j.radi.2017.09.004

[20] Seibert, J. A., & Morin, R. L. (2011). The standardized exposure index for digital radiography: an opportunity for optimization of radiation dose to the pediatric population. *Pediatric Radiology*, 41(5), 573–581. doi:10.1007/s00247-010-1954-6

[21] Butler, M. L., Rainford, L., Last, J., & Brennan, P. C. (2010). Are exposure index values consistent in clinical practice? A multi-manufacturer investigation. Radiation Protection Dosimetry, 139(1-3), 371–374. doi:10.1093/rpd/ncq094

[22] AAPM. Acceptance Testing and Quality Control of Photostimulable Storage Phosphor Imaging Systems. 93. 2006. 21–22 p

[23] Muhammad Irsal; (2021). Exposure Factor Control with Exposure Index Guide As Optimizing Efforts in Chest Pa Examination. *Journal of Physics: Conference Series.* doi:10.1088/1742-6596/1842/1/012059

[24] Seeram E, Davidson R, Bushong S, Swan H. Optimizing the exposure indicator as a dose management strategy in computed radiography. *Radiol Technol.* 2016;87(4):380–91.

[25] Seeram E, Davidson R, Bushong S, Swan H. (2013). Radiation dose optimization research: Exposure technique approaches in CR imaging - A literature review. *Radiography* 19(4):331–8.