

Can Ultrasound Replace CT in Peripheral Lung Biopsy Guidance: A Comparative Study

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Abstract

Background: Selecting the most effective guidance method for peripheral lung biopsy is a priority for interventional radiologists. The clinical trials comparing efficacy and safety of ultrasound (US) and computerized tomography (CT) as biopsy-guiding modalities for peripheral lung biopsy techniques are limited in the literature, and most of them are retrospective.

Aim of Study: To compare the efficacy and safety of biopsy guided by US versus CT for lung lesions with pleural contact.

Patients and Methods: This is a prospective comparative study; included 40 patients underwent image-guided biopsy at Nasser Institute Hospital, Cairo, Egypt. From June 2018 to May 2020. Lesion size, location, length of pleural contact, number of needle passes, and number of tissues cores, procedure times, complications, and histopathology reports were documented for each biopsy. Statistical analysis using Fisher's exact test and *t*-test, (Alfa-point=0.05).

Results: US-guided group had significantly fewer complications; 15% (3/20) versus 40% (8/20) for CT-guided group; ($p=0.036$). Fewer number of needles passes were required for US-guided biopsies (mean, 2.7 passes ± 0.8 (SD)) than for CT-guided biopsies (mean, 3.4 passes ± 1.2 (SD)); ($p=0.04$). Procedural times were significantly shorter in the US-guidance group, with a mean procedure time of 6.3 minutes ± 2.2 (SD) compared to 21.8 minutes ± 5.7 (SD) for CT-guided biopsies; ($p=0.0001$).

Conclusion: US guidance should be thought of as a primary tool for guidance of peripheral lung lesions' biopsy, because it is superior to CT in safety and time-saving with comparable accuracy.

Key Words: US-guidance – CT-guidance – Peripheral lung lesions.

Introduction

The primary objective when performing percutaneous thoracic biopsy is to obtain an adequate

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tissue sample to establish a diagnosis in a way that is both safe and meets published diagnostic accuracy rates [1].

CT is the most widely used guidance technique for percutaneous transthoracic interventional procedures and is has been integrated in clinical practice for about a century. However, being of ionizing nature, with no real-time properties and the visualization of transverse sections only are the major limitations of CT guidance. On the other hand, US-guidance provides always on real-time visualization, making the procedure faster and free of hazards of ionizing radiation. In addition, US equipments are less expensive than CT systems and are more widely available [2].

Whereas CT-guided transthoracic needle biopsy is well accepted, there is some bias against the use of US in guidance by many radiologists and chest physicians. An example is a recent comprehensive article covering the diagnosis of lung cancer, recommended US-guidance for thoracentesis only, and discussed CT-guidance for transthoracic biopsy of chest lesions with no mention of US as a biopsy guidance method [3].

Aim of study:

To evaluate the hypothesis, that US has a comparable efficacy and superior safety profile to CT in biopsy-guidance of peripheral lung lesions.

Patients and Methods

This study involved 40 patients. Table (1), presented by thoracic mass lesions in CT-chest and referred to the Radiology Department at Nasser Institute Hospital for Research and Treatment, Cairo, Egypt, for image-guided biopsy, from June 2018 to May 2020.

A written informed consent was taken from all participants after proper explanation of the study.

Table (1): Patients' demographics.

Characteristics	US-guidance	CT-guidance
No. of patients	20	20
Males	14 (70%)	13 (65%)
Females	6 (30%)	7 (35%)
<i>Age:</i>		
Mean	51 years	55 years
Range	3-75 years	13-79 years
Smoking history	12 (60%)	12 (60%)
Males	11 (55%)	11 (55%)
Females	1 (5%)	1 (5%)

Study design:

This is a prospective comparative study.

Inclusion criteria:

Lesions with pleural contact by CT (excluding fissures), with accessible acoustic window by ultrasound.

Exclusion criteria:

Lesions with no pleural contact, lesions of chest-wall-origin, patients with uncorrectable bleeding diathesis, and patients on mechanical ventilation.

Technique:

Firstly comes reviewing of patient's history, previous studies and coagulation profile. Proper patient positioning, local anesthesia under complete aseptic conditions (In non-cooperative patients general anesthesia was applied). 18-gauge Tru-cut needles (GTA®, Italy) were used without a coaxial sheath.

US-guidance (Figs. 1,2), using both curvilinear low-frequency (3.5-5MHz) and linear high frequency (7.5-13MHz) transducers. Tru-cut biopsy needle was introduced via free-hand technique under real-time visualization, during a single breath hold, the biopsy gun was fired and withdrawn to collect the specimen in a jar containing 4% formaldehyde.

CT-guidance (Figs. 3,4), A laser beam used to localize the slice of interest. Optimal access point marked with the needle of anesthesia after injecting local anesthetic solution. Tru-cut biopsy needle was introduced to the lesion via free-hand-technique with multiple CT-shots to manipulate the passage directly inside the lesion (step-and-shot sequence), when accurately positioned; the biopsy gun fired and withdrawn to collect the specimen.

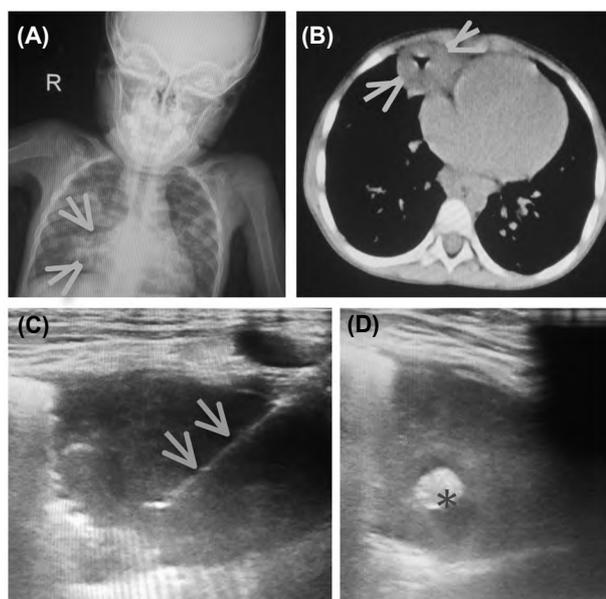


Fig. (1): Ultrasound-guided biopsy of a right anterior paramediastinal mass using a linear probe, in a three years old male child known to have Langerhans cell histiocytosis with multiple nodular lung infiltrates, which were stationary over 3 months' time not responding to antibiotic therapy. The procedural lasted for 5 minutes (25 minutes including general anesthesia induction and regression). Two needle passes yielded two cores of greyish-red tissue. Post-procedural minor complication in the form of minimal self-limiting intra-lesional hematoma occurred. Histopathology and complementary microbiology revealed pneumonic infection with multi-drug-resistant (MDR) Klebsiella. (A) Chest X-ray, and (B) Axial CT images mediastinal window showing a pleural-based cavitory lesion (arrows) in the medial segment of the right middle lobe. (C) Ultrasound guided needle insertion (arrows). (D) A well-defined hyperechoic intralobular hematoma (asterisk) disappeared in the next follow-up.



Fig. (2): Ultrasound guided biopsy of a right apical mass using a curved 3.5-5 MHz probe, in a 52 years old male, presented by gradual onset of right shoulder pain for 3 months, he underwent X-ray study of the right shoulder which revealed right shoulder X-ray examination a right apical lung mass (Film not shown). Four needle passes (in 12 minutes) yielded four cores of whitish tissue. No complications happened. Histopathology revealed keratinizing squamous cell carcinoma. (A) CT image coronal lung window. (B) Ultrasound B-mode image with color and spectral Doppler showing low resistive arterial wave. (C) Ultrasound guided needle insertion (arrows). (D) Colored photo showing four cores of whitish tissue in a formalin containing tube.

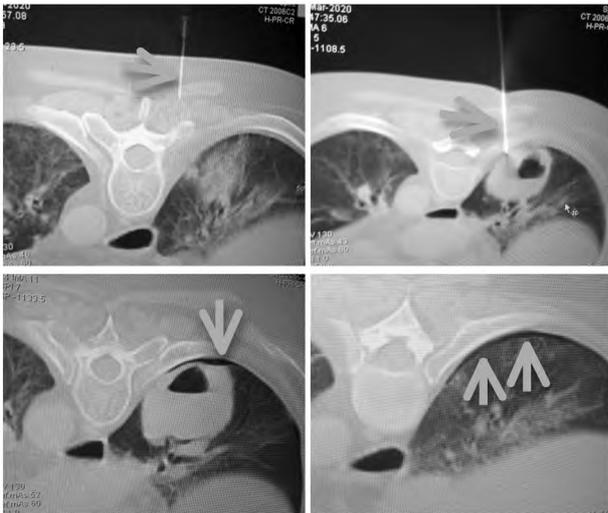


Fig. (3): CT-guided biopsy from a pleural-based rounded cavitory lesion within the superior segment of the right lower lobe in a 49 years old female, presented with dyspnea and hemoptysis. The procedure lasted for 16 minutes. Minor complication in the form of minimal self-limiting-pneumothorax. Pathology reported cavitating squamous cell carcinoma. (A) Axial CT image (lung-window) showing a pleural-based rounded cavitory lesion with local anesthesia syringe (arrow). (B) Axial CT image (lung-window) showing the needle introduction through a right para-midline approach into the solid part of the lesion. (C) Shows minimal pneumothorax (arrow). (D) Follow up axial CT image done four-hour post puncture showing stationary amount of minimal pneumothorax (arrows).



Fig. (4): CT-guided biopsy in a 53 years-old male, presented with dyspnea. The procedure lasted for 22 minutes and included four passes that yielded two cores of greyish-red material. No complications occurred. Pathology reported lung adenocarcinoma. (A&B) Axial CT image mediastinal window, with local anaesthesia syringe (A) and an 18-G tru-cut needle (B) Within the pleural-based lesion in close contact to the vertebral column, descending thoracic aorta (asterisk) and right main bronchus. (C) Post-procedural axial CT image lung window, showing no complications. (D) Colored photograph of the two long cores of greyish-red material.

Evaluation for complications; Immediate post-procedural CT-scanning or US-scanning performed for patients in each guidance group respectively to assess for immediate complications. Plain X-ray was performed for all patients, to assess for

pneumothorax one-hour & four-hour post procedural. Repetitive observations of vital signs and oxygen saturation levels in the first four-hours to manage any potential complications and prevent serious outcomes.

Data collection: Patients' data including; age, gender and smoking history. Exact lesion location. Lesion's size and pleural contact (in axial plane). Number of needle passes. Number of obtained tissue cores. Total procedure times with-and-without general anesthesia (if applied); calculated from patient entrance to CT or US room till his/her ambulation to the observatory suite, (times were correlated to documented clock on US-images and CT-images where the first and last needles were seen inside the lesion). All complications were self-limiting (pneumothorax, hemothorax, intra-lesional hemorrhage, and extra-thoracic Surgical emphysema), No major complications occurred. Histopathology reports were traced and documented.

Statistical analysis:

IBM® SPSS® 22, (SPSS Inc., Chicago, Illinois, USA). Categorical variables were compared using a Fisher's exact test, and continuous variables were compared using the two-tailed *t*-test, with a criterion of statistical significance of 0.05 (*p*-value).

Results

Significantly, fewer complications were seen for US-guided biopsies; 15% (3/20) versus 40% (8/20) for CT (*p*=0.036). Looking at complications' rates across pleural contact subgroups, fewer complications were seen with US-guided biopsy than with CT-guided biopsy in all groups. (*p*=0.031). Chart (1).

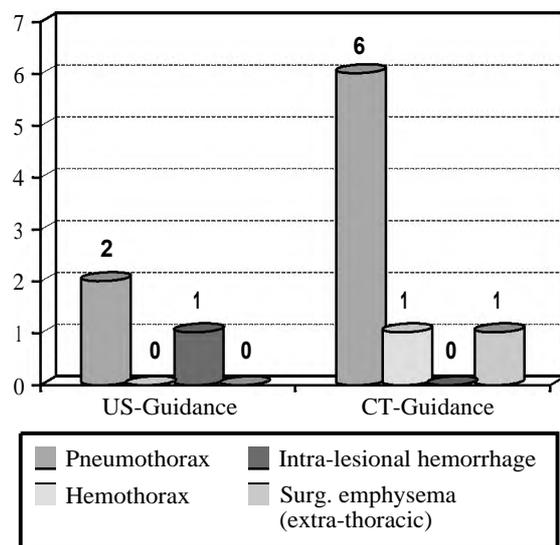


Chart (1): Incidence of complications in US-guidance and CT-guidance groups.

Pneumothorax alone represented about 73% (8/11) of all encountered complications. All of the eight cases had minimal self-limiting pneumothoraces that were managed conservatively with no need for chest tube insertion or hospitalization, and almost totally disappeared in the 4-hour post-procedural plain X-ray follow-up.

Subgroup analysis of the pleural contact in relation to the overall complication incidence, showed a statistically significant relation; that lesions with pleural contact 10-50mm have the least complication rates, while the subcentimetric lesions have the highest complication rates. ($p=0.036$) Table (2).

Table (2): Subgroups analysis of pleural contact and overall incidence of complications.

	Complications' incidence (US&CT)	<i>p</i> -value
Subgroups of pleural contact (US&CT)	11/40 (complications)/ (total number of cases)	
> 10mm	3/4 (75%)	0.036
10-30mm	2/12 (16.7%)	
31-50mm	2/13 (15.4%)	
51-100mm	4/9 (44.4%)	
> 100mm	0/2 (0%)	

Procedural times were significantly shorter in US-guidance group, with a mean procedure time of 6.3 ± 2.2 (SD) minutes (range; 3-11 minutes) compared with 21.8 ± 5.7 (SD) minutes (range; 12-34 minutes) for CT-guided biopsies. ($p=0.0001$).

Two cases needed general anesthesia, one US-guided 3 years old boy, and one CT-guided 13 years old teenager, the total procedure times including anesthesia, showed five-fold increase in US-case; (25 minutes, while the biopsy itself consumed 5 minutes only) and three-fold increase in CT-case (37 minutes, while the biopsy itself consumed 12 minutes only), denoting significantly shorter procedural times if the situation did not compel anesthesia. ($p>0.05$).

Subgroup analysis of the pleural contact and times of procedures, revealed a statistically significant relation in US-group only; The smaller the pleural contact the shorter the time needed for biopsy ($p=0.004$), while in CT-group no definite pattern of correlation could be generated between time and pleural contact. ($p=0.935$).

Significantly fewer passes were required for US-guided biopsies [mean, 2.7 ± 0.8 (SD) passes; range, 2-4 passes] than for CT-guided biopsies [mean, 3.4 ± 1.2 (SD) passes; range, 2-6 passes],

($p=0.04$). Despite the fewer number of passes in the US-group, no significant difference in number of obtained tissue cores [mean, 2.0 ± 0.9 (SD) cores; range, 1-4 cores] for the US-guided biopsies versus [mean, 2.2 ± 0.7 (SD) cores; range, 1-3 cores] for CT-guided biopsies. ($p=0.423$).

Malignant results were more common than benign for both US and CT guidance; 95% (19/20) and 85% (17/20) for US and CT-guidance, respectively. ($p=0.298$).

Adenocarcinoma was the most commonly encountered lung malignancy 42.5% (17/40), followed by squamous cell carcinoma 17.5% (7/40), then large cell carcinoma 12.5% (5/40), the least encountered was small cell carcinoma 7.5% (3/40), while metastases of different origins represented 10% (4/40). Tenth of overall cases were benign lesions (4/40). Chart (2).

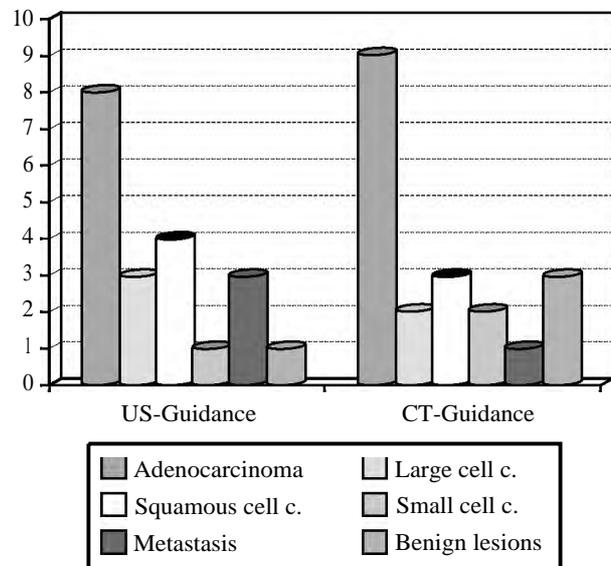


Chart (2): Incidence of pathology in US-guidance and CT-guidance groups.

A higher tendency for malignancy was detected in the smokers' group 95.8% (23/24); compared to the non-smokers' group 81.3% (13/16). ($p=0.167$).

Discussion

The current study found advantage of US over CT in decreased number of needle passes without compromising the diagnostic accuracy, similar findings were reported by Sconfienza et al., [4] in a retrospective study which included 103 US-guided cases and 170 CT-guided cases conducted over an 11 years' period, and found that US was associated with fewer needle passes than CT with trends to more accurate pathological diagnoses.

The advantage of US over CT in time saving was reported by Lee et al., [5] who retrospectively compared between 150 US-guided cases and 100 CT-guided cases conducted over a 12 years' period, and concluded that US was associated with much less time consumption than CT, more than 40% reduction in procedural times. They also reported much more time consumption when general anesthesia was applied.

Sconfienza et al., [4] also found much less time consumption in the US group; 42% time saving with US compared with CT, however their study retrospectively included the times documented on the PACS images of the procedure, neglecting the times consumed for pre and post-procedural patient preparation and positioning.

The favorable safety profile with US compared to CT is reported by many authors in the context of superiority of US-guidance [1,4-6].

In the current study; the predominant complication encountered for both groups was pneumothorax 73% (8 cases of pneumothorax out of the all 11 complicated cases). The higher rate of pneumothorax associated with CT-guided biopsies has been reported [7-9].

Zhuo et al., [2] explain This relative disadvantage of CT due to longer needle dwell times across the pleura and lack of real-time visualization of needle during the actual sampling.

In contradiction to the current study; Tekin et al., [10] retrospectively compared 81 US-guided and 100 CT-guided biopsies, in Turkey over a 4-years' period, they found no significant difference between US-guidance and CT-guidance in diagnostic efficacy and rate of complications. However, they believed that US guidance should be prioritized in percutaneous lung biopsy procedures for pleural-based lesions, as patients are not subjected to radiation in US, and the duration of the procedure is shorter, also the cost is lower.

Mychajlowycz et al., [11] aimed at evaluating time-consumption and efficacy of CT-guidance and US-guidance. They evaluated retrospectively 43 US-guided and 115 CT-guided biopsies, in Canada over one-year period, and suggested that US-guidance has significantly shorter waiting-times than CT-guidance. They also found that Ultrasound and CT guidance have similar safety and diagnostic adequacy.

Lee et al., [5] plotted lesion-size and pleural-contact together in relation to the rate of complication, they found that; the smaller the lesion

(<10mm) and the smaller the length of pleural contact (<10mm) the higher the complications' rate.

In the current study, a concordant evidence on relation between length of pleural contact and rate of complications ($p=0.036$), being more safe in the subgroups of (10-50mm) \rightarrow (16%), with higher rates on the larger subgroups (>100mm) \rightarrow (44.4%) and even much higher rate of complications in the sub-centimetric group (<10mm) \rightarrow (75%).

Jeon et al., [12] analyzed the results of 97 US-guided peripheral lung biopsies conducted in multiple centers in south Korea over 2-years' period. They found significant differences in complications' rates for lesions with pleural contact greater than 30mm (i.e., poorer outcomes with pleural contact less than 30mm). However, their data were retrospective and describing US-guidance only with no comparison to CT.

The current study found trends toward increasing incidence of malignancy among smokers' group (95.8%) more than the non-smokers' group (81.3%); ($p=0.167$), these data are consistent with El-Sharawy et al., [6] who studied retrospectively the differences between pathological results of 50 US-guided biopsies and 50 CT-guided biopsies undertaken in pulmonology department in Tanta university hospitals over a 4-years' period, and found association between smoking and higher incidence of malignancy across the Egyptian population. Interestingly adenocarcinoma was also the most commonly encountered lung malignancy followed by squamous cell carcinoma, then large cell carcinoma in their study, while benign lesions were the least pathologically proven diagnoses.

Conclusion:

US guidance should be considered as a first priority for biopsy of peripheral lung lesions with (10-50mm) pleural contact regardless of lesion size or site, because it is superior to CT guidance in; fewer number of needle passes with much less time consumption and much less rate of complications without compromising the diagnostic accuracy, in the context of being free from hazards of ionizing radiation for patients and operators.

Conflicts of interest:

There are no conflicts of interest.

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هل يمكن أن تحل الموجات فوق الصوتية محل الأشعة المقطعية في إرشاد الخزعات الرئوية الطرفية : دراسة مقارنة

شملت هذه الدراسة مقارنة لأربعين حالة من المترددين على مستشفى معهد ناصر للبحوث والعلاج بالقاهرة، لإجراء خزعة رئوية طرفية موجهة بالأشعة، في الفترة من يونيو ٢٠١٨ حتى مايو ٢٠٢٠. نصف الحالات تم إنجازها بإرشاد الموجات فوق الصوتية، والنصف الآخر تم بإرشاد الأشعة المقطعية، وتضمنت دراسة حجم الآفة الصدرية وطول سطح تلامسها مع الغشاء البلوري وموقعها الدقيق في فصوص الرئة، ومقارنة هذه المعلومات مع عدد مرات وخز إبرة العينة وكمية النسيج المسحوبة فعلياً، وبالتقرير النهائي لتشخيص معمل الأنسجة. كما تمت دراسة الأوقات المستغرقة في إجراء الخزعات بداية من وقت دخول المريض إلى غرفة الأشعة وحتى خروجه إلى غرفة الملاحظة.

أظهرت نتائج هذه الدراسة أن إرشاد الخزعات الرئوية باستخدام الموجات فوق الصوتية كان مصحوباً بعدد أقل من وخز إبر العينات مقارنة بإرشاد الأشعة المقطعية (٢.٧ وخزة ± 0.8 مقارنة بـ ٣.٤ وخزة ± 1.2 على الترتيب، قيمة الاحتمالية = ٠.٠٤)، انعكست قلة مرات الوخز على قصر المدة المستغرقة لإجراء الخزعة فكانت أقل في مجموعة إرشاد الموجات فوق الصوتية عنها في مجموعة إرشاد الأشعة المقطعية (٦.٣ دقيقة ± 2.2 مقارنة بـ ٢١.٨ دقيقة ± 0.7 على الترتيب، قيمة الاحتمالية = ٠.٠٠٠١)، أيضاً فإن هذان العاملان من قلة مرات الوخز وقصر الوقت المستغرق اتسقا مع زيادة نسبة الأمان بقلة حدوث المضاعفات في مجموعة إرشاد الموجات فوق الصوتية (١٥٪) عنها في مجموعة إرشاد الأشعة المقطعية (٤٠٪)، (قيمة الاحتمالية = ٠.٠٤٢).