Section: Radiodiagnosis

Original Research Article

CT- GUIDED FREEHAND VERSUS ROBOTIC NEEDLE BIOPSY OF LUNG NODULES

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ABSTRACT

Background: CT-guided lung biopsy is a common procedure in clinical radiology for the histopathological characterization of lung lesions. It is accompanied with radiation exposure and not very uncommonly complications. Robotic assistance has been introduced in an attempt to simplify and speed up the procedure. This article intends to compare the various parameters of the procedure pursued manually and with robotic assistance and establish a possible preferability of one over the other. **Aims:** 1. To compare the accuracy of manual versus robotic needle placement for lung biopsies. 2. To compare the radiation dose, operation time and the incidence of complications the patients were subjected to in manual versus robotic approach to the procedure. **Settings and Design:** Ours is a prospective case study done in the Department of Radiodiagnosis and Imaging, Sher-I-Kashmir Institute of Medical Sciences over a span of six months. **Materials and Methods:** Manual and robot guided biopsy of thirty patients each with no contraindications to the procedure was done and the parameters of interest noted and compared. **Statistical Analysis:** All continuous variables were analyzed in terms of mean and standard deviation. All the comparisons were done using student t-test after finding the normal distribution of data. **Result:** The robotic positioning of needle was seen to be more accurate with significant reduction in the radiation dose and duration of the procedure. **Conclusion:** Robotic biopsy may pave a way for a safer and easier approach to sample the lung lesions with improvement in overall treatment capabilities.

INTRODUCTION

CT-guided percutaneous lung biopsy is an important tool in the diagnosis of pulmonary pathologies due to its high diagnostic yield. Robotic systems have come into vogue to improve and simplify the procedure. With the high precision offered, procedures could be speeded up with significantly decreased radiation exposure and complications.[1] Our study aims at comparing the conventional manual and the newer robotic approaches in terms of the total time invested, the number of confirmatory scans and the consequent radiation exposure.

MATERIALS AND METHODS

Our study population consisted of 60 patients in the age group of 55-70 years of which half were randomly subjected to manual CT-guided biopsy and the rest to the robotic assisted biopsy. One subjects from the latter group due to gross motion during the needle advancement suffered mild pneumothorax and the procedure was abandoned.

The inclusion criteria for the procedure being a contrast enhanced CT documented accessible lung lesion with indeterminate or suspicious imaging morphology.

The exclusion criteria were an uncooperative patient, deranged coagulogram and lesions smaller than 10mm.

Manual biopsy was accomplished with choosing the proposed trajectory of the needle on a planning CT that included the entire lung fields. The site was infiltrated with 10ml of 2% lignocaine and the point of needle entry confirmed by taking a limited confirmatory CT keeping the needle of the syringe in place as a makeshift localizer. This was followed by a series of limited confirmatory CT imaging with each increment of the needle advancement and angle adjustment.

The robotic biopsy was pursued using the MAXIO system (Perfint Healthcare Pvt. Ltd.) which consists of a control panel, connector panel, end effector axis and an integrated planning station(Figure.1). The end effector is an electromagnetic arm that moves to position the needle at a certain angle and depth as chosen by the radiologist. It consists of a pair of sterile grippers on which the needle is mounted which is then manually advanced by the operator. The planning station is connected to the CT console for receiving images and to the electromagnetic arm for execution of the plan.

In both the manual and robotic approaches the procedure was followed by a check CT of the entire lung fields to assess for complications. A total of six coaxial needle passes were taken in each case.

The measurement of the duration of biopsy was defined as the time between the point of acquisition of the planning CT and the procurement of the sample. The time needed to dock the robot and for its table marker verification was excluded because it wasn't to be repeated for every patient but just once at the beginning of the day.

Each biopsy was done using 18Gx 10cm disposable core biopsy semi-automatic biopsy gun with a compatible coaxial biopsy needle.

The procedure was carried out by a radiologist with a four year experience in the field and accompanied by two trainees on a 16-slice scanner (SEIMENS) with a slice thickness of 2mm and a reconstruction interval of 1mm with the tube voltage and current being 120 kVp and 110 mAs respectively.

Statistics

All continuous variables were analyzed in terms of mean and standard deviation. All the comparisons were done using student t-test after finding the normal distribution of data. The data was analyzed with the help of SPSSV-23.0.

RESULTS

Our study included a total of sixty patients with a mean age of 65 years with 90% (54) of them being males. Most of the patients were biopsied in the prone position (80%) with the vertical oblique needle approach being the commonest (65%). The average size of the lesions biopsied 3.2cm (range 2.5 -6cm).

Table 1: Shows the mean values of the lung trespassed and the time taken for the biopsy in the two different approaches taken up for the study

	Lung trespassed(cm)	Duration of biopsy(minutes)
Manual biopsy	1.87	24.8
Robot assisted biopsy	2.6	16.3

Table 2: Shows the distribution of complications ascribed to each approach

	Number of complications	Percentage
Manual biopsy	05	16%
Robot assisted biopsy	03	10%

Table 3: Shows the average number of confirmatory scans and radiation exposure involved in the two approaches

	Number of confirmatory scans*	Radiation exposure (mGy)
Manual biopsy	05	28.4
Robot assisted biopsy	01	15.1

****rounded off to the nearest whole number***

Figure 1: Showing the robotic system deployed in the study with its individual components viz (1) grippers (2) electromagnetic arm and (3) control panel

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(2)

Figure 2: Showing the stepwise approach for robotic biopsy (1) Axial prone scan of thorax taken for planning (2) Appropriate positioning of biopsy gun in place done in a single move as planned on the robot (3) Post biopsy check scan showing minimal hemorrhage along the biopsy tract. Note the ring artefact in the images

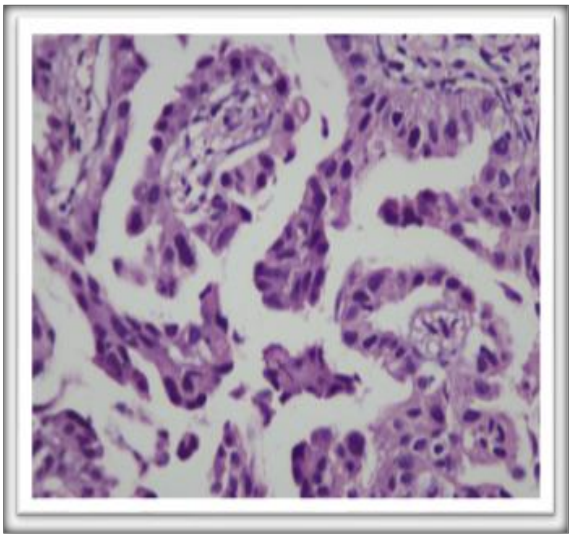

Figure 3: Photomicrograph from CT guided lung biopsy showing tumor cells forming glands-adenocarcinoma lung (HPE 40x)

DISCUSSION

Ct-guided interventions are an important method for biopsy of suspicious lesions and tumor ablation. The accuracy of needle placement is entirely dependent on the experience of the clinician. The presence of critical organs like vessels in the proximity of target lesions entails a very low margin of error. Manual CT-guided procedures usually require multiple confirmatory scans and needle adjustments with consequent increased radiation dose to the patient.[2,3]
Recent advances have been helpful in providing robot assisted navigation systems for needle placement in interventional procedures.[4-9]
Our study demonstrated a significant difference in the time taken for the biopsy with the robot catalyzing the procedure. The decrease in time was ascribed to the meticulous planning allowed by the robotic navigation. While manual biopsy requires a step and shoot technique with scan validation needed for every needle manipulation. MAXIO is capable of planning complex 3D angles with simultaneous angulation along the mediolateral and craniocaudal axis at any depth. There is auto 3D generation of the image stack and presentation of same in 3D view. These features allow for the need of a very few number of scans and attempts at needle readjustment between planning and execution. In our study two patients subjected to manual biopsy needed a repeat puncture, however, none was done with the ones subjected to robotic biopsy.
The number of confirmatory scans was also brought down significantly with the robot assistance with the stereotactic accessory bringing it down to an average of one. This was because of the excellent planning with consequent decreased repositioning attempts.
Wouter J. Heerink et al. in their study on robot assisted CT-guided tumour ablation reported the number of repositionings as zero (range zero to zero) and one (range, zero to seven) for robotic and manual procedures respectively.[10]
In terms of accuracy the robot offered a better outcome in terms of the lateral error which was defined as the least distance between the final needle position which was deemed acceptable and the target point described on the planning scan. The lateral error was 11mm and 3mm with the freehand and robotic techniques respectively. This was in harmony with the results of Wouter. J Heerink et al. where the lateral error decreased from 16.1 to 5.6mm with the robotic assistance.[10]
Hyung Jin WON et al. in their study with robot for biopsy using abdominal phantom reported an accuracy of 2mm (0-2.6mm) which was calculated as the distance from the trajectory on planning and the one after the final positioning.[11]
The incidence of complications wasn't significantly different in the two approaches taken up in our study with the commonest complication being pneumothorax.

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Regarding the radiation exposure to the patient, our study demonstrated superiority of the robot in terms of significantly minimizing the radiation exposure.

Xiao F. He et al,[12] in their study on robot-assisted ablation of pancreatic carcinoma reported a significant decrease in the number of scans, puncture time and the total time of electrode deployment with accessorizing the procedure with the robotic navigation. This indicated an increase in puncture accuracy and decrease in the number of repeat scans, thereby decreasing the radiation dose and operating time.

Though the robot is equipped with a patient immobilizer and breath hold monitor for respiratory gating which make the procedure safer, none was used during any of the sessions in our study in view of the lack of need for any of our subjects.

A limitation of the robot could be that though the learning curve of its operation seems quite shallow, we faced a few hiccups in the steps of its docking and table marker verification.

CONCLUSION

The study concluded that CT-guided lung biopsies could be done in a more meticulous manner with robotic assistance with lesser operation time and radiation dose to the patient. This newer advent in technology could give a boost to CT-guided interventions making them safer and more reliable.

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