Ultra Low Dose Radiation Protocol (80 Kv, 3 Mas) for Ct-Guided Percutaneous Needle Biopsy of Pulmonary Lesions: Feasibility, Efficacy and Safety

Daniele Morosetti1†, Matteo Stefanini2†, Cristina Pace1†, Gianluigi Sergiacomi1†, Giorgia Rossi1†, Areeza Di Martino1†, Armando Raso1†, Silvia Roma1†, Amedeo Ferlosio3†, Roberto Floris1†

Abstract

Aim: To prospectively determine the feasibility of Ultra Low Dose (ULD) for computed tomography (CT)-guided percutaneous needle biopsy (PNB) of lung lesions, and to evaluate the efficacy and safety of ULD protocol.

Materials and Methods: CT-guided needle biopsy of pulmonary lesions were prospectively collected between September 2016 and September 2017, using ultra low-low dose (80 kV, 3 mAs) CT protocol. Has been investigated efficacy understood as numbers of diagnostic biopsy and quantity and type of complications, distinIFA the major from the minor, relating to lesion's size and pulmonary site.

Results and Discussion: A total of 45 biopsies in 27 men (60%) and 18% women (40%), performed using the ULD protocol were selected. The overall technical success rate was 82.22% (37 patients). There have been only two (4.44%) major complications, that has required hospitalization, and twenty-one patients (46.67%) with minor complication but nobody of these has need of thoracostomy tube placement. We found in our study a significant correlation between complications and node size. These data were compared to a retrospective re-view obtained by data from patients who underwent CT-guided ultra-low dose found in literatures (but we not found in literatures a voltage below 100 Kv and electric intensity lower of 7,5 mAs in similar studies). These results are comparable, so we can affirmed that this protocol is safe enough for patients. Another important result, that we haven't found in other similar study, is relationship between the complications and biopsy sites, that will be very important to make a patient's selection before biopsy. Finally in this study almost totality of patients (95.5%) has effects the procedure in "day hospital system" and so easier in terms of costs and assist-tance for the sanitary structure in comparison to surgical procedures.

Conclusion: We have demonstrated safety, efficacy and feasibility, using this very ultra low dose protocol, it is compared to other similar study. We investigated, also, relationship between complications and node size and biopsy site and we can affirmed that these informations biopsy site and we can affirmed that these informations are very significant to select patients to procedure. This is important to create an efficacy model of management of patients, with a reduction of morbidity and sanita-ry economic saving.

Introduction

Percutaneous needle biopsy (PNB) is defined as placement of a needle(s) into a suspected abnormal lesion or organ for the purpose of obtaining tissue or cells for diagnosis. [1] It has a role in the recommended plan of management when evaluating solitary pulmonary nodules, and masses, multiple nodules, or persistent focal inffillates. [2] Image-guided percutaneous biopsy is less invasive than open or excisional biopsy and is associated with lower morbidity and mortality and thus considered the initial approach for diagnosis. [1] CT- scanners are more routinely used as a guidance tool for various types of interventional radiological procedures. [3] For patients as these, that have necessity to undergo to multiple scanning during a radiological intervention of CT-guided biopsy, is very important to reduce total radiological dose received.

If we compared with CT fluoroscopy, that provides the physician immediate feedback and can be a valuable tool to dynamically assist various types of percutaneous interventions. However, the fixed position of the scanning plane in combination with high exposure factors may lead to high cumulative patient skin doses that can reach deterministic thresholds.

The staff is also exposed to a considerable amount of scatter radiation while standing next to the patient during the procedures. CT fluoroscopy doses are markedly higher than classic CT-scan doses and are comparable to doses from other interventional radiological procedures. They consequently require adequate radiation protection management. Reducing the radiation dose while optimizing image quality remains an important issue. [3] In this study the CT-guided percutaneous needle biopsies of pulmonary needle have been effected using a ultra-low dose protocol (80 kV, 3mAs) for all patients and none radiation exposure for the staff and has been evaluated the feasibility and limitations associated with this new protocol.

Materials and Methods

ULD (80 kV, 3 mAs) CT-guided biopsy of pulmonary lesions were prospectively collected of a total of 45 patients, between September 2016 and September 2017.

The indications for PNB include, but are not limited to:
1. To establish the benign or malignant nature of a lesion.
2. To establish the extent of disease or the presence of metastases.
3. To establish the response of therapy and to monitor disease progression.

Open Access

Tracking number: JRS104
Received: 23 February 2019
Accepted: 01 May 2019
Published: 20 May 2019

Corresponding Author

Cristina Pace, University of Rome Tor Vergata, Department of Radiology Diagnostics and Molecular Imaging, Interventional radiology, Nuclear Medicine and Radiation Therapy, Rome, Italy. Email: cristina.pace@hotmail.it

Citation


Abbreviations : PNB percutaneous needle biopsy ; ULD ultra low dose.

Copyright: © 2019 Morosetti D, et al. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Publisher Acknowledgement

• This article has been edited by the Journal of Royal Science with a help of Royal Authors, including the commissioning, peer review process and editorial aspects up to the point of acceptance. Overall research credit goes to author(s).
• Any further research and comments regarding this article may publish as continues version for quality purpose.
• Readers are requested to verify the journal archive for updated version.
cannulas are placed for oxygen therapy at a flow of 4-6 l/min in each patient before the procedure. During the procedure, nasal cannulas are placed for oxygen therapy at a flow of 4-6 l/min in order to reduce diaphragmatic excursions. The patient is also hemodynamic monitored throughout the procedure. All patients, according to the location of the lesion on the CT image, underwent ULD scan in the supine, prone or decubitus positions. The Interventional Radiologist select site of interest and localizing and guiding scans performed. It is then proceeded with the administration of lidocaine on the access site. The biopsies have been effected by a single Interventional Radiologist with a 19 gauge outer needle and an 20 gauge inner automated cutting with 2 cm of extensions (Cook Medical). Have been carried every time 4-5 collettings by using a GE Lightspeed VCT 64-slice with thickness of 2,5 mm detector configuration, pitch of 0.984, table speed of 39.4 mm/rotation, 0.5 second gantry rotation, helical mode.

The site of biopsy has been classified according to location: Subpleural (0.1–2.0 cm) and Pleural-based. The lesion's size of pulmonary lesion were measured (the average of the largest two orthogonal dimensions in axial plane) and divided into categories smaller and larger than 3 cm.

Complications were analyzed and related to on specific guidelines that have been published by the American College of Radiology (ACR) and Society of Interventional Radiology (SIR) outlining the principles for performing PNB safely [4], as shown in table 1. These guidelines were made using the most recent literature available, and include indications and suggested thresholds for success rates and complication rates. [1] On these guidelines the complications can be stratified on the basis of outcome.

### Minor Complications:
A. No therapy, no consequence
B. Nominal therapy, no consequence; includes overnight admission for observation only.

### Major Complications:
C. Require therapy, minor hospitalization (48 hours)
D. Require major therapy, unplanned increase in level of care, prolonged hospitalization (48 hours).
E. Permanent adverse sequelae
F. Death [1]

The lesion's size of pulmonary lesion were measured (the average of the largest two orthogonal dimensions in axial plane) and divided into categories smaller and larger than 3 cm.

The site of biopsy has been classified according to location: Pleural-based, Subpleural (0.1–2.0 cm) and Deep (> 2.0 cm). [5]

These informations are related to number and type of complications. Total dose received, length of procedure and technical success were evaluated and collected. Radiation dose data were recorded in the form of dose length product (DLP), which is the product of scan length in centimeter and the volume CT dose index for each individual scan event. DLP is measured in milligray centimeter (mGy-cm). [6] Technical success is defined as the procurement of sufficient material to establish a pathologic diagnosis or guide appropriate patient management [1]. The Fisher exact test was used to compare the number and type of complication and nodule size and the biopsied site. P values were two-tailed with a significance level of P < 0.05.

<table>
<thead>
<tr>
<th>Table 1: Suggested success rate and complication rate thresholds for transthoracic percutaneous needle biopsy from the American College of Radiology and Society of Interventional Radiology.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Complication</strong></td>
</tr>
<tr>
<td>Thoracostomy tube placement requiring prolonged admission, pleurodesis or catheter exchange</td>
</tr>
<tr>
<td>Hemoptysis requiring hospitalization or specific therapy transthoracic biopsy</td>
</tr>
<tr>
<td>Air embolism</td>
</tr>
<tr>
<td><strong>Minor Complication</strong></td>
</tr>
<tr>
<td>Thoracostomy tube placement</td>
</tr>
<tr>
<td>Pneumothorax</td>
</tr>
</tbody>
</table>

Results

A total of 45 biopsies in 27 men (60%) and 18 women (40%), performed using the ULD protocol, between Sept. 2016 and Sept. 2017, were selected. The patients ranged in age from 31-82 years, with an average age of 68.56 years. The lesion sizes ranged from 1-12 cm, with an average size of 4.06 cm and were divided into categories smaller and larger than 3 cm: respectively 23 smaller (51.1%) and 22 larger (48.9%). Besides every biopsy has been classified related to the site of the introduction of the cannula and the radiological site of the lesion site. In accordance to biopsy location the lesions are 28 (62.2%) pleural-based, 14 (31.1%) subpleural which is from 0.1 to 2.0 cm from the pleura and 3 (6.7%) deep that is > 2.0 cm from pleura. The figure 1 shows the images of CT-guided lung biopsies with the ULD technique and shows how the image quality is kept high despite the use of low dose.

These informations were correlated with efficacy of procedure and complications. The overall technical success rate was 82.22% (37 patients). The diagnoses were: 25 pulmonary malignant tumors (55.56%) of which 15 adenocarcinoma, 5 squamous carcinoma, 3 neuroendocrine cancer, 1 mesothelioma cancer and 1 tumor not unidentified; other 12 patients (26.66%) have been diagnoses of benign pulmonary lesions like inflammation or hamartoma. For the other 8 patients (17.78%) has not been possible to determine a histological diagnosis for which they have been submitted to further diagnostic close examinations. Figure 2 shows these result Considering the Patient's safety, we have calculated that there have been only 2 (4.44%) major complications that has required hospitalization, only one >48 hours, but nobody of these that has need of thoracostomy tube placement. Twenty-one patients (46.67%) had minor complication: 17 of these (37.78%) have developed pneumothorax, but of these only 3 (6.67%) requiring drain's catheter placement, that is remove at the end of procedure, because resolved by simple aspiration. So the total of these pneumothorax has had a spontaneous resolution in the turn of few hours from the procedure without necessity of hospitalisation. Among minor complication we have also appraised 9 patients (20.0%) that have developed small intraparenchimal hematoma with fast spontaneous resolution. All of these patients that developed minor complication has effected the procedure in "day hospital system" and discharged after average 6,15 hours to biopsy (minimum 3,6 and maximum 8,5 hours).

These complications were correlated to the nodule size and to the biopsied site. In the present study a significant relationship was found between number and type of complication and nodule size (r: -0,375, p.<0,05) and the biopsied site (r: 0,413 p.<0,01).

Considering radiation dose, that were recorded in the form of dose length product (DLP), in this study is 186,71 mGycm.

Discussion

The radiation dose depends on the radiation intensity and exposure time. The penetrability of an X-ray is determined by the voltage, while its quantity is determined by the tube current. The lower the tube current, the more reduced is the radiation dose. Therefore, the radiation dose can be decreased without changing the X-ray penetration, by minimizing the tube current or exposure time to a certain degree.[7] In this study the CT-guided percutaneous needle biopsies of pulmonary needle have been effected using a ultra-low dose protocol using 80 KV and 3mA for all patients.

Our data were compared to a retrospective review obtained by data from patients who underwent the standard-dose protocol for CT-guided and ultra-low dose found in literatures. [4, 5, 7, 8]. We not found in literatures a voltage below 100 Kv and electric intensity lower of 7,5 mAs in similar studies. Then our study is a first and initial experience to investigate the feasibility, efficacy and safety with this new protocol.

Our success rate of the ULD biopsies, defined as ability to obtain a tissue sample for diagnosis, was 82.22%. This result is comparable to other ULD study when this rate is form 96%[7] to 76,5% [8]. In comparison of all these study, only S. Adiga, et al. study [4] reported different percentage of malignant (72,2%) and benign lesions (20,6%). If we compared with our study we found a same higher presence of malignant diagnosis (55,56%) on total biopsies, but with an inferior percentage compared to above study.

The rate of uncomplicated pneumothorax was 37,78% (of these only 6,67% requiring drain's catheter placement), and none pneumothorax requiring tube placement, both well within the ACR and SIR guidelines [2] of 12-45% of PNX and 2-15% tube placement, respectively.

About the 2 patients (4,44%) with major complications, nobody of these has need of thoracostomy tube placement, and the necessity of hospitalization was due at other clinical problems. So we can affirmed that this protocol is safe enough to meet the reference standard criteria intended for standard CT radiation doses. Relating to the effect of lesion size on the execution of the ULD we compared our study with Rizzo et al. study [9] that...
have shown like complications were associated with small lesion size; in particular they found that for every increasing increment of the 10 mm in lesion size the risk of pneumothorax was reduced of 4% and parenchymal hemorrhage of 3%. This might be a result of increased number of needle passes required. The same results we found in our study with a significant correlation between complications and nodule size (r: -0.375, p.<0.05) as shown in figure 3.

Another similar work, the Coner et al study [10], investigated factors influencing the number of acquired scan series and thus radiation dose in CT-guided and they found a relationship between smaller lesions and higher total doses of radiation because to take more time to biopsy. But this hypothesis isn’t confirmed in the Adiga et al. [4] study and none relationship was found. We have not investigated and this is a first limitations, but this aspect will be an interesting correlation to investigate in a future study.

Another important result, that we haven’t found in other similar study, is relationship between the complications and biopsies site. Only Meng et al study take a classification about upper, middle and lower biopsies location but they found only that haven’t significant relationship between ULD and standard dose groups.

Another important result, that we haven’t found in other similar study, is relationship between the complications and biopsies site. Only Meng et al study take a classification about upper, middle and lower biopsies location but they found only that haven’t significant relationship between ULD and standard dose groups.

Instead in this study we found a correlation about higher incidence of complications and deeper biopsied site (r: 0.413 p.<0.01) but not about pulmonary location of nodule (upper, middle and based).

This information will be very important to make a patient’s selection before biopsy, particularly for these patients with relative contraindication.

Another important date that we have investigated is about hospital cost and assistance. In this study almost totality of patients (95.5%) has effect the procedure in “day hospital system” (discharge after around 6 hours to biopsy) and so easier in terms of costs and assistance for the sanitary structure in comparison to surgical procedures that need the hospitalization, also in absence of complications.

Finally, other limitations of this study includes its nonrandomized nature, the absence of a standard dose group to compared the ULD groups and the limited number of total biopsy, but we hope that this is only the first step of our new experience and other study will be made.

Conclusions

This new study, with use of a very low radiological dose for CT-guided percutaneous needle biopsy of pulmonary lesions, shows that it is possible to reduce the dose up to 80 KV and 3 mAs without lost in effectiveness and safety for the patients. We can finally conclude saying that this procedure results to be sure, burdened by low dose for the patient and any exposure for the operator, that needs little waste in terms of sanitary economy and organizational plant but effective to make a quickly diagnosis.

References


Author information

Daniele Morosetti (Morosetti D)†
Matteo Stefanini (Stefanini M)†
Cristina Pace (Pace C)†
Gianluigi Sergiacomi (Sergiacomi G)†
Giorgia Rossi (Rossi G)†
Arezia Di Martino (Di Martino A)†
Armando Raso (Raso A)†
Silvia Roma (Roma S)†
Amedeo Ferlosio (Ferlosio A)†
Roberto Floris (Floris R)†

†University of Rome Tor Vergata, Department of Radiology Diagnostics and Molecular Imaging, Interventional Radiology, Nuclear Medicine and Radiation Therapy, Rome, Italy.
‡Gasilino Hospital, Department of Radiology Diagnostic and Interventional Radiology, Rome, Italy.
§University of Rome Tor Vergata, Institute of Anatomic Pathology, Rome, Italy.

Corresponding Author

Cristina Pace, University of Rome Tor Vergata, Department of Radiology Diagnostics and Molecular Imaging, Interventional radiology, Nuclear Medicine and Radiation Therapy, Rome, Italy. Email: cristina-pace(at)hotmail.it