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Epidemiologic evaluation of pleurisy diagnosed by surgical pleural biopsy using data from a nationwide administrative database

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Abstract

Background: Pleural biopsies for investigating the causes of pleurisy are performed through modalities including needle biopsies, local anesthetic thoracoscopic procedures, and surgery (video-assisted thoracoscopic surgery and open thoracotomy). To date, there have been no large-scale nationwide epidemiological studies regarding pleurisy diagnosed via surgical pleural biopsy. This study examined the epidemiology of pleurisy diagnosed via surgical pleural biopsy in a Japanese nationwide administrative database.

Methods: We evaluated Japanese Diagnosis Procedure Combination data of 24 173 patients who underwent video-assisted thoracoscopic surgery or open thoracotomy and received a diagnosis of pleurisy between April 2014 and March 2020. In addition to pleurisy diagnoses, the patients' clinical information, including age, sex, smoking status (pack-years), dyspnea grade, length of in-hospital stay, and comorbidities, were extracted from the dataset.

Results: This study included data from 1699 patients. The most frequent causes of pleurisy were neoplastic diseases (55.9%; malignant mesothelioma 22.5%, lung cancer 15.7%, lymphoma 2.5%), followed by infectious diseases (24.0%; tuberculosis 16.2%, parapneumonic pleural effusion 3.6%, empyema 3.5%, nontuberculous mycobacteriosis 0.5%), collagen vascular diseases (2.8%; rheumatoid arthritis 1.3%, immunoglobulin G4-related diseases 0.7%, systemic lupus erythematosus 0.3%), and paragonimiasis (0.1%).

Conclusions: Neoplastic diseases, including malignant mesothelioma and lung cancer, were frequently and accurately diagnosed as pleurisy via surgical pleural biopsy. The next leading cause was infectious diseases such as mycobacterial infections. Physicians should consider performing surgical biopsy in light of the knowledge regarding the etiology of pleurisy when a definitive diagnosis cannot be made via needle pleural biopsy.

KEYWORDS
biopsy, pleural diseases, pleural effusion, pleurisy, surgical pleural biopsy

INTRODUCTION

Pleural effusion is a condition in which excess fluid accumulates in the thoracic cavity. This condition occurs when the balance between the production and drainage of pleural effusion is disturbed. Identifying the etiologies of pleural effusion and pleurisy (inflammation of the tissues that line the lungs and chest cavity) is essential for proper diagnosis and treatment. In most cases, a diagnosis of pleurisy is established based on a patient's medical history and physical findings, including an analysis of pleural effusion; however, approximately 26% of pleural effusion cases cannot be diagnosed according to these methods and require additional examination.[1] In such cases, the following types of pleural biopsies are frequently performed to investigate the cause of pleurisy: needle pleural biopsy (i.e. closed pleural biopsy) using Cope or Abrams needles, local

anesthetic thoracoscopic pleural biopsy, video-assisted thoracic surgery (VATS), and open thoracotomy.[2] The diagnostic rate for VATS pleural biopsy reportedly exceeds 90%.[3,4]

The Japanese Diagnosis Procedure Combination (DPC) is a nationwide administrative claims database of inpatient care, covering almost all hospitalizations in the acute phase of illness in Japan.[5] The DPC includes data on admission and discharge details, including the diagnosis, as recorded at the time of admission and discharge.[6] There are some prior diagnostic rate and etiological data available for pleurisy, for

example a previous study reported a higher diagnostic yield for local anesthetic thoracoscopic pleural biopsy (25/29, 86.2%) as compared with needle pleural biopsy (18/29, 62.1%).[7] A retrospective study of 1926 patients undergoing medical thoracoscopy for the diagnosis of pleural diseases indicated that 44.6% of the patients had malignant disease (i.e. mesothelioma, pleural metastasis), while 51.2% presented with benign diseases (i.e. parapneumonic effusion, tuberculosis).[8] A study among 1034 patients with pleural effusion who underwent closed pleural biopsy reported similar percentages of patients with malignant disease (45.07%; lung adenocarcinoma 24.37%, mesothelioma 10.16%), as well as nonmalignant diseases such as tuberculosis (11.22%) and nonspecific inflammation (36.56%).[9] However, to date, there have been no nationwide epidemiological data regarding the etiology of pleurisy diagnosed via surgical pleural biopsy (i.e. thoracoscopic and open pleural biopsies). Thus, we investigated the etiology of pleurisy diagnosed via surgical pleural biopsy within the Japanese DPC database.
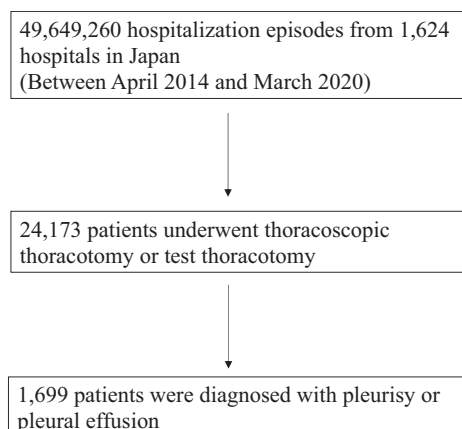

FIGURE 1 Patient selection and enrollment diagram

METHODS

Subjects and the source database

We extracted data from the DPC, the Japanese national case-mix system database of the Ministry of Health, Labour

TABLE 1 Patient characteristics at admission

Patient characteristics	Open thoracotomy (K488-00) n = 65	VATS (K488-03) n = 265	VATS with pathological specimen (K488-04) n = 1369	p value	Total n = 1699
In-hospital days	32.0 ± 29.9	23.4 ± 24.2	20.8 ± 18.2	<0.05	21.6 ± 19.9
Age (years)	69.4 ± 13.3	69.4 ± 12.8	71.7 ± 12.2	<0.05	71.3 ± 12.4
Male	51 (78.5%)	186 (70.2%)	1080 (78.9%)	<0.05	1317 (77.5%)
Pack-years	25.3 ± 29.6	17.1 ± 25.5	21.4 ± 30.3	<0.05	20.9 ± 29.6
Hugh-Jones grade				0.17	
1	36 (55.4)	140 (52.8)	695 (50.8%)		871 (51.3%)
2	10 (15.4)	67 (25.3)	293 (21.4%)		370 (21.8%)
3	6 (9.2)	25 (9.4%)	194 (14.2%)		225 (13.2%)
4	10 (15.4%)	20 (7.5%)	131 (9.6%)		161 (9.5%)
5	3 (4.6%)	13 (4.9%)	56 (4.1%)		72 (4.2%)
Comorbidity					
Diabetes	7 (10.8%)	49 (18.5%)	310 (22.6%)	<0.05	366 (21.5%)
Hypertension	8 (12.3%)	59 (22.3%)	181 (13.2%)	<0.05	248 (14.6%)
Ischemic heart disease	3 (4.6%)	17 (6.4%)	55 (4.0%)	0.22	75 (4.4%)
Chronic heart failure	3 (4.6%)	11 (4.2%)	88 (6.4%)	0.32	102 (6.0%)
Cerebrovascular disease	1 (1.5%)	10 (3.8%)	23 (1.7%)	0.08	34 (2.0%)
Dementia	1 (1.5%)	2 (0.8%)	20 (1.5%)	0.65	23 (1.4%)
Chronic obstructive pulmonary disease	0 (0%)	6 (2.3%)	33 (2.4%)	0.45	39 (2.1%)
Asthma	0 (0%)	8 (3.0%)	34 (2.5%)	0.37	42 (2.5%)
Liver disease	3 (4.6%)	17 (6.4%)	57 (4.2%)	0.27	77 (4.5%)

Note: Data are presented as mean ± standard deviation or frequencies (%).
Abbreviations: VATS, video-assisted thoracic surgery.

TABLE 2 Diagnoses of patients with pleural effusion or pleurisy undergoing surgical biopsy

Result	Open thoracotomy (K488-00)	VATS (K488-03)	VATS with pathological specimen (K488-04)	p value	Total
Malignant diseases	42 (64.6)	159 (60.0)	749 (54.7)	0.10	950 (55.9)
Malignant mesothelioma	14 (21.5)	59 (22.3)	309 (22.6)	0.98	382 (22.5)
Lung cancer (metastatic)	13 (20.0)	52 (19.6)	201 (14.7)	0.08	266 (15.7)
Breast cancer (metastatic)	0 (0)	14 (5.3)	13 (0.9)	<0.05	27 (1.6)
Pancreatic cancer (metastatic)	0 (0)	2 (0.8)	2 (0.1)	0.16	4 (0.2)
Other cancers (metastatic)	12 (18.5)	23 (8.7)	172 (12.6)	0.06	207 (12.2)
Lymphoma	1 (1.5)	9 (3.4)	32 (2.3)	0.53	42 (2.5)
Sarcoma	2 (3.1)	0 (0)	3 (0.2)	<0.05	5 (0.3)
Others	0 (0)	0 (0)	17 (1.2)	0.13	17 (1.0)
Infectious disease	12 (18.5)	48 (18.1)	348 (25.4)	<0.05	408 (24.0)
Tuberculosis	4 (6.2)	21 (7.9)	251 (18.3)	<0.05	276 (16.2)
Parapneumonic pleural effusion	3 (4.6)	9 (3.4)	50 (3.7)	0.90	62 (3.6)
Empyema	3 (4.6)	16 (6.0)	41 (3.0)	<0.05	60 (3.5)
Nontuberculous mycobacteriosis	2 (3.1)	2 (0.8)	4 (0.3)	<0.05	8 (0.5)
Paragonimiasis	0 (0)	0 (0)	2 (0.1)	0.79	2 (0.1)
Collagen disease	1 (1.5)	7 (2.6)	39 (2.8)	0.81	47 (2.8)
Rheumatoid arthritis	1 (1.5)	1 (0.4)	20 (1.5)	0.36	22 (1.3)
IgG4-related disease	0 (0)	3 (1.1)	9 (0.7)	0.55	12 (0.7)
Systemic lupus erythematosus	0 (0)	3 (1.1)	2 (0.1)	<0.05	5 (0.3)
Other collagen diseases	0 (0)	0 (0)	8 (0.6)	0.38	8 (0.5)
Others	8 (12.3)	32 (12.1)	107 (7.8)	<0.05	147 (8.7)
Heart failure	0 (0)	9 (3.4)	30 (2.2)	0.22	39 (2.3)
Benign asbestos pleural effusion	0 (0)	4 (1.5)	25 (1.8)	0.52	29 (1.7)
Uremic	1 (1.5)	3 (1.1)	20 (1.5)	0.91	24 (1.4)
Hepatic	1 (1.5)	5 (1.9)	7 (0.5)	<0.05	13 (0.8)
Chylothorax	4 (6.2)	4 (1.5)	4 (0.3)	<0.05	12 (0.7)
Pulmonary thromboembolism	2 (3.1)	2 (0.8)	7 (0.5)	<0.05	11 (0.6)
Sarcoidosis	0 (0)	3 (1.1)	5 (0.4)	0.21	8 (0.5)
Hypoalbuminemia	0 (0)	1 (0.4)	3 (0.2)	0.82	4 (0.2)
Traumatic	0 (0)	0 (0)	4 (0.3)	0.62	4 (0.2)
Amyloidosis	0 (0)	1 (0.4)	2 (0.1)	0.67	3 (0.2)
Unknown	2 (3.1)	19 (7.2)	126 (9.2)	0.14	147 (8.7)
Total	65 (100)	265 (100)	1369 (100)		1699 (100)

Abbreviation: VATS, video-assisted thoracic surgery.

and Welfare. The DPC is a patient classification system based on each patient's diagnosis and the procedures each patient underwent during their hospital stay. Most Japanese acute care hospitals are reimbursed based on a combination of DPC-based per-diem and fee-for-service payments. The DPC database collects information regarding the primary disease, comorbid disease(s) reported on admission, disease(s) that developed during hospitalization, and data on personal information (e.g. age, sex, physical data, smoking history, hospitalization, discharge destination, comorbidities, and complications during hospitalization written in Japanese text and coded using the International Classification and Related Health Problems 10th Revision

[ICD-10] codes).[6] In this study, we retrospectively examined the records of patients who underwent VATS (procedure code K488-03) or VATS with obtaining pathological specimen (procedure code K488-04) or open thoracotomy (procedure code K488-00) for lung or pleural disease, and subsequently evaluated those who presented with DPC codes of pleural effusion and/or pleurisy between April 2014 and March 2020. The following clinical information was extracted: smoking status (pack-years), dyspnea grade, in-hospital stay (days), and comorbidities (diabetes, hypertension, ischemic heart disease, chronic heart failure, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, asthma, and liver disease). The Institutional Review Board of

T A B L E 3 The rate of comorbidity in the three major categories

Comorbidity	Malignant diseases[a] n = 950	Infectious diseases[b] n = 408	Collagen diseases[c] n = 47	p value
Diabetes	218 (22.9%)	70 (17.2%)	11 (23.4%)	0.053
Hypertension	152 (16.0%)	53 (13.0%)	6 (12.8%)	0.33
Ischemic heart disease	38 (4.0%)	14 (3.4%)	4 (8.5%)	0.24
Chronic heart failure	45 (4.7%)	17 (4.2%)	1 (2.1%)	0.65
Cerebrovascular disease	22 (2.3%)	7 (1.7%)	0 (0%)	0.46
Dementia	15 (1.6%)	5 (1.2%)	0 (0%)	0.62
Chronic obstructive pulmonary disease	27 (2.8%)	3 (0.7%)	1 (2.1%)	0.053
Asthma	27 (2.8%)	7 (1.7%)	0 (0%)	0.25
Liver disease	8 (0.8%)	0 (0%)	0 (0%)	0.15

[a]Malignant diseases: malignant mesothelioma, lung cancer (metastatic), breast cancer (metastatic), pancreatic cancer (metastatic), other cancer (metastatic), lymphoma, sarcoma.
[b]Infectious diseases: tuberculosis, parapneumonic pleural effusion, empyema, nontuberculous mycobacteriosis, paragonimiasis.
[c]Collagen diseases: rheumatoid arthritis, IgG4-related disease, systemic lupus erythematosus, other collagen diseases.

the University of Occupational and Environmental Health, Japan approved this study (R002-007).

Statistical analysis

Categorical variables were compared using the chi-square test or Fisher's exact test, while continuous variables were compared using Student's t-tests or the Mann–Whitney U-test as appropriate. The statistical analyses were performed using the SPSS software package (version 27; IBM Corporation). Statistical significance was set at $P < 0.05$.

RESULTS

From April 2014 to March 2020 ~49.6 million hospitalizations occurred at 1624 hospitals in Japan, of which 24 173 patients underwent VATS with/without pathological specimen or open thoracotomy. Of the 24 173 patients, 1699 were diagnosed with pleural effusion and/or pleurisy at admission and were consequently enrolled in this study (Figure 1). Patient characteristics for each group (open thoracotomy [K488-00], VATS [K488-03], and VATS with pathological specimen [K488-04]) on admission are shown in Table 1. Among the three groups, age was significantly higher in the K488-4 group (K488-00 69.4 ± 13.3, K488-03 69.4 ± 12.8, K488-04 71.7 ± 12.2; $p < 0.05$), and in-hospital days and pack-years were significantly higher in the K488-00 group. The percentage of men was significantly lower in the K488-03 group compared to the other groups. In comorbidity, diabetes was significantly higher in the K488-04 group and hypertension was significantly higher in the K488-03 group compared to the other groups. Table 2 reveals the diagnoses of patients with pleural effusion or pleurisy for each group (K488-00, K488-03, and K488-04). The most frequent causes of pleurisy were malignant diseases (K488-00 64.6%, K488-03 60.0%, K488-04 54.7%;

$p = 0.10$, total 55.9%), followed by infectious diseases (K488-00 18.5%, K488-03 18.1%, K488-04 25.4%; $p < 0.05$, total 24.0%) and collagen vascular diseases (K488-00 1.5%, K488-03 2.6%, K488-04 2.8%; $p = 0.81$, total 2.8%); 147 (8.7%) of the 1669 patients had an unknown etiology. The respective rates for each malignant disease were as follows: malignant mesothelioma (K488-00 21.5%, K488-03 22.3%, K488-04 22.6%; $p = 0.98$, total 22.5%), lung cancer (K488-00 20.0%, K488-03 19.6%, K488-04 14.7%; $p = 0.08$, total 15.7%), breast cancer (K488-00 0%, K488-03 5.3%, K488-04 0.9%; $p < 0.05$, total 1.6%), and malignant lymphoma (K488-00 1.5%, K488-03 3.4%, K488-04, 2.3%; $p = 0.53$, total 2.5%). The respective rates for each infectious disease were as follows: tuberculosis (K488-00 6.2%, K488-03 7.9%, K488-04 18.3%; $p < 0.05$, total 16.2%), parapneumonic pleural effusion (K488-00 4.6%, K488-03 3.4%, K488-04 3.7%; $p = 0.90$, total 3.6%), empyema thoracis (K488-00 4.6%, K488-03 6.0%, K488-04 3.0%; $p < 0.05$, total 3.5%), and nontuberculosis mycobacteriosis (NTM) (K488-00 3.1%, K488-03 0.8%, K488-04 0.3%; $p < 0.05$, total 0.5%). Other diagnoses included rare diseases such as sarcoidosis (K488-00 0%, K488-03 1.1%, K488-04 0.4%; $p = 0.21$, total 0.5%), immunoglobulin G4-related disease (K488-00 0%, K488-03 1.1%, K488-04 0.7%; $p = 0.55$, total 0.7%), and paragonimiasis (K488-00 0%, K488-03 0%, K488-04 0.1%; $p = 0.79$, total 0.1%; Table 2). In addition, no significant difference was found in the rate of comorbidity among the three major categories (malignant diseases, infectious diseases, and collagen diseases; Table 3).

DISCUSSION

In this study, we first examined the etiology of pleurisy diagnosed via surgical pleural biopsy using a large-scale Japanese nationwide DPC database and elucidated the etiology of pleuritis diagnosed via surgical pleural biopsy (i.e. VATS or open thoracotomy). As a result, we found that the most

frequent diagnoses of pleurisy made by surgical pleural biopsy were due to malignant disease (55.9%), including malignant mesothelioma, lung cancer, and breast cancer, followed by infectious disease (i.e. tuberculosis, empyema thoracis, and NTM). Our study reported incidence rates for rare etiologies of pleurisy, including collagen diseases[10] and NTM[11]; these diseases have frequently been reported as case reports (vs. systematic epidemiologic or clinical studies) in prior research.

In this study, 950 of the 1699 patients (55.9%) presented with malignant pleural effusion (MPE). Since MPE generally has a poor prognosis and an urgent diagnosis of this condition is occasionally necessary, the median survival time in patients with MPE after diagnosis is 3–12 months.[12] The prognosis for this disease can now be effectively estimated using a predictive model.[13,14] The diagnostic sensitivity of cytology for pleural effusion varies depending on the primary malignant lesion.[15] However, the cytological diagnostic rate of malignant pleural effusion following the first thoracentesis is reported as 40–60%, and additional thoracentesis does not statistically significantly improve the diagnostic rate.[15] In relation to the sensitivity of thoracentesis for malignancy, a study conducted in 725 patients with pleural effusion demonstrated a higher diagnostic sensitivity in patients with lung cancer (adenocarcinoma 78%, 71/91; squamous cell carcinoma 39%, 9/23; small cell lung cancer 54%, 7/13), breast cancer (85%, 140/165), and pancreatic cancer (86%, 19/22), a lower sensitivity in patients with sarcoma (20%, 6/29), and a very low sensitivity in mesothelioma patients (0%, 0/5).[15] In addition, in a report investigating 21 patients with pleural effusion associated with non-Hodgkin's lymphoma, 18 (86%) of the patients with exudative pleural effusion tested positive with regard to pleural effusion cytology.[16] Compared with these results, our study demonstrated that malignant pleural mesothelioma was the most common diagnosis obtained via surgical biopsy because of the relatively low sensitivity of thoracentesis in patients with mesothelioma,[15] although recent developments of cytological examinations including cell block procedure have been providing precise diagnoses in pleural mesothelioma.[17] The diagnosis rate of lung cancer with pleural effusion was reported to be moderate (39–78%)[15]; this was the second most commonly detected disease in this study, in line with its relatively high prevalence as reported previously.[18] For the above reasons, as shown in this study, the proportion of malignant mesothelioma cases (which are inherently difficult to diagnose via thoracentesis) was high and the proportion of lung cancer (which had a moderate diagnostic rate) was also high; however, the proportions of breast cancer and lymphoma cases that were highly diagnostic via thoracentesis were low in this study.

In contrast to infectious pleurisy, tuberculous pleurisy is usually diagnosed based on the detection of *Mycobacterium tuberculosis* in sputum, pleural effusion, or pleural biopsy, and/or through the detection of caseous granulomas in pleural biopsy specimens. Among patients with tuberculous pleurisy, less than 40% of pleural effusion cultures are reportedly positive for mycobacterial cultures.[19] Parapneumonic pleural effusion is often diagnosed based on clinical symptoms and the results of thoracentesis; anaerobic pleurisy may not manifest typical symptoms, such as fever, chest pain, or associated pneumonia,[20] and precise results are often difficult to obtain within anaerobic cultures, which occasionally necessitates a surgical pleural biopsy. NTM pleurisy is a rare disease mainly reported in compromised hosts (e.g. patients with acquired immunodeficiency syndrome),[11] and presents in only approximately 1.4% of patients with NTM.[21] Although the incidence of NTM pleurisy was low in the current study, NTM pleurisy requires proper treatment, including drainage and proper antimicrobial care.[21] Therefore, surgical pleural biopsy has been established as a good diagnostic option in the early diagnosis of NTM pleurisy.

Lupus pleurisy is the most common respiratory disorder associated with systemic lupus erythematosus (SLE), with an incidence rate of 30–60% in SLE patients. Compared to other collagen diseases and vasculitis, pleurisy occurs more commonly among patients with SLE; it is considered a characteristic lesion of SLE and is included as one of the SLE diagnostic criteria.[22] Since lupus pleurisy is often diagnosed based on symptoms and thoracentesis findings, the proportion of lupus pleurisy cases enrolled in this study was small. IgG4-related disease (IgG4-RD) is a chronic systemic fibroinflammatory disease characterized by three central pathological features: lymphoplasmacytic infiltration, obliterative phlebitis, and storiform fibrosis.[23] Pleural lesions are found in approximately 40% of patients with IgG4-RD.[24] Pleural symptoms of IgG4-RD include pleural nodules, pleurisy with fibrosis, and pleural effusion.[25] IgG4-RD pleural lesions are frequently associated with other organ diseases; however, IgG4-RD pleurisy without other organ lesions has likewise been reported.[26,27] In recent years, IgG4-RD has been detected in some cases of undiagnosed pleural effusion[28]; however, the frequency of this occurrence has not been clear to date because of its low prevalence. In our study, IgG4-RD accounted for 0.7% of patients undergoing surgical pleural biopsy.

There have been two studies of MPE conducted using a national database in the United States. One study evaluated 349 041 hospitalizations for MPE from 2009 to 2013 and revealed that the etiologies of MPE were the following: lung cancer 44.3%, breast cancer 19.8%, ovarian cancer 6.7%, lymphoma 5.8%, and gastric cancer 1.6%.[29] Another study assessed 126 825 admissions for MPE in 2012 and revealed that lung (37.8%), breast (15.2%), hematologic (11.2%), gastrointestinal tract (11.0%), and gynecologic (9.0%) malignancies were the primary etiological causes of MPE.[30] Similar to our results, lung cancer was the most frequent etiology in patients with MPE. However, these results from the United States focused only on MPE: malignant mesothelioma and other conditions were not evaluated in these two studies.

This study has several limitations. First, pathological data and detailed clinical data were not available in the DPC database, all diagnostic names were assigned based on the

decisions and clinical judgment of the attending physicians, and the final pathological diagnosis was unknown in part of the patients. Second, the study was conducted between April 2014 and March 2020 (i.e. before the coronavirus disease-2019 [COVID-19] outbreak in Japan). Third, since the enrolled subjects were those who underwent surgical biopsies, patients in poor general condition may not have been included in this study.

CONCLUSION

In a nationwide DPC database, we found that the most frequent diagnosis of pleurisy made by surgical pleural biopsy was due to malignant diseases, including malignant mesothelioma, metastatic lung cancer, and breast cancer, followed by infectious diseases (i.e. tuberculosis and empyema thoracis). Acknowledging these epidemiological data within continuing education and other physician outreach efforts may help physicians and surgeons obtain definitive diagnoses more effectively following an undiagnostic needle pleural biopsy of pleural effusion. Accurate and efficient diagnoses may be obtained through performing surgical pleural biopsy, especially in MPE patients. Our findings guide future research directions and, if confirmed, will ultimately provide information for effective medical guidelines and medical decision-making.

CONFLICT OF INTEREST
The authors have no conflict of interest.

ETHICS APPROVAL

This study was approved by the Ethical Committee of the University of Occupational and Environmental Health (Japan) (R002-007).

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REFERENCES
1. Conces DJ Jr, Schwenk GR Jr, Doering PR, Glant MD. Thoracic needle biopsy. Improved results utilizing a team approach. Chest. 1987;91:813–6.
2. Ali MS, Light RW, Maldonado F. Pleuroscopy or video-assisted thoracoscopic surgery for exudative pleural effusion: a comparative overview. J Thorac Dis. 2019;11:3207–16.
3. Dixon G, de Fonseka D, Maskell N. Pleural controversies: image guided biopsy vs. Thoracoscopy for undiagnosed pleural effusions? J Thorac Dis. 2015;7:1041–51.
4. Dadaş E, Erdoğdu E, Toker A, Ersöz M, Okay T. Effectiveness of video-assisted thoracoscopic surgery in undiagnosed exudative pleural effusions. Turk Thorac J. 2019;20:188–91.
5. Hayashida K, Murakami G, Matsuda S, Fushimi K. History and profile of diagnosis procedure combination (DPC): development of a real data collection system for acute inpatient care in Japan. J Epidemiol. 2021;31:1–11.
6. Matsuda S. Development of case mix based evaluation system in Japan. Jpn Hosp. 2016;35:35–44.
7. Haridas N, K PS, T PR, P TJ, Chetambath R. Medical thoracoscopy vs. closed pleural biopsy in pleural effusions: a randomized controlled study. J Clin Diagn Res. 2014;8:Mc01-4.
8. Wan YY, Zhai CC, Lin XS, Yao ZH, Liu QH, Zhu L, et al. Safety and complications of medical thoracoscopy in the management of pleural diseases. BMC Pulm Med. 2019;19:125.
9. Baez-Saldana R, Rumbo-Nava U, Escobar-Rojas A, Castillo-González P, León-Dueñas S, Aguirre-Pérez T, et al. Accuracy of closed pleural biopsy in the diagnosis of malignant pleural effusion. J Bras Pneumol. 2017;43:424–30.
10. Noguchi S, Yatera K, Jinbo M, Yamada S, Shimabukuro I, Yamasaki K, et al. IgG4-related lung disease associated with autoimmune hemolytic anemia: a case report and a literature review. Intern Med. 2016;55:2469–74.
11. Haider A, Schliep T, Zeana C. Nontuberculous mycobacterium disease with pleural empyema in a patient with advanced AIDS. Am J Med Sci. 2009;338:418–20.
12. Roberts ME, Neville E, Berrisford RG, Antunes G, Ali NJ. Management of a malignant pleural effusion: British Thoracic Society pleural disease guideline 2010. Thorax. 2010;65(Suppl 2):ii32–40.
13. Clive AO, Kahan BC, Hooper CE, Bhatnagar R, Morley AJ, Zahan-Evans N, et al. Predicting survival in malignant pleural effusion: development and validation of the LENT prognostic score. Thorax. 2014;69:1098–104.
14. Psallidas I, Kanellakis NI, Gerry S, Thézénas ML, Charles PD, Samsonova A, et al. Development and validation of response markers to predict survival and pleurodesis success in patients with malignant pleural effusion (PROMISE): a multicohort analysis. Lancet Oncol. 2018;19:930–9.
15. Grosu HB, Kazzaz F, Vakil E, Molina S, Ost D. Sensitivity of initial thoracentesis for malignant pleural effusion stratified by tumor type in patients with strong evidence of metastatic disease. Respiration. 2018;96:363–9.
16. Alexandrakis MG, Passam FH, Kyriakou DS, Bouros D. Pleural effusions in hematologic malignancies. Chest. 2004;125:1546–55.
17. Husain AN, Colby TV, Ordóñez NG, Allen TC, Attanoos RL, Beasley MB, et al. Guidelines for pathologic diagnosis of malignant mesothelioma 2017 update of the consensus statement from the international mesothelioma interest group. Arch Pathol Lab Med. 2018;142:89–108.
18. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68:394–424.
19. Porcel JM. Tuberculous pleural effusion. Lung. 2009;187:263–70.
20. Light RW, MacGregor MI, Ball WC Jr, Luchsinger PC. Diagnostic significance of pleural fluid pH and PCO_2. Chest. 1973;64:591–6.
21. Ando T, Kawashima M, Matsui H, Takeda K, Sato R, Ohshima N, et al. Clinical features and prognosis of nontuberculous mycobacterial pleuritis. Respiration. 2018;96:507–13.
22. Aringer M, Costenbader K, Daikh D, Costenbader K, Daikh D, Brinks R, et al. 2019 European league against rheumatism/American College of Rheumatology classification criteria for systemic lupus erythematosus. Ann Rheum Dis. 2019;78:1151–9.
23. Kamisawa T, Zen Y, Pillai S, Stone JH. IgG4-related disease. Lancet. 2015;385:1460–71.
24. Fei Y, Shi J, Lin W, Chen Y, Feng R, Wu Q, et al. Intrathoracic involvements of immunoglobulin G4-related sclerosing disease. Medicine. 2015;94:e2150.
25. Zen Y, Inoue D, Kitao A, Onodera M, Abo H, Miyayama S, et al. IgG4-related lung and pleural disease: a clinicopathologic study of 21 cases. Am J Surg Pathol. 2009;33:1886–93.
26. Kita T, Araya T, Ichikawa Y, Terada N, Kawashima A, Kasashima S, et al. IgG4-related pleuritis with no other organ involvement. Am J Med Sci. 2018;356:487–91.
27. Corcoran JP, Culver EL, Psallidas I, Hallifax RJ, Davies SJ, Bateman AC, et al. A 63-year-old man with a recurrent right-sided pleural effusion. Thorax. 2015;70:504–7.

28. Kasashima S, Kawashima A, Ozaki S, Kita T, Araya T, Ohta Y, et al. Clinicopathological features of immunoglobulin G4-related pleural lesions and diagnostic utility of pleural effusion cytology. Cytopathology. 2019;30:285–94.

29. Chatterjee K, Goyal A, Kakkera K, Meena N. Etiology of malignant pleural effusion and utilization of diagnostic and therapeutic procedures: a nationwide analysis. J Bronchology Interv Pulmonol. 2017;24:e10–2.

30. Taghizadeh N, Fortin M, Tremblay A. US hospitalizations for malignant pleural effusions: data from the 2012 National Inpatient Sample. Chest. 2017;151:845–54.