CT-guided percutaneous transthoracic needle biopsy of lung lesions – 2-year experience at the Institute of Radiology in Ljubljana

Igor Kocijančič and Ksenija Kocijančič

Institute of Radiology, University Clinical Centre Ljubljana, Ljubljana, Slovenia

Background. *In 1883, Leyden described percutaneous lung biopsy, but it was not until 1970s that image guided fine needle chest biopsy gained widespread acceptance. Haaga and Alfidi reported CT-guided thoracic biopsy in 1976. Currently, tissue sampling of a thoracic lesion is indicated when the diagnosis is not obtained by the endobronchial technique and when the cytological diagnosis will modify the stage of the disease or influence the therapeutic strategy. Cytology obtained by small-gauge needle aspiration biopsy confirms the nature of the lesion in 80 – 95% of cases and carry a low incidence of major complications according to the literature. The purpose of this retrospective analysis was to provide basic data about diagnostic accuracy and incidence of pneumothorax and chest tube insertion with respect to percutaneous transthoracic CT-guided needle biopsy of lung lesions.*

Methods. *After positioning of the patient we performed a spiral CT of the thorax with the accordingly placed metal mark, which helped us to set the optimal cutaneous entry point. After that we re-checked the localisation of the lesion and marked the entry point with a pen and clean the surface to keep it sterile. After we applied local anaesthetic subcutaneously, we used coaxial 18G Gallini aspiration biopsy needles with cutting tip for CT- guided aspiration cytologic examination. The length of the needle was chosen according to the distance of the targeted lesion.*

Results. *From January 2005 to January 2007 forty-three patients – 24 men and 19 women who were 26-79 years old (mean +/- SD, 59.8 +/- 10 years) were referred to the Institute of Radiology to undergo the PTNB. One patient was referred twice. Consequently, the hospital records and images of 44 consecutive cases of percutaneous transthoracic fine needle aspiration biopsy procedure were retrospectively analysed.*

The overall diagnostic accuracy was 93.2%, the pneumothorax rate was 27.2% and the chest tube insertion rate with percutaneous transthoracic CT-guided needle biopsy was 4.5%.

Conclusions. *Based on these cases, our 2-year experience is indicating that percutaneous transthoracic CT-guided needle biopsy is an effective and safe procedure for evaluation of undetermined lung lesions.*

Key words: lung neoplasms – pathology, biopsy needle; pneumothorax

Received 22 September 2007

Accepted 29 September 2007

Correspondence to: Assist. Prof. Igor Kocijančič, MD, PhD, Institute of Radiology, Clinical Center Ljubljana, Zaloška 2, SI - 1000 Ljubljana, Slovenia; Phone: + 386 1 520 85 31; Fax: + 386 1 520 24 97; E-mail: igor.koc@kclj.si

Introduction

In 1883, Leyden first described percutaneous lung biopsy, but it was not until the 1970s that image guided fine needle lung biopsy gained widespread acceptance. In this early years percutaneous lung biopsies and advances in cytopathology were reported as well in our institution[1,2]. Haaga and Alfidi[3] first reported the CT-guided biopsy in 1976. Since that many authors confirmed the technique as safe and accurate in diagnosing benign and malignant lesion of the chest.[4-8] Nowadays, tissue sampling of a thoracic lesion is indicated when the diagnosis is not obtained by endobronchial technique and when cytological diagnosis will modify the stage of the disease or influence the therapeutic strategy.

With the advent of lung cancer screening using low-dose helical CT an increased incidence of smaller lung lesion and also small lung cancer has been reported in some countries.[9,10] It is well known that the detection of lung cancer in early stage may improve the prognosis of such patients.[11-13] In management of solitary pulmonary nodule we use a repeated CT examination with the evaluation of volume change of the small pulmonary nodule but when an increase in size is recognized on follow-up CT examination a verification of the lesion becomes mandatory. Beside this, main indications for percutaneous transthoracic needl e biopsy (PTNB) are: pulmonary nodule or nodules without specific diagnostic criteria on computed tomography (CT) ascertaining benignity; pulmonary nodule(s) or mass(es) suggestive of malignancy, pulmonary nodule in a patient with a history of extrapulmonary primary malignancy, a residual nonregressive lesion following radiotherapy and chemotherapy, a residual nonregressive infiltrate following specific antibiotic therapy, chronic diffuse pulmonary infiltrate in selected cases.

The need for the preoperative diagnosis of a solitary pulmonary nodule depends on the pretest probability of diagnosing a lesion that would obviate an unnecessary thoracoscopy or thoracotomy.[16]

Concerning CT characteristics of pulmonary nodules, it is known that 43% of nodules smaller than 1 cm are benign as well as that 97% of nodules bigger than 3 cm are malignant. Thirty-three % of primary malignant nodules have regular contours and 46% of benign nodules are spiculated. Twenty-six % of benign nodules and 5% of malignant nodules are more or less calcified while 21% of benign and 40% of malignant nodules show air bronchogram.

Overall, a correct diagnosis can be established by CT in 66-98% cases.[17]

The aim of this analysis was to provide basic data about the diagnostic accuracy and frequency of complications of lung biopsy procedures with CT guidance of needle insertion over the last two years.

Methods

When the transthoracic needle biopsy was performed, the procedure itself, possible complications and its accuracy had been carefully explained to the patient. Upon this conversation the patient was requested to sign the Informed consent form.

The clinicians obtained routine partial thromboplastine time (PTT), prothrombine time (PT) and platelets level in all patients.

We performed CT guided PTNB, which enabled a precise localisation of the lesion. All procedures were conducted on a multislice CT scanner (Somatom 16, Siemens, Erlangen, Germany) by two radiologists experienced in thoracic radiology and image-guided biopsy techniques. The scanning parameters of the Somatom 16 were 120 kVp, 120-200 mA, 1.5 mm collimation; 3- to 5-mm slice thickness and a table speed of 30 mm/sec (pitch up-to 1.5). Biopsies were performed without injection of i.v. contrast media. Necrotic tissue and cystic lesions were identified during prior diagnostic contrast enhanced CT. Unenhanced CT scans were reviewed with a lung window setting (window width 1600 HU, window level -600 HU) and with a mediastinal window setting (window width 350 HU, window level 35 HU).

The position of the patient was then selected according to the desired needle path. It should be remembered that the position of the lesion can vary considerably when changing position from supine to prone or to oblique. The needle path should avoid transversing intercostals vessels so the needle entry was optimally defined at mid intercostals space whenever possible. In addition, it was necessary to try avoiding transgression of a pleural fissure, bullae or puncture of large vessel, bronchi and the oesophagus. We tried to insert the needle through the normal lung and to keep the length of the needle path to a minimum. We believed this reduced the risk for complication to a minimum.

The patient was instructed to stop breathing after normal inspiration at functional residual capacity. The technique of breath-holding was explained to each patient and was practiced shortly before the procedure.

To evaluate the procedure we could use adjusted (narrow) spiral scans or thick collimation (1 cm) sequence scans. The real time CT control should be avoided due to high doses for the patient and the staff.

After positioning of the patient we performed a spiral CT of the thorax with the accordingly placed metal mark, which helped to set the optimal cutaneous entry point. After that we re-checked the localisation of the lesion with regard to its anatomical environment. Once having the patient positioned at the desired table position, we marked the entry point with a pen and cleaned the surface to keep it sterile. We applied the local anaesthetic subcutaneously (2-5 ml 2% lidocain) and waited a few minutes. We do not apply any sedo-analgesia on routine basis.

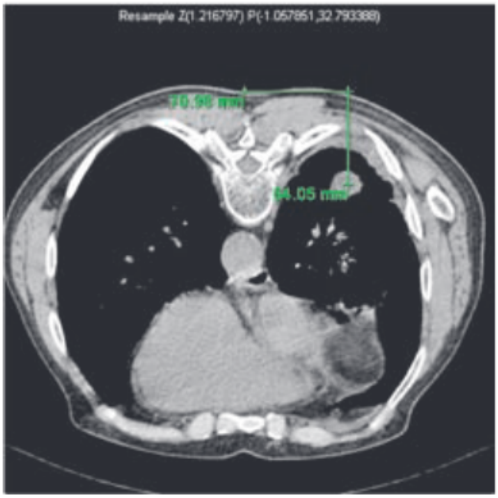

Figure 1. CT scan showing the puncture plan to diagnose the solitary pulmonary nodule in right lower lobe of 68-year-old man. Note the distance between the metal mark along the thoracic spine and the entry site and between the entry site and the centre of the nodule.

For CT- guided aspiration cytologic examination coaxial 18G Gallini aspiration biopsy needles with cutting tip were used. The length of the needle was chosen according to the distance of the targeted lesion.

The cytologist was always present to check the quality of the material. If needed, additional percutaneous passes were performed to get the satisfactory tissue sample.

Finally, the patient underwent post-procedural CT scan to check for possible complications (pneumothorax, haemorrhage, pleural effusion...). In case of large pneumothorax or moderately to severe dyspnoeic patient the placement of chest catheter or tube was considered. Others had the size of pneumothorax re-evaluated 7 days after the last follow-up examination if the patient was asymptomatic. In case of the increased pneumothorax (on follow-up chest radiographs) or the patient becoming symptomatic or large pneumothorax was found, a chest tube was placed.

Following the biopsy the patient was turned around to lie on the side which had been punctured for 15 to 30 minutes to prevent the possibility of pneumothorax evolution or progress.

Patients were generally observed, advised to stay in a recumbent position and under the medical staff supervision for at least for 4 to 5 hours after biopsy, then an erect expiratory chest X-ray was obtained. If normal, the compliant patients were discharged home. In the event a patient became symptomatic, an immediate follow up erect expiratory posteroanterior chest radiograph was obtained and in case of large pneumothorax (>30%) a chest catheter or tube was considered.

Figure 2. The same patient as at Figure 1. The lesion was penetrated, the tip of the needle was checked and aspiration specimen was obtained. The on-site cytologist confirmed the adequacy of the sample which was typical for adenocarcinoma.

Results

From January 2005 to January 2007 43 patients – 24 men and 19 women who were 26-79 years old (mean +/- SD, 59.8 +/- 10 years) were referred to the Institute of Radiology to undergo the PTNB. One patient was referred twice.

Consequently, the hospital records and images of 44 consecutive cases of percutaneous transthoracic fine needle aspiration biopsy procedure were retrospectively analysed. Diameter of pulmonary nodules/masses was measured on lung window settings. They measured from 0.8 cm to 6 cm in diameter (mean 2.3 cm, SD+/- 1.3 cm).

Cytological results were compared to the histological diagnosis after the surgery or to clinic and/or imaging follow up findings. To ascertain the benign nature of a lung nodule we used the following criteria: a technically successful biopsy, fair aspiration that is not normal lung, no signs of malignancy among aspirated cells and normal finding on bronchoscopy.

In our study, aspiration specimens were cytologically diagnosed into three groups by an experienced cytologist and/or by a cytology counsel as follows: negative for malignant cells 14/44 (32%) specimens, insufficient component 2/44 (4.5%) specimens and malignant lesion 28/44 (63.5%) specimens. All malignant lesions were nodules: 8 adenocarcinoma, 8 non-small cell lung cancer, 1 small-cell lung cancer, 2 carcinoids, 1 bronchiolo alveolar carcinoma, 1 lymphoma and 7 metastases. Unspecific/inflammatory lesions (n=7) were most frequently benign lesions.

The overall diagnostic accuracy, pneumothorax rate and chest tube insertion rate were determined.

Positive results at PTNB were considered to be true-positive when surgically confirmed, in case of biopsy of another site confirmed cancer with the same cytological characteristics, when the lesion increased in size or other proven metastases were found. According to the medical information all 28 cytologically positive cases turned out to be true positive.

Negative results at PTNB were considered to be true-negative when surgically confirmed, when the lesion disappeared or decreased in size on subsequent follow-up examinations or when it remains stable on the follow-up CT for 24 months. Thirteen of 14 cytologically negative cases turned out to be true negative.

There was one false-negative case. This was a solitary mass in an elderly, smoking women, located in the apex of the left lung, surrounded by a few non-specific parenchymal changes. Cytology revealed no malignant cells but the lesion was surgically removed since it was asymptomatic and not seen on radiographs a few months ago. The histology examination of removed tissue showed adenocarcinoma.

We considered true-positive and true-negative findings to be diagnosed cases while false-positive cases, false-negative cases and insufficient samples were considered non-diagnosed cases.

The overall diagnostic accuracy of PTNB (number of accurately diagnosed cases/total number of PTNB) turned out to be 93.2% in our series.

There were no major peri or post-procedural complications observed. During or after the biopsy we diagnosed pneumothorax in 12/44 patients. In two of them the chest catheter or tube was inserted. That makes the pneumothorax rate to be 27.2% and the chest tube insertion rate to be 4.5%. In 5 patients minor, asymptomatic intraparenchymal bleeding was observed. There was also one case of major parenchymal bleeding immediately after the needle position (prior to the first sample taking), accompanied by moderate hemoptysis. After a while symptoms decreased, the procedure was resumed and also successfully completed. In the post-procedural course the patient experienced a few minor events of haemoptysis which spontaneously resolved within a week.

Figure 3. CT section through the level of small pulmonary nodule in 66-year-old man. The tip of the aspiration needle is clearly seen in the peripheral part of the lesion. Small pneumothorax already developed although this was the first attempt to target the lesion.

In 36/44 (82%) cases of PTNB, the co-operating on-site cytologist evaluated the cytological sample from an initial puncture as being sufficient for the diagnosis. However, in the remaining 8 cases patients we had to repeat the puncture and sample taking up to maximum four times. Even then the final cytology report in two cases indicated the tissue sample as inadequate. Both lesions were small (less than 1.5 cm) and deep (needle path more than 10 cm long) – the so called "difficult thoracic lesions". The retrospective analysis of the procedures evaluated both to be inaccurately targeted.

Discussion

Haaga and Alfidi reported the first case of aspiration biopsy guided by CT in 1976.[3] Ever since the technique have expanded and many papers confirmed it as safe and accurate in diagnosing benign and malignant lesions of the chest.[4-8]

According to the published data so far, the percutaneous needle aspiration biopsy is a safe and accurate technique to diagnose benignant and malignant pulmonary lesions.[4-8,14-28]

Only the puncture of vascular structure such as an aneurysm or pulmonary arteriovenous malformation represent is absolutely contraindicated. The correct diagnosis should be obtained with contrast enhanced cross section imaging modalities such as CT and magnetic resonance imaging (MRI). Relative contraindications are: puncture of both lungs within the same session, puncture of only one functional lung, chronic respiratory insufficiency, pulmonary arterial hypertension, cardiac insufficiency, recent acute coronary event, severe emphysema and uncorrected coagulation defect. Cough, dyspnoea and reduced patient cooperation are further limiting factors. Mechanical ventilation is also a relative contraindication of PTNB.

The overall diagnostic accuracy (93.2%) was very high in our series and exceeds most of the ranges of results of CT-guided biopsy, reported in the literature, which include the data on pulmonary nodules of any size[2-6,12-26] as well as that of fiberoptic bronchoscopy.[29]

The pneumothorax rate (27.2%) as well as the chest tube insertion rate (4.5%) in our series were within the ranges of results of CT-guided biopsy reported in the literature.[16,24-28] Two important factors that affect the diagnostic accuracy are lesion size and needle path length. Many investigators report that diagnostic accuracies of CT-guided needle aspiration biopsies were influenced mainly by the lesion size[4-7,17-20,25-28] but only one suggesting needle path length is a more important factor in the diagnostic accuracy of CT-guided transthoracic needle aspiration biopsy.[16] It is also indicated that solitary pulmonary nodules of 10 mm or less should be followed up by repeated CT rather than biopsies because the diagnostic accuracy for these nodules is significantly lower than for larger solitary pulmonary nodules.[16] The percentage of predicted FEV1 is a well known measure of the degree of chronic obstructive pulmonary disease in patients[22] while decreased FEV1 is suggested to be a factor influencing pneumothorax rate.[5,21]

Beside the percentage of predicted FEV1 of the patient also the needle path length and the number of needle passes were often considered to be related to the pneumothorax rate as well as to the chest tube insertion one. Other factors like lesion size, needle-pleural angle, needle size, location of the nodule and needle approach sometimes did but sometimes did not improve pneumothorax and chest tube insertion rates.[5,6,16,18-21,27,26]

Unfortunately, the number of our cases is too low to allow the reliable stepwise regression analysis to test the importance of these factors that may affect the diagnostic accuracy, pneumothorax rate and chest tube insertion rate.

Knowing that the number of punctures can significantly affect pneumothorax and chest tube insertion rate, some investigators recently applied a coaxial technique for CT-guided thoracic interventions[19,20,30,31] in order to reduce both of them. In case of such technique the leading needle only once passes through the pleural space regardless to the numbers of tissue sampling and, consequently, the risk for pneumothorax has been reduced. In our study we did not adapt a coaxial technique since the great majority of our procedures ended up with a sufficient sample of tissue after only a single puncture. For such workflow it is necessary to cooperate with the on-site cytologist in order to repuncture and obtain another specimen in cases of insufficient material for the diagnosis from the initial attempt.

We always considered the needle path length because a longer needle path tends to damage a larger part of lung parenchyma in between the pleura and the target lesion and may, consequently, increase the risk of pneumothorax. Hence, it is preferably to try an accurate single puncture of target lesion and to plan the needle trajectory to be as short as possible.

Other possible complications (e.g. intraparenchymal bleeding, pleural effusion, infection) are not common. Air embolism, a rare but potentially fatal complication can happen during CT-guided PTNB of the lung.[23]

In conclusion, our results confirmed CT-guided transthoracic needle biopsy as a useful and safe diagnostic tool for the determination of different lung lesions. The overall diagnostic accuracy, pneumothorax rate and chest tube insertion rate are within ranges, reported by other authors. From our experience and according to the data in the literature an accurate single puncture with the shortest needle path should be applied in order to minimize the risk of complication. If there is no on-site cytologist present, one should consider the coaxial technique of CT-guided biopsy, which probably has the potential to further reduce the chest tube insertion rate which is significantly increased if the operator risks an additional puncture.

References

1. Jereb M, Us Krasovec M. Transthoracic needle biopsy of mediastinal and hilar lesions. *Cancer* 1977; **40**: 1354-7.
2. Jereb M. The usefulness of needle biopsy in chest lesions of different sizes and locations. *Radiology* 1980; 134: 13-5.
3. Haaga JR, Alfidi RJ. Precise biopsy localisation by computer tomography. *Radiology* 1976; **118:** 603-7.
4. Westcott JL. Direct percutaneous needle aspiration of localized lesions: results in 422 patients. *Radiology* 1980; **137:** 31-5.
5. Kazerooni EA, Lim FT, Mikhail A, Martinez FJ. Risk of pneumothorax in CT-guided transthoracic aspiration needle biopsy of the lung. *Radiology* 1996; **198:** 371-5.
6. Li H, Boiselle PM, Shepard JO, Trotman-Dickenson B, McLoud TC. Diagnostic accuracy and safety of CT-guided percutaneous needle aspiration biopsy of the lung: comparison of small and large pulmonary nodules. *AJR Am J Roentgenol* 1996; **167:** 105-9.
7. Khouri NF, Stitik FP, Erozan YS. Transthoracic needle aspiration biopsy of benign and malignant lung lesion. *AJR Am J Roentgenol* 1985; **144:** 281-8.
8. Stanley JH, Fish GD, Andriole JG. Lung lesions: cytologic diagnosis by fine-needle biopsy. *Radiology* 1987; **162:** 389-91.
9. Barsky SH, Cameron R, Osann KE, Tomita D, Holmes EC. Rising incidence of bronchioloalveolar lung carcinoma and its unique clinicopathologic features. *Cancer* 1994; **73:** 1163-70.
10. Travis WD, Travis LB, Devesa SS. Lung cancer. *Cancer* 1995; **75(S1):** 191-202.
11. Sone S, Takashima S, Li F, Honda T, Maruyama Y, Hasegawa M, et al. Mass screening for lung cancer with mobile spiral computed tomography scanner. *Lancet* 1998; **351:** 1242-5.
12. Marshall D, Simpson KN, Earle CC, Chu C. Potential cost-effectiveness of one-time screening for lung cancer (LC) in a high-risk cohort. Lung *Cancer* 2001; **32:** 227-36.
13. Henschke CI, Naidich DP, Yankelevitz DF, McGuinness G, McCauley DI, Smith, et al. Early Lung Cancer Action Project: initial findings on repeat screenings. *Cancer* 2001; **92:** 153-9.
14. Klein JS, Zarka MA. Transthoracic needle biopsy: An Overview. *J Thorac Imaging* 1997; **12:** 232-49.
15. Minami M, Kawauchi N, Oka H, Itai Y, Sasaki Y: High resolution CT of small lung nodules: Malignancy versus Benignancy. *Radiology* 1992; **185:** 357-60.
16. Ohno Y, Hatabu H, Taneka D, Higashino T, Watanabe H, Ohbayashi C, et al. CT-guided transthoracic needle aspiration biopsy of small solitary pulmonary nodules. *AJR Am J Roentgenol* 2003; **180**: 1665-9.

17. Laurent F, Latrabe V, Vergier B, Michel P. Percutaneous CT-guided biopsy of the lung: comparison between aspiration and automated cutting needles using a coaxial technique. *Cardiovascular Intervent Radiol* 2000; **23:** 266-72.

18. Garcia-Rio F, Pino JM, Casadevall J, Gómez L, Atienza JM, Díaz-Lobato S, et al. Use of spirometry to predict risk of pneumothorax in CT-guided transthoracic needle aspiration biopsy of the lung. *J Comput Assist Tomogr* 1996; **20:** 20-3.

19. Laurent F, Michel P, Latrabe V, Tunon de Lara M, Marthan R. Pneumothoraces and chest tube insertion after CT-guided transthoracic lung biopsy using a coaxial technique: incidence and risk factors. *AJR Am J Roentgenol* 1999; **172:** 1049-53.

20. vanSonnenberg E, Casola G, Ho M, Neff CC, Varney RR, Wittich GR, et al. Difficult thoracic lesions: CT-guided biopsy experience in 150 cases. *Radiology* 1988; **167:** 457-61.

21. Ko JP, Shepard JO, Drucker EA, Aquino SL, Sharma A, Sabloff B, et al. Factors influencing pneumothorax rate at lung biopsy: are dwell time and angle of pleural puncture contributing factors? *Radiology* 2001; **218:** 491-6.

22. American Thoracic Society. Lung function testing: selection of reference values and interpretative strategies. *Am Rev Respire Dis* 1991; **144:** 1202-18.

23. Hirasawa S, Hirasawa H, Taketomi-Takahashi A, Morita H, Tsushima Y, Amanuma M, et al. Air embolism detected during computed tomography fluoroscopically guided transthoracic needle biopsy. *Cardiovasc Intervet Radiol* 2007 (in press).

24. Kinoshita F, Kato T, Sugiura K, Nishimura M, Kinshita T, Hashimoto M, et al. CT-guided transthoracic needle biopsy using a puncture sitedown positioning technique. *AJR Am J Roentgenol* 2006; **187:** 926-32.

25. Heck SL, Blom P, Berstad A. Accuracy and complications in computed tomography fluoroscopy-guided needle biopsies of lung masses. *Eur Radiol* 2006; **16:** 1387-92.

26. Lourenco R, Camacho R, Barata MJ, Canario D, Gaspar A, Cyrne C. CT-guided percutaneous transthoracic biopsy in the evaluation of undetermined pulmonary lesions. *Rev Port Pneumol* 2006; **12:** 503-24.

27. Andreson JM, Murchison J, Patel D. CT-guided lung biopsy; factors influencing diagnostic yield and complication rate. *Clin Radiol* 2003; **58:** 791-7.

28. Gupta S, Krishnamurthy S, Broemeling LD, Morello FA, Wallace MJ, Ahrar K, et al. Small subpleural pulmonary lesions: short- versus long-needle path CT-guided biopsy. Comparison of diagnostic yields and complications. *Radiology* 2005; **234:** 631-7.

29. Baaklini WA, Reinoso MA, Gorin AB, Sharafkaneh A, Manian P. Diagnostic yield of fiberoptic bronchoscopy in evaluating solitary pulmonary nodules. *Chest* 2000; **117:** 1049-54.

30. Charig MJ, Phillips AJ. CT-guided cutting-needle biopsy of lung lesion-safety and efficacy of an outpatient service. *Clin Radiol* 2000; **55:** 964-9.

31. Geraghty PR, Kee ST, McFarlane G, Razavi MK, Sze DY, Dake MD. CT-guided needle aspiration biopsy of pulmonary nodules: needle size and pneumothorax rate. *Radiology* 2003; **229:** 475-81.