DOI Number: 10.37506/v20/i1/2020/mlu/194551

Study on Minimum Transmission Dose for Establishing X-Ray Imaging

Sinyoung Yu

Doctoral Course, Far East University, Department of Health Science, Graduate School, Korea

Abstract

Background/Objectives: When acquiring medical images using X-ray, optimal medical imaging quality must be achieved with minimal exposure of the x-ray generator.

Method/Statistical Analysis: The experiment was conducted based on the exposure conditions that are mainly used in the clinic. The exposure conditions of Hand, Skull, and Chest examinations were determined as the test subjects, and X-Rays were exposed to each partial phantom. The original data was obtained by exposing X-Rays three times for each phantom, and the values of the pixels were analyzed using the Image J program.

Findings: As the transmitted dose increased, the pixel value increased in proportion to the average intensity. As the X-ray exposure conditions were reduced, the maximum, minimum, and average values of the entire pixel were lowered. In step 1, which is the basic exposure condition of Hand, the average value of all pixels was reduced from 818.311 in step 5, which was the lowest exposure condition. Similar reductions were observed in the skull and chest exposure. When the pixel value is viewed as the transmitted dose value, it is confirmed that the pixel value of the image reflects the transmitted dose value. Signal-to-noise ratios varied with exposure conditions.

Improvements/Applications: These results alone made it difficult to find the optimal transmission dose for making images. Additional measurements of the doses exposed at each step will yield better results. Later we will continue to study through more diverse and accurate experiments.

Keywords: *Pixel value, Radiation dose, Transmission dose, Exposure dose, Histogram.*

Introduction

The use of medical radiation can benefit society as well as patients. However, inadequate use of radiation can pose a risk to the patient. Therefore, proper protection and management of medical radiation has been proposed. The principle of medical radiation shielding lies in the justification and optimization of actions[1-2]. Justification is determined by careful judgment when the benefit of the purpose of the test can be obtained more than the damage to the patient due to the radiological test[3]. And optimization is to keep the exposure dose as low as possible while obtaining optimal results from radiography applied to the patient. Radiologists who use medical radiation to examine patients will need ongoing effort and research[4-5].

In addition, due to the accident of a nuclear power plant, the public's interest in radiation is increasing and anxiety is rising. The radiologist is an expert in the field of radiation, and it is desirable to use the radiation as safely as possible and to reduce the exposure dose to the patient to solve the anxiety caused by the test[6].

X-ray is a non-invasive technique that provides image information in the human body, and is currently a

Corresponding Author:
Sinyoung Yu
Doctoral Course, Far East University, Department of Health Science, Graduate School, Korea
e-mail: ryusinyoung@gmail.com

large part of the medical imaging field[7-8]. Since the use of X-rays is indispensable for the diagnosis of diseases in the human body, optimal medical image quality need to be obtained with minimal exposure of the X-ray generator when acquiring medical images[9-10].

Digital X-ray equipment has a broader range of dynamic range and linearity of dose than film-screen system, and this reduces the resampling rate and enables consistent image quality through adjusting the gray scale.

However, since the image quality can be maintained even when excessive dose is used, efforts are needed to reduce the radiation dose of patient by radiologist, and related studies and research on the improvement of the performance of the digital detector for dose reduction have been continuously reported[11].

Therefore in this study, we will analyze some conditions of x-ray examinations currently used in the clinic and examine how the image quality deteriorates as the exposure conditions are lowered[12]. In addition, the goal of this study is to find the exposure conditions that can be inspected without degrading the image quality while decreasing the exposure conditions step by step.

Method

The subjects were the exposure conditions of Chest, Hand and Skull that are currently used in the clinical trial. The standard was used as the exposure conditions that are commonly used, and the experiment was performed by reducing kVp and ma in five steps. Subject to be imaged for each exposure condition was used as a Kyotokagaku body phantom PBU-50. The equipment used in the study was DR-GEM GXR-C40SD X-ray. Raw data of the image obtained as a result of the test was obtained and analyzed by Image J program.

In order to see the reproducibility of the x-ray equipment before the experiment, 10 x-ray exposures were performed without a phantom in a 35 * 35cm field. All 10 times were set as the same exposure condition. The purpose of the Image J program is to determine the mean, standard deviation, and to determine whether similar values are produced under the same exposure conditions.

Original images are obtained under five exposure conditions using the human body phantom of Chest, Hand and Skull. Analyze raw data using Image J program. Set the part with phantom as the region of interest and the part without phantom in the background and measure it.

Hand exposure condition 1 is 50kVp 100mA 5mAs. Hand exposure condition 2 is 48kVp 100mA 4mAs. Exposure condition number 3 is 46kVp 100mA 3. 2mAs. Exposure condition number 4 is 44kVp 100mA 2. 5mAs. The final exposure condition number 5 is 42kVp 100mA 1. 6mAs. The original data is obtained by exposing three times for each exposure condition.

Skull exposure condition 1 is 70kVp 200mA 12. 8mAs. Skull exposure condition 2 is 65kVp200mA 10mAs. Exposure condition number 3 is 60kVp200mA 8mAs. Exposure condition number 4 is 55kVp200mA 6. 4mAs. The final exposure condition number 5 is 50kVp200mA 5mAs. The original data is obtained by exposing three times for each exposure condition.

Abdomen exposure condition 1 is 85kVp 200mA 32mAs. Abdomen exposure condition 2 is 80kVp200mA 25mAs. Exposure condition number 3 is 75kVp200mA 20mAs. Exposure condition number 4 is 70kVp200mA 16mAs. The final exposure condition number 5 is 65kVp200mA 12. 8mAs. The original data is obtained by exposing three times for each exposure condition.

Result and Discussion

The results of the first reproducibility test showed no significant difference in all 10 times [Figure 1]. Therefore, the reproducibility of the equipment was determined to be reliable.

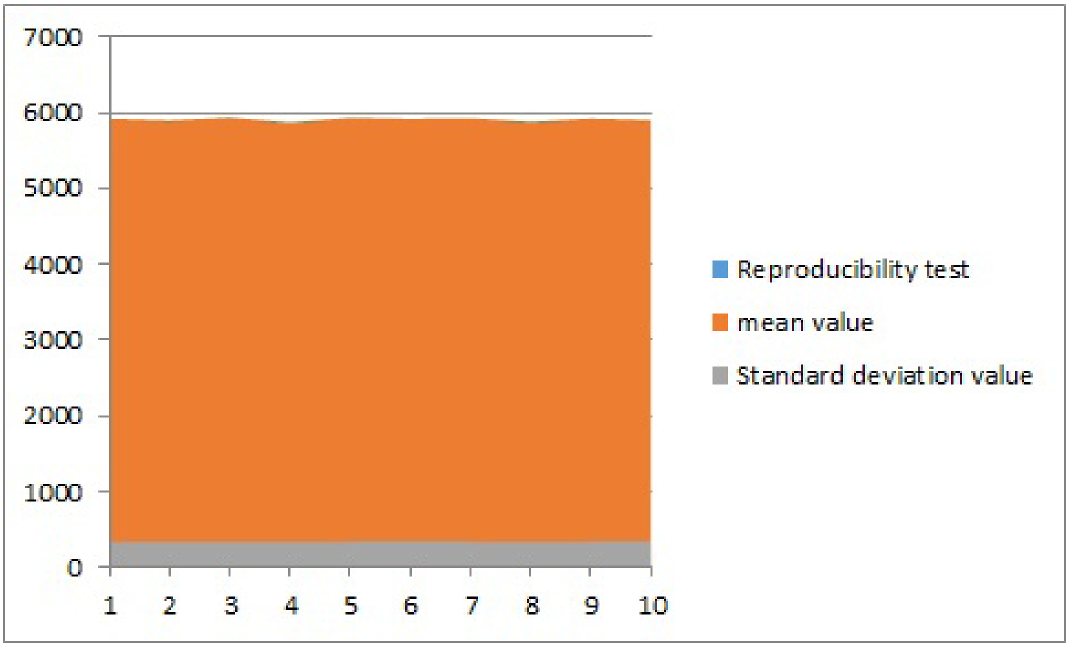

Figure 1. Reproducibility test

The results under Hand and abdomen exposure showed that the average value of all pixels decreased as the dose decreased. The average pixel value was reduced 33.42% when a 2 times the exposure conditions in the first time exposure conditions. When changing from exposure condition 2 to exposure condition 3, the average pixel value decreased by 55.42% based on condition 1. The change from exposure 3 to exposure 4 decreased 71.86% based on condition 1. In the last five exposure conditions, the average pixel value decreased by 85.35% based on the first exposure condition. Even under abdomen exposure conditions, as the dose decreased, the average value of all pixels decreased. The average pixel value was reduced 20.77% when a 2 times the exposure conditions in the first time exposure conditions. When changing from exposure condition 2 to exposure condition 3, the average pixel value decreased by 39.00% based on condition 1. The change from exposure 3 to exposure 4 decreased 56.15% based on condition 1. In the last five exposure conditions, the average pixel value decreased 74.16% based on the first exposure condition [Figure 2].

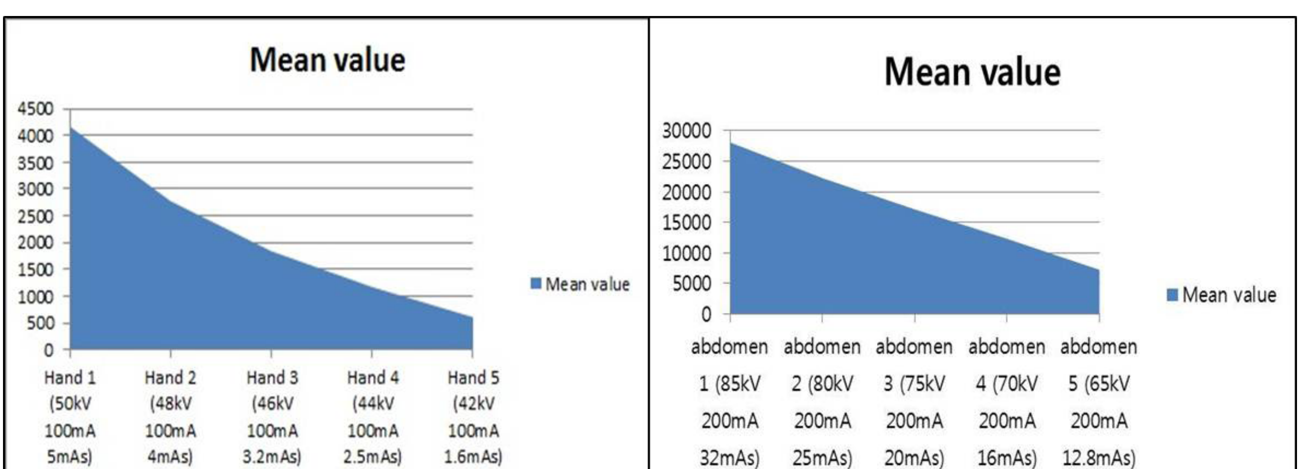

Figure 2. Hand and Abdomen mean value

When visually assessing the five-stage image, the difference between the fourth and fifth exposure conditions of the hand was significantly different [Figure 3].

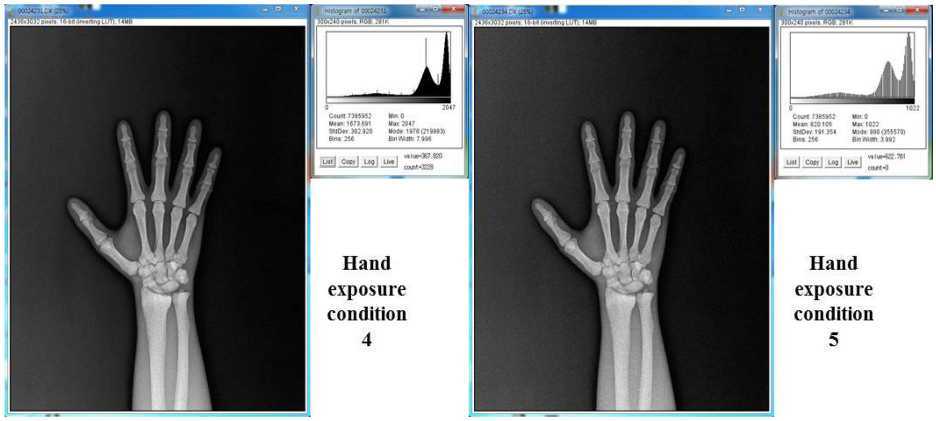

Figure 3. Visual evaluation of Hand images

When evaluated by visual observation of the image of 5 showed a definite difference between image Abdomen second exposure condition, and the third exposure condition [Figure 4].

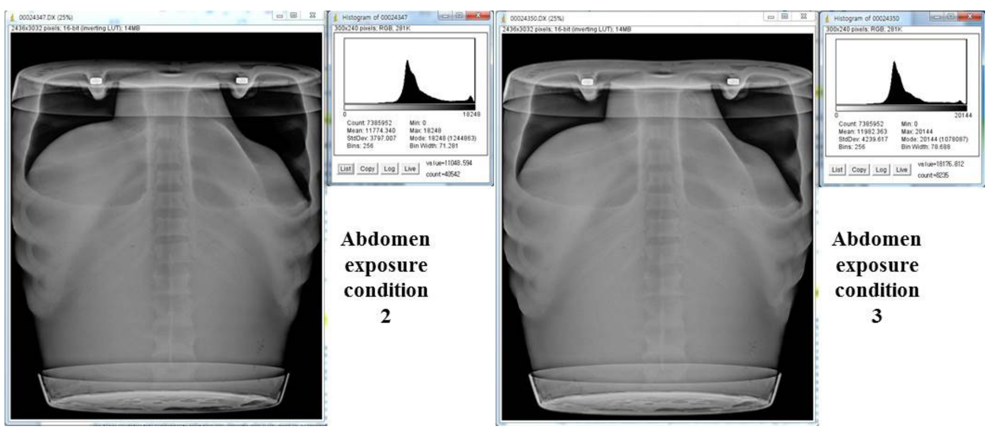

Figure 4. Visual evaluation of Abdomen images

[Table 1] shows the skull exposure condition, as the dose decreased, the average value of all pixels decreased. The average pixel value was reduced 41.88% when a 2 times the exposure conditions in the first time exposure conditions. When changing from exposure condition 2 to exposure condition 3, the average pixel value decreased 66.58% based on condition 1. When changing from exposure 3 to exposure 4 it was 81.68% decrease based on condition 1. In the last five exposure conditions, the average pixel value decreased by 85.78% based on the first exposure condition.

Table 1. Skull exposure condition mean value

Exposure Condition	Mean Value	Percent Ratio
skull 1 (70kV 200mA 12.8mAs)	31310.00	100%
skull 2 (65kV 200mA 10mAs)	18195.17	41.88% decrease
skull 3 (60kV 200mA 8mAs)	10462.85	66.58% decrease
skull 4 (55kV 200mA 6.4mAs)	5733.41	81.68% decrease
skull 5 (50kV 200mA 5mAs)	4451.10	85.78% decrease

When visually assessing the five-stage image, the difference between the fourth and fifth exposure conditions of the Skull was significantly different [Figure 5].

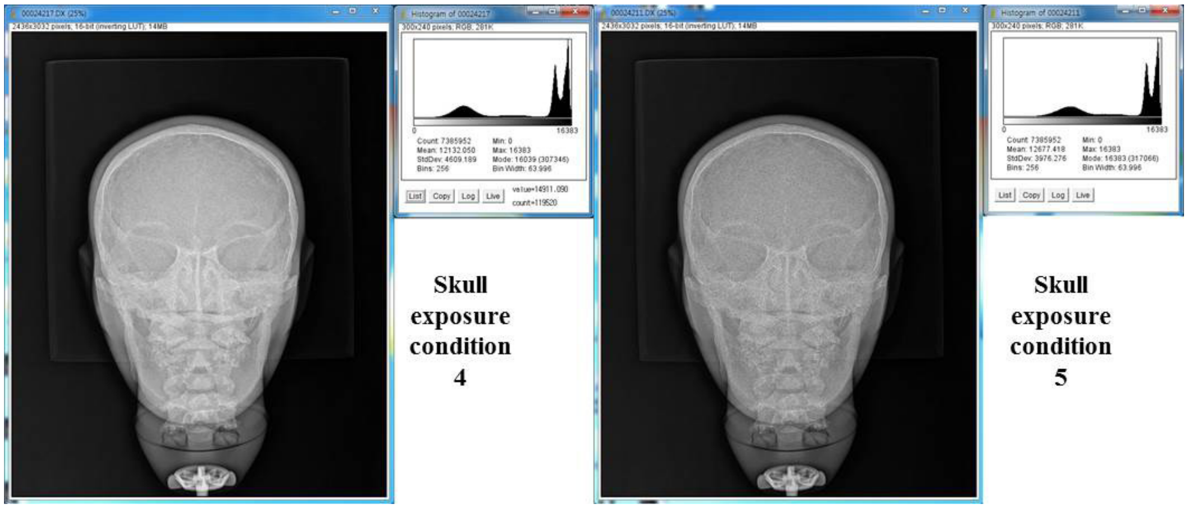

Figure 5. Visual evaluation of Skull images

Discussion

As a result of this study, it was confirmed that the pixel value decreased as the exposure dose decreased. It was also found that the value of the pixel reflected the amount of transmitted X-rays. In the case of the hand examination condition, it can be seen that the fourth condition is the most optimal condition in the visually determined image. In the abdominal examination condition, the second condition before the image suddenly deteriorated was the optimal condition to reduce and obtain the dose. In the case of Skull examination, the fourth condition was found to reduce the transmission dose and obtain a good image.

However, further experimentation will be required for these data to be reliable. The reduced transmission dose can be measured with a dosimetry to compensate for the reliability. In addition, more cases of data can be obtained to ensure the reliability of the data.

Conclusion

The X-ray ray imaging equipment used in the medical field differs from each manufacturer and the performance of each component, so the X-ray dose required to acquire an appropriate image is different. In addition, since the transmission dose is different for each site, it is necessary to adjust the exposure conditions.

When examining the change of the pixel value according to the change of the exposure condition, it was found that the pixel value reflects the dose. In this study, the change of pixel value according to the change of exposure condition and percent reduction of pixel value by condition were analyzed and confirmed. When the image was evaluated by the pixel value and the naked eye, the fourth exposure condition in the Hand and the fourth exposure condition in the Skull were found to be good conditions. And in Abdomen, the second exposure condition was good. However, with these results alone, it is difficult to find the optimal transmission dose to make an image. I will continue to study through more accurate experiments later.

Ethical Clearance: Not required

Source of Funding: Self

Conflict of Interest: Nil

References

1. M. Köner, C. H. Weber, S. Wirth, K.-J. Pfeifer, M. F. Reiser, and M. Treitl, "Advances in Digital Radiography: Physical Principles and System Overview 1", Radiographics, vol.27, 2007. pp.675-686.
2. M. Yaffe and J. Rowlands, "X-ray detectors for digital radiography", Physics in Medicine and Biology, 1997, 42, pp.1.
3. Kroft LJ, Veldkamp WJ, Mertens BJ, van Delft JP, Geleijns J. Detection ofsimulated nodules

on clinical radiographs: dose reduction at digital posteroanteriorchest radiology. Radiology 241:392-398; 2006.

4. Okka WH, Claude BS, Michael S, et al. Chest radiography with a flat-paneldetector; Image quality with dose rediction after copper filtration. Radiology237:691-700; 2005.
5. Burgess A. E. : Physical Measuremets of Heavy Metal Foils, British Journal ofRadiology. 1977. 55:252-254.
6. Berrington de Gonzalez A, Darby S, Risk of cancer from diagnostic X-rays, estimates for the UK and 14 other countries, Lancet 2004 (363), pp345-351.
7. Mohammad Javad Keikhai Farzaneh, Mahdi Shirin Shandiz, Mojtaba Vardian, Mohammad Reza Deevband, Mohammad Reza Karden, The Quality Control of Diagnostic Radiology Devices in Hospitals of Sistan and Baluchestan, Indian Journal of Science and Technology, Nov 2011 Vol 4 (No.11), pp 1458-1459.
8. Mi-Hwa Lee, Hong-Ryang Jung, Change in Exposure Index according to the Subject and Foreign Body Movement of Position, Indian Journal of Science and Technology, October 2015 Vol 8(26), pp 1-5.
9. M. Anto Bennet, Resmi R. Nair, V. Mahalakshmi G. Janakiraman. Performance and Analysis of Ground-Glass Pattern Detection in Lung Disease based on High-Resolution Computed Tomography. Indian Journal of Science and Technology, 2016 January Vol 9(2), DOI: 10.17485/ijst/2016/v9i2/71285.
10. In-Gyu you, Cheong-hwan Lim, Young-Cheol Joo. A Study on the of Justification of Low Dose Chest Computed Tomography during Health Examinations. Indian Journal of Science and Technology, 2015 January Vol 8(S1), 231-235.
11. Nam-Gil Choi, Jae-Bok Han, Jong-Nam Song, Wok Kim, Myo-Young Jung, Ho-Jin Seong. The Research on the Volume of Artificial Structure by the Change of Scan Parameter in CT Inspection. Indian Journal of Science and Technology, 2016 July Vol 9(25), DOI: 10.17485/ijst/2016/v9i25/97200.
12. Brunner CC, Kyprianou IS. Material-specific transfer function model and SNR in CT. Phys Med Biol. 2013 Oct 21;58(20):7447-61.