Editorial

Potential of dynamic chest radiography for preoperative evaluation of pleural adhesions

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Comment on: Watanabe T, Suzuki E, Yoshii N, *et al.* Preoperative detection of pleural adhesions using dynamic chest radiography: prospective analysis. J Thorac Dis 2023;15:1096-105.

Keywords: X-rays; dynamic chest radiography (DCR); lung disease; surgery; perioperative management

Submitted Jul 31, 2023. Accepted for publication Aug 25, 2023. Published online Sep 15, 2023.
doi: 10.21037/jtd-23-1192
View this article at: https://dx.doi.org/10.21037/jtd-23-1192

Pleural adhesions are pathological bands that span the pleural space between the parietal and visceral layers of the pleura, as the end consequences of inflammation (1). Such adhesions constitute crucial clinical information pertinent to thoracic surgery. Thoracic surgeons, particularly those in the early stages of their learning curve, often consider dense pleural adhesions as a contraindication for video-assisted thoracic surgery (VATS). This is because of the technical challenges associated with the presence of these adhesions, which often correlate with conversion to thoracotomy and an increase in postoperative complications (1). A study examining 593 patients with non-small cell lung carcinoma who underwent VATS reported significant correlations between the presence of pleural adhesions and various outcomes, including an increased rate of conversion to thoracotomy, increased incidence of surgical complications, prolonged duration of intrathoracic drainage, and extended hospital stay (1). Another study investigating 144 patients who underwent lobectomy revealed that the presence of extensive pleural adhesions, particularly in the lower third of the thoracic cavity, was significantly associated with increased rates of conversion to open surgery and complications (2).

The options available for accurately diagnosing pleural adhesions are limited. To date, transthoracic ultrasound (US) (3), respiratory dynamic computed tomography (CT) (4-6), and dynamic cine magnetic resonance imaging (MRI) (7-9) have been proposed as diagnostic methods for pleural adhesions. However, these imaging modalities have constraints that make their universal application in preoperative testing impractical. US imaging requires skilled operators and is associated with poor reproducibility, dynamic CT involves high patient radiation exposure to achieve diagnostic reference levels (10), and MRI is limited by accessibility and cost issues (11).

Dynamic chest radiography (DCR) has emerged as a promising new imaging modality, receiving considerable attention. It is a functional radiographic modality based on a flat-panel detector that allows clear visualization of lung ventilation, diaphragmatic movement, and pulmonary circulation (12). In a standard examination, X-ray pulse irradiation is used 15 times/s to capture dynamic chest images via a high-sensitivity flat-panel detector, followed by functional evaluation using dedicated analysis software. The process requires no contrast agent, and the imaging time is approximately 6–15 s, with imaging possible in both standing and supine positions using portable devices (13). The patient's ionizing radiation exposure is <1.9 mGy,

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Table 1 Diagnostic ability of dynamic chest radiography for pleural adhesions

Author	Dynamic chest radiography mode	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Watanabe *et al.* (15)	Combination of PL, FE, and LM modes	64.5%	91.0%	74.1%	88.0%
Watanabe *et al.* (15), Tanaka *et al.* (17)	Low motion area ratio in the LM mode	84.0%	61.2%	30.9%	94.9%
Tanaka *et al.* (16)	FE mode	88%	83.5%	52.4%	97.1%

PL mode, reference frame ratio calculation processing mode; FE mode, frequency enhancement processing mode; LM mode, lung motion tracking processing mode.

which falls within the dose limit for bidirectional chest radiography recommended by the International Atomic Energy Agency (14). Software from Konica Minolta (Tokyo, Japan) enables analysis of six different types of functional images, in addition to the single-shot original, using the following modes: (I) the frequency enhancement processing mode (FE mode), which emphasizes the image contour; (II) the bone suppression processing mode (BS mode), which provides an image with the ribs removed; (III) the diaphragm motion tracking processing mode (DM mode), which automatically tracks vertical diaphragmatic movement; (IV) the reference frame ratio calculation processing mode (PL mode), for evaluating local lung ventilation; (V) the cross-correlation calculation mode (PH mode), for assessing pulmonary circulation; and (VI) the lung motion tracking processing mode (LM mode), for tracking vertical lung movement. Given its low radiation exposure and high reproducibility, DCR holds great promise for diagnosing pleural adhesions and invasion.

In a study published in a previous issue of the *Journal of Thoracic Disease*, Watanabe *et al.* reported on the diagnostic efficacy of DCR for pleural adhesions (15). The most substantial novelty of this study is its evaluation of the diagnostic ability of DCR, particularly the LM mode. A total of 120 patients with thoracic disease were prospectively enrolled to investigate the ability of DCR to detect pleural adhesions preoperatively. Pleural adhesions were defined as lesions that spread over >20% of the pleural cavity and/or required >5 min to dissect. DCR was performed in 119 patients (99.2%), yielding a sensitivity of 64.5%, specificity of 91.0%, positive predictive value (PPV) of 74.1%, and negative predictive value (NPV) of 88.0% for diagnosing pleural adhesions. The diagnostic approach employed two methods: one involved the combined use of three modes (PL, FE, and LM), and the other involved the calculation of the low-motion area (LMA). In a previous study using the FE mode of DCR, pleural adhesions were evaluated on the basis of three abnormal motions (restricted motion, structural tension, and distorted motion) (16). However, this method is subjective, as the results depend on the skill of the evaluator (15).

The PL mode is designed to visualize local ventilation within the lung field by identifying regions of low frequency within thoracic motion images and illustrating them as sky-blue areas. Initially, the authors assessed whether local ventilation was satisfactory using the PL mode. If there were areas of inadequate ventilation in the bilateral lung fields, the images were additionally evaluated using FE and LM modes. The FE mode, which has been used in previous studies, accentuates the contours of the image, making movements and changes in subtle structures more visible (16). The LM mode automatically tracks and visualizes vertical movements within the lung field, allowing evaluation of lung mobility. The focus on vertical movements permits detection of changes that correspond to the upward and downward movements of the diaphragm. Although combining these three different modes for analysis can increase complexity, it also allows the use of the distinct features of each mode.

LMA refers to the region in the LM mode that demonstrates <1.5 mm movement during exhalation. The LMA ratio is the LMA divided by the area of the lung field on the surgical side. The LMA ratio was significantly higher in patients with pleural adhesions than in patients without pleural adhesions (52.0%±17.2% *vs.* 36.9%±13.0%, P<0.001). This trend is further supported by the results of a retrospective study by Tanaka *et al.* that investigated 146 patients with lung cancer using the LMA ratio alone, showing results different from those of Watanabe *et al.* (sensitivity, 84.0%; specificity, 61.2%; PPV, 30.9%; and NPV, 94.9%) (17). The findings of these two studies suggest that an increased LMA ratio could be a candidate sign to suspect pleural adhesion. In the study by Tanaka *et al.*, the diagnostic ability of the LMA ratio was demonstrated by an area under the curve of 0.793 at a cutoff value of 49.0% (17).

DCR is a promising strategy for evaluating pleural adhesions. However, there are a few points of caution in its practical application, and further research (both technological and in terms of clinical data accumulation) is required. The first point of caution is the propensity for false negatives in the mediastinum and lung apex. The second is the variance in diagnostic ability depending on the mode used (*Table 1*). Paying attention to these points, accumulating clinical data, and establishing more refined diagnostic methods will help determine the future of this strategy.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Thoracic Disease*. The article did not undergo external peer review.

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1192/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Yamamoto S, Sakamaki F. Potential of dynamic chest radiography for preoperative evaluation of pleural adhesions. J Thorac Dis 2023;15(10):5278-5281. doi: 10.21037/jtd-23-1192