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# Development of Shielding Apron and Evaluation of a Gonad Shield for Pediatric Chest and Breast X-ray Examinations

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**Abstract**

**Background/Objectives**: This study was important to reduce genital radiation exposure during pediatric chest and breast X-ray, evaluate ease of a newly developed shielded apron, and helped parents and assistants monitor patient's movements.

**Methods/Statistical analysis**: If there are a various factors, such as pediatric patients, difficulty to accurately position due to the movement of the patient. To solve such problems, examinations are often conducted with the assistance of parents and helpers who control a patient's movements during pediatric chest and breast X-ray examination. During the process, parents and helpers are unnecessarily exposed to radiation even though they wear aprons.

**Findings**: This syudy, a newly developed shield was developed to prevent unnecessary radiation exposure by comparing the radiation dose associated with the use of gonad shield aprons in chest and breast X-ray of pediatrics patients. In this study, we use a newly developed shielding apron to shield the genitals during chest and breast X-ray and to reduce unnecessary radiation exposure to parents and helpers who control a patient's movements during examinations.

**Improvements/Applications**: Using a newly developed shield apron at chest and breast X-rays reduces genital radiation exposure and unnecessary radiation dosage for parents and helpers controlling pediatric patients movement.

***Keywords*:** Pediatric, Chest X-ray, Breast X- ray, Shield, Apron, Radiation

## 1. Introduction

Patients undergoing medically necessary X-ray examinations of radiation are exposed to X-rays. The use of ionizing radiation is recognized worldwise as an essential tools for protecting and improving human health. However, these also represent the largest artificial radiation exposure for the general public. In many, especially in the developing world, existing radiography is still the important tool compared to other imaging techniques such as computed radiography, digital radiography, computed tomography and magnetic resonance imaging. In 2007, a report on Radiation Protection Dosimetry (RPD) detailed diagnosis of radiation dose by the procedure of radiation in Korea[1]. The report included pediatric exposure from a medical X-ray examination. Despite the advancements of other modern imaging technologies, the use of X-rays in medical radiography has been added. Undoubtedly, there are tremendous advantages in diagnosis and treatment, and there is no doubt that the treatment of patient has improved significantly. The International Commission on Radiological Protection (ICRP) is committed to the rapid development of the use of radiation in. The radiological protection system covers all aspects including patients who can receive treatment exposure, protection of former and gates, volunteers in biology[2]. A number of studies have reported on the effects of radiation status and the conditions present during the trial in diagnostic tests using X-rays[3-8]. The International Commission on Radiological Protection (ICRP) needs to distinguish between other types of radiation exposure and therapeutic exposure, depending on the specific characteristics[9-11]. Radiation is used to obtain the information needed for consultations and arbitrators, the capacity cannot be significantly reduced[12-16]. However, optimizing protection in all situations, including treatment exposures, is an important principle. Optimizing protection is not about minimizing radiation dose, but balancing damage and benefits. In particular, one of the most important factors for optimization is age at radiation exposure. It is well known that pediatric patients must be treated differently than adult patients. In part, this is because infants and children who are taking the average dose have a higher risk of developing cancer than adults. The longer a child expects to live, the longer the harmful effects of radiation can be. Organs and tissues are sensitive to the effects of radiation[17-20]. The purpose of this study is to adjust the importance

of radiation protection for a patients and caregivers who conduct radiological examinations of pediatric patients.

## 2. Materials and Methods

It order to produce a shielding apron for chest and breast X-ray examinations in pediatric patients (3 years of age or younger) and evaluate its effectiveness, acrylic phantom and lead shielding aprons (mmPb) were used. To evaluate radiation dose, an Ionization Chamber (Model 451P-DE-SI-RAY, FLUKE BIOMEDICAL, USA), which completed correction, was used. For imaging, we used an imaging system for pediatric patients(DRS-2D, LISTEM, KOREA), which meets the standard requirements for a diagnostic radiation device (grounding equipment checks, exterior leakage current test, irradiation dose reproducibility test, tube voltage test, tube current test, and X-ray radiation dose test, etc.) defined by the Ministry of Health and Welfare, no. 185.

Figure 1 shows setting of the radiation device, phantom, and ionization chamber used to measure scattered rays. Figure 2 shows setup when the apron for shield from scattered rays was not applied (A) and setup when the apron for shielding from scattered rays was applied (B). The thickness of the acrylic phantom was set at 5 cm by considering the average thickness of the chests of children aged 3 or younger, and radiation exposure was measured at 30 cm from the legs, considering the location of the gonads. For the exposure parameters, we adopted conditions that are often used in pediatric chest anteroposterior projection (chest AP) (60 kVp, 320 mA, 16 ms). The width of the collimator was set at $25 \times 20$ $cm^2$ considering the width of children's chests. Measurements were taken five times each with and without the shielding apron and the average measurements were compared. Distance between the X-ray tube and acrylic surface set at 95 cm [Figure 1, Figure 2].

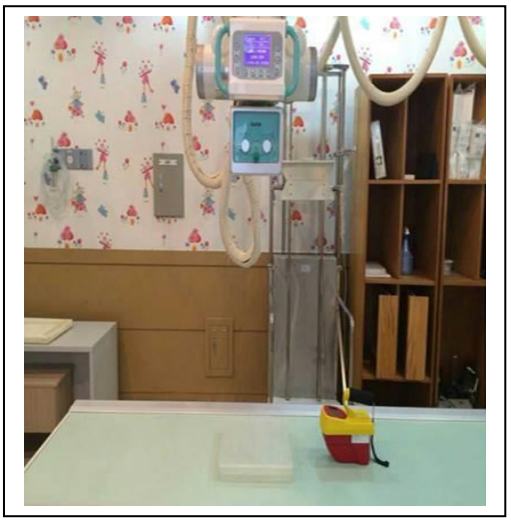

**Figure 1. Setting of the radiation device, phantom, and ionization chamber used to measure scattered rays**

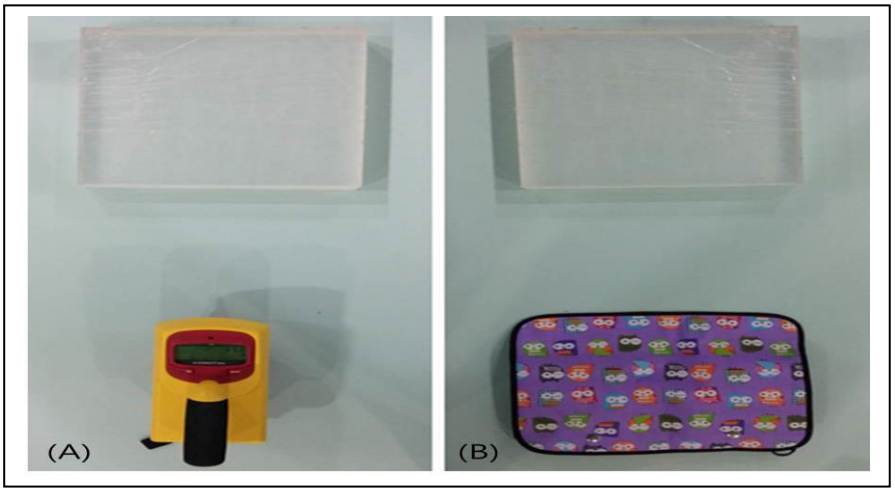


**Figure 2. Setup when the apron for shielding from scattered rays was not applied (A) and Setup when the apron for shielding from scattered rays was applied (B)**

## 3. Results and Discussion

### 3.1. *Usefulness of the produced shielding apron*

Figure 3 shows the newly produced chest shielding apron for pediatric patients. In the case of pediatric patients, there is a high chance of re-examination being necessary during X-ray examination owing to patient movements, and parents and helpers' assistance is often needed to reduce such movements. Considering this situation, a newly designed shielding apron was produced with a focus on reducing the radiation exposure dose received by children's gonads and radiation exposure to parents and helpers. A pair of gloves was attached to the inside of the shielding apron to fix the body so that movements would be minimized. Outside of the shielding apron, a waterproof cloth was used to make it easy to remove pollutants. The outer surface of the waterproof cloth was made up of a material with characters popular among children. The gloves to fix children's bodies were made to be washable to prevent contamination in long-term use. The size of the shielding apron was 30 (length) × 25 cm (width) [Figure 3].


**Figure 3. The newly produced chest-shielding apron for pediatric patients**
**(A) Outside of the shielding apron**
**(B) Inside of the shielding apron**
**(C) Side of the shielding apron**

### 3.2. *Radiation dose in the gonad area depending on the use of the shielding apron*

AS shown in Table 1 dose of scattered rays in gonad with or without a shielding apron during pediatric chest

entrance surface dose were found to be in the 17-80 μGy range[24-25]. According to the British standards, a 1 mm thick lead shield absorbs 99.4% of radiation[26]. Gonadal shielding is in accordance with ALARA's key principles (as low as reasonably achievable)[27-28] and the Children's Image Campaign[29].

Children need to control radiation exposure more closely than adults, because they are more sensitive to radiation and live longer. Chest X-ray is the most frequently conducted examination in both adults and children in most hospitals. This is because it is cost-effective and can generate results easily and quickly. Also, if necessary, the same examination can be conducted several times on the same patient. Therefore, it is necessary to minimize the exposure in order to obtain the image information necessary for inspection. For this reason, regulations should be implemented that include establishment of radiographic conditions that minimize exposure dose, prohibition of unnecessary re-examination, control of the optimal amount of radiation, shielding of organs sensitive to radiation, and, in the case of children, prohibition of re-examination due to movements.

This study compared the dose of scattered rays depending on the use of a shielding apron for the gonads in chest and breast X-ray of pediatrics patients and evaluated the usefulness of the newly developed shielding apron to prevent unnecessary radiation exposure to parents and helpers who control children's movements during chest and breast X-ray exams. When the shielding apron was not used for the gonads, the average amount of radiation owing to scattered rays was small, 0.09 μSv. However, given that pediatric patients are more sensitive to radiation and have longer lives than adults, efforts must be made to reduce radiation exposure, regardless of small exposure dose. In addition, when the newly developed shielding apron was used, the dose of scattered rays received by the genitals was 0.00 μSv. That is, the exposure dose in the genital area of pediatric patients could be effectively reduced and the shielding apron was effective in reducing exposure dose to parents and helpers who controlled the movements of pediatric patients during examinations.

This study had certain limitations. Though it targeted young children aged 3 or below, it did not conduct research depending on patient body type. In addition, in the case of children aged 3 or younger, many variables exist that can ruin an examination (irregular breathing, the atmosphere of the examination room, movements, etc.), so there is high chance of failure and re-examination of the same body part. Future studies need to take such into account so that they can complement the limitations of this study.

## 4. Conclusion

In this study, a newly developed shield was developed to prevent unnecessary radiation exposure by comparing the radiation dose associated with the use of gonad shield aprons in chest and breast X-ray of pediatrics patients. the study found that during chest and breast X-ray examination, the use of a newly developed shielding apron in the genital area reduced radiation exposure to the genitals and decreased the amount of unnecessary radiation exposure to parents and helpers who controlled the movements of pediatric patients.

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