Editorial

Where are we on (preventing) pneumothorax after (cone-beam) computed tomography-guided lung biopsy?

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In patients with lung lesions obtaining histology of the lesion plays an important role in obtaining the diagnosis and therapy planning. Most patients undergo bronchoscopy in order to obtain a tissue sample of the lesion. However, success rates leading to a diagnosis ranges from 30-80% depending on the sampling method (biopsy, fine needle aspiration or bronchoalveolar lavage) (1).

In case of a non-diagnostic bronchoscopy, computed tomography (CT)-guided or cone-beam CT (CBCT)-guided percutaneous lung biopsy plays a crucial role as the next step in the diagnostic work-up. It has been established as a safe and effective means of obtaining tissue for diagnosis and—if needed—molecular testing. In around 92-95% of patients a diagnosis can be made based on the acquired material (2).

The downside of percutaneous lung biopsies is development of complications such as pneumothorax, pulmonary hemorrhage, air embolism and tumor seeding of the pleura and chest wall (3-5).

Pneumothorax is the most common complication of (CB)CT-guided percutaneous lung biopsy. The incidence is reported in a range of 16.2-31.8%. Most of these require no intervention, however in 1.9-9.9% of cases insertion of a drainage catheter is needed because the patient develops dyspnea, hypoxemia or chest pain (6-11).

There has been a lot of research determining the important factors in the development of pneumothoraces. In a recent retrospective study in 1,191 patients, Kim *et al*. described significant risk factors determining the incidence of pneumothorax in patients after CBCT-guided percutaneous transthoracic lung biopsy using a coaxial needle biopsy technique. They found that patients who developed a pneumothorax were significantly older, and more often male. Also, emphysema along the needle tract [odds ratio (OR) 2.9], crossing of bullae (OR 2.4) or fissures (OR 1.8) and longer pleura-to-target distance (OR 2.5) significantly increases the change of developing a pneumothorax. However, the strongest risk factor was the number of pleural punctures per procedure (OR 5.8) (10).

In another recent publication, Nour-Eldin *et al*. found similar risk factors for the development of a pneumothorax after percutaneous CT-guided lung biopsy in 650 patients. In their retrospective study they identified emphysema, crossing a pulmonary fissure and longer biopsy tract (>2.5 cm) as significant risk factors. They also found that higher number of pleural re-entries was significantly associated with a higher incidence of pneumothorax. Of course without using a coaxial needle technique, the risk of more pleural re-entries is higher. They also found that during procedures where a coaxial needle was used, the diagnostic yield of lung biopsy was higher than in procedures without use of a coaxial needle (11). This is probably due to the fact that it is easier to take multiple biopsies using a coaxial needle.

Besides these identified risk factors, research is also starting to emerge on new ways of preventing pneumothorax. Some authors recently investigated the feasibility and success rates of sealing the biopsy tract by different methods.

For instance, Li *et al*. have been evaluating the usefulness of using normal saline for sealing the needle tract after CT-guided biopsy in a prospective randomized, controlled trial in 322 patients. They found a significant difference in pneumothorax rate between the patient group without sealing the needle tract (26.1%) versus the procedures with needle track sealing with saline (6.2%) (12).

Zaetta *et al*. tried sealing the biopsy tract with a plug made of desiccated polyethylene glycol hydrogel, extruded as a solid cylinder of 2.5 cm in length by 0.1 cm in diameter. Compared with control subjects, treatment subjects had fewer pneumothoraces (18% *vs*. 31%), and fewer chest tubes placed (4% *vs*. 11%), although study size was small (N=78) so this study lacked power (13).

Sealing of the biopsy tract was also evaluated by Kim *et al*. in 1,191 patients. They tried to achieve this by using rapid ipsilateral decubitus position. Patients were asked to roll over directly after CBCT-guided lung biopsy, in order to place the puncture site down. They compared this cohort to a retrospective study group who were also placed puncture site down, but only after these patients were evaluated for success of the procedure and identification of potential complications. They found, however not significant, the rapid rollover group had a slightly higher pneumothorax rate than the retrospective group (23.1% *vs*. 19.8%, P=0.164). Notwithstanding, the rapid rollover group required significantly less drainage catheter placement for pneumothorax (1.6% *vs*. 4.2%) (10). The results of Kim *et al*. are contrary to the results of O'Neill *et al*. In their evaluation of the rapid needle-out patient-rollover approach, they found a decreased incidence of pneumothorax in the rapid rollover group (23% *vs*. 37%; P=0.04) and a decreased number of drainage catheter insertion (4% *vs*. 15%; P=0.029). A possible explanation for this is that the patient rollover time was shorter in this study (9.5±4.8 seconds), compared to the study of Kim *et al*. (24.6±9.2 seconds) (10,14). Moore and co-workers reported substantially reduced rates of pneumothoraces that necessitated insertion of a drainage catheter (15,16) by placing the patient puncture-site down after lung biopsy, while Collings *et al*. found no effect of placing the patient biopsy-side down on the subsequent rate of pneumothorax (16).

Wagner *et al*. tried to treat pneumothorax after transcutaneous CT guided lung biopsy. This was done by aspiration and injecting up to 15 mL of autologous blood into the pleural space ('pleural blood patching') followed by placing the patient in ipsilateral decubitus position for 1 hour after the procedure. The result of this intervention was a significant reduction of chest tubes placements from 53.3% to 13.6% compared to aspiration of pneumothorax alone, and therefore reduced the need for hospital admission of these patients (17).

Two major conclusions can be drawn from this recent literature.

One: the best way to try and prevent the occurrence of pneumothorax is avoiding the danger areas (e.g., the risk factors: emphysema, pleural fissures and bullae) during needle insertion. This can be challenging, as it may require an oblique or even double-oblique approach. Among others, Braak *et al*. investigated the feasibility and effectiveness of using CBCT with needle planning software. They found that as a result of the wide range of angulation and rotation of the C arm, double oblique approaches were easier to perform and therefore it could be easier to avoid the danger areas (6). Furthermore, CBCT-guidance has more advantages compared to conventional CT-guidance such as: more open sterile workspace, compared to the restrictions of a CT system; real-time fluoroscopic feedback easier to track needle placement and better identification and compensation of patient movement (6,18,19). Effective doses of percutaneous lung biopsy procedures using CBCT were comparable to the same procedure using conventional CT with or without fluoroscopy (6).

Two: to decrease the chance of developing a pneumothorax is to prevent multiple pleural punctures during one procedure. The use of the coaxial needle technique is an effective way to achieve this. After crossing the pleura once and maneuver the needle tip of the coaxial needle in close proximity to the target lesion, it is possible to perform multiple biopsies using a tru-cut biopsy needle. Hereby the incidence of pneumothorax is decreased, while at the same time increasing the diagnostic yield because more tissue can be obtained in a single pleural puncture procedure.

Sometimes, the criteria of avoiding fissures and areas of emphysema cannot be met. In that case, taking the shortest route to the lesion is the best option. Since a longer biopsy tract (longer than 2.5 cm) is associated with higher incidence of pneumothorax, it is worthwhile to try and make the pleura-to-target distance as short as possible when performing (CB)CT-guided lung biopsies.

One can argue if it is worthwhile to perform a rapid-rollover approach post-biopsy to place the puncture site down to prevent air leakage. The literature on this subject is equivocal, especially on the number of pneumothoraces (10,14-16). However there is a tendency for lower number of drainage catheters placed only (10). The role of rapid-rollover approach after biopsy is for now unknown and at discretion of the operator. The effect of plugging the biopsy tract using various methods show promising results, however the specific role is still not all clear (13).

Further research is needed, especially on the topic of preventing and/or treating pneumothoraces during the percutaneous lung biopsy procedures. For now, reducing the chance of the development of a pneumothorax by taking the risk factors into account seems to be the best bet.

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Footnote

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