의학석사 학위논문

공기정복술을 시행 받은 소아 회결장 장중첩증 환자에서 유효선량과 장기방사선량에 관한 연구

Assessment of Effective Dose and Organ Specific Dose at Pneumatic Reduction of Pediatric Ileocolic Intussusception

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서울대학교 대학원

의학과 영상의학 전공

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전 선 경

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위 원 장 김 인 원 (인)

부위원장 천 정 은 (인)

위 원 김 현 영 (인)

Abstract

Assessment of Effective Dose and Organ Specific Dose at Pneumatic Reduction of Pediatric Ileocolic Intussusception

Sun Kyung Jeon
Department of Radiology, College of Medicine
The Graduate School
Seoul National University

Introduction: The purpose of this study was to estimate the radiation doses in children for pneumatic reduction of ileocolic intussusception on the basis of in-phantom dosimetry and conversion factor from dose-area product (DAP) to the effective dose and to identify patients or procedure-related factors contributing to higher radiation doses.

Materials and Methods: The data of 68 children who underwent a total of 86 pneumatic reductions of ileocolic intussusception between December 2014 and December 2016 were retrospectively analyzed. The fluoroscopic time and DAP of pneumatic reduction

were collected. The relationship between radiation dose and patients or procedural factors such as age, weight, body mass index (BMI), the time of procedure, radiologists' experience, and presence of pathologic lead points were analyzed. A 5-year equivalent anthropomorphic phantom (ATOM CIRS 705 - D model) was exposed to mock pneumatic reduction procedures using mean, median, and maximum fluoroscopic times and DAP derived from clinical data. Organ-specific equivalent dose, effective dose, and conversion factors were calculated. For the direct comparison, additional radiation exposure to phantom using the routine abdominal radiography protocol was performed, and an effective dose was calculated.

Results: An 88.4% (76/86) success rate per procedure and 91.2% (62/68) success rate per patient were achieved without any complications. The mean fluoroscopic time was 134.8 s (range: 24-1140 s) and the mean DAP was 49.06 cGycm^2 (range: 1.7-420.4 cGycm2). The mean fluoroscopic time and DAP were significantly less in successful procedures compared to failed procedures (all Ps <0.001). The outcome of pneumatic reduction was the only independent factor for higher dosing (OR, 25.0; p=0.004). The mean and maximum estimated effective doses during the experimental study referenced with fluoroscopic time derived from

clinical data collection were 0.25 and 2.15 mSv, which were equivalent to 4 to 36 abdominal radiographs. The derived conversion factor was 0.51 mSv/Gycm^2.

Conclusion: The mean effective dose for pneumatic reduction of intussusception was equivalent to 4 abdominal radiographs. Except for the outcome of reduction, there were no significant patient or procedural factors associated with radiation dose. Dose data and conversion factors derived from this study could be applied to estimate the effective dose for pneumatic reduction of pediatric ileocolic intussusception.

Keywords : Radiation dose, Intussusception, Reduction, Children

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INTRODUCTION

Ileocolic intussusception is a common pediatric emergency most frequent in children younger than 3 years old (1, 2). Pressure reduction of intussusception is necessary to prevent complications such as bowel infarction, perforation, and death. Non-operative, pressure reduction under imaging guidance is the first-line therapy, with a success rate of 65-88% (3, 4). Although radiologic management of intussusception varied according to what techniques were used, which include either hydrostatic or pneumatic reduction, either of which can be performed under fluoroscopic or sonographic guidance, fluoroscopy-guided pneumatic reduction has gained wide acceptance due to its several advantages (3, 5). It is easy to perform, quick and clean, and in comparison with contrast enema, requires less radiation exposure because air in the bowels absorb less X-rays compared to radiopaque contrast media (6, 7).

Despite its advantages, fluoroscopic guided pneumatic reduction has an inevitable disadvantage, the issue of radiation exposure. In 2000, Heenan et al. (5, 7, 8) reported a mean screening time of 439 s, with a mean dose area product (DAP) of 369 cGycm2 for pediatric pneumatic reduction of intussusception. In this study, the longest fluoroscopic time of successful reduction

was 21 min and this administered an effective dose of 12.73 mSv, which is equivalent to approximately 400 abdominal films for a 1-year-old. Several recent technical innovations, such as pulsed fluoroscopy and the last-image-hold technique, and improved knowledge and caution in radiologists regarding radiation risks might have reduced patient radiation dose. However, detailed data on organ specific doses and effective doses for pneumatic reduction of intussusception determined using an anthropomorphic phantom have rarely reported (5).

The purpose of this study was to estimate radiation doses in children for pneumatic reduction of ileocolic intussusception on the basis of in-phantom dosimetry and conversion factor from dose-area product (DAP) to the effective dose and to identify patients or procedure related factors contributing to higher radiation doses.

MATERIALS AND METHODS

Our institutional review board approved this study and waived the requirement for informed consent. This study was composed of two main parts. The first part consisted of clinical data collection, including fluoroscopic time and measured DAP. The second part was performed via an experimental study using anthropomorphic phantoms to derive organ-specific and effective doses for pneumatic reduction of intussusception. Parameters to evaluate radiation dose for the phantom study were determined from clinical data.

Clinical data collection

The clinical and radiological database was reviewed, and 68 children (44 boys and 24 girls) ages 2 months to 6.5 years (mean age ± standard deviation (SD): 2.21 ± 1.40 years) who underwent a total of 86 pneumatic reductions of ileocolic intussusception from December 2014 to December 2016 were identified. The demographic characteristics of the study population are summarized in Table 1. Diagnosis of intussusception was established by ultrasonography with a 3- to 9-MHz linear transducer (Philips

iU22, Philips, Eindhoven, The Netherlands). All patients with clinically suspected intussusception had abdominal radiographs taken before pneumatic reduction to assess possible complications, such as perforation or ileus.

All residents and radiologists of the department had received radiation risk training. All examinations and interventional procedures were supervised by an experienced pediatric radiologist. If performed afterhours (holidays, Saturdays, Sundays, or 6:00 p.m.–7:30 a.m. Monday–Friday) by a resident, the procedures were required to be supervised by an on–call radiologist and were discussed with a pediatric radiologist the following day. The 86 procedures were performed by board–certified pediatric radiologists (n=4) with 3–12 years of clinical experience and residents (n=21) in our department. The children were placed in a supine position and sedation was not routinely administered in all patients. A 14Fr Foley catheter was introduced into the rectum and secured with a 5 cc balloon. Pneumatic reductions required the use of a one–piece handheld pressure gauge and were proceeded with caution so that the pressure did not exceed 120 mmHg. Fluoroscopic monitoring of the gas–filled colon was maintained throughout the procedure using the EasyDiagnost Eleva fluoroscopy system (Philips, Eindhoven, Netherlands) with an overcoach X–ray

tube using a pulsed fluoroscopy option (1.56 images/s). As with routine protocol of pneumatic reduction, the 3 Fr/s, 70 kVp, 100 ma, 50 ms settings were used. Images were acquired using additional filtration via 0.2 mm copper, an image intensifier, a fixed grid of 36 lines per centimeter, and last-image-hold. Radiation dose data for each procedure was recorded using reported DAP values and fluoroscopic time via built-in measurement methods calibrated in situ.

To identify patients and procedural factors that contributed to a higher radiation dose, clinical information of patients such as height, weight, body mass index (BMI) and presence of pathologic leading points, and procedural factors such as radiologists' experience, time at which the procedure was performed (workday or after hours) were analyzed. The χ^2 test or Fisher's exact test, Student's t-test, and simple linear regression analysis were performed to determine patient and procedural factors associated with higher dosing. Thereafter, binary logistic regression analyses using the forward projection method were performed to determine the independent factors associated with higher dosing. For binary logistic regression analysis, DAP values were divided into two groups (low DAP/high DAP) based on the 3rd quartile of DAP value (22.6 $cGycm^2$). All statistical analyses were performed using SPSS

Statistics for Windows Version 21.0 (IBM Corp., Armonk, NY, USA).

Experimental Study

Experimental pneumatic reduction procedures were performed using a 5-year age-equivalent anthropomorphic pediatric phantom (ATOM model 705; CIRS, Norfolk, VA) and the same fluoroscopic unit. The height and weight of the phantom were 110 cm and 19 kg, respectively. The anteroposterior and lateral diameters of the pediatric phantom at the upper abdomen level were 14 cm and 17 cm, respectively. The phantom had 26 slices with a slice thickness of 2.5 cm, and consisted of materials of four different densities to represent four different tissues (bone, soft tissue, brain tissue, and lung tissue). This phantom had 176 removable plugs to place dosimeters at specific locations within organs (Fig.1). Optically stimulated luminescent dosimeters (OSLD) (InLight/OSL NanoDot™, Landauer Inc., Glenwood, IL, USA) were inserted into every hole of the anthropomorphic phantom to directly measure organ doses. OSLD was a circular disk with a 5 mm diameter and 0.2 mm thickness made of carbon-doped aluminuoxide with a 0.05-mm thick polyester-film cover layer, housed within a 10 mm × 10 mm × 2 mm light-tight plastic holder. Microstar InLight® reader (Landauer Inc., Glenwood, IL, USA) was used to read the recorded

exposed radiation doses of each dosimeter. After using the dosimeters, they underwent annealing for more than 5 hours using a fluorescent lamp for the next study.

A total of 21 organ-specific locations, with one or two locations for each organ, were chosen (Supplementary material 1). Thereafter, each scan was repeated two times and averaged for calculation of the effective dose in each scan mode. The effective dose was calculated with the following equation: $E=\sum WT*HT$, where WT is a committee-defined dimensionless, tissue-specific weighting factor and HT is the tissue-specific equivalent dose in tissues (9). The committee-defined dimensionless, tissue-specific weighting factors were based on International Commission on Radiological Protection publication 103 (10). Since the distribution of active bone marrow is age-dependent, a previous study was referenced to obtain tissue-specific equivalent doses of the bone marrow (11).

To assess organ-specific and effective doses, fluoroscopy was exposed to the phantom with a mean, median, and maximum fluoroscopic time and DAP, which were derived from clinical data analysis. Subsequently, the conversion factor from DAP to the effective dose was calculated. In addition, to directly compare the effective dose, a routine plain abdominal radiograph was taken using

59.8 kVp and 6.4 mAs settings to the phantom (mean DAP of 1.69 uGym2). Abdominal radiography was performed using DRX-Evolution (Carestream, Rochester, NY, USA) three times and averaged for calculation.

RESULTS

Among a total of 68 patients, in 61 patients, initial pneumatic reduction was successful (89.7%). Among seven patients, in whom initial pneumatic reduction failed, four patients underwent delayed repeat enema. The time of the delay ranged from 30 minutes to 3 hours and depended on the clinical well-being of the child. In 25% (1/4), delayed repeat attempts were successful, and the remaining three patients who did not receive delayed repeat attempts finally underwent surgery (Fig. 2). During laparotomy, four patients required a simple manual reduction, while two required more complicated procedures, such as ileocolectomy or right hemicolectomy due to ischemic bowel or a pathological lead point. One patient had a pathological lead point; small bowel lymphoma in a 6-year-old boy. There were no complications such as perforation. Of the 61 patients with successful outcomes, 14 patients received additional pneumatic reduction due to recurred intussusception. Recurrent intussusception occurred within 4 hours to 1 month, and recurred once in 11 patients and recurred twice in 3 patients. All pneumatic reductions performed for recurrent intussusception were successful (100%, 14/14).

The mean fluoroscopic time was 134.76±177.0 s (range: 24-1140 s, median 66.5 s). Mean fluoroscopic time was significantly less for successful reductions than failed reductions, at 97.12±101.54 s compared with 420.90±327.02 s (p=0.01), respectively. The mean DAP was 49.03±68.24 cGycm^2 (range: 1.7-420.4 cGycm^2, median 22.6 cGycm^2). The mean DAP was significantly less for successful reductions than failed reductions (34.68±36.45 vs. 158.02±134.06 cGycm^2, p=0.02). There was a linear correlation between fluoroscopic time and DAP (r^2 = 0.832) (Fig. 3). There were no significant differences between demographic characteristics and procedure success: patient's age (p=0.87), weight, and BMI. There was no significant relationship between fluoroscopic time and patients' age (p=0.420), weight (p=0.458) and BMI (p=0.861), respectively. Similarly, there was no significant correlation between DAP and patient age (p=0.754), body weight (p=0.851), and BMI (p=0.939), respectively.

Regarding when the procedures were performed, 39 procedures were performed during workdays and 47 procedures afterhours. The success rate was not significantly different according to the time of the procedure (working day 89.5% (34/39) vs. afterhours 87.2% (41/47), p=1.00). There were no statistically significant differences in fluoroscopic time and DAP according to the time of

the procedure (working day vs. after hours; 147.2 s vs. 124.4 s and 43.5 vs. 53.7 cGycm^2, p = 0.56 and 0.49, respectively). In addition, there was no significant difference in success rate, fluoroscopic time, and DAP according to radiologists' experience (residents vs. board-certified radiologists, 86.1% (62/72), 143.0 s and 52.0 cGycm^2 vs. 100% (14/14), 92.5 s and 33.8 cGycm^2, p= 0.36, 0.33 and 0.36, respectively). The demographic characteristics of each group are summarized in Supplementary material 2.

After multivariate stepwise logistic regression analysis, the pneumatic reduction outcome was the only independent factor for higher dosing (OR, 25.0; p=0.004) (Table 2)

When the phantom was exposed to radiation phantom using mean, median, and maximum fluoroscopic times derived from clinical data collection (134.8 s, 66.5 s, and 1140 s, respectively), estimated effective doses were 0.25 mSv, 0.12 mSv, and 2.15 mSv, respectively. Compared with estimated effective doses of plain abdominal radiographs using the phantom study (0.06 mSv), estimated effective doses of pneumatic reduction using mean, median, and maximum fluoroscopic times were equivalent to 4.2, 2 and 36 abdominal radiographs, respectively. The detailed tissue-specific equivalent doses are summarized in Table 3. The derived conversion factor (mSv/Gycm^2) was 0.51.

DISCUSSION

Fluoroscopy-guided pneumatic reduction of intussusception has been widely accepted because it is cleaner, safer, and faster, with less radiation when compared to liquid enema (4, 12, 13). In a recent report by Kaplan et al.(14), the mean DAP was 2.7-fold lower for air enema than for liquid enema, while the mean fluoroscopy time was similar between techniques. However, radiation exposure of pneumatic reduction is still problematic in pediatric patients, and ultrasonography-guided reduction with either water or air has been reported in several studies (4, 15-19) as an alternative to fluoroscopy. Although ultrasonography offers many advantages in establishing a diagnosis as well as monitoring the reduction procedure, and a recent randomized trial (20) reported a higher overall success rate of ultrasonography guided hydrostatic reduction, it has been assumed to require greater experience to use ultrasonography guidance with a longer procedural time (3, 21). In the same context, pneumatic reduction was chosen because it is simple, quick, and easy-to-learn, and there is little information in the literature regarding the ease of recognition of perforation when using hydrostatic reduction

techniques under ultrasonography guidance.

The published success rate of pneumatic reduction ranges from 76–96% (4, 22). In this study, the success rate per procedure was 88.4% (76/86) and the success rate per patient was 91.2% (62/68), which does not appear different from the results of previous studies. In previous studies that reported the success rate of pneumatic reduction with or without sedation, the success rate under sedation was higher than without sedation (23, 24). Thus, the lower success rate of this study compared to a recent study by Cullmann et al.(22) could be explained by the difference in administration of sedation. In addition, as this hospital is a tertiary hospital, the frequency of complicated cases referred from outside hospitals could be another factor in our low success rate.

To the best of our knowledge, there are few recent studies that calculated radiation dose during fluoroscopy–guided pneumatic reduction. In this study, the mean fluoroscopic time was 134.8 s and mean DAP was 49.0 cGycm^2, which were smaller than those of previous studies using non–pulsed fluoroscopy (5), but larger than recent studies using pulsed fluoroscopy (22) (Table 4). This also could be explained by the administration of sedation and complexity of cases, considering the range of fluoroscopic time and DAP is broader and the maximum value is larger in this study. Although

sedation has advantages such as a higher success rate and shorter fluoroscopic time, we chose not to administer sedation because the safety of this practice is yet to be determined. In previous studies, sedated patients had higher rates of bowel perforation during the procedure, and higher rates of early intussusception recurrence (23).

Through the experimental study using the anthropomorphic phantom, the effective dose was calculated and estimated using the mean and maximum DAP values from the clinical studies and derived from the conversion factor. The mean estimated effective dose was 0.25 mSv and the maximum estimated effective dose was 2.15 mSv. There have not been enough studies regarding the effective dose of pneumatic reduction to compare the results of this study. According to a previous study by Heenan et al.(5), the mean estimated effective dose was 2.08 mSv and the maximum estimated effective dose was 13.40 mSv, which were much higher than those of this study.

The pediatric phantom used in this study was a 5-year-old model, where height and weight were 110 cm and 19 kg, respectively. Considering the mean age of clinical data collection was 2.2 years and the mean weight was 12.4 kg, effective doses derived from this phantom study could thus be overestimated. Nevertheless, since the

same phantom and methodology were used to compare fluoroscopy and abdominal radiography, comparison of the relative risk between fluoroscopy-guided pneumatic reduction and abdominal radiograph would be valid. In our study, the mean effective dose for pneumatic reduction was equivalent to 4 abdominal radiographs, and the effective dose could be increased to equate to 36 abdominal radiographs in a single procedure.

This study has several limitations. First, its retrospective design and the small number of cases limited the generalizability of our findings. Second, the used phantom in experimental study was made based on a 5-year-old model; thus, the estimated values could be different from the population of clinical situation, considering that the majority of intussusception occurred between 3 months to 3 years of age. Therefore, we provided equivalent dose data compared with plain abdominal radiographs using the same phantom. In conclusion, in this study, the mean estimated effective dose was 0.25 mSv with a fluoroscopic time of approximately 2 minutes, which is equivalent to 4 abdominal radiographs. The estimated effective doses could be increased to 2.15 mSv, which is equivalent to 36 abdominal radiographs, especially in complicated cases resulting in reduction failure. Except for the outcome of reduction, there were no significant patient or procedural factors associated

with radiation dose. Information from this study is expected to give radiologists and physicians the ability to recognize the risk of radiation doses during fluoroscopy-guided pneumatic reduction.

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Table 1. Characteristics of the Study Population

	All	Successful reduction (n=76)	Failed reduction (n=10)	p-value
Sex (M:F)	57:29	49:27	8:2	0.95
Age (years)	2.19±1.44	2.21 ± 1.40	2.12±1.82	0.53
Weight (kg)	12.40±3.57	12.43±3.59	12.25±3.57	0.60
BMI (kg/m^2)	16.29±2.44	16.58 ± 2.77	15.73 ± 1.62	0.35
Leading cause	1	0	1	NA
Fluoroscopic time (s)	134.76±17 7.0	97.12±101.54	420.90±327. 02	0.01
DAP ($cGycm^2$)	49.03±68.2 4	34.68±36.45	158.02±134. 06	0.02

NOTE- NA = no data available. BMI = body mass index. Values are mean ± standard deviation.

Table 2. Multivariate Regression Analysis

	Low DAP (n=58)	High DAP (n=28)	p-value	Odds Ratio
Age (years)*	2.20±1.38	2.19±1.56	0.939	0.99
BMI*	16.1±2.47	16.1±2.73	0.258	0.88
Time of procedure† (daytime : after hours)	30 : 28	9 : 19	0.111	2.51
Radiologist's experience† (residents : board-certified)	47:11	25:3	0.793	1.07
Success of reduction† (success : failure)	57 : 1	19 : 9	0.004	25.0

NOTE. *Values are mean ± standard deviation. †Values are number of patients

Table 3. Effective Dose and Organ-specific Dose

	Fluoroscopic time of clinical data (s)			Abdominal radiograph
	Mean (134.8 s)	Median (66.5 s)	Maximum (1140 s)	
Tissue-specific equivalent dose (mGy)				
Heart	0.15	0.07	1.29	0.10
Esophagus	0.25	0.12	2.14	0.10
Lung	0.30	0.14	2.6	0.12
Liver	0.41	0.19	3.50	0.17
Gallbladder	0.28	0.13	2.38	0.19
Spleen	0.32	0.15	2.71	0.08
Stomach	0.46	0.21	3.97	0.11
Pancreas	0.44	0.20	3.74	0.10
Kidneys	0.86	0.40	7.37	0.07
Adrenal glands	0.70	0.32	6.00	0.17
Small bowel	0.37	0.17	3.16	0.13
Colon	0.75	0.34	6.39	0.06
Uterus and cervix	0.43	0.20	3.65	0.09
Bladder	0.44	0.20	3.80	0.11
Prostate	0.44	0.20	3.73	0.10
Gonad	0.12	0.06	1.04	0.08
Bone marrow*	0.56	0.26	4.81	0.06
Effective dose (mSv)	0.25	0.12	2.15	0.06
Equivalent No. of abdominal radiograph	4.16	2	35.8	

NOTE. No. = numbers

* Organ-specific locations for bone marrow include: thoracic spine (1) and pelvic bone (1)

Table 4. Comparison of Radiation Dose and Outcomes between Our Study and Others

	Our study	Cullmann et al.(2015)	Heenan et al.(2000)	Karlsson et al.(1994)
No. of patients	68	45	143	45
No. of reduction procedures	86	48	153	45
Type of reduction	Pneumatic	Pneumatic	Pneumatic	Hydrostatic
Fluoroscopic monitoring	Pulsed	Pulsed	Non-pulsed	Non-pulsed
Mean fluoroscopic time (s)*	134.8 (24-1140)	53.8 (1-320)	354.0 (15-1,356)	NA
Median fluoroscopic time (s)*	66.5 (24-1140)	33.0 (1-320)	NA	270.0 (66-1,992)
Mean DAP ($cGycm^2$)*	49.0 (1.7-420.4)	11.4 (1-145)	366.5 (30-1,356)	NA
Median DAP ($cGycm^2$)*	22.6 (1.7-420.4)	5.45 (1-145)	NA	NA
Success rate	88.4% (76/86)	95.8% (46/48)	76.5% (117/153)	93.3% (42/45)
Complications	No complication	1 perforation	1 perforation	NA

NOTE. NA = no data available * data in parentheses is range

Supplmentary Material 1. Numbers of organ-specific locations according to organs

Organs	Number of organ-specific locations
Heart	1
Esophagus	2
Lung	2
Liver	2
Gallbladder	1
Spleen	1
Stomach	2
Pancreas	1
Kidneys	1
Adrenal glands	1
Small bowel	1
Colon	1
Uterus and cervix	1
Bladder	1
Prostate	1
Gonad	1
Bone marrow*	2

* Organ-specific locations for bone marrow include: thoracic spine (1), and pelvic bone (1)

Supplementary Material 2. Characteristics of the Study Population

2-1. Time of Procedure (Workday vs. After hours)

	Daytime (n=39)	After hours (n=47)	p-value
Sex (M:F)	23:16	34:13	0.19
Age (years)	2.08 ± 1.40	2.30±1.38	0.87
Weight (kg)	11.8±3.59	12.86±3.53	0.16
BMI (kg/m^2)	16.4 ± 2.31	16.8 ± 2.78	0.54
Success rate (%)*	89.5 (34/39)	87.2 (41/47)	1.00
Fluoroscopic time (s)	147.2±223.6	124.4±127.8	0.56
DAP (cGycm^2)	43.5±80.4	53.7±56.8	0.49

BMI = body mass index. Values are mean ± standard deviation. * Values are percentage

2-2. Radiologists' experience (residents vs. board-certified radiologists)

	Residents (n=72)	Board-certified radiologists (n=14)	p-value
Sex (M:F)¥	51:21	6:8	0.63
Age (years)	2.30 ± 1.41	1.70±1.53	0.16
Weight (kg)	12.61±3.45	11.12±4.10	0.16
BMI (kg/m^2)	16.6 ± 2.56	16.7± 2.70	0.82
Success rate (%)*	86.1 (62/72)	100 (14/14)	0.36
Fluoroscopic time (s)	142.99±190.57	92.50±60.06	0.33
DAP (cGycm^2)	51.99±72.32	33.79±39.82	0.36

BMI = body mass index. Values are mean ± standard deviation. * Values are percentage ¥Comparison was performed using Fischer's exact test .

Fig 1. A 5-year equivalent anthropomorphic phantom (ATOM CIRS 705-D model, Norfolk, VA) (a) Photograph of the outlook of phantom. (b) Cross sections of the brain, chest and pelvis of the phantom. Plugs are removed for the insertion of optically stimulated luminescent dosimeters (OSLD).

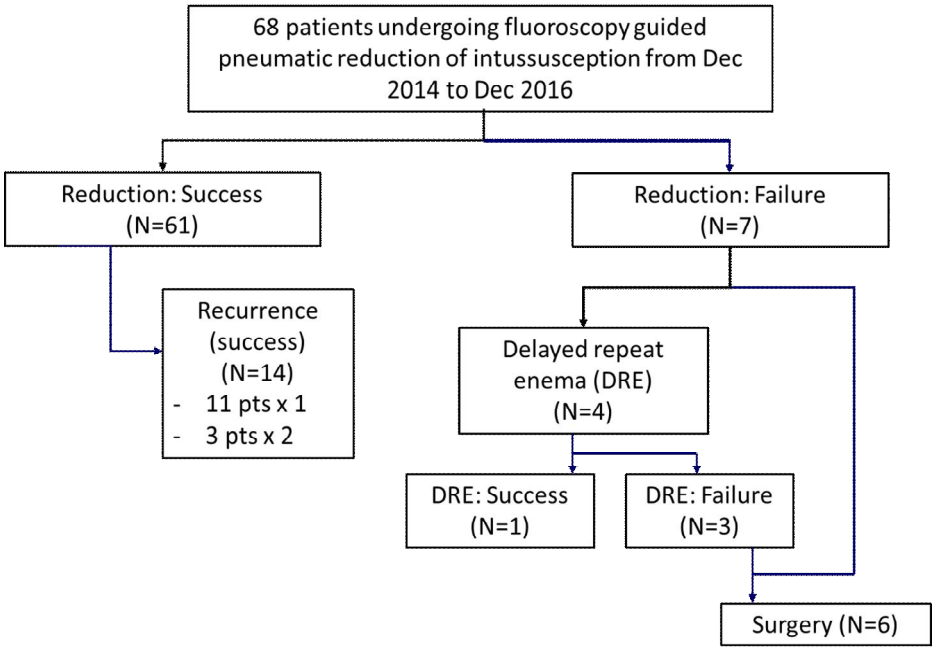

Fig 2. A flow chart of the study population.

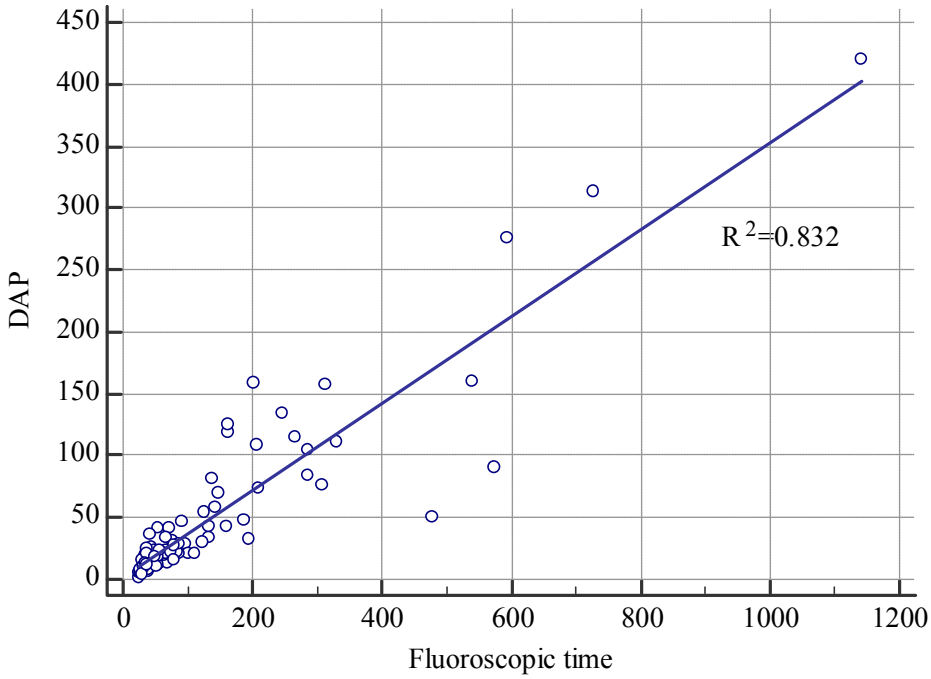

Figure 3. Analysis of correlation between DAP and fluoroscopic time

초 록

공기정복술을 시행 받은 소아 회결장 장중첩증 환자에서 유효선량과 장기방사선량에 관한 연구

배경 및 목적: 본 연구에서는 수집한 실제 임상 결과와 팬텀을 사용한 실험 결과의 직접 선량측정을 바탕으로 소아 환자의 회결장 장중첩증에서의 공기정복술의 방사선량을 평가하고, 변환계수를 구하여 유효선량을 예측하고자 한다. 또한, 선량을 증가시키는 환자 및 시술 관련 요인을 확인하고자 한다.

재료 및 방법: 실제 임상 결과를 분석하기 위해 2014년 12월부터 2016년 12월에 걸쳐 68명의 소아환자에서 시행된 86 건의 시술을 후향적으로 분석하였다. 방사선 조사 시간과 검사시 발생한 면적선량을 기계에 내장된 방사선 기록장치를 사용하여 측정, 기록하였다. 환자의 연령, 몸무게, 체질량 지수, 시술 시간대와 시술을 시행한 영상의학과 의사의 경력 및 병적 선두의 유무와 검사시 발생한 면적선량의 관계를 분석하였다. 가상 검사는 5세 소아의 평균 크기를 재현한 팬텀 모델(ATOM CIRS 705 - D모델)을 사용하여 임상결과 분석에서 도출된 평균, 중앙 그리고 최대 방사선 조사시간 및 면적선량을 조사하여 진행되었다. 이를 통해 장기 방사선량 및 유효 방사선량, 변환계수를 계산하였다. 직접적인 비교를 위해, 실제 사용하고 있는 복부 단순촬영 표준 프로토콜을 팬텀에 모의 조사하여 공기정복술의 방사선량과 비교하였다.

결과: 시술 별 성공률은 88.4% (76/86), 환자 별 성공률은 91.2% (62.28) 이었고, 시술합병증은 없었다. 방사선 조사시간의 평균값은

134.8초 (범위: 24-1140초) 였고, 면적선량의 평균값은 49.06 cGycm2 (범위: 1.7 - 420.4 cGycm2) 였다. 성공한 시술에서의 방사선 조사시간과 면적선량의 평균값은 실패한 시술에서보다 통계적으로 유의하게 작았다. 시술의 성공 여부만이 유일하게 높은 방사선량과 관련된 독립된 요인이었다. (OR, 10.9, P=0.03). 팬텀을 사용한 가상 검사에서의 유효 선량 평균값은 0.25 mSv, 최대값은 2.15 mSv였고, 이는 각각 복부 단순촬영 4장과 36장에 해당되는 방사선량이었다. 계산된 변환 계수는 0.51 mSv/Gycm2이었다.

결론: 본 연구에서 투시유도하 공기정복술의 방사선 유효선량의 평균값은 복부 단순촬영 4장 정도에 해당되는 값이었다. 시술 성공 여부 외에 방사선량과 관련된 환자 및 시술 관련 요인은 없었다. 이러한 선량 정보와 계산된 변환 계수는 실제 환자의 검사에서 유효선량을 예측하는 데에 적용될 수 있을 것으로 생각된다.

주요어 : 소아, 장중첩증, 공기정복술, 방사선량, 유효선량
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