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Adequacy of Transthoracic Needle Biopsy Samples in the Diagnosis of a Peripheral Lung Lesion – Comparing Success Rates of Various Imaging Modalities

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Abstract: The aim of the study was to test whether a difference in the imaging modality (CT, Fluoroscopy, or Ultrasound) would result in a higher biopsy success rate for the diagnosis of lung cancer. A total of 144 transthoracic needle biopsies performed under guidance of different imaging modalities were retrospectively reviewed at King Abdulaziz Medical city in Riyadh between 2008 and 2012. A biopsy was counted a success whenever a definitive diagnosis could be achieved. CT guided biopsies revealed 51 successes out of 86 total samples, fluoroscopy guided biopsies revealed 8 successes out of 20 total samples, while for ultrasound guided biopsies, 30 successes out of 38 biopsies gave a definitive diagnosis. Comparing CT guided biopsies vs. Fluoroscopy guided biopsies, we got a p-value of 0.1884 which is clinically insignificant, 95% Confidence Interval [-0.07628, 0.46233]. On comparison of CT guided biopsies vs. ultrasound guided biopsies the p-value was 0.05558 which is also clinically insignificant, 95% Confidence Interval [-0.38150, -0.011399]. When ultrasound guided biopsies were compared to the fluoroscopy guided biopsies a p-value of 0.007461 < 0.025 was achieved which is clinically highly significant, 95% Confidence Interval [-0.38150, -0.011399]. It was determined with 95% confidence that there is a clinically significant difference (p-value of 0.007461) between success rates of Fluoroscopy guided biopsies and ultrasound guided biopsies, but not between the other pairs of modalities. Further investigations with larger sample size are warranted to compare the efficacy of fluoroscopy and ultrasound based imaging modalities for transthoracic needle biopsy.

Keywords: Small-Cell Lung Cancer, Non-small Cell Lung Cancer, Computed Tomography, CT-Fluoroscopy, Ultrasound, Transthoracic Needle Aspiration, PACS

1. Introduction

Lung cancer is the leading cause of cancer related deaths in the industrialized world [1]. According to the American Cancer Society, approximately 224,390 new cases of lung cancer will be diagnosed in the United Sates in the year 2016 and 158,080 deaths will be due to lung cancer related causes, accounting for 27% of all cancer deaths [2].

Lung cancer is classified into two groups; Small-cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC). Squamous cell carcinoma, large-cell carcinoma, and adenocarcinoma are all classified under NSCLC [1]. Nearly 4.5-14 million CT scan examinations of the chest are done annually in the United States for the possible detection of lung cancer underlining the importance of definitive and safer diagnostic procedures. [3, 4] Pulmonary nodules are present not only in lung cancers but may also represent

metastases of breast and colon cancers. Early detection of malignancy is important for treatment and with improvement in technology, identification of small lung nodules is now possible. [5-7]

Peripheral pulmonary nodules of suspicious nature present a dilemma. Choice of diagnostic procedure for biopsy of possible malignant lung nodules is made in accordance with several aspects; such as the size and location of tumour, accessibility of the lesion and the primary tumour, availability of the clinical expert and potential complications. A procedure that is well tolerated, can give maximum information and is minimally invasive to the patient is the most preferred technique. [6-10]

The diagnosis of lung cancer for patients with a peripheral lesion is established through transthoracic needle aspiration (TTNA) as recommended by the American College of Chest Physicians evidence-based clinical practice guidelines [11]. The TTNA is a biopsy technique that utilizes guidance by CT, ultrasound and/or fluoroscopy to reach percutaneous peripheral nodules without relying on central airways. The biopsy can be taken with imaging guidance of fluoroscopy, CT, or ultrasound depending on the site and position of the lesion, availability of the equipment, and preference of the operator [12]. A report by Manhire et al suggested that within TTNA, no association exists between complication rates and needle type and size [13]. TTNA has diagnostic yields of greater than 90%, which is higher than any other non-surgical approach [14] Other viable diagnostic options for indeterminate pulmonary lesions such as flexible bronchoscopy and its ancillary procedures have lower success rates ranging from (14-63%). [15]

The disadvantages of TTNA however, are very high rates of pneumothorax (ranging between15–25%) while other bronchoscopic approaches have much lower rates (~1.5%). [16] Air embolism and tumour seeding are other complications associated with the technique. [16-18] Due to this reason, the American College of Chest Physicians recommends TTNA for lung nodules present without a bronchus sign only when RP-EBUS (radial endobronchial ultrasound) is not available. [13] Although transthoracic needle aspiration is a technically demanding procedure, documented evidence has shown that it is accurate with limited morbidity. [6,7, 10]

Image guidance is a crucial aspect of the TTNA technique. Currently computed tomography (CT), computed tomography fluoroscopy (CT-fluoroscopy) and ultrasound (US) guided procedures are most commonly used for imaging the biopsy area. Compared with conventional CT, Fluoroscopy guided transthoracic biopsies are considered superior because they require fewer needle passes. Moreover, use of Fluoroscopy considerably shortens the procedure time by up to ~27%. [14] The shorter procedure time and fewer needle passes also results in fewer complications being associated with Fluoroscopy guided biopsies. [14, 15] Various groups have shown lower pneumothorax rates for Fluoroscopy guided transthoracic needle biopsies. [14-18] The only drawback of using Fluoroscopy is the risk of exposure to radiation for both patients and radiologists, which can be minimized by using the 'quick check' method. [20, 21] Ultrasound guided TTNA biopsies are generally well tolerated probably because lung lesions guided by ultrasounds are peripheral in nature with less chances of pneumothorax. [22]

2. Methods and Patients

In this study, data from a total of 144 transthoracic needle biopsies carried out at King Abdulaziz Medical city in Riyadh, Saudi Arabia, during the period of four years, from 2008 to 2012, was retrospectively reviewed. The transthoracic needle biopsies were performed under the guidance of three different imaging modalities of CT, CT-fluoroscopy and ultrasound. Data was extracted from the PACS (picture archiving and communication system) of the radiology department, all consecutive biopsies done during the period were included in the study, Core biopsies from the mediastinum or pleura were not included. Sampling was counted as being a 'success' if a definitive diagnosis of malignancy or a benign sample was obtained following cytology or microbiology report, whereas 'non-specific diagnosis' or 'inadequate size of sample' were counted as failures.

Choice of imaging module was made according to the size and location of lesion. Statistical analysis of differences in various imaging modalities was done using the $\chi 2$ test and reported as P values. A P value of $<.05$ was considered statistically significant.

3. Results and Discussion

3.1. Patient Demographics

Table 1 gives a summary of baseline characteristics and the demographic profile of the patients enrolled in the retrospective study. Of the total 144 patients, 97 were female and 47 were females. Mean age of patients was 66.20 years. Figure 1 (a, b and c) describes the adequacy of TTNA biopsies for different patient profiles. The success rate were in general independent of gender and age.

Table 1. *Demographic characteristics of the patients. Values are represented as frequency (%). * p values were generated comparing 1 category against the other category grouped as one.*

	All Samples n= 144		**Adequacy of tissue samples obtained**				
			Success n=89		**Failure n=55**		**p value**
Age mean years (SD)	66.20	(11.51)	66.88	(11.47)	65.077	(11.61)	0.375
Gender							
Male	97	(67.40)	60	(61.86)	37	(38.14)	0.986

	All Samples n= 144		Adequacy of tissue samples obtained				
			Success n=89		Failure n=55		p value
Female	47	(32.60)	29	(61.70)	18	(38.30)	
Total	144	(100.00)					
Modality							
CT	86	(59.70)	51	(59.30)	35	(40.70)	0.282*
Fluoro	20	(13.90)	8	(40.00)	12	(60.00)	0.029*
US	38	(26.40)	30	(78.95)	8	(21.05)	0.008*
Total	144	(100.00)					

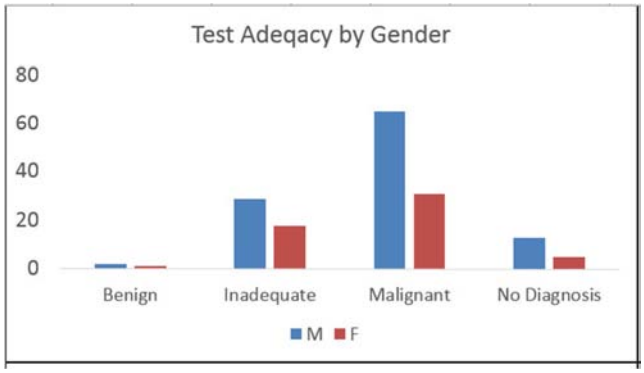

Figure 1a. *Adequacy of TTNA biopsy procedure by gender.*

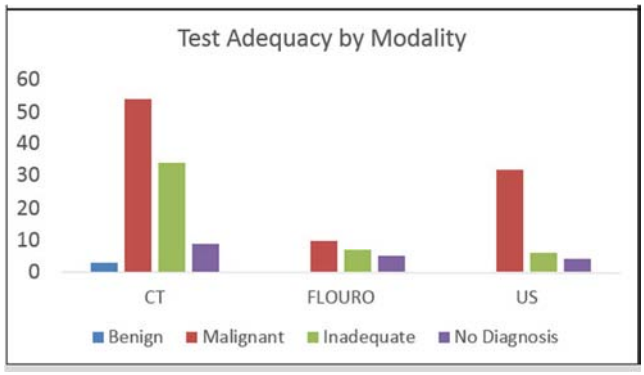

Figure 1b. *Success rate of TTNA by the imaging modality used.*

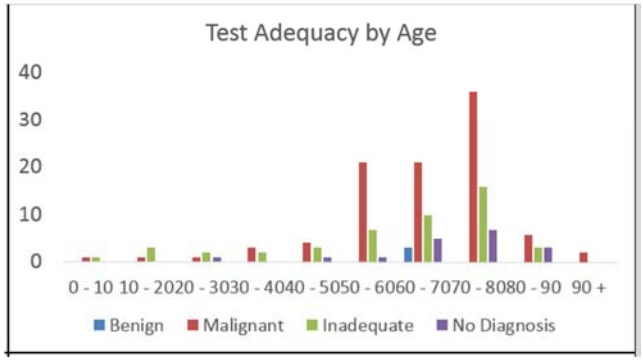

Figure 1c. *Adequacy of the procedure as plotted against age of the patients. Data is plotted as frequency (%).*

3.2. Success Rate of Different Imaging Modalities

The success rate for conventional CT-guided biopsies was ~59.3% (51 of 86 total samples), fluoroscopy guided biopsies revealed 8 successes out of 20 total samples (40%), and ultrasound guided biopsies revealed a success rate of 78.9% (30 successes out of 38 total samples). Overall the diagnostic yield of image guided TTNA biopsy in our study was around 60% which is somewhat lesser than that in reported literature (70-90%). [22] This could be due to the small sample size and/or very stringent conditions of counting a biopsy a success. Moreover, the diagnostic yield is also influenced by the size of the nodule with lobes >2cm giving better definitive diagnosis. [15] Other studies have also reported that for benign lesions, percutaneous lung biopsy shows low sensitivity and diagnostic accuracy (11-88%). []

3.3. Statistical Comparison of the Different Imaging Modalities

Comparing CT guided biopsies (51 successes out of 86) vs. Fluoroscopy guided biopsies (8 successes out of 20) the p-value of 0.1884 was obtained which clinically insignificant, 95% Confidence Interval [-0.07628, 0.46233].

When we compared CT guided biopsies (51 successes out of 86) vs. ultrasound guided biopsies (30 successes out of 38) the p-value was 0.05558, which is also clinically insignificant, 95% Confidence Interval [-0.38150, -0.011399].

On comparison of ultrasound guided biopsies (30 successes out of 38) vs. Fluoroscopy guided biopsies (8 successes out of 20) the p-value was $0.007461 < 0.025$ which is clinically highly significant, 95% Confidence Interval [-0.38150, -0.011399].

This study has all limitations inherent to retrospective, non-randomized studies. Therefore, we included only definitive diagnosis as established by the biopsy only and not any subsequent tests that may have been performed. We propose these interesting results are further investigated. A prospective study with a larger sample size designed specifically to study difference in fluoroscopy and ultrasound guided TTNA should be undertaken.

4. Conclusion

No significant differences were found between CT guided biopsies and Fluoroscopy guided biopsies or CT guided biopsies and ultrasound guided biopsies. However, the difference in the success rates of Fluoroscopy guided biopsies and ultrasound guided biopsies was a statistically significant one, which needs further testing with a larger sample size. It was determined with 95% confidence that there is a clinically significant difference (p-value of 0.007461) between the Fluoroscopy guided biopsies and ultrasound guided biopsies modalities, but not between the other pairs of modalities.

Abbreviations Used

(SCLC) Small-cell lung cancer
(NSCLC) Non-small cell lung cancer
(CT) Computed tomography
(CT-fluoroscopy) Computed tomography fluoroscopy
(US) Ultrasound
(TTNA) Transthoracic needle aspiration
PACS (picture archiving and communication system)

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