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● *Original Contribution*

# ULTRASOUND-GUIDED PERCUTANEOUS NEEDLE BIOPSY FOR PERIPHERAL PULMONARY LESIONS: DIAGNOSTIC ACCURACY AND INFLUENCING FACTORS

Yu-Qing Guo, Xin-Hong Liao, Zhi-Xian Li, Yuan-Yuan Chen, Si-Da Wang, Ji-Han Wang, Xian-Shan Liao, and Yuan Luo

First Affiliated Hospital of Guangxi Medical University, Department of Ultrasound Diagnosis, Nanning, China

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**Abstract—A retrospective study was carried out to evaluate the diagnostic accuracy and the factors influencing the diagnostic accuracy of 648 procedures of ultrasound-guided percutaneous needle biopsy (PNB) for peripheral pulmonary lesions (PPLs). We reviewed the histopathology results, the clinical records and the procedure reports of these 648 biopsies and the final diagnoses of 637 PPLs to determine the diagnostic accuracy of ultrasound-guided PNB. Factors that influenced the diagnostic accuracy were assessed by analysis of the biopsy procedures, which were classified as diagnostic cases (true-positive and true-negative) and non-diagnostic cases (false-positive, false-negative and indeterminate). Statistical analyses of factors that related to patient demographic characteristics, lesion characteristics and biopsy details were performed to determine possible effects on diagnostic accuracy. Biopsies were successfully performed in all cases, and 11 patients underwent second biopsies for the same lesions. Among the 637 PPLs, there were 326 (51.2%) malignant lesions, 272 (42.7%) benign lesions and 39 (6.1%) indeterminate lesions. Of the 272 benign lesions, 114 (41.9%) were found to be tuberculous. The overall diagnostic accuracy was 81.8%, and the rates of hemoptysis, symptomatic pneumothorax and chest-tube insertion were 8.0%, 1.7% and 0.9%, respectively. Lesions sizes were divided into 3 groups according to the measurement by ultrasound. For lesions that measured ≤20 mm, 21–49 mm and ≥50 mm, the diagnostic accuracy was 72.0%, 86.8% and 79.7%, while sensitivity and specificity were 54.3%–79.2%, 88.3%–90.7% and 79.4%–89.5% and 77.3%–100%, 96.8%–100% and 58.6%–100%, respectively. Diagnostic accuracy was significantly affected by lesion size when lesion size was measured by ultrasound ($p = 0.006$) and computed tomography (CT) ($p = 0.001$). In the 3 lesion groups of ≤20 mm, 21–49 mm or ≥50 mm, diagnostic accuracy among each group was significantly different ($p < 0.001$). When lesion size was measured by ultrasound ($p < 0.001$) and CT ($p < 0.001$) and the 3 groups were analyzed ($p < 0.001$), there was a statistically significant relationship between lesion size and the presence of necrosis. The rates of the presence of necrosis in lesions that measured ≤20 mm, 21–49 mm and ≥50 mm were 3.9%, 11.7% and 28.8%, respectively. No significance was found for age ($p = 0.119$), gender ($p = 0.25$), lesion location ($p = 0.55$), the presence of necrosis ($p = 0.226$), patient position ($p = 0.25$), needle size ($p = 0.26$), puncture angle ($p = 0.34$) and needle passes ($p = 0.21$). Ultrasound-guided PNB is an effective and safe diagnostic method for PPLs; the diagnostic accuracy is significantly affected by lesion size and decreases in smaller (≤20 mm) and larger (≥50 mm) lesions. (E-mail: zhixianli2017@163.com)** **© 2018 The Author(s). Published by Elsevier Inc. on behalf of World Federation for Ultrasound in Medicine & Biology. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).**

*Key Words:* **Ultrasound, Percutaneous needle biopsy, Peripheral pulmonary lesions.**

## INTRODUCTION

Peripheral pulmonary lesions (PPLs) are very common and being detected with increasing frequency in recent years (Shepherd 2016). PPLs are defined as lesions not only abutting the pleura but also having an accessible ultrasound window (Yang 1997; Yang et al. 1992). Currently, image-guided percutaneous needle biopsy (PNB) has been generally recognized as playing a crucial role in diagnosing various lung lesions, with high diagnostic performance and safety (Heck et al. 2006; vanSonnenberg et al. 2013).

The PNB with computed tomography (CT) guidance is a well-established and safe method for the diagnosis of a variety of pulmonary lesions (Hiraki et al. 2009; Montaudon et al. 2004). However, ultrasound is as effective and safe as CT for the guidance of PNB for PPLs and offers some advantages (Sconfienza et al. 2013). Ultrasound

Address correspondence to: Zhi-Xian Li, Department of Ultrasound Diagnosis, First Affiliated Hospital of Guangxi Medical University, No.6 Shuangyong Road, Qingxiu District, Nanning, 530021, Guangxi, China. E-mail: zhixianli2017@163.com

can be used for real-time visualization and multi-planar monitoring for blood vessels and accurate localization of target lesions that move during respiration. In addition, fine adjustment of the needles can be made throughout the procedures. Moreover, freedom from radiation hazards, safety, rapidity and cost-effectiveness are other advantages of ultrasound (Liao et al. 2000; Sheth et al. 1999). Therefore, ultrasound has been recommended as a good choice for biopsy guidance of PPLs (Sconfienza et al. 2013).

More recently, a series of studies have been conducted to evaluate the efficacy and the factors influencing the diagnostic accuracy of lung biopsies (Kothary et al. 2009; Montaudon et al. 2004). However, most focused on CT guidance (Heck et al. 2006; Hiraki et al. 2009; Kothary et al. 2009; Montaudon et al. 2004) or investigated pooled data from peripheral thoracic lesions (Liao et al. 2000; Sconfienza et al. 2013). In most of these instances, the total number of PNB for PPLs under ultrasound guidance was relatively small. Few large studies have focused merely on the efficacy and the influencing factors that relate to ultrasound-guided PNB for PPLs (Liao et al. 2000; Sconfienza et al. 2013; Sheth et al. 1999). Therefore, the purpose of this study was to evaluate the diagnostic accuracy and the factors influencing the diagnostic accuracy of ultrasound-guided PNB for PPLs in a large series.

## MATERIALS AND METHODS

*Patients*

From March 2014 to January 2017, a cohort of 648 consecutive ultrasound-guided PNB procedures for PPLs in 637 patients at our hospital were included in the study. All procedures were performed on hospitalized patients. All patients (i) had undergone enhanced chest CT; (ii) were free of any contraindications before biopsy; and (iii) were able to tolerate the operation positions and cooperate with breathing instructions during biopsy. All procedures were performed in accordance with the Declaration of Helsinki, and the study was approved by the institutional review board of the First Affiliated Hospital of Guangxi Medical University, Nanning, China. Written informed consent was obtained from all participants or statutory guardians before biopsy, and patient consent for inclusion was waived because of the retrospective nature of the study.

Biopsy contraindications were as follows: (i) uncorrectable or intractable coagulopathy; (ii) inability to cooperate with breathing instructions, as in the case of severe pulmonary emphysema, severe pulmonary hypertension, respiratory failure or the presence of consciousness and mental disorders; (iii) lack of ultrasound visualization or a safe biopsy route; and (iv) recent myocardial infarction or unstable angina.

*Procedure*

All biopsies were assessed and performed by two experienced sonographers in our department. Previous examinations that used commercially available ultrasound systems (Logiq9, GE, CT, USA, or AcusonS2000, Siemens, Munich, Germany) equipped with 2.5–4.0 MHz or 3.5–5.5 MHz multi-frequency convex array transducers and color Doppler were available. Based on the location of the lesions, all patients were examined in prone, supine or lateral decubitus positions. Before each biopsy, the size, the vascularity and the surrounding structures of the target lesion, as well as the optimal needle depth and path, were measured and evaluated. All biopsies were performed with commercially available ultrasound systems (Preirus or EUB6500, Hitachi, Tokyo, Japan) configured with 1–5 MHz or 2–5 MHz dedicated convex-array puncture probes (EUP-B715 or EUP-B514, Hitachi). The probes were equipped with needle-guided attachments of various angle selections (0°, 15° and 30°). Before biopsy, the probe was cleaned with 75% ethanol solution for at least 5 min and then put on a sterile plastic film to ensure complete sterilization. The adjustable biopsy gun (MG1522, BARD Magnum, Bard Peripheral Vascular, Tempe, AZ, USA) equipped with 2 selectable penetration depths of 15 mm and 22 mm for drawing out the specimens, and supplementary 18-gauge or 16-gauge biopsy needles (BARD Magnum Disposable Needle, Bard Peripheral Vascular) were used in all biopsies. After skin sterilization and local anesthetic (2% lidocaine), the needle was inserted and advanced into the target lesion under ultrasound-guided real-time visualization. Care was taken to avoid penetrating both aerated lung tissue and large vessels inside the lesions.

After each biopsy, the specimen was put on a small piece of sterile filter paper and was examined by gross inspection by the operator to judge the quality of the specimen and determine whether further sampling was required. If the specimen presented a complete, solid strip, we could suppose that the quality of the specimen was good and that there was a high probability of having punctured the area of viable tissue. Further specimens were obtained after the previous biopsy procedure. If the specimen presented a red, solid strip, there was a high probability of having punctured an area of muscle tissue and having missed the specimen. The operator then would reassess the biopsy procedure to obtain specimens from the lesion itself. If the specimen presented as black, purulent, fragile, fragmented or liquid, we could assume that the specimen was unsatisfactory and there was a high probability of having punctured an area of necrotic tissue and having mistaken the specimen. Then the operator would reassess the necrosis of the lesion, and further sampling of several samples from the most likely viable tissue and various parts of the lesion would be taken. After the biopsy procedures, the resected specimens were immediately put in 10%