Original Article

Does needle gauge affect complication rates of computed tomography-guided lung biopsy?

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Background: It has been thought a larger bore biopsy needle may yield a better sample for molecular testing, but this could potentially expose the patient to higher pneumothorax rates. This study aims to determine if a larger bore biopsy system results in more complications.

Methods: A total of 193 patients who underwent computed tomography (CT)-guided lung biopsy in a single tertiary center from 2013–2021 were evaluated retrospectively. Patients were divided into two groups, patients who underwent lung biopsy using the 17/18-gauge (18G) biopsy system and the 19/20-gauge (20G) biopsy system. Data recorded included biopsy needle gauge, nodule location and size, plug use, positioning, the length of the intraparenchymal tract, number of biopsy passes, pneumothorax, chest tube insertion, and admission.

Results: The mean age was 64.1±12.4 years. The median diameter of the lung nodules was 1.95 cm, and the median depth of the intraparenchymal needle tract was 2.7 cm. Pneumothorax was identified during the procedure by CT fluoroscopy or on post-procedural chest X-ray (CXR). The overall rate of pneumothorax among all patients was 35.2%, and 10.9% of the study population (i.e., 30.1% of patients with pneumothorax) required chest tube insertion. The rate of pneumothorax or chest tube insertion was not significantly different between patients who underwent lung biopsy using 17/18G or 19/20G biopsy system. Patients who developed pneumothorax were older, with smaller-sized pulmonary nodules and longer length of the intraparenchymal tract. The pathologic sensitivity of the 18G gun was higher than that of the 20G gun (93% sensitivity, 100% specificity *vs.* 79.5% sensitivity, 100% specificity). In the multivariate logistic regression fitted model, the length of the intraparenchymal tract was the only factor predictive of post-procedural pneumothorax and chest tube insertion. An intraparenchymal needle tract length of greater than 2 cm was identified to have the best threshold to predict pneumothorax [sensitivity: 73.5%; false positive rate: 57.6%; area under the curve: 66.27%].

Conclusions: Findings suggest similar rates of pneumothorax and chest tube insertion using small 19/20G *vs.* 17/18G biopsy systems. The 18G system was more sensitive compared to the 20G system in determining pathologic results. Increasing length of lung parenchyma needle tract and smaller lung nodules appear to be risk factors for pneumothorax. Physicians should plan on intraparenchymal tracts that are less than 2 cm to decrease the chance of pneumothorax.

Keywords: Computed tomography-guided lung biopsy (CT-guided lung biopsy); pulmonary nodule; pneumothorax

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Introduction

The biopsy of suspicious lung nodules represents a unique challenge of balancing adequate tissue sampling with minimizing complications (1). With the growing tailored therapeutic regimes for cancer, it is paramount to gain adequate tissue sampling for pathology and molecular testing for specific tumor markers and sensitivities, which may be improved by utilizing larger needle gauge systems and increasing the number of passes (2,3). To this effect fine needle aspiration (FNA) biopsy, which is performed with a smaller needle [typically 22 gauge (22G)], has been replaced by core biopsy (4).

Past literature suggests that needle gauges may alter pneumothorax rates (5,6). Using a larger co-axial needle and biopsy system has the potential for other complications, such as hemoptysis, hemothorax, or air embolization (7). This can lead to further complications including hospital admission, chest tube placement, and increasing the length of hospitalization (6). This study was conducted to determine if using a larger core biopsy system (17/18G *vs.* 19/20G) results in greater patient complications. This manuscript is written following the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-240/rc).

Highlight box

Key findings

- This retrospective study of 193 patients who underwent computed tomography (CT)-guided lung biopsy compared the complication rates between 18 gauge (18G) and 20 gauge (20G) co-axial biopsy gun systems. The overall pneumothorax rate was 35.2%, with 10.9% requiring chest tube insertion and 11.9% of patients requiring hospital admission. There were no significant differences in complication rates between the two groups. Patients that developed pneumothoraxes demonstrated longer lengths of lung parenchyma traversed and smaller lung nodules. The 18G system was more sensitive compared to the 20G system in determining pathologic results. The length of lung parenchyma traversed during the biopsy was identified as the sole predictor of pneumothorax and chest tube insertion by a binary logistic regression model, with an identified threshold of 2 cm determined by receiver operating characteristic analysis.

What is known and what is new?

- Prior studies denoted that larger gauge biopsy systems result in higher complication rates. The study challenges that notion by comparing 18G systems with smaller 20G systems and emphasizes the importance of minimizing the intraparenchymal needle tract length while maintaining a safe trajectory to reduce the risk pneumothorax and chest tube insertion.

What is the implication, and what should change now?

- These findings suggest that physicians may consider safely using larger gauge biopsy systems to obtain larger samples with greater sensitivity that may be suitable for biomarker testing and should emphasize planning for the shortest and safest intraparenchymal tract, preferably less than 2 cm. This may help mitigate the risk of pneumothorax/chest tube insertion, regardless of needle gauge. Future research should explore the impact of differing needle gauges on diagnostic yield and biomarker testing.

Methods

One hundred and ninety-three patients who underwent computed tomography (CT)-guided lung biopsy from 2013–2021 were evaluated in a single-center retrospective study via reviewing the electronic medical records and imaging at Picture Archiving and Communication Systems (PACS) collected from an Institutional Review Board (IRB) approved database of interventional radiology procedures. The primary indication for CT-guided lung biopsy was concerning radiologic imaging findings or enlargement of lung nodules. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Review Board of University of Miami (IRB No. 20070111). As this was a retrospective study, informed consent was not obtained.

Data recorded included demographics, history of smoking, the diameter (G) of the biopsy needle introducer and biopsy needle, the location of the nodule and its diameter, use of plug following biopsy, the distance within the lung parenchyma that needle introducer traversed, the number of passes, post-procedural pneumothorax, hospital admission, and chest tube insertion. The presence and visual grading of emphysema was determined by reviewing cross-sectional imaging by a board-certified radiologist. The distance of lung parenchyma traversed was determined by using the measuring tool in PACS measuring from the lung pleura to the needle tip. Patients were divided into two groups: Group

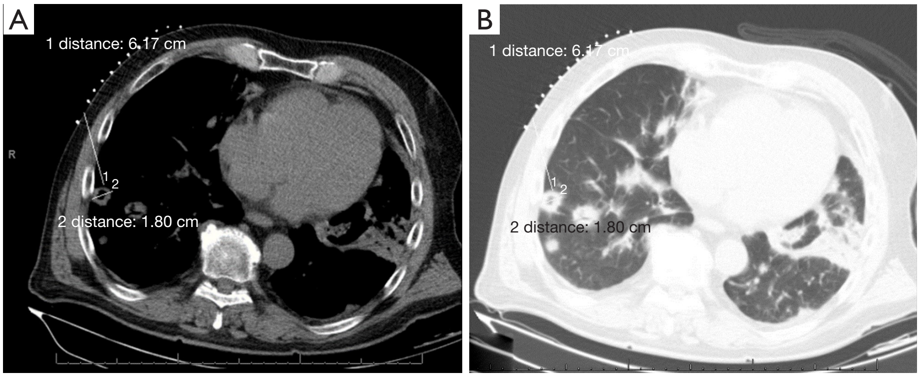

Figure 1 Planned lung biopsy trajectory. A 67-year-old male with a history of bladder cancer and a 1.8 cm cavitary nodule in the right lower lobe presented for biopsy. Planned trajectory in mediastinal window (A) and lung window (B).

A consisted of 138 patients (71.5%) who underwent biopsy with the 18G biopsy gun (with a 17G introducer system) and Group B included 55 patients (28.5%) for whom the 20G gun (with a 19G introducer) was used.

All biopsies were obtained with the Temno® coaxial biopsy gun system (Merit Medical Systems, South Jordan, UT, USA). All biopsies were performed by a single board-certified interventional radiologist or interventional radiology fellows under the direct supervision of an attending interventional radiologist. The trajectory was predetermined on a prior CT (*Figure 1*). Patients were positioned prone, lateral decubitus, or supine to obtain the safest trajectory while minimizing the distance traversed through the lung parenchyma. Biopsy trajectories avoided crossing lung fissures and pulmonary bullae. If a positron emission tomography (PET) scan was previously obtained the operator attempted to biopsy the zone of maximum metabolic activity. Under CT guidance the larger co-axial needle (17G or 19G) was advanced to the nodule, through which the biopsy gun (18G or 20G respectively) was introduced to perform a pass to obtain tissue. An average of three passes were attempted on each target lesion in order to obtain an adequate tissue sample, and pathological results from the biopsy were collected. Biosentry plugs were utilized in 39 patients (20.2%). The decision to place a plug following lung biopsy was at the discretion of the operator. To deploy the large plug correctly the Argon BioPince® introducer (Argon Medical Devices, Plano, TX, USA) was used rather than the smaller Temno® introducer.

A final CT scan of the lung was obtained at the completion of the biopsy. Also, a chest X-ray (CXR) was performed 1–2 hours following the procedure as per institution protocol. Pneumothorax (PTX) was identified by CT peri-operatively or on a follow-up CXR (*Figures 2,3*). If only a trace amount of air was seen on post biopsy intra procedural CT but not confirmed on a subsequent CXR 1–2 hours later, this was deemed to be introduced air. The pneumothorax size, rate of expansion, and clinical presentation determined the decision for chest tube insertion by the board-certified interventional radiologist. Chest tubes were inserted in instances where symptomatic pneumothoraxes were identified, either during intraoperative CT or subsequent CXR. These interventions were prompted by observed comparative declines in pulse oximetry readings alongside the manifestation of dyspnea.

Statistical analysis

The normality of continuous variables was determined using the Shapiro-Wilk test and confirmed visually by Q-Q plots and density plots. Continuous variables were examined as means (and standard deviations) or median (interquartile range) as appropriate. Comparison between the groups at a single time point was assessed with unpaired *t*-test for normally distributed data, or Wilcoxon test for non-parametric data. Discrete variables were summarized as counts (percentages) and compared across study groups using the Fisher exact test or chi-squared test as appropriate. A binary logistic regression model was fitted to identify independent predictors of pneumothorax. All statistical analyses were performed using R version 4.3.0 [R Core Team (2023)] with two-tailed P values <0.05 considered statistically significant.

Results

The mean age was 64.1±12.4 years, 47.7% had a smoking

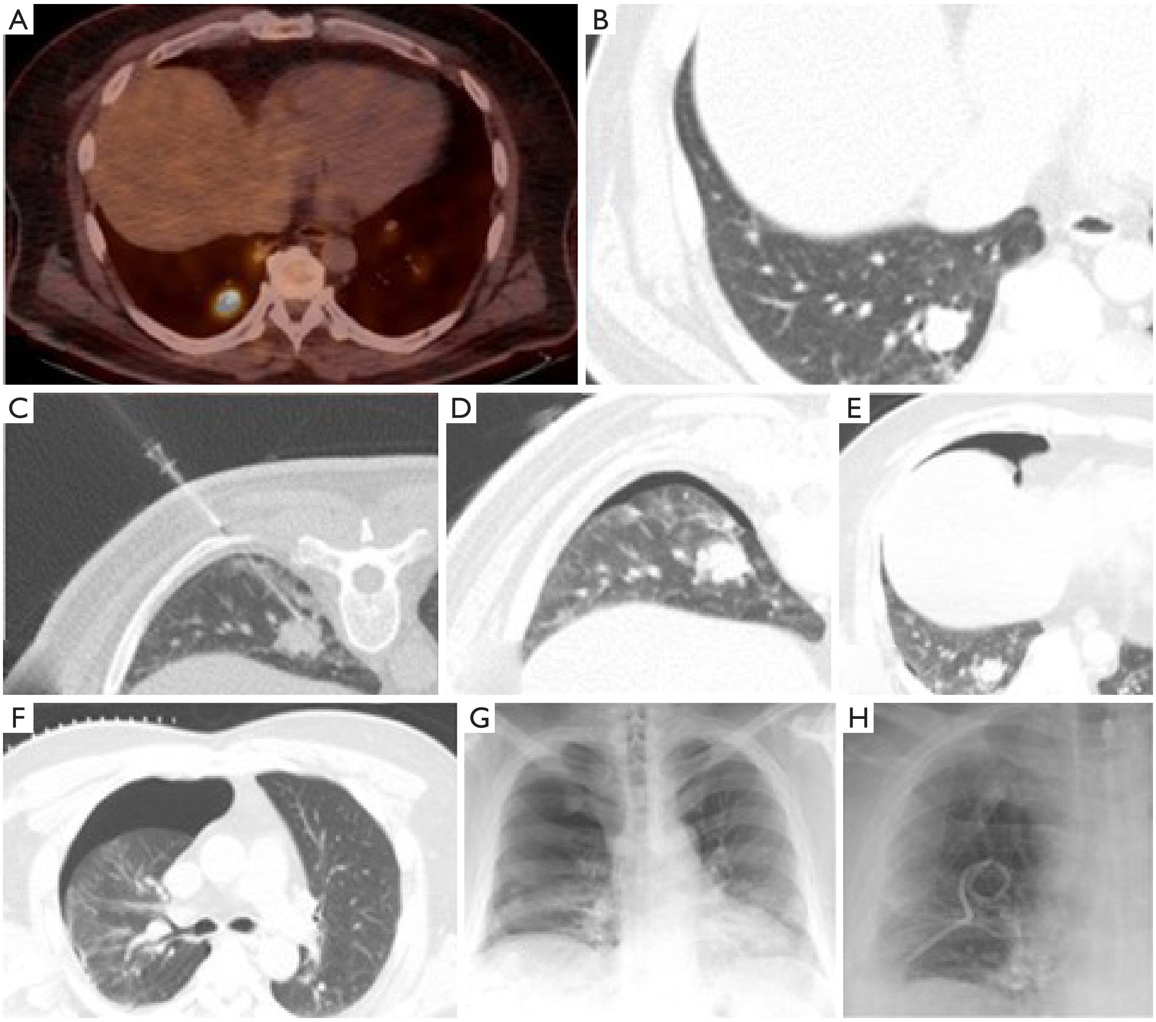

Figure 2 Chest tube insertion following pneumothorax developing during core needle biopsy. A 59-year-old gentleman with a history of thyroid cancer presented with a 1.8 cm FDG avid pulmonary nodule in the right lower lobe (A,B). The nodule was biopsied with a 17/18G coaxial system, with 3 passes, and 4.8 cm of lung traversed (C). CT immediately after the procedure demonstrated a small right-sided pneumothorax (D,E). The patient remained asymptomatic during post-procedural observation, repeated CXRs did not demonstrate expansion of the pneumothorax, and the patient was discharged. However, 4 days later during a routine outpatient imaging a larger pneumothorax was identified (F). Although the patient remained asymptomatic, a pigtail chest tube was placed, and the patient was admitted overnight and discharged the next day (G,H). FDG, fluorodeoxyglucose; CT, computed tomography; CXR, chest X-ray; G, gauge.

history, and 18.1% had emphysema present on cross-sectional imaging. The median diameter of the lung nodules was 1.95 cm [interquartile range (IQR), 1.4–2.73 cm], and the depth of the intraparenchymal needle tract was 2.7 cm (IQR, 1.5–4.3 cm). The overall rate of pneumothorax among all patients was 35.2% and 10.9% of the study population (i.e., 30.1% of patients with pneumothorax) required chest tube insertion. A total of 23 patients (11.9%) had to be admitted after the CT-guided lung biopsy and spent a median of 1 day (range, 0–5 days) in the hospital. A total of 9 patients (4.7%) developed clinically significant hemoptysis following biopsy requiring prolonged observation or admission to the hospital after the procedure.

Table 1 demonstrates baseline characteristics and technical details of the procedure and compares outcomes between Group A and Group B. The rate of pneumothorax, hemoptysis, and admission was not significantly different

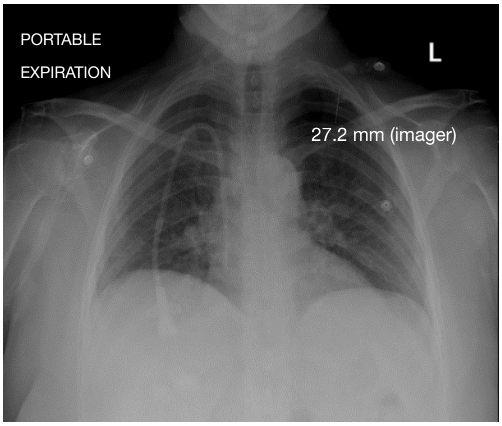

Figure 3 Delayed pneumothorax on post-procedural chest X-ray.

between the two groups. There was no difference in the presence of emphysema or emphysema grading between both groups. *Table 2* compares different risk factors between patients who developed pneumothorax with other patients. Patients who had pneumothorax appeared to have smaller diameter pulmonary nodules with longer lengths of intraparenchymal needle tract while being of older age. No air embolisms occurred in either group. The pathologic sensitivity and specificity of the 18G biopsy gun were 93% and 100%, respectively, while the sensitivity and specificity of the 20G gun were 79.5% and 100%, respectively.

Variables analyzed in the binary logistical regression included the gauge of the biopsy needle introducer, the diameter of the nodule, the use of the Biosentry plug, age, and the length of the lung parenchyma traversed. Binary logistic regression models were fitted to predict post-procedural pneumothorax and requirement for chest tube placement. The length of lung parenchyma traveled during the procedure was the only variable that was significantly predictive of the post-procedural pneumothorax [odds ratio (OR): 1.29, 95% confidence interval (CI): 1.10–1.52, P=0.002] and chest tube placement (OR: 1.53, 95% CI: 1.20–1.94, P<0.001). Biopsy needle introducer (P=0.23, P=0.71), diameter of the nodule (P=0.30, P=0.85), the use of Biosentry plug (P=0.20, P=0.90), and age (P=0.051, P=0.67) all failed to reach significance in both models respectively. A receiver operating characteristic (ROC) curve based on the fitted model of pneumothorax was created, and a traversed length of 2 cm within the lung parenchyma was chosen to have the best threshold to predict pneumothorax [sensitivity: 73.5%; false positive rate: 57.6%; area under the curve (AUC): 66.27%] (*Figure 4*).

Table 1 Comparison of demographic, explanatory, and outcome variables between Groups A and B patients

Variables	Group A	Group B	P value
Number	138 (71.5)	55 (28.5)	
Age (years)	64.20±12.5	63.75±12.3	0.82
Male	64 (46.4)	32 (58.2)	0.19
Smoker	59 (42.8)	33 (60.0)	0.09
Pack years	5 [0–30]	10 [0–40]	0.29
Emphysema	25 (18.6)	10 (16.9)	0.84
Emphysema grading			0.82
No emphysema	111 (82.8)	50 (84.7)	
Paraseptal	6 (4.5)	1 (1.7)	
Bronchial airway disease	1 (0.07)	0	
Mild centrilobular emphysema	10 (7.5)	4 (6.8)	
Moderate upper lobe cle	4 (3.0)	4 (6.8)	
Moderate to severe	1 (0.07)	0	
Moderate upper and lower	1 (0.07)	0	
BMI (kg/m^2)	27.1±5.9	26.7±5.3	0.68
Diameter of nodule (cm)	2.0 [1.5–2.9]	1.9 [1.4–2.5]	0.13
Traversed parenchyma (cm)	2.7 [1.2–4.2]	2.9 [1.7–4.9]	0.35
Location			0.06
Upper	55 (39.9)	30 (54.5)	
Middle	9 (6.5)	0	
Lower	71 (51.5)	23 (41.8)	
Lingula	3 (2.2)	2 (3.6)	
Patient positioning			0.53
Supine	66 (47.8)	31 (56.4)	
Prone	58 (42.0)	22 (40.0)	
L. Decubitus	9 (6.5)	1 (1.8)	
R. Decubitus	5 (3.6)	1 (1.8)	
Cavitation	14 (10.1)	6 (10.9)	>0.99
Biosentry plug use	27 (19.6)	12 (21.8)	0.88
No. of passes	3 [3–4]	3 [3–4]	0.99
Pneumothorax	44 (31.9)	24 (43.6)	0.17
Chest tube	16 (11.6)	5 (9.1)	0.80
Hemoptysis	7 (5.1)	2 (3.6)	0.71
Admission	18 (13.0)	5 (9.1)	0.60

Data are presented as mean ± SD, median [IQR], or number (percentage). Group A had CT-guided lung biopsy using an 18-gauge needle (17-gauge introducer) system. Group B underwent CT-guided lung biopsy using a 20-gauge needle (19-gauge introducer) system. CT, computed tomography; SD, standard deviation; IQR, interquartile range; cle, centrilobular emphysema; BMI, body mass index.

Table 2 Comparison of risk factors between patients who developed pneumothorax and others

Variable	No pneumothorax	Pneumothorax	P value
Age (years)	62.66±13.2	66.66±10.2	0.02*
Male	60 (48.0)	36 (52.9)	0.61
Smoker	57 (45.6)	35 (51.5)	0.58
Emphysema	20 (16.0)	15 (22.1)	0.33
Emphysema grading			0.40
No emphysema	108 (86.4)	53 (77.9)	
Paraseptal	4 (3.2)	3 (4.4)	
Bronchial airway disease	1 (0.8)	0	
Mild centrilobular emphysema	8 (6.4)	6 (8.8)	
Moderate upper lobe cle	4 (3.2)	4 (5.9)	
Moderate to severe	0	1 (1.5)	
Moderate upper and lower	0	1 (1.5)	
Biosentry plug use	21 (16.8)	18 (26.5)	0.16
No. of passes	3 [3–4]	3 [3–3.25]	0.62
Diameter of nodule	2.1 [1.5–3.1]	1.7 [1.3–2.43]	0.007*
Intraparenchymal tract length	2.3 [1–3.7]	3.65 [2–5.43]	<0.001*
Cavitation	16 (12.8)	4 (5.9)	0.21

Data are presented as mean ± SD, median [IQR], or number (percentage). *, statistically significant. SD, standard deviation; IQR, interquartile range; cle, centrilobular emphysema.

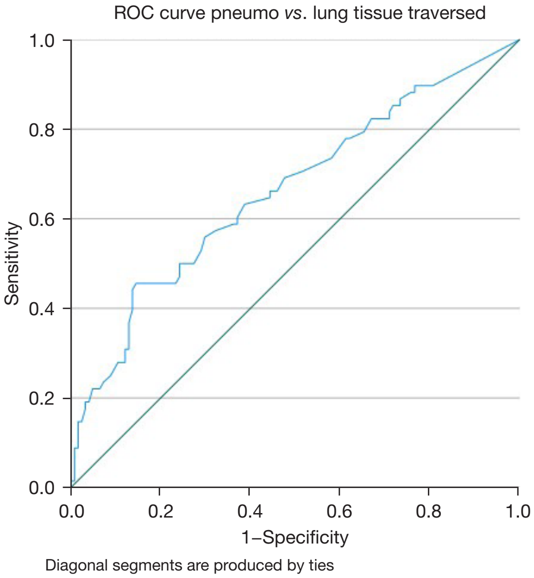

Figure 4 ROC curve of pneumothorax *vs.* lung tissue traversed. ROC, receiver operating characteristic.

Discussion

CT-guided transthoracic lung biopsy is a standard diagnostic procedure to evaluate the histology of suspicious lung nodules (8-10). In this study, the overall pneumothorax rate of pneumothorax was 35.2%, with 10.9% requiring chest tube insertion and 11.9% requiring admission to hospital. SIR Quality Improvement Guidelines on percutaneous needle biopsy provide an expected pneumothorax rate of 12–45% for thoracic percutaneous needle biopsy, with rates greater than 45% requiring a quality improvement (QI) review (11). Other studies have demonstrated a pneumothorax rate ranging from 17–49.2% with chest tube insertion rates 1.1–19.6% (*Table 3*) (4,12-26).

In a metanalysis of 36 studies on 23,104 patients who underwent CT-guided lung biopsy, the use of large-bore biopsy needles (≤18G) was associated with increased pneumothorax rate (35.3% *vs.* 25.1%, OR: 1.55, 95% CI: 1.19–2.01) and chest tube insertion (16.1% *vs.* 11.7%, OR: 1.39, 95% CI: 1.18–1.62). However, the meta-analysis included studies with guide needles as large as 13G (5). In this study, the rate of pneumothorax, chest tube insertion, or hospital admission was not significantly different using a 17/18G or 19/20G biopsy system (see *Table 1*). Other factors should be evaluated in future studies such as whether an 18G system results in a more favorable pulmonary hemorrhage pattern as described by De Filippo *et al.* thus protecting against PTX (27).

While the 18G and 20G biopsy guns had identical specificities, the 18G gun had a higher sensitivity of diagnosing the confirmed pathologic diagnosis (93% *vs.* 79.5%). In addition, while in this study, the number of passes between both cohorts did not defer, Moore *et al.* in a study of 209 patients undergoing CT-guided lung biopsy of various needle gauges (18G, 17G, 19.5G, 21G) demonstrated that fewer passes were required with an 18G needle as opposed to a 21G needle (3). Moore *et al.* also did not find any significant association between the needle's gauge and the rate of complications (3). Pneumothorax after CT-guided biopsy of the pulmonary nodule appeared to be associated with age, smaller pulmonary nodules, and

Table 3 Reported rates of pneumothorax and chest tube insertion in other studies

Studies	Total pneumothorax, n (%)	Chest tube/drainage, n (%)
Sabatino *et al.* (4)	306 (33.8)	18 (5.9)
Zhu *et al.* (12)	16 (14.8)	2 (1.86)
Iguchi *et al.* (13)	38 (37.3)	10 (9.8)
Marel *et al.* (14)	38 (38.0)	5 (4.95)
Taleb *et al.* (15)	169 (30.5) early; 24 (8.6) delayed	10 (3.6)
Sargent *et al.* (16)	179 (26.7)	35 (19.6)
Asai *et al.* (17)	41 (40.2)	3 (7.3)
Drumm *et al.* (18)	70 (38.0)	18 (9.8)
Zhang *et al.* (19)	272 (40.2)	19 (7.0)
Ashraf *et al.* (20)	119 (40.0)	29 (9.6)
Kuriyama *et al.* (21)	160 (49.2)	Not reported
Schulze *et al.* (22)	144 (21.7)	40 (6.0)
Kim *et al.* (23)	263 (21.4)	36 (3.0)
Lim *et al.* (24)	114 (29.9)	7 (1.8)
Lee *et al.* (25)	196 (17.0)	13 (1.1)
Hiraki *et al.* (26)	464 (42.3)	55 (11.9)

longer intraparenchymal needle tracts (*Table 2*). These risk factors have been previously echoed in prior studies in the literature (5,15,28). The length of the intraparenchymal needle traverse, however, was the only predictive factor of post-procedural pneumothorax and chest tube placement in the fitted model and a parenchymal length greater than 2 cm was the optimized threshold on the ROC curve for the occurrence of pneumothorax. We surmise that it may take a longer trajectory to reach the smaller nodules, so the strong power of the depth of needle traverse may be overpowering the nodule size in the regression model. Similar to this study, Taleb *et al.* reviewed 325 CT-guided biopsies and found the intraparenchymal needle tract to be the only independent predictor of delayed pneumothorax or clinically significant delayed pneumothorax (15). In addition, Huo *et al.* in their meta-analysis showed that the pneumothorax rate was significantly higher (36.1%) in >2 cm deep lesions compared to 18% in more superficial lesions (5). Therefore, choosing the shortest possible intraparenchymal tract to avoid tracts that are more than 2 cm long in preprocedural planning of CT-guided lung biopsy may be a significant modifiable factor in reducing the risk of pneumothorax.

Method for pneumothorax detection, and protocol for intervention deferred across studies (5). Taleb *et al.* labeled pneumothorax seen on CT scan as "early pneumothorax" and those discovered on subsequent CXRs as "delayed pneumothorax (15). In this study if a small amount of air was seen on immediate post-procedure CT, did not expand, and was not visible on post-procedure CXR, it was considered introduced air, not a true pneumothorax. Perhaps reporting should favor clinically significant pneumothorax such as those that require intervention or further hospitalization.

Limitations of this study include a small sample size, single-center, single operator, and retrospective design. The decision to place a chest tube was based on clinical judgment rather than objective criteria. Future complications may be improved upon by positioning the patient biopsy site down to decrease the amount of introduced air and the risk of pneumothorax. Further studies would benefit from a larger sample size along with a prospective design in a better-controlled environment.

In addition, further studies should focus on whether different gauge biopsy needles would affect the diagnostic yield in histology evaluation and diagnostic biomarkers. In a retrospective review of 170 percutaneous lung biopsies with 20G biopsy needles, 82.9% of specimens had adequate tumor tissue for the required biomarkers (10). Lee-Mateus *et al.* in a meta-analysis study of 14 studies on 1296 participants analyzed the sensitivity of different needle gauges used in endobronchial ultrasound transbronchial needle aspiration and found that 19G (93%), 21G (87.6%) and 22G (85%) needles present a similarly high diagnostic but decreasing sensitivity, a trend also seen with our pathologic reports; however, the 19G needle provided superior sample volume for molecular and immunohistochemical testing improving diagnostic yield (29). Given the potential for better diagnostic accuracy and the possibility of obtaining adequate tissue for molecular testing, it may be reasonable to consider using a larger bore biopsy system, given the rates of the complications are similar.

Conclusions

In conclusion, this study suggests similar rates of pneumothorax, hemoptysis, hospital admission, and chest tube insertion following CT-guided transthoracic core lung biopsy with small (19/20G) or large (17/18G) bore co-axial biopsy gun systems. Smaller lung nodules and longer lengths of lung parenchyma traversed are associated with higher pneumothorax rates. The 18G biopsy gun was more sensitive compared to the 20G gun in determining pathologic results. Physicians should identify the shortest safest intraparenchymal tract, ideally less than 2 cm avoiding bullae, fissures, or vessels for CT-guided lung biopsy to decrease the chance of pneumothorax and chest tube insertion.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-240/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-240/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-240/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Institutional Review Board of University of Miami (IRB No. 20070111). As this was a retrospective study, informed consent was not obtained.

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