CT-GUIDED LUNG BIOPSY: EFFECT OF BIOPSY-SIDE DOWN POSITION ON PNEUMOTHORAX AND CHEST TUBE PLACEMENT

- CRITICAL APPRAISAL-

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ORIGINAL RESEARCH • THORACIC IMAGING

Radiology

CT-guided Lung Biopsy: Effect of Biopsy-side Down Position on Pneumothorax and Chest Tube Placement

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Conflicts of interest are listed at the end of this article.

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OVERVIEW

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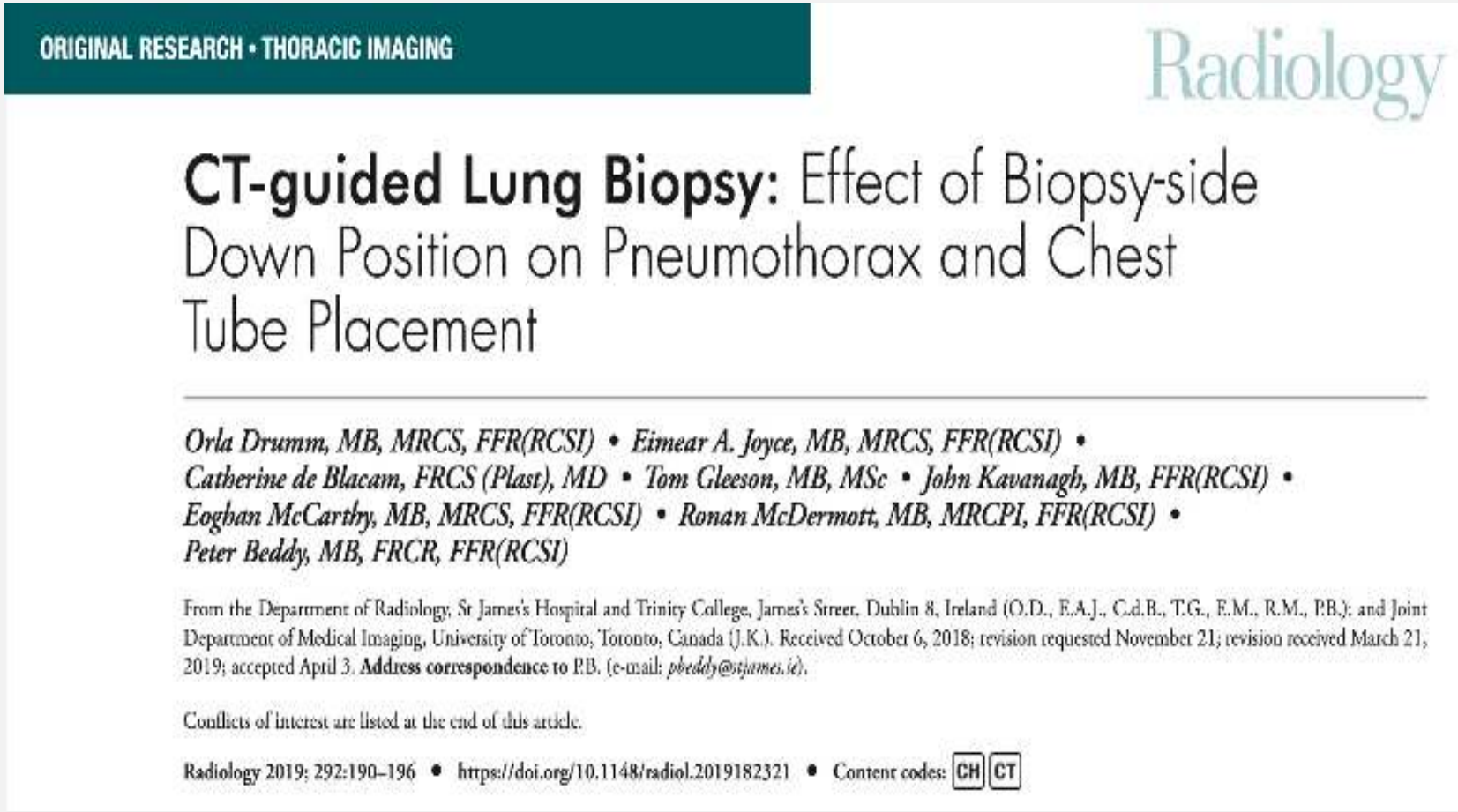
- Good impact factor (6.22)
- Original research article
- Clearly describe the title of the research
- Open access: RSNA Radiology, PubMed



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- The authors involved were clearly written
- Institutions and units involved are clearly stated
- Single center study

ABSTRACT

The Spire of Dublin

Background: Supine or prone positioning of the patient on the gantry table is the current standard of care for CT-guided lung biopsy; positioning biopsy side down was hypothesized to be associated with lower pneumothorax rate.

Purpose: To assess the effect of positioning patients biopsy side down during CT-guided lung biopsy on the incidence of pneumothorax, chest drain placement, and hemoptysis.

Materials and Methods: This retrospective study was performed between January 2013 and December 2016 in a tertiary referral oncology center. Patients undergoing CT-guided lung biopsy were either positioned in *(a)* the standard prone or supine position or *(b)* the lateral decubitus position with the biopsy side down. The relationship between patient position and pneumothorax, drain placement, and hemoptysis was assessed by using multivariable logistic regression models.

- Background, purpose/aims of the study were written in a concise and clear manner
- However, there was additional aim noted that was not mentioned in the title of the study (incidence of hemoptysis)
- Study design, duration, tools, samples population involved : clearly stated
- Statistical analysis was also mentioned

Results: A total of 373 consecutive patients (mean age ± standard deviation, 68 years ± 10), including 196 women and 177 men, were included in the study. Among these patients, 184 were positioned either prone or supine depending on the most direct path to the lesion and 189 were positioned biopsy side down. Pneumothorax occurred in 50 of 184 (27.2%) patients who were positioned either prone or supine and in 20 of 189 (10.6%) patients who were positioned biopsy side down ($P < .001$). Drain placement was required in 10 of 184 (5.4%) patients who were positioned either prone or supine and in eight of 189 (4.2%) patients who were positioned biopsy side down ($P = .54$). Hemoptysis occurred in 19 of 184 (10.3%) patients who were positioned prone or supine and in 10 of 189 (5.3%) patients who were positioned biopsy side down ($P = .07$). Prone or supine patient position ($P = .001$, odds ratio [OR] = 2.7 [95% confidence interval {CI}: 1.4, 4.9]), emphysema along the needle path ($P = .02$, OR = 2.1 [95% CI: 1.1, 4.0]), and lesion size ($P = .02$, OR = 1.0 [95% CI: 0.9, 1.0]) were independent risk factors for developing pneumothorax.

Conclusion: Positioning a patient biopsy side down for percutaneous CT-guided lung biopsy reduced the incidence of pneumothorax compared with the supine or prone position.

- Results were summarized in a succinct manner. The purpose of the study were addressed.
- Results of the multiple regression analysis for the independent risk factors for developing pneumothorax was also summarized.
- Conclusion – clearly written

INTRODUCTION

Percutaneous CT-guided transthoracic lung biopsy is an established technique for obtaining a tissue diagnosis from pulmonary masses. The procedure has high diagnostic accuracy, ranging 82%–98% (1–5). Complications are relatively frequent, with the incidence of pneumothorax varying 15%–54% (1,5–10) and a chest drain required in 1.4%–16.7% of patients (6,7,9–11). Hemoptysis is also a relatively frequent complication (0.8%–14.4%), but it is generally self-limited (1,5,8,9,11,12).

The development of a pneumothorax during the biopsy results in a more technically challenging procedure, and chest tube insertion may necessitate hospital admission (13–15). Various technical modifications have been published to reduce the incidence of pneumothorax, with a focus on patient positioning (10,15–17). In 1982, Zidulka et al demonstrated that placing dogs in the lateral decubitus position reduced the incidence of pneumothorax after pleural puncture (18). A number of subsequent studies have reported variable results on the effects of patient positioning after biopsy (15,17,19–24). The "rapid rollover technique" after lung biopsy demonstrated a substantial reduction in the incidence of pneumothorax after biopsy; however, a larger study using this technique did not achieve the same results (16,23).

An alternative approach might be to position the patient biopsy side down during the procedure and approach the lesion from the anterior or posterior chest wall. Positioning a patient biopsy side down during the procedure may decrease the incidence of hemoptysis as parenchymal hemorrhage enters the airways dependently (eg, by gravity). We hypothesized that performing a lung biopsy in the biopsy-side down position would reduce the incidence of complications (eg, pneumothorax, chest tube or drain placement, and hemoptysis).

The purpose of this study was to assess the effect of positioning a patient biopsy side down during percutaneous CT-guided transthoracic lung biopsy on the incidence of complications.

- Briefly written introduction
- Prevalence of common complications from CT guided lung biopsy described.
- Brief introduction on pneumothorax.
- Existing modifications to reduce incidence of pneumothorax from previous study explained.
- Hypothesis clearly stated. Purpose of the study mentioned.

Study Population

This retrospective study was approved by our institution's internal review board. There was no industry or financial support obtained. We analyzed consecutive patient studies performed between January 2013 and December 2016 at St James's Hospital, Dublin, Ireland, a tertiary referral oncology center. Patients were included if they had an indeterminate or suspicious parenchymal lung mass that was unsuitable for transbronchial biopsy or if they had undergone an unsuccessful transbronchial biopsy and a tissue diagnosis was requested by the attending pulmonologist or cardiothoracic surgeon. Patients were excluded from the study if they had severe pulmonary hypertension or the lesion was considered to be in an unsuitable location for percutaneous CT-guided lung biopsy. No lesions were excluded during the study period. The final study population included 373 consecutively recruited patients. Between January 2013 and June 2014, 184 patients underwent biopsy in either the prone or supine position. Between July 2014 and December 2016, 189 patients underwent biopsy in the biopsy-side down position (Fig 1).

STUDY DESIGN

- Study protocol compliance to the regulatory body
- Clearly stated study design
- Data collection interval explained
- Convenient sampling
- Inclusion and exclusion criteria briefly stated
- Number of samples recruited mentioned
- ? Randomization of samples – different timing for recruiting samples

Biopsy Technique

Written informed consent was obtained from all patients for the biopsy procedure. Two attending radiologists (R.M. and P.B., with 12 and 7 years of experience in CT-guided lung biopsy, respectively) performed all procedures. Procedures were performed under CT guidance on a 64-section multidetector CT (Somatom Sensation; Siemens, Erlangen, Germany) or a Toshiba Aquilion 64 (Toshiba Medical Systems, Otawara, Japan) with a 19-gauge coaxial needle and a 20-gauge automated core biopsy needle (Bard Monopty Disposable Core Biopsy Device; Bard, Tempe, Ariz). In the prone or supine group, 134 patients were positioned in the supine position and 50 in the prone position. The prone or supine position was chosen depending on the most direct needle path to the lesion, avoiding the fissures if possible (Fig 2). In the biopsy-side down group, patients were positioned in the lateral decubitus position with the lesion side closest to the CT table (biopsy side down) (Fig 3).

a follow-up posteroanterior chest radiograph the next day, the patient was discharged and monitored with daily posteroanterior chest radiographs as an outpatient. If the pneumothorax exceeded 40% and the patient remained asymptomatic, the patient was monitored in the hospital until the pneumothorax reduced in size to less than 25%. A patient with a pneumothorax who became symptomatic (dyspnea or chest pain) or who had reduced oxygen saturation had either a 12-F pigtail drain (Mac-Loc Multipurpose Drainage Catheter; Cook, Bloomington, Ind) inserted by the radiologist who performed the biopsy or a 20-F drain (Arrow Pneumothorax Set; Teleflex Medical, Morrisville, NC) inserted by the cardiothoracic team.

To plan the biopsy, an initial non–contrast-material–enhanced CT was obtained and reconstructed at 3-mm increments. The needle path was then chosen through the anterior or posterior chest wall depending on the most direct needle path to the lesion, avoiding the fissures if at all possible. All biopsies were performed using a coaxial technique. The skin, subcutaneous tissues, and parietal pleura were anesthetized with 1% lidocaine. A single pleural puncture was performed with a 19-gauge coaxial needle. The needle was positioned adjacent to the lesion and 20-gauge core biopsies were performed. After the procedure, patients who were in the prone or supine position had the needle removed rapidly and were rolled onto the biopsy-side down position. Patients in the biopsy-side down group had the needle removed after the procedure and remained positioned biopsy side down. No sealant (blood patch) was used after the biopsy. All patients were then transferred from the CT table to the recovery ward in the biopsy-side down position.

All patients were monitored for 3 hours after the procedure. Routine vital signs were recorded and patients remained in the biopsy-side down position for 2 hours. If patients remained stable, they were positioned supine for a further 1 hour. An erect posteroanterior chest radiograph was obtained at 3 hours after the procedure. If the chest radiograph showed no pneumothorax, the patient was discharged. If the patient had an asymptomatic pneumothorax measuring less than 25%, the patient was discharged. The size of the pneumothorax was calculated by using a previously validated measurement tool (25).

The decision to insert a chest drainage catheter was made by the radiologists who performed the biopsy in conjunction with the referring physician (pulmonologist or cardiothoracic surgeon). A patient with an asymptomatic pneumothorax between 25% and 40% was admitted to the hospital overnight. If the pneumothorax was stable or decreased in size on

- Experienced personnel involved (12- and 7-years experience in CT guided biopsy).
  Not mentioned whether general radiologist/IR.
- Equipment used mentioned
- Procedural steps explained.
  Number of cores sample obtained/each patient ?not standardized.

- Post procedure steps were also explained.
- Management steps of complication: pneumothorax clearly stated.

- Management for other type of complications (eg: hemothorax) were not mentioned.
- For biopsy-side down group, subjective criteria to decide for approach (anterior vs posterior).

Statistical Analysis

χ^2 (2 × 2 table) was used to test for statistically significant differences between dichotomous variables. χ^2 (R × 2 table) was used to test for differences between categorical variables. The Student *t* test (invented by William Gosset) was used to test for differences between continuous variables (C.d.B.).

Comparison between groups was performed using multivariable logistic regression. A logistic regression attempts to predict the probability that an observation falls into one of two categories of a dichotomous dependent variable based on one or more independent variables that can be either continuous or categorical. The model was run for each of the three dichotomous dependent variables of interest: pneumothorax, chest drain placement, and hemoptysis. Biopsy position, patient age, sex, emphysema, pleural distance, number of cores, and lesion location were the independent variables. As per Harrell 2001 (27), 15 was used as the minimum number of observations per independent variable. Therefore, crossing fissures could not be included as an independent variable. Patients with lesions in the right middle lobe or lingula, as well as patients with lung fibrosis, were excluded from the analysis due to low numbers of observations (Fig 1). A *P* value of less than .05 was considered indicative of statistical significance. All analyses were performed by using commercially available software (IBM SPSS Statistics for MAC, version 25.0; IBM, Armonk, NY).

STATISTICAL ANALYSIS

- Chi squared test
- Multivariable logistic regression

- Variable of interest and independent variables clearly stated
- Statistical significance level stated

- No elaboration regarding sample size calculation?

RESULT

Table 1: Patient Demographics

Demographic	No. of Lung Biopsies			
	All (n = 373)	Prone or Supine (n = 184)	Biopsy Side Down (n = 189)	P Value
Female	196 (52.5)	102 (55.4)	94 (49.7)	.31
Age (y)*	67.7 ± 10.2 (23–90)	67.4 ± 10.6 (23–89)	67.9 ± 10.0 (27–90)	.68
Emphysema	178 (47.7)	98 (53.2)	80 (42.3)	.08
Pulmonary fibrosis	4 (1.1)	1 (0.5)	3 (1.6)	

Note—Unless stated otherwise, data are number of biopsies. Data in parentheses are percentages. χ^2 (2 × 2), χ^2 (R × 2), and the Student t test were used to calculate the statistical difference between groups of categorical, dichotomous, and continuous variables, respectively.

* Data are mean ± standard deviation. Data in parentheses are ranges.

- Descriptive data - clearly presented in a table
- Patient clinical condition at the time of procedure were not specifically stated (under room air, intubated, etc)

Table 2: Lesion Characteristics for Patients Positioned Prone or Supine versus Biopsy Side Down

Lesion Characteristic	No. of Lung Biopsies		*P* Value
	Prone or Supine (n = 184)	Biopsy Side Down (n = 189)	
Size (mm)*	19.5 ± 11.4	20.8 ± 10.6	.25
Skin-to-lesion distance (mm)*	67.9 ± 21.5	61.9 ± 23.1	.01
Pleura-to-lesion distance (mm)*	21.1 ± 14.1	24.2 ± 19.8	.07
No. of cores*	1.8 ± 0.64	1.8 ± 0.62	.59
Fissures crossed	9 (4.8)	16 (8.5)	.23
Location			.01
Right upper lobe	61 (33.2)	67 (35.4)	…
Left upper lobe	53 (28.8)	35 (18.5)	…
Right lower lobe	18 (9.8)	43 (22.7)	…
Left lower lobe	38 (20.7)	33 (17.5)	…
Middle lobe	11 (6.0)	7 (3.7)	…
Lingula	3 (1.6)	4 (2.1)	…

Note—Unless stated otherwise, data are number of biopsies. Data in parentheses are percentages. χ^2 (2 × 2), χ^2 (R × 2), and the Student t test were used to calculate the statistical difference between groups of categorical, dichotomous, and continuous variables, respectively.

*Data are mean ± standard deviation.

- Descriptive statistics for the lesion clearly summarize in a table
- For biopsy side down group : anterior or posterior approach not specifically mentioned in results

Pneumothorax occurred in 50 of 184 (27.2%) patients who were positioned either prone or supine and in 20 of 189 (10.6%) patients who were positioned biopsy side down ($P < .001$). Drain placement was required in 10 of 184 (5.4%) patients who were positioned either prone or supine and in eight of 189 (4.2%) patients who were positioned biopsy side down ($P = .54$). Hemoptysis occurred in 19 of 184 (10.3%) patients who were positioned prone or supine and in 10 of 189 (5.3%) patients who were positioned biopsy side down ($P = .07$). There was no difference in the incidence of pneumothorax ($P = .72$), drain placement ($P = .56$), or hemoptysis ($P = .32$) between the prone or supine positioning in the patients who were positioned either prone or supine. There was no difference in the complication rates between the two radiologists (pneumothorax, $P = .11$; drain insertion, $P = .71$; hemoptysis, $P = .52$).

- Complication rates between the 2 radiologist were stated in text (no difference)
- Incidence of pneumothorax, drain placement and hemoptysis in the different groups were only mentioned in the text (not summarized in a table).

Table 3: Multivariable Logistic Regression Predicting Likelihood of Pneumothorax

Variable	Odds Ratio	95% CI	*P* Value
Biopsy position	2.7	1.4, 4.9	.001
Age (y)	1.0	1.0, 1.0	.96
Sex	0.9	0.6, 1.7	.79
Pleural distance (cm)	1.0	1.0, 1.0	.15
Emphysema	2.1	1.1, 4.0	.02
No. of cores	1.8	1.2, 2.9	.05
Size (cm)	1.0	0.9, 1.0	.02
Lesion location			
Right upper lobe	1.1	0.5, 2.5	.81
Right lower lobe	0.3	0.1, 1.2	.09
Left upper lobe	1.2	0.5, 2.8	.67

Note.—The total number of cases in the cohort for the multivariable analysis was 337, with 62 pneumothoraces. Biopsy position is for the prone or supine group compared with the biopsy-side down group; sex is for female compared with male patients; emphysema is compared with no emphysema. Lesion location (right upper lobe, right lower lobe, left upper lobe) is compared with left lower lobe. CI = confidence interval.

Table 4: Multivariate Logistic Regression Predicting Likelihood of Chest Drain Insertion

Variable	Relative Risk	95% CI	*P* Value
Biopsy position	1.0	0.2, 2.2	.47
Age (y)	1.0	1.0, 1.1	.37
Sex	1.0	0.5, 4.5	.53
Pleural distance (cm)	1.0	1.0, 1.1	.03
Emphysema	1.0	1.2, 18.6	.03
No. of cores	1.0	0.4, 2.5	.96
Size (cm)	1.0	0.9, 1.0	.37
Lesion location			
Right upper lobe	0.9	0.1, 1.5	.16
Right lower lobe	0.8	0.0, 1.5	.11
Left upper lobe	1.0	0.1, 2.5	.36

Note.—The total number of cases in the cohort for the multivariate analysis was 337, with 14 drains inserted. Biopsy position is for the prone or supine group compared with the biopsy-side down group; sex is for female compared with male patients; emphysema is compared with no emphysema. Lesion location (right upper lobe, right lower lobe, left upper lobe) is compared with left lower lobe. CI = confidence interval.

Table 5: Multivariate Logistic Regression Predicting Likelihood of Hemoptysis

Variable	Relative Risk	95% CI	*P* Value
Biopsy position	1.0	0.9, 5.7	.09
Age (y)	1.0	1.0, 1.1	.22
Sex	1.0	0.7, 4.4	.23
Pleural distance (cm)	1.0	1.0, 1.1	.04
Emphysema	0.9	0.2, 1.3	.18
No. of cores	1.0	0.4, 1.7	.68
Size (cm)	1.0	0.9, 1.0	.42
Lesion location			
Right upper lobe	1.0	0.3, 3.5	.90
Right lower lobe	1.0	0.3, 5.3	.75
Left upper lobe	1.0	0.2, 2.8	.67

Note.—The total number of cases in the cohort for the multivariate analysis was 337, with 23 patients reported with hemoptysis. Biopsy position is for the prone or supine group compared with the biopsy-side down group; sex is for female compared with male patients; emphysema is compared with no emphysema. Lesion location (right upper lobe, right lower lobe, left upper lobe) is compared with left lower lobe. CI = confidence interval.

- Statistical results for all the variables of interest are presented clearly in separate tables
- Independent risk factors which are statistically significant were highlighted in the text

DISCUSSION

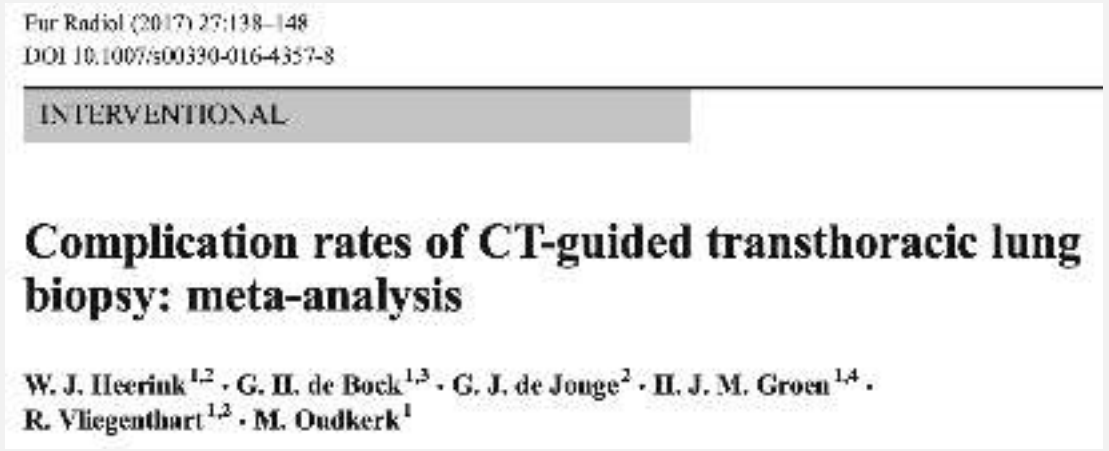
Pneumothorax is the most common complication that occurs during (or immediately after) a percutaneous CT-guided lung biopsy, with a recent meta-analysis of 12 753 cases reporting an incidence of 25.3% (10). Our study demonstrates that positioning a patient biopsy side down during a percutaneous CT-guided lung biopsy resulted in a substantial reduction in the pneumothorax rate (biopsy side down, 10.6% vs prone or supine, 27.2%; $P < .001$). In addition to the reduced incidence of pneumothorax, the technical success rate (completed tissue sampling) for patients positioned biopsy side down was higher than for those positioned in the more traditional prone or supine approach (100% vs 97.8%, respectively; $P = .04$). Our data suggest that patient positioning during and immediately after the procedure are important factors in the development of a pneumothorax.

Important contributing factors to develop pneumothorax discussed

The rate of chest tube or drain insertion in our study (4.8%) was comparable with that found in a recent meta-analysis of 12753 lung biopsies (5.6%) (10). The presence of emphysema was a significant risk factor for chest tube or drain placement in our cohort. Chest tube drainage often requires a hospital admission and is more costly (31,32). There was no significant difference between the two groups in the rate of chest tube or drain placement. The relatively low rate in the prone or supine position may reflect that these patients were rapidly rolled into the biopsy-side down position after the biopsy, which has been shown to reduce the rate of tube placement (17). Patient factors have an influence on whether chest tube drainage is required. For example, patients with emphysema are more likely to require tube drainage due to a lower respiratory reserve and can quickly become dyspneic if a pneumothorax develops (7,33–35). We confirm the previously published findings by Haraki et al that lesion depth from the pleural surface is an independent risk factor for chest tube or drain placement (7).

The incidence of hemoptysis in our cohort was reduced in patients who were positioned biopsy side down versus supine or prone (5.3% vs 10.3%, respectively); however, this did not reach significance. The reported rates of hemoptysis following lung biopsy range 1.8% to 14.4% (1,5,8,9,11,12,36). Placement of the patient in the biopsy-side down or lateral decubitus position has been described if hemoptysis develops during a lung biopsy as it isolates the hemorrhage in the dependent lung and protects the

- Data in current study are comparable to study with larger sample
- Factors which contribute to the outcome were discussed


Eur Radiol (2017) 27:138–148
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INTERVENTIONAL

Complication rates of CT-guided transthoracic lung biopsy: meta-analysis

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large airways and contralateral lung from aspirating this blood (37). The incidence of hemoptysis was greater with increasing depth from the pleural surface. This is because central lesions are closer to larger vessels and bronchi, which makes hemoptysis more likely if the biopsy needle crosses these structures (12,38).

An approach to reducing the rate of pneumothorax was previously reported by Kinoshita et al. In that study, a modified CT table was constructed with a biopsy window to enable the operator to perform the procedure with the patient positioned biopsy side down, with a pneumothorax rate of 12.9% (24). Zidulka et al postulated that the reduced incidence of pneumothorax by using the biopsy-side down position is due to a reduction in the alveoli surrounding the needle path, which results in airway closure, greater resistance to collateral ventilation in the dependent lung, a reduction in the alveolar-to-pleural pressure gradient at the puncture site, and a gravity-dependent accumulation of hemorrhage along the needle track (18,20). Essentially when the patient is biopsy side down, the weight of the lung increases pleural apposition and compresses the alveoli, which helps to seal the biopsy track.

- Cause of the complication explained
- Comparison with prior related studies
- Theory behind postulated hypothesis explained

LIMITATION

- Retrospective
- The needle-out to rollover time in the prone or supine group was not reported, and a shorter rollover time has been shown to be associated with a reduced pneumothorax rate
- The procedure time was not recorded for the two groups, - unable to assess whether it took longer to perform the procedure biopsy side down.
- It is possible that changes in patient positioning may increase the risk of rare complications (eg, air embolism and death) – not reported in this study
- Some of the events could not be included in the multivariate analysis, as the incidence is too small. Eg : crossing fissure → pneumothorax.

Our study has the following limitations. The study was retrospective, which is obviously inferior to a randomized control trial to assess this technique. The needle-out to rollover time in the prone or supine group was not reported, and a shorter rollover time has been shown to be associated with a reduced pneumothorax rate (17,23). The procedure time was not recorded for the two groups, so we were unable to assess whether it took longer to perform the procedure biopsy side down. The overall volume of procedures per day on each scanner did not change during our study and we believe there was no additional time required to perform the procedures biopsy side down. It is possible that changes in patient positioning may increase the risk of rare complications (eg, air embolism and death); however, we were fortunate that no such complications occurred during our study.

Hence, we were unable to assess for such an uncommon event. Some events could not be included in the multivariate analysis as the incidences were too small; in particular, we excluded crossing of fissures, which has been previously associated with patients developing a pneumothorax (13).

In conclusion, positioning the patient biopsy side down during percutaneous CT-guided lung biopsy reduces the incidence of pneumothorax; however, it did not affect the rate of chest tube or drain insertion or the incidence of hemoptysis. This technique is a simple approach to reduce the incidence of pneumothorax in patients undergoing CT-guided lung biopsy.

CONCLUSION

Brief and concise summary

OVERALL

- This is a good article. Good comparison between the groups.
- Strength of the study
- Practically applicable
- Large sample size

- Potentially can be practiced in our department because;

+ No. of CT guided lung biopsy cases
+ Does not require special apparatus/ equipment or device.
+ No extra cost + Another option for patient positioning.

However, need to assess on a case-to-case basis (eg lesion characteristic, patient tolerance, patient baseline clinical condition).

HUSM - OUR CENTER EXPERIENCE (BRIEF SUMMARY)

- CT Guided Biopsy procedures retrieved from PACS : interval 16/7/2021 – 16/1/2022 (6 months duration)
- Total cases of CT guided lung biopsy: 19 cases (left lung 11, right lung 8)
- Positioning: Prone 11, Supine 3, Lateral/oblique (side with lesion up) 5

NO STATISTICAL ANALYSIS PERFORMED

<u>Complications:</u>

- Prone : pneumothorax 6 cases, hemothorax 1 case
- Lateral/oblique : pneumothorax 1 case (right side up)
- Supine : 0 cases of pneumothorax
- Total number of pneumothorax: 8
- NO pneumothorax : 11 cases (prone 4, supine 3, right side up 2, left side up 2)

REFERENCES

- Drumm, O., Joyce, E.A., de Blacam, C., Gleeson, T., Kavanagh, J., McCarthy, E., McDermott, R. and Beddy, P., 2019. CT-guided lung biopsy: effect of biopsy-side down position on pneumothorax and chest tube placement. *Radiology*, *292*(1), pp.190-196.

THANK YOU

Quadrangle, NUI Galway, Ireland (1845)