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Comparison between computed tomography-guided core and fine needle lung biopsy

A meta-analysis

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Abstract

Background: This meta-analysis was conducted to compare the safety and diagnostic performance between computed tomography (CT)-guided core needle biopsy (CNB) and fine-needle aspiration biopsy (FNAB) in lung nodules/masses patients.

Methods: All relevant studies in the Pubmed, Embase, and Cochrane Library databases that were published as of June 2020 were identified. RevMan version 5.3 was used for all data analyses.

Results: In total, 9 relevant studies were included in the present meta-analysis. These studies were all retrospective and analyzed outcomes associated with 2175 procedures, including both CT-guided CNB (n = 819) and FNAB (n = 1356) procedures. CNB was associated with significantly higher sample adequacy rates than was FNAB (95.7% vs 85.8%, OR: 0.26; $P < .00001$), while diagnostic accuracy rates did not differ between these groups (90.1% vs 87.6%, OR: 0.8; $P = .46$). In addition, no differences in rates of pneumothorax (28.6% vs 23.0%, OR: 1.15; $P = .71$), hemorrhage (17.3% vs 20.1%, OR: 0.91; $P = .62$), and chest tube insertion (5.9% vs 4.9%, OR: 1.01; $P = .97$) were detected between these groups. Significant heterogeneity among included studies was detected for the diagnostic accuracy ($I^2 = 57\%$) and pneumothorax ($I^2 = 77\%$) endpoints. There were no significant differences between CNB and FNAB with respect to diagnostic accuracy rates for lung nodules ($P = .90$). In addition, we detected no evidence of significant publication bias.

Conclusions: CT-guided CNB could achieve better sample adequacy than FNAB did during the lung biopsy procedure. However, the CNB did not show any superiorities in items of diagnostic accuracy and safety.

Abbreviations: CNB = core needle biopsy, CT = computed tomography, FNAB = fine-needle aspiration biopsy, OR = odds ratio.

Keywords: biopsy, core needle, fine needle, lung

1. Introduction

Computed tomography (CT)-guided lung biopsy is commonly used to diagnose lung nodules and masses, and can reliably achieve diagnostic accuracy rates of 88% to 97%.[1–5] A number of factors can influence the ultimate diagnostic accuracy of this biopsy approach, including the type of needle use (fine or core needles), the type of guidance employed (conventional CT, CT fluoroscopy, or cone-beam CT), and use of the co-axial technique.[6–12] Among these factors, the types of needles are most notable.[13–21]

Many studies to date have compared rates of sample adequacy, diagnostic accuracy, and complications between lung nodules/masses patients that underwent core needle biopsy (CNB) or fine-needle aspiration biopsy (FNAB).[13–21] However, several of these endpoints in these studies, however, were controversial, leading to inconsistent findings. For example, the comparative results of diagnostic accuracy rates varied largely among those studies.[13,14,18–21] Furthermore, the comparative results of complications also varied among those studies.[16–21] Therefore, a meta-analysis should be conducted to make the evidence-based recommendations regarding the optimal use of CT-guided CNB and FNAB for the diagnosis of lung diseases. At present, we only found 1 meta-analysis which compared the diagnostic accuracy between CNB and FNAB for lung lesions.[22]

In this meta-analysis, we aimed to compare the safety and diagnostic performance between CT-guided CNB and FNAB for lung nodules/masses.

2. Materials and methods

The Institutional Review Board of Affiliated Hospital of North Sichuan Medical College approved this study.

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The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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2.1. Study selection

We searched the Pubmed, Embase, and Cochrane Library databases for relevant studies published as of June 2020. Search strategy was: (((((cutting[Title/Abstract]) OR (core[Title/Abstract])) OR (biopsy[Title/Abstract])) AND ((fine needle[Title/Abstract]) OR (aspiration[Title/Abstract]))) AND ((computed tomography[Title/Abstract]) OR (CT[Title/Abstract]))) AND (((lung[Title/Abstract]) OR (pulmonary[Title/Abstract])) OR (thoracic[Title/Abstract])).

Studies were eligible for inclusion if they met the following criteria: studies were either randomized controlled trials (RCTs) or nonrandomized studies comparing CT-guided CNB and FNAB analyses of lung nodules/masses patients, and studies were published in English. Studies were excluded if they were: noncomparative studies; animal studies; or reviews.

2.2. Data extraction

Two researchers independently extracted all data from included studies, with a third researcher resolving any discrepancies. Extracted data included baseline study parameters, patient baseline data, and biopsy-associated outcomes.

2.3. Quality assessment

The quality of RCTs was assessed by the Cochrane risk of bias tool, while the retrospective study's quality was assessed using the Newcastle–Ottawa scale, with a maximum possible quality score of 9 points.[23]

2.4. Endpoints

Sample adequacy, diagnostic accuracy, pneumothorax rates, hemorrhage rates, and rates of chest tube insertion for complication were all endpoints in this analysis. The diagnostic accuracy was the primary endpoint. Sample adequacy was defined based upon sufficient sample having been obtained to permit a biopsy-based diagnosis. Diagnostic accuracy was defined as the precise diagnosis of a malignant or benign condition as a fraction of all definitive results.[10]

2.5. Statistical analyses

RevMan version 5.3 (The Cochrane Collaboration, London, UK) was used for all meta-analyses. Dichotomous variables were analyzed via the Mantel–Haenszel method to assess pooled odds ratios (ORs) and 95% confidence intervals. Heterogeneity was analyzed based upon X^2 tests and the I^2 statistic, with $I^2 > 50\%$ being indicative of significant heterogeneity. When significant heterogeneity was found, meta-analyses were performed with a random-effects model, whereas they were otherwise analyzed by a fixed-effects model. Potential sources of heterogeneity were evaluated through subgroup and sensitivity analyses, while the publication bias was assessed by funnel plots.

3. Results

3.1. Study characteristics

Through our initial search strategy, we identified 3340 studies that were potentially relevant, of which 9 were ultimately included in the present meta-analysis (Fig. 1). These studies incorporated data corresponding to 2175 procedures, including both CT-guided CNB (n=819) and FNAB (n=1356) procedures conducted in lung disease patients.

Baseline data and characteristics corresponding to these 9 studies are compiled in Tables 1 and 2. Two of these studies were specifically focused on lung nodule biopsy.[14,19] Only 1 study both used normal CT and CT-fluoroscopic guided biopsy.[14] The biopsy-related outcomes were shown in Table 3.

3.2. Quality assessment

All of these studies were retrospective in nature and were associated with Newcastle–Ottawa scores ranging from 6 to 8.

3.3. Sample adequacy

A total of 5 of these studies reported rates of sample adequacy.[13,15–17,21] Pooled analyses revealed that CT-guided CNB was associated with higher rates of sample adequacy relative to CT-guided FNAB (95.7% vs 85.8%, OR: 0.26; $P < .00001$, Fig. 2A). This result indicated that core needle could obtain more adequate sample than fine needle did. No significant heterogeneity was found ($I^2 = 0\%$), and we detected no evidence of publication bias.

3.4. Diagnostic accuracy

Six of the included studies reported diagnostic accuracy rates,[13,14,18–21] which were found to be comparable between these 2 groups (90.1% vs 87.6%, OR: 0.8; $P = .46$, Fig. 2B). This result indicated that CNB and FNAB had the similar diagnostic ability for lung nodules/masses. Significant heterogeneity was found ($I^2 = 57\%$), but we detected no evidence of publication bias.

3.5. Pneumothorax

Pneumothorax rates were reported in 6 studies,[16–21] and no significant differences in pneumothorax incidence were found between these 2 groups (28.6% vs 23.0%, OR: 1.15; $P = .71$, Fig. 2C). This result indicated that core needle did not increase the risk of pneumothorax. Significant heterogeneity was found ($I^2 = 77\%$), but we detected no evidence of publication bias.

3.6. Hemorrhage

Hemorrhage incidence was reported in 5 of the included studies,[17–21] and no significant differences in hemorrhage rates were found between these 2 groups (17.3% vs 20.1%, OR: 0.91; $P = .62$, Fig. 2D). This result indicated that core needle did not increase the risk of hemorrhage. No significant heterogeneity was found ($I^2 = 19\%$), and we detected no evidence of publication bias.

3.7. Chest tube insertion for complication

The rates of chest tube insertion for complication were reported in 4 studies,[16,18,20,21] and no significant differences in the rates of chest tube insertion for complication were found between these 2 groups (5.9% vs 4.9%, OR: 1.01; $P = .97$, Fig. 2E). This result indicated that core needle did not increase the rate of requirement of chest tube. Significant heterogeneity was not found ($I^2 = 0\%$). We detected no evidence of publication bias.

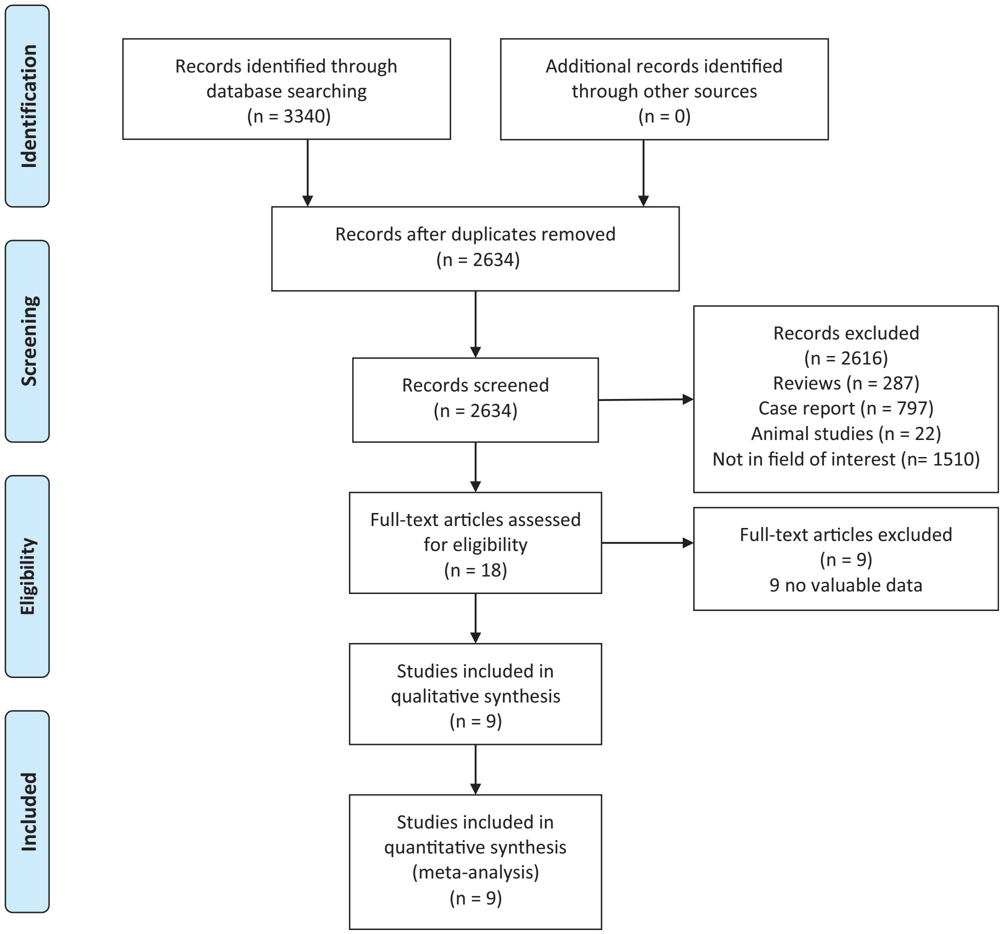

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Figure 1. Study flowchart.

3.8. Sensitivity analysis

We performed sensitivity analysis for the diagnostic accuracy and pneumothorax endpoints. For diagnostic accuracy, when the study made by Capalbo et al[19] was removed, the significant heterogeneity disappeared (I^2 decreased from 57%–23%). After removing the Capalbo et al[19] study, the pooled diagnostic accuracy were still comparable between these 2 groups (91.1% vs 86.9%; OR: 0.65, $P=.07$).

For pneumothorax rate, when the study made by Beslic et al[17] was removed, the significant heterogeneity disappeared (I^2 decreased from 77% to 49%). After removing the Beslic et al[17] study, the pooled pneumothorax rates were still

Table 1

Baseline data of the 9 studies.

Study	Year	Lung disease	Country	Design	Quality assessments	
					Jade score	Newcastle–Ottawa score
Laurent et al[13]	2000	All	France	Retrospective	–	8
Ohno et al[14]	2004	Nodules	Japan	Retrospective	–	6
Chojniak et al[15]	2006	All	Brazil	Retrospective	–	6
Lourenço et al[16]	2006	All	Portugal	Retrospective	–	6
Beslic et al[17]	2012	All	Bosnia and Herzegovina	Retrospective	–	6
Tuna et al[18]	2013	All	Turkey	Retrospective	–	8
Capalbo et al[19]	2014	Nodules	Italy	Retrospective	–	6
Ocak et al[20]	2016	All	Belgium	Retrospective	–	8
Sangha et al[21]	2016	Nodules	Canada	Retrospective	–	8

Table 2

Characteristics of the included studies.

Study	Groups	Patients	Procedures	Lesion size (mm)	Age (yr)	Needle size	Co-axial used
Laurent et al[13]	CNB	97	98	35	65.4	18.5G	Yes
	FNAB	125	125	35.8	61.9	22G	
Ohno et al[14]	CNB	154	154	Not given	63.3 ± 16.8 for all patients	18G	Not mentioned
	FNAB	242	242	Not given		22G	
Chojniak et al[15]	CNB	Not given	82	Not given	Not given	16–18G	Not mentioned
	FNAB	Not given	448	Not given	Not given	22G	
Lourenço et al[16]	CNB	92 for all patients	13	38 for all patients	64.4 for all patients	Not given	Not mentioned
	FNAB		89			Not given	
Beslic et al[17]	CNB	95	95	Not given	58.9 for all patients	14G	Not mentioned
	FNAB	147	147	Not given		20–22G	
Tun et ala[18]	CNB	83	83	Not given	60	18G	Not mentioned
	FNAB	22	22	Not given	59	18–22G	
Capalbo et al[19]	CNB	121 for all patients	66	38	Not given	18–21G	Not mentioned
	FNAB		56	29	Not given	21–22G	
Ocak et al[20]	CNB	99	102	37	66	14G	Not mentioned
	FNAB	92	102	36	64	22G	
Sangha et al[21]	CNB	243 for all patients	126	32	65.8	20G	Not mentioned
	FNAB		125	30	67.3	22G	

CNB = core needle biopsy, FNAB = fine needle aspiration biopsy.

comparable between these 2 groups (27.9% vs 28.1%; OR: 0.90, $P = .71$).

3.9. Subgroup analyses

Two studies focused on the lung nodule biopsy.[14,19] Only diagnostic accuracy rates could be found in both of the 2 studies (Table 4). No significant differences in the relative diagnostic accuracy of CT-guided CNB and FNAB (89.6% vs 88.6%, OR: 0.97, $P = .90$) was found. This result indicated that CNB and FNAB had the similar diagnostic ability for lung nodules. No heterogeneity was found ($I^2 = 0\%$).

Two studies used 14G core needle.[17,20] Both of the 2 studies reported the pneumothorax and hemorrhage rates (Table 5). CT-guided CNB was associated with higher pneumothorax rates relative to CT-guided FNAB (31.4% vs 13.0%, OR: 2.95; $P = .005$). Significant heterogeneity was found ($I^2 = 59\%$). No significant differences in the relative hemorrhage rates of CT-guided CNB and FNAB (7.7% vs 6.3%, OR: 1.53, $P = .27$) was found. No heterogeneity was found ($I^2 = 8\%$). These findings indicated that 14G core needle only increased the risk of pneumothorax.

4. Discussion

Herein, we compared sample adequacy, diagnostic accuracy, and complication rates associated with CT-guided CNB and CT-guided FNAB in lung nodules/masses patients. Our pooled analyses suggest that CNB is associated with higher rates of sample adequacy, indicating that this approach can more reliably yield sample quantities sufficient to permit biopsy-based diagnosis. While FNAB can achieve moderate-to-high diagnostic

Table 3

Raw data of the biopsy-related outcomes.

Study	Groups	Sample adequacy	Diagnostic accuracy	Pneumothorax	Hemorrhage	Chest tube insertion
Laurent et al[13]	CNB	97/98 (99.0%)	92/97 (94.8%)	Not given	Not given	Not given
	FNAB	121/125 (96.8%)	109/125 (87.2%)	Not given	Not given	Not given
Ohno et al[14]	CNB	Not given	136/154 (88.3%)	Not given	Not given	Not given
	FNAB	Not given	209/242 (86.4%)	Not given	Not given	Not given
Chojniak et al[15]	CNB	78/82 (95.1%)	Not given	Not given	Not given	Not given
	FNAB	392/448 (87.5%)	Not given	Not given	Not given	Not given
Lourenço et al[16]	CNB	13/13 (100%)	Not given	0/13 (0%)	Not given	0/13 (0%)
	FNAB	72/89 (80.9%)	Not given	11/89 (12.4%)	Not given	1/89 (1.1%)
Beslic et al[17]	CNB	92/95 (96.8%)	Not given	30/95 (31.6%)	14/95 (14.7%)	Not given
	FNAB	117/147 (79.6%)	Not given	14/147 (9.5%)	13/147 (8.8%)	Not given
Tuna et al[18]	CNB	Not given	77/83 (92.8%)	7/83 (8.4%)	1/83 (1.2%)	4/83 (4.8%)
	FNAB	Not given	18/22 (81.8%)	4/22 (18.2%)	1/22 (4.5%)	2/22 (9.1%)
Capalbo et al[19]	CNB	Not given	54/66 (81.8%)	12/66 (18.2%)	5/66 (7.6%)	Not given
	FNAB	Not given	53/56 (94.6%)	14/56 (25.0%)	8/56 (14.3%)	Not given
Ocak et al[20]	CNB	Not given	92/102 (90.2%)	31/99 (31.3%)	1/99 (1.0%)	10/99 (10.1%)
	FNAB	Not given	84/102 (82.4%)	17/92 (18.5%)	2/92 (2.2%)	11/92 (12.0%)
Sangha et al[21]	CNB	116/126 (92.1%)	106/116 (91.4%)	58/126 (46.0%)	60/126 (47.6%)	5/126 (4.0%)
	FNAB	99/125 (79.2%)	93/99 (93.9%)	62/125 (49.6%)	65/125 (52.0%)	2/125 (1.6%)

CNB = core needle biopsy, FNAB = fine needle aspiration biopsy.

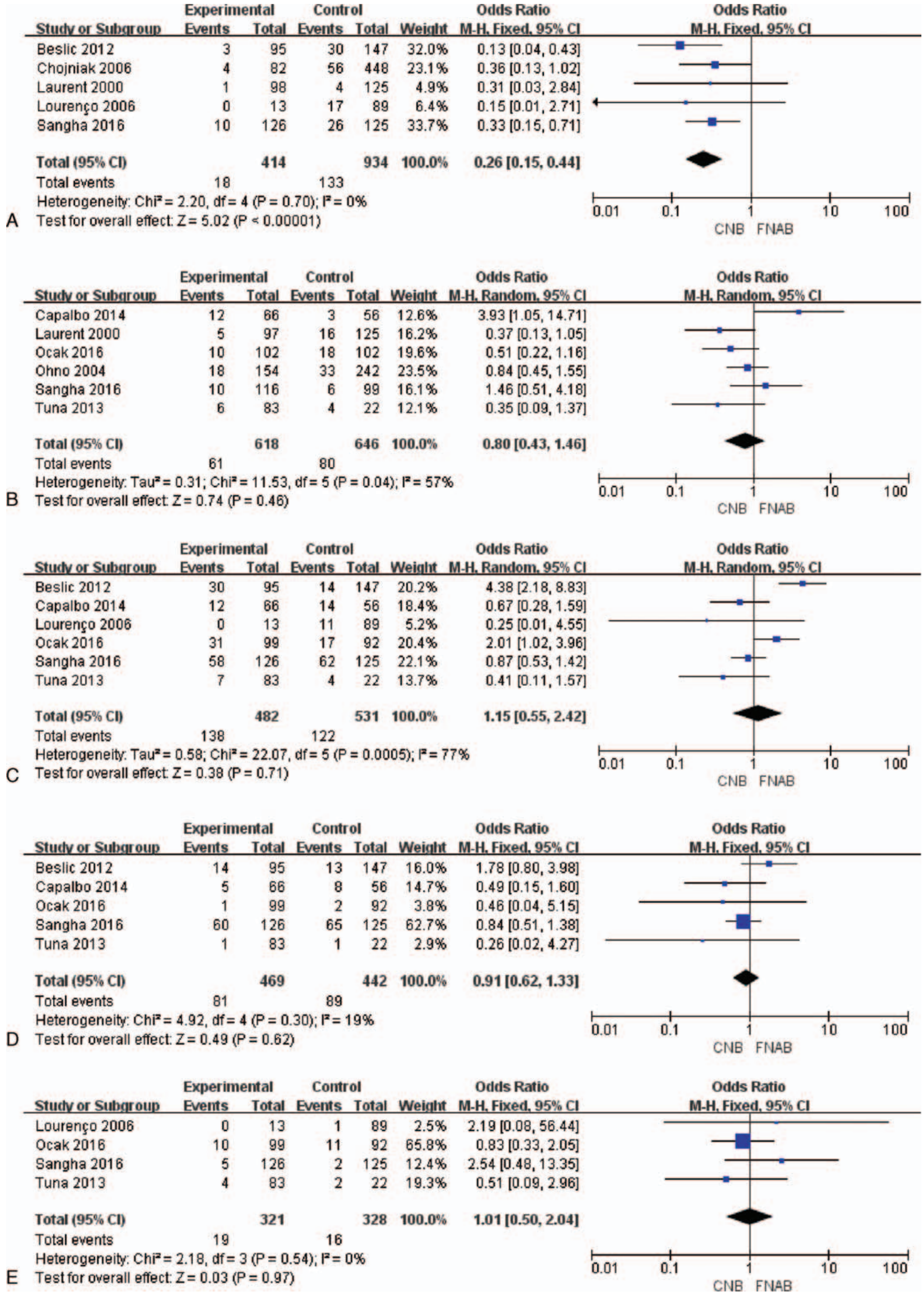

Figure 2. Forest plots showing comparisons in (A) sample adequacy, (B) diagnostic accuracy, (C) pneumothorax, (D) hemorrhage, and (E) chest tube insertion rates between these 2 groups. CI = confidence interval, CNB = core needle biopsy, FNAB = fine needle aspiration biopsy.

accuracy rates (64%–97%) in lung nodules/masses,[14,24–26] the relatively small amount of sample yielded by this approach can limit its utility.[14] Relative to FNAB, CNB can collect larger volumes of sample tissue owing to the use of a core needle that can better cut diseased tissue. All included studies detected significantly higher rates of sample adequacy associated with CNB relative to FNAB.[13,15–17,21]

While CNB can yield larger sample volumes relative to FNAB, in this meta-analysis we found that these 2 approaches were associated with comparable rates of diagnostic accuracy (90.1% vs 87.6%, $P = .46$). The pooled diagnostic accuracy of CT-guided CNB in this analysis was similar to rates that have been previously reported (90%–96%).[27–29] This finding may be the result of a number of different factors. For one, diagnostic

Table 4

Meta-analytic pooled results based on the studies regarding of lung nodules.

	Number of studies	OR or HR (95% CI)	Heterogeneity	Favor
Diagnostic accuracy	2	0.97 (0.57, 1.64), $P=.90$	$I^2=0\%$	–

CI = confidence interval, HR = hazard ratio, OR = odd ratio.

Table 5

Meta-analytic pooled results based on the studies which used 14G core needle.

	Number of studies	OR or HR (95% CI)	Heterogeneity	Favor
Pneumothorax	2	2.95 (1.38, 6.34), $P=.005$	$I^2=59\%$	FNAB
Hemorrhage	2	1.53 (0.72, 3.25), $P=.27$	$I^2=8\%$	–

CI = confidence interval, FNAB = fine-needle aspiration biopsy, HR = hazard ratio, OR = odd ratio.

accuracy may have been determined based upon cases for which sufficient sample was obtained. In addition, these researches were all retrospective and thus susceptible to potential bias. Furthermore, other factors in addition to needle type may influence the diagnostic accuracy of these biopsy approaches. While there was no significant difference in diagnostic accuracy between these 2 groups, Ocak et al[20] determined that CNB was able to yield greater precision in the cancer subtyping and associated precision diagnostic efforts.

To identify potential sources of heterogeneity, we conducted a subgroup analysis based upon the type of lung disease for which patients were undergoing biopsy (lung nodules). We detected no significant differences in diagnostic accuracy between CNB and FNAB in the subgroup analysis. Sensitivity analyses suggested that the study conducted by Tuna et al[18] was the primary source of heterogeneity in this analysis. Tuna et al[18] found the rate of diagnostic accuracy to be significantly higher in their FNAB patient group relative to their CNB patient group (94.8% vs 81.8%). The mean lesion size in this study was significantly larger in the CNB group relative to the FNAB group (38 mm vs 29 mm).[18] Larger lesion sizes may be associated with higher rates of misdiagnosis owing to a greater chance of collecting larger quantities of nonmalignant tissue upon biopsy.[30]

A previous meta-analysis assessed the diagnostic accuracy of CT-guided CNB and FNAB for lung lesions.[31] The results demonstrated that both CNB and FNAB could be accepted as the useful diagnostic methods to distinguish benign and malignant pulmonary lesions with the summary receiver operating characteristic of 0.98 and 0.98. However, that meta-analysis did not compare the diagnostic accuracy between CNB and FNAB.[22] Compared to the previous meta-analysis, this present meta-analysis had many advantages: we compared the diagnostic performance between CNB and FNAB; except for the diagnostic performance, we also compared the complication rates between these 2 methods.

Pneumothorax is an important outcome when assessing CT-guided lung biopsy. Herein, we found that pneumothorax incidence rates were similar in these 2 groups (28.6% vs 23.0%, $P=.71$), and this finding may indicate that core needle did not increase the risk of pneumothorax. In our included studies, Beslic et al[17] and Ocak et al[20] utilized 14G core needles, and we detected significantly higher rates of pneumothorax in the CNB group relative to the FNAB group (31.4% vs 13.0%, OR: 2.95; $P=.005$) based on the subgroup analysis. In other studies, core needle sizes ranged from 18G to 21G, and fine needle sizes ranged from 18G to 22G.[16,18,19,21] Overall, our findings suggest that pneumothorax rates were similar between these 2 groups. However, the 14G core needle should be avoided.

Rates of hemorrhage were found to be comparable between groups in this meta-analysis. Risk of hemorrhage has been shown to increase when biopsying deep or pleural-based lesions,[20] and this risk is also elevated when assessing hypervascular tumors, patients with pulmonary hypertension, and patients with clotting disorders.[20] Other studies have also found small, basal, deep, and central lesions, ground-glass opacities, and CNB to all be related to bleeding risk.[31,32] While smaller needles are generally thought to reduce the risk of hemorrhage, this belief is largely based upon inter-study comparisons.[33]

Among the patients with biopsy-related complications, only a small part of the cases required chest tube insertion.[10] Herein, we found that chest tube insertion rates were both low and similar in these 2 groups (5.9% vs 4.9%, $P=.97$). Therefore, we believe that different needle types display no differences in biopsy-related complications requiring chest tube insertion.

There are certain limitations to this meta-analysis. For one, all studies included herein were retrospective and are thus susceptible to selection bias. When high-quality RCTs pertaining to this topic are published, we will conduct an updated meta-analysis incorporating these new data. Second, core needle sizes varied significantly between included studies (14G–21G). Whether or not a co-axial technique was used was also not clarified in many of the included studies, potentially further biasing these results. We additionally detected significant heterogeneity pertaining to many of our analyzed outcomes. While we did conduct subgroup and sensitivity analyses to identify potential sources of this heterogeneity, it is still vital that additional high-quality studies be conducted to validate and expand upon our findings.

In summary, the results of this meta-analysis demonstrated that CT-guided CNB could achieve better sample adequacy than FNAB did during the lung biopsy procedure. However, the CNB did not show any superiorities in items of diagnostic accuracy and safety. Further high-quality RCTs are still needed.

Author contributions

Data curation: Yong Li, Ya-Yong Huang, Wei Cao.
Formal analysis: Fang Yang.
Methodology: Wei Cao.
Supervision: Ya-Yong Huang.
Writing – original draft: Yong Li.
Writing – review & editing: Ya-Yong Huang.

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