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The 5th Dynamic Digital Radiography Seminar

Date and time : 13:00 to 17:00, Saturday, June 17, 2023

Venue : Online

CONTENTS

KONICA MINOLTA JAPAN, INC.

Overview

Konica Minolta, Inc. held the 5th Dynamic Digital Radiography Seminar online on Saturday, June 17, 2023. Dynamic X-ray images are moving images obtained by using a digital X-ray dynamic imaging system (Dynamic Digital Radiography: DDR) developed by Konica Minolta, Inc. This system captures moving images in combination with an X-ray equipment for diagnosis "RADspeed Pro" (by Shimadzu Corporation) or with a portable X-ray imaging system for round visits "AeroDR TX m01" released in March 2022 and a cassette-type digital X-ray imaging device "AeroDR fine motion" (both manufactured by Konica Minolta) and performs analytical processing on the X-ray video analysis workstation "KINOSIS" enabling visualization and quantification of movements and extraction of changes in signal values associated with movements.

In the seminar, Mr. Kazuhiro Kobayashi (Director, Healthcare Headquarters, Konica Minolta, Inc.) delivered an opening address and Mai Harada (Department of Modality, Healthcare Headquarters, Konica Minolta, Inc.) made a manufacturer's lecture, followed by lectures on various themes.

Part 1: Special Lecture

In Part 1, Dr. Yuzo Yamasaki (Department of Clinical Radiology, Graduate School of Medical Sciences, Kyushu University) gave a special lecture titled "Dynamic chest radiography for pulmonary vascular diseases: clinical applications and correlation with other imaging modalities." The chairperson was Dr. Haruhiko Kondoh (Director of Kyorin University Hospital). Dr. Yamasaki received the Cum Laude at the 108th Radiological Society of North America (RSNA 2022) and his lecture was based on that presentation.

Part 2: Research Reports

Then, research reports were presented in Part 2. The chairperson was Prof. Kei Takase (Diagnostic Radiology, Tohoku University School of Medicine). First, Dr. Yuri Kon (Department of Emergency and Critical Care Medicine, St. Marianna University School of Medicine) gave a lecture entitled "Actual Use of Dynamic Portable X-ray examination in Emergency Medical Treatment." Dr. Kon stated that in the emergency intensive care field, traveling for testing is high-risk and portable DDR that can be performed at the bedside is extremely useful. Next, Dr. Hiroaki Hiraiwa (Department of Cardiology, Nagoya University Graduate School of Medicine) gave a lecture entitled "An Attempt to Evaluate Cardiac Function and Hemodynamics in Heart Failure Patients using Dynamic Digital Radiography (DDR)." Dr. Hiraiwa reported that DDR has been shown to be useful in evaluating cardiac function and hemodynamics in patients with heart failure. At the end of Part 2, a video recording of a lecture by Thomas Simon FitzMaurice (Specialties Registrar in Respiratory Medicine, Liverpool Heart and Chest Hospital) entitled "Implementation of dynamic digital radiography in research and clinical practice: a UK perspective" was shown on clinical applications in the UK. The video introduced the Liverpool Heart and Chest Hospital, where he works, created a standard operating procedure (SOP) for DDR and incorporated it into the image diagnosis workflow, which resulted in increased requests from local clinicians.

Part 3: Clinical Reports

In Part 3, Dr. Atsuko Kurosaki (Department of Diagnostic Radiology, Fukujuji Hospital, Japan Anti-Tuberculosis Association) was invited as chairperson and clinical reports were presented. To begin, Dr. Shinsuke Uchida

(Department of General Thoracic Surgery, Juntendo University Hospital) gave a report titled "How to Apply Dynamic Imaging to Actual Clinical Practice - From the field of thoracic surgery practice," stating that DDR can evaluate pulmonary blood flow in addition to dynamic evaluation of pleurodesis and is expected to be a minimally invasive evaluation method for pulmonary embolism. Then, Mr. Tsuyoshi Okawa (Radiology, Medical Technology Department, Fujieda Municipal General Hospital at the same hospital) was present and gave a report on three topics regarding the application of dynamic imaging at the hospital. First, Dr. Toshinari Ema (Department of Respiratory Surgery at the same hospital) took to the podium and gave a lecture entitled "Experience in Using Chest Dynamic Imaging in the Field of Respiratory Surgery - Application to preoperative adhesion prediction and tumor site differentiation." Dr. Ema introduced that measurements of decreased diaphragm movement on the affected side obtained by DDR have been suggested to be helpful in predicting pleurodesis. Next, Dr. Shigeya Suzuki (Department of Orthopedic Surgery at the same hospital) presented a case in which a treatment plan was decided based on DDR for wrist pain examination and a good postoperative course was achieved under the title "Clinical Application of DDR in Wrist Joint Diseases." Finally, Ms. Eriko Sato (Radiology, Medical Technology Department at the same hospital) gave a report entitled "Wrist X-ray Dynamic Imaging at Fujieda Municipal General Hospital," in which she discussed the examination of DDR imaging conditions in the field of orthopedics.

Part 4: Review and Executive Remarks

Following the above lectures, a review was held in Part 4. Prof. Terumitsu Hasebe (Department of Radiology, Tokai University School of Medicine) served as the chairperson and in addition to the three chairpersons of Parts 1 to 3, Dr. Shoji Kudoh (Representative Director, Japan Anti-Tuberculosis Association), Dr. Yoshikazu Inoue (Consultant, Osaka Fukujuji Hospital, Osaka Anti-Tuberculosis Association), Dr. Yasuhiro Gon (Professor, Division of Respiratory Medicine, Department of Internal Medicine, Nihon University), Dr. Rie Tanaka (Associate professor, College of Medical, Pharmaceutical and Health Sciences, Kanazawa University) and Mr. Ryotaro Yuji (Radiological Technology Division, Department of Clinical Technology, Tokai University Hachioji Hospital) mounted the podium. At this seminar, Dr. Takase praised DDR for its greater potential in response to reports on the spread of DDR in other countries. Also, Dr. Kondoh expressed hope that feedback from portable imaging cases will help eliminate pitfalls. Furthermore, although this was the first time that specific clinical reports in the field of orthopedics were presented, Dr. Kurosaki stated that he would like to accumulate cases in the field of orthopedics through "DDRAtlas," a digital case collection of DDR, which he also supervises. Moreover, as Dr. Hiraiwa indicated in Part 2, Dr. Gon expressed his hope that DDR would be applied clinically as a simpler testing method. On the other hand, from the perspective of a medical radiologic technologist, Mr. Yuji pointed out the need for standardization of imaging procedures that take into account the balance between exposure dose and reproducibility and Dr. Tanaka introduced a user group that disseminates and shares information about DDR.

Finally, Dr. Inoue and Dr. Kudoh gave executive remarks to conclude the seminar.

Dynamic chest radiography for pulmonary vascular diseases: clinical applications and correlation with other imaging modalities

Yuzo Yamasaki, MD, PhD Department of Clinical Radiology, Graduate School of Medical Sciences, Kyushu University

Dynamic chest radiography (DCR) is a functional image of the lungs taken using an FPD and has become possible with the advent of large-field FPDs, improved detector sensitivity and advances in computer analysis and image processing techniques. The speaker presented an abstract on the topic of DCR at the 2022 Radiological Society of North America educational exhibit and was awarded the Cum Laude. This presentation will provide an overview of the award-winning abstract.

Pulmonary Blood Flow Evaluation by DCR

DCR is a technique for generating X-ray dynamic images consisting of a series of chest X-ray images using a pulsed X-ray generator and an FPD. The images can be taken in a general radiography room and by analyzing the acquired sequential images with the "KINOSIS" X-ray motion picture analysis workstation, a pulmonary blood flow image (perfusion image) can be created. Ventilation images can also be created by taking images while breathing. From now on, pulmonary blood flow images will be introduced in particular.

Modalities that can assess pulmonary blood flow include CT pulmonary angiography, pulmonary blood flow scintigraphy, MRA and angiography. DCR is less invasive than these, has no contraindications and has the major advantages of being able to be performed in a short time, at low cost and with low radiation exposure. In addition, DCR can be carried out either in recumbent or upright position and especially in the upright position, it is possible to obtain physiological information that cannot be obtained with other diagnostic imaging techniques.

There are two types of pulmonary blood flow images obtained by DCR: cross-correlation method ("PH1-MODE" in KINOSIS) and reference frame subtraction method ("PH2-MODE" in KINOSIS). The latter allows semi-quantitative evaluation of regional pulmonary blood flow as in pulmonary blood flow scintigraphy.

In the evaluation of pulmonary blood flow by DCR, we read a plain chest radiograph followed by pulmonary perfusion imaging and consider blood flow abnormalities when abnormalities are observed only in pulmonary blood flow images. It is important to evaluate pulmonary blood flow images together with plain chest radiographs because atel-

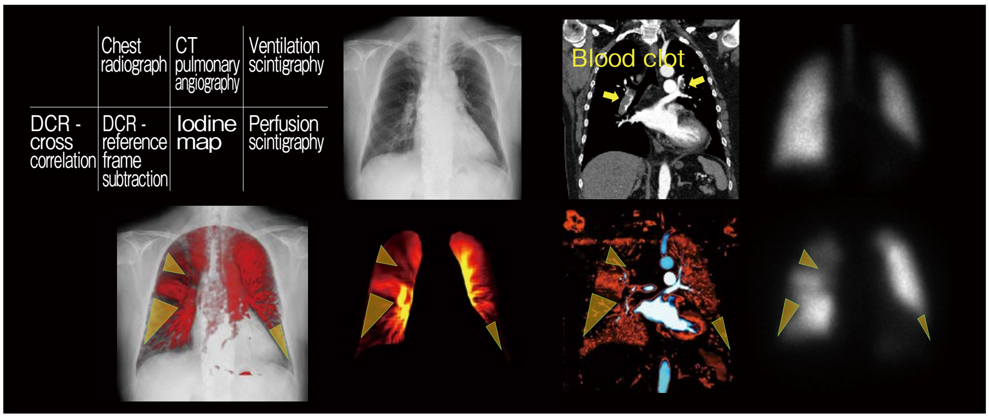

Fig.1 Case 1: Acute pulmonary thromboembolism
(Reproduced from reference 1)

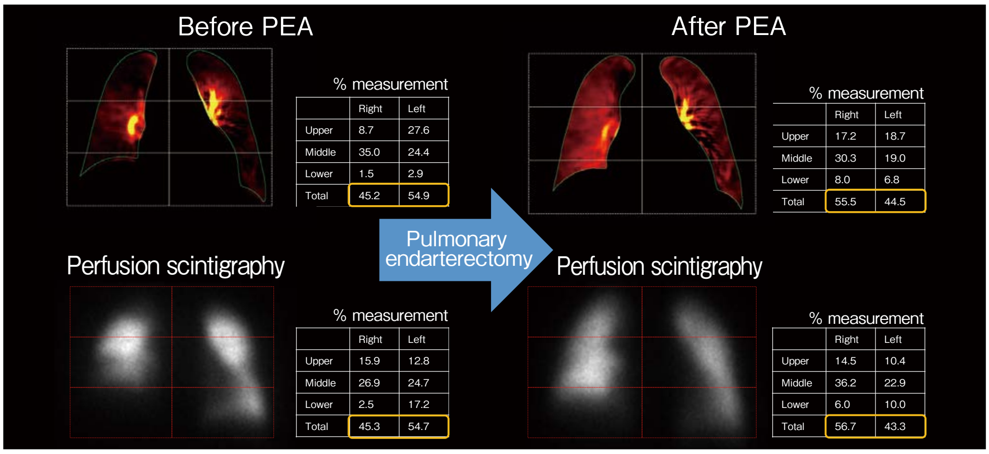

Fig.2: Case 2: Chronic thromboembolic pulmonary hypertension
(Reproduced from reference 3)

ectasis and pleural effusion may be mistaken for blood flow defects on pulmonary blood flow images.

Case Presentation

・**Case 1 (Acute pulmonary thromboembolism):** In acute pulmonary thromboembolism, wedge-shaped defects are seen on DCR as well as on iodine maps and pulmonary perfusion scintigraphy[1] **(Fig.1).** DCR may be effective in cases where contrast agents are contraindicated or at night when other modalities cannot be used, because it is noninvasive and easy to perform.

・**Case 2 (Chronic thromboembolic pulmonary hypertension: CTEPH):** Pulmonary hypertension can be classified into 5 groups, but only pulmonary hypertension due to impaired blood flow such as CTEPH differs from the other groups in that numerous wedge-shaped defects are seen in both lungs on imaging. Although pulmonary ventilation/blood flow (V/Q) scintigraphy is recommended for exclusion diagnosis of CTEPH in suspected cases of pulmonary hypertension, we thought that DCR could be a substitute for V/Q scintigraphy and conducted a study at our hospital[2]. The sensitivity, specificity and accuracy for differentiating CTEPH from non-CTEPH were 100%, 86% and 94%, and 97%, 86% and 92% for V/Q scintigraphy and DCR respectively, indicating that DCR had a diagnostic performance almost equal to that of V/Q scintigraphy. In the postoperative evaluation of CTEPH, DCR can be used to evaluate the restoration of blood flow, etc.[3] **(Fig.2)**

・**Case 3 (Pulmonary hypertension):** The changes in blood flow distribution can be evaluated by comparing the upright and recumbent positions in the DCR. In the control group, blood flow increased and decreased in the upper and lower lung fields respectively after shifting from the upright to recumbent position. On the other hand, in patients with pulmonary hypertension, blood flow decreased and increased in the upper and lower lung fields respectively.

・**Case 4 (Case of left pulmonary artery stenosis after stent placement):** Because pulmonary artery stenosis can occur in adult patients with congenital heart disease, MRI and pulmonary perfusion scintigraphy are used to evaluate abnormalities in left and right pulmonary blood flow distribution, but DCR can also be used for that evaluation. Case 4 is a patient of left pulmonary artery stenosis after stent placement and quantitative evaluation by DCR can confirm that blood flow has improved after the procedure[4].

Summary

DCR provides images similar to CT pulmonary angiography, pulmonary blood flow scintigraphy and angiography and is expected to be applied to a variety of pulmonary blood flow diseases in the future.

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Actual Use of Dynamic Portable X-ray examination in Emergency Medicine

Yuri Kon, MD Department of Emergency and Critical Care Medicine, St. Marianna University School of Medicine

With the introduction of dynamic chest radiography (DCR), plain radiographs which were previously still images can now be displayed as moving images. In addition, various types of analysis are now possible using the "KINOSIS" X-ray motion picture analysis workstation. Furthermore, recently, DCR has become possible at the bedside using portable X-ray imaging equipment and its use is expected to expand in the field of emergency intensive care. In this lecture, I will report our experience in using DCR with portable X-ray equipment in emergency medical care.

Case Presentation

Case 1 is a patient of acute respiratory distress syndrome caused by novel coronavirus pneumonia. Plain radiographs and CT images on arrival at the hospital showed extensive ground-glass opacity and the patient's respiratory condition deteriorated rapidly even after tracheal intubation. Although lung movement was observed on dynamic imaging, PL-MODE, which visualizes density changes in the lung fields accompanying respiration, showed poor signal changes in the bilateral middle lung fields and the medial side of the right lower lung field. So, we performed prone position therapy. After prone therapy, the signal spread to the relatively peripheral lung fields was observed and blood gas (pCO_2) values was also improved **(Fig.1)**. Thus, if the pathophysiology can be clarified by analysis of DCR and KINOSIS, it will be a major indicator of ventilatory therapy for severe respiratory failure.

Case 2 was a patient with severe sepsis due to pneumonia and because cardiac contractions were almost nonexistent, the VA-ECMO, extracorporeal membrane oxygenation (ECMO) that assists cardiac function, was placed in the patient. Comparison of the changes in cardiac ROI signal values on dynamic images on Day 1 and on Day 6 when VA-ECMO was withdrawn showed that the changes were larger and more consistent with heart rate on Day 6 **(Fig.2)**. So, we can expect that changes in cardiac signal values can be used as an indicator of cardi-

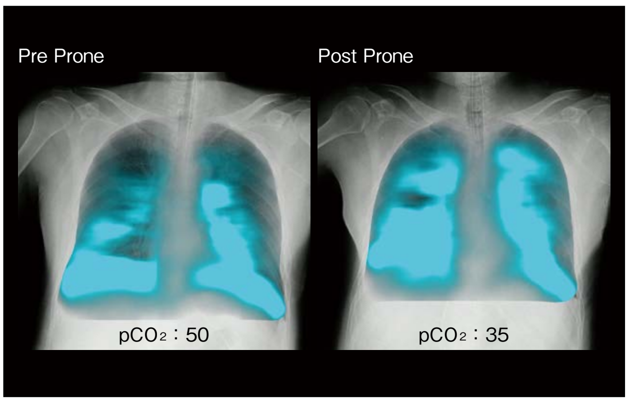

Fig.1 Case 1: Acute respiratory distress syndrome

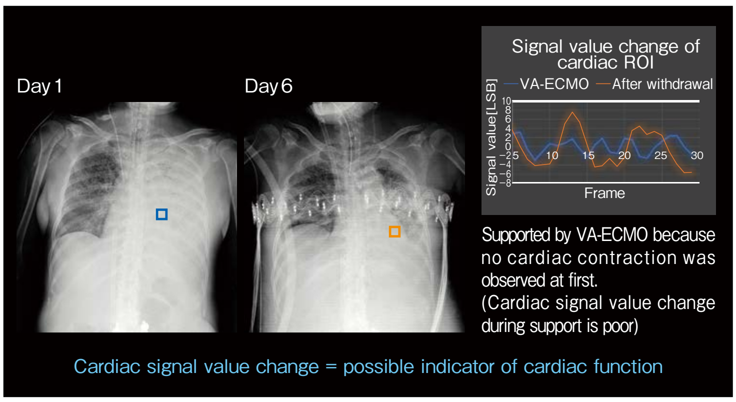

Fig.2 Case 2: Signal value change of cardiac ROI in a case of severe sepsis due to pneumonia

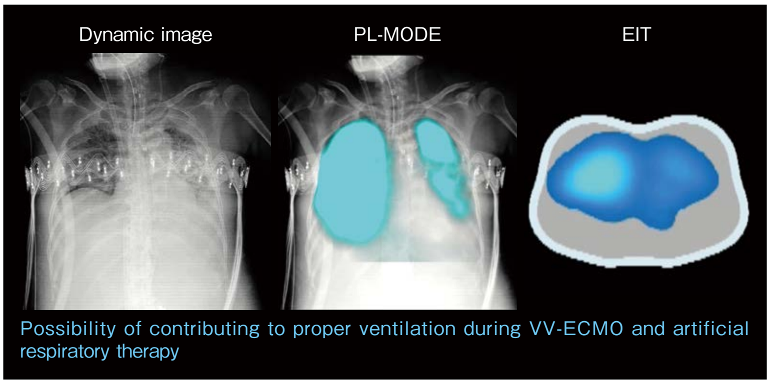

Fig.3 Case 2: PL-MODE image during VV-ECMO

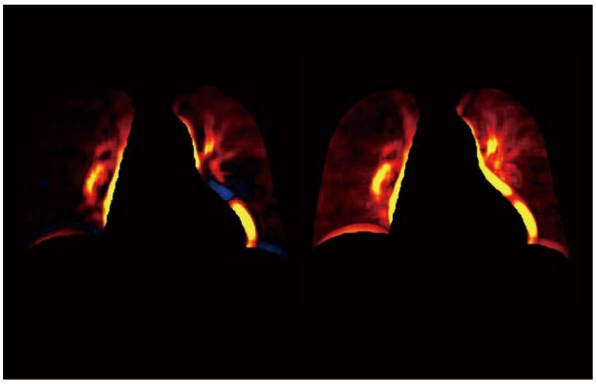

Fig.4 Case 3: Pulmonary embolism

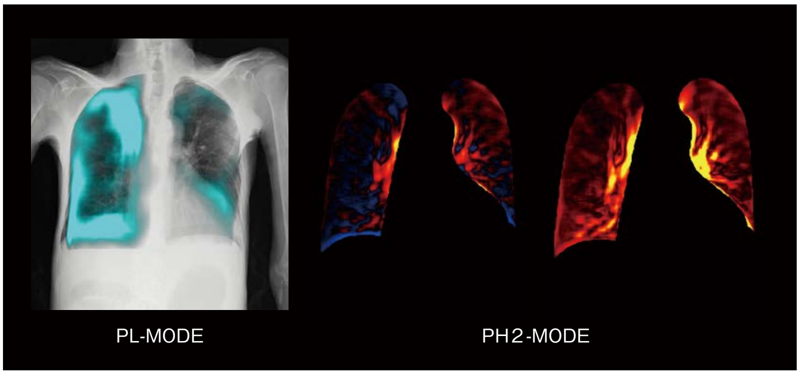

Fig.5 Case 4: Emphysema

ac function. In addition, because this patient had severe pneumonia, VV-ECMO, which assists pulmonary function, was placed after VA-ECMO. The PL-MODE image of DCR showed a decrease in signal value in the left lung field (**Fig.3**). So, respiratory therapy was continued with a focus on the left side. PL-MODE may replace electrical impedance tomography (EIT) that images regional ventilation distribution in the lungs and may contribute to proper ventilation during VV-ECMO and artificial respiratory therapy.

Case 3 is a patient with a pulmonary embolism (PE) in which DCR was performed with breath-holding. PH2-MODE, which visualizes blood flow in the lung fields, showed signal deficits in the right lower middle and left lower lung fields (**Fig.4**). The usefulness of PH2-MODE in DCR with breath hold for the diagnosis of PE has already been reported in a paper 1). Additionally, since PH 2-MODE is also useful for excluding PE, it may be applicable to PE rule-out in emergency situations. Furthermore, Westermark's sign, which is difficult to assess with general radiography, can be clarified on DCR and KINOSIS analysis images under free breathing and thus PE can be excluded or detected even in patients in poor condition who cannot hold their breath.

Case 4 is a patient of severe emphysema. In emphysema patients, the lung fields become overinflated and lack movement, resulting in a decreased signal value in PL-MODE. Also, PH2-MODE extracts changes caused by peripheral vascular narrowing due to emphysema, resulting in a lower signal value (**Fig.5**). In differentiating PE from pulmonary emphysema, a decrease in signal value that is not consistent with vascular dominance can be judged as emphysema, however it is required to compositely evaluate the patient's medical history, echocardiographic findings and other factors.

Summary

In the field of emergency intensive care, moving a critically ill patient for examination is hazardous and poses a great risk. DCR with a portable radiography system allows not only morphological but also functional evaluation by observing movement at bedside and is expected to become a very important examination tool in the future.

●References

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An Attempt to Evaluate Cardiac Function and Hemodynamics in Heart Failure Patients using Dynamic Digital Radiography (DDR)

Hiroaki Hiraiwa Department of Cardiology, Nagoya University Graduate School of Medicine

Invasive right heart catheterization (RHC) is necessary for accurate assessment of cardiac function and hemodynamics in patients with heart failure. In recent years, however, dynamic digital radiography (DDR) has come to be utilized as a minimally invasive, real-time modality that can evaluate pulmonary ventilation and blood flow. Although DDR is expected to become a new minimally invasive hemodynamic evaluation method for heart failure patients, there have been no studies using DDR in heart failure patients. Therefore, we examined the correlation between hemodynamic parameters measured by RHC and imaging parameters measured by DDR to determine whether DDR is a new hemodynamic evaluation method for heart failure patients.[1]

Discussion of hemodynamic evaluation by DDR[1]

1. Purpose and Methods

We investigated whether hemodynamic parameters based on RHC can be estimated using DDR in heart failure patients. Twenty hemodynamically stable heart failure patients underwent RHC and DDR on the same day. DDR was performed in the upright and recumbent positions and patients with pacemakers, implantable cardioverter-defibrillators, or other implants indwelled and patients with breath-holding difficulties were excluded.

DDR is versatile and inexpensive because it can use existing general radiography equipment. Continuous imaging at 15 fps is performed and a 7-second breath holding is required for each imaging session. The average exposure dose per exposure is approximately 0.8 mGy, so the total dose for plain frontal and lateral chest X-rays is lower than the total dose.

In this study, five ROIs were set at the aortic arch, right pulmonary artery main trunk, left main pulmonary artery trunk, right atrium and left ventricular apex and changes in pixel values were measured **(Fig.1)**. The average pixel value of each ROI was measured in all frames and a

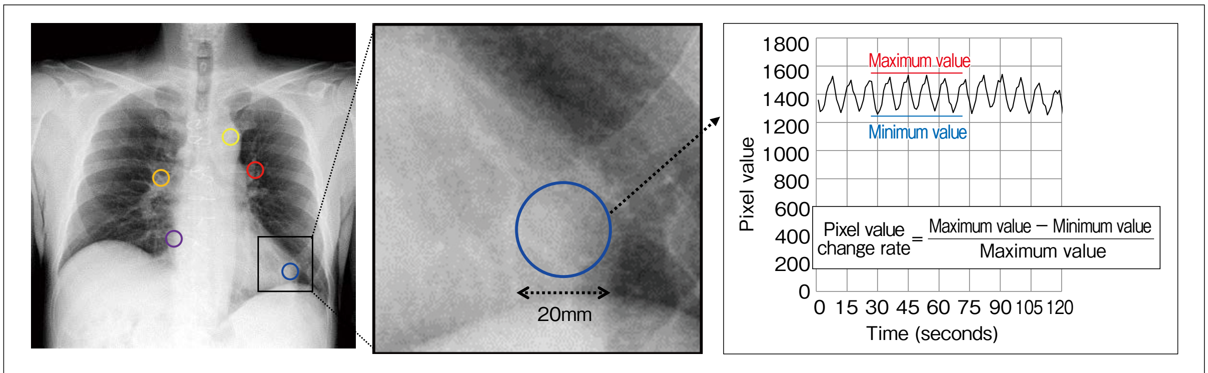

Fig.1 ROI position and pixel value waveform in DDR image

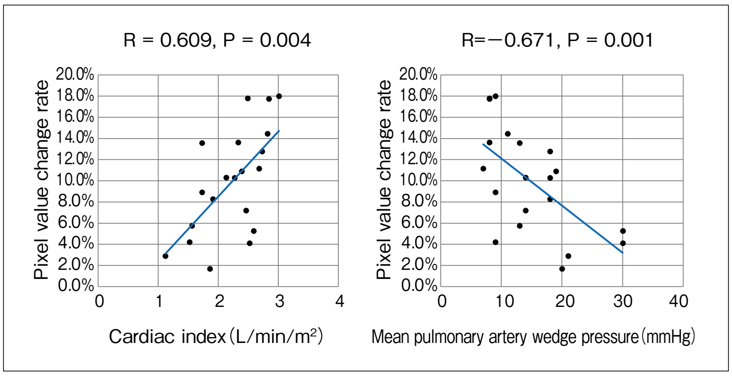

Fig.2 Correlation between pixel value change rate and hemodynamic parameters in apex ROI (recumbent position)

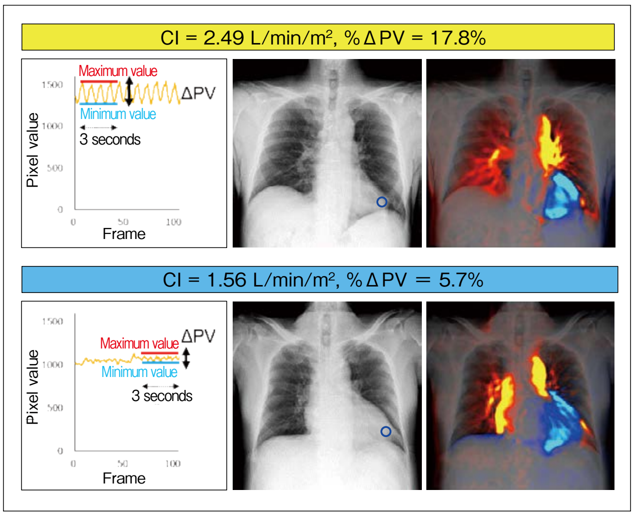

Fig.3 Identification of patients with low cardiac output using pixel value change rate in apical ROI.

frame interval of 3 seconds was selected to minimize the difference between the maximum and minimum pixel values in the waveform. The ratio of the pixel value change to the maximum pixel value was defined as the pixel value change rate and calculated.

2. Patient background

The median age was 67 years and 17 of the 20 patients were male. Most of the patients had NYHA classification I or II, 30% of the causes of heart failure were ischemic cardiomyopathy and basic drugs for the treatment of heart failure had been introduced in more than half of the cases. The median of brain natriuretic peptide, a biomarker for heart failure, was 209.9 pg/mL. On echocardiography, the median left ventricular ejection fraction was as low as 38%. RHC showed mean right atrial pressure: 6 mmHg, mean pulmonary artery wedge pressure: 14 mmHg and cardiac index: 2.36 L/min/m^2.

3. Results

Looking at the correlation between pixel values and hemodynamic parameters in the upright position for the five ROIs, we found that the pixel value change rate in the apex ROI had a significant positive or negative correlation with hemodynamic parameters. A similar trend was observed in the recumbent position, with a stronger correlation than in the upright position. **Fig.2** shows a correlation diagram in the recumbent position.

The results of ROC analysis showed that heart failure patients with low cardiac output could be identified by setting the cutoff value of the pixel value change rate in the apex ROI to 10.6% (AUC: 0.792, sensitivity: 0.875, specificity: 0.667, P=0.031).

The upper row in **Fig.3** shows a DDR image of a heart failure patient with cardiac output maintained, and the lower row shows a DDR image of a heart failure patient with low cardiac output respectively.

4. Discussion

We considered the mechanism by which the pixel value change rate in the apical ROI reflects cardiac output. It was inferred that the apex of the heart overlaps less with surrounding structures than ROIs of other regions and may be less affected by this. As a result, it was considered that the pixel value change rate in the apical ROI may reflect temporal changes in blood volume (cardiac output).

5. Conclusion

DDR is simpler and less invasive than RHC and may be useful in evaluating cardiac function and hemodynamics in heart failure.

Summary

Further development of DDR is expected as a new imaging modality that can comprehensively assess cardiac function and hemodynamics. We would like to aim for clinical applications that are useful in heart failure treatment, such as the construction of versatile hemodynamic prediction models and prognosis prediction models using DDR.

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Implementation of dynamic digital radiography in research and clinical practice: a UK perspective

Thomas Simon FitzMaurice Specialties Registrar in Respiratory Medicine, Liverpool Heart and Chest Hospital

Approximately four years have passed since we introduced dynamic digital radiography (DDR) at our hospital located in Liverpool, UK. In this lecture, I will introduce the background to the introduction of DDR at our hospital and our clinical research efforts aimed at expanding its clinical application.

Introducing DDR into Clinical Workflow

At our hospital, we use an overhead traveling X-ray equipment to take images. DDR is highly versatile, and our hospital primarily uses it for diagnosing and evaluating phrenic nerve paralysis and dysfunction (**Fig.1**). DDR can graph the movement of the diaphragm and quantify the degree of dysfunction. In addition to lower radiation exposure compared to fluoroscopy, it allows rapid and realistic imaging based on actual clinical situations[1)] and in a patient with suspected sequelae of COVID-19, imaging was possible with a drainage tube connected to the intercostal space[2)].

We reported the cases of DDR at the in-hospital radiology and respiratory disease department meetings and created a standard operating procedure (SOP) for the evaluation of phrenic nerve palsy. SOP can be linked with PACS and image diagnosis workflow, making it easy to incorporate DDR into clinical workflow and the number of requests for DDR from clinicians is increasing.

Clinical Research Aimed at Expanding the Field of DDR

At our hospital, we are conducting clinical research with the aim of applying DDR to diseases other than phrenic nerve paralysis[3)]. One of these is the investigation of cystic fibrosis. Cystic fibrosis often causes worsening of chest symptoms and decreased lung function, but it is difficult to measure with standard tests such as spirometry and there are concerns that actual physiological changes may not be reflected. The results of DDR measurements of changes in pulmonary function before and after treatment for exacerbations showed improvement in pulmonary function, including an increase in diaphragm contrac-

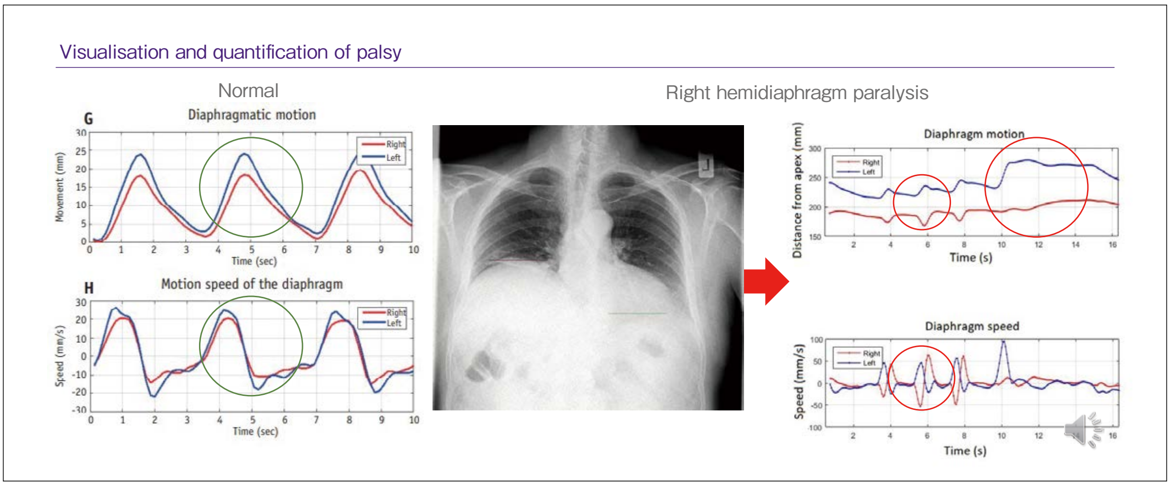

Fig.1 Evaluation of phrenic nerve paralysis and dysfunction using DDR (cited from reference 1)

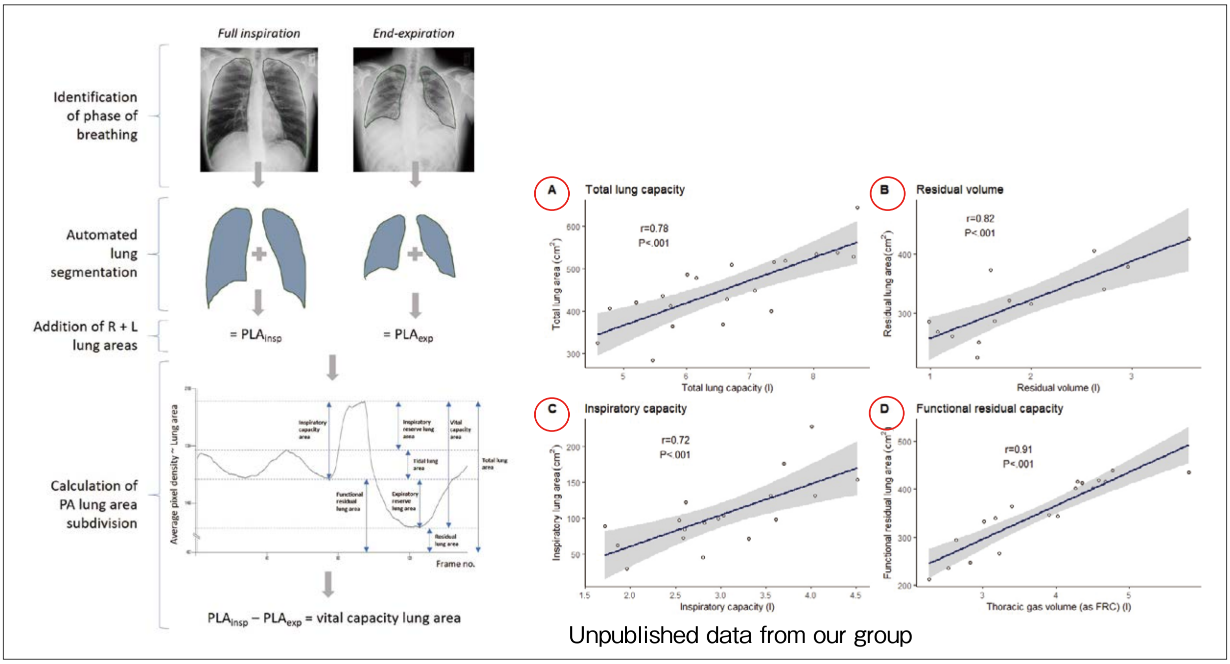

Fig.2 Comparison of PLA measurements by DDR and plethysmography (cited from reference 6)

tion during deep breathing and a decrease in projected lung areas (PLA) at end-expiration[4]. Similar results were obtained after treatment with a cystic fibrosis transmembrane conductance regulator (CFTR) modulator in patients with bronchiectasis, indicating that DDR can measure the reduction of inflammation and restoration effect on lung physiological function[5]. The results also suggested an association between body mass index (BMI) and changes in PLA at full inspiration/end-expiration.

Furthermore, we measured PLA at different respiratory phases by DDR and verified the correlation between the lung volumes and plethysmographic measurements. In a study of 20 patients with cystic fibrosis, significant correlations were found between PLA measurements by DDR and plethysmographic measurements such as total lung capacity (TLC), residual volume (RV), inspiratory capacity (IC) and functional residual capacity (FRC) [6] **(Fig.2)**.

We also studied evaluations such as bronchoscopic lung volume reduction (BLVR), where DDR visualized reduced PLA and the position of the diaphragm during the phase of expiration confirming improved thoracic cavity movement[7]. These measurements are useful in predicting prognosis and DDR has advantages in terms of cost and speed, making it a potential alternative to plethysmography and CT. Furthermore, the lateral view of the airway by DDR also visualizes large airway collapse, suggesting that invasive procedures such as CT imaging or bronchoscopy may be unnecessary[8].

Summary

DDR allows functional and physiological evaluation using many indexes such as diaphragmatic motion, ventilation and perfusion. Although there are issues with comparison to conventional methods and insufficient data on healthy people, we would like to work on verification for further practical application. Particularly in acute stages such as emergency and intensive care, DDR is useful in terms of simplicity and wide applicability and has the potential to lead to more efficient workflow. To promote the clinical application of DDR, it is necessary to conduct larger and more diverse patient cohorts, set reference values and publish in academic journals.

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How to Apply Dynamic Imaging to Actual Clinical Practice

- From the field of thoracic surgery practice-

Shinsuke Uchida Department of General Thoracic Surgery, Juntendo University Hospital

A plain chest X-ray is an essential test in respiratory surgery practice, but chest dynamic digital radiography (hereinafter referred to as "DDR") is also useful for tumor evaluation by observing the motion of lesions associated with breathing. Information obtained from still images such as the maximum inspiratory and expiratory phase is limited. However, dynamic imaging can capture dynamic images of the breathing cycle and can be performed in any position such as upright, sitting, or recumbent. The exposure dose for DDR is about 1.7 mGy, compared to 1.9 mGy for simple chest radiography (frontal/lateral). Furthermore, it has been reported that DDR has a good correlation with contrast-enhanced CT and pulmonary perfusion scintigraphy in the evaluation of pulmonary blood flow. In this lecture, I will discuss the clinical application of dynamic imaging technology in thoracic surgery.

Clinical Application of Dynamic Imaging in Respiratory Surgery

We introduced dynamic imaging in 2022 and have used it mainly for evaluation of pleural adhesion, qualitative evaluation of tumor invasion, quantification of diaphragmatic movement before and after surgery and evaluation of its time-course change and verification of pulmonary embolism by visualizing postoperative pulmonary vascular blood flow. Actual cases are presented below:

1. Evaluation of pleural adhesion

Case 1 is a patient of total intrathoracic adhesion. Chest CT showed significant bronchiectasis and organizing pneumonia in the left upper lobe of the lung. In dynamic imaging, the narrowing of the left thorax and decreased diaphragmatic movement were clearly visible on LM-MODE, which displays the excursion of each region in the lung fields accompanying with respiration in vector and color **(Fig.1).**

Since surgery for total intrathoracic adhesions requires dissection of adhesions, which increases operative duration and intraoperative blood loss, it is useful to predict intrathoracic adhesions preoperatively by dynamic imaging. In fact, there have been reports on the prediction of intrathoracic adhesions by dynamic imaging [1].

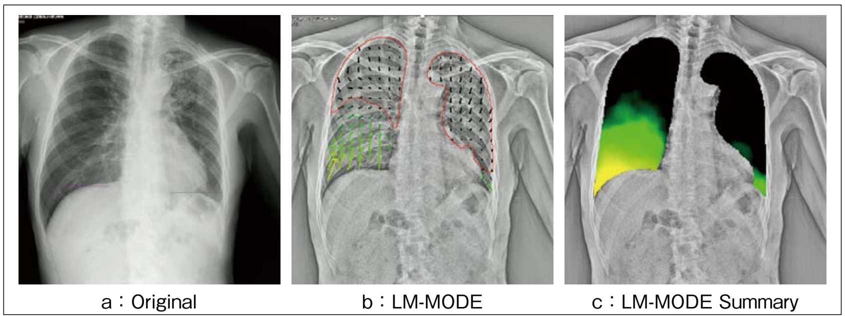

Fig.1 Case 1: Total adhesion in the thoracic cavity

Fig.2 Case 2: Chest wall invasive lung cancer

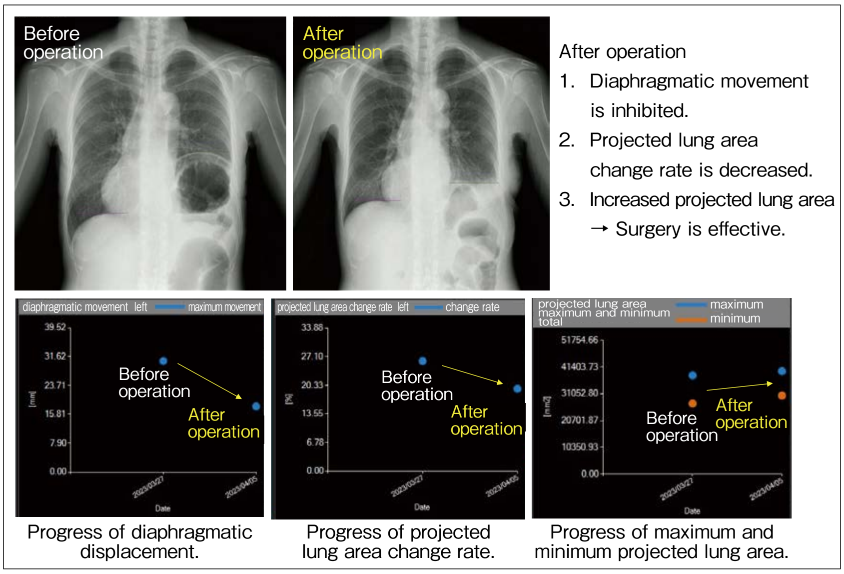

Fig.3 Case 3: Diaphragmatic relaxation

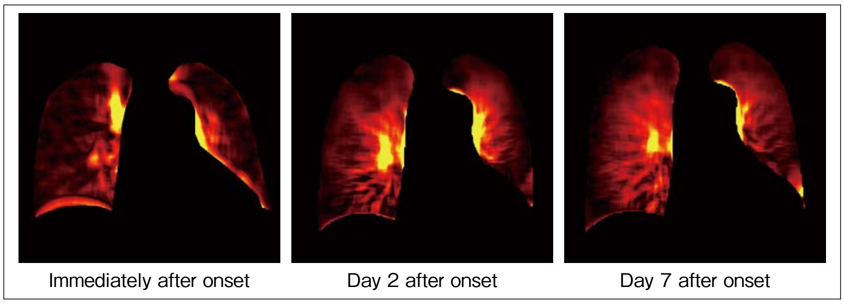

Fig.4 Case 4: Pulmonary embolism

2. Qualitative evaluation of tumor invasion

Case 2 is a patient of chest wall invasive lung cancer, in which CT showed a solid mass with a maximum diameter of 80 mm directly invading the second, third and fourth ribs of the left upper lung lobe. LM-MODE for preoperative DDR showed no vector movement in the area coinciding with the mass, suggesting adhesion or invasion into the surrounding tissue **(Fig.2)**. Surgery also showed invasion into the ribs and a combined rib resection was performed. Dynamic imaging is also useful in the evaluation of chest wall involvement.

3. Quantification of pre- and postoperative diaphragmatic movements and evaluation of time-course change

Case 3 is a patient of diaphragmatic relaxation. After surgery for an anterior mediastinal tumor, a left diaphragmatic nerve palsy was observed and the patient's abdominal symptoms worsened over a long period of time, so surgery was indicated. CT follow-up pointed out elevation of the left diaphragm and relaxation of the diaphragm. LM-MODE for preoperative DDR pointed out paradoxical motion of the left diaphragm during inspiration. The patient underwent diaphragm plication and comparison of pre- and postoperative DDR and graphs quantifying the movement of the structures pointed out that the displacement of the diaphragm was suppressed, the rate of change of lung field area decreased and the maximum and minimum projected lung areas increased after surgery, confirming the effectiveness of the surgery **(Fig.3)**.

4. Verification of pulmonary embolism by visualizing postoperative pulmonary vascular blood flow

Case 4 is a patient with postoperative pulmonary embolism. After left lower lobectomy and mediastinal lymph node dissection for lung cancer, the patient developed coldness, sensation of dyspnea and hypoxemia on Day 1 after operation. Contrast-enhanced CT pointed out multiple sporadic pulmonary emboli on both sides of the lungs. Anticoagulation therapy was started, and DDR was performed immediately after onset, on Day 2 and Day 7. When visualizing the blood flow in the lung field by PH2-MODE, the black spots indicating decreased blood flow improved over time. Contrast-enhanced CT taken on Day 7 also showed that the thrombus had almost disappeared.

There is a report that the blood flow evaluation images by pulmonary blood flow scintigraphy, cardiac catheterization test and DDR match in patients with chronic pulmonary hypertension [2], suggesting that DDR may be useful for evaluating pulmonary emboli.

Summary

It is supposed that DDR is useful in the field of thoracic surgery because it is minimally invasive with low radiation exposure and provides more information than conventional methods. In addition to dynamic evaluation, DDR is capable of blood flow evaluation, so it is expected to be a minimally invasive method for evaluating pulmonary embolism and other conditions.

●References

1) Tanaka, R., et al., *J. Appl. Clin. Med. Phys.*, 24(7): e14036, 2023.
2) Yamazaki, Y., et al., *Eur. Heart* J., 41(26): 2506, 2020.

Experience in Using Chest Dynamic Digital Radiography in the Field of Respiratory Surgery

- Application to preoperative adhesion prediction and tumor site differentiation-

Toshinari Ema Department of Respiratory Surgery, Fujieda Municipal General Hospital

Fujieda Municipal General Hospital is a core regional hospital with 564 beds and 35 departments. Dynamic digital radiography (DDR) has various uses and benefits in the field of respiratory surgery. In this presentation, I will report our experience in using DDR for prediction of pleural adhesions and differentiation of diseases.

Prediction of pleural adhesions

1. Visual Prediction

Prediction of severe pleural adhesions is an important factor in determining surgical technique and predicting operative duration. Open chest surgery and thoracoscopic surgery or robot-assisted surgery are often chosen when severe adhesions are present and not present respectively. In our respiratory surgery department, 74 chest DDRs were performed in 68 patients between June 2022 and March 2023. 13 out of 64 patients who underwent lung resection were found to have severe adhesions (Operative duration is extended by approximately 30 minutes or more due to synechiotomy or thoracoscopic surgery is difficult due to adhesions).

To visually predict the presence or absence of adhesion by DDR, we need to see how much the intrapulmonary structures such as nodules, masses (lesions) and peripheral blood vessels or minor fissure in right lung and thoracic wall, including dorsal ribs are displaced to one another due to breathing movement. If there is adhesion, the nodule or mass shadow and the rib shadow can be seen to move in the same way relative to each other without displacement. However, because the movement of the lung apex is relatively small, it may be difficult to predict adhesions based on the movement of the lesion when the lesion is located in the upper lung field.

In Case 1, a mass shadow with infiltrative shadow located in the right upper middle lung field (**Fig.1a**, the part surrounded by a circle) did not seem to move from the rib shadow on DDR image. So, we judged that they were adhered to each other and chose open chest surgery. Meanwhile, in FE-MODE, it was confirmed that the pulmonary blood vessels at the periphery of the middle and lower lung fields moved displaced with the ribs (**Fig. 1b**, the part surrounded by a circle), suggesting that there were few or no adhesions in that site. Surgical findings pointed out the extensive adhesions in the tumor site with only minimal adhesions in the middle and lower lobes.

Case 2 is a patient in which there was actually adhesion, although it was predicted preoperatively that

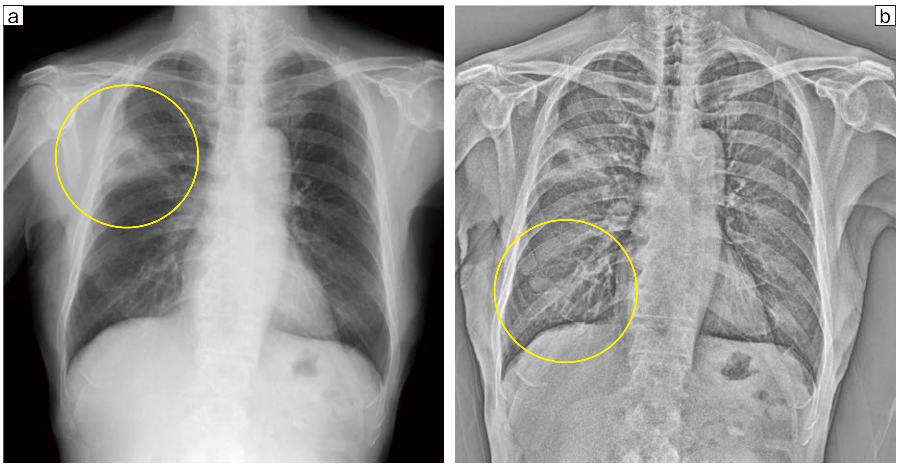

Fig.1 Case 1: with adhesions

Fig.2 Case 2: Difficult to predict adhesions.

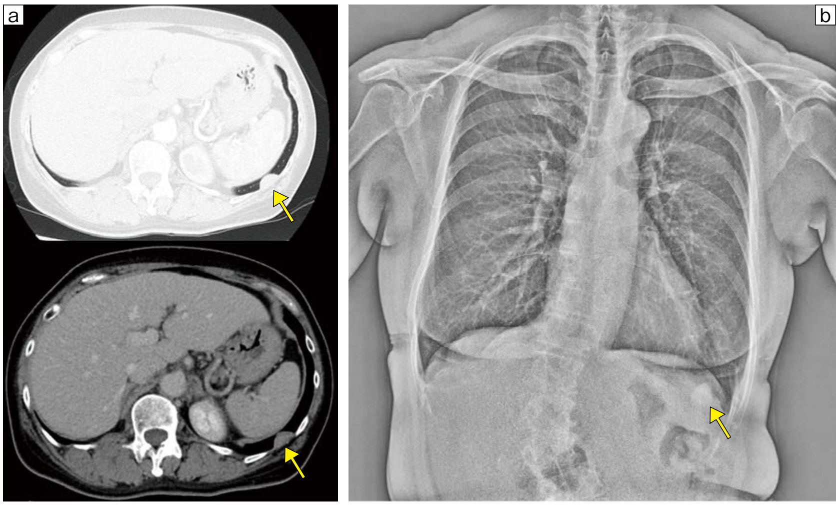

Fig.3 Case 3: A case that helped differentiate between diseases.

there would be no adhesion. On DDR image **(Fig.2)**, the nodules and five ribs in the right upper lung field were moving displaced with one another and also the vessels in the lung field moved well, so we concluded that there was no adhesion. Surgical findings showed no adhesions in the nodal area of the upper lung field as expected, but a gross adhesion was observed on the diaphragmatic surface. It would be difficult to detect adhesions on the diaphragmatic surface, especially when DDR is performed in the upright position because the lungs ride on the diaphragm during breathing movement.

2. Prediction from measurements

In 64 patients who underwent pneumonectomy (13 with adhesions and 51 without adhesions), we investigated the prediction of adhesions based on diaphragmatic excursion and projected lung area change rate. Diaphragmatic excursion (momentum) was compared between patients with and without adhesions after confirming that there were no differences between the left and right sides or between the healthy and affected sides. The results showed that the diaphragmatic excursion on the affected side was significantly lower in the group with adhesions ($P = 0.027$). There was no significant difference in the change rate of the affected side area. The ROC curve for detecting the adhesions by the diaphragmatic excursion on the affected side showed that the excursion less than 35 mm may be associated with adhesions (AUC: 0.70, sensitivity: 0.538, specificity: 0.863).

Disease Differentiation

Now, I present a case in which DDR was useful for differentiating diseases. In case 3, the patient was diagnosed eight years ago with an abnormal shadow in the chest and was followed up for suspected chest wall tumor, which gradually increased in size and surgery was decided upon. Preoperative plain chest radiography failed to detect any tumor and CT **(Fig.3a)** showed a 22mm lesion (indicated by arrow) protruding into the thoracic cavity in the left 10th intercostal space, suggesting a chest wall tumor. On the other hand, DDR in FE-MODE **(Fig.3b)** visualized a nodule shadow (indicated by arrow), which appeared to be a tumor and was observed to move with the lung accompanying with breathing movement. This finding suggested a high possibility of visceral pleural disease and after a comprehensive review, surgery was initiated using the surgical approach of pulmonary resection. Surgical findings revealed a tumor with pleural changes in S^{10} of the left lung. Thoracoscopic partial lung resection was carried out and pathological examination gave a diagnosis of a benign solitary fibrous tumor (SFT).

Summary

In the field of respiratory surgery, chest DDR is useful in identifying the presence or absence of pleural adhesions and differentiating diseases. It is expected to assist in the diagnosis of postoperative complications and in the analysis of pre- and postoperative respiratory status.

Clinical Application of DDR in Wrist Joint Diseases

Shigeya Suzuki Department of Orthopedic Surgery, Fujieda Municipal General Hospital

The wrist is a complex joint with complicated anatomy, and it is often difficult to determine the cause of wrist pain. We have been using dynamic digital radiography (DDR) for diagnosing wrist pain since 2022 and now I report its usefulness and potential.

Usefulness of DDR in dynamic ulnocarpal abutment syndrome

Ulnocarpal abutment syndrome is a disorder in which the ulnar head collides with the ulnar carpal bones to cause ulnar wrist joint pain. The disease usually occurs when the ulnar head is higher than the ulnar border of the radius [ulnar variance (UV) (+)]. However, even when UV is 0 or (–), there are pathological conditions in which automatic movement of the wrist joint causes collision between the ulnar head and carpal bones. This is called dynamic ulnocarpal abutment syndrome, which is often diagnosed by clinical findings and MRI, however, many cases are difficult to diagnose.

Case 1: A case useful for differentiating a disease.

A 62 y.o. female. When an MRI scan was performed at a previous hospital for left wrist joint pain that appeared without any trigger, Kienböck's disease (aseptic necrosis of lunate bone) was suspected, and the patient was referred to our hospital one year after the onset of the pain.

Initial hospital presentation: Pain and tenderness in the ulnar side of the wrist, markedly decreased left grip strength and ulnar gliding test (+). A plain radiograph showed translucency of the lunate bone. UV was 0 mm. There was no image of crushing of the lunate bone. Dynamic ulnar thrust syndrome was considered based on the clinical findings and plain X-ray findings, however, interpretation of MRI showed that the brightness change in the lunate extended to the center of the lunate, which is different from a typical MRI finding of ulnocarpal abutment syndrome (brightness change localized to the ulnar side of the lunate). So, Kienböck's disease was suspected. Therefore, we performed DDR.

When radial and ulnar flexion were imaged using AP images with the fingers in a grip position, UV (+) of the ulna was observed and it was also confirmed that the ulna collided with the center of the lunate during radial flexion **(Fig.1)**. Based on this finding, we diagnosed her with dynamic ulnocarpal abutment syndrome and carried out shorten-

Fig.1 DDR of case 1
a: During ulnar flexion b: During radial flexion

ing osteotomy on ulnar. The findings at the time of surgery were null variance for the ulna during passive radial and ulnar flexion under general anesthesia, which was different from the dynamics while awake. In addition, arthroscopic findings pointed out that cartilage damage in the lunate extended relatively to the radial side. We carried out 2mm shortening osteotomy and 9 months after surgery, the pain completely disappeared, and grip strength recovered. In this case, we could carry out surgery confident that the patient had dynamic ulnocarpal abutment syndrome and explain that the lesion distribution according to MRI spread to the central part of the lunate because we confirmed UV (+) and collision of the ulna with the middle section of the lunate during radial flexion by DDR. We also had a preconceived notion that the ulnar gliding test reproduced the impact between the lunate and ulna. In the present case, we observed that the lunate moved to the radial side and did not collide with the ulna during ulnar flexion, thus we got a new insight.

Fig.2 DDR of case 2
a: During radial flexion b: During ulnar flexion

Case 2: A case useful for understanding the clinical state.

A 15 y.o. female. The patient played volleyball as part of her junior high school club activity. She hoped to continue playing volleyball in high school. She fell down on a skateboard and visited another hospital because of right wrist joint pain. She had the affected area immobilized in a brace for three months because dehiscence of distal radioulnar joint (DRUJ) was observed. As the pain continued, she was referred to our hospital for further evaluation. Initial hospital presentation (four months after the injury) included ulnar gliding test (+) and piano key sign (+), suggesting instability of DRUJ. Plain X-ray images showed DRUJ dehiscence (+) and UV + 0.5 mm. In addition, MRI showed damage to the ulnar part of the triangular fibrocartilage complex (TFCC), but no change in brightness was observed on the ulnar side of the lunate. It was determined that DRUJ instability due to TFCC injury was the cause of the pain and conservative treatment was performed for an additional 3 months, but there was no improvement. With the hope of returning to sports as soon as possible, surgical treatment was chosen. Initially, we considered that TFCC suture alone would be sufficient, and that concomitant use of ulnar shortening osteotomy was unnecessary because there were no findings of ulnocarpal abutment on MRI. However, DDR in the grip position revealed apparent instability of the distal radioulnar joint. Furthermore, because the dynamic UV (+) of the ulna was prominent **(Fig.2)**, it was determined that the patient had coexisting dynamic ulnocarpal abutment syndrome. During surgery, the TFCC was sutured to the ulnar fossa and an ulnar shortening osteotomy of approximately 2mm was performed. Six months after the surgery, the pain completely disappeared, and the patient returned to sports. In this case, DDR showed that the ulna had UV (+) and collided with the lunate in the middle position of the wrist joint, which allowed us to perform the necessary treatment and obtain a good postoperative result.

Summary and Discussion

Dynamic ulnocarpal abutment syndrome, which is often difficult to diagnose, was easily diagnosed using DDR. In recent years, wide awake hand surgery, which allows automatic hand movement during surgery, has been used to allow diagnosis and improve surgical outcomes. Similarly, by performing DDR, it may be possible to obtain new knowledge about bone dynamics during automatic movement.

Wrist X-ray Dynamic Imaging at Fujieda Municipal General Hospital

Eriko Sato/Tsuyoshi Okawa Radiology, Medical Technology Department, Fujieda Municipal General Hospital

At our hospital, dynamic digital radiography (DDR) is performed as a routine examination for patients with wrist joint pain such as wrist instability and ulnocarpal abutment syndrome. Compared to fluoroscopy, DDR has the advantage of being easier to manage reservations, allowing same-day orders to be taken immediately and images (videos) can be viewed using PACS. In this lecture, we will introduce the imaging method and imaging conditions for wrist joint DDR at our hospital.

Points in imaging

1. Instructions to the patient

Explain to the patient that this is not a general radiographic examination, but a shooting a video of hand movement, that the patient should perform radial and ulnar flexion exercises in the gripping position, hold the hand tightly and move only the wrist slowly. It is important to have the patient understand the details of the test in advance and obtain their cooperation.

2. Positioning (Fig.1)

At our hospital, DDR is only possible on a standing platform. For positioning, the hand should be in a grip position, with the elbow to forearm horizontal and parallel to the FPD. Place the elbow on a hand rest with the elbow flexed at 90° and be careful not to rotate the hand during radial or ulnar flexion. Correct positioning is important because poor positioning may prevent correct assessment of joint movement and lead to misdiagnosis.
Additionally, since leaving the grid attached results in images with a lot of noise, after careful consideration, our hospital has adopted imaging without the grid. Therefore, when taking pictures on a standing platform, be careful not to forget to remove the grid.

3. Flow of imaging (Fig.2)

For the examination, positioning should be performed after questioning the patient about symptoms in detail. After confirming the radiation field and center point, explain the radial and ulnar flexion movements and have the patient practice the actual movements to confirm that there are no problems with the movements. Be sure to check the movements in advance, as it is often not possible to move them correctly with verbal explanation alone. Auto-voice should not be used during DDR and the examination should be carried out with verbal instructions by technician.

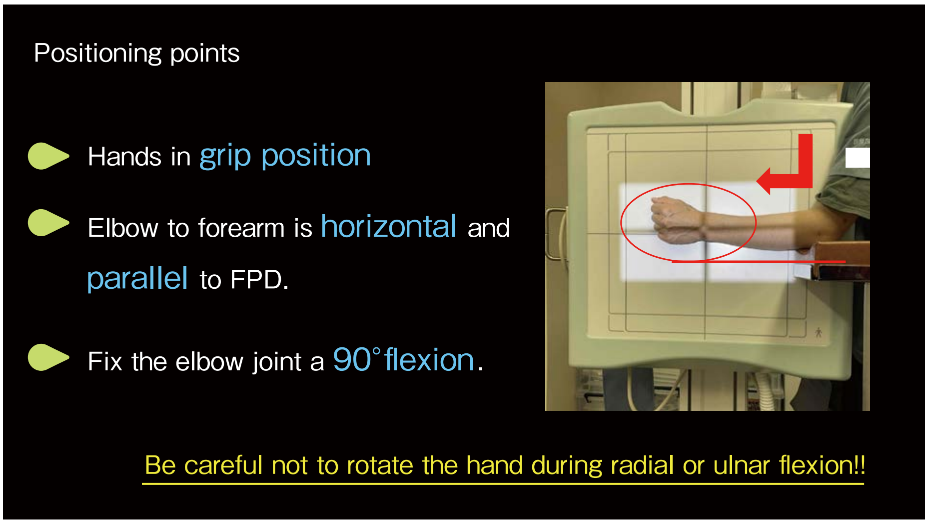

Fig.1 Positioning points

4. PACS transfer

The captured images are transferred to the PACS after making into the size of 203×254cm to match regular plain X-ray images of the wrist joint.

Discussion of imaging conditions

We discussed whether the manufacturer's default imaging conditions (tube voltage: 50 kV, tube current: 80 mA, acquisition time: 4 ms, fps: 15, no grid, SID: 120 cm) were appropriate for DDR of the wrist joint. In the study, the exposure dose (incident surface dose) and image quality (IQFinv., CNR) were evaluated using plain wrist X-ray photography as a reference. The imaging conditions were tube voltage: 50 kV, tube current: 80 mA, imaging time: 42/1.6/1 ms for DDR and tube voltage: 50 kV, tube current: 50 mA and imaging time: 40 ms for plain X-ray imaging and measurements and analyzes were performed for each.

As a result, the surface incident dose of DDR was 2 mGy when dynamic imaging was performed for up to 20 seconds with a default imaging time of 4 ms, which was 50 times higher than the dose of 0.04 mGy in plain radiography (measured at our hospital).

Regarding IQFinv. (the higher the value, the higher the visibility), the reference showed the highest value of 3.64 and all DDR conditions were lower than the reference. Furthermore, the difference between plain X-ray photography and DDR was larger than the difference between conditions of DDR. CNR values were 5.02 and 5.78 for reference and default imaging time respectively, both showing almost equivalent values. When the imaging time was shorter than the default value, the CNR value became lower. In DDR, the phantom images had more noise than the reference and the noise increased as the imaging time became shorter. There is a large difference in image quality between plain X-ray photography and DDR but since the targets of evaluation are different for both, we believe that it is not necessary to pursue equivalent image quality.

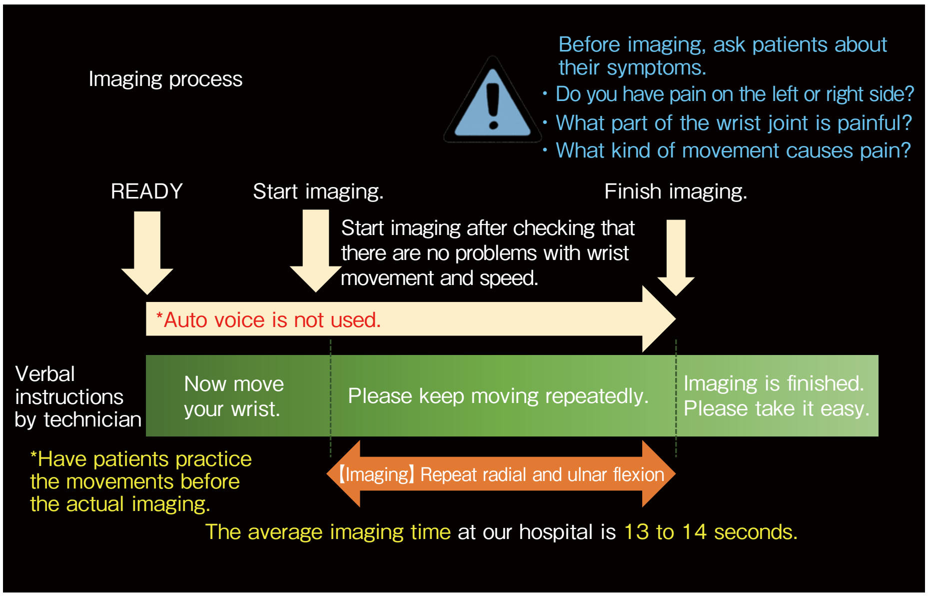

Fig.2 Imaging process

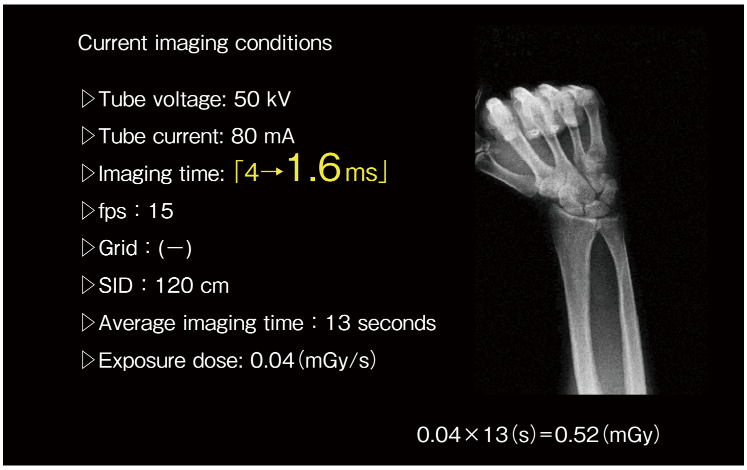

Fig.3 Current imaging conditions at our hospital Current imaging conditions

Comparing DDR at each imaging time, the image quality of the default condition of 4 ms is better than 1.6 ms or 1 ms, but because the exposure dose is higher and the purpose is to evaluate movement, at our hospital, the imaging time for wrist joint DDR was set at 1.6 ms (**Fig.3**). By this, the exposure dose was reduced from 0.1 mGy/s under the default condition of 4 ms to 0.04 mGy/s, resulting in a 60% reduction in radiation exposure.

In the future, we would like to consider addressing not only the wrist joint area but also a variety of other diseases and further optimizing imaging conditions.

Review

Chairperson

Terumitsu Hasebe, MD, PhD Professor, Department of Radiology, Tokai University School of Medicine

Commentators

Haruhiko Kondoh, MD, PhD Director, Kyorin University Hospital *Chairman of Department 1
Kei Takase, MD, PhD Professor, Diagnostic Radiology, Tohoku University School of Medicine *Chairperson of Part 2
Atsuko Kurosaki, MD, PhD Director, Department of Diagnostic Radiology, Fukujuji Hospital, Japan Anti-Tuberculosis Association *Chairman of Part 3
Yasuhiro Gon, MD, PhD Professor, Division of Respiratory Medicine, Department of Internal Medicine, Nihon University
Rie Tanaka, PhD Associate Professor, College of Medical, Pharmaceutical and Health Sciences, Kanazawa University
Ryotaro Yuji Radiological Technology Division, Department of Clinical Technology, Tokai University Hachioji Hospital
Yoshikazu Inoue, MD, PhD Consultant, Osaka Fukujuji Hospital, Osaka Anti-Tuberculosis Association
Shoji Kudoh, MD, PhD Representative Director, Japan Anti-Tuberculosis Association

In Part 4, in addition to the three chairpersons of Parts 1 through 3, a total of eight commentators, including physicians and radiologist who have been involved in dynamic digital radiography (DDR) since the first seminar was held, participated and gave a review of the seminar. In addition to the findings and clinical application examples reported in each lecture, there was a lively discussion about future challenges and prospects for DDR, such as the standardization of imaging techniques and medical fees.

Review of Parts 1 to 3

Report of research and application examples overseas and the first clinical case in the field of orthopedics

Dr. Hasebe: This time, in addition to reports based on RSNA award-winning themes and introductions of clinical applications in the UK, many new clinical findings were reported. This seminar is now in its fifth year, and I feel that the phase of research and clinical practice is changing.

Dr. Kondoh: In the special lecture given by Dr. Yuzo Yamasaki in Part 1, he reported on the usefulness of dynamic digital radiography (DDR) in evaluating pulmonary blood flow. Among these, applications for pulmonary thromboembolism (PE) and chronic thromboembolic pulmonary hypertension (CTEPH) are likely to expand to other facilities in the future. In addition, portable imaging devices are useful in dealing with acute cases and future feedback may help eliminate pitfalls.

Dr. Takase: That's right. The advent of portable imaging equipment is extremely significant, as it allows testing to be performed without having to move from the intensive care unit. Furthermore, the ability to evaluate prone position therapy in real time, as reported by Dr. Yuri Kon, is a feature unique to DDR and the X-ray dynamic image analysis workstation "KINOSIS." And Dr. FitzMaurice's report proposed the possibility of DDR including physiological analysis. Additionally, Part 2 also showed efforts toward quantitative evaluation, giving a sense of the future potential of DDR.

Dr. Gon: Many patients come to our hospital with a chief complaint of chronic shortness of breath. Although it is necessary to differentiate between respiratory and circulatory diseases, it is often not possible to immediately perform tests such as cardiac ultrasound due to examination frame and time constraints. Therefore, as Dr. Hiroaki Hiraiwa has shown, there is a need for DDR to be applied clinically as a simpler testing method.

Dr. Kurosaki: DDR has been expected to be useful in the field of orthopedics since beginning of its development, but a concrete clinical report was made for the first time in Part 3 of this 5th seminar. In the DDR digital case book "DDRAtlas" published in 2022, we would like to accumulate cases in the orthopedic field in addition to the respiratory field that is currently available.

Dr. Kudoh: In radiology, the realization of higher-definition images, as exemplified by high-resolution

CT, has been pursued. Separately, DDR has evolved "from form to function," and it is of great significance that data regarding functional evaluation was presented at this seminar.

Dr. Inoue: DDR is a technology that Japan is proud to share with the world and I learned a lot from today's presentations. Although some challenges and pitfalls were identified, interest in DDR is increasing and many presentations are expected in the future.

Future issues and prospects surrounding DDR (1)

The need for standardization of imaging techniques.

Dr. Tanaka: Obtaining moving images useful for functional evaluation requires highly difficult imaging techniques. In particular, in follow-up for respiratory diseases, reproducibility is affected by conditions such as deep breathing and breath-holding. We are currently holding a user meeting sponsored by Konica Minolta to disseminate and share information about DDR and we believe that it is important for radiology department and other departments to work together to develop imaging techniques and protocols.

Mr. Yuji: DDR is a test that is easy for doctors to order because it is a low burden on patients, but on the other hand, simplicity for the radiology technician responsible for imaging is also important. For example, in the field of orthopedics, it is necessary to communicate with patients during imaging in order to have patients move their arms and other parts as appropriate. At the same time, it is necessary to standardize imaging techniques and procedures, considering the balance between exposure dose and maintaining reproducibility.

Future issues and prospects surrounding DDR (2)

Expectations for DDR to be included in insurance.

Dr. Takase: Obtaining moving images with an accuracy that can be applied to diagnosis requires a certain amount of effort, so it may be difficult for facilities to apply it clinically unless they can secure personnel and other costs. For example, it may be possible to initially demonstrate its usefulness in a limited area, such as observing changes in respiratory function in the ICU and achieve insurance coverage and then gradually expand the scope of coverage.

Dr. Kudoh: I have heard that the Federation of Surgical Societies and Social Insurance Committees (Gaihoren) is currently lobbying for DDR to be included in insurance. We are confident that insurance coverage will become a reality.

Summary

Dr. Hasebe: As the amount of information obtained through DDR increases, new findings that are different from those of the past are being revealed. However, its history is still short and there is still plenty of room for development in terms of imaging techniques and range of applications. We hope that medical professionals who watched this seminar will provide further clinical reports and propose new ideas.

General review

General review 1

Yoshikazu Inoue MD, PhD Consultant, Osaka Fukujuji Hospital, Osaka Anti-Tuberculosis Association

"Fleishner Society," an international association for chest imaging diagnosis, has published the latest results on the diagnosis of chest diseases, mainly using images. In 2020, as chairman, I held the event in Osaka, but it was held virtually due to the spread of the new coronavirus infection (COVID-19) and in 2021, it was also scheduled to be held in Italy, but it was held virtually. In 2022, it was held locally in Amsterdam, Netherlands and in 2023, it was held locally in California, USA.

Discussions continued even when face-to-face meetings were not possible, but the most important topic during that time was image evaluation using artificial intelligence (AI). Currently, efforts are being made to quantify CT images using AI in a variety of fields, including tumors and diffuse lung diseases. Although a certain degree of quantification has been achieved, the current situation is that the use of AI for dynamic images has not made much progress. Under these circumstances, dynamic digital radiography (DDR), which captures and evaluates plain X-rays as moving images, is extremely revolutionary. This is a highly anticipated technology that Japan is leading in research and development.

In addition, reliable learning by teaching data based on doctors' diagnoses is important for image evaluation by AI and we believe that it will take a little more time to achieve quantification and diagnoses based on it. Furthermore, diagnosis by AI is based on morphology. DDR uses two-dimensional plain radiographs and is extremely easy to simplify. Another major development is that the exposure dose is low, and the advent of portable X-ray imaging equipment has made it possible to take images anywhere.

In Part 4, there was a discussion about the insurance coverage of DDR, and it is expected that the insurance coverage will enable its use in many facilities, leading to the accumulation of more data and the expansion of the actual clinical application range. Additionally, the simplicity of the technology supports its development around the world. When I think of DDR, I remember the song "Dance Dance Revolution," which was popular a long time ago. The full notation of DDR is "Dynamic Digital Radiography," but I thought that the "R" at the end could also mean "Revolution."

General review 2

Shoji Kudoh MD, PhD Representative Director, Japan Anti-Tuberculosis Association

The 5th dynamic digital radiography seminar was held and following the previous 4 seminars, substantial reports were given. This time, it was a very meaningful seminar, starting with a wonderful special lecture by Dr. Yuzo Yamasaki, followed by reports from overseas and lectures on the fields of cardiovascular and thoracic surgery, moreover, the first lecture on orthopedic surgery was also presented.

I have been involved in DDR since 2008, and since the presentation by Fukujuji Hospital was awarded a prize at the 3rd Respiratory Function Imaging Conference in

2011, I have been feeling a sense of mission to disseminate DDR, which continues to evolve "From Morphology to Function," from Japan to the world, as I mentioned in Part 4. Subsequently, Dr. Yoshitake Yamada (Harvard Medical School, now at Keio University) and Dr. Rie Tanaka, a commentator for Part 4, received the award at the Radiological Society of North America (RSNA) in 2016, and Dr. Yamasaki received the award in 2022. Additionally, DDR has now been introduced at more than 150 facilities around the world, including approximately 80 facilities in Japan and more than 60 English papers have been published. DDR has definitely been accepted around the world and I am confident that it will continue to develop.

In addition, under Dr. Hiroto Hatabu (Harvard Medical School), who has been a leader in DDR for many years, research and development of DDR has been carried out in an even wider area, and domestically, as Dr. Tanaka introduced in Part 4, user meetings are being held sponsored by Konica Minolta.

Dr. FitzMaurice, who delivered lecture in the Part 2, works at a hospital in Liverpool, UK and is actively working on clinical applications of DDR. We received his message from Liverpool, famous for the Beatles and are very happy to see the connection between that city and Japan. We sincerely hope that we will disseminate DDR from Japan to the rest of the world and that this wonderful technology will contribute to the development of medical care around the world in the future.

The 5th Dynamic Digital Radiography Seminar

Date and Time：June 17, 2023 (Saturday) 13：00-17：00
Venue: Online

Chairperson:
Part 1：Haruhiko Kondoh, MD, PhD (Director of Kyorin University Hospital)
Part 2：Kei Takase, MD, PhD (Professor, Diagnostic Radiology, Tohoku University School of Medicine)
Part 3：Atsuko Kurosaki, MD, PhD (Director, Department of Diagnostic Radiology, Fukujuji Hospital, Japan Anti-Tuberculosis Association)
Part 4：Terumitsu Hasebe, MD, PhD (Department of Radiology, Tokai University School of Medicine)

Part 4 Commentator:
Yasuhiro Gon, MD, PhD (Professor, Division of Respiratory Medicine, Department of Internal Medicine, Nihon University)
Rie Tanaka, PhD (Associate Professor, College of Medical, Pharmaceutical and Health Sciences, Kanazawa University)
Ryotaro Yuji (Radiological Technology Division, Department of Clinical Technology , Tokai University Hachioji Hospital)
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And Chairperson of Part 1 to 3.