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Can Peripheral Bronchopleural Fistula Demonstrated on Computed Tomography be Treated Conservatively? A Retrospective Analysis

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Purpose: Peripheral bronchopleural fistulas (BPF) are communications between a peripheral bronchus or the lung parenchyma and the pleural space. Although reported cases with peripheral BPF might have typical symptoms, we postulate that there may be BPF patients without typical symptoms who are diagnosed on computed tomography (CT) for the first time.

Materials and Methods: We searched retrospectively for how frequently BPF is found on CT in cases with known or suspected empyema or hydropneumothorax. Also, we examined the clinical charts to ascertain if a diagnosis of BPF was suspected in the CT reports or clinically, and to determine the outcome of each case.

Results: Thirteen thoracic cavities of 12 patients were included in this study. Of these, BPF was suspected clinically in only 1. Mention in the CT report about the presence of BPF was found in 2 cases. An apparent finding of BPF on CT was found in 7 of 13 (53%) thoracic cavities of 6 cases. The outcomes were that 1 patient died 1 month later due to multiple organ failure, and 1 patient was discharged subsequently after CT. In the other 10 cases, there was no exacerbation of the symptom regardless of definite evidence of BPF on CT.

Conclusions: In conclusion, when there is hydropneumothorax on CT, it is important for radiologists to diligently search for findings of peripheral BPF and to document it. However, a reference about the need for a surgical approach for BPF may not be required.

Key Words: bronchopleural fistula, peripheral bronchopleural fistula, CT, empyema, hydropneumothorax

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Bronchopleural fistulas (BPF) can be categorized as central or peripheral. Central BPFs involve large airways and usually occur after trauma or after lung resection.[1–4] They can be localized with bronchoscopy and usually require surgical repair.[5] Peripheral BPFs are communications between a peripheral bronchus or the lung parenchyma and the pleural space. They are usually not visible at bronchoscopy and are often diagnosed clinically. The major causes of peripheral BPF include surgery, bronchiectasis, necrotizing pneumonia and abscess, cancer, tuberculosis, infarction, penetrating trauma, and barotauma.[6–12]

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Symptoms of peripheral BPF include an air leak, a prolonged pneumothorax combined with a pleural effusion (hydropneumothorax), and aspiration pneumonia caused by absorption of the pus flowing backward through the bronchus from an empyema.[13,14] When we find a prolonged pleural effusion or an encapsulated pleural effusion on chest computed tomography (CT), empyema is suggested. And when an air bubble or air/fluid level formation is observed in the pleural effusion in empyema patients,[1] external insertion of a needle or tube during thoracentesis and drainage,[2] gas-producing bacterial infection, or[3] air from a BPF is considered to be the cause.

Cases in which a gas image is mixed in a pleural effusion may be encountered frequently, and the possibility of the air originating from outside the body is thought to be the highest; we often make a CT report reflecting that in such cases. Peripheral BPF seems to be less frequent; however, in BPF on CT, the apparent continuation of a bronchus or the lung parenchyma to the pleural space can lead to a definite diagnosis of BPF.[1,2,6,15]

The frequency of the presence of these findings in peripheral BPF demonstrated on CT is reported as 50% to 76%, and the thin-slice CT and multisectional maximal intensity projection image are reported to be useful in imaging an apparent BPF.[1,6,15] Although reported cases with peripheral BPF might have typical symptoms and a CT to evaluate the condition, we postulate that there may be BPF patients without typical symptoms who can be diagnosed on CT for the first time.

In this study, we searched retrospectively for how frequently BPF is found on CT in cases with known or suspected empyema or hydropneumothorax and the outcome of each case.

SUBJECTS AND METHODS

This study was approved by the institutional review boards of the 3 participating institutions. Informed consent was waived because this was a retrospective review of patient records and images.

First, we extracted the cases with a mention in the CT interpretation reports of empyema, its suspicion, or hydropneumothorax among the cases undergoing chest CT from January 2005 to December 2010. Cases were selected and tentatively diagnosed as having BPF if gas was present in a pleural effusion on the CT and if it was unlikely that air had entered the thoracic cavity from the outside, for example, by the insertion of a drainage tube.

One of the authors (S.M.) examined clinical records in these cases to determine if BPF was suspected clinically or radiographically. Also, the clinical record of the patient's course and follow-up CT images after the CT were investigated. If an empyema was confirmed to be caused by gas-producing bacteria, the case was not classified as a BPF case.

Also, we examined CT images in detail to determine the frequency of an apparent BPF, that is, continuation of a bronchus or the lung parenchyma to the pleural space in these cases. The CT

TABLE 1. Clinical Information and CT Findings of Cases With Peripheral Bronchopleural Fistula

Case No.	Age/Sex	BPF Demonstration on CT	Invasive Procedure to Thorax	Clinical Diagnosis/Status	CT Section Thickeness (mm)	CT or Clinical Diagnosis of BPF	Clinical Outcome	Thoracentesis After CT With HP
1	42/F	Yes	No	Pneumonia	2.5	—	Improved	Yes
2	64/F	Yes	No	Necrotizing pneumonia	2.5	—	Death due to multiple organ failure	Yes
3	58/M	Yes	No	Pulmonary abscess	2.0	Mention of BPF in CT report	Improved	No
4	54/M	Yes	No	Pulmonary tuberculosis	2.5	—	No follow-up	NA
5 right	69/F	Yes	No	Chronic tuberculous empyema	2.5	—	No change	Yes
5 left		Yes	No	Chronic tuberculous empyema	2.5	—	Improved	Yes
6	87/M	No	No	Pneumonia	2.5	—	Improved	Yes
7	65/M	No	No	S/P hepatectomy for hepatoma	5.0	—	Improved	Yes
8	77/M	Yes	Yes	S/P RFA for lung cancer	7.5	Mention of BPF in CT report	Improved	No
9	19/M	No	Yes	S/P VATS for pleural mass	2.5	—	No change	No
10	67/M	No	Yes	S/P resection of lung cancer	2.5	Clinical diagnosis of BPF	Improved	Yes (MRSA was detected)
11	53/F	No	Yes	S/P resection of metastatic lung cancer	1.0	—	Improved	No
12	26/F	No	Yes	S/P RFA for metastatic lung cancer	0.625	—	Improved	Yes

Case 5 had BPF bilaterally. In case 7, unintentional thoracentesis during abdominal drainage tube insertion (possible malpractice) was suspected.

RFA indicates radiofrequency ablation; VATS, video-assisted thoracic surgery; MRSA, methicillin-resistant *Staphylococcus aureus*; HP, hydropneumothorax; S/P, status post; F, female; M, male.

scanning was performed with multiple scanners: Lightspeed QX/I with 4-row detectors, Lightspeed VCT with 64-row detectors (GE Medical Systems, Milwaukee, WI), Aquilion 4 with 4-row detectors, Aquilion 64 with 64-detectors, and Aquilion ONE with 320-row detectors (Toshiba Medical Systems, Otawara, Tochigi, Japan). Chest CT images with 5- to 10-mm section thickness were acquired first, and subsequently, a thin-section CT with 0.625- to 2.5-mm section thickness was frequently added.

A detailed reinterpretation was performed by 5 diagnostic radiologists (R.I., M.T., N.T., H.K., and T.Y. with 5, 6, 6, 14, and 14 years of experience, respectively) without the knowledge of the patients' outcome to judge the presence of an apparent

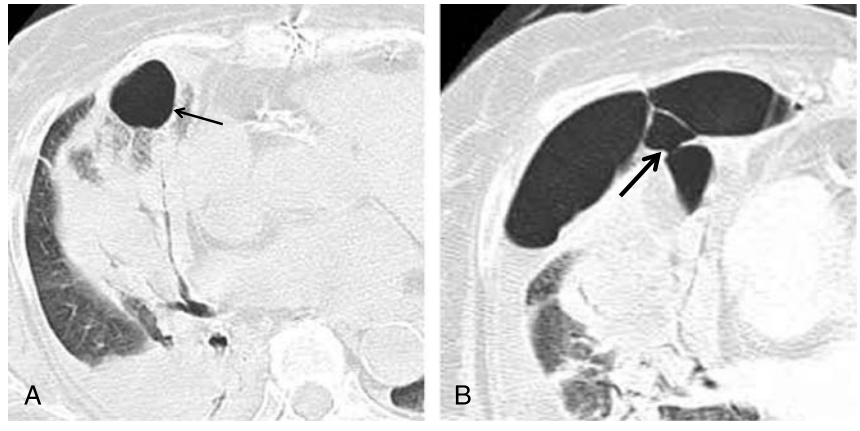

FIGURE 1. Case 2: A 64-year-old woman with necrotizing pneumonia. A, CT scans obtained in a woman who had persistent pneumonia show a cavitary, round lesion (arrow) in the consolidated right middle lobe that is a probable lung abscess. B, Follow-up CT scan obtained one month later demonstrates the air-containing abscess with an open communication (arrow) between the abscess and the pleural space. In this case, the fistula was not noted in the CT report. The patient died of multiple organ failure approximately 2 months later.

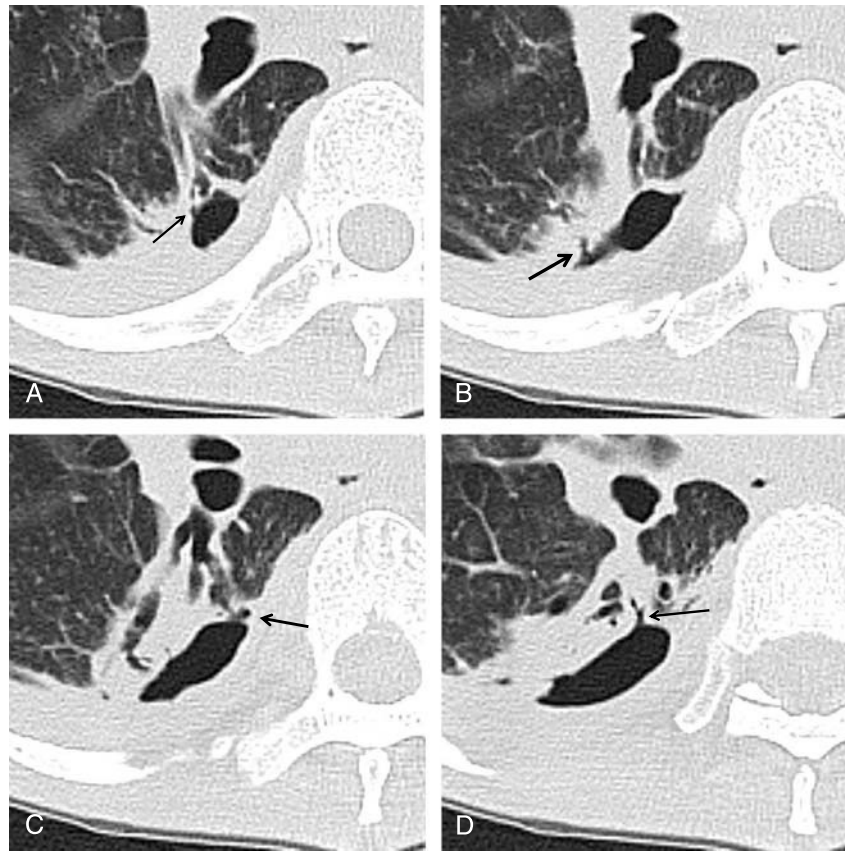

FIGURE 2. Case 3: A 58-year-old man with empyema. CT scan shows multiple ectatic airways (A–D, arrows) at the periphery of the right lower lobe, communicating with a pocket of pleural air. These defects are multiple peripheral bronchopleural fistulas. In this case, the fistulas were mentioned in the CT report. The fistulas were reduced during the course of conservative treatment.

BPF using axial images of the most thin section series by consensus, and the ratio of cases with an apparent BPF in them was calculated.

RESULTS

There were 35 CT reports that mentioned empyema, its suspicion, or a hydropneumothorax. Intrathoracic air was judged as not having entered the thoracic cavity from the outside of the body, for example, by the insertion of drainage tubes, in 12 cases. In 1 case, both the right and left thoracic cavities were involved; therefore, 13 thoracic cavities were included in this study. Table 1 shows the details about the clinical information and CT findings in each case.

Five cases underwent invasive procedures of the thoracic cavity before the CT scan, including 2 with lung tumor resection, 2 with radiofrequency ablation therapy for lung tumors, and 1 with surgical biopsy of a pleural mass. As for the other cases, 3 had tuberculous pleurisy or pneumonia, 2 had pneumonia, and 1 had necrotizing pneumonia. One case was suspected to have tube insertion error with thoracenteses during abdominal drainage.

A statement in the CT report about the presence of BPF was found in 2 cases. There was only 1 case in which BPF was suspected clinically because of an air leak. In this case, the communication of a bronchus or lung with the pleural space was not proven with the bronchoscope and could not be observed on CT. As for the other 9 cases, the diagnosis of BPF was not made. A pleural effusion needle aspiration or drainage was

FIGURE 3. Case 9: A 77-year-old man after CT-guided radiofrequency ablation therapy for a primary lung cancer. The CT shows a large parenchymal defect (arrow) in the tumor after radiofrequency ablation therapy, with communication to the pleural space in the setting of a localized pneumothorax. A parenchymal pleural fistula was mentioned in the CT report. The fistula and pleural air disappeared 2 months later.

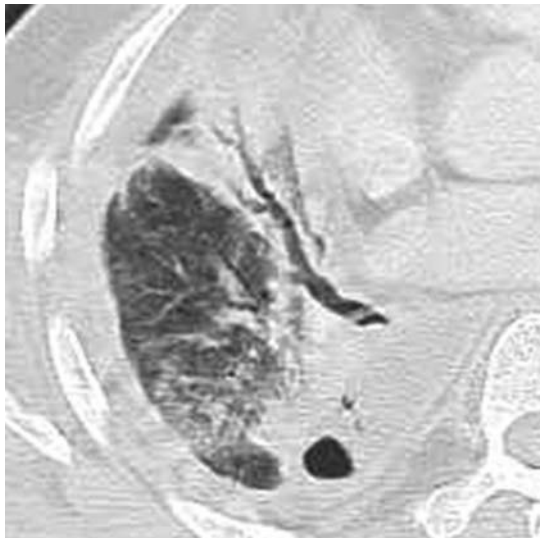

FIGURE 4. Case 10: A 67-year-old man after right lower lobectomy for a primary lung cancer. CT shows a hydropneumothorax secondary to an empyema due to methicillin-resistant *Staphylococcus aureus*. No apparent BPF is noted. Clinically, BPF was strongly suspected, but the empyema was cured by conservative medical therapy.

performed in 7 cases. The diagnosis of empyema caused by methicillin-resistant *Staphylococcus aureus* was made in 1 case, but the causative organism was not detected in the other cases.

Regarding continuation of a bronchus or the lung to the pleural space that is an apparent finding of BPF on CT, it was found in 7 of 13 (53%) thoracic cavities (Figs. 1–3) and not found in 6 (Fig. 4). Eleven thoracic cavities had images with thin-section CT ranging from 0.625-mm to 2.5-mm sections throughout the whole lung, where BPF was found in 6 of 12 (50%). The other 2 cases had 5-mm and 7.5-mm sections, respectively, without thin-section CT, and BPF was not demonstrated in the case of 5-mm section.

Regarding the outcomes of the patients, 1 died 1 month later due to multiple organ failure. This case was the patient with a pulmonary pleural fistula due to necrotizing pneumonia (Fig. 1). One patient was discharged subsequently after CT, and no information about outcome was obtained. In the other 4 cases (5 thoracic cavities), there was no exacerbation of the symptoms by BPF. In 3 of them, reduction or loss of hydropneumothorax on CT was observed, and in 1 case, it was constant. In all 6 cases with no apparent BPF on CT, no exacerbation of the symptoms and reduction or loss of hydropneumothorax on CT was observed.

DISCUSSION

Among the cases that we evaluated, 8 were diagnosed with BPF: 7 thoracic cavities in 6 cases with apparent continuation of a bronchus or the lung to the pleural space on CT, and 1 case without evidence of continuation of a bronchus or the lung to the pleural space, but with a clinically apparent air leak. For the other 5 cases, there was no clear evidence of BPF. Thoracentesis was not done in 3 patients who had had invasive thoracic procedures and in whom empyema due to gas-producing bacteria was not suspected. Therefore, we concluded that in these cases, the intrathoracic gas was due to BPF because it is clear that there was no possibility of having air flow into the thoracic cavity from outside of the body, nor was empyema due to gas-producing bacteria.

Except for a patient who died of multiple organ failure and a case with no follow-up information, there was no evidence for aggravation of the overall status by BPF or an increase in the hydropneumothorax in the other cases regardless of definite evidence of BPF on CT. Therefore, most cases in this study were improved by conservative treatment.

Ricci et al[1] report a correlation between CT findings and the need for interventions, such as the BPF closure operation in peripheral BPF. In their report, except for the cases of bullae in which a BPF is too small to depict by CT, a BPF closure operation was performed in 8 of 11 cases (73%) in which BPF was found on CT and in only 3 of 10 (30%) cases in which there was no detectable BPF.[1] They also analyzed in the same way the peripheral BPF not caused by bullae in 20 cases that Westcott and Volpe[6] reported. They operated or planned surgery for 4 of 10 cases (40%) with apparent BPF on CT, whereas in the cases with no apparent BPF, all underwent conservative treatment. Ricci et al[1] concluded that it was necessary to perform a closure operation when BPF was found on CT because it was larger than a BPF that was not found on CT.

In our survey, a closure procedure for BPF by surgery or bronchoscopy was not performed in all 12 cases probably for 2 reasons. First, an aggressive surgical intervention would not be performed in our institution for a case without an air leak. The other considerable reason is that only 2 cases had BPF documented in a CT report, and a clinician did not notice the presence of BPF in most cases. However, conservative treatment was successful in 10 of 11 patients who could be followed-up. Even in 5 cases with apparent BPF seen on CT and followed-up, conservative treatment worked in 4 cases (80%).

The conclusion of Ricci et al[1] is "because BPF observed on CT is large enough to be depicted on CT and too large to be cured by the conservative treatment, they may need surgical adaptation." Based on the results of the previous reports, it was uncertain whether a BPF large enough to be depicted on CT could be relieved even by conservative treatment. From the results of our data, we consider that initially, conservative treatment is enough, even if a peripheral BPF is found on CT.

However, we had a case of significant lung deficiency produced by necrotizing pneumonia shown in Figure 1. Although a surgical approach for disclosure of the BPF should have been performed, it was not done because both radiologists and clinicians did not notice its presence. In this case, we cannot deny that BPF led to an exacerbation of the respiratory status. When a large pulmonary defect communicating to the pleural space is depicted on CT, a recommendation for urgent interventional closure is probably necessary.

In conclusion, when initially there is hydropneumothorax on a CT image, whether it is caused by empyema or not, it is important that radiologists diligently search for findings of peripheral BPF and clearly describe it if present. However, a reference about the need for a surgical approach for BPF may not be required.

Because the present study is retrospective and the CT reports were searched by the key words of empyema, empyema suspicion, and hydropneumothorax, a question remains whether the search precisely extracted all cases of BPF. Also, the number of enrolled cases is too small to definitively prove the conclusion. Further prospective studies will be necessary to determine whether conservative treatment is enough for cases with apparent peripheral BPF observed on CT.

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