R/F

A Study of Pediatric Fluoroscopic Examinations
(A Method of Dose Reduction with a Removable Anti-Scatter Grid and Selectable Multi Beam Hardening Filter)

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1. Introduction

Fussa Hospital, located in the western part of the Tama area of Tokyo, is a core hospital with 316 beds and responsible for community medicine in two cities (Fussa City and Hamura City) and one town (Mizuho Town). 15 radiological technologists and 2 radiologists in the Department of Radiological Technology, the Division of Medical Technology work full-time. We perform various types of general radiography, fluoroscopic exam, mammography, dental radiography, lithotripsy, CT, MRI, diagnostic imaging, nuclear examination and therapy, radiotherapy, and angiography (IVR) **(Fig. 1)**.
In October 2008, the hospital reopened after renovations and the majority of its diagnostic imaging systems were converted to FPD-equipped systems. Our R/F systems is renewed in 2018, and various fluoroscopic examinations are carried out by introducing 3 of Shimadzu's SONIALVISION G4 systems. One of these systems is equipped with Tomosynthesis and SLOT radiography and works in the field of orthopedics where it performs digital tomography on various joints, SLOT radiography of full spine and full leg, and other applications **(Fig. 2)**.
At our hospital, fluoroscopic examination is utilized by a wide range of departments such as surgery, orthopedics, urology, pediatrics, gynecology, and internal medicine. In particular, pediatric urological and surgical examinations are actively performed and our R/F systems are in full use (for voiding cystourethrography, pediatric enema, GI exam, etc.).

2. Background

Fluoroscopy has been performed in all age groups, however, examinations in pediatric include examinations and radiography using other modalities and multiples examinations may be performed. Needless to say, there is a high risk of radiation injury for patient's future, and it is essential to reduce the exposure dose. In addition, there are papers and discussions that suggest the risk of inducing childhood cancer worldwide.
The SONIALVISION G4 systems which our hospital introduced this time, have a removable anti-scatter grid function and a selectable multi beam hardening (BH) filter function, and it has the possibility of drastic dose reduction.
Both physicians and nurses are involved in pediatric fluoroscopic examinations, and reduction of exposure dose for operators and medical staffs is also an issue in this field. In December 2018, our hospital

Fig.1 View of Fussa Hospital

Fig.2 SONIALVISION G4

was certified as a facility of radiation exposure reduction and is actively working to reduce exposure not just in pediatric medicine, but for all examinations and in all medical fields.
In this paper, we report the result of an investigation of an examination environment for pediatrics that minimizes dose while maintaining image quality.

3. Removable Anti-Scatter Grid and Selectable Multi Beam Hardening (BH) Filter

The SONIALVISION G4 systems introduced this time can manually detach the anti-scatter grid. BH filters can also be changed on the SONIALVISION G4 control console. The anti-scatter grid has a grid ratio of 10:1, uses an aluminum interspacer, and has 44 lines/cm at a focal distance of 120 cm. The grid can be installed and removed manually with ease from the side of the main unit of the system. The grid can be removed simply pulling it out and it can be fixed without stress even in the reinsertion **(Fig. 3)**.
Three different BH filters can be selected from the touch panel on the console: 0.1 mm, 0.2 mm, and 0.3 mm Cu. There is also an option to use no BH filter. These options can be selected during an examination with a single tap on the touch panel **(Fig. 3)**.

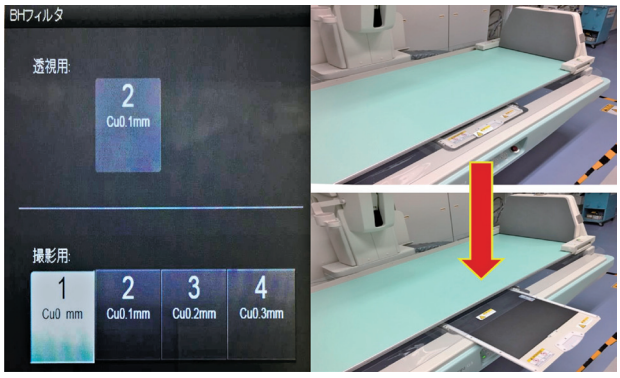

Fig.3 Console View of Selectable multi BH Filter Options (Left) and Anti-Scatter Grid Installation Method (Right)

The source-image distance (SID) of the system can also be set to 110 cm, 120 cm, and 150 cm and exposure dose of patient can be reduced by using a longer SID. And this function is also one of the feature of SONIALVISION G4 that the examinations can be performed so that the X-ray tube may not interfere the operator in the special examination environment of pediatrics.

4. Investigation Methods

In order to search for the optimal examination environment for pediatrics, the measurement experiment of the following items was carried out in total 8 kinds of combination of the anti-scatter grid with or without and with four different BH filter configurations (none, 0.1 mm, 0.2 mm, and 0.3 mm) including the usual examination settings. The usual examination setup is with an anti-scatter grid and no BH filter.

1. (1) Entrance surface dose, (2) Dose-area product, (3) Fluoroscopy tube voltage, (4) Fluoroscopy tube current, and (5) Fluoroscopy dose rate.
2. (1) Contrast-to-noise ratio (CNR) and (2) Figure of Merit (FOM)
3. Visual evaluation of Burger phantom **(Fig. 4)**
4. Visual evaluation of human phantom **(Fig. 4)**

Visual evaluation of a Burger phantom was performed on 8 images taken under each condition by 15 radiological technologists at our hospital **(Fig. 4)**.

Fig.4 **a)** Burger Phantom Measurement Method
b) Human Phantom Measurement Method
c) Visual Evaluation of Burger Phantom
d) Visual Evaluation of Human Phantom

For visual evaluation of the human phantom, wrist joint human phantom was used in place of an infant's body. In the usual examination setting (With grid and no BH filter), our hospital's 15 radiological technologists performed a 5-point evaluation on 7 images taken under each conditions.

The evaluation items are following 1 ~ 5 items and overall balance, 6 items in total.

In this evaluation, since the wrist joint human body phantom was assumed to be the infant's body, each position of the wrist joint was assumed to be each position of the infant.

(1) Able to verify overlapping of the radius and navicular bone (a line at the end of the radius): trachea
(2) Able to trace the outline of the trapezium bone: gastric gas
(3) Able to trace the outline of the capitate bone: kidneys
(4) Able to verify a gap between the lunar bone and triquetral bone: ureter
(5) Able to discern a gap between the second and third metacarpal bones: intestinal tract

• Overall balance

Each of these items was evaluated on a 5-point as "inferior", "slightly inferior", "unchanged", "little better", or "better".

5. Results

1-(1) Entrance surface dose (Fig. 5 left)

The result of entrance surface dose was lower without the grid (Grid(-)) than with the grid (Grid(+)). Also, the difference by the type of the BH filter showed the greater the filter thickness the lower the entrance surface dose.

1-(2) Dose-area product (Fig. 5 right)

Similar to the results for entrance surface dose, the dose-area product was lower without the grid (Grid(-)) and the greater the thickness of the BH filter the lower the dose-area product.

1-(3)(4)(5) (3) Fluoroscopy tube voltage, (4) Fluoroscopy tube current, and (5) Fluoroscopy dose rate (Fig. 6)

As for a result of fluoroscopic parameters, because BH filter for fluoroscopy is fixed at 0.1 mm Cu due to the specification of the system, we report only the results of the difference between with / without the Grid. Fluoroscopy tube voltage, tube current, and dose rate were all lower without the grid (Grid(-)) than with the grid (Grid(+)).

2-(1) Contrast noise ratio (Fig. 7 left)

The CNR was higher with the grid (Grid(+)) than without the grid (Grid(-)) and the greater the thickness of the BH filter the higher the CNR.

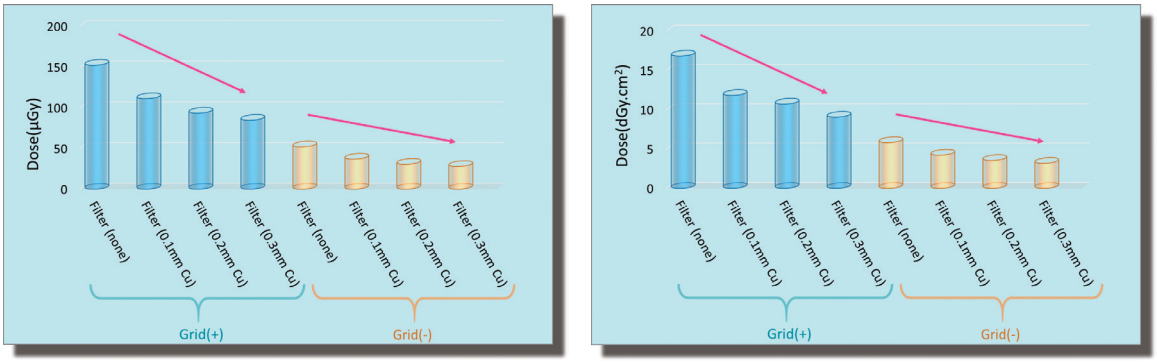

Fig.5 Entrance Surface Dose Results (Left) and Dose Area Product Results (Right)

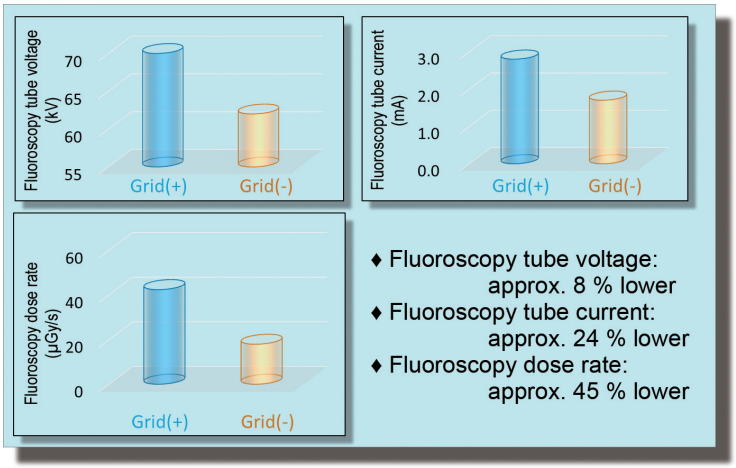

Fig.6 Fluoroscopy Tube Voltage, Fluoroscopy Tube Current, and Fluoroscopy Dose Rate Results

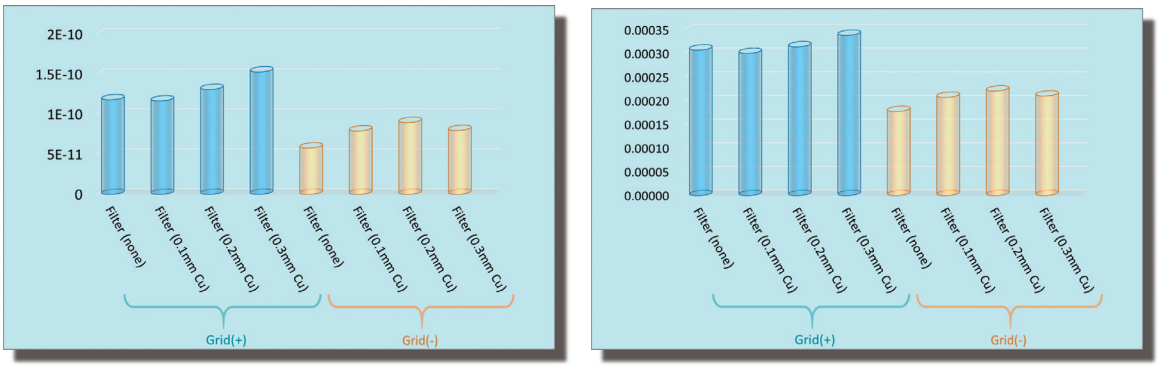

Fig.7 Contrast Noise Ratio (Left) and Figure of Merit (Right)

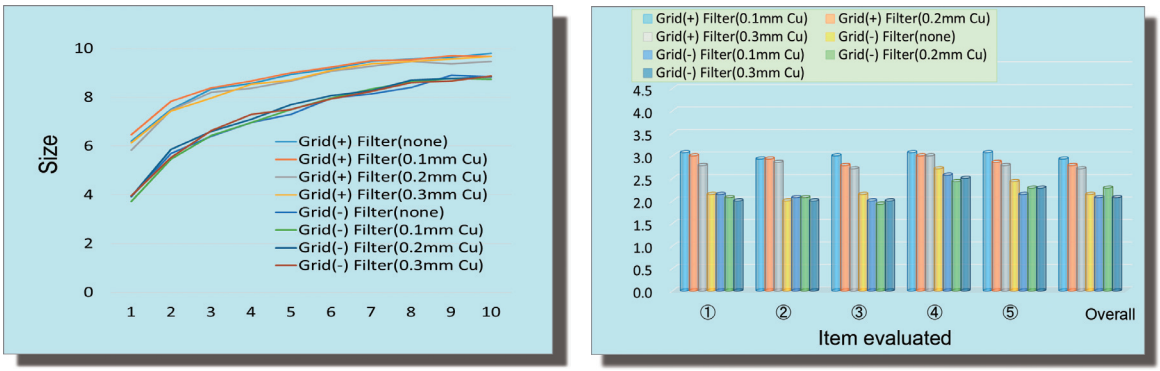

Fig.8 Visual Evaluation of Burger Phantom (Left) and Visual Evaluation of Human Phantom (Right)

2-(2) Figure of Merit (FOM) (Fig. 7 right)

Similar to the CNR, the FOM was higher with the grid (Grid(+)) and the greater the thickness of the BH filter the higher the FOM.

3 Visual evaluation of Burger phantom (Fig. 8 left)

The result of visual evaluation of the Burger phantom is with the grid (Grid(+)) resulted in a slightly better than without the grid (Grid(-)).

The difference of thickness of BH filter had no substantial effect on the visual evaluation results.

4 Visual evaluation of human phantom (Fig. 8 right)

Similar to the Burger phantom, with the grid (Grid(+)) resulted in a slightly better visual evaluation of the human phantom than without the grid (Grid(-)).

6. Discussion

- In the entrance surface dose and the fluoroscopic parameters, the effect of reduction in dose was recognized using the grid and changing the BH filter. It is considered that it is caused by lowering of X-ray condition and removal of soft X-rays by the filter.
- As for CNR, the thicker the BH filter, the slightly better the result was.

  Though CNR seemed to decrease in general, this result is probably the characteristic of this system, when it is estimated from exposure time and digital value etc.. And, it is considered that the difference of the Grid (with / without) is caused by the difference of contrast caused by scattered X-ray.
- For FOM, regardless of the Grid (with / without), the use of the BH filter gave good result.

  This result is probably due to the effect of a reduced dose and the CNR.
- As for results for visual evaluation of a Burger phantom and human phantom, the difference between the existence of the Grid was recognized. The BH filter did not affect the results from visual evaluation.

Based on the above findings, physical evaluation showed that using the BH filter was beneficial for reducing exposure dose, while visual evaluation with phantoms showed that using the BH filter had no major effect. This is considered to be an effect of limiting phantom thickness to 10 cm, because this investigation is an examination of the pediatrics. Also, though without the Grid (Grid(-)) reduced the exposure dose, it also resulted in slightly poorer results from visual evaluation. Nevertheless, since our hospital mainly uses pediatric fluoroscopic examinations to observe larger structures such as the colon and ureter rather than fine structures,

the slight reduction in image quality seen in this investigation is not enough to draw concern **(Fig. 9)**.

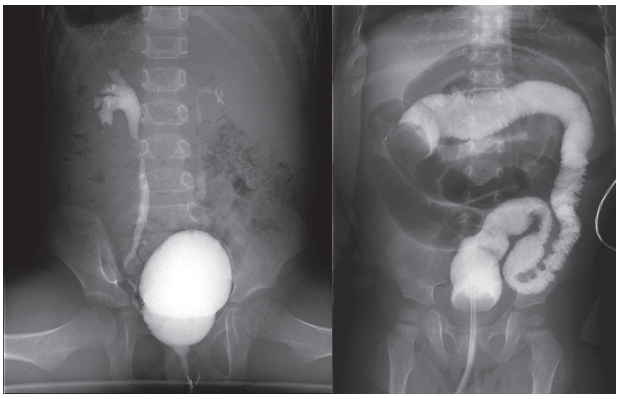

Fig.9 Clinical Images
Pediatric Voiding Cystourethrography (Left)
Pediatric Enema (Right)

7. Conclusion

Because our hospital runs rotations using different imaging modalities from one day to the next, our staff are not permanently responsible for particular modalities. For this reason, it is particularly important our medical staffs understand the details of each fluoroscopic examination before the examination. Understanding the details of an examination may avoid unnecessary fluoroscopy or radiography for an examination. In addition, using procedural functions and setting protocols for pediatric allows all the radiological technologist to carry out fluoroscopic examination in fluoroscopic condition that take advantages of the removable anti-scatter grid function and the selectable multi BH filter function. In this way, we believe we have established an examination environment that reduces the exposure dose.

In some cases in our hospital, the conditions are set for without Grid, and the thickness of BH filter is changed for each purpose of the pediatric fluoroscopic examination **(Table 1)**.

We would like to continue our efforts to further reduce the exposure dose of patients and operators, not only in pediatric examinations but for all fluoroscopic examinations.

Table 1 Examination conditions at our hospital

	Grid	Filter
Intussusception	—	0.3mm
Urinary system examinations	—	0.1mm
Reductions	—	0.3mm
Others	—	0.2mm

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