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CT-guided core needle biopsy of small (≤20 mm) subpleural pulmonary lesions: value of the long transpulmonary needle path

J.H. Yu [a], B. Li [b], X.X. Yu [b], Y. Du [b], H.F. Yang [b], X.X. Xu [b], C. Zhang [b], Y. Li [b,*]

[a] Department of Ultrasound, The Affiliated Hospital of North Sichuan Medical College, 63 Wenhua Road, Nanchong City, Sichuan Province, 637000, China
[b] Department of Radiology, The Affiliated Hospital of North Sichuan Medical College, 63 Wenhua Road, Nanchong City, Sichuan Province, 637000, China

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AIM: To evaluate the accuracy and complications of computed tomography (CT)-guided core needle biopsy (CNB) of small (≤20 mm) subpleural pulmonary lesions with the use of the long transpulmonary needle path.

MATERIALS AND METHODS: A retrospective study was undertaken comprising 235 patients who underwent CT-guided CNB of small (≤20 mm) subpleural pulmonary lesions. One of two needle paths was used: a long (≥10 mm) transpulmonary needle path (n=164, group A) or a short (<10 mm) transpulmonary needle path (n=71, group B). Diagnostic accuracy, pneumothorax, and bleeding rates were compared between the two groups.

RESULTS: The diagnostic accuracy in group A was significantly higher than that in group B (93.9% versus 81.7%, p=0.004), particularly in patients with 5–10 mm lesions (89.2% versus 53.3%, p=0.013). The mean length of the transpulmonary needle path was 23.9 mm in group A and 5.9 mm in group B (p<0.001). The mean number of pleural punctures in group A was 1.01 and 1.11 in group B (p=0.016), but for patients with more than one puncture, the short transpulmonary path was not associated with a higher accuracy rate. The incidence of bleeding was 22% in group A and 9.9% in group B (p=0.028).

CONCLUSION: Diagnostic accuracy for small subpleural pulmonary lesions with the use of the long transpulmonary needle path was higher than that with the use of the short transpulmonary needle path, especially for 5–10 mm lesions; however, the long transpulmonary needle path was associated with a higher rate of bleeding.

Introduction

With the increased use of low-dose computed tomography (CT) screening, the detection rate of small pulmonary lesions has been increased in recent times. CT-guided core needle biopsy (CNB) has high diagnostic accuracy for pulmonary lesions with acceptable complications[1–3]; however, several reports have suggested that small pulmonary lesions, especially those in subpleural area, can be extremely challenging to sample due to respiratory movement.[4–7] Furthermore, CT-guided lung biopsy for subpleural lesions correlates with a high rate of pneumothorax.[5]

When a small pulmonary lesion is in a subpleural location, a direct puncture involving the needle traversing a

* Guarantor and correspondent: Y. Li, Department of Radiology, Affiliated Hospital of North Sichuan Medical College, 63 Wenhua Road, Nanchong City, Sichuan Province, 637000, China. Tel.: +86 13890766535; fax: +86 0817 2222856.
E-mail address: 552410618@qq.com (Y. Li).

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short distance of aerated lung or an indirect puncture involving a long transpulmonary needle path can be used to sample lesions. As reported by Tanaka *et al.*,[7] the use of a long transpulmonary needle path has a high success rate for small subpleural lesions and reduces the rate of pneumothorax; however, Gupta *et al.*[4] described a higher diagnostic yield and a higher frequency of chest tube insertion in subpleural lesions with the use of long-needle path biopsy.

There are few articles on the use of the long transpulmonary needle path for small subpleural pulmonary lesions, and these results are based on a relatively limited number of patients and are contradictory.[4,7,8] The purpose of this retrospective study was to assess the diagnostic accuracy and complications of CT-guided CNB of small (≤20 mm) subpleural pulmonary lesions with the use of the long transpulmonary needle path in a large-scale study.

Materials and methods

Patients

From October 2013 to September 2016, 235 consecutive patients (139 men, 96 women; range: 28–84, mean age of 60.2±10.3 years) who had undergone CT-guided CNBs for small (≤20 mm) subpleural pulmonary lesions were included in this retrospective study. Informed consent was obtained before biopsy in all cases, and this retrospective study was approved by the Institutional Review Board.

For the purposes of this study, a subpleural lesion was defined as a lesion surrounded by aerated lung that measured 1–10 mm in width. Exclusion criteria were lesions that were located behind the scapula or rib with no other available path except a long transpulmonary needle path, lesions <5 mm in maximum diameter, lesions located under pulmonary fissures, lesions suspected to be of vascular origin, lesions that were in contact with the pleural surface at the site of needle insertion, patients or family members who refused the procedure, and patients who could not follow verbal instructions.

Before the biopsy, coagulation factors, such as prothrombin time and platelet count, were checked. Patients were not taking any anticoagulants or platelet inhibitors for at least 1 week.

Biopsy procedure

One of the three radiologists who had 5–10 years of experience in thoracic biopsies performed all biopsies. A 16-section helical CT machine (MX 16-slice, Philips and Neusoft Medical Systems, China) was used. Depending on the lesion location, the patient was placed on the CT table in the supine, prone, or lateral decubitus positions. Imaging parameters were 120 KVp, 120 mA, and 3–5 mm section thickness. The images were reviewed with a lung window setting (window width, 2,000 HU; window level, −500 HU).

The biopsy approach for CNB of subpleural lesions was classified as either a long or short transpulmonary needle path. A needle path was selected to avoid emphysema, bullae, blebs, fissures, and vascular structures during biopsy if possible. The site of puncture was aseptically prepared and draped, and approximately 3 ml of 1% xylocaine was administered for local anaesthesia. Breath-holding was limited to when the coaxial needle (19 G, TruGuide, Bard, Tempe, AZ, USA) was crossing the pleura. When the coaxial needle tip had reached the lung lesion, the stylet was removed, and samples were then obtained by using the matching 20 G cutting needle and biopsy gun (Magnum, Bard, Tempe, AZ, USA). The penetration length was selected according to the lesion size and the anatomical position of lesion. At the Affiliated Hospital of North Sichuan Medical College, the standard practice is to obtain two to three specimens. Subsequent specimens were obtained from various areas within the lesion by manually moving the outer needle in order to sample at random. Each specimen was fixed in 10% formalin solution. After completion of the biopsy, during extraction of the coaxial sheath, 1–3 ml normal saline was instilled into the puncture access.[9] After the procedure, CT was undertaken to check for any post-biopsy complication. The degree of pneumothorax was graded as mild if the distance between the parietal and the visceral pleura was <2 cm, moderate if it was ≥2 cm but ≤4 cm, and severe if it was >4 cm.[10] Bleeding complications were graded as mild (haemorrhage was viewed on CT images as haziness in adjacent air spaces of the lesions or along needle tracks), moderate (occurrence of less than five episodes of haemoptysis, estimated to be <30 ml blood or minimal haemothorax), and severe (haemoptysis or haemothorax associated with haemodynamic instability).[10] All patients were returned to the care units for monitoring by nursing staff, and had a follow-up posteroanterior chest radiograph obtained at 6 hours, or sooner if they became symptomatic. If pneumothorax was absent, patients were discharged. If a severe pneumothorax was found or if the patient became dyspnoeic, the placement of a chest tube was considered.

Data collection

For this study, all patients were divided into two groups. In group A, a long (≥10 mm) transpulmonary needle path was used. In group B, a short (<10 mm) transpulmonary needle path was used. The two groups were compared according to factors potentially influencing the results and the occurrence of complications. Patient factors included gender, age, and emphysema detected on CT. The degree of background pulmonary emphysema was graded semi-quantitatively as none, mild, moderate, and prominent.[3] Lesion factors included lesion size, lesion location, lesion necrosis, and the length of the needle path. Lesion size was measured along the maximum long-axis diameter at lung window settings. Lesion necrosis was defined as a non-enhancing low-attenuation area. Procedural factors included patient position, mean number of pleural punctures, and individual radiologist. The length of the needle path was used to describe a length of the aerated lung segment traversed by the coaxial needle. A positive CNB finding was considered a true positive when there was surgical confirmation, when biopsy of another site revealed malignancy with the same histological characteristics. A negative CNB finding was considered a true negative when

there was surgical confirmation and when the lesion subsequently disappeared or decreased in size or when the lesion remained stable on follow-up CT for at least 2 years. A positive finding was considered false positive when there was surgical resection with benign disease, or when there was lesion regression at follow-up CT in the absence of therapy. A negative finding was considered a false negative when a malignant lesion was confirmed by surgical resection and when the lesion increased in size.

Statistical analysis

Categorical variables were analysed using the chi-square test. The two-tailed *t*-test was used for the mean of a continuous variable. These tests were performed by using SPSS software (SPSS, Chicago, IL, USA). A *p*-value of <0.05 was considered significant.

Results

There were no differences concerning patient characteristics, lesion size, lesion location, patient position, lesion necrosis, and individual radiologist in the two groups ($p>0.05$; Table 1). The mean lengths of the needle paths was 23.9±9.5 mm in group A and 5.9±2.3 mm in group B ($p<0.001$). In group A, all patients underwent a single pleural puncture except for one patient; however, of the 71 patients in group B, seven (10%) required more than one pleural puncture, the mean number of pleural punctures in group B was significantly greater than that in group A (1.11 versus 1.01, $p<0.05$).

Table 1
Baseline characteristics in the two groups.

Variable	Group A	Group B	*p*-Value
Age (years; mean±SD)	61.0±9.4	58.6±11.9	0.138
Male/female	96/68	43/28	0.772
Emphysema on CT			0.897
None	132	55	
Mild	15	8	
Moderate	11	6	
Prominent	6	2	
Lesion size (mm; mean±SD)	15.9±3.3	15.0±3.7	0.077
5–10 (n=52)	37	15	0.808
11–20 (n=183)	127	56	
The length of the needle path (mm; mean±SD)	23.9±9.5	5.9±2.3	0.000
Lesion location			0.074
Right upper lobe	44	15	
Right middle lobe	10	6	
Right lower lobe	29	22	
Left upper lobe	49	12	
Left lower lobe	32	16	
Lesion necrosis	11	4	0.985
Patient position			0.916
Supine	75	33	
Prone	89	38	
Mean no. of pleural punctures	1.01	1.11	0.016
Radiologist			0.600
A	59	30	
B	52	22	
C	53	19	

Table 2
The diagnostic yields of the two groups.

Variable	Group A	Group B	*p*-Value
Accuracy (%)	93.9 (154/164)	81.7 (58/71)	0.004
No. of true-positive findings	112	40	NA
No. of true-negative findings	42	18	NA
No. of false-positive findings	0	0	NA
No. of false-negative findings	10	13	NA
Sensitivity (%)	91.8 (112/122)	75.5 (40/53)	0.003
Specificity (%)	100 (42/42)	100 (18/18)	NS
Positive predictive value (%)	100 (112/112)	100 (40/40)	NS
Negative predictive value (%)	80.8 (42/52)	58.1 (18/31)	0.025

NA, not applicable; NS, not significant.

Table 2 showed the diagnostic yields of the two groups. The overall diagnostic accuracy was 90.2% (212/235). Diagnostic accuracy with use of the long transpulmonary needle path was higher than that with use of the short transpulmonary needle path (93.9% versus 81.7%, p=0.004). Furthermore, the former approach (n=164) showed significantly better results than did the latter approach (n=71), with sensitivity rates of 91.8% and 75.5%, respectively (p=0.003), and negative predictive value of 80.8% and 58.1%, respectively (p=0.025; Table 2). There was no significant difference in specificity and positive predictive value between the two groups. In group A, among the 10 false-negative biopsy cases, six were diagnosed with fibrous tissue, two were necrosis, and others were inflammation and hyperplasia of alveolar cells. One hundred and three of the 164 cases, which included 89 true-positive cases, four true-negative cases, and 10 false-negative cases, underwent surgical resection. In 89 malignant and four benign cases, the final pathological finding at surgery was identical to the histological finding from biopsy. Among 10 false-negative cases, eight were diagnosed with adenocarcinoma, and two were metastases. In group B, of the 71 patients with diagnostic CNB results, 39.4% (28 of 71) continued onto surgery. In 16 patients, the final pathological finding at surgery was identical to the histological finding from biopsy. Among the 13 patients with false-negative results, 12 (92.3%) continued onto surgery and malignancy was finally diagnosed in these patients. In the remaining one patient with false-negative results, follow-up radiological and clinical findings were consistent with cancer.

In Table 3, the diagnostic accuracies were further analysed in subgroups according to lesion size, number of pleural punctures, and group. Diagnostic accuracy for a lesion size of 5–10 mm in group A was significantly greater than that in group B (p=0.013). In group B, diagnostic accuracy for 11–20 mm lesions was considerably higher than those for 5–10 mm lesions (p=0.005). In group A, diagnostic accuracy increased with the lesion size; however, the improvement in accuracy was not statistically significant (p=0.331). Diagnostic accuracy for patients with a single puncture in group A was significantly higher than that in group B (p=0.010). Furthermore, for patients with more than one puncture, the short transpulmonary route (group B) was not associated with a higher accuracy rate.

Table 3
The diagnostic accuracy based on lesion size, number of pleural punctures, and group.

Variable	Diagnostic accuracy		*p*-Value
	Group A (*n*=164)	Group B (*n*=71)	
Lesion size (mm)			
5–10 (*n*=52)	33/37 (89.2)	8/15 (53.3)	0.013
11–20 (*n*=183)	121/127 (95.3)	50/56 (89.3)	0.236
p-Value	0.331	0.005	NA
No. of pleural punctures			
1 (*n*=227)	153/163 (93.9)	53/64 (82.8)	0.010
≥2 (*n*=8)	1/1 (100)	5/7 (71.4)	NA
p-Value	NA	0.822	NA

Data are numbers of patients, with percentages in parentheses.
NA, not applicable.

Table 4 showed the complications in the two groups. Pneumothoraces detected by CT after biopsy procedures included 19 cases in group A and six cases in group B, respectively (p=0.474). Furthermore, there was no significant difference in the chest tube placement rate in both groups. None had bronchopleural fistula in either of two groups. The presence of bleeding was significantly lower in group B than in group A (9.9% versus 22.0%; p=0.028). None had haemothorax or haemodynamic instability in either of two groups. In group A, 14 pneumothoraces were mild and three were moderate, two were severe. Four moderate-to-severe pneumothoraces were successfully converted to mild pneumothoraces by manual aspiration while patients were still on the CT table. One patient with severe pneumothorax underwent chest tube placement. Bleeding occurred in 36 of 164 patients (22.0%), including lung parenchymal haemorrhage in 29 (17.7%) patients, which was considered mild, and haemoptysis in seven (4.3%) patients, which was considered moderate and required further follow-up. In group B, pneumothorax occurred in six of the 71 biopsy procedures (8.5%; Table 4). Of those, 83.3% were mild (five of six procedures), and 16.7% were severe (one of six procedures). One patient with symptomatic (shortness of breath and severe chest pain) underwent chest tube insertion, while five patients were simply observed. Seven patients had mild bleeding as seen on the CT sections. All patients had lung parenchymal haemorrhage that settled spontaneously.

Discussion

Several studies have demonstrated the technical challenge of sampling small subpleural pulmonary lesions with CT-guided biopsy.[4–8] There are a number of disadvantages of using a short transpulmonary needle path for biopsy of subpleural lesions. First, the short transpulmonary route does not allow for correction or redirection of the needle path without pulling needle back across the pleural surface.[8] Second, attempts to use the short distance for puncture of the subpleural lesions often fail because of respiratory motion.[4] Finally, a needle that traverses a short transpulmonary route is unstable and likely to dislodge into the pleural space owing to lung movement during breathing.[6] Clinical observation revealed that at least two advantages of the long transpulmonary needle path to be considered are: (1) a long transpulmonary needle path through the aerated lung provides room for needle to anchor and correct, and (2) the long transpulmonary route is more flexible as it allows the use of a posterior or anterior approach to avoid the overlying bone structures and offers more passage options than the short transpulmonary route.

Moore believed that a direct (short transpulmonary needle path) puncture may be unwise when a small pulmonary lesion is in a subpleural location.[6] In the present authors' experience, using a long transpulmonary needle path, targeted subpleural area is much wider than that of the short transpulmonary needle path. Tanaka *et al.*[7] reported that in their series of 61 lung lesions (62 samples) measuring <2.5 cm, the success rate of the oblique path (long transpulmonary needle path) was higher than that of the near right-angle path (short transpulmonary needle path; 26/32, 81.2% versus 13/30 43.3%). Wallace *et al.*[8] compared the tangential approach (long transpulmonary needle path) with the direct approach to determine the optimal needle path for sampling small (≤10 mm) subpleural pulmonary lesions. In their series of 30 subpleural lesions, the tangential approach showed significantly better results than did the direct approach, with the accuracy rates of 100% and 64%, respectively, and the sensitivity rates of 100% and 50%, respectively. In another study involving 176 subpleural lung lesions measuring up to 2 cm, Gupta *et al.*[4] reported that there was a significant difference between diagnostic yields in long-needle-path approach (94%) when compared with those in short-needle-path approach (71%). In the present study, diagnostic accuracy and sensitivity with use of the long transpulmonary needle path (93.9% and 91.8% respectively) was significantly higher than that with use of the short transpulmonary needle path (81.7% and 75.5% respectively). Furthermore, for 5–10 mm lesions and for patients with a single puncture, the long transpulmonary route (group A) was associated with a higher accuracy rate than the short transpulmonary route (group B); however, there are two important differences between the present study and the previous studies. First, lesions that were located behind the scapula or rib with no other available path than a long transpulmonary needle path were excluded. Second, if aerated lung is not violated, there is a lower frequency of pneumothorax[2,5,11]; therefore, in the present study, patients in whom the lung lesion was in contact with the chest wall at the site of needle insertion were also excluded.

Table 4
Complications in the two groups.

Complication	Group A	Group B	*p*-Value
Pneumothorax	19 (11.6%)	6 (8.5%)	0.474
Chest tube placement	1 (0.6%)	1 (1.4%)	0.514
Bleeding	36 (22.0%)	7 (9.9%)	0.028

Pneumothorax is the most frequent complication of CT-guided transthoracic biopsy.[1,2,12–14] The small subpleural lung lesions biopsies are not only difficult to perform, but also these lesions are risky for pneumothorax.[4–7] In the present study, the incidence of pneumothorax was higher in group A (11.6%) than that in group B (8.5%), which was statistically insignificant. There is still considerable disagreement about the correlation between pneumothorax rate and the lesion–pleurae distance. Many studies have reported that lesion–pleurae distance was a significant risk factor of pneumothorax and an increased rate of pneumothorax was significantly correlated with the increase in the lesion–pleural distance.[2,14–17] As reported by Ohno *et al.*,[17] it would be reasonable to hypothesise that a longer needle path tends to damage to a larger part of the lung parenchyma between the pleura and the pulmonary lesion; however, Yeow *et al.*[5] reported that the pneumothorax rate dramatically increased once the aerated lung was violated, but this rate did not further increase with increasing lesion depth. Furthermore, subpleural lung lesions that were 0.1–2 cm from the pleura surface correlated with a higher rate of pneumothorax as compared to those farther from the pleura. In the present study, although the mean lengths of the needle paths in groups A and B were 23.9±9.5 and 5.9±2.3 mm, respectively, the two biopsy approaches were associated with similar rates of pneumothorax and chest tube placement. Similar findings have been reported by Wallace *et al.*[8]; however, Gupta *et al.*[4] reported that patients who underwent biopsy using a long-needle-path had significantly higher chest tube placement rate than that those using a short needle path. Compared with the rates of pneumothorax and chest tube placement reported in the literature, the relatively low overall rates in the present study could be related to various factors such as lesion factors, biopsy technical factors, and so on.[2,5,14–17] One possible explanation could be that normal saline was used to seal the needle track. A previous study revealed that a significant reduction in the rates of pneumothorax and chest tube placement was demonstrated by filling the needle track with normal saline after CT-guided lung biopsy.[9] Regarding haemorrhage, the higher prevalence of pulmonary haemorrhage was seen with use of the long transpulmonary needle path. This was not surprising considering the fact that the possibility of lung vascular injury along the needle path to lesion is increased by using a longer transpulmonary path.[4] In most cases, lung parenchymal haemorrhage was considered mild, asymptomatic alveolar haemorrhaging, or needle tract bleeding, and had lung parenchymal haemorrhage settled spontaneously in all patients.

One limitation of the present study was its retrospective nature. The individual operator's preference for a needle path, based on expertise level, is also difficult to evaluate; however, there were no differences in patient characteristics, lesion size, lesion location, patient position, and individual radiologist between the two groups, and so statistically meaningful comparison of the two biopsy techniques was possible.

In conclusion, this study showed that use of the long transpulmonary needle path for small (≤20 mm) subpleural pulmonary lesions resulted in higher diagnostic accuracy, especially for 5–10 mm lesions; however, this approach had a higher frequency of bleeding compared with the short transpulmonary needle path technique.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

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