Japan Safe Radiology 2018

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Background/introduction

Diagnostic imaging has progressed very quickly and has greatly contributed to clinical medicine. Large-sized medical imaging systems including CT and MRI have become common in our country, and patients can undergo such examinations everywhere. On the other hand, it is difficult to utilize the imaging data obtained at individual hospitals on a nationwide basis. Several problems remain to be solved, including poor efficiency in clinical practices, overly high medical bills and concerns about medical safety. We believe that the advance of Information and Communication Technology (ICT) may enable us to use "big data" to solve some of these problems.

The Japanese Radiological Society (JRS) is advocating the development of so-called "Japan Safe Radiology." The aim of this project is to construct a system for network-type management of diagnostic imaging nationwide. Concretely, we aim to generate, analyze and utilize a national database of diagnostic imaging and thereby to improve medical techniques in terms of safety, standardization and optimization of image scanning, and also to apply it to medical policy. The characteristic of this project is to carry out an "all Japan" organization under the auspices of the largest society related to diagnostic imaging in our country (JRS) in cooperation with JIRA (Japan Medical Imaging and Radiological Systems Industries Association). This attempt is the first in the world and wholly original. A structure that collects information on radiation doses and utilizes it has been partially constructed in the United States [1]. However, there is no management system that integrates medical imaging data on the national level. In this project a storage server and registry server will be newly established. Information on medical imaging data collected all over the country will be integrated in the servers. By utilizing this imaging data, new medical technology may be developed, and multi-center collaboration studies may also be designed with ease, resulting in the promotion of clinical study. Specific items to be carried out include (1) proper distribution of medical equipment and radiologists, (2) development of a Clinical Decision Support (CDS) system for proper utilization of medical equipment, (3) network-type management of radiation exposure doses (Dose Index Registry: DIR), (4) proper quantitation of medical imaging data based on the establishment of Japan's Quantitative Imaging Biomarker Alliance (J-QIBA) and (5) unification of diagnostic reports. The final goal of our project is the clinical application of artificial intelligence (A.I.). In the next section we present describe in greater detail the activities to be advanced in Japan Safe Radiology.
Description of activity and work performed

The overall structure of "Japan Safe Radiology" is shown in Fig. 1.

The first goal at which "Japan Safe Radiology" is aimed is unified management of medical resources: i.e., the establishment of a national database of diagnostic imaging (Japan Medical Imaging database: J-MID). The database will be generated by collecting CT and MRI images from medical institutions all over the country. Collected data will be shared, analyzed and utilized as big data. We have already started to design and develop a small-sized system using data from six medical institutions. In the future this system will be extended to all university hospitals, general hospitals and clinics. Our goal was to construct an environmental where the image presentation service can be utilized on the Cloud. Design and development will be performed for the gateway system of a client, which can respond to every PACS maker (Fig. 2). From there, consideration will be given to the integration of this database to include other domains such as endoscopic and pathological images. Cooperation with JIRA will be necessary to accomplish this project.

Below, we will report the progress of the construction of J-MID system. First, we established the J-MID server at Kyushu University and then established a gateway server at each of the five collaborative medical facilities (5 university hospitals and 1 general hospital) to be connected, and they were connected by a high-speed and highly secure network called SINET 5-VPN.

In January 2018, we started sending CT images and their report data to the J-MID server and started collecting data to the database. In March 2018, we plan to add two additional universities as collaborative medical facilities, it becomes 8 facilities (7 university hospitals 1 general hospital).

As a schedule, we plan to expand the scale to 10 collaborative medical facilities by March 2019 and 20 facilities by March 2020. Although we are currently focusing only on CT, we are now considering doing this with multimodality such as MRI and other X-ray images in the future.

We advanced the following six items based on this J-MID. Regarding progressing projects, we described their progress at the end of the section

# Proper distribution of medical equipment and radiologists

In our country the number of large-sized medical imaging systems such as CT and MRI has been increasing compared with that in other technologically advanced nations (Figs. 3 and 4). On the other hand, the number of radiologists is running short, and about 2.09 times the number of radiologists employed in Japan are currently required to interpret CT and MRI examinations (Fig. 5) [2]. Also, the medical equipment is unevenly distributed,
and the regional gaps in radiological medical practice are large. In order to narrow these regional gaps, both medical equipment and radiologists should be distributed more appropriately, based on the data of J-MID.

# Development of a Clinical Decision Support (CDS) system for proper utilization of medical equipment

We plan to develop a CDS system. Using this system a diagnostic examination suitable for each patient’s condition will be automatically selected in clinical practice. The guidelines for the choice of a diagnostic examination will be stored in this system. On the occasion of an initial examination order a physician could call up relevant patient data from the registry server of J-MID, based upon which a proper examination for the patient will be automatically selected. Reduction in the orders of duplicated examinations, improvement in diagnostic accuracy, reduction of medical radiation exposure and medical expenses, improvement in the quality of a radiologist’s report, and overall advances in the efficiency of clinical practice, etc. are expected.

We have developed CDS system for limited disease and tried at limited facilities to verify feasibility of CDS in Japan. First, at the Juntendo University Hospital, pilot study has been started for minor head injuries in children. In addition, pilot study is planned for lumbar MRI examination for lumbago at 8 practitioners.

# Network-type management of radiation exposure dose (Dose Index Registry: DIR)

In addition to image data, radiation exposure doses will be collected from J-MID, with the aim of developing a system that performs automatic statistical interpretation (Dose Index Registry: DIR). Eventually the optimization of scanning protocols and radiation exposure doses will be performed, and improvements in medical safety will be seen. The exposure doses for coronary CT at each national university of our country is shown in Figs. 6 and 7. The diagnostic reference level is set at the 75th percentile of the dose distribution from a survey conducted across a broad user base in Japan. As shown in the figures, the exposure dose differs markedly among institutions. The optimization of an exposure dose should be considered at some institutions. In cooperation with Japan Network for Research and Information on Medical Exposures (J-RIME), which is aiming to standardize radiation exposure across large-scale imaging systems, new evidence could be obtained.

At this time, hardware and software which is necessary for DIR has been introduced. Analysis will be started as soon as J-MID data is accumulated.

# Proper quantitation of medical imaging data based on the establishment of Japan Quantitative Imaging Biomarker Alliance: J-QIBA)

An imaging biomarker is an indicator that can express disorders noninvasively and quantitatively. Many researchers have undertaken clinical studies, and various useful biomarkers have been reported globally. However, due to differences in medical
equipment, scanning protocols and calculation methods, it is difficult to make direct comparisons of imaging biomarkers obtained at different institutions. This has been an unsolved problem worldwide. In this project the standardization of quantitative imaging biomarkers will be attempted based on imaging information of J-MID. A platform for advancing accuracy and standardizing imaging biomarkers will be structured so that they do not differ among various vendors and equipment.

Currently, as J-QIBA, we are trying standardization of diffusion tensor image; visualization of nerve fiber tract, MR elastography; evaluation of liver fibrosis, and T1 / T2 value measurement, etc. In the future we will expand this activity widely. By standardizing images, we can build high-quality J-MID in the future and may lead to development of more accurate diagnostic imaging support system using artificial intelligence.

# Unification of diagnostic reports

Not only imaging data but also diagnostic reports will be collected, as much as possible, by J-MID. This will enable us to compare new data with a large dataset of previous images and reports at individual institutions in daily practice. By integration with the database of pathological imaging and reports we will be able to share rare cases, contributing to the education of radiologists and the improvement in their diagnostic performance. In the future, part of this database could also be utilized to fine-tune the JRS registration system and evaluate medical treatment fees and hospital evaluation systems, etc.

Now, we are constructing a system that sends diagnostic CT reports from report server in each collaborating facility to the J-MID server after anonymizing. We plan to start structuring the report in the future, for the development of diagnostic imaging support system using artificial intelligence, described later.

# Clinical application of artificial intelligence (A.I.)

Diagnostic imaging support using A.I. has been improving, and the technology for differentiating and classifying extreme variations in imaging by deep machine learning has recently been established. In this project, an automatic diagnosis system based on deep learning will be constructed using accurate annotation including the kind of diagnostic imaging, the site of disease, the final diagnosis and other medical data (findings and diagnostic information, etc.). Various new applications or services could develop by environmental management such as big imaging information that has perfect anonymity. Moreover, this environmental management will lead to the training of human talent for analytics in the field of diagnostic imaging.

Appropriate image data, teacher data, high-performance computer, and learning program are needed for the development of image diagnosis system using artificial intelligence. Now, we are preparing to start the development of diagnostic imaging support system using artificial intelligence, as soon as J-MID becomes available.
**Fig. 1:** The overall structure of "Japan Safe Radiology"

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Fig. 2: Design and development will be performed for the gateway system of a client, which can respond to every PACS maker

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**Fig. 3**: Computed Tomography scanners per million population

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Fig. 4: Magnetic Resonance Imaging units per million population

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**Table 1** Summary of diagnostic radiology parameters regarding CT and MRI

<table>
<thead>
<tr>
<th>Parameter</th>
<th>CT</th>
<th>MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of examinations</td>
<td>8,446,036</td>
<td>3,219,649</td>
</tr>
<tr>
<td>Total number of reports with scanned regions provided</td>
<td>8,763,915</td>
<td>3,833,420</td>
</tr>
<tr>
<td>Image interpretation rate</td>
<td>81.6 %</td>
<td>80.3 %</td>
</tr>
<tr>
<td>Number of interpretation reports from full-time diagnostic radiologists</td>
<td>6,814,230</td>
<td>2,938,461</td>
</tr>
<tr>
<td>Number of current interpretation reports per day per one diagnostic radiologist</td>
<td>15.99</td>
<td>6.89</td>
</tr>
<tr>
<td>Average work period of full-time diagnostic radiologists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time spent on image interpretation</td>
<td>24.11 h/week</td>
<td></td>
</tr>
<tr>
<td>Number of interpretation reports per day per diagnostic radiologist within 1 hospital day (8 h)</td>
<td>13.92</td>
<td>6.00</td>
</tr>
<tr>
<td>Number of interpretation reports per day per diagnostic radiologist within 1 hospital day if all the working hours are designated to interpretation</td>
<td>26.5</td>
<td>11.4</td>
</tr>
<tr>
<td>Number of full-time diagnostic radiologists required to complete all CT and MRI interpretation reports in our survey</td>
<td>2,605.1 (1.49 times)</td>
<td></td>
</tr>
<tr>
<td>Total number of examinations in September 2011 in Japan</td>
<td>2,357,580</td>
<td>1,121,831</td>
</tr>
<tr>
<td>Estimated number of examinations with scanned regions considered per day in Japan (in 2011)</td>
<td>122,316</td>
<td>66,784</td>
</tr>
<tr>
<td>Number of diagnostic radiologists registered in 2011</td>
<td>4551</td>
<td></td>
</tr>
<tr>
<td>Number of full-time diagnostic radiologists required to complete all CT and MRI interpretation reports in Japan</td>
<td>9,503 (2.09 times)</td>
<td></td>
</tr>
</tbody>
</table>

Data in parentheses are ratios of full-time diagnostic radiologists required to current full-time diagnostic radiologists.


**Fig. 5**: Summary of diagnostic radiology parameters regarding CT and MRI

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Fig. 6: CTDI volume of coronary CT

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Fig. 7: DLP of coronary CT

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Conclusion and recommendations

In this presentation we have outlined a future view of "Japan Safe Radiology". We have clarified the problems that Japan faces with advanced medical imaging at the present time and have started to address them by imagining the establishment of a new system for diagnostic imaging. Various hurdles remain. However, our aim is to use cutting-edge data processing systems to develop a system in Japan that can serve as a model for other countries worldwide.
Personal/organisational information

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