▸원 저◂

ISSN 1226-2854

The Study on the Attenuation of X-ray and Imaging Quality by Contents in Stomach

– 위장내 음식물에 따른 방사선 감약 및 화질에 관한 연구 –

[1)]Department of Radiological Technology, Gwangju Health College University
[2)]Department of Nuclear Engineering, Chosun University
[3)]Department of Physical Therapy, Gwangju Health College University

Kyung-Rae Dong[1,2)] · Youn-Sang Ji[1)] · Chang-Bok Kim[1)]
Seong-Kwan Choi[1)] · Sang-In Moon[1)] · Kevin Dieter[3)]

— Abstract —

This study examined the change in the attenuation of X-rays with the ROI (Region of Interest) in DR (Digital Radiography) according to the stomach contents by manufacturing a tissue equivalent material phantom to simulate real stomach tissue based on the assumption that there is some attenuation of X-rays and a difference in imaging quality according to the stomach contents. The transit dosage by the attenuation of X-rays decreased with increasing protein thickness, which altered the average ROI values in the film and DR images. A comparison of the change in average ROI values of the film and DR image showed that the image in film caused larger density changes with varying thickness of protein than the image by DR. The results indicate that NPO (nothing by mouth) is more important in film system than in DR system.

Key Words : NPO, Protein, X-ray attenuation, Tissue equivalence

Ⅰ. INTRODUCTION

X-rays from X-ray tubes produce a monochrome contrast that is dependent on the density distribution. X-rays traveling a constant distance while taking an image can attenuate according to the inverse square law of distance and interactions through the absorption and diffusion of materials. Attenuation by the absorption of materials is the largest of the three attenuations of human tissue as the human body interacts with x-rays. The absorption of x-rays is different in soft tissue, bone, fat, gas, etc. The difference in absorption is generated by the density and atomic number of each tissue. The density of a subject is an important factor that influences attenuation, and is expressed by the total physical mass in a given space volume[1,8~9)]. The absorption of x-rays varies in proportional to the density of tissue. Compared to fat,

*접수일(2008년 12월 11일), 심사일(2009년 2월 6일), 확정일(2009년 3월 3일)

교신저자 : 지연상, (506-701) 광주광역시 광산구 신창동 683-3번지
광주보건대학 방사선과
TEL : 062-958-7665, FAX : 062-958-7669
E-mail : jiysg@mail.ghc.ac.kr

or gas, which has low tissue density, soft tissue has a high tissue density. Therefore, the absorption of x-rays increases with decreasing dose. The difference in absorption increases with increasing atomic number. Because bone and metal has a higher atomic number than soft tissue, their attenuation is also large. The stomach is an organ that stores contents transiently in the interior of the body, and is made from soft tissue. It forms the largest part of the digestive organs[2,10]. Generally, it is located in the center of the body. It is normally considered essential to demand NPO (nothing by mouth) as a prior measure before an inspection to check for the presence of abnormalities, as well as to improve the image quality when filming the abdomen[3,11-14]. Abnormalities, such as the presence of residual gas, free gas in the abdominal cavity, or abnormal gas in the digestive organ, can affect the image quality. However, there are no reports showing how the stomach contents can influence the imaging quality. This study examined the influence of NPO on the X-ray image quality by analyzing the attenuation change in x-ray absorption, and density values on the film according to the protein thickness.

Ⅱ. MATERIAL AND METHOD

1. STUDY OBJECTS

The reproducibility of the output power in kVp, mA, mAs from x-ray radiation equipment (Dong-A sts-28) was measured using a multi function meter. The phantom was manufactured using Styrofoam, Acrylic and Millet based on an image derived from CT from an adult abdomen (thickness, 20 cm) (Fig. 1). Beef was used as a tissue equivalent material for the contents in stomach, and was minced to a size of 1 mm using a blender, which is the same condition as the masticatory, vermiculation movement in the stomach. Subsequently, the minced beef was placed in glacial acetic acid at pH 2~3 for approximately 3 hours. The distance between the x-ray equipment and measuring instrument was fixed to 100 cm, which is similar to an experiment arrangement plan (Fig. 2). The experimental factors were fixed at 70 kVp and 30 mAs, which is the same as the filming technical factors for general abdominal imaging in adults. The degree of attenuation was measured as the change in thickness of the material at 1 cm intervals. After the image was obtained by each F/S and DR (Digital Radiography), the density based on the thickness was calculated. The degree of dosage attenuation and the numerical value of the ROI (region of interest) were measured according to the thickness of beef.

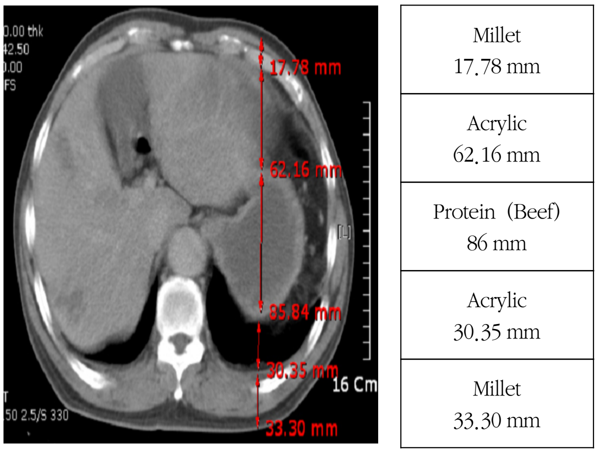
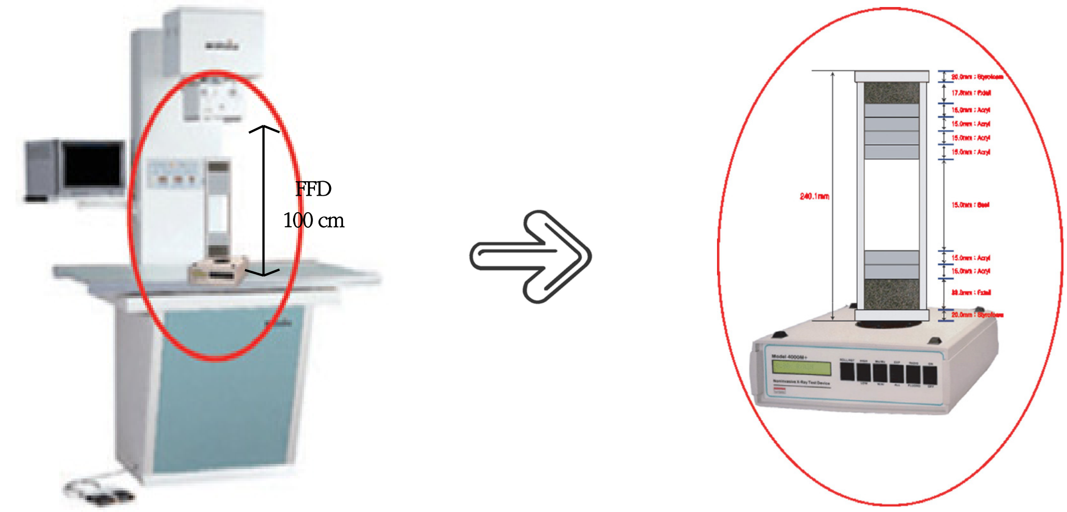


Fig. 1. CT image of the phantom

2. MATERIAL

In this study, phantoms (Styrofoam, Acrylic [1.5T] 5X5 cm-6 Ea, Acrylic[0.1T] 5X5 cm 2 Ea, and Millet) were produced based on the image derived from Computed Tomography PONTO XE (HITACHI, Japan) of an adult abdomen (thickness 20 cm). The phantoms' exposure to radiation dose from the General Radiographic X-ray Generator (DONG-A X-RAY, KOREA) and the Digital X-ray Generator VIDIX (HITACHI, JAPAN) were measured by Multi-function meter MODEL 240A (RMI, USA) and the X-ray Test Device Model 4000M+ Ion Chamber 6000-528 (VICTOREEN, JAPAN). In order to acquire the im-



(a) experiment equipment

(b) Enlargement image of phantom and Ion chamber using tissue equivalence material

Fig. 2. A dosage attenuation experimental arrangement plan using a phantom
(a) Experiment equipment
(b) Enlargement image of phantom and Ion chamber using tissue equivalence material

age from film 10X12 Cassette 2 Ea and 10X12 Film 4 Ea were used and generated by Automatic pro-cessor DSP5000 (DOOSAN, KOREA).

3. STATISTICAL ANALYSIS

The data was analyzed using the SPSS (Window 15.1 ; SPSS Inc., Chicago, IL, USA) statistics program. The CV (coefficient of variation) and PAE (Percentage Average Error) were used to reproduce the output power from the x-ray equipment. The dosage attenuation based on the protein thickness, concentration change in the film, and concentration change in the ROI in DR were compared and ana-lyzed using one-way ANOVA. A post-hoc analysis of Scheffe was applied as a post-hoc test method if there was a significant difference between the groups according to ANOVA. A t-test was carried out using the percentage to compare the density changes in the film and DR. A p value <0.05 was considered significant.

Ⅲ. RESULTS

1. Reproducibility of the output power from the x-ray equipment

Table 1 shows data on the reproducibility of the

Table 1. Data showing the reproducibility of the output power in the x-ray equipment

Times	Irradiation Requirement		
	70 kvp	150 mA	30 mAs
1	70	150	30.585
2	69	148	30.600
3	70	149	30.570
4	70	150	30.583
5	68	148	30.495
6	69	149	30.542
7	70	149	30.563
8	70	148	30.542
9	70	148	30.495
10	69	148	30.570
GM	69.5	148.7	30.554
GDS	0.7	0.8	0.03
CV	0.01	0.005	0.001
PAE(%)	0.71	-1.85	0.87

Table 2. Change in dosage according to the protein thickness (Unit : μGy)

Item	Classification	N	GM±GSD	Percentage of change (%)	F-value	p
Thickness	0	10	68.80±0.99[a]	100%	1768.85	0.000*
	1	10	64.50±0.52[b]	93.8%		
	2	10	60.30±0.67[c]	87.7%		
	3	10	54.50±1.08[d]	79.2%		
	4	10	51.30±0.67[e]	74.6%		
	5	10	48.40±0.69[f]	70.4%		
	6	10	45.40±0.51[g]	66%		
	7	10	42.60±0.51[h]	61.9%		
	8	10	41.10±0.73[i]	59.7%		

Note) post-hoc test of Scheffe. The group of same alphabet means the same group of average level. The alphabet order means a difference between groups.
* p 〈 0.001

output power in kVp, mA, mAs from the x-ray radiation equipment. The PAE allowance of normal x-ray radiation equipment was kVp, ±10%, mA, ±15%, and mAs, ±20%. In this study, The PAE allowance of the Dong-A sts-18 machine is as follows : kVp = 0.71%, mA = -1.85%, and mAs = 0.87%. Hence, the stability of x-ray output was confirmed.

2. Dosage change according to the protein thickness

There was a significant difference in dosage according to the beef thickness from 0 to 8 cm. Post-hoc analysis of Scheffe revealed the highest dose at a thickness of 0 cm(a) followed in order by 1 cm(b) 2 cm(c) 3 cm(d) 4 cm(e) 5 cm(f) 6 cm(g) 7 cm(h) 8 cm(i)(Table 2).

3. Change in concentration according to the protein thickness in the film image

There was a significant difference in the concentration of the film image. Post-hoc analysis of Scheffe revealed the highest concentration at a thickness of 0 cm(a) followed in order by 1 cm(b) 2 cm(c) 3 cm(d) 4 cm(e) 5 cm(f) 6 cm(g) 7 cm(h) and 8 cm(i) (Table 3, Fig. 3).

Table 3. Change in concentration according to the protein thickness in film image (Unit : Density)

Item	Classification	N	GM±GSD	Percentage of change (%)	F-value	p
Thickness	0	10	2.62±.007[a]	100%	16667.66	0.000*
	1	10	2.18±.007[b]	93.8%		
	2	10	2.01±.005[c]	87.7%		
	3	10	1.84±.007[d]	79.2%		
	4	10	1.81±.005[e]	74.6%		
	5	10	1.69±.008[f]	70.4%		
	6	10	1.49±.010[g]	66%		
	7	10	1.38±.004[h]	61.9%		
	8	10	1.27±.008[i]	59.7%		

Note) post-hoc test of Scheffe. The group of same alphabet means the same group of average level. The alphabet order means a difference between groups.
* p 〈 0.001

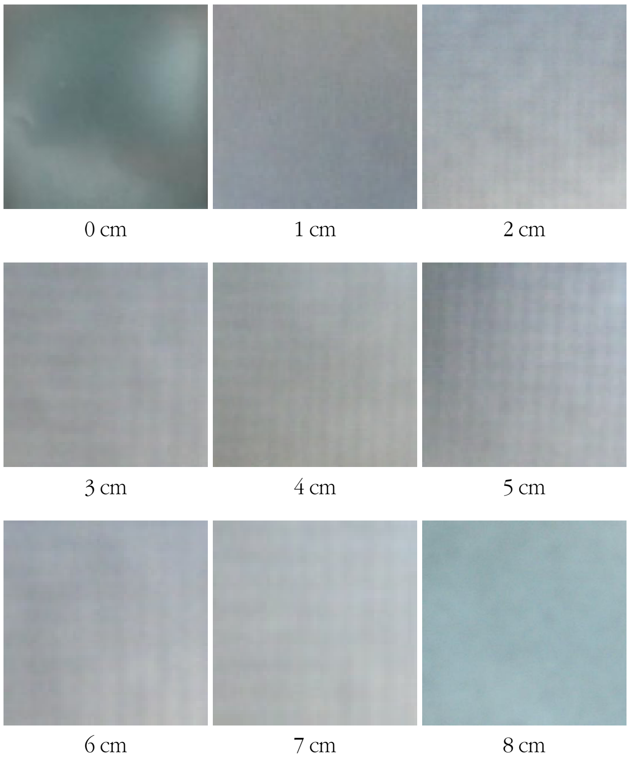


Fig. 3. Change in the Film image according to the protein thickness

4. Change in ROI mean value according to the protein thickness in the DR image

There was a significant difference in the mean value according to protein thickness and ROI in the DR image. Post-hoc analysis of Scheffe revealed the highest change in ROI mean value at a thickness of 0 cm~5 cm(a) followed in order of 6 cm(b) 7 cm(c) 8 cm(d) (Table 4, Fig. 4–6).

5. Comparison of the ROI mean value according to the protein thickness in the film and DR image

There was 48.5% attenuation at 8 cm, i.e. 51.5% in the film image assuming that a protein thickness of 0 cm = 100% in film. On the other hand, the attenuation was 89.34% at 8 cm, i.e. 10.7% in the DR image assuming that 0 cm = 100% in ROI mean value (Table 3). A t-test was carried out to compare the two concentration changes using the percentage, and showed −4.93, p = 0.000. Therefore, there is a significant difference between the film and DR image (Table 5).

Table 4. Change in the ROI mean value according to the protein thickness in the DR image (Unit : Density)

Item	Classification	N	GM±GSD	Percentage of change (%)	F-value	p
Thickness	0	10	2825.98±67.33[a]	100%	15.17	0.000*
	1	10	2806.30±66.41[a]	99.3%		
	2	10	2791.93±75.07[a]	98.8%		
	3	10	2780.62±62.40[a]	98.4%		
	4	10	2748.32±36.31[a]	97.2%		
	5	10	2710.00±46.22[a]	96.6%		
	6	10	2666.34±20.34[b]	94.3%		
	7	10	2606.21±68.62[c]	92.2%		
	8	10	2525.29±58.25[d]	89.3%		

Note) post-hoc test of Scheffe. The group of same alphabet means the same group of average level. The alphabet order means a difference between groups.
* p < 0.001

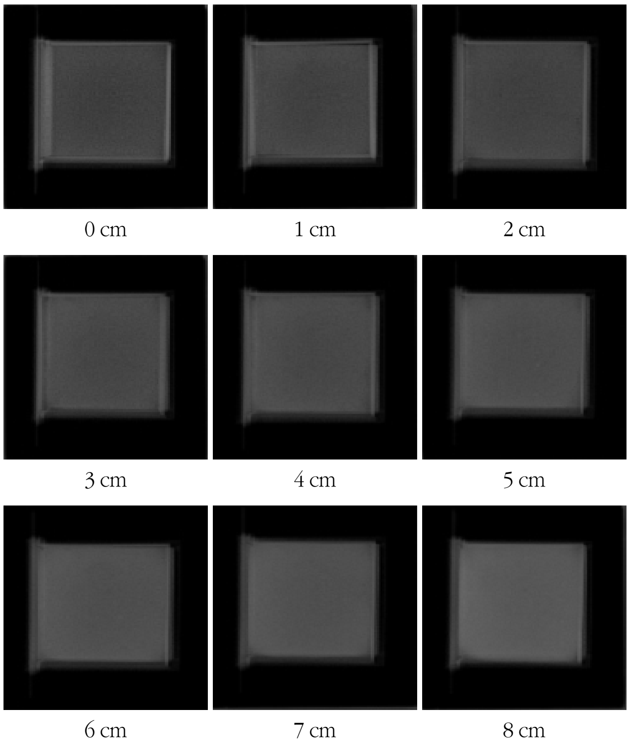


Fig. 4. Change in the DR image according to the protein thickness

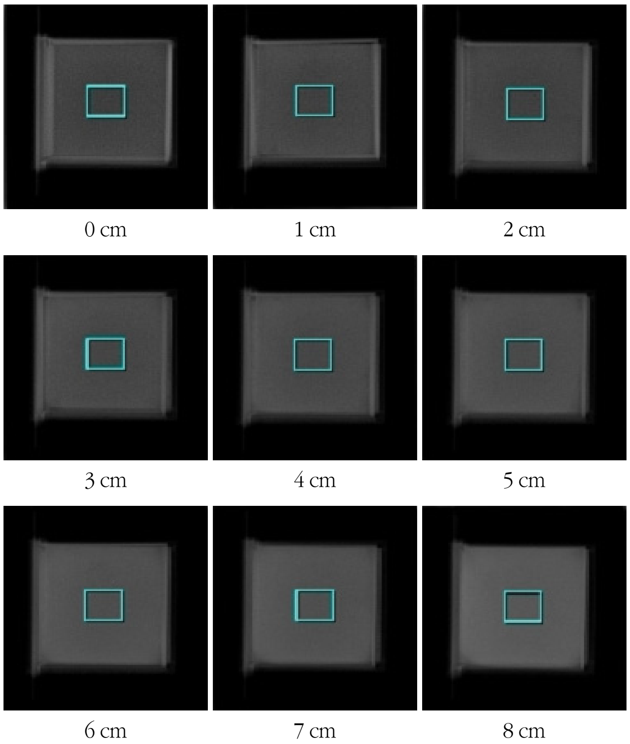


Fig. 5. The ROI of the DR image according to the protein thickness

Table 5. Comparison of the ROI mean value according to the protein thickness in the film and DR image

Classification	n	GM±GSD	t	p
Density	9	69.08±16.10	-4.93	0.000*
ROI	9	96.23±3.6		

* $p < 0.001$

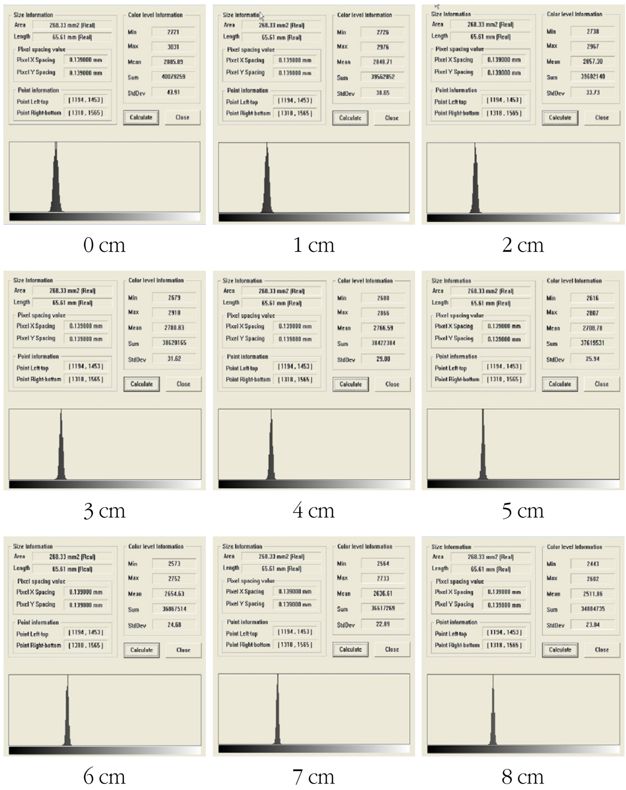


Fig. 6. ROI numerical value of the DR image according the protein thickness

Ⅳ. DISCUSSION

The thickness of the subject is an important factor determining a change in transit dosage. Soft tissue occupies 40-50% of the human body and contains areas highly sensitive to radiation. When soft tissue is irradiated, the absorption dosage increases, and the transit dosage with increasing thickness of the subject[4]. This can decrease the image quality by scattered rays due to a physical phenomenon. A phantom of a human body experiment model was produced using tissue equivalence material to determine the change in dosage according to the protein thickness in the stomach. A part that indicates the stomach was set up after obtaining an abdomen CT (Computed Tomography) image of an adult (Thickness 20 cm), assuming that the ribs do not overlap. In addition, the following were deducted from the upper part to the lower part after the thickness of each tissue was measured : Fat, 17.78 mm ; Soft tissue, 62.16 mm ; Stomach, 86 mm ; Soft tissue, 30.35 mm ; and Fat 33.30 mm. A positive number that takes the decimal point down was used to produce the phantom. Acrylic (1.04 g/cm^3) and Millet (0.89g/cm^3) were used as the equivalent of soft tissue (1.0 g/cm^3) and fat (0.91 g/cm^3) respectively[5,12]. An outer ring of the phantom was produced in 5×5×22.8 (width × length × height) using Styrofoam, which has little influence on the attenuation. The stomach facilitates the excretion of hormone like gastrine, stimulates the secretion of gastric juices containing hydrochloric acid, digestive enzymes and mucus as soon as protein enters the stomach, which need to be considered when reproducing the protein state in the stomach[6,13~15]. Therefore, protein is degraded more finely than in the mouth. The amount of gastric secretion is at least 1.2~1.6 ℓ . The time in which the contents remain in the stomach ranges from 3 to 4 hours on average, 6 hours the most. The stomach contents were minced very finely using a mixer, enough to identify the resolution in the experiment[7,16~18]. The minced beef was also stored in glacial acetic acid at pH 2~3 for 4 hours to mimic the effect of pH in the stomach, thereby reproducing the stomach contents.

Ⅴ. CONCLUSION

This study examined the importance of NPO using a phantom produced from a tissue equivalent material to the stomach. The attenuation change in x-rays and the ROI value in the DR image according to the real contents in the stomach were compared and analyzed. The results showed a significant difference in the attenuation of x-ray, image quality according to the stomach contents between the film and DR image. The results are summarized as follows :

1. The experiment on the reproducibility of X-ray equipment showed a resulting CV of ±5%. Therefore, the dosage was relatively constant.
2. The transit dosage according to the beef (protein) thickness at 70 kVp and 30 mAs decreased with increasing thickness due to the attenuation of x-rays ($P < 0.001$).
3. The concentration in the film decreased with increasing beef (protein) thickness.
4. The change in the ROI mean values in the image from the DR system decreased with increasing protein thickness.
5. The concentration values in the film according to protein thickness decreased 51.5% from 0 cm to 8 cm. On the other hand, the ROI mean values in the DR image decreased 10.7% from 0 cm to 8 cm.

Overall, these results show that NPO is more important in simple radiography using film than in DR imaging.

Reference

1. Youngil Kim, Deokmun Kwon, Seongsu Kim *et al.*: Analog & Digital·Pacs, Daihak Seorim, 21-33, 2007
2. Jungho Kang, Sewon Oh : Physiology, Pyeonemhong, 275-280, 2003
3. Research Council for Daehan Imaging in Medicin : Chung-gu Munhwa a Publishing Company, 451-459, 2006
4. Jin Kwon, Myoungsook Kwon : Analysis and Minimization of Structural Error in Weft Knitting, Journal of the Korean Society of Costume, 57(5), 1-11, 2007
5. Hosu Lee : Box bolus of Manufacture and Tissue Equivalence's Character which for Uniform Exposure of Extremity, The Journal of the Korean Radio the Rapeutic Technology, 11(1), 90-93, 1999
6. Soungock Park : Distribution of X-ray According

to the Thickness of Soft Tissue in Radiography, Journal of Korean Society of Radiological Technology, 11(2), 3–15, 1988

7. Jeunghee An, Jiyoung Kim, Jinsil Seong : Proteomics of Protein Expression Profiling in Tissues with Different Radiosensitivity, Journal of Korean Society for Therapeutic Radiology and Oncology, 22(4), 298–306, 2004
8. Youhyun Kim, Jonghak Choi, Sungsoo Kim *et al.*: Utilization of Diagnostic Equipments and Patient Dose for Diagnostic Radiological Procedures in Korea, Korean Journal of Medical Physics, 16(1), 10–15, 2005
9. Jinoh Lim, Taehyung Kim, Yanghwa Jung, Wonchan Choi, Jihoon Shin, Hoyoung Song : Usefuless of Multi–functional Gastroduodenal Coil Catheter with Phantom, Journal of Korean Society of Radiological Technology, 26(4), 21–26, 2003
10. Boosoon Kim : Morphological Changes of Stomach Tissue on Nil Per Os of Rats Treated Single lrradiation, Journal of Korean Society of Radiological Technology, 21(1), 69–78, 1998
11. Seungran Park, Jongwon Park, Seungmoo Noh : Automatic Segmentation of Stomach from the CT Image, 99 Journal of Korean Institute of Information Scientists and Engineers, 26(2), 428–430, 1999
12. Siyoung Chang : Definition and Difference Between Dose Equivalent and Equivalent Dose in Radiation Dose Measurement and Evaluation, Journal of the Korean Association for Radiation Protection, 18(3), 1–7, 1993
13. Weesaing Kang : Effect of an Acrylic Plate and SSD on Dose Profile and Depth Dose Distribution of 9 MeV Electron Beams, Korean Journal of Medical Physics, 9(2), 65–71, 1998
14. Jina Jang, Soonnyung Heo, Hoenam Kim *et al.*: Dose Verification Using Pelvic Phantom in High Dose Rate HDR Brachytherapy, Korean Journal of Medical Physics, 14(1), 15–19, 2003
15. Hyekyung Son, Sanghoon Lee, Sora Nam, Heejoung Kim : Radiation Dose During Transmission Measurement in Whole Body PET/CT Scan., Korean Journal of Medical Physics, 17(2), 89–95, 2006
16. Changlae Lee, Seongsu Jeon, Sora Nam, Hyomin Cho, Jiyoung Jung, Heejoung Kim : Dose Measurements Using Phantoms for Tube Voltage, Tube Current, Slice Thickness in MDCT., Korean Journal of Medical Physics, 18(3), 139–143, 2007
17. Moonchan Kim, Jongsuck Lim, Hyungro Park, Youhyun Kim : A Study on the Exposure Dose for the Computed Tomography, Journal of Radi– ological Science and Technology, 27(2), 73–74, 2004
18. Sunchil Kim. Jaeeun Jung : Study on Image Quality and Dosage Comparison of F/S System and DR System, Journal of Korean Society of Radiological Technology, 26(3), 7–11, 2003

• 국문초록

위장내 음식물에 따른 방사선 감약 및 화질에 관한 연구

동경래[1,2] · 지연상[1] · 김창복[1] · 최성관[1] · 문상인[1] · 디터 케빈[3]

광주보건대학 방사선과[1] · 조선대학교 원자력공학과[2] · 광주보건대학 물리치료과[3]

인체의 40~50%인 연부조직에 X선을 조사하면 연부조직의 두께에 따라 투과선량이 감소하며 영상에도 질적 저하를 가져온다. 본 연구는 복부 촬영시 위장내 내용물에 따라 X선 감약 및 화질에 차이가 나타날 수 있다는 가정 하에 실제 위의 조직과 비슷한 조직등가물질 phantom을 제작하여 실제 위장내 내용물에 따른 X선의 감약 변화와 DR (Digital Ridiography)의 ROI수치를 비교해보았다. 단백질 두께가 증가할수록 X–선 감약에 의한 투과선량이 감소되었으며($p < 0.001$), Film과 DR 영상에서의 ROI Mean값의 변화도 감소하였다($p < 0.001$). Film과 DR 영상에서의 ROI Mean값에 대한 비교는 Film이 DR 영상에 비해 단백질 두께에 따른 농도의 변화 값이 크게 나타났다($p < 0.001$).

이와 같은 결과를 종합해 볼 때 DR system 촬영 보다는 필름을 사용하는 단순촬영에서 금식(NPO ; nothing by mouth)의 필요성이 더 중요함을 알 수 있다.

중심 단어: 금식, 단백질, X선 감약, 조직등가물질