Percutaneus needle biopsy of small lung lesions - useful techniques in patient positioning, needle insertion and complication risk reduction

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Aims and objectives

The wide use of computed tomography (CT) in chest radiology leads to increased detection of small pulmonary nodules. CT-guided transthoracic needle biopsy is well-established technique to confirm malignant character of these lesions [1]. Lung cancer smaller than 2 cm without lymph nodes or extended metastases, according to 7th TNM lung cancer classification is classified as Ia stage [2]. Overall 10-yers survival for such a cancers after lobar resection, was estimated up to 92% [3]. According to National Comprehensive Cancer Network 2016 guideline [4], histological confirmation of lung cancer before radical operation such as lobectomy or pneumonectomy with lymphadenectomy is an obligation what can be realized by percutaneous biopsy. Lung lesion smaller than 2cm, especially unfavorably located, may present a difficult challenge for radiologist. Yankelevitz et al. presented systematic instructions for proper lung biopsy procedure and several pitfalls related to technical factors, nodule characteristic or complications during the procedures [5, 6]. Awareness of how pitfalls may be avoided and the use of specific techniques could improve biopsy sensitivity and safety.

The purpose of the study is to present both outcomes of core biopsy (CB) and fine needle aspiration biopsy (FNAB) in small tumors as well as a few of useful techniques in patient positioning, needle insertion and complication risk reduction.
Methods and materials

The structure of the presentation was divided into two parts.

In the first part the specifications of the included group and statistic tools will be presented. In the second part useful tips and techniques in needle placement, patient positioning and the way for complication risk reduction will be described.

Part one

Between April 2013 and August 2016 593 transthoracic biopsies were performed in Department of Radiology Medical University of Gdansk by the same radiologist (M.J-G). Out of these, 506 biopsies were performed due to lung tumor, and 214 of these lung lesions was smaller than 2cm in the longest diameter and entered the final analysis.

Before the procedure informed consent was obtained in all cases. Patient were placed in prone, supine or decubitus position according to tumor location to obtain both the shortest distance from pleura and the most comfortable position for patient. 1% solution of lidocaine was used for local anesthesia.

All biopsies were performed under the control of CT or CT-fluoroscopy using 128-rows CT scanner.

Patients who underwent FNAB and CB were included. For FNAB 22 guage 88mm, 127mm or 200mm long were used. For CB procedure 14, 16, 18 or 20 guage needles 100mm, 120mm, 160mm were used.

Control CT scan was performed within 5 minutes after needle removal. Additionally control X-ray was performed the day after procedure.

Several data were collected in the database:

- connected with tumor (size, location)
- connected with the procedure (needle size, use of CT fluoroscopy)
- complications in CT and in X-ray
- need of chest tube placement
- histological results

For statistical analysis raw numbers and percentage were used for descriptive data. For results comparison for FNAB and CB chi-square test was used.
Sensitivity for malignancy detection was calculated with the formula

\[ \text{Sensitivity} = \frac{TP}{TP+FN} \times 100\% \]

**TP**: true positive result

**FN**: false negative result

True positive result was defined when malignancy revealed after FNAB or CB was confirmed by surgical resection or other diagnostic procedure such as surgical excision, endobronchial ultrasound guided biopsy (EBUS), bronchofiberoscopy or diagnostic thoracoscopy.

False negative result was defined, when biopsy revealed no malignancy, but after surgery or other diagnostic procedures the neoplastic character was confirmed.

Patients with result not confirming neoplasm (negative) without any further diagnostic work-up or CT control were excluded from sensitivity calculation.

**Part two**

Patients in whom specific techniques were applied were documented with CT scans and will be presented in results.
Results

Part one

FNAB was performed in 126 cases, CB in 82 cases. In six tumors both FNAB and CB were performed during one procedure. Seventy five CB were performed with the use of CT-fluoroscopy.

Median tumor size was 14,3mm, most commonly (58%) located in upper lobes. Coaxial 88mm needle for FNAB and 100mm core needle 18guage long for CB were most commonly used.

Sensitivities for malignancy detection of FNAB and CB were respectively 75% and 88%. Pneumothorax requiring chest drainage occurred 14% of FNAB and in 11% of CB cases. Hemoptysis was common complication after core and rare after aspiration biopsy (18% vs 2,3% respectively). The most common complications are presented in table 1.

<table>
<thead>
<tr>
<th>Biopsies in lung lesions &lt;2cm</th>
<th>FNAB</th>
<th>CB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>126</td>
<td>82</td>
</tr>
<tr>
<td>CT- Fluoroscopy</td>
<td>0</td>
<td>75 (91%)</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>75%</td>
<td>88%</td>
</tr>
<tr>
<td>Penumothorax in X-Ray</td>
<td>47 (37%)</td>
<td>31 (37%)</td>
</tr>
<tr>
<td>Chest tube placement</td>
<td>18 (14%)</td>
<td>9 (11%)</td>
</tr>
<tr>
<td>Intersitial hemorage</td>
<td>37 (29%)</td>
<td>48 (58%)</td>
</tr>
<tr>
<td>Heamoptysis</td>
<td>3 (2,3%)</td>
<td>15 (18%)</td>
</tr>
<tr>
<td>Pleural hematoma</td>
<td>2 (1,6%)</td>
<td>1 (1,2%)</td>
</tr>
</tbody>
</table>

The most common histopathologic finding in both diagnostic techniques was non-small cell lung cancer with predominance of adenocarcinoma (30%).

Part two
The procedure of lung lesion biopsy as any other invasive procedure should be planned carefully. First step is appropriate patient's positioning. Figure 1 and 2 shows positioning patient according to the tumor location.

Most preferable position is prone position in which ribs move less during breathing than in supine position. We found that prone position reduces patient's anxiety when the needle cannot be seen.

We observed also that in both prone or supine position arm elevation could be crucial for tumor accessibility. A small subpleural nodule which in prone, arms-up position was covered by scapula (Figure 3 ), became easily accessible after changing position of arms - parallel to the body (figure 4 and 5).

Decubitus position is considered to be the most challenging due to its instability, but even in that position, small tricks are necessary to improve tumor access. In figure 6, after first CT scan the tumor in decubitus position is located behind the rib. The chest was lean posteriorly and the tumor was reachable (Figure 7, 8).

No specific breathing instruction are given to majority of biopsies. For juxtaphrenic small nodules we found expiratory trick useful. In that trick we ask patient to exhale and stop breathing during needle placement and each CT scan - first and controls. That maneuver enable to visualize the tumor in comparable position each time. Access to that tumor is presented in figure 9 and 10.

We assume that each lung nodule is accessible in needle biopsy. Although, in some cases the biopsy could be difficult to perform due to unfavorable tumor location - near the vital structure or behind rib, sternum or rib cartilage. In these cases needle angulation was the only possible way to rich the tumor.

In case I the tumor is behind the rib, and even changing arm position did not help. Finally the needle was angled and the tumor was reached (Fig. 11 and movie 1 - annotated as Fig 12). The next two photos shows needle angulation in order to avoid vessel injury (Fig. 13 and movie 2 - annotated as Fig. 14 ).

Pneumothorax is one of the most common complication after lung tumor biopsy, especially when emphysema is present. In our institution we try to set the needle trajectory in soft tissue and intercostals space without touching the lung. Only after the trajectory is fixed correctly we insert the needle deeply to reach the tumor. In fig. 15-18 we present the usefulness of that technique.
Fig. 1: Planing patient position according to tumor location

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**Fig. 2:** Tumors location for decubitus position

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**Fig. 3:** Tumor in prone position arms up - covered behind scapula.

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Fig. 4: The same tumor in prone position with ipsilateral arm located parallelly.

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Fig. 5: After changing arm position - tumor is accessible.

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Fig. 6: Small tumor in decubitus position - covered by rib

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**Fig. 7:** Access to the same tumor as in Fig 6 - after leaning patient slightly.

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**Fig. 8:** The same tumor as in fig 6 and 7 - the needle inside the tumor.

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**Fig. 9:** Juxtaphrenic small nodule - because of breathing movement - the biopsy seemed tricky

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**Fig. 10:** The same tumor as in Fig 9 - exhale maneuver enabled needle access.

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**Fig. 11:** Small tumor in third segment of right lung - located behind the rib

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**Fig. 12:** Movie - needle angulation to reach the tumor presented in fig 11.

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Fig. 13: Needle angulation to avoid vessels injury - red arrow - vena cava - green arrow - internal thoracic vessels

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**Fig. 14:** Needle angulation - to reach tumor and avoid vena cava injury.

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**Fig. 15:** Fixing needle trajectory in soft tissue and intercostals space without touching the lung - to reach the small tumor near the pericardium.

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**Fig. 16:** Another step in fixing needle trajectory

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Fig. 17: Put the needle deeper when the trajectory is fixed...

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Fig. 18: to reach the tricky located small tumor.

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Conclusion

Percutaneous needle biopsy using both FNA and CB is a simple, quick, safe and highly accurate procedure in the diagnosis of small lung lesions. Zhang et al. in meta-analysis compared sensitivity for FNAB and CB with fluoroscopy from several studies. According to the report an overall sensitivity for diagnosis of malignancy for FNAB and for CB with CT fluoroscopy was reported 68-95% and 84-97% respectively [7]. Unfortunately this analysis took into account all nodule sizes, without giving separate attention to small nodules. In our analysis we defined small nodule as solid mass or grand glass opacity less than 2cm in the longest axis, what is reflect stage T1a according to the lung cancer 7th TNM staging, which is further qualified as Ia stage, if no metastases are proved [2]. According to Henschke et al., lung cancer in the earliest stage could be successfully treated with 10-years survival rate approximately 92%, when operated radically within 30 days from diagnosis [3]. In literature researchers defined small nodules differently. Li et al. analyzed fine needle aspiration biopsies of nodules smaller or equal to 1,5cm, and the sensitivity was calculated for 72%[8]. Moreover in 2013, Li released the analysis of core biopsy of nodules smaller the 2cm where he calculated sensitivity for 90,2%, and his results was comparable to our study[9]. Other studies have shown that the diagnostic yield of CT guided needle lung biopsy is lower in smaller lesions and that rule was confirmed for both FNAB and CB technique [10, 11]. Results from our study where sensitivity for FNAB and CB for small nodules are respectively 75% and 88% are comparable to other studies and further acceptable.

Pneumothorax (PNX), lung hemorrhage and hemoptysis are the most common complications occurring after lung needle biopsy, but the rate of complications varies greatly in literature. Heerink et al. in a wide meta-analysis compared minor and major complication rate taking into account 49 studies - 32 papers about CB and 17 about FNAB[12]. Complications were divided to minor and major according to Society of Interventional Radiology Guidelines [13], and are listed in table 2.

<table>
<thead>
<tr>
<th>Minor complication</th>
<th>Major complication</th>
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<tbody>
<tr>
<td>pneumothorax without the need of intervention*</td>
<td>pneumothorax requiring intervention*</td>
</tr>
<tr>
<td>pulmonary hemorrhage</td>
<td>hemothorax</td>
</tr>
<tr>
<td>transient hemoptysis</td>
<td>air embolism</td>
</tr>
<tr>
<td></td>
<td>needle tract seeding</td>
</tr>
<tr>
<td></td>
<td>death</td>
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Heerink concluded that complications occurred more often in core biopsy than in FNAB, but major complication rate (especially pneumothorax requiring intervention) is similar in core biopsy and FNAB. Author also mentioned that the risk factor for complication in FNAB group is smaller nodule size, but did not proved that rule for CB. When we compared our results with the biggest cohorts mentioned in the analysis (Hiraki et al. - group of 1098 CBs, 42% of PNX, 5% with the need of intervention, Kuban et al. - group of 1002 CBs, 30% PNX, 16% of PNX with intervention, D'Alessandro et all - group of 594 FNABs, 17% of PNX, 5% of PNX with intervention), our pneumothorax rate without and with chest tube placement (37% and 14% for FNAB, 37% and 11% for CB) seems to be high. Similarly, our rate of parenchymal hemorrhage and is relatively high in CB group (respectively 58% and 18%) but low in FNAB group (respectively 29% and 2.3%). In literature the hemorrhage and hemoptysis rate varies respectively form 2.9%-54% and 0%-14% for CB, and 2%-29% and 0%-5% for FNAB.

Only few studies in the meta-analysis put the attention to small nodules but the results are contradictory especially for core biopsy. Laurent et al. divided the cohort of performed CBs into two groups according to nodule size less or more than 2cm [14] Study showed, that in the group of smaller nodules there is tendency to higher rate of interventions due to PNX (3% vs 0.7%), and higher parenchymal hemorrhage rate (43% vs 14%), without any difference in hemoptysis rate (6% vs 5.2%). Average tumor size in Yamauchi study of CBs was 17mm, and he reported 0% pneumothorax with intervention and 14.4% of hemoptysis [15]. In the other side, Rotolo presented study of CBs where mean tumor size was also 17mm and reported 9.4% of pneumothorax with intervention and only 0.5% of hemoptysis [16]. The report of FNABs for small nodules (mean size 9mm) was presented by Ng et al. who showed 50% of pneumothorax and 9% of pneumothorax with intervention without any specific information about other complications [17]. In Heerink meta-analysis confront larger nodules, but in all cases hemoptysis rate did not exceed 5%.

Our study showed that pneumothorax rate could be high and should be reduced in further practice performing both core or FNAB. Hemoptysis after CB as other researchers documented is common complication but rare after FNAB, but is classified as minor complication, so even relatively high rate of that complication could be accepted.

Yankelevitz D. and Cham M.D. presented systematically instructions for proper lung biopsy procedure and several pitfalls related to technical factors, nodule characteristic or complications during the procedures [5, 6]. In our presentation we added some more techniques, that could be useful in daily practice. Described maneuvers with changing patient arm position or slightly leaning patient body enables better access to the tumor.
Needle angulation and exhalation maneuver are reserved for tricky located tumors when even patient position changing does not help. All mentioned techniques allow proper needle positioning within the tumor and further obtaining diagnostic material.

Moreover, Cham mention techniques, which reduce pneumothorax after procedure, but most of them such as manual aspiration or thoracic vent placement are intervention techniques[6]. We believe that putting special care in fixing needle trajectory properly in soft tissue and intercostals space before reaching the tumor could reduce the pneumothorax incidence.

In conclusion, both core and fine needle aspiration are safe and effective methods for confirmation of malignant character in small lung tumors. Using special techniques could improve overall sensitivity of these procedures and reduces complications.
References

