EAS Journal of Radiology and Imaging Technology
Abbreviated Key Title: EAS J Radiol Imaging Technol
ISSN: 2663-1008 (Print) & ISSN: 2663-7340 (Online)
Published By East African Scholars Publisher, Kenya

Volume-4 | Issue-2 | Mar-Apr-2022 | DOI: 10.36349/easjrit.2022.v04i02.001

OPEN ACCESS

Original Research Article

Imaging-guided Percutaneous Core-Needle Biopsy of Central Pulmonary Masses with Atelectasis: Comparison of The CT Versus the Ultrasound-Guided Procedures

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Article History
Received: 22.01.2022
Accepted: 01.03.2022
Published: 11.03.2022

Journal homepage:
https://www.easpublisher.com

Quick Response Code

Abstract: ***Aim:*** To compare the safety and efficacy of percutaneous computed tomography (CT)-guided core-needle biopsy (CNB) of pulmonary central masses versus ultrasound (US)-guided procedure. ***Materials and Methods***: CT-guided and US-guided CNB of central lung lesions performed between May 2014 and January 2022 were retrospectively analysed at our hospital. Biopsies were performed using 18-G needles with a coaxial system. CT images, histopathology reports, medical records, and procedural details for all patients were reviewed to evaluate the biopsy route, complications, and diagnostic accuracy. According to the imaging equipment used, biopsies were divided into US-guided and CT-guided approaches for comparison. ***Results:*** A total of 65 patients, who had undergone 65 CNBs for central lung masses were reviewed. Ultrasound guided biopsies of central lung masses (n=22) were performed safely via a direct pathway. In this group, the sensitivity, specificity, and accuracy were 94.4%, 75% and 90.9%, respectively. In the CT guided biopsy group, there were 43 patients and we observed a sensitivity, specificity and accuracy of 86.1%, 85.7% and 86%. There were statistically significant differences in the diagnostic accuracy and lesion visibility rate among the different biopsy techniques. There was no difference in complication rates between groups. ***Conclusion:*** Percutaneous US-guided CNB using a18-G catheter with axial is more efficient technique than CT-guided procedure in the cases of central lung biopsies with atelectasis; however, as this series was small, more data is required.

Key words: Central lung lesion; Core needle biopsy; Ultrasound-guided; transthoracic; Computed tomography-guided; lung malignancies.

INTRODUCTION

Chest tumours, in particular lung cancer, remain one of the most common causes of cancer-related death worldwide. With the diffusion of spiral CT, an increasing number of lung and mediastinal lesions is detected and histological diagnosis is often necessary to determine the most appropriate management of these lesion [1].

Bronchoscopy with bronchoalveolar lavage, transbronchial biopsy, open lung biopsy, and percutaneous imaging-guided biopsy are commonly performed to obtain tissue for diagnostic work-up. Imaging-guided biopsies can be performed with fine-needle aspiration biopsy (FNAB), core-needle biopsy (CNB). Effective treatment depends on the biopsy results, including antimicrobial therapy targeted at the specific fungus or bacteria, steroids for non-infectious processes, or chemotherapy targeted at a malignancy [2].

The complications associated with imaging-guided FNAB or CNB include pneumothorax (which may require the placement of a chest tube), hemothorax, hemoptysis, air embolism, and death. In general, the occurrence rates of major complications are relatively low for CT-guided procedures, ranging between 4% and 6% [3]. However, in general, CNB has higher diagnostic yield than FNAB [4-7].

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To our knowledge, prior studies of imaging-guided central lung lesion biopsies with atelectasis have not evaluated the diagnostic yield and outcomes of ultrasound versus CT-guided procedure. The aim of this study was to evaluate and compare the diagnostic yield and complication rate between these two procedures. In particular, we hypothesized that ultrasound guided imaging would have a higher diagnostic yield than CT-guided lung biopsy in this patient population due to higher contrast seen on ultrasonography between lesion tissue and atelectasis.

MATERIALS AND METHODS

Patient Population

This retrospective study was approved by the Institutional Review Board. Informed consent was waived due to the retrospective and anonymous nature of the analysis. The radiology information system was searched to identify patients who had undergone computed tomography (CT)- guided percutaneous thoracic CNB between May 2014 and January 2022, and all biopsy-associated images were reviewed. Medical records were retrieved from the health information register. All relevant biopsy data, including imaging of each central lung mass, coagulation profile, route of biopsy, immediate and delayed complications, other diagnostic procedures, final diagnosis, were reviewed.

Patients who had central lung masses with large atelectasis were included. Non-diagnostic bronchoscopy biopsies results were other inclusion criteria. Patients who had undergone second percutaneous lung biopsies with different techniques (for example, first CT guided biopsy negative and second US guided biopsy positive) were excluded. A total of 65 patients were included and more than 142 biopsies excluded.

Using the Society of Interventional Radiology (SIR) classification, complications were divided into minor and major events by outcome. Each central lung mass had been evaluated by contrast enhancement CT before referral for biopsy. The mass size was determined by its maximum diameter on axial sections. Anti-platelet medications, including aspirin and clopidogrel, were discontinued 5 days prior to biopsy. The coagulation profile was checked within last week before the biopsy using the desired international normalised ratio (<1.5) and platelet count (>50,000/ml). The indication for and risks of the biopsy, especially the possibility of haemorrhage and pneumothorax, were explained thoroughly before the procedure. All patients provided written informed consent for the procedure. No premedication of antibiotics or preparation was required.

Biopsy Technique

Every CNB was performed using either a 17-G coaxial introducer needle with a matching 18-G biopsy needle. The biopsy procedures were done under CT guidance (SOMATOM Sensation, Siemens Medical Solutions, Forchheim, Germany and HiSpeed or BrightSpeed; GE Medical Systems, Milwaukee, WI, USA) and US guidance (LOGIQ P9, General Electric Company, Boston, United States). Only local anaesthesia was required. The biopsy routes were obligatory trans-atelectasia in US guidance and variable in CT guidance. An immediate follow-up CT examination wasn't necessary in all patients to identify possible complications.

Specimen preparation and statistical analysis

All specimens were fixed in 10% formalin solution for histopathology. Upon histological examination, a result was regarded as non-diagnostic if it yielded insufficient material for analysis, was necrotic, or had atypical cells (atypia). Clinical characteristics and biopsy results were compared using Student's t-test for continuous variables and a chi-square or Fisher's exact test for categorical variables. A p value<0.05 was considered statistically significant.

The final diagnoses were determined at histopathology of the biopsies as well as clinical and imaging follow-ups. The diagnostic efficacy and complications using 18-G biopsy needles using CT and US-guidance were compared.

RESULTS

Patients

Patient characteristics, lesion, and biopsy technique are summarised in Table 1. In total, 65 consecutive patients with central lung lesions underwent 43 CT-guided percutaneous CNBs and 22 US-guided CNBs. There were 42 men and 23 women (mean age 53.6 years, range 25-74 years) in this group. Tumour size, assessed by the longest diameter, ranged from 3 to 9 cm with a mean of 5 cm.

Final diagnoses and diagnostic efficacy

Of 65 patients, 43 underwent CT-guided CNB. Final diagnoses were made based on histological findings in only 32 cases. Of the other 22 patients, 20 US-guided biopsies were diagnostic and only 2 were not. In 65 cases there were: 55(84.6%) malignancies; 5(7.7%) non-neoplastic lesions and 5(7.7%) non diagnostic. Table 2 summarises the final diagnoses of the 65 patients. Five results were non-diagnostic: two were necrotic, two showed atypia, and one had insufficient material for diagnosis. The diagnostic yield of total percutaneous CNB was 80% (52/65).

For CT-guided group, CNB yielded true-positive results in 32 biopsies and true-negative results in 6 biopsies. Besides the four non-diagnostic results, false-negative findings occurred in five biopsies. There were one false-positive. The sensitivity, specificity, PPV, and NPV were 86.1%, 85.7%, 96.8%, and 54.5%, respectively. The overall accuracy was 86%.

For US-guided group, CNB yielded true-positive results in 17 biopsies and true-negative results in 3 biopsies. False-negative and false positive findings occurred in two biopsies. The sensitivity, specificity, PPV, and NPV were 94.4%, 75%, 94.4%, and 75%, respectively. The overall accuracy was 90.9%.

Margins of lesion visibility were good at 53.5% in the CT group and 81.8% in the US-guided procedure. There was a statistically significant difference between the rates of good margin visibility favouring US-guided technique.

Complications

Complications occurred in 12 biopsies (18.4%) from 65 patients, including 8 minor pneumothorax and 9 minor bleeding (haemoptysis and hemothorax) (combined complication in 5 patients) without any major event or death. Patients with minor pneumothorax or bleeding remained asymptomatic, and no chest tube placement or blood transfusions or further management were necessary. There was no statistically significant difference in complication rates between CT and US-guided CNB groups.

Table 3 compare the diagnostic performance by approach and safety in each groups.

Table 1: Patient details and biopsy techniques

No. of patients	**65**
Age (years)	Mean 53.6
Tumour size (cm):mean diameter (+/- SD)	5±1.9
Position (supine/prone/lateral)	30/22/13
Emphysema in vicinity of lesion	40
No. of specimens obtained per lesion Mean ± SD	2.7 ± 1.0
Depth of lung lesion from pleura Mean ± SD	3.5±1.6

Table 2: Final diagnosis of 65 patients who underwent core-needle biopsy

Diagnosis	**Number of patients (%)**
Malignancy	*55 (84.6)*
Adenocarcinoma	25 (38.4)
Squamous cell carcinoma	20 (30.7)
Small cell carcinoma	6 (9.2)
Lymphoma	2 (3)
Neuroendocrine tumour	1 (1.5)
Metastasis	1 (1.5)
Non-neoplastic or benign tumours	*5 (7.7)*
Tuberculosis	3 (4.6)
Organizing pneumonia	1 (1.5)
Mycoplasma pneumonia	1 (1.5)
Non-diagnostic	*5 (7.7)*

Table 3: Comparison of diagnostic performance by approach and safety

	CT-guided	US-guided	p-value
No. of patients	43	22	
Accuracy	86	90.9	0.012
Sensitivity	86.1	94.4	0.018
Margin visibility (well/poor)	23/20	18/4	<0.000
No. of pneumothorax	5(11.6%)	3(13.6%)	0.716
No. of chest tube placement needed for pneumothorax	0	0	
No. of bleeding (hemoptysis / hemothorax)	6(13.9%)	3(13.6%)	0.812
No. of specimens obtained per lesion Mean ± SD	2.7 ± 1.0	2.6±1.1	0.771
Depth of lung lesion from pleura Mean ± SD	3.5±1.6	3.2±1.8	0.614

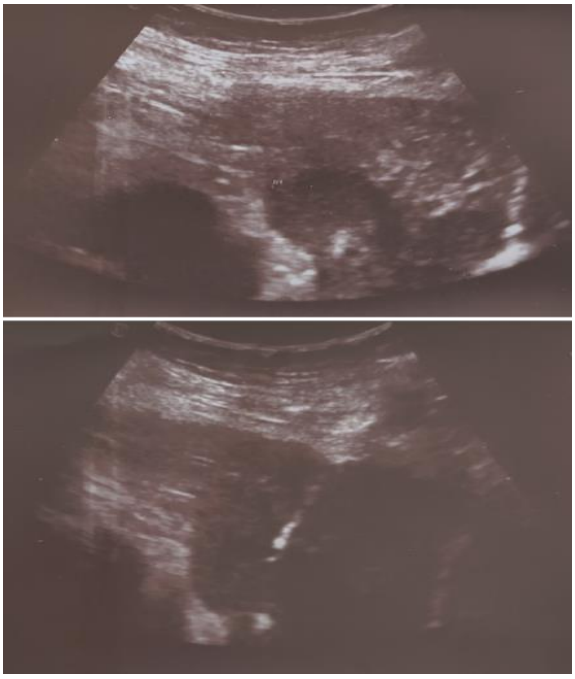

Fig 1: (a) Ultrasound of chest demonstrating good contrast between central lung tumour and atelectasis. (b) US guided biopsy yielded 3 specimens. Final diagnosis was lung adenocarcinoma

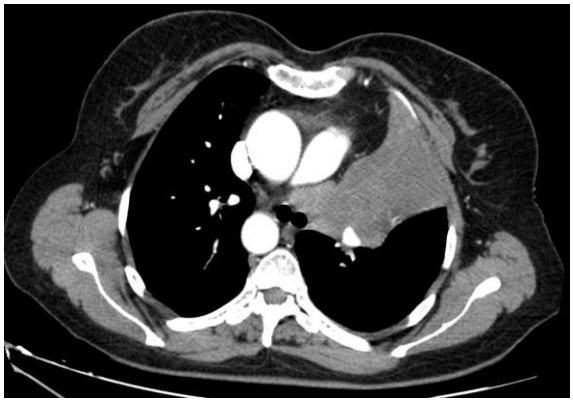

Fig 2: Contrast enhanced CT objectified, in the same patient, a poor discrimination of lesion margin

DISCUSSION

Currently, imaging-guided biopsy represents a paramount methods for obtaining tissue specimens in patients with lung nodules; treatment protocols are based on histological types; thus, biopsy is obligatory required, when technically feasible, or in case other techniques (such as bronchoscopy with lavage) are non-diagnostic.

There are several methods for lung lesions biopsy, including ultrasound (US) and computed tomography (CT) fluoroscopy, but CT is most frequent procedure employed because of its high spatial and contrast resolution as well as its 3D imaging ability;

Transbronchial needle aspiration during bronchoscopy or under ultrasound guidance is still considered the reference technique for the diagnosis of hilar masses [8, 9]. However, when bronchoscopy cannot be performed or is inconclusive, hilar masses can be accurately diagnosed by imaging-guided biopsy.

CT, fluoroscopy and US may all be used to guide chest biopsies and operators should be familiar with the advantage and limitations of each one [10]. Parameters affecting the selection of the most appropriate imaging technique are lesions site, size and visibility as well as its relationship with critical anatomical structures to be avoided [11]. Whenever possible, chest biopsies should be performed under US guidance to exploit the advantages of real-time monitoring without radiation exposure to patients and operators [12]; however, US guidance is limited to superficial lesions adjacent to the chest wall and/or to lesions delineated by pleural effusion sufficient to create a suitable interface for ultrasound penetration. In central and paramediastinal lung lesions we assist frequently to atelectasis with lung consolidation or hepatization and US will become a more accurate guidance technique with good visibility of the tumour margin (Fig 1a & 1b). In our study, 86% of the US group presented good margin discrimination and just a half of patients in the CT group presented well demarcated boundaries (Fig 2).

In the vast majority of cases, CT is the preferred guidance method for chest biopsies due to its optimal spatial and contrast resolution as well as its 3D imaging ability. Furthermore an intravenous contrast agent can be used to differentiate target lesions from atelectasis, necrosis and vascular structures. On the other hand, real-time monitoring of lesions movement with US guidance allows reducing needle passes and procedure time [13]. To simplify the approach and to increase the speed and reliability of step-and-shoot CT-guided chest biopsies, several technical advances have been proposed, including augmented reality and use of robotic platforms [14]. Furthermore, if a PET/CT is available, the needle should be led to the most enhancing area of the lesion to increase diagnostic accuracy.

Thus, an accuracy of 90.9% was observed in the US group versus 86% in the CT group; sensitivity was respectively higher 94.4 Vs. 86.1%. These data show a relative superiority of the US as a guidance method, but data on CT-guided biopsies were more significant because of the higher number of cases in comparison with US-guided biopsies. Although US guided biopsy is highly accurate for diagnosing central lung malignancies, in the present study, the NPV was only 75%. It is probably due to the small number of patient included in this group.

Ultrasound versus CT In a recent meta-analysis, Di Bardino et al. compared the diagnostic accuracy of ultrasound and CT-guided thoracic biopsy.

The overall pooled diagnostic accuracy of ultrasound-guided biopsy was 88.7% (446/503), with a sensitivity of 91.5% (366/ 400) and a specificity of around 100% for the diagnosis of malignancy. The overall pooled diagnostic accuracy of CT-guided biopsy was 92.1% (9567/10,383), with a sensitivity of 92.1% (7343/7975) and a specificity of around 100% for the diagnosis of malignancy [15].

Our study demonstrated that accuracy and sensitivity in both techniques were correlated to size and depth of the lesion. However, emphysema and age seem to be not influencing the efficacy and safety in both groups.

Complications occurred in 12 biopsies (18.4%) from 65 patients, including 8 minor pneumothorax and 9 minor bleeding (hemoptysis and hemothorax) (combined complication in 5 patients), which was at the upper end of the rates reported in previous studies and can probably be attributed, at least partly, to the underestimation of minor haemorrhage by ultrasonography. Nevertheless, most episodes of pneumothorax and haemorrhage were self-limiting and clinically insignificant. No death or chest tube placement occurred.

Therefore, US-guided CNB biopsy is a reasonable choice for central lung lesion if atelectasis is available. According to the present study, there are no significant differences in complication rate between these two procedures.

This study had several limitations. It was retrospective, and the choice of US versus CT guidance and size of the needle was determined by individual operators based on operator preference, patient risk factors, and lesion characteristics, rather than a standardized protocol. The group comparisons are, therefore, also partially confounded with the effects of competing risk factors. Our study did not assess the survival benefit from any treatment changes instituted after biopsy. Additionally, we did not assess any further clinical or interventional work-up after non-diagnostic biopsies.

In conclusion, our Hospital experience demonstrates that, to an experienced operator, ultrasound guidance is an ideal technique in the assessment of central pulmonary lesions with atelectasis, with the advantages of fast, cost-effective, real time visualisation and lack of radiation. The present results add to further discussions on the use of such techniques and will stimulate incorporation into prospective studies for a definite understanding of its benefits.

Conflict of Interest: The authors declare no conflict of interest.

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Cite This Article: S. Bellasri, B. Slioui, N.Hammoune, H. Janah, A. Benjelloun, R. Benchanna, I. Samri, Azami, A. Zidane, E. Atmane & A. Mouhsine (2022). Imaging-guided Percutaneous Core-Needle Biopsy of Central Pulmonary Masses with Atelectasis: Comparison of The CT Versus the Ultrasound-Guided Procedures. *EAS J Radiol Imaging Technol*, *4*(2), 10-15.