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Research paper

Change in PSNR According to Kvp, Mas and SID in CR System and DR System

Kyoungho Choi[1], Jae Young Jung[2], Hyang Ji Jung[3], Eun Jeong Heo[4], Jin Kyu Ko[5], Jung Keun Cho[6*]

[1,2,3,4,5,6*]*Department of Radiologic Science, Jeonju University, 55069 Republic of Korea*
[*]*Corresponding author E-mail: cjk0129@jj.ac.kr*

Abstract

F/S System could not obtain the image valuable for diagnostics unless it was taken under the precise exposure condition according to the patient's somatotype but CR and DR systems can obtain good quality of image by the post-processing after obtain the image under sufficient exposure condition. However, it may expose the patient more than required as it can obtain the image not under the best condition. In this study, the results of assessing the chest images obtained by the changes in mAs, kVp and SID quantitatively represented high PSNR of SID 180 cm, 120 kVp and 3.2 mAs in common in the CR and DR systems. In DR system, the quality of image shows clear differences by the exposure condition depending on the presence of AEC. Particularly, since DR system has marginal condition that represents the difference if the quality of image is good or bad, the study on the optimum exposure condition should be made by equipment.

Keyword: *CR system, DR system, PSNR, kVp*

1. Introduction

PSNR (Peak Signal-to-noise ratio) represents the noise ratio against the peak signal and it is used when evaluating the picture quality loss information in the lossy image or video compression (Kim et al., 2011). Recently, the medical image is being substituted rapidly with the digital image by CR(computed radiography) and DR(digital radiography) instead of analog image using F/S(film-screen) detector (Jo et al., 2008).

In CR system, the image information can be obtained if scanning IP(image plat), which the X-Ray information are accumulated after filming with IP coated with fluorescent material, with laser beam. The development of scientific technology and CR system accelerate the conversion from the analog image to digital image by accelerating the changes in the diagnostic radiology. Recently, as the digital radiologic technology, which has been developed based on CR system, developed the flat panel detectors, which can convert the image information to digital signal directly, DR system was emerged.

CR and DR systems have various advantages compared to F/S detector. Above all, F/S system requires the darkroom to develop the film and the space to store them but CR and DR systems do not need separate space. In case of using film, F/S system needs the film and the developer constantly but CR and DR system do not incur any cost except the initial cost. In addition, F/S detector produced the image by optimum kVp and mAs in the past but CR and DR system can change the picture quality by adjusting the contrast and sharpness by computer when the concentration is low due to low dose of radiation. Inversely, in case of overexposure, the picture quality can be adjusted with the concentration of the readable area. That is, F/S system could not obtain the image having diagnostic value without precise exposure condition according to the patient's somatotype but CR and DR systems can obtain the good quality picture by the post-processing after obtaining the sufficient exposure condition. However, as it can obtain the image not under the best condition, the radiation dose more than necessary can be applied to the patient (Kim et al., 2015).

In the DR system, if the exposure condition is excessive or insufficient by the post-processing process by AEC(auto exposure control), it is hard for interpreter or inspector to recognize the visual change in the image (Kim et al., 2011).The advantage of digital technology apparently has potential to enhance the radiant ray work but it is true that it implies the risk to abuse the radiation, and although in F/S system, contrast, light and shadow, etc of the image according to the radiation exposure are the criteria to imply the over- or under-exposure, in the digital system, the contrast, light and shadow, etc. are not influenced greatly by the exposure dose (Lee et al., 2013).Someone has compared and analyzed the exposure condition between F/S system and CR system to materialize the idealistic image of abdominal plain film[4]. However, they suggested the dose value to be able to obtain the image from optimum F/S system according to the quantitative analysis. The purpose of this study is to evaluate the chest images obtained by varying the dose and the quality of radiation and to contribute to the reduction of patient's exposure.

2. Materials and Methods

2.1 Test Equipment

In this study, DR system(exprimer EVS 4343, DR-TEC, Korea) and which X-ray equipment(GXR-C4-5) equipped with Toshiba E7239X(140 kHU) tube and FPD (flat panel detector) are combined, CR system(CR 875, KODAC, Japan), which single-sided reading reader and the image plate of 35 x 43 cm^2 (2,048×2500) pixel matrix are combined, and the chest phantom were used.

2.2. Method

To find out how the qualitative value from CR and DR images are changed according to the exposure condition, the images at the quality of radiation (80, 90, 100, 110, 120 kVp) and at each mAs according to the changes in the object distance and the images at the quality of radiation (0.96, 1.92, 3.2, 3.84, 5.12, 6.4, 8, 10.2 mAs) and at the each object distance using chest phantom in the PA (posterior-anterior projection) direction as shown in [Table I]. The quantitative evaluation and analysis were performed by obtaining PSNR values using ICY program after obtaining the uncompressed files in DICOM format through MedPax®.

Table I : Parameters

system	CR				DR			
kVp	80	90		100		110	120	
mAs	0.96	1.92	3.2	3.84	5.12	6.4	8	10.2
SID(cm)	100				180			

3. Results and Discussion

3.1 PSNR by Dose Based on 110 kVp in CR System (SID: 100cm)

In the results of comparing PSNR by mAs based on 110 kVp and SID of 100 cm in CR system, the lower the tube voltage and the tube current, PSNR was generally reduced but PSNR at 3.84 mAs represented similar value to the value at 10.2 mAs. In CR system, when filming chest with SID of 100 cm, the exposure condition at 120 kVp and 2.84 mAs or at 100 kVp and 5.12 mAs was represented to be appropriate as seen in [Table II].

Table Ⅱ : Changes in PSNR by Dose Based on 110 kVp in CR System(SID: 100cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	3.5414	3.5804	1.0437	1.2502	0.7660	0.5833	0.3957	-1.0866
90	1.7054	6.9000	4.4775	3.8291	4.1531	4.0381	2.6318	2.3208
100	7.3824	9.2573	8.5588	4.5152	9.6241	8.9401	8.9221	9.0514
110	R [1]	R	R	R	R	R	R	R
120	8.5414	7.4967	8.8900	10.0126	8.7939	9.0684	9.8806	10.0485

3.2. PSNR by Dose Based On 110 Kvp in CR System (SID: 180cm)

In the results of comparing PSNR by mAs based on 110 kVp and SID of 180 cm in CR system, the lower the tube voltage and the tube current, PSNR was reduced but PSNR at 3.2 mAs represented similar value to the value at 8 mAs. In CR system, when filming chest with SID of 180 cm, the exposure condition at 120 kVp and 3.12 mAs or at 100 kVp and 6.4 mAs was represented to be appropriate as seen in [Table III].

Table III: Changes in PSNR by Dose Based on 110 kVp in CR System (SID: 180cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	-1.0070	1.5730	0.7465	3.3242	3.2481	3.0143	2.7841	1.8780
90	2.1190	4.3885	6.1310	6.2001	5.0053	5.4420	4.8577	-
100	0.5283	5.0953	7.0945	7.8265	6.6903	9.0031	8.0013	6.2108
110	R	R	R	R	R	R	R	R
120	4.2939	6.2171	9.1076	8.9152	6.1029	8.1794	9.6257	8.6996

3.3. PSNR by Dose Based on 110 Kvp in DR System (SID: 100cm)

In the results of comparing PSNR by mAs based on 110 kVp and SID of 100 cm in DR system compared to CR system, it was hard to find the functional relation between the tube voltage and tube current, and unusually high PSNR was represented in specific exposure condition as seen in [Table IV]. In DR system, when filming chest with SID of 100 cm, PSNR was highest at 120 kVp and 3.84 mAs and is deemed to be exposure condition showing the limit as it represented considerable difference with PSNR at 3.2 mAs.

Table IV : Changes in PSNR by Dose Based on 110 kVp in DR System (SID: 100cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	-6.7374	-9.6477	-7.3139	-10.1873	6.4210	-6.1969	-4.4288	-2.5493
90	-5.8868	-4.4865	-1.5486	-6.5614	-3.9626	-2.2740	2.5528	1.6012
100	-1.7399	0.4384	6.1940	-3.3384	8.4465	9.6565	7.3048	5.9850
110	R	R	R	R	R	R	R	R
120	1.6429	-2.3723	-0.7260	12.6053	9.2205	8.6592	6.8346	8.7283

3.4. PSNR by Dose Based on 110 Kvp in DR System (SID: 180cm)

In the results of comparing PSNR by mAs based on 100 kVp and SID of 180 cm in DR system, the lower the tube voltage and the tube current, PSNR was increased as seen in [Table V]. When filming the chest at SID of 180 cm, PSNR was highest at 120 kVp and 10.2 mAs followed by PSNR at 100 kVp and 10.2 mAs but to reduce the patient's exposure dose, the exposure condition at 120 kVp and 5.12 mAs, which have shown small difference with the highest PSNR, is appropriate.

Table V : Changes in PSNR by Dose Based on 110 kVp in DR System (SID: 180cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	-1.6114	-11.0878	-9.9272	-2.2307	-4.0432	-2.5716	-0.1319	1.6657
90	-2.1274	-9.0753	-0.2145	0.4413	1.5204	3.4049	5.3636	8.2268
100	-0.9604	0.8257	4.2152	5.4509	6.0980	8.5471	11.4772	12.4412
110	R	R	R	R	R	R	R	R
120	-7.5392	3.2968	2.9192	6.7843	10.8385	11.8001	12.3219	13.3414

3.5. PSNR by Kvp Based on 3.84 Mas in CR System (SID: 100cm)

In the results of comparing PSNR by kVp based on 3.84 mAs and SID of 100 cm in CR system, the highest value was represented at 110 kVp and 3.2 mAs followed by PSNR at 120 kVp and 3.2 mAs It was hard to find the functional relation of PSNR with tube voltage and the tube current as seen in [Table VI].

Table VI : Changes in PSNR by kVp Based on 3.84 mAs in CR System (SID: 100cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	2.1580	5.8697	5.4684	R	8.1333	6.4194	4.9027	1.9596
90	-0.0989	7.6540	10.7299	R	8.1339	6.2520	2.6200	1.0682
100	0.5844	3.0900	4.4824	R	4.9956	4.0273	2.5558	1.3611
110	1.5676	4.7064	11.2287	R	9.3221	6.9448	4.6513	2.5933
120	1.2616	4.8291	10.1795	R	9.2799	6.9165	4.7356	2.9001

3.6. PSNR by Kvp Based on 3.84 Mas in CR System (SID: 180cm)

In the results of comparing PSNR by kVp based on 3.84 mAs and SID of 180 cm in CR system, the higher the tube voltage and the tube current, PSNR was increased as seen in [Table VII]. The highest value was represented at 120 kVp and 3.2 mAs followed by PSNR at 110 kVp and 3.2 mAs.

Table VII : Changes in PSNR by kVp Based on 3.84 mAs in CR System (SID: 180cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	-2.7436	0.3325	0.8444	R	5.6580	3.8780	4.6265	3.7803
90	0.3810	4.3576	6.7986	R	7.1897	5.6904	5.2364	-
100	5.7262	4.8690	7.1815	R	6.3487	6.6853	7.1640	3.2042
110	2.4568	6.0916	8.7083	R	6.3863	8.6233	6.0889	4.1852
120	2.7534	5.6201	9.9050	R	8.5105	6.6723	5.6272	3.6244

3.7. PSNR by Kvp Based on 3.84 Mas in DR System (SID: 100cm)

In the results of comparing PSNR by kVp based on 3.84 mAs and SID of 180 cm in DR system compared to CR system, it was hard to find the functional relation of PSNR with the tube voltage and the tube current and unusually high PSNR was represented at the specific condition. When filming the chest at SID of 100cm in DR system, the highest PSNR was represented at 120 kVp and 3.2 mAs followed by PSNR at 120 kVp and 1.02 mAs. In addition, as PSNR showed significant different with PSNR at 120 kVp and 0.96 mAs, it is deemed to be the exposure condition having limitation as seen in [Table VIII]. PSNR was increased. The highest value was represented at 120 kVp and 3.2 mAs followed by PSNR at 110 kVp and 3.2 mAs.

Table VIII : Changes in PSNR by kVp Based on 3.84 mAs in DR System (SID: 100cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80 (kVp)	-6.6531	-2.3277	4.7693	R	-9.4429	0.3793	-1.0308	-10.3468
90	-6.9024	-0.0606	7.3592	R	6.3638	5.9986	-5.9696	-4.5139
100	-6.3675	1.3932	10.4850	R	-3.5718	-1.5815	-0.1730	2.9670
110	-7.0524	-2.2174	-1.0218	R	9.5739	4.9118	1.3333	-2.0569
120	-3.6396	10.9125	13.8264	R	6.2867	2.2515	-1.3736	-3.4169

3.8. PSNR by Kvp Based on 3.84 Mas in DR System (SID: 180cm)

In the results of comparing PSNR by kVp based on 3.94 mAs and SID of 180 cm in DR sysyem, it was hard to find the functional relation of PSNR with the tube voltage and tube current as seen in [Table IX]. The maximum value was shown at 120 kVp and 9 mAs and did not show big difference at 120 kVp and 5.12 mAs. In addition, as it showed the significant difference with PSNR at 120 kVp and 1.92 mAs, it is deemed to be the exposure condition having limitation.

Table IX : Changes in PSNR by kVp Based on 3.84 mAs in DR System (SID: 180cm)

	0.96 (mAs)	1.92	3.2	3.84	5.12	6.4	8	10.2
80	-10.6889	-11.0245	-9.2211	R	-0.0250	0.1300	-0.4108	-1.1518

(kVp)								
90	-10.9499	-8.7209	3.1093	R	3.4325	1.9215	0.8833	-0.6505
100	-11.5065	0.2228	5.5041	R	5.7740	4.3320	2.2909	1.9649
110	-10.4397	1.5063	4.1398	R	6.7706	6.3218	6.3097	6.3939
120	-4.6479	-1.1479	9.0289	R	10.6296	10.8260	10.8898	9.9119

4. Conclusion

The diagnostic radiology using X-ray is the diagnosis method having the longest history since the X-ray was discovered in 1895 and at the same time, easy and rapidly accessible diagnosis method. The chest PA projection, the projection technique adapted in this study out of the various projection techniques currently available, has advantage to diagnose the pneumothorax, pneumonia, tuberculosis, tumor, pleural effusion, etc. However, since it uses X-ray no matter how great advantage it has, it needs the strong regulation as it accompanies the radiation exposure that may affect the human body. The advanced medical countries such as Great Britain and the United States recognized the hazard of radiation exposure and establish firmly the infrastructures for radiation dose management. To obtain the image having diagnostic value, it needs the clear understanding on the optimal exposure condition, which makes the optimum image, and at the same time, it requires the efforts to minimize unnecessary exposure dose to the patient. To minimize the exposure, no re-projection should be made and the optimum exposure condition should be used. As it has been developed to CR and DR system from F/S system, since the appropriate image is made by adjusting the picture quality by the development of post image processing technology and AEC in spite of excessive exposure condition, the re-projection problem was solved partially. However, AEC having advantage that facilitates the projection exposes the patient on the radiation dose more than required. In this study, following conclusion was obtained by acquiring the image by parameter (kVp, mAs, SID) depending on AEC, which is the structural characteristic of CR and DR systems and by comparing their PSNRs.

First, in the results of comparing PSNR by mAs and SID based on 100 kVp in CR system, the difference in maximum PSNR according to SID was nearly not found and generally, the higher the tube voltage and the tuber current, the more PSNR was increased. The optimum exposure condition reducing the patient's exposure is at SID of 180 cm, 120 kVp and 3.2 mAs.

Second, in the results of comparing PSNR by mAs and SID based on 110 kVp in DR system, the difference in maximum PSNR according to SID was nearly not found, it was hard to find the functional relation of PSNR with the tube voltage and tube current and showed the characteristic that the marginal exposure condition is clearly distinguished. The optimum exposure condition reducing the patient's exposure is at SID of 180 cm, 120 kVp and 5.12 mAs.

Third, in the results of comparing PSNR by kVp and SID based on 3.84 mAs in CR system, the difference in maximum PSNR according to SID was nearly not found and the optimum exposure condition reducing the patient's exposure is at SID of 180 cm, 120 kVp and 3.2 mAs.

Fourth, in the results of comparing PSNR by SID and kVp based on 3.84 mAs in DR system compared to CR system, it was hard to find the functional relation of PSNR with the tube voltage and tube current and showed the characteristic that the marginal exposure condition is clearly distinguished. The optimum exposure condition reducing the patient's exposure is at SID of 180 cm, 120 kVp and 3.2 mAs.

Aggregating above, CR system and DR system show the clear difference in picture quality by each exposure condition according to the presence of ACE. Particularly, since in DR system, the marginal exposure condition, which shows the good quality and bad quality picture, exists, the research on the optimum exposure condition should be made by equipment.

References

[1] Dongyoung, K., Jihae, L., Myungsoo, K., Boram, H., Cheonhee, L., Soyeong, K., Sohyun, A., Rena, L., 2011. Setting up a CR Based Filmless Environment for the Radiation Oncology: Korean journal of medical physics, 22(3): 155-162

[2] Gwangho, J., Yeonghan, K., Busun, K., 2008. A Study on the Exposure Parameter and Patient Dose for Digital Radiography System in Dae Goo: Journal of radiological science and technology, 31(2): 177-182.

[3] Hore, A., Ziou, D., 2010. Image Quality Metrics: PSNR vs. SSIM: International Conference on Pattern Recognition, (4): 2366-2369

[4] Hyeon, A., Changsoo, K., Junghoon, K., 2015. Evaluation of Image Quality for Radiographic Positioning using IEC Radiation Quality in the Digital Radiography System: Journal of Contents, 15(7): 289-299.

[5] Hyunjong, K., Jungwon, K., Soohyung, L., Jooyeon, K., Mooyoung, K., 2015. Radiation Exposure through Private Health Examinations in Korea: Korean Journal of Health Promotion, 15(3): 136-140.

[6] Jaein, K., Yangseop, L., Dongsoo, J., Mincheol, J., Seungho, B., Kwanseop, L., Dongyun, H., 2011. A Study on the Proper Chest Exposure Conditions of Mobile Digital X-ray Unit by Exposure Index: Journal of the Korean society for digital imaging in medicine, 13(3): 139-144.

[7] Jincheol, P., Sanghoon, L., 2009. Structural Similarity Based Video Quality Metric using Human Visual System: Journal of broadcast engineering, 14(1): 36-43.

[8] Jungu, C., 2008. Analysis of Factors that Affect Dose Increase and Image Deterioration in Digital Radiography: Dankuk University

[9] Keonghsung, L., 1997. A Review of Technical Factors and Evaluation Methods to Improve the Image Quality of Chest Radiography: Journal of Cheju Hanna University, 21: 309-331.

[10] Kwangjae, L., Mingi, K., Jongwoong, L., Hocheol, K., 2013. Research for The Environmental Optimization of Dose and Image quality in Digital Radiography: Journal of the Institute of Electronics Engineers of Korea, 50(2): 203-209.

[11] Minsun, Y., Jaeseung, L., Inchul, I., 2012. Evaluation of Approximate Exposure to Low-dose Ionizing Radiation from Medical Images using a Computed Radiography (CR) System: Journal of the Korean Society of Radiology, 6(6): 455-464.

[12] Sangheok, S., Youngkeun, S., Jaebong, K., 2007. The Comparative Analysis of Exposure Conditions between F/S and C/R System for an Ideal Image in Simple Abdomen: Journal of the Korean society of medical digital imaging technology, 9(1): 37-43.

[13] Sangkwang, L., Wonyeong, Y., Yeongho, S., 2012. Trends in Visual Quality Assessment: Electronics and Telecommunications Trends, 27(3): 383-89.

[14] Whal, L., 2011. Current status of medical radiation exposure and regulation efforts: The Journal of the Korean Medical Association, 54(12): 1248-52.