Indian Journal of Science and Technology, Vol 9(24), DOI: 10.17485/ijst/2016/v9i24/96164, June 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

A Study on Patient Gown in Digital Radiography Examination

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Abstract

Background/Objectives: The image quality was degraded due to the image noise in accordance with the performance improvement of diagnostic DR system. This study aims to present and recommend the effect on an image when hospitalized patients undergo the examination without wearing an examination gown in the chest PA test using radiography. **Methods/Statistical Analysis**: The experiment in this study was conducted by using the DR system of DK Company. In regard to the comparison experiment between the patient gown and the examination gown, Thorax Phantom was utilized. The Phantom specification is RS-111. The image was obtained by utilizing AEC by varying the dose (mAs) and tube voltage (kVp) while putting both the patient gown and the examination gown on the phantom. Then, the gray value of the obtained image was measured based on the 7 points that were to measure the density at the Japan Anti-Tuberculosis Association through the Image J program. **Findings:** In the case of descriptive statistics, it was found that there was only a small number of the factors that inhibited the quality of an image because the examination gown was closer to the mean value of phantom than the patient gown on the basis of the phantom. As for the analysis in relation to the measurement area, there was a significant difference at the 2 point spot and the 7 point spot in relation to the patient gown and examination gown of phantom in accordance with the tube voltage. As for the correlation analysis, there was a significant difference between the phantom, the patient gown and the examination gown. Hence, there was a relationship between these three groups. The most influencing factor of the DR development is the patient gown or the examination gown. **Application/Improvements:** It is believed that it would be possible to enhance the quality of an image by conducting an examination with the examination gown and comparing it with the patient gown in the radiography lab.

Keywords: Artifact, Chest PA, DR System, Gray Value

1. Introduction

The global health and medical paradigm is being shifted from disease treatment to prevention. As a result, the use of medical radiography is on the rise. The number of diagnostic radiography examination in Korea is rapidly rising at an annual rate of 35 percent from 160 million cases in 2007 to 220 million cases in 2011[1]. With the advent of diagnostic medical image equipment, the film screen system is being evolved to the digital radiography (DR) system, thereby reducing radiography exposure and acquiring high quality images. Thanks to the advancement of DR devices, it is now possible to obtain high quality images. Moreover, these newly developed DR devices removed image noise (artifact) resulting from the developing machine when the film was used in the past. It is now possible to substantially reduce the reshooting rate by the dose condition through the correction of images at the work station by utilizing histogram after obtaining an image.

Those images using the DR system were improved in terms of image quality. However, the artifacts are generated due to the patient gown for hospitalization and the examination gown of the radiography lab (hereinafter referred to as examination gown). The patient gown and examination gown for hospitalization are generally used

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in the examination process using X-ray. Hence, they aim to improve image quality by removing such foreign materials as accessories, buttons, iron and mark. However, the reality is that the hospital patient gown and examination gown are produced and commercialized with the functional and convenient designs. It would be good to have a patient gown or an examination gown through which radiography (X-ray) can be transmitted. But the reality is not so[2]. In addition, as for hospitalized patients, they undergo the examination with their hospitalized patient gown rather than wearing an examination gown. In such case, the distinction between a hospitalized patient gown and an examination gown is blurred, thereby leading to a serious problem. That is to say, it would become easy to obtain and delete an image at the DR system due to those patient gowns and examination gowns that have no specification or criterion. As a result, there is a concern over being insensitive to the radiation exposure from reshooting when there are artifacts that are overlapped with a lesion. The purpose of this study was to observe possible artifacts and problems associated with images when using the patient gown and examination gown in the DR system environment. To this end, this study aims to obtain and analyze the images of the phantom, the hospitalized patient gown and the examination gown of radiography lab in accordance with the diagnostic reference level in relation to the Chest PA examination, which was one of the frequently used examinations using radiography. Furthermore, this study aims to examine the measures to form high quality image by comparing the gray value at the program of Image J.

2. Materials and Methods

2.1 Objects of Study

The radiologists of the general hospitals, hospitals and private clinics were directly instructed on the purpose of this study for the purpose of identifying the status of gowns during radiography examination and evaluating the quality of images depending on gowns. Then, the hospitalized patient gowns and the examination gowns of radiography labs were collected. In regard to the hospitalized patient gown and examination gown, the number of the general hospitals was 18, accounting for 90 percent. In contrast, there were only 2 clinics that accounted for 10 percent (Table 1).

Table 1. Objects of Study

General Hospital		Hospital		Total	
N	%	N	%	N	%
18	90%	2	10%	20	100%

2.2 Method of Study

- Status of examination gown in radiography examination

The author of this study conducted the phone survey on the status of gowns in the radiography lab for the hospitalized patients at the 200 medical institutions.

- Acquisition of images in accordance with the change in Chest PA tube voltage and dose by wearing the examination gown

This study obtained the Chest PA image by putting the hospitalized patient gown and the examination gown of the radiography lab on the phantom (RS-111), which were collected from the 20 medical institutions (Figure1).

The dose was fixed at 4mAs for the shooting. Also, the tube voltage was varied to 100kVp, 105kVp, 110kVp, 115kVp and 120kVp. The tube voltage was fixed at 100kVp and varied to 2mAs, 3.2mAs, 4mAs, 5mAs and 6.3mAs for the shooting. The object distance (source-to-image-receptor distance; SID) was set at 180cm.

Figure 1. Acqusition of Phantom Image.

- Image Analysis

The dose and tube voltage (kVp) were varied by using the phantom and the phantom wearing the patient gown and examination gown. Each was repeated five times. A total of 210 obtained images were saved in DICOM file. The Image J was used to measure the mean value (gray value) based on the 7 point spot of tuberculosis evaluation of the Japan Anti-Tuberculosis Association (Figure 2). To minimize the error when measuring 7 points, the image was expanded up to 300 percent for setting the region of interest (ROI). Then, the measurement value with high frequency was selected after measuring each five times. Finally, the quantitative comparative evaluation was con-

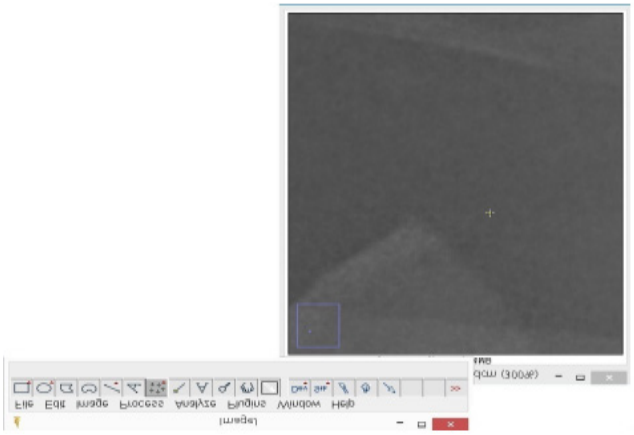

Figure 2. Analysis of Image J.

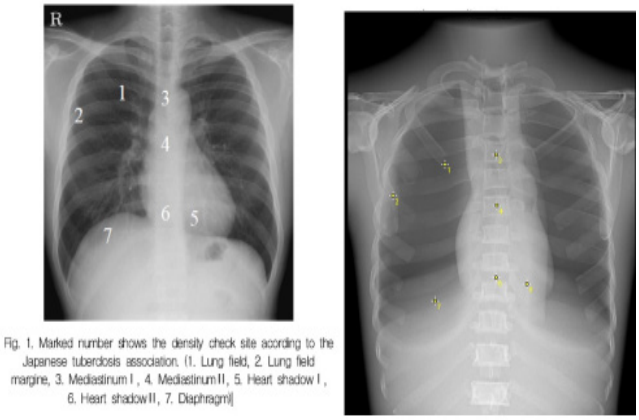

Fig. 1. Marked number shows the density check site according to the Japanese tuberdosis association. (1. Lung field, 2. Lung field margine, 3. Mediastinum I , 4. Mediastinum II, 5. Heart shadow I , 6. Heart shadow II, 7. Diaphragm)

Figure 3. Japan Anti-Tuberculosis Association 7 point.

ducted. In regard to the Tuberculosis evaluation of the Japan Anti-Tuberculosis Association, Point 1 is the high density area between Rib 5 and Rib 6 on the right of lung. Point 2 is the overlapped area of anterior Rib 5 and posterior Rib 6 on the right of the periphery of lung. Point 3 is the transmission part of mediastinal carnia organ. Point 4 is the area right below mediastina carnia. Point 5 is the abdominal aortic at the descending aorta between the shade area of heart I 10 and Rib 11. Point 6 is thoracic vertebrae part 10 and 11 of the shade area of heart. Point 7 is the abdominal aortic at the center of right diaphragm inside diaphragm (Figure 3).

- Statistical Analysis

As for data analysis, SPSS (Version 12.0 for window) was utilized. The gray value was deducted through descriptive statistics, correlation analysis and one-sample t-test. To compare the mean values of the examination gown and patient gown based on the gray value of phantom, descriptive statistics were used. To examine the correlation, correlation analysis was performed. Moreover, one-sample t-test was performed to compare the phantom with the examination gown and patient gown. The 7 point spots of Japan Anti-Tuberculosis Association were compared through one-way ANOVA for examining the differences in the 7 point spot and the mean value of phantom between the examination gown and patient gown.

3. Results

3.1 Status on the Gowns for Radiography Examination

Among the total of 71 medical institutions located in Seoul and Gyeonggi-do, only those hospitalized patients in the 2 medical institutions underwent the examination with the examination gown. The patients in a majority of these medical institutions underwent the examination with their hospitalized gown. In Gyeongsang-region, the hospitalized patients in only 1 medical institution out of the 63 medical institutions underwent the examination with the examination gown. There was no medical institution in Chungcheong-region, Gangwon-region, Jella-region and Jeju-region, which made it mandatory for patients to wear the examination gown for examination. Out of the 200 medical institutions, the patients hospitalized at the 197 medical institutions (98.5 percent) underwent the examination with their hospitalization gown. Only those patients in the 3 medical institutions (1.5 percent) underwent the examination with the examination gown (Table 2).

Table 2. Status on the gowns for radiography examination

Division	N	Patient Gown	Examination Gown
Seoul and Gyeonggi-do	71	69	2
Chungcheong-region	16	16	0
Gyeongsang-region	63	62	1
Jella-region	35	35	0
Gangwon-region	8	8	0
Jeju-region	7	7	0
total	200	197(98.5%)	3(1.5%)

3.2 Image Analysis in Relation to the Change in Dose

- Analysis on gray value of phantom, patient gown and examination gown

In the case of shooting by varying the dose while fixing the tube voltage (kVp), the mean gray value of phantom was found to be 10,172.51, whereas the mean gray value of patient gown was 9,840.41 and the mean gray value of examination gown was 10,239.46.

The difference in the gray value between the phantom and the patient gown was -332.10, whereas the difference in the gray value between the phantom and the examination gown was 66.95 (Table 3).

Table 3. Analysis on gray value of phantom, patient gown and examination gown

Section	Gray Value Average	Standard Deviation	Gray Value Difference
phantom	10,172.51	2341.84	
patient gown	9,840.41	2280.38	-332.10
examination gown	10,239.46	2339.83	66.95

- Correlation analysis of phantom, patient gown and examination gown

In the case of shooting by varying the dose to 2mAs, 3.2mAs, 4mAs, 5mAs and 6.3mAs while fixing the tube voltage (kVp), there was a significant difference between the following three groups: phantom, patient gown and examination gown. Hence, there was a correlation between these three groups ($p<.001$) (Table 4).

Table 4. Correlation analysis of phantom, patient gown and examination gown

Section	Phantom	Examination Gown	Patient Gown
phantom	1		
examination gown	0.998***	1	
patient gown	0.950***	0.963***	1

*** $p<.001$

- Analysis on phantom, patient gown and examination gown depending on measurement area

One-sample t-test was performed to examine the difference between the phantom and the patient and examination gowns for each point. As a result, there was no significant difference with the phantom (Table 5).

Table 5. Analysis on phantom, patient gown and examination gown depending on measurement area

Point	Section	M(SD)	t
1 point	patient gown	5,282.10(608.56)	-.316
	examination gown	5,532.62(707.90)	.520
2 point	patient gown	8,454.07(692.96)	-.061
	examination gown	8,473.73(865.81)	.002
3 point	patient gown	10,062.23(1,127.22)	-.962
	examination gown	10,477.65(1,250.69)	-.124
4 point	patient gown	10,660.65(889.18)	-.868
	examination gown	11,102.19(1,082.36)	.199
5 point	patient gown	11,967.98(541.66)	-.099
	examination gown	12,069.72(663.85)	.262
6 point	patient gown	11,909.01(804.90)	-.741
	examination gown	12,213.92(914.18)	.094
7 point	patient gown	9,984.68(306.98)	.256
	examination gown	10,059.53(354.70)	.693

3.3 Image Analysis in Relation to the Change in Tube Voltage

- Gray value analysis of phantom, patient gown and examination gown

In the case of shooting by varying the tube voltage while fixing the dose (mAs)t, the mean gray value of phantom was found to be 9,170.86, whereas the mean gray value of patient gown was 9,716.35 and the mean gray value of examination gown was 9,746.24.

The difference in the gray value between the phantom and the patient gown was 545.49, whereas the difference in the gray value between the phantom and the examination gown was 575.38 (Table 6).

- Correlation analysis of phantom, patient gown and examination gown

In the case of shooting by varying the tube voltage to 100kVp, 105kVp, 110kVp, 115kVp and 120kVp while fixing the dose (mAs), there was a significant difference

between the following three groups: phantom, patient gown and examination gown. Hence, there was a correlation between these three groups (p<.001) (Table 7).

Table 6. Gray value analysis of phantom, patient gown and examination gown

Section	Gray Value Average	Standard Deviation	Gray Value Difference
phantom	9,170.86	2,250.59	
patient gown	9,716.35	2,293.48	545.49
examination gown	9,746.24	2,299.75	575.38

- Analysis on phantom, patient gown and examination gown depending on measurement area

One-sample t-test was performed to examine the difference between the phantom and the patient and examination gowns for each point. In this regard, this study analyzed the mean gray value of 8,385.38 for the patient gown and the mean gray value of 8,155.97 for the examination gown for each group with the mean gray value of 7,424.80 for the phantom as the verification value when performing one-sample t-test in relation to Point 2. As a result, there was a significant difference between the phantom and the patient and examination gowns.

This study analyzed the mean gray value of 10,005.77 for the patient gown and the mean gray value of 10,543.49 for the examination gown for each group with the mean gray value of 9,607.00 for the phantom as the verification value when performing one-sample t-test in relation to Point 7. As a result, there was a significant difference between the phantom and the patient and examination gowns (Table 8).

4. Discussion

It has been 100 years since X-ray was first utilized in the medical field. In addition, the advancement of computer technology in the past 20 years developed the new technologies for expanding the spectrum of medical image in radiography. Despite the rapid advancement of radiology, still the general radiography shooting accounts for 80 percent of the total examinations related to lung, bone and stomach. That is, it accounts for the largest portion in radiology[3]. Hence it is imperative for radiologists to make more efforts to obtain high quality image information. Moreover, they should provide high quality services to patients.

With the advent of detector, the examination gown in radiography lab plays an important role in medical image diagnosis. The patient gowns and examination gowns used in the medical institutions have a variety of shapes and forms. Furthermore, they focus too much on functionality and convenience. As for the hospitalized patient gowns, they have various shapes and forms depending on the treatment department. Even, the hospitalized patient gown for orthopedic patients, the conveniently-wearing patient gown and the antibacterial and aromatic patient gowns are commercially available. In the case of the examination gown in radiography lab, the night gown with thick materials to show luxurious in terms of hospital service, there exist such unusual gowns as the examination gown with the same format. A one-piece type examination gown that can be easily worn, the examination gown that is bound from side so that no button is included in the image and the examination gown that is bound in inner side and again bound at outer side.

Although it is ideal to conduct radiography examination with full naked condition such as the phantom, it is nevertheless necessary to put an examination gown on patients given the human dignity and legal frame for obtaining an image. Therefore, this study aimed to conduct a comparative research based on the image of phantom, which is similar to full naked condition for the hospitalized patient gown at the medical institutions and the examination gown in the radiography lab.

As shown in the thesis of Roh, it would be difficult to get fully naked. Moreover, the wrinkle or overlapping of patient gown or examination gown generates image noise[2]. As a result, everyone is well aware of the importance of gown to such an extent as to create a patient gown with a non-woven fabric. Moreover, it was possible to verify the effects on the image quality through MTF analysis. In this study, only the hospitalized patients in the 3 hospitals (1.5 percent) out of the 200 hospitals nationwide wore the examination gown when undergoing radiography examination. This indicates that 98.5 percent of the medical institutions conduct radiography examination with the patient gown even though the radiography examination gown is available at these medical institutions.

To compare the image quality of patient gown and examination gown amid an increasing number of DR devices and the rapid improvement of image quality, this study aimed to present the problems associated with the gown in the DR examination by evaluating the chest test images with Image J based on the phantom image.

Table 7. Correlation analysis of phantom, patient gown and examination gown

	phantom	examination gown	patient gown
phantom	1		
patient gown	0.991***	1	
examination gown	0.973***	0.973***	1

***p<.001

Table 8. Analysis on phantom, patient gown and examination gown depending on measurement area

Point	Section	M(SD)	t
1 point	patient gown	5,242.76(331.86)	1.851
	examination gown	5,348.97(417.45)	2.041
2 point	patient gown	8,385.38(618.49)	3.473
	examination gown	8,155.97(634.33)	2.577
3 point	patient gown	10,042.56(1,202.11)	1.160
	examination gown	10,029.95(1,254.67)	1.088
4 point	patient gown	10,672.00(1,004.75)	.646
	examination gown	10,637.89(1,020.51)	.559
5 point	patient gown	11,875.40(650.32)	2.080
	examination gown	11,620.04(597.70)	1.308
6 point	patient gown	11,789.64(1,227.23)	1.213
	examination gown	11,887.40(882.91)	1.933
7 point	patient gown	10,005.77(1,148.93)	5.987
	examination gown	10,543.49(1,134.26)	1.846

In the image obtained by varying the dose (mAs) while fixing kVp, the examination gown had a larger difference in the gray value from the phantom image compared with the patient gown. This indicates that the examination gown will generate better image quality than the patient gown.

In the image obtained by varying kVp while fixing the dose (mAs), the examination gown had a larger difference in the gray value from the phantom image compared with the patient gown. This indicates that the examination gown will generate better image quality than the patient gown.

One-sample t-test was performed to examine the difference between the phantom and the patient and examination gowns for each point from the image in accordance with the change in dose (mAs). As a result, there was no significant difference from the phantom for each group. However, in the image resulting from the change in the tube voltage (kVp), there was a significant difference at Point 2 and Point 7 in relation to the phantom, patient gown and examination gown depending on the measurement area. This indicates the suspicion possibility of Tuberculosis as shown in the Tuberculosis density evaluation method of Japan X-ray examination and also the study of Ahn[4]. Hence, it would affect the diagnostic value in the image of chest examination. In addition, there was a significant correlation between the phantom, patient gown and examination gown. This implies that it is required to undertake the chest examination with the examination gown rather than the patient gown.

Following are the limitations of this study: This study was limited to chest PA examination. Moreover, this study did not measure the image noise resulting from the points other than those 7 points.

This study statistically measured and analyzed the gray value with Image J program in relation to the effects of hospitalized patient gown used in the radiography lab and the examination gown of radiography lab on images from the change of dose (mAs) and tube voltage (kVp) on the basis of the phantom image..

5. Conclusion

It was found that the 197 medical institutions (98.5 percent) conducted radiography examination with the patient gown for their hospitalized patients. In case of the shooting by the varying dose (mAs) while fixing the tube voltage (kVp), the examination gown had a larger difference in the gray value than the patient gown. In case of the shooting by the varying the tube voltage (kVp) while fixing the dose (mAs), the examination gown had a larger difference in the gray value than the patient gown. As a result of this study, there was a significant relationship on the images in accordance with the change in the dose and tube voltage in the patient gown and examination gown in reference with the phantom image. Therefore, it would be required to wear the examination gown in the chest radiography examination. Moreover, it would also be imperative to research and develop a standardized exami-

nation gown of radiography lab, which is suitable for the digital medical environment.

6. References

1. Ministry of Food and Drug Safety, Korea's national annual diagnostic radiography examination. 2014.
2. Nog HT, Jung JS, Shin JN, Shin HS, Jin DE, Kang SH, Lim JS. A study concerning Image quality evaluation of SMS nonwoven fabric examination gown for image quality improvement. 2007; 10(2):31-35.
3. Jung JS, Choi BU, Kim SH, Kim YM, Sim JN. The patient dose reduction of the use AEC markers on the X-ray chest radiography with automatic exposure control. Radiation Science and Technology. 2014; 37:177-85.
4. Ahn BJ. Korea Institute of Radiology: A comparative study for resolution and density of chest imaging using film/screen, CR and DR. 2010; 4(1):25-30.
5. Lee SH. Central University: The hospital medical staff clothing and Patient Gown Study on Design Development, Doctoral thesis. 2012; p. 179–88.
6. Park JE, Nam YR, Choo HS. Korea Society of Costume: Study on the develop ent Patient Gown for spinal surgery patients. 2012; 62:205-19.
7. Park Ye-Woon, Lim Cheong-Hwan, Jung Hong-Ryang, et al. Appropriate Inspection Distance of Digital X-ray Imaging Equipment for Diagnosis. Indian Journal of Science and Technology. 2015; 8(Supp. 8):380-86.
8. Chang-Gyu Kim. The Application of a Water Filter to Reduce Radiation Bone Mineral Densitometry(BMD). Indian Journal of Science and Technology. 2015; 8(Supp. 9):352-57.
9. Lee JS, Ko SJ, Kang SS, et al. Quantitative Evaluation of Image Quality using Automatic Exposure Control and Sensitivity in the Digital Chest Image. The Journal of the Korea Contents Association. 2013; 13(8):275–83.
10. Sohn Sunju. Gender Disparities in the Limited Access to Health Care and the Impact There of on Mental Health. Indian Journal of Science and Technology. 2015; 8(Supp. 7):352-56.