

Is the rapid needle-out patient-rollover approach after CT-guided lung biopsy really effective for pneumothorax prevention?

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Introduction

Percutaneous CT-guided lung biopsy (PCLB) is a frequently performed procedure for sampling lung lesions. Pneumothorax is the most common complication of PCLB (range, 4-60%), requiring chest tube insertion in 0.2-8% procedures (1). Insertion of chest tube not only increases the procedure related morbidity, but also increases the hospital stay. Pneumothorax rates vary widely in different series depending on the technique, equipment used, size of lesions targeted and whether pneumothorax was defined on a chest X-ray or post procedure CT. High detection rate of pneumothorax on immediate post procedure CT scans are due to the high sensitivity of CT for detecting even very little pleural air.

Factors associate with risk of post biopsy pneumothorax

Several studies have assessed the factors associated with risk of post biopsy pneumothorax and implicated various factors; however, there is no consensus opinion (1-3). The factors may be broadly classified as those related to the patient characteristics, lesions characteristics or to the procedure technique. Patient related risk factors include, age more than 60 years, chronic obstructive pulmonary disease (COPD), bulla and emphysema in the needle path. COPD and emphysema are strong risk factors for occurrence of pneumothorax requiring chest tube drainage. Lesion related risk factors include small lesion size, greater lesion depth and whether aerated lung was transgressed. Lesions <2 cm are technically difficult to target, requiring more needle redirections, and sometimes multiple pleural punctures. A

deep lesion location is associated with more complications as more aerated lung is violated and needle redirection is usually needed. While biopsy from larger lesions in contact with pleura is easy; tiny sub-pleural lesions are notoriously difficult to target and associated with a high rate of pneumothorax (2). Tiny subpleural lesions allow shallow needle anchoring, which is prone to dislodgement. Often the overlying ribs prevent access to small subpleural lesions and if the initial puncture misses the lesion, there is no space for needle manipulation and invariably a second puncture is required. Similarly, small lower lobe lesions are more difficult to target, due to positional variation with respiratory movement. Needle inserted in the lower lobes is more unstable due to excessive movements with respiration resulting in chances of needle dislodgment and pleural tear.

Procedure related factors associated with risk of pneumothorax include, a less experienced operator, technically difficult biopsy, needle insertion less perpendicular to pleura, longer procedure duration and multiple needle passes. Presence of pleural thickening and previous surgery has been associated with lower chances of pneumothorax (3). Although patient and lesion related risk factors cannot be changed, improvisations in lung biopsy technique include choosing a short needle path, avoiding aerated lung, avoiding fissures, avoiding bulla and emphysematous lung, use of co-axial technique to obtain multiple samples and avoiding multiple pleural punctures (4,5). Moore has suggested that limiting pleural punctures to one is an important approach towards reducing pneumothorax (5). CT fluoroscopy is an important development, which allows real time monitoring of the needle towards the lung lesion (6). Although CT

fluoroscopy is associated with radiation exposure to the operator's hand; it is very useful for targeting lung lesions, which move frequently with respiration.

Maneuvers for minimizing post biopsy pneumothorax

Various maneuvers for minimizing post biopsy pneumothorax have been described. These include simple activity restrictions like recumbent positioning, and refraining from coughing, excessive talking, straining, or sitting up unassisted (5). Injection of various substances like autologous blood, Gelfoam or normal saline, into the needle path while withdrawing the introducer needle, have been shown to reduce post biopsy pneumothorax and may be considered for high risk patients (4,5,7). However, these interventions are not widely followed.

In 1982, Zidulka *et al.* demonstrated the effect of puncture-site down positioning, on the rate of pneumothorax formation in a dog model (8). They proposed that placing the site of pleural air leak in a dependent position causes reduction in alveolar size and alveolar to pleural pressure gradient, resulting in decreased rate of pneumothorax formation. In 1990, Cassel and Birnberg have described the effect of placing patients in the needle puncture-site down position, immediately after needle removal and leaving them in that position for 3 hours (9). They reported a decrease in the incidence of postbiopsy pneumothorax from approximately 20% to 5% and the incidence of pneumothorax that necessitated treatment from approximately 10% to 0%. Puncture-site down positioning results in good apposition of the two pleural layers as the air collects in a non-dependent position and the weight of the lung moves puncture-site into a dependent position. Moreover, hemorrhagic fluid also accumulates in dependent position around the puncture-site; all contributing in sealing of leakage site. As puncture-site down positioning after biopsy is a simple and non-invasive technique, it has been widely adopted and many investigators have reported favorable results.

In 1991, Moore *et al.* studied the effect of patient positioning after needle aspiration lung biopsy (10). Patients were placed in a recumbent position with puncture site down (n=36) or up (n=19) for at least 1 hour. Although the pneumothorax rate was not different in the two groups; chest tube placement was required in 3% patients of puncture-site down group and 21% patients of puncture-site up group. Kinoshita *et al.* did modifications in the CT table, which allowed the entire lung biopsy from a puncture-

site down approach (11). They constructed a "puncture window" on the CT table with a needle holder attached from below. Pneumothorax was seen in 12.9% patients, with 2.7% requiring chest tube placement. However, the practice of performing biopsy from a puncture-site down approach is difficult in routine practice. Some authors have not found the technique of puncture-site down positioning effective for pneumothorax prevention (12-14). Collings *et al.* in 210 needle biopsies, shown that puncture-site down post biopsy positioning does not reduce the incidence of pneumothorax or pneumothorax requiring chest tube placement (12).

Due to controversy over the effect of puncture-site down positioning over pneumothorax rate, O'Neill *et al.* conducted a study in year 2008-2009 (15). They assumed that the differences in the needle-out patient-rollover time could be the main cause of the controversy on the effect of the puncture-site down position. Eighty-one biopsies were performed without (group 1) and 120 were performed with a rapid needle-out patient-rollover approach (group 2). Although in both groups, the patients were rolled on to the stretcher passively with manual assistance from procedural staff and put in puncture-site down position; in group 2 it was rapidly done after removing the needle. No post procedure CT was done and erect chest X-ray was done 1 and 4 hours later. In symptomatic patients, radiographs were obtained immediately. Asymptomatic patients were maintained in the assigned recumbent position for 1 hour and then allowed to sit upright. They found that a rapid needle-out patient-rollover time of approximately 10 seconds significantly decreased the rate of pneumothorax (37% *vs.* 23%) and pneumothorax necessitating drainage catheter placement (15% *vs.* 4%). Use of rapid rollover technique attenuated the effect of risk factors like emphysema, more needle redirections and more pleural punctures per patient. In a review article in 1998, Moore EH has also emphasized that to achieve the full effect of the puncture-site down position, it should be done immediately after needle withdrawal.

Kim *et al.* recently published their experience on effect of rapid needle-out patient-rollover approach over pneumothorax rate after cone beam CT-guided lung biopsy (16). They conducted a retrospective study on 1,227 patients using a CBCT system (Allura Xper FD20; Philips Healthcare, The Netherlands) with virtual guidance system (XperGuide software, Philips Healthcare, The Netherlands). A 17-gauge coaxial introducer with an 18-gauge cutting needle was used in all patients. The first (conventional) group of their study included 617 lung

biopsies done from May 2011 to Feb 2012, in which after needle withdrawal, first a post-procedural CT was done in same position and reviewed by the operator, and then the patients were shifted over onto a stretcher in puncture-site down position. In the second (rapid-rollover) group, from March 2012 to December 2012, 610 patients were rolled over on the CT table itself, into a puncture-site down position as quickly as possible and then post procedure CBCT was acquired in puncture-site down position. Mean needle-out patient-rollover time in the rapid-rollover group was 24.6 ± 9.2 seconds. There were no significant differences in overall pneumothorax rates between conventional and rapid-rollover groups (19.8% *vs.* 23.1%). However, pneumothorax requiring drainage catheter placement was significantly lower in rapid-rollover-group (1.6%) than conventional group (4.2%). They speculated that higher rate of overall pneumothorax; particularly pneumothorax occurring immediately after biopsy in the rapid-rollover group might be due to the uncontrolled respiration of the patient during the vigorous turnover on a narrow CBCT table, potentially facilitating air leaks through the puncture site. Interestingly, the incidence of delayed pneumothorax (3 hour or later) in the rapid-rollover group was substantially lower than the conventional group, suggesting early sealing of pleura in rapid-rollover group.

In cases of post biopsy pneumothorax, some techniques have been proposed to reduce its progression. Yamagami *et al.* have suggested that percutaneous manual aspiration of post biopsy pneumothorax performed immediately after biopsy may prevent further progression of pneumothorax and subsequent chest tube placement (17). In their study, if the post biopsy pneumothorax was moderate or large, it was manually aspirated with an 18-gauge Angiocath. Immediate manual aspiration of excess pleural air allows better re-approximation of visceral and parietal pleura and prevent further air leak. They also speculated that performing immediate percutaneous aspiration even for an asymptomatic and small pneumothorax reduces the possibility of a chest tube insertion. However, most of small pneumothoraces remain stable and may be observed with oxygen inhalation. Aspiration of a small asymptomatic pneumothorax is not only difficult but may lead to inadvertent additional pleural punctures (18). Simple aspiration of pneumothorax, combined with a pleural blood patch technique has been described by Wagner *et al.* (19). The technique of pleural blood patching consisted of pneumothorax aspiration, followed by 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. This technique has shown a reduction in the need for chest tube placement. Opposite side aspiration has also been described if simple aspiration fails to resolve the pneumothorax (20). Again the idea is to put the punctured pleural surface in a dependent position which promotes sealing of leakage site.

Conclusions

The practice of immediate rolling the patient to a puncture-site down position after needle withdrawal should be adopted, as it incurs no extra cost or inconvenience to the patient. However, it should be done gently by manual assistance from procedural staff. Patients should be rolled on the CT table itself, followed by a post procedure CT scan to look for any immediate complication. If a small pneumothorax develops, patient should be observed for another 10-15 minutes on the CT table, to monitor its progression. If manual aspiration or chest tube insertion is indicated, it could also be performed under CT guidance. Patient should rest in puncture-site down position for at least 2-4 hours. An upright X-ray within 1-2 hours after biopsy should be avoided, unless patient develops any symptom. Other possible benefit of a puncture-site down positioning is that it reduces spread of alveolar hemorrhage to other areas of the lung. We congratulate Dr. Jung Im Kim and his colleagues for conducting a thorough study to evaluate the effect of various risk factors on the rate of pneumothorax and the protective effect of rapid puncture-site down positioning. The only weakness of this study is its retrospective design, and that the needle out rollover time was not documented in the conventional group.

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Footnote

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