Computed Tomography–Navigated Transthoracic Core Biopsy of Pulmonary Lesions:

Which Factors Affect Diagnostic Yield and Complication Rates?[1]

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Rationale and Objectives. Only a few studies have systematically evaluated risk factors for pneumothorax and pulmonary hemorrhage in computed tomographically (CT)-guided transthoracic lung biopsy (TLB). We evaluated the diagnostic yield of CT-guided TLB and determined risk factors for pneumothorax and hemorrhage.

Methods. One hundred seventy-two CT-guided TLBs were performed on 159 patients (mean age 66 ± 11 years; 72% male) using a 16-gauge core biopsy needle. Lesion and patient characteristics, lung function analysis, CT signs of emphysema, histopathologic diagnoses, and complications were recorded. Statistical analysis was performed with multivariate regression analysis.

Results. Histopathologic diagnosis was established in 153 cases (89%). Although lesion size was higher (47 ± 29 vs. 43 ± 35 mm, $P = .191$) and depth was lower (22 ± 23 vs. 6 ± 23mm, $P = .350$) in procedures with histopathologic diagnosis, no parameter showed significant impact on diagnostic yield. Sensitivity and specificity for detection of malignancy were 93% and 100%, respectively, whereas positive and negative predictive values were 100% and 88%. Overall accuracy was 95%. Pneumothorax occurred in 45 procedures (26%). Hemorrhage was recorded in 17 procedures (10%). There was higher frequency of pneumothorax in smaller lesions (35 ± 23 vs. 50 ± 31 mm, $P = .003$; odds ratio = .96) and greater depth (29 ± 29 vs. 20 ± 19 mm, $P = .05$; odds ratio = 1.03). CT signs of emphysema revealed higher incidence of hemorrhage (35% vs. 23%; $P = .04$; odds ratio=41.03). Other parameters were nonsignificant.

Conclusions. The high diagnostic yield of CT-guided TLB was not affected by lesion characteristics or emphysema. Pneumothorax rate was influenced by lesion size and depth. Hemorrhage was associated with CT signs of emphysema.

Key Words. Lung; computed tomography; biopsy; guidance; tumor; pulmonary nodule.

Shortly after clinical approval of computed tomography (CT) in 1975, Haaga and Alfidi (1) reported the first CT-guided biopsy. Since then, CT has continuously improved and expanded the scope of thoracic lesions amenable to image-guided biopsy. Although efforts have been made to use ultrasound (2) and magnetic resonance imaging (3) as guiding tools in thoracic biopsies, CT-guided transthoracic lung biopsy (TLB) has become a widely accepted procedure for evaluation of intrapulmonary masses of unknown etiology. The method provides high diagnostic accuracy and has a relatively low complication rate. The spectrum of possible complications includes pulmonary

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hemorrhage, hemoptysis, air embolism (4–6), heart arrest (7), pericardial tamponade, neoplastic seeding (7,8), pneumothorax, and even death (9). According to the authors of numerous studies, the incidence of pneumothorax ranges from 10% to 54% (10–21); thus, a number of attempts have been made to prevent procedure-related complications including use of thin or ultrathin needles (11,16,22,23), respiratory gating (24), lower angulation of the biopsy needle trajectory (20), and precautions in positioning the patient during (25,26) and after the procedure (10,27,28). Furthermore, factors that are unrelated to the biopsy procedure, including patient age (11), lesion size (12,29,30), lesion depth (12,13,15,20,30), presence of emphysema (13,16,29), and obstructive lung disease (13,15,16,20), have been identified as risk factors for pneumothorax and chest tube placement. Due to the fact that pneumothorax is the most common complication following CT-guided TLB, only a few studies have systematically evaluated risk factors for post-interventional pulmonary hemorrhage. Nevertheless, serious pulmonary hemorrhage following TLB has been described, which may lead to severe hemoptysis or even death (7,30,31). Furthermore, results of previous studies concerning CT-guided TLB are difficult to compare owing to various statistical methods (univariate vs. multivariate analysis) and different biopsy systems, including fine-needle aspiration techniques and core biopsies, with some authors reporting inconsistent or even contradictory results (14,30), indicating that the incidence of different TLB-related complications is a multivariate and complex problem and that pneumothorax and hemorrhage may be caused by different factors.

The purposes of this retrospective study were to evaluate the diagnostic yield of CT-guided TLB using a core system and to determine risk factors for procedure-related complications, including pneumothorax and pulmonary hemorrhage.

MATERIALS AND METHODS

The study was approved by the ethics committee of the Ruhr-University of Bochum, Germany. Prior to the performed biopsies, written informed consent was given by all patients after the nature of the procedure had been fully explained.

Patient Selection

One hundred seventy-two TLB procedures were performed between August 1995 and March 2007 in a consecutive series of 159 patients in our institute. All investigations had been done for histopathologic evaluation of a pulmonary mass or nodule. In 146 patients, a single TLB was performed; 13 patients underwent biopsy twice. Patients' gender and age were documented based on the medical records. Furthermore, patient records were cross-referenced in the pulmonary function laboratory, and results of pulmonary function testing conducted within 1 month of the biopsy procedure were recorded if available. In total, 105 patients (111 TLB procedures) underwent pulmonary function testing. All investigations were performed using a calibrated pneumotachograph (Master Lab; Jaeger, Wuerzburg, Germany). Pulmonary function testing included the following parameters: forced expiratory volume in 1 second (FEV_1), percentage of predicted FEV_1 (FEV_1%), forced vital capacity (FVC), percentage of predicted FVC (FVC%), intrathoracic gas volume (ITGV), percentage of predicted ITGV (ITGV%), and FEV_1/FVC ratio.

Biopsy Procedure

All examinations were done by four physicians (interventional radiologists with at least 5 years of training) at the Institute of Diagnostic Radiology, Interventional Radiology and Nuclear Medicine, Berufsgenossenschaftliches Universitaetsklinikum Bergmannsheil GmbH, Ruhr-University of Bochum, Germany. From August 1995 to May 2000, a one-slice spiral-CT (SR 7000; Philips, Amsterdam, The Netherlands) was used. From May 2000 to October 2003, examinations were performed on a four-section scanner (SOMATOM Volume Zoom; Siemens, Erlangen, Germany); from November 2003 on, a 16-row scanner (SOMATOM Sensation 16; Siemens) was used. Furthermore, all patients underwent a complete clinical evaluation including history, physical examination, and standard laboratory workup. No patient had findings suggestive of a bleeding disorder. Prothrombin time, partial thromboplastin time, and platelet count were normal in all patients.

After placing the patient on the examination table (on the side, prone, or supine), a topogram and a prebiopsy scan were taken. The CT slice that best showed the target pulmonary lesion was chosen. The intended entrance point of the biopsy needle, its depth, and the distance from the skin were determined at the scanner console. When drawing a trajectory from the intended biopsy site to the skin surface, the shortest vertical intercostal approach that avoided bullae, vascular structures, and pleural fissures was chosen. A skin marker was made using