Computed Radiography for Major Airway in Pediatrics

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This paper shows the efficacy of computed radiography for major airway in pediatrics. For this purpose, we examined 40 children (range 2 weeks to 14 years; mean 2.3 years) using Fuji Computed Radiography (FCR) and radiation dose using pediatric phantom under FCR and conventional film and screen system.

In comparison study with FCR and conventional film and screen system, FCR images are superior to conventional system in all cases. Scorings were done for the quality of the image of the pharynx, the trachea, and both main bronchi.

In phantom study to check radiation dose, radiation dose could be reduced 1/6 of the value using high speed film and screen and 1/15 of the value using conventional speed film and screen.

FCR also showed clear airway images in all cases but technical failure to evaluate the clinical lesion.

These results suggest that FCR is the adequate imaging modality to evaluate the major airway in children.

**key words**: computed radiography, airway, pediatrics

Radiological evaluation of major airway is important in children who have major airway diseases, but it is not quite easy to obtain adequate images because of technical limitation by regular film-screen combination system.

Recent advance of the electronic-computer technolgy has provided us a new era of diagnostic imaging including digital radiography. By one of such digital radiography systems so-called Fuji Computed Radiography (FCR) designed by Fuji Photo Film Co., high quality images in the major airway were able to be obtained.

The purpose of this paper is to show the efficacies of FCR in major airway diseases of children.
Methods

Patients

Forty children (24 males and 16 females) were examined with FCR system. The mean age was 2.3 years ranging 2 weeks to 14 years. Thirteen patients supposed to have intubation difficulty because of congenital anomaly; such as Apert syndrome, Crouzon disease, and so on. Eleven patients had segmental atelectasis and/or emphysema associated with congenital heart disease. Eleven patients had been intubated. Three patients had congenital tracheal stenosis. Two patients had acquired tracheal stenosis. As a comparison study, 10 patients underwent both FCR and conventional X-ray examination.

FCR system

FCR system utilizes a stimulable phosphor as an area detector system which is read out by scanning laser beam. This detector has two distinct stages of image generation. There are the exposure and the read out stages which are required to be separated in time. Imaging plate specially designed for this system is exposed in exactly the same way as conventional X-ray generating equipment. Phosphostimulable phosphors are capable of storing the energy absorbed in quasistable states when excited by X-ray.

Imaging plate is then scanned by laser beam. The latent image stored in the imaging plate is released as fluorescent light following stimulation of the phosphor by scanning laser beam. The fluorescent light is collected by photomultiplier tube and is then converted to analog electric signals. They are then converted to digital signals and fed into the image processor.

The image processor is a high speed electronic computer which mathematically integrates the dot-and-dash image. It heightens or lowers the contrast and increases or reduces the density of specific parts of the image so that the different parts of the image will stand out more clearly under visual observation. These digital signals are stored and then fed into the image recorder.

The image recorder reverses the digital signals to analog signals the converts to light of corresponding intensities and scans the film with the laser beams to imprint a precise image on it. 

Block diagram of FCR system is demonstrated on Fig. 1.

Scorings in phantom study

Scoring was performed by 6 radiologists. Five checking points were selected as follows; Humeral head, cork overlapped with the rib (right and left), and cork not overlapped with the rib (right and left). Scorings were based on the evaluation of the findings as; 1: satisfactorily

![Fig. 1 A block diagram of FCR](image-url)
seen, 2: moderately seen, 3: poorly seen, 4: not seen. As a comparison study, 5 pairs of film and screen were selected (Table 1).

Scorings in clinical study

Scoring numbers are based on as follows; 2: satisfactory, 1: moderate, 0: non-visualized. Evaluated regions are the trachea on frontal and lateral views, both main bronchi on frontal view and the pharyngeal cavity on lateral view.

Results

Phantom examinations for radiation dose

The results are summarized on Table 1.

It is possible to summate the informations of double or triple plates in one cassette using penetrated X-ray quanta through the first imaging plate to the next imaging plate. Using such technique, almost the same pictures were taken under 1/3 of the exposure as compared with that of using one imaging plate.

So, using FCR system radiation dose could be reduced at least to 1/2–1/6 of the value using high screen and to 1/5–1/15 of the value using conventional speed film and screen.

To check density control of FCR, we compared routine FCR and ten times overexposed FCR under pediatric phantom. The image qualities were the same on both study.
Results in clinical cases

FCR showed clear major airway images in all cases but technical failure on both lateral and frontal views (Fig. 2 and Fig. 3).

To avoid unnecessary radiation exposure, we had performed 10 comparison studies using conventional film and screen system. The results are shown on Table 2. In all cases, FCR images are superior to those of conventional films (Fig. 4).

In other clinical cases, FCR demonstrated clear and satisfactory anatomy of the major airway to evaluate the lesion. No tracheography was recommended in any case.

As a demonstration of abnormal major airway by FCR, three cases are presented on Fig. 4, 5, and 6.

Discussion

FCR makes it possible to have 1) wide exposure latitude, 2) density control, 3) contrast control, 4) minification effect, 5) summation, 6) subtraction, and 7) special frequency enhancement.

Our study showed that the airway of the neck portion and of the intrathoracic portion as well as of the oral and nasal portions can be almost equally and clearly demonstrated in all cases except for position error. This is mainly due to wide exposure latitude. It is almost impossible in aged group to demonstrate the airway from the pharynx to the trachea on a lateral view in
conventional film and screen system.

Our phantom study using ten times overexposure to evaluate density control documented that inadequate examination due to overexposure becomes practically null. This is very much beneficial for the examination with mobile portable X-ray unit.

Contrast control, minification, and spatial frequency enhancement on FCR enable to demonstrate the major airway more clearly in comparison with regular radiographic image with conventional film and screen as shown on
Table 2.

Because of these characteristics, FCR can reduce the radiation dosage. In our phantom study, it can be reduced to 1/15 of the dose under conventional speed film and screen. This is a benefit of FCR as compared with xeroradiography which has also an enhancement effect. Xeroradiography is not accepted in routine usage for pediatric patients because of its requirement of a large exposure dosage.

In pediatrics, especially in infant, it is frequently difficult to evaluate the major airway on plain film. Fiberscopic examination and tracheo-bronchography are sometimes planned for such cases. They give us a clear image of the major airway. However, they may be invasive examination. In our clinical study, FCR showed clear images of the major airway both on lateral and frontal views. So, at least, tracheography could be avoided.

Eleven cases of our patients had acyanotic congenital heart disease. It is well known that acyanotic congenital heart disease with pulmonary hypertension can cause bronchial obstruction. Unfortunately, such patients have cardiomegaly and congested lungs, and so it is difficult to reveal the major airway on conventional plain film. Even though our 11 patients had same difficulties, FCR demonstrated clear images of the bronchus.

In conclusion, FCR gives us a satisfactory image of the major airway with minimal radiation exposure as compared with conventional film and screen system in pediatrics.

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Legends

**Fig. 2** A 1-year-old boy with double outlet right ventricle

Right and left films were processed from one plate. The left image was treated with spatial frequency enhancement. It demonstrates a clear image of the major airway.

**Fig. 3** A 2-year-old boy with craniosynostosis

Note that the major airway is satisfactorily demonstrated from the pharynx to the trachea on one image. Airway at the thoracic inlet is frequently underexposed and not visualized with conventional X-ray examination.

**Fig. 4** A 5-month-old girl with VSD and pulmonary hypertension

A is a picture with FCR, and B is a picture with conventional film and screen. FCR shows that left main bronchus is displaced downward by enlarged main PA but patent (arrow).

**Fig. 5** A 2-month-old girl with congenital stenosis of the trachea

FCR images reveal an irregular narrowing of the trachea in its proximal intrathoracic portion both on frontal and lateral views.

**Fig. 6** A 3-year-old boy with Noonan syndrome who had intubation difficulty

A granuloma is well delineated along the anterior wall of the upper trachea which is faintly recognized on the conventional radiograph (B) (arrow).
References


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