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Ashraf Mohammed Fathy Dawoud
Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Hossam Mohammed Zayton
Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt

El Atafy El Metwaly El Atafy
Cardiothoracic Surgery Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Reda Abdelsame Elarabawy
Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Yosra Fouad Mohammed Rashad
Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Corresponding Author:
Ashraf Mohammed Fathy Dawoud
Radiodiagnosis Department, Faculty of Medicine, Tanta University, Tanta, Egypt

Ultrasound guided biopsy in peripheral thoracic lesions versus to CT guided biopsy: A comparative study

Ashraf Mohammed Fathy Dawoud, Hossam Mohammed Zayton, El Atafy El Metwaly El Atafy, Reda Abdelsame Elarabawy and Yosra Fouad Mohammed Rashad

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Abstract

Background: In addition to providing real-time needle imaging during a breath-hold, ultrasound (US) has the benefits of mobility, affordability, and possible time savings without posing a risk to patients' or healthcare professionals' radiation doses. This research set out to assess the safety and effectiveness of both CT and US-guided biopsies in the management of peripheral thoracic tumors.

Methods: This current study was carried out on 50 patients aged from 3 to 79 years old, both sexes, with one or multiple thoracic lesions detected in CT chest, at least one of these lesions has pleural contact, with accessible acoustic window. All cases were biopsied under local anesthesia, except two cases who needed general anesthesia.

Results: Pleural contact-complication incidence correlation is insignificant. Only the US group showed a significant relationship between pleural contact and operation schedule. US-guided biopsies needed fewer passes than CT-guided (P=0.04). US-guided biopsies yielded similar soft tissue cores to CT-guided biopsies despite fewer passes.

Conclusions: It is recommended to prioritize US advice for biopsies of peripheral lung and pleural lesions that have pleural contact between 10 to 50 mm, regardless of the size or location of the lesion. This is because US guidance is more effective than CT guidance.

Keywords: US, computed tomography, peripheral thoracic masses, biopsy

Introduction

A minimally invasive technique that is widely accepted, effective, and safe for the collection of tissue specimens from a variety of intrathoracic lesions is imaging-guided percutaneous transthoracic biopsy [1].

The main goal of percutaneous thoracic biopsy is to collect a sufficient tissue sample for diagnosis, ensuring safety and achieving or surpassing the diagnostic accuracy rates reported in literature [2].

Efficient collection of tissue samples was crucial for accurately diagnosing, predicting the outcome, and customizing treatment in the age of advanced customized medicine [2, 3].

For the first time, the new classification of the World Health Organization (WHO) was pertinent to resection specimens, tiny biopsies, and cytological material. This was crucial, as only microscopic biopsy and/or cytology specimens are obtained from approximately two-thirds of lung cancer patients. There were suggestions regarding the management of this material in order to ensure a precise diagnosis with the least amount of material, as immunohistochemical and/or molecular analyses may be necessary [4].

Image-guided percutaneous biopsy is not only often used for puncturing pleural effusion, but also for diagnosing space occupying masses in the chest wall, pleura, lung, or anterior mediastinum [5].

Choosing the best method for image guidance and needle technique in peripheral lung and pleural based biopsy can be challenging, especially when dealing with small lesions or minimal pleural contact. Computed tomography (CT) and radiography are the main diagnostic tools for thoracic imaging. However, ultrasound (US) has valuable applications in the chest that are not fully utilized [6, 7].

CT imaging offers the most comprehensive assessment for various lung and mediastinal disorders. However, it should only be used as an intervention when the specific location and route of puncture cannot be accurately determined by sonography [6].

US enables real-time imaging of needles while the patient holds their breath. This technique is advantageous since it is portable, cost-effective, and may save time for both patients and healthcare professionals. Additionally, it eliminates the need to worry about radiation exposure. Although CT is often used to sample central lung lesions that are surrounded by aerated lung or when there is no viable acoustic window, it has also been increasingly used for peripheral lung lesions [8-10].

Despite the acknowledged benefits and past achievements of the US, many medical institutions still fail to fully employ it for peripheral lung biopsy. The potential for higher accuracy, speed, and safety of US guidance compared to CT guidance makes it advisable to explore using US guidance for the biopsy of peripheral lung lesions [11].

This research aimed to assess the safety and effectiveness of US-guided biopsy and CT-guided biopsy for treating peripheral thoracic tumors.

Patients and Methods

The research was conducted from December 2021 to November 2023 with the sanction of the Ethical Committee at Tanta University Hospitals in Tanta, Egypt. The patient or their relatives provided written consent that was informed.

This study included 50 patients aged from 3 to 79 years old, both sexes, with one or multiple thoracic lesions detected in CT chest, at least one of these lesions has pleural contact (excluding fissures), with accessible acoustic window.

Exclusion criteria were patients with one or multiple deep lung lesions detected in CT chest; none of them has pleural contact, patients with abnormal coagulation indices, patients with severe tachypnea (could not hold their breath).

All patients underwent history-taking, laboratory investigations (including coagulation profile tests such as international normalized ratio (INR), prothrombin time (PT), activated partial thromboplastin time (APTT), Prothrombin activity, and platelet count), and radiological investigations (such as plain X-ray, ultrasound (US), computed tomography (CT), positron emission tomography (PET)-CT, magnetic resonance imaging (MRI), and isotope studies if necessary) to identify the specific lesion that required a biopsy.

Procedure

The patient was positioned prone, supine or on a lateral decubitus (right or left). The area of skin was sterilized. Local anaesthetia by injecting a solution of lidocaine with a maximum dose of 20ml of a 2% solution, (usually 3-5ml) under the epidermis and deeper in subcutaneous and muscular structures down to pleural surface. The injection continued until a "bleb" or bubble was formed under the skin around 3mm in diameter as a mark for further true-cut needle insertions. In very young patients or non-cooperative patients, general anesthesia was performed. An 18-gauge Tru-cut needles "20 cm blade length and 2.5 cm throw length" (GTA®, Medilab; Italy) were used to biopsy the lung lesions; either disposable needle blade with a reusable autoclavable automatic gun or completely disposable semi-automatic needle. There was an absence of a coaxial sheath. A restricted planning ultrasound was performed inside the region of interest (ROI) to provide a safe and clear sonographic window for the biopsy, allowing for the identification and avoidance of intercostal vessels along the predicted needle route. This included a comprehensive assessment using color Doppler imaging. A CT-guided localization laser beam is used to precisely identify the location of the lesion on the specific slice of interest and accurately direct the angle of puncture.

CT scanning is used to precisely navigate the needle into the lesion. Once the needle is perfectly positioned, the biopsy gun is fired and then withdrawn to collect the specimen. The specimen is collected in a jar that already contains 4% formaldehyde. Biopsies were performed on small lesions by passing through a lung that was filled with air. This was done to get enough tissue for anchoring and to reduce the risk of puncturing the pleura.

Post-Procedural: CT scanning or US scanning was conducted on patients to evaluate for the presence of hemothorax, pneumothorax, or pulmonary bleeding. A plain X-ray was conducted on all patients to evaluate for pneumothorax, typically performed one hour after the procedure, and repeated four hours later if there were clinical indications. During the first 4-hour period after the procedure, patients should observe a period of rest in bed and should be advised to avoid activities that might potentially elevate chest pressure. Vital signs will be observed again four times during the first hour, followed by two observations in the second hour, and one observation in each of the remaining two hours.

Complications were documented and classified into four categories: Minor problems include self-limiting pneumothorax or hemothorax, intra-lesional bleeding, and surgical emphysema (outside the chest). Major complications include pneumothorax or hemothorax that need a chest tube and hospitalization. Catastrophic complications may result in death or lengthy hospitalization.

Statistical analysis

SPSS v26 software (IBM Inc., Chicago, IL, USA) was employed to conduct the statistical analysis. The mean and standard deviation (SD) of the quantitative variables were presented and contrasted between the two groups using an unpaired Student's t-test. The Chi-square or Fisher's exact test was employed to evaluate qualitative variables, which were presented as frequency and percentage (%), as appropriate. Statistical significance was determined to be a two-tailed P-Value less than 0.05.

Results

There were no significant differences in demographics data, lesion size, duration of pleural contact, and pleural contact of their lesions between the individuals having US and those undergoing computed tomography (CT). The US-guidance group had notably lower procedural times in comparison to CT-guided biopsies. The value of P is 0.0001. Table 1.

Table 1: (Patients' demographics, lesion size, pleural contact and procedure's duration in US guidance and CT-guidance groups) and (distribution of patient according to pleural contact of their lesions)

		US guidance (N=25)	CT guidance (N=25)	P
Age (years)		51 years	55 years	0.389
Sex	Males	16 (64%)	15 (60%)	0.644
	Females	9 (36%)	10 (40%)	
Smoking history	Males	11(91.6%)	13 (92.8%)	0.646
	Females	1 (8.3%)	1(7.14%)	
Lesion size (mm)		57.5±30.1	59.8±31.6	0.819
Pleural contact (mm)		43.1±28.9	36.3±28.5	0.456
Procedure's duration		6.3±2.2	21.8±5.7	0.0001*
Pleural contact				
< 10 mm		0	8	0.019*
10-30 mm		10	5	
31-50 mm		8	9	
51-100 mm		6	2	
Larger than 100 mm		1	1	

A subgroup analysis was conducted to examine the relationship between pleural contact and the timing of procedures. The results showed a significant correlation in the US group, where a smaller pleural contact was associated with a shorter time needed for biopsy (P = 0.004). However, in the CT group, no clear pattern of correlation was found between time and pleural contact (P = 0.935). Table 2.

Table 2: Relation between pleural contact and duration of the procedure in US guidance and CT-guidance groups

	US guidance (N=25)	CT guidance (N=25)
Time of procedure (excluding general anesthesia time), (minutes)	6.3±2.2	21.8±5.7
Pleural contact (mm)	43.1±28.9	36.3±28.5
P value	0.004*	0.935

An analysis of subgroups was conducted to examine the relationship between pleural contact and the incidence of complications, considering both US and CT guidance. The results showed that there was no significant relationship. However, it was observed that lesions with pleural contact measuring 10-50 mm had the lowest rates of complications, while lesions measuring less than one centimeter had the highest rates of complications. Table 3.

Table 3: Relation between pleural contact (subgroups) and overall incidence of complications

Subgroups of pleural contact (US and CT)	Complication incidence (US and CT) 11 (complications)/50 (total number of cases)	P
< 10 mm	3/8 (37.5%)	0.385
10-30 mm	2/15 (13.33%)	
31-50 mm	2/17 (11.76%)	
51-100 mm	4/8 (50%)	
Larger than 100 mm	0/2 (0%)	

In the US-guidance group, 76% of patients did not have difficulties, compared to 60% in the CT-guidance group. On the other hand, 24% of patients in the US-guidance group had issues, whereas 40% in the CT-guidance group had complications. Table 4.

Table 4: Overall incidence of complications in US guidance and CT guidance groups

	US guidance (N=25)	CT guidance (N=25)
No complications	19 (76%)	15 (60%)
Complications	6 (24%)	10 (40%)

The number of passes needed for US-guided biopsies was significantly lower compared to CT-guided biopsies (P=0.04). Although the US group had fewer passes, there was no statistically significant difference in the number of acquired cores of soft tissue material between the US guided biopsies and the CT-guided biopsies (P=0.423). Table 5.

Table 5: Relation between numbers of needle passes and numbers of obtained cores in US guidance and CT-guidance groups

	US guidance (N=25)	CT guidance (N=25)	P
No of needle Passes	2.7±08	3.4±1.2	0.04*
No of obtained Cores	2.0±0.9	2.2±0.7	0.423

Discussion

Computed tomography (CT) is very effective in providing clear differentiation between structures and precise determination of spatial details. It also allows for precise positioning of needles, making it the most often used approach for guiding percutaneous transthoracic interventional treatments. This is particularly accurate when dealing with tiny lesions or lesions that are difficult to get a sample from, since it may need numerous section acquisitions and repositioning of the needle. These issues may exacerbate patient pain and prolong the duration of needle placement across the pleura [12, 13].

The results of the current study revealed significant time saving (about 70%) with US guidance than with CT guidance, with mean procedural durations about 6.3 minutes ± 2.2 (SD) in US group and 21.8 minutes ± 5.7 (SD) in CT group. American research conducted in 2018 by Lee *et al*. indicated that using US exclusively for the whole operation resulted in a more than 50% decrease in procedural times compared to using CT. Unsurprisingly, they also reported much greater time consumption when general anesthesia was administered [11]. Sconfienza *et al*. discovered a significant reduction in time consumption in the US group, with a 42% time saving compared to CT. The mean procedural time for the US group was 5.4 minutes ± 2.8, while the CT group had a mean procedural time of 9.3 minutes ± 4.2. However, it is important to note that their study only considered the times recorded on the PACS images of the procedure, and did not take into account the time spent on pre and post-procedural patient preparation and positioning [10].

Additionally, the complication rate was considerably lower with US-guidance than with CT-guidance in the current study, 15% (3/20) versus 40% (8/20), respectively. ($P > 0.05$). In all groups except the group over 100 mm, the rates of complications were lower with US-guided biopsy than with CT-guided biopsy when the pleural contact subgroups were analyzed. However, the risk of complications was the same for both techniques in the group over 100 mm. In the same context of the superiority of US-guidance safety, Sheth *et al*. reported comparable safety rates [14].

In the current study, it is unsurprising that the most prevalent complication seen in both groups was pneumothorax, which accounted for 73% of all troublesome instances (8 out of 11 cases). Unlike the current investigation, Tekin *et al*. Found no significant difference in the diagnostic accuracy and complication rates between percutaneous transthoracic biopsies of pleural-based lung lesions guided by US and computed tomography (CT). Nevertheless, they contended that percutaneous lung biopsy operations for pleural-based lesions should prioritize US guidance since it eliminates radiation exposure for patients, reduces procedure length, and lowers costs [15]. Another recent study held in Canada by Mychajlowycz, *et al*. found that US and CT guidance have similar safety and diagnostic adequacy, while the current study found that US is safer than CT, with at least the same accuracy {Mychajlowycz, 2021 #28}.

In the current study no statistically significant pattern of relation could be generated between the lesion size and the rate of complications, with trends for higher complication rates in the smaller lesions (less than 30 mm in size) especially in the CT-guidance group. Lee *et al*.'s investigation revealed that there is a positive correlation between the size of lesions (less than 10mm in maximum axial diameter) and the length of pleural contact (less than 10mm) with the likelihood of problems. In other words, smaller lesions and shorter pleural contact are associated with a greater rate of complications [11]. Jeon *et al*. discovered substantial variations in complication rates for lesions that had pleural contact above 30 mm [16].

The current study shows a trend toward increasing malignancy through males than females included in the study; 24 males were diagnosed with different subtypes of lung malignancies out of 27 (88.9%), while 12 females were diagnosed with different subtypes of lung malignancies out of 13 (92.3%), in spite of having no statistically significant relation, the overall larger number of males (27 compared to 13) enrolled in the study resulted in larger overall number of affected men (24) than women (12). This agrees with the results declared by Siegel *et al*. in cancer statistics that men are more vulnerable to lung cancer [17]. These data are consistent with El-Shimy, *et al*. found that smoking is associated with higher incidence of malignancy across the Egyptian population [18].

Although the current study provides compelling data, it had few limitations; the small sample size across the various pleural-contact subgroups and the total absence of lesions with sub-centimetric pleural contact length in the US-guided group. Additionally, there were constraints associated with selection bias. Specifically, image guidance was ultimately determined by the radiologist's preference, which was reached after a consensus with the referring physician. This decision is likely to be influenced by the individual's training background and comfort level with each modality.

Despite these limitations, the findings of the present investigation have led to the determination that having a strong understanding and comfort level with the pros and cons of each guiding method is essential to satisfy the need for minimally invasive image-guided biopsy. The clinical uses of US are feasible because of its safe nature, quick procedure times, ability to be done in a single breath hold, and decreased number of samples needed, all while maintaining diagnostic adequacy.

Figure 1

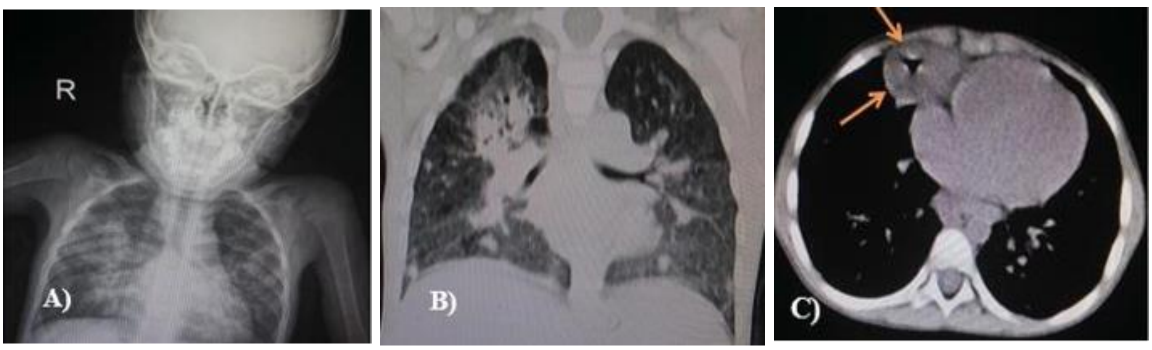

Fig 1: A) Chest X-ray, and B) coronal CT image lung window; showing multiple bilateral illdefined nodular infiltrates and consolidations with air-Broncho grams. C and D) axial CT images mediastinal window (C) and lung window (D) showing a pleural based cavitary lesion (arrows) is the medial segment of the right middle lobe. E) US guided needle insertion within the lesion (arrows), with the tip seen safely away from the aerated lung. F) A well-defined hyperechoic rounded area (asterisk) at the site of the needle tip corresponding to intra-lesional hematoma, which showed stationary size for two days, then complete resolution in the follow up 1 week next

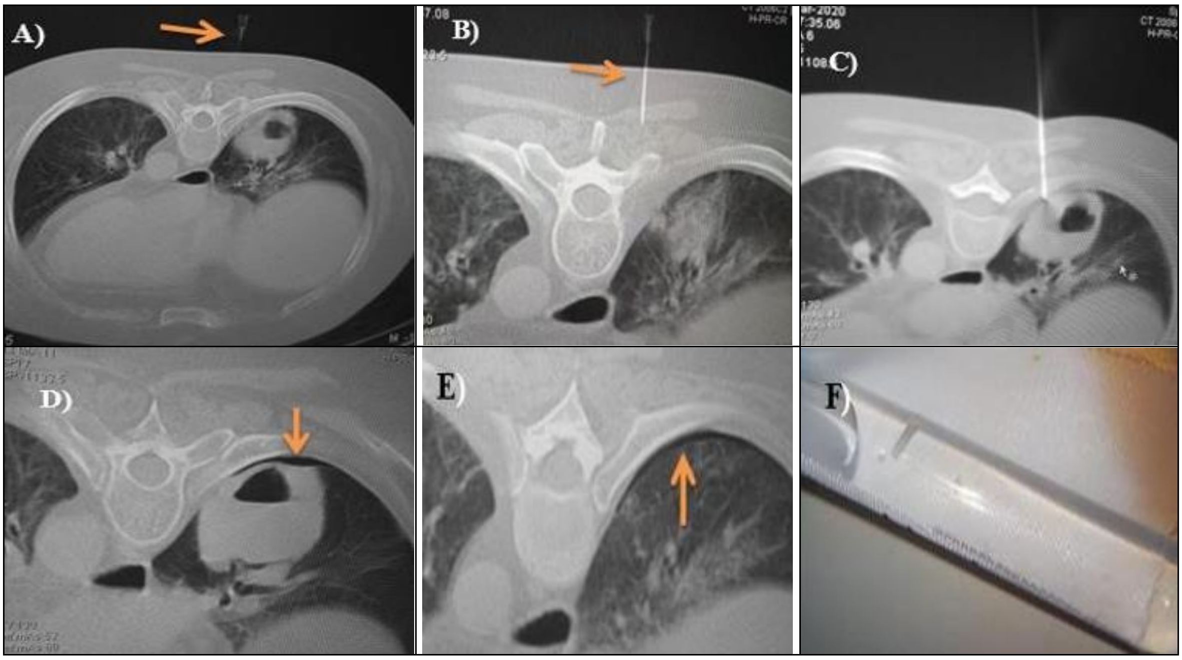

Fig 2: A and B) Axial CT scans (lung window) of a patient lying face down, displaying a rounded cavity lesion originating from the pleura. Also visible is a syringe with local anesthetic (indicated by an arrow), which was utilized to evaluate the track of the biopsy needle. C) This axial CT picture (lung window) shows the needle being inserted into the solid portion of the lesion using a right paramidline perpendicular approach. D) This axial CT picture, using a lung window, shows a little amount of air in the pleural space (shown by the arrow), sometimes known as a minor pneumothorax. E) Subsequent axial CT imaging (lung window) performed four hours after the puncture reveals a stable, small amount of pneumothorax (shown by the arrow). F) Colored image depicting the acquired small cylindrical sample and fragments of pale-colored substance.

Conclusions

It is recommended to prioritize US advice for biopsies of peripheral lung and pleural lesions that have pleural contact between 10 to 50 mm, regardless of the size or location of the lesion. This is because US guidance is more effective than CT guidance.

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Conflict of Interest: Nil

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