Can CT Scanning Be Used To Select Patients With Unilateral Primary Spontaneous Pneumothorax for Bilateral Surgery?*

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Study objectives: Despite advances in the surgical treatment of spontaneous pneumothorax, the timing of surgical intervention continues to be a subject of controversy. We test the hypothesis that CT scanning can help to predict the probability of the occurrence of primary spontaneous pneumothorax (PSP) by detecting lung bullae.

Design: Prospective, longitudinal cohort study.

Patients and methods: Between May 1994 to March 1995, 28 consecutive patients (23 men; age range, 18 to 47 years; mean, 29 years) with unilateral PSP who were to undergo video-assisted thoracic surgery (VATS) received preoperative CT of the thorax. CT scans were interpreted by one radiologist blinded to the clinical data for the presence of bullae in both lungs. All patients were followed-up in our outpatient clinic for an average of 59.0 months (range, 54 to 64 months).

Results: Eighty-eight percent of the blebs or bullae identified intraoperatively were demonstrated on preoperative CT scans. CT scans also showed the presence of lung blebs or bullae in the contralateral lung in 15 patients (53.6%). During the follow-up period, 4 of these 15 patients (26.7%) with contralateral blebs developed PSP in the untreated lung; none of the patients who did not have contralateral blebs (n = 13) developed PSP (p = 0.04 [χ² analysis]).

Conclusions: The detection of lung bullae by CT scanning in the contralateral lung following unilateral PSP is associated with a higher rate of subsequent occurrence of pneumothorax in that lung. Thus, CT scanning can be used to predict the risk of occurrence of this condition, allowing preemptive surgical intervention in selected patients.

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Key words: CT; predicting factors; spontaneous pneumothorax; video-assisted thoracic surgery

Abbreviations: PSP = primary spontaneous pneumothorax; VATS = video-assisted thoracic surgery

Primary spontaneous pneumothorax (PSP) is a common condition with significant socioeconomic impact. One of the key aims in the management of pneumothorax is to prevent recurrence. Without definitive surgical treatment, it has been estimated that the recurrence of PSP is 28% after 5 years of follow-up. With definitive treatment such as bullectomy and mechanical pleurodesis, this is reduced to 2 to 5%. With the advent of video-assisted thoracic surgery (VATS), the same procedure as in open surgery can be performed but with much reduced chest wall trauma, little postoperative pulmonary dysfunction, and less postoperative pain, resulting in a shorter hospital stay and earlier recovery. Conventional surgical algorithms were previously developed on the basis of morbidity associated with a standard thoracotomy. In the light of a new surgical approach carrying a much lowered operative morbidity, the previous indications for surgery may need to be reevaluated. The question now is could we select unilateral PSP patients who are at risk for developing contralateral PSP for bilateral surgery?

PSP is thought to result from the rupture of a small, thin-walled lung bulla. These bullae may not be readily visible on plain chest radiographs. CT scanning, however, has been shown to accurately...
detect such changes in the lung even if the chest radiograph looks normal.\textsuperscript{12-16} In a case-controlled study of nonsmoking, non-\textalpha;-antitrypsin-deficient patients with healed pneumothoraces, Bense et al\textsuperscript{14} showed that such patients had emphysema-like lung changes in the affected lung that were readily detectable by CT scanning. Nevertheless, what has not been convincingly demonstrated was whether the detection of such changes on CT scans should alter the strategy of surgical management.\textsuperscript{17}

The potential of CT scanning to predict the risk of PSP has been investigated. However, previous studies\textsuperscript{18,19} have been limited by small cohorts, short follow-up periods, and lack of controls. No statistical significance has been demonstrated so far on the predictive value of CT scans. This prospective, longitudinal study was specifically designed to explore further the use of CT scanning in detecting lung bullae and, hence, its use as a tool in predicting the risks of PSP.

**Materials and Methods**

Between May 1994 and March 1995, 31 consecutive patients who presented with unilateral PSP and planned to undergo ipsilateral VATS as definitive treatment were recruited for this study. Indications for surgery were recurrent PSP (n = 17), tension pneumothorax at presentation (n = 6), persistent air leak (n = 6), or patient occupation (eg, flight crew) (n = 2). We do not recommend surgery for an uncomplicated first-time pneumothorax.\textsuperscript{4} Two patients declined to participate in the study, and one other patient defaulted on follow-up; therefore, they were excluded from the final analysis.

The 28 remaining patients were studied after giving informed consent. There were 23 men and 5 women. Their ages ranged from 18 to 47 years, with a mean of 29 years. Eleven of the pneumothoraces were on the right side, and 17 were on the left. None of the patients had a personal or family history of \textalpha;-antitrypsin deficiency. None had any significant underlying pulmonary disease or any lung surgery before this admission.

All patients had a pneumothorax that was confirmed by chest radiograph on admission. Each pneumothorax was managed by tube thoracostomy and drainage with low suction before surgery. After reexpanding the lung and achieving a stable satisfactory clinical condition, a high-resolution CT scan of the thorax was performed on each patient. Plain CT scans (lung windows only) were performed using a spiral CT scanner (model B7999RP-CT HiSpeed Advantage RP Scanner; GE Medical Systems; Milwaukee, WI). A slice thickness of 1 mm and a section spacing of 10 mm were selected.

All CT scans were reviewed by the same radiologist, who was blinded to the clinical data. By convention, blebs are defined by the radiologist to be small air collections < 1 cm in diameter, as opposed to bullae, which are > 1 cm in diameter. Particular attention was focused on the detection of lung blebs or bullae in both the affected lung with the pneumothorax and the contralateral lung (Fig 1).

![Figure 1. Typical CT image of a PSP patient with bilateral apical lung bullae. Note that a chest drain is in place.](http://publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21950/)

Of the 28 patients, 22 (78.6\%) were found to have lung blebs or bullae on preoperative CT scans in the lung affected by PSP. No significant differences were found between the groups in clinical variables such as age, sex, and smoking habits. None of the VATS procedures required conversion to open thoracotomy. There was no mortality. On average, patients were discharged home on the second postoperative day. There was no significant postoperative morbidity found after discharge.

Of the 28 patients, 22 (78.6\%) were found to have lung blebs or bullae on preoperative CT scans in the lung affected by PSP, as is shown in Figure 1. Of the six patients with no preoperative CT evidence of lung blebs or bullae on the side of the pneumothorax, three were found to have such lesions during VATS. Thus, the overall sensitivity of CT scan in the detection of such lesions is 88\%. Among the 28 patients, CT scans showed the presence of lung lesions in the contralateral lung in 15 patients (53.6\%).
During the follow-up period, it was found that 5 of the 28 patients had subsequently developed PSP. Only one patient had a recurrent pneumothorax in the lung that had been operated on. It was noted that a bleb was not found radiologically or intraoperatively in this patient. The other four subsequent PSPs occurred in the contralateral lung at 3, 5, 16, and 22 months following the initial PSP presentation. The contralateral occurrence rate is, thus, 14.3% after an average follow-up period of 59.0 months (range, 54 to 64 months). All four patients were found to have lung blebs in the contralateral lung on preoperative CT scans. Hence, contralateral PSP occurred in 4 of 15 patients (26.7%) in the study group. None of the 13 control patients, who had no contralateral lung blebs or bullae on CT scans, developed contralateral PSP during the follow-up period.

These results indicate that the detection of contralateral lung blebs or bullae by CT scans is associated with a significantly higher risk (26.7%) of developing PSP in that lung subsequently compared to lungs in which no such lesions are found (p = 0.04).

**Discussion**

We found that 88% of the lung blebs or bullae that were identified intraoperatively could be detected preoperatively by CT. This detection rate is comparable to that previously reported. In this study, the only case of recurrence occurred in a lung that had been operated on in which lung blebs could not be identified intraoperatively, confirming the previously reported significance of the failure to detect lung blebs intraoperatively as a predictor of recurrence.

Of particular interest in this study are the blebs in the contralateral lung, which is essentially a “virgin” lung at the time of first presentation. Earlier studies have demonstrated contralateral occurrence rates after a unilateral PSP to be approximately 5.2 to 14.6%. However, if contralateral blebs could be seen on plain chest radiography, that rate rose to 29%. CT scanning is superior to plain chest radiography in the detection of emphysema-like changes in the lung. In our study, more than half of the patients (53.5%) with unilateral PSP were found to have lung blebs or bullae in the contralateral lung that were apparent on CT scans.

Over a mean follow-up period of 59 months after the initial unilateral PSP, 26.7% of the patients in our series who had contralateral blebs that were seen on CT scans developed contralateral occurrences compared to none in the control group. Therefore, positive CT scan findings are associated with significantly higher contralateral occurrence after unilateral PSP. This group of patients may, therefore, benefit from early surgical intervention to preempt PSP occurrence.

Considering the use of CT scanning for this purpose, the sensitivity of the CT scan obviously will depend on the protocol used for scanning. We used 1-mm thick slices with 10-mm section spacing. Although our CT study may have missed smaller blebs, this study yielded detection rates that were comparable to those in other studies using finer section spacing. It is technically possible to achieve much closer section spacing, but this would entail greater costs, as well as greater demand on CT scanning time. Whether using more rigorous scanning protocols will give higher bleb detection rates is debatable, and further study is needed to define the best CT scanning protocol. On a more practical note, however, we realize that CT scanning is both expensive and not readily accessible in many centers for routine scanning of PSP patients. It is envisaged that further clinical trials will be necessary to determine the cost-effectiveness of this approach.

Besides the actual protocol used, one must also consider how to evaluate the findings on the CT images produced. It has been proposed that CT detection of very minute emphysematous-like changes in the lung may be irrelevant to the overall management of patients at risk for PSP. Warner et al have suggested that quantifying the CT findings using a scoring system based on the size and number of blebs seen may enhance the predictive value of CT scans for PSP occurrence, even though no statistical significance was found. We have tried the scoring system of Warner et al in the current study. However, we could not find any correlation between that score and the subsequent occurrence of PSP. This finding tends to suggest that the mere detection of the presence of contralateral blebs or bullae on CT scans is sufficient as a predictor of future contralateral PSP occurrence and that detailed quantification may not be necessary. This observation may need to be confirmed in a larger study.

The concept of using CT scanning to detect apical bullae in the management of PSP has been put forward previously. However, to our knowledge, this is the first controlled study investigating the use of CT scanning in selecting PSP patients for bilateral surgery. The idea of bilateral surgery for unilateral PSP is not new. Baronofsky et al advocated this approach in 1957. The differences here are the following: (1) we now have a much less traumatic approach for the surgical management of this condition, and simultaneous bilateral VATS procedures...
have been shown to be well-accepted by patients; we now have a much more refined imaging modality; and we are only offering this procedure to selected patients. Based on the findings of our study, we have since offered bilateral surgery to an airline flight crew member and to a frequent air traveler as a result of findings on their CT scans. Also, we now recommend CT scanning to selected patients with PSP who wish to know more about the status of their contralateral lung with a view to preemptive bilateral surgery, as well as to patients who are in “high-risk” occupations (like scuba diving) and to those who are unreliable to return for follow-up. We emphasize selected groups because for the majority of patients, we do not currently recommend routine preoperative CT scanning of the thorax, outside of an investigational protocol setting because of the additional resource implication.

In conclusion, we have demonstrated the predictive value of CT scanning in the management of PSP. Further prospective randomized studies to better define the cost-effectiveness of this approach are warranted.

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