AJR FOCUS ON:

CT-Guided Lung Biopsies: Pleural Blood Patching Reduces the Rate of Chest Tube Placement for Postbiopsy Pneumothorax

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OBJECTIVE. The objective of our study was to determine whether pleural blood patching reduces the need for chest tube placement and hospital admission for pneumothorax complicating CT-guided percutaneous lung biopsy.

MATERIALS AND METHODS. We reviewed 463 CT-guided lung biopsies performed between August 2006 and March 2010 to determine whether intervention for pneumothorax was required and patient outcome. Intervention was categorized as simple aspiration, aspiration and intrapleural blood patching, or chest tube placement and hospital admission. The technique for pleural blood patching consisted of complete pneumothorax aspiration, immediate placement of up to 15 mL of peripheral autologous blood into the pleural space, and positioning the patient in the ipsilateral decubitus position for 1 hour after the procedure.

RESULTS. Intervention for pneumothorax was necessary in 45 of 463 patients (9.7%) and 19 of 463 patients (4.1%) required chest tube placement. Pleural blood patching as a method to treat a postbiopsy pneumothorax and avoid further intervention was associated with a significantly higher success rate than simple aspiration: 19 of 22 (86.4%) vs seven of 15 (46.7%) (odds ratio = 7.2, $p = 0.03$), respectively.

CONCLUSION. Aspiration with intrapleural blood patching is superior to simple aspiration to treat pneumothorax associated with CT-guided lung biopsy. Pleural blood patching reduces the need for chest tube placement and hospital admission in this patient population.

Percutaneous CT-guided lung biopsy is a commonly performed image-guided procedure worldwide. Although lung biopsy is generally considered to be safe, pneumothorax occurs in approximately 20–53% of cases, and chest tube placement is required in 2–14% of cases [1–7]. Placement of a chest tube often requires hospital admission for observation, and multiple chest radiographs are necessary before tube removal. Reducing the rate of chest tube placement after percutaneous lung biopsy would decrease the morbidity associated with chest tube placement and hospitalization and would reduce biopsy-associated costs [8, 9]. Studies have shown the feasibility of using small-bore catheters to aspirate the pneumothorax at the conclusion of the biopsy, with immediate removal of the catheter (simple aspiration). Although these studies reported successful same-day patient discharge in many cases because of decreased rates of chest tube placement [10–12], in our anecdotal experience, the rate of recurrent pneumothorax requiring additional intervention and observation after simple aspiration has remained unacceptably high.

In an effort to further decrease postbiopsy chest tube and hospital admission rates, we modified the simple aspiration technique to include intrapleural instillation of autologous blood (pleural blood patching) in an attempt to seal the source of air leakage. High-volume pleural blood patching is well established in thoracic surgery where it has been shown to be effective in treating persistent air leaks [13–18]. Although the use of intraparenchymal autologous blood patching has been shown to decrease the incidence of postbiopsy pneumothorax [19–21], we are not aware of a study that investigates intrapleural blood patching to treat pneumothorax after CT-guided percutaneous lung biopsy. The purpose of this study was to retrospectively compare simple aspiration versus aspiration with pleural blood patching for the treatment of postbiopsy pneumothorax.

Keywords: blood patching, chest tube, CT-guided biopsy, lung biopsy, pneumothorax

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Materials and Methods

Our institutional review board approved this retrospective HIPAA-compliant study. All patients undergoing lung biopsy provided written informed consent at the time of the procedure for both the biopsy and possible treatment of a complicating pneumothorax.

Patients and Procedures

All procedures were performed by an experienced subspecialty-trained attending radiologist or by a trainee (fellow or resident) under the direct supervision of an attending radiologist. CT guidance was used with a coaxial technique using 19- to 21-gauge introducer needles. Ultrasound guidance was used for select peripheral nodules. Fine-needle aspiration or core biopsy was performed depending on the opinion of the attending radiologist. Factors contributing to the final decision regarding biopsy type included the size, location, and suspected histology of the lesion. All procedures were performed while the patient was under conscious sedation with IV fentanyl and midazolam (Versed, Roche Laboratories).

Before February 2008, the primary interventions for a pneumothorax were simple aspiration followed by observation with serial chest radiographs or chest tube placement with subsequent hospital admission. The indications for chest tube intervention for a pneumothorax included a rapidly expanding, large, or symptomatic pneumothorax or a medically tenuous patient with a pneumothorax. Simple aspiration was generally performed through either the indwelling introducer needle or a separately inserted 5-French catheter (Yueh Centesis, Cook Medical). Simple aspiration consisted of active removal of air from the pleural space by either syringe suction via a three-way valve or wall suction as needed. If the pneumothorax could be controlled with aspiration—that is, if it did not rapidly reaccumulate, the patient was placed biopsy side down and transferred to our recovery unit to undergo both clinical and radiographic follow-up. If the pneumothorax rapidly reaccumulated so the patient could not be safely transferred to the recovery unit, simple aspiration was considered to have failed and a chest tube was placed. Even after the development of a pneumothorax, every effort was made to complete the procedure.

In February 2008, we introduced pleural blood patching to our practice. The technique involves complete aspiration of the pneumothorax through the introducer needle or a 5-French Yueh Centesis catheter, placement of up to 15 mL of autologous blood into the pleural space, immediate catheter withdrawal, and placement of the patient with the biopsy side down for 1 hour. After pleural blood patching, patients were observed for 4 hours and were followed with serial chest radiographs. Asymptomatic patients with stable or improved radiographic findings were discharged 4 hours after the procedure, but if the patient became symptomatic or the pneumothorax enlarged, a chest tube was placed and the patient was admitted to the hospital. For four of the patients in this group, treatment by simple aspiration alone had failed and pleural blood patching was subsequently performed.

Data Collection

This HIPAA-compliant study was approved by the human subjects committee of our institutional review board with a waiver of informed consent. We performed a retrospective review of 463 lung biopsies performed from August 2006 to March 2010. Patients who required intervention for a pneumothorax were identified, and both patient and procedural data were recorded including the age and sex of the patient, nodule size, depth from the pleura to the nodule along the needle track, size of the introducer needle, number of fine-needle aspiration passes, number of core biopsy passes, time of onset of a significant pneumothorax with respect to the biopsy procedure, nature of the intervention (simple aspiration, pleural blood patching, immediate chest tube placement), and amount of autologous blood used for the pleural patch. Patient follow-up included a telephone call the day after the procedure to check on the patient. In addition, for the purposes of this study, a medical record review was performed to identify any delayed or missed complications. The clinical outcome of the patient was determined and recorded.

Statistical Analysis

No cases were excluded from analysis. The overall rate of chest tube placement with hospital admission was determined and the success rate of simple aspiration was compared with the success rate of pleural blood patching as a treatment of pneumothorax. Success was defined as same-day discharge without further intervention and failure was defined as further intervention with either pleural blood patching (in the case of simple aspiration) or chest tube placement with hospital admission. For real-value variables such as age, Welch t tests were used. Binary variables were tested with a Fisher exact test. All p values were based on two-sided tests; p values less than 0.05 were considered statistically significant.

Results

A total of 463 lung biopsies were performed during the study period. Intervention for pneumothorax was necessary in 45 of 463 patients

TABLE 1: Clinical and Procedural Characteristics of Patients With Biopsy-Associated Pneumothorax That Required Therapy

Characteristic	Simple Aspiration	Pleural Blood Patching	*p*
Age (y)			1.0
Mean	65.1	66.0	
SD	10.4	11.5	
Sex (% of patients)			0.75
Female	29	36	
Male	71	64	
Needle used			
21 gauge	0	1	
20 gauge	14	12	
19 gauge	3	15	
No. of FNA passes			0.41
Mean	4.4	3.8	
SD	2.5	2.0	
Size of nodule (cm)			0.02
Mean	1.5	2.2	
SD	0.3	1.5	
Distance from pleura to nodule (cm)			0.63
Mean	2.5	2.2	
SD	1.8	2.4	

Note—FNA = fine-needle aspiration.

(9.7%) and 19 of 463 patients (4.1%) required chest tube placement. The demographic and procedural details for patients who required intervention are provided in Table 1.

Of the 45 cases requiring intervention, the operator elected to immediately place a definitive chest tube in three patients, including one patient with a prior contralateral pneumonectomy. Case management and intervention are summarized by the flowchart shown in Figure 1. Simple aspiration was performed in 15 cases. Of the 15 cases treated with simple aspiration, simple aspiration failed in eight cases (53.3%): Chest tube placement followed by hospital admission was required in four cases (Fig. 2) and a pleural blood patch as a salvage procedure was required in four cases (Fig. 3). In 18 patients, pleural blood patching was immediately performed. Of the 22 patients treated with pleural blood patching, three patients (13.6%) eventually required chest tube placement and hospital admission; however, of the four patients who underwent pleural blood patching as a salvage technique because simple aspiration failed, all four were successfully discharged the same day as the biopsy. Pleural blood patching failed in three patients, but all were noted to have enlarging pneumothoraces and clinical symptoms while being followed in the recovery unit after the procedure. Nine patients had pneumothoraces that were asymptomatic or stable initially but became symptomatic or enlarged during postprocedure monitoring (eight cases) or after discharge (one case). These patients were all treated with chest tube placement (1 hour to 3 days after the conclusion of the biopsy procedure) and hospital admission.

The majority of patients who required chest tube placement during the study period (12/19, 63.2%) were patients in whom neither aspiration nor pleural blood patching was attempted or patients in whom a delayed pneumothorax developed and a chest tube was placed as the sole treatment. Overall, taking into account the four patients in whom failed simple aspiration was followed by successful pleural blood patching, the rate of success for pleural blood patching was significantly higher than that for simple aspiration: 19 of 22 (86.4%) versus seven of 15 (46.7%) (odds ratio = 7.2, $p = 0.03$), respectively. There were no known complications of the pleural blood patching technique.

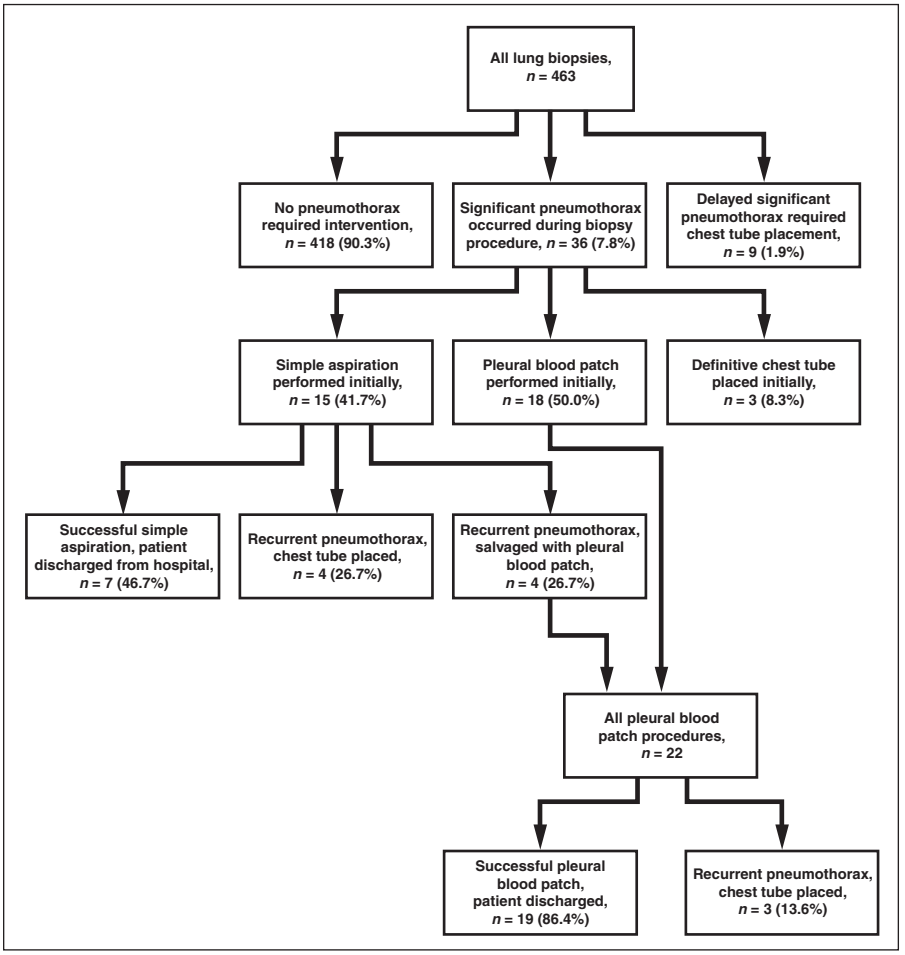

Fig. 1—Flowchart summarizes patient management and interventions.

Discussion

Pneumothorax is a common complication of CT-guided lung biopsy and often requires chest tube placement and patient hospitalization. Simple aspiration of a pneumothorax was successful in only 47% of cases (Fig. 1), whereas combined aspiration with intrapleural blood patching was successful in 86% of cases, decreasing the need for chest tube placement after CT-guided lung biopsy. Because chest tube placement usually results in hospitalization, the intrapleural blood patching technique has the potential to decrease medical expenditures and patient inconvenience.

In 1996, Yankelevitz et al. [10] described manual aspiration of a pneumothorax after a biopsy procedure via an 18-gauge IV catheter, immediate removal of the catheter, and placement of the patient in the ipsilateral decubitus position. They found that this technique eliminated the need for chest tube insertion in 12 of 17 cases (71%). In 2009, Yamagami et al. [12] reported a large series in which manual aspiration was successful in avoiding chest tube placement in 84 of 112 cases (75%). Our success rate with pleural blood patching (86%) exceeds the previously published rates with simple aspiration and is significantly better than our success rate with simple aspiration (47%).

The reason for our low rate of success with simple aspiration is unclear but may be related to the fact that we have a somewhat biased patient population: We have two services that perform biopsies in our institution, and for historical reasons, our service tends to be referred patients with more comorbidities (especially pulmonary) and those with small lesions. Thus, the patient population may be more susceptible to both pneumothoraces and failure of simple aspiration. The higher success rate with pleural blood patching achieved in this study population is in spite of the fact that we have been increasing the number of core biopsies that we perform, which means that there was an increase in the number of core biopsies and in the size of the introducer needle used in patients who had pleural blood patching (added later in

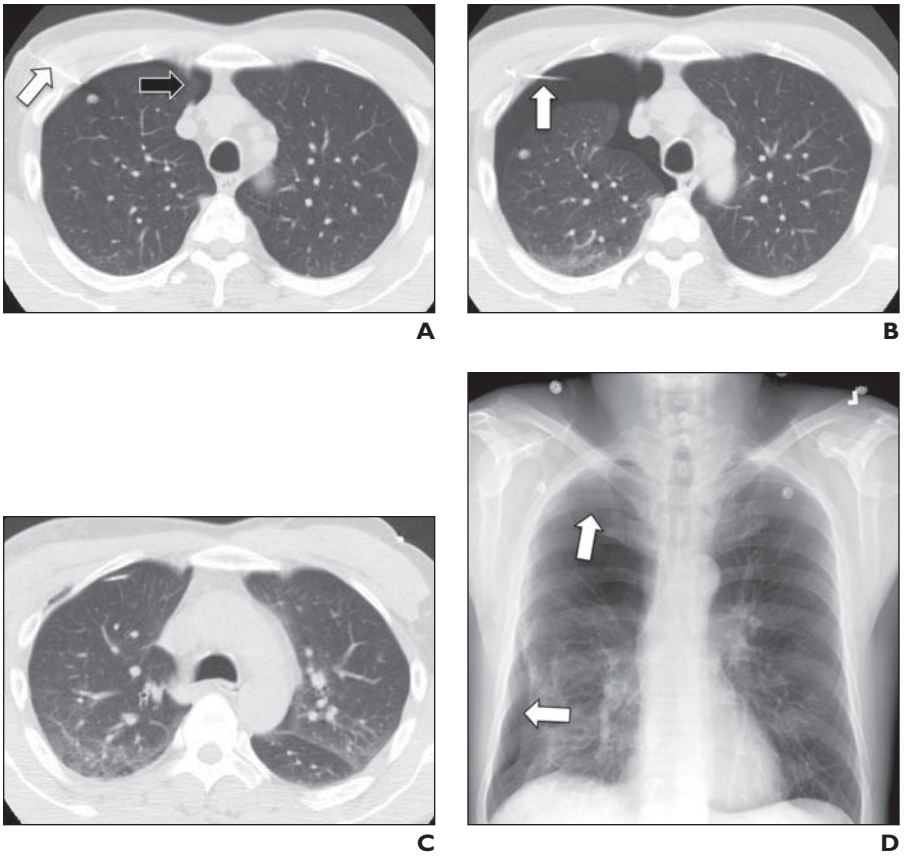

Fig. 2—50-year-old man undergoing biopsy of 8-mm right upper lobe pulmonary nodule.
A, Soon after biopsy needle (*white arrow*) was placed, pneumothorax (*black arrow*) developed. Pneumothorax enlarged and was interfering with targeting.
B, Therefore, 5-French catheter (Yueh Centesis, Cook Medical) was placed in pleural space (*arrow*) and air was aspirated to allow procedure to be completed.
C, At end of procedure, air was again completely aspirated, tube was removed, and patient was observed in recovery unit.
D, Follow-up chest radiograph obtained 2 hours after biopsy reveals significant pneumothorax (*arrows*) has developed; also, patient was having increased difficulty breathing. Therefore, chest tube was placed and patient was admitted to hospital.

our program) as compared with the patients who underwent simple aspiration. Additionally, in a series by Yamagami et al. [12], the overall chest tube placement rate was 33 of 642 (5.1%). Our chest tube placement rate of 4.1% is slightly lower, likely because of the high success rate of pleural blood patching as a method to decrease chest tube placement.

Although simple aspiration is a valuable technique, we believe that the addition of a pleural blood patch imparts increased benefit with little added cost, risk, or procedural time. In our series, four patients underwent simple aspiration initially and simple aspiration failed, so pleural blood patching was performed as a salvage therapy. Although this sample is small, it is worth noting that all four of these patients were discharged the same day as the procedure, thus directly illustrating the additional benefit that can be derived from a pleural blood patch (Fig. 2).

The pleural blood patch technique described in this article is a modification of a procedure that has been previously described in the postlobectomy setting [13–18]. Shackcloth et al. [14] reported a randomized controlled trial in which patients with persistent air leak on the fifth day after lobectomy were randomized either to instillation of 120 mL of autologous blood into the pleural space via the existing chest tube or to continued pleural drainage (with crossover and pleural blood instillation on the 10th postoperative day if needed). The time to chest tube removal (median, 6.5 vs 12 days) and hospital discharge (8 vs 13.5 days) were both significantly less in the intervention group.

The proposed mechanism of action of pleural blood patching is formation of a patch of clotted blood that adheres to the site of air leakage [17]. In the postsurgical setting, 50–150 mL of blood is commonly used for this procedure [17]. In our experience with pleural blood patching, we have used a much smaller volume (4–15 mL). Potentially, this smaller volume is successful because we are injecting the blood at the pleural puncture site and then immediately positioning the patient so that the biopsy site is as dependent as possible. It is possible that a larger volume of blood could be beneficial and perhaps more efficacious. For instance, we postulate that the failure of pleural blood patching in one case was related to a needle trajectory that crossed the minor fissure and to incomplete aspiration of the pneumothorax. Thus, the blood patch was not able to be applied directly to the puncture site and a larger volume of blood may have resulted in a better outcome.

Delayed or slowly developing pneumothoraces in our study were treated with immediate chest tube placement. The role of both simple aspiration and pleural blood patching is unclear in these patients. Both techniques were used only during or immediately after the biopsy procedure. During our study period, nine patients who had no significant pneumothorax at the conclusion of the procedure developed a pneumothorax that required chest tube placement and hospital admission after initial discharge. All of these patients had at least a small pneumothorax on a radiograph obtained 1 hour after biopsy. Similar to our results, Yamagami et al. [12] reported five patients with delayed-onset pneumothorax. All of the cases of delayed pneumothorax in our study group were treated with chest tube placement. We have never attempted pleural blood patching in the setting of a delayed pneumothorax, but it is possible that this technique would be successful in these patients.

This study has several limitations including its retrospective design. The primary comparison in this study is between groups of patients having lung biopsy procedures before and after we began using pleural blood patching to treat pneumothorax. Although we are not aware of any other significant change in our biopsy practice during the study period, the study design does not allow us to completely control for confounding variables. A second potential limitation is the lack of a standardized procedure for pleural blood patching, with use of varying volumes of blood. All pleural blood patch procedures had the following steps in common: aspiration of the pneumothorax as completely as possible, instillation of autolo-

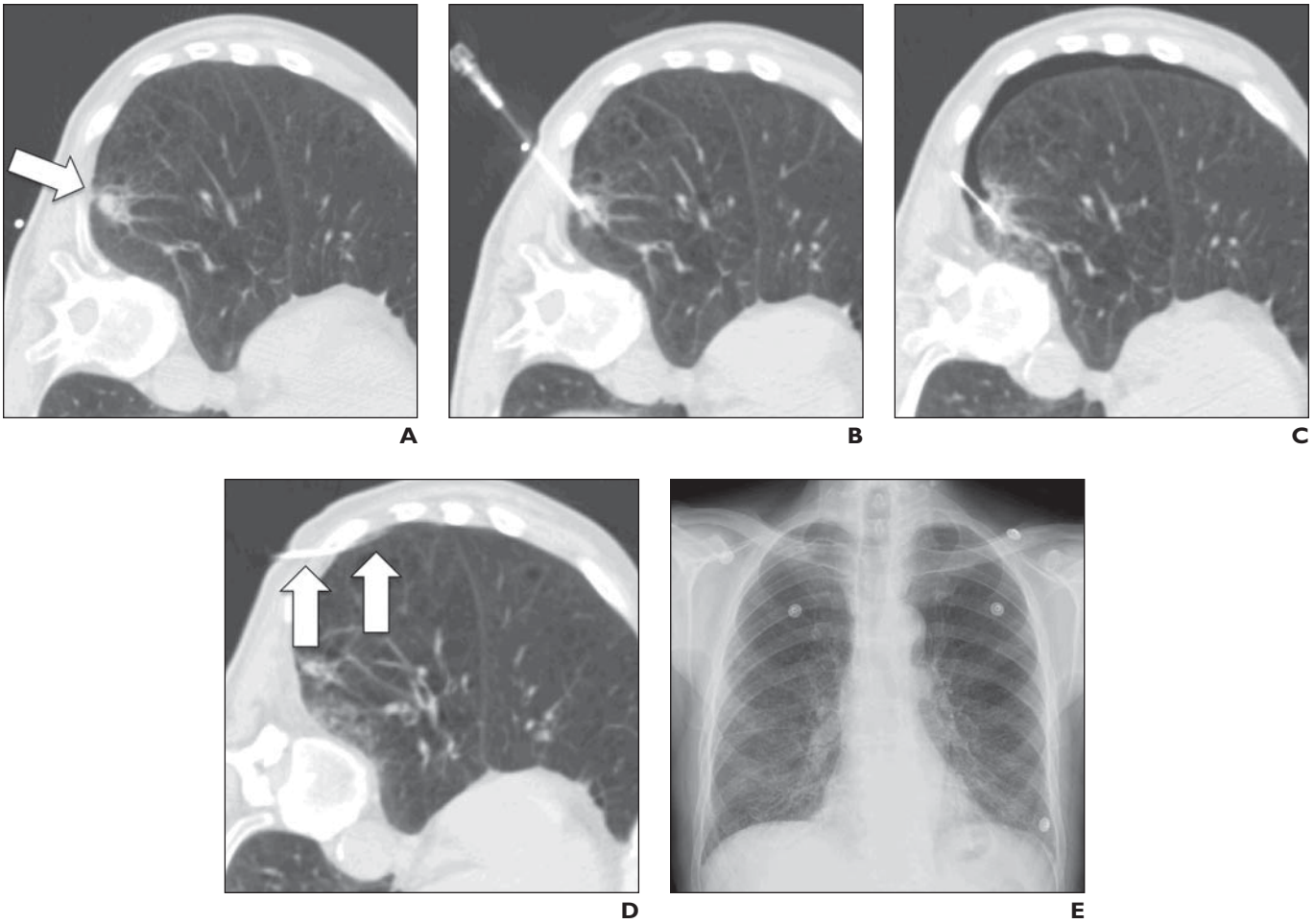

Fig. 3—73-year-old man with severe emphysema undergoing biopsy of spiculated 1.4-cm right lower lobe pulmonary nodule.
A, Decubitus unenhanced CT image obtained before biopsy shows nodule (*arrow*) within subpleural space of right lower lobe.
B, Initial placement of introducer needle was satisfactory and fine-needle aspiration was performed.
C, Initial cytology specimen was not adequate and repeat sampling was requested. During interval, pneumothorax developed and needle moved.
D, Next, 5-French catheter (Yueh Centesis, Cook Medical) was placed (*arrows*), and repeated aspiration of air allowed procedure to be completed satisfactorily. However, pneumothorax continuously reaccumulated after simple aspiration. Therefore, pleural blood patch was placed.
E, Follow-up chest radiograph obtained 3 hours after procedure shows pneumothorax has not recurred. Patient was successfully discharged from hospital later the same day as biopsy.

gous blood into the pleural space, and placement of the patient in the ipsilateral decubitus position. As we have developed more experience with the technique, the variation has decreased and a consensus about the volume of blood to be used (i.e., at least 15 mL) has developed. Another potential limitation of the technique is the theoretic risk for inducing pleural adhesions. However, patients who require chest tube placement are likely to develop more significant adhesive disease than these patients and the volume of blood administered for pleural blood patching remains quite small.

In conclusion, pleural blood patching is a useful technique that appears to decrease the need for chest tube placement in patients who have a pneumothorax requiring intervention after CT-guided lung biopsy. Pleural blood patching adds little time, risk, or cost to the treatment of a postbiopsy pneumothorax but has the potential to benefit patients and to save resources by reducing the rate of chest tube placement and hospitalization after lung biopsy.

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