

# Experience Using MobileDaRt Evolution EFX Version in Perinatal Medicine



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## 1. Introduction

Kurashiki Central Hospital is situated in Kurashiki City, Okayama Prefecture, and was founded on June 2 1923 as Kurabo Central Hospital by Magosaburo Ohara, the President of Kurabo Industries Ltd. Magosaburo Ohara demanded the best above all else, and built the hospital based on three design principles: treatment-centered hospital (treatment truly for the patient, and not for research), a bright rather than traditional hospital, and a model hospital for the East. In 1927, the hospital became financially independent and changed its name to Kurashiki Central Hospital. In 1934 the hospital became a foundation and in 2013 changed to a public interest incorporated foundation. Out of respect for the philosophy of the hospital founder, its corporate name was chosen to be "Ohara Healthcare Foundation" (Fig. 1).

Our hospital has 1161 beds and 2930 employees, including 457 doctors, 1269 nurses, and 89 radiological technologists. Hospital employees have made it their mission to continue the patient-centered care principle of the hospital founder throughout the years in an appropriate manner, not only in terms of day-to-day medical care, but also through the expansion and remodeling of hospital buildings. In our current climate of social structural reform and major changes in the medical

sector, we believe the right path for this hospital is to achieve the status of best flagship hospital for acute care in the region via true community-based healthcare. The hospital's mission is also providing world-class health care, and in March 2016 the hospital received Joint Commission International (JCI) accreditation in the form of their Gold Seal of Approval<sup>®</sup>, an accreditation that is recognized worldwide.

## 2. Background to Acquiring MobileDaRt Evolution EFX Version

In 2010, Kurashiki Central Hospital increased the number of beds in its Neonatal Department of the General Perinatal Medical Center, and now has a neonatal intensive care unit (NICU) with 21 beds and growing care unit (GCU) with 30 beds. The hospital sees a high number of seriously ill infants, admitting 50 to 80 infants with very low birth weight annually and 50 to 70 infants with congenital heart disease annually, and increasingly performs portable radiography of premature neonates. Combining the NICU and GCU, up to 10 of these bedside examinations are performed each day, and 3,500 portable radiography examinations of premature neonates are performed each year. Portable radiography is often performed daily for



Fig.1 Kurashiki Central Hospital

premature neonate patients as their condition is liable to change suddenly. Premature neonates are also highly sensitive to radiation exposure, so we prefer to perform portable radiography with the minimum necessary dose.

In light of this, we decided to obtain a mobile X-ray system equipped with a flat panel detector (FPD) that is capable of reducing the exposure dose and improved image quality. Shimadzu's MobileDaRt Evolution EFX version system (hereinafter MobileDaRt Evolution, **Fig. 2**) was chosen based on its ease of use that allows not only radiological technologists, but also doctors working in the NICU to use the system during the night in extreme emergencies. Given the choice between an inbuilt digital radiography image processing system (hereinafter DR system) made by Canon or Fujifilm, we chose a Fujifilm DR system since we had already used a Fujifilm DR system and are familiar with its operation. An FPD size of 10 × 12 inches was also chosen as it fits in the incubator cassette holder. This FPD is light at just 1.6 kg, so female technologists can also handle it with ease. The FPD uses columnar cesium iodide (CsI) crystals for its scintillator, and is more sensitive than imaging plates (IPs).

Alongside acquiring the new mobile X-ray system, our hospital reviewed the radiography conditions used for portable radiography of premature neonates. Image quality was discussed with doctors working in the NICU, and radiography conditions of an X-ray tube-to-detector distance of 110 cm, tube voltage of 70 kV, and exposure dose of 0.32 mAs were chosen. These conditions have allowed us to reduce the entrance surface dose (ESD) to just 25 % of our previous system.



**Fig. 2** MobileDaRt Evolution EFX version

### 3. Experience in Use

#### 3.1. Operation

The MobileDaRt Evolution used at our hospital combines a Shimadzu mobile X-ray system and Fujifilm DR CALNEO Smart compact FPD. The image processing unit included in the DR system is Fujifilm's Console Advance. Although our MobileDaRt Evolution is not integrated with our radiology information system (RIS), a hospital computer compatible with RIS is installed inside the NICU, and transmits examination information to the mobile X-ray system when performing examinations. Acquisition of examination information and post-examination transmission of images are performed using hospital wireless LAN.

#### 3.2. Workflow of Portable Radiography of Premature Neonates

The workflow used at our hospital is described below.

- (1) Patient information is transmitted from an RIS-enabled hospital computer in the NICU to MobileDaRt Evolution.
- (2) The mobile X-ray system is powered on, and the DR system is started up. (Start-up takes approximately 2 minutes.)
- (3) Transmitted patient information is acquired automatically after start-up of the DR system. It is confirmed that all patient information has been transmitted to the mobile X-ray system.
- (4) The system is moved to the patient's incubator, and patient verification is performed.
- (5) Patient verification is performed by reading the patient-assigned barcode with a barcode reader.
- (6) The examination screen starts up as soon as the barcode is read.
- (7) Together with a nurse, patient name, date of birth, and radiography region of interest are confirmed, then radiography is performed.
- (8) The acquired images are checked, and sent to the picture archiving and communication system (PACS).
- (9) After all examinations are complete, examination information is concluded on the RIS.
- (10) The DR system is turned off, and the mobile X-ray system is powered off.

This is our current workflow. The previous computed radiography (CR) system required enough IP cassettes for planned and additional X-ray images to be brought to the patient bedside in advance before performing examinations. Checking these images could only be performed after all

radiography examinations were complete, returning to the radiography room, and processing the IP cassettes in reading equipment. This created a substantial time lag between examination and image checking. Since introducing MobileDaRt Evolution, only a single FPD is needed at the patient's bedside, and as many images as wanted can be obtained while battery charge remains. The time from image capture to image checking is just 2 seconds (preview image display time), which allows for immediate confirmation of intracorporeal tube placement and repeated radiography.

### 3.3. Experience in Use

The examination screen starts up as soon as patient verification is completed by reading the patient's barcode with a barcode reader. This has reduced the labor required to start examinations manually. Since the operator no longer needs to select from a large number of examination orders by hand, it also reduces human operational errors. The DR system is easy to use since it has the same Console Advance used in the plain radiography room, and technologists are already familiar with its operation. Also, having the DR system built into the mobile X-ray system simplifies operation, as examination orders and radiography conditions can be linked. MobileDaRt Evolution is easy to operate even by technologists using it for the first time.

The mobile X-ray system has a power assisted driving feature that makes moving the system easy, which reduces stress on the technologist. Positioning has also been made easier as the X-ray tube on the mobile X-ray system can be moved horizontally, and an LED used for the collimator lamp allows easy visibility even in a brightly lit room (Fig. 3). Unfortunately, we cannot use an



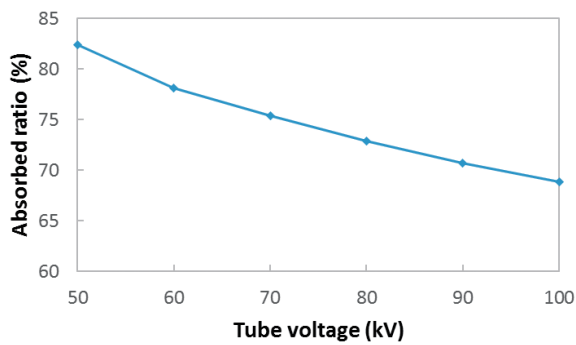
Fig.3 Simulated Radiography Using MobileDaRt Evolution

ultrasound distance meter since the incubator reflects the ultrasound waves. The DR system takes just 2 minutes to start up, so after powering the system on, by the time it reaches the incubator it is ready for use. This start-up time is also quick enough for portable radiography in emergency situations. In the past, we had an incident in which the battery in the system ran out completely and radiography could not be performed for 2 to 3 hours while the battery recharged. At our hospital, when morning radiography examinations are complete, sometimes no examinations are performed until the following morning, and we presume the battery ran out completely because the DR system and mobile X-ray system were left turned on for 24 hours after morning use. We now ensure the system is left charging at the end of every examination so the battery does not become fully run out.

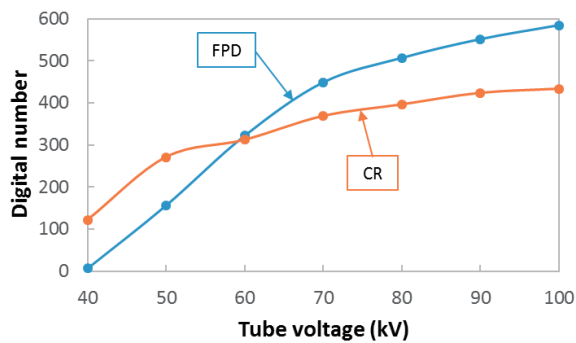
### 3.4. Radiography Conditions and Entrance Surface Dose

At our hospital, MobileDaRt Evolution is used in the NICU and GCU, and the exposure dose is set to the minimum level for the mobile X-ray system, which is 0.32 mAs. It is very useful as portable radiography of premature neonates can be performed with a very small exposure dose. As mentioned earlier, radiography conditions are set to an imaging distance of 110 cm and tube voltage of 70 kV to balance the FPD tube voltage characteristics with the ESD. The establishment of portable radiography of premature neonates based on absorbed dose has been reported at the 72nd Annual Meeting of the Japanese Society of Radiological Technology (Fig. 4 to 6).

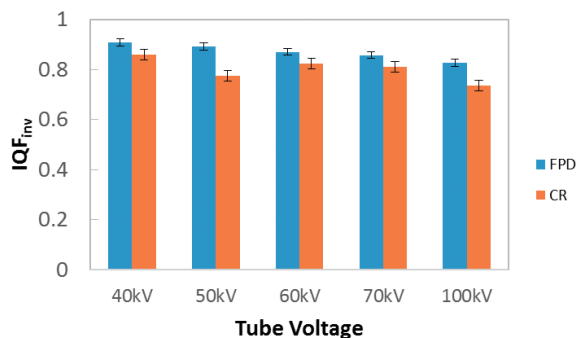
The entrance surface dose (ESD) is 0.02 mGy, as mentioned earlier in the radiography conditions. This is 1/10 the dose of diagnostic reference levels (DRLs), and equivalent to a 25 % reduction in dose compared to the ESD of the previous system used at our hospital. In the future, we expect that FPDs become more mainstream, leading to an increase in low-dose radiography, and that stability in the low-dose region becomes an important feature of X-ray generators. The MobileDaRt Evolution now used at our hospital has been stable at low doses, with a coefficient of variance of 0.05 or less for an exposure dose of 0.32 mAs.



**Fig.4** Proportion of X-Rays Absorbed by Absorber (Solid Water, 6 cm thick)



**Fig.5** FPD and CR Tube Voltage Characteristics



**Fig.6** FPD and CR Image Quality Index

## 4. Challenges

Other challenges recognized since obtaining MobileDaRt Evolution are shown below.

- (1) Shortening the battery charging time
- (2) Making the barcode reader wireless
- (3) Allowing RIS operation by remote control  
(Not possible at the time of MobileDaRt Evolution acquisition)

We eagerly look forward to seeing improvements in the matters shown above, and the development of a system with even better operability.

## 5. Summary

Introducing MobileDaRt Evolution to our hospital has allowed us to perform portable radiography of premature neonates using an FPD. By setting radiography conditions to balance image quality against exposure dose, radiography using an FPD has allowed us to reduce the exposure dose without image degradation. Examination workflow throughput has also been improved by removing the need to carry a large number of cassettes for examinations, and making immediate image confirmation and image transmission to PACS both one-step operations.

We can also now send RIS information to the mobile X-ray system using hospital wireless LAN, making it easier to obtain additional X-ray images.