

Experiences Using the MobileDaRt Evolution Digital Mobile X-Ray System in a Simulated Large-Scale Mass Disaster



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1. Introduction

Osaka General Medical Center (**Fig. 1**) is located in Sumiyoshi-ku among six residential districts in the south of Osaka (Sumiyoshi-ku, Suminoe-ku, Abeno-ku, Nishinari-ku, Hirano-ku, Higashisumiyoshi-ku). It is close to the green environments of Nagai Park with its sports stadiums, Sumiyoshi Grand Shrine, and Sumiyoshi Park. The medical center functions as a general hospital to support diverse medical needs. To provide safe, high-quality medical treatments, it comprises 28 medical departments within five divisions: Acute Care Division, Specialized Medicine Division, Central Division, Advanced Medical Center, and the Disabilities Treatment and Rehabilitation Division. The medical center offers a total of 768 beds (734 on general wards, 34 on mental wards).

Since becoming an independent administrative institution in April 2006 and merging with the Osaka Prefectural Hospital for Persons with Disabilities in 2007, we have worked in collaboration with the neighboring Osaka Prefectural Self-Reliance Center for Persons with Disabilities and the associated Counseling and Support Center to operate the Rehabilitation Center for Persons with Disabilities, which is unrivalled in Japan.

It is the only general hospital among the five prefectural hospitals in Osaka Prefecture. It boasts the first specialist emergency medicine department established in Japan in 1974, which handles many health policy activities, including tertiary emergency medicine.

It functions as the core disaster medical center in Osaka Prefecture and is responsible for receiving victims and providing initial treatment in the event of a large-scale mass disaster.



Fig. 1 Osaka General Medical Center

2. Functions as a Core Disaster Medical Center

One core disaster medical center exists at a specified location in each prefecture of Japan. Our medical center functions as the core disaster medical center for Osaka Prefecture, and as such conducts disaster medical training for the disaster base hospitals and public disaster medical drills. Should a real disaster hit Osaka Prefecture, it would be our duty not only to receive victims and provide initial treatment but also to regulate the transfer of patients between disaster base hospitals and the dispatch of emergency medical teams. When the JR Fukuchiyama Line derailment accident occurred in Amagasaki, we collaborated with the core disaster medical center in Hyogo Prefecture to transfer patients to disaster base hospitals in Osaka Prefecture. After the Great East Japan Earthquake hit on March 11 2011, we immediately dispatched Disaster Medical Assistance Teams (DMAT) and controlled the intake of patients to hospitals in Osaka Prefecture.

The Rehabilitation Center for Persons with Disabilities established in April 2007 can function as a support facility for the disaster base hospitals by receiving patients and providing initial treatments (**Fig. 2**).

The first floor houses the Headquarters for Disaster Countermeasures, triage zone, and treatment area for patients with green triage tags. The second and third floors can hold approximately 400 patients with yellow and red triage tags. Equipment such as medical gas cylinders and beds are arranged to provide more efficient critical care medicine (**Fig. 3**) and the building was constructed to facilitate patient transfer to operating theaters and helicopters. Water tanks and electric generators are provided for essential services.

Every year this facility is used for a simulated large-scale mass disaster drill. This year for the first time, we participated in this event with our Shimadzu MobileDaRt Evolution digital mobile X-ray system (**Fig. 4**). We describe our experiences below.



Fig. 2 (a) Rehabilitation Center for Persons with Disabilities (Support Facility for the Disaster Base Hospitals)
 (b) Disaster Assistance Zone (Sports Hall)
 (c) Storeroom



Fig. 3 Pipe Connections Embedded in Walls and Floor



Fig. 4

3. Overview of MobileDaRt Evolution

Our new MobileDaRt Evolution is a digital mobile X-ray system with a flat panel detector (FPD). **Table 1** shows the basic specifications of the unit.¹⁾

The new thinner large-view-field FPD has a thickness close to a conventional film cassette and is lighter than previous FPDs. Carrying and positioning the FPD is extremely simple.

The 32 kW high output of the system permits radiography in a short time. It offers images with little motion blur for children and other patients who find it difficult to hold a posture and in emergency situations where a stationary state cannot be maintained.

Images appear just three seconds after radiography, so the images can be immediately checked for poor positioning or blurring due to body movement. While the FPD is still in place under the patient, the operator can rapidly determine whether positioning adjustment or re-imaging due to body movement is required.

Maximum output	32 kW (20 msec)
Rated output	16 kW (100 msec)
Tube voltage	40 to 133 kV
Maximum tube current	400 mA
Tube current-time product	0.32 to 320 mAs
Tube focal point	0.7/1.3 mm
FPD	Equipped with FPD
Imaging method	Scintillator + a-Si
Scintillator	GOS
Effective field of view	35 × 43 cm
Total number of pixels	2208 × 2688
Pixel pitch	160 × 160 μm
Output gradation	12 bit (4096 gradations)
Size	480 (W) × 481 (H) × 15 (D) mm
Weight	3.4 kg (excluding a grid)

Table 1 Basic Specifications of MobileDaRt Evolution

4. Utility of MobileDaRt Evolution

When asked what is needed to provide medical treatment when essential services such as electricity and water are cut off, we as medical personnel who experienced the Great Hanshin Earthquake reply that we need such a digital mobile X-ray system with a flat panel detector (FPD). That's because it is a self-contained system.

The utility of the MobileDaRt Evolution with FPD is its ability to provide images just three seconds after radiography for observation onsite, which is not possible with cassette radiography. The system incorporates a 15-inch touch panel LCD monitor. We, X-ray technologists feel that the onsite

observation of images immediately after radiography is the greatest merit of the system. However, we were concerned about the performance of the monitor for image observation. So, we used a Howlett chart to evaluate the unit monitor.

The Howlett chart is designed for the visual evaluation of images (Fig. 5). A Howlett chart incorporates sets of 13 donut-shaped rings of different diameters (different spatial frequencies) arranged in nine positions, making a total of 117 rings. The ratio of the outside diameter and inside diameter of the donut-shaped rings is 3:1. The Howlett chart is made of copper sheet and is available in two thicknesses: 35 μm and 70 μm . Images of the chart are taken using the system being evaluated, and size of the donut-ring shadows that can be subjectively recognized are determined²⁾. We used a 70 μm Howlett chart. While the details are omitted here, the image quality that allows distinction down to the minimum donut-ring diameter was denoted as image quality (IQ) = 13, and the image quality that permits distinction of all the maximum-diameter donut-rings was denoted as image quality (IQ) = 1. The relationship between the image quality value and spatial frequency of the donut ring is expressed as $\text{IQ} = 5.0 + 13.3 \cdot \log S$, as shown in Table 2. Where, IQ represents the image quality value and S represents the spatial frequency of the donut ring.

The digital mobile X-ray system with FPD was used to take images of the Howlett chart and a 3 cm acrylic board. The images were taken at 50 kV tube voltage. These radiography conditions offer sufficient X-ray exposure dose to eliminate noise resulting from inadequate exposure. The images were displayed fitted to the size of the system monitor (QA-Mag and 3 \times magnification), hospital reference monitor (1M), and the image interpretation monitor (2M), and the visual detectability offered by each monitor was evaluated. Fig. 6 shows the visual detectability of the Howlett chart offered by each monitor. The horizontal axis shows the type of monitor and the vertical axis represents the IQ value. Normally, images are transferred to the hospital server and then displayed on the hospital reference monitor (1M) or the image interpretation monitor (2M). A comparison with these two monitors shows the visual detectability of the system monitor (QA-Mag) to be clearly inferior. However, enlarging the image on the system monitor obtains visual detectability approximately equivalent to the other monitors. Consequently, the immediacy provided by the MobileDaRt Evolution digital mobile X-ray system with FPD can be used effectively if the displayed images are enlarged. Apart from simply enlarging the images, we believe that applying image processing to the digital images would present further possibilities.

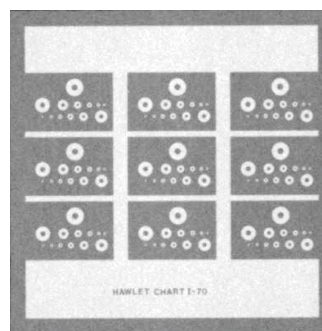


Fig. 5 Image of a Howlett Chart

Image quality (IQ) value	1	2	3	4	5	6	7	8	9	10	11	12	13
Spatial frequency (L/mm)	0.5	0.6	0.7	0.83	1.00	1.19	1.43	1.72	2.00	2.35	2.73	3.33	4.00

Table 2 Relationship Between Image Quality Value and Spatial Frequency of the Donut Ring

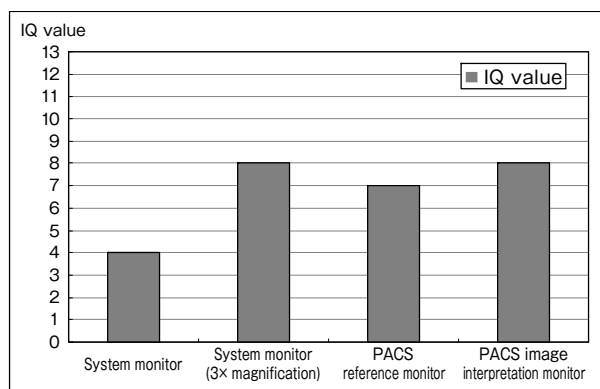


Fig. 6 Visual Detectability of the Howlett Chart

5. Use at Disaster Medical Drills

During disaster medical drills, the patients are selected in the triage zone on the first floor of the Rehabilitation Center for Persons with Disabilities and then the mock injured (volunteers) are transported to the third-floor sports hall (Fig. 7). When radiography of the injured is requested, we take the images with the digital mobile X-ray system. As most of the "injured" are assumed to be trauma patients, requests for frontal chest and pelvic radiographs are inevitably the most common. During actual drills, two X-ray technologists are allocated to a single digital mobile X-ray system. Before we had the MobileDaRt Evolution, no radiography method was available apart from cassette radiography. So, of the two X-ray technologists, one was kept busy transporting the exposed cassettes to the image processor for processing. From the technologists' workflow viewpoint, as the mobile X-ray system could carry only a limited number of cassettes, the more the number of radiography requests increased, the more time one of the technologists had to spend carrying and processing the cassettes. Therefore, the other technologist had to

handle all the patient positioning and imaging tasks alone. To make things worse, the image processor could not keep up, meaning inadequate cassettes were available for radiography. From the doctors' workflow viewpoint, the requesting physician either had to leave the patient and go to the location where the image display monitor is installed to observe the images, or rely on another physician to check the images and pass on the information. Either way, checking the images took some time. However, the MobileDaRt Evolution should be able to improve the workflow for the X-ray technologists and physicians alike.

When the MobileDaRt Evolution was used in a disaster drill, it could be moved up next to the patient to allow input of the patient information. During normal operations, the patient information is acquired from the ordering system. During a disaster, the disaster ID on each patient's triage tag is directly entered into the unit. Thanks to the built-in 15-inch touch panel LCD monitor, it was comparatively easy to input the information. After entering the patient information, simply confirm the request form, set the radiography method for the system and start imaging. We do not actually use X-ray exposure during the drills. We just displayed images from an image list preset in the system. The physicians highly regarded the ability to immediately view images without leaving the patient's side (Fig. 8). The X-ray technologists saw the benefits of smooth operation by two operators even when handling large numbers of radiography requests, whereby one technologist operated the system and the other positioned the patient. As it is impossible to predict when a disaster will occur, there may not be many personnel available. Therefore, we believe that the MobileDaRt Evolution would be useful in disaster medicine situations, thanks to its efficient and smooth operation.



Fig. 7 Scene at Disaster Drill



Fig. 8 Physicians Observing Images on Built-In Monitor



Fig. 9 Scene During Radiography

6. Requests

Even during the short time of the disaster drill, we felt that the batteries discharged more than expected. During a real disaster, the MobileDaRt Evolution would probably need to move more and take more images, so we would like to see improvements to maintain the power supply capacity, such as high-speed battery charging.

7. Conclusions

Compared to cassette radiography, the utility of the MobileDaRt Evolution derives from its immediacy (the ability to view images immediately after they are taken) and the excellent workflow.

This investigation focused on the restricted method of operation in a disaster drill situation, but we hope to investigate other applications in the future (Fig. 10).



Fig. 10 Mr. Funahashi, chief technologist at the Center, explains MobileDaRt Evolution to the Governor of Osaka Prefecture

References

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