Computed Tomography-Guided Lung Biopsy: Does a Rural Hospital Do Better?

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ABSTRACT

Background: Lung percutaneous needle biopsy (PNB) is routinely used to diagnose lung cancer. The most prevalent complications of PNB are pneumothorax and bleeding. Differences in characteristics of medical procedures between rural and urban hospitals are well known.

Objectives: To compare characteristics of patients and lesions between two hospitals and to evaluate whether lung PNB complications differ in rural vs. urban settings.

Methods: The authors examined case records of 561 patients who underwent lung biopsy at two different medical centers in Israel: Tel Aviv Sourasky Medical Center (urban) and Barzilai Medical Center (rural). To evaluate the complication rates, the authors analyzed findings from chest X-ray performed 2 hours after biopsy and computed tomography (CT) images at the site of biopsy.

Results: The study comprised 180 patients who underwent lung biopsy at Barzilai and 454 at Sourasky. The rate of pneumothorax did not differ between centers (12% at Barzilai and 19% at Sourasky, P = 0.08). Distance from pleura was positively correlated to pneumothorax occurrence in both centers; however, neither lesion size nor lesion locus was found to be a risk factor for pneumothorax. Mild bleeding at the biopsy site occurred equally at Barzilai and Sourasky (32% vs. 36%, P = 0.3, respectively). Furthermore, immediate CT post-biopsy at Barzilai showed 95% negative predictive value, showing that a CT scan performed immediately after lung biopsy cannot replace the routine follow-up chest X-ray in predicting iatrogenic pneumothorax.

Conclusions: CT-guided percutaneous lung biopsies are comparable between rural and urban hospitals regarding procedure characteristics and complication rates.

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KEY WORDS: lung biopsy, lung cancer, pneumothorax, rural, urban

Computed tomography (CT)-guided percutaneous needle biopsy (PNB) is a safe and precise method for the diagnosis of different pathologies in the thorax [1,2]. The most prevalent complication of this procedure is pneumothorax, of which the reported prevalence ranges between 15–29% [3]. Pneumothorax can lead to a considerable reduction in patient health and longer hospitalization periods [4]. Recently we reported that the lesion's distance from the pleura is the most significant risk factor for pneumothorax [5]. These findings are concordant to the published literature [4].

Health differences exist between urban and rural populations, with those in rural areas experiencing more chronic health issues and having less access to services.

Given the data that shows higher rates of chronic illnesses, increased workload for rural clinicians, and decreased access of care for rural residents, it is not hard to assume that the care provided to rural patients might be of lower quality or in some other way inferior to that in urban settings. Comparisons between pulmonary practice in rural and urban hospitals are anecdotal and scarce; therefore, we examined the differences in yield and complications of CT-guided lung biopsies in both settings. A second aim of our study was to strengthen our newly published data that a routine immediate post-procedure CT scan (ICT) to identify pneumothorax cannot replace the follow-up chest X-ray in patients undergoing percutaneous lung biopsy, and that detected bleeding on ICT has protective properties against the development of pneumothorax.

We compared data from Tel Aviv Sourasky Medical Center (an urban hospital) to data from Barzilai Medical Center (a rural hospital). Although locating in a medium size city (Ashkelon), and with affiliation to Ben Gurion University, Barzilai Medical Center is considered a rural hospital in Israel.

PATIENTS AND METHODS

STUDY DESIGN

We retrospectively examined case-records of 108 patients who underwent percutaneous lung biopsy in the Division of Pulmonary Medicine at Barzilai Medical Center, a rural hospital. We reviewed patient imaging studies (chest CT results acquired immediately after the procedure, which is referred to as ICT, and a chest X-ray performed 2 hours after biopsy) and compared the procedure characteristics to the same procedures done at the Department of Pulmonary Diseases at Tel Aviv Sourasky Medical Center.

The study was approved by the local ethics committee and conformed to the principles outlined in the Declaration of Helsinki.

PERCUTANEOUS LUNG BIOPSY AND IMAGE ANALYSIS

All patients underwent CT-guided percutaneous lung biopsy in accordance with common procedure guidelines [6,7]. Patients did not receive any conscious sedation during the procedure. An ICT was conducted immediately after the removal of the needle to document potential immediate complications such as pneumothorax or bleeding. The ICT included CT images at the site of the biopsy. The patients were observed for 2 hours at the vicinity of the procedure room. Chest X-ray was performed if any clinical deterioration was present or after completion of the 2-hour observation period. Any clinical complication was treated immediately at the procedure site.

We measured lesion size in length and width as well as the location and distance from pleura, and documented the presence of bleeding surrounding the puncture area. Lesion location was defined as being present at the upper lobes (both left and right) vs. lower lobes (including right middle lobe). ICT scans and chest X-rays were manually surveyed by trained pulmonologists at our division.

COMPLICATION DIAGNOSIS

A follow-up chest X-ray is routinely obtained 2 hours after biopsy in order to assess procedure-related pneumothorax. The need for chest tube insertion was documented for all patients diagnosed with pneumothorax. Rate of bleeding at the site of puncture was collected during the pulmonologist survey of the ICT. The results from the two different cohorts, from the two different hospitals were compared.

STATISTICAL ANALYSIS

All continuous variables are displayed as mean ± SD for normally distributed variables or median (interquartile range) for variables with abnormal distribution. Categorical variables are displayed as numbers (%) of subjects within each group. The different characteristics in patients at TLVMC and BMC were compared by a Student's *t*-test for normally distributed variables and by the Mann-Whitney U test for non-normally distributed ones. To assess associations among categorical variables, we used a chi-square test. We measured sensitivity and specificity values for the ability of ICT to detect pneumothorax present on chest X-ray 2-hours after the procedure.

To isolate significant risk factors for the development of pneumothorax, we performed multivariate logistic regression to predict the presence of pneumothorax on chest X-ray. The model was adjusted for the following covariates: lesion length and width, lesion distance from the pleura, categorized location of the lesion, and the presence of bleeding on ICT. *P*-values of <0.05 were considered statistically significant.

We used the IBM SPSS Statistics 22.0 statistical package (IBM Corporation, Armonk, New York, USA) and GraphPad Prism version 7.00 (GraphPad Software, La Jolla, CA, USA) for all statistical analysis.

RESULTS

Lesion size and demographic parameters did not differ between cohorts. The distance from pleura was lower in BMC cohort compared to TLVMC (1 ± 1.2vs. 1.9 ± 3.1, respectively, p<0.01), and lesion location was dissimilar as well, with more lesions in upper lobes in the TLVMC cohort compared to BMC cohort (45% vs. 39%, accordingly. *P* = 0.03) [Table 1].

Table 1. Patient characteristics according to the medical center where the biopsy was performed

Characteristic		Tel Aviv Sourasky Medical Center	Barzilai Medical Center	*P* value
Number of subjects		454	108	
Pneumothorax on chest X-ray, n		87 (19%)	13 (12%)	0.08
Bleeding observed		165 (36%)	34 (32%)	0.3
Required chest tube, n		25 (6%)	2 (2%)	0.1
Lesion length, cm		2.7 ± 1.8	2.8 ± 1.7	0.5
Distance from pleura, cm		1.9 ± 3.1	1 ± 1.2	< 0.01
Lesion locus	Upper lobes	202 (45%)	42 (39%)	0.03
	Lower lobes	225 (50%)	66 (61%)	

Data presented as mean ± standard deviation or number (%)

In the BMC cohort, a total of 13 patients (12%) were diagnosed with pneumothorax on chest X-ray performed 2-hourspost-procedure. Two patients required chest tube insertion accounting for 15% of pneumothorax and 1.8% of all lung biopsies. In the TLVMC cohort, 19% of patients had pneumothorax and 5.5% required chest tube insertion. Although the rates of pneumothorax were mildly higher in TLVMC they were not statistically significant (*P* = 0.082) [Table 1]. As in the TLVMC cohort, multivariate analysis of the risk factors for developing pneumothorax in the BMC cohort showed that the lesion's distance from the pleura predicted higher rates of pneumothorax (OR= 1.76, 95%CI; 1.05–2.95, *P* = 0.031). However, the lesion's size and locus were not significant predictors of pneumothorax, similar to TLVMC results [5] [Figure 1A].

Bleeding surrounding the puncture area spotted on ICT occurred in 34 patients (32%) undergoing the procedure, in the BMC cohort. This complication rate was similarly prevalent in the TLVMC cohort, in which bleeding was observed in 36% of patients, (P = 0.3). It is noteworthy that clinically significant sequel were not observed in both cohorts.

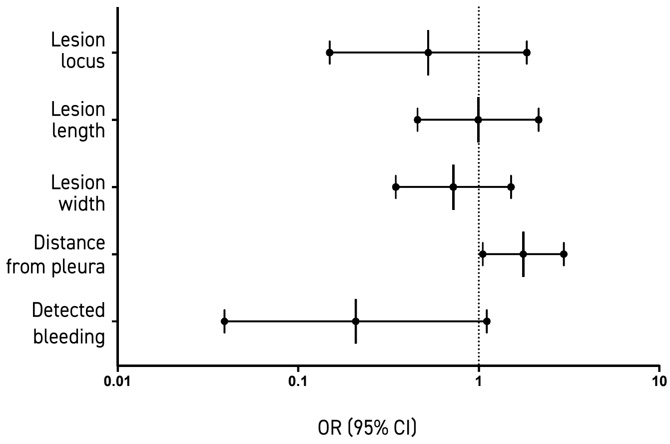
When analyzing the diagnostic yield of ICT in detecting iatrogenic pneumothorax in the BMC cohort, we found the ICT detected 69.2% of patients diagnosed with pneumothorax on chest X-ray. Interestingly and in line with the TLVMC cohort, ICT demonstrated a negative predictive value of only 95%, meaning 4 patients (5%) with a negative ICT did eventually develop pneumothorax seen on chest X-ray 2-hourspost-procedure [Figure 2].

ICT identified 15 patients (16%) with pneumothorax that did not develop into a significant pneumothorax identified on chest X-ray, accounting for a specificity rate of 84% for ICT in predicting pneumothorax.

Finally, our analysis demonstrated that bleeding surrounding the puncture area spotted on ICT showed a trend for negative prediction for development of PNX on chest X-ray (OR

Figure 1. Multivariate analysis to predict pneumothorax diagnosis on chest X-ray

[A] At Barzilai Medical Center. The forest plot presents the odds ratio of multivariate logistic regression to predict pneumothorax on chest X-ray 2 hours post-lung biopsy. The sampled lesion's distance from the pleura is the only significant predictor in the model (P < 0.031). Longer distance predicts higher rate of pneumothorax. Detected bleeding on immediate post-procedure computed tomography seems to have a protective effect for pneumothorax occurrence, with only a trend toward significance (P = 0.066)
95%CI = 95% confidence interval, OR = odds ratio



[B] Combining Barzilai Medical Center and Tel Aviv Sourasky Medical Center cohorts. The forest plot presents the odds ratio of multivariate logistic regression to predict pneumothorax on chest X-ray 2-hours post-lung biopsy. The sampled lesion's distance from the pleura, the lesion's locus and detected bleeding on immediate post-procedure computed tomography are significant predictors in the model. Deeper lesions predict higher rates of pneumothorax (P < 0.001), lesion's located in upper lobes predict higher rates of pneumothorax (P = 0.01), and detected bleeding has a protective effect (P = 0.001)
95%CI = 95% confidence interval, OR = odds ratio

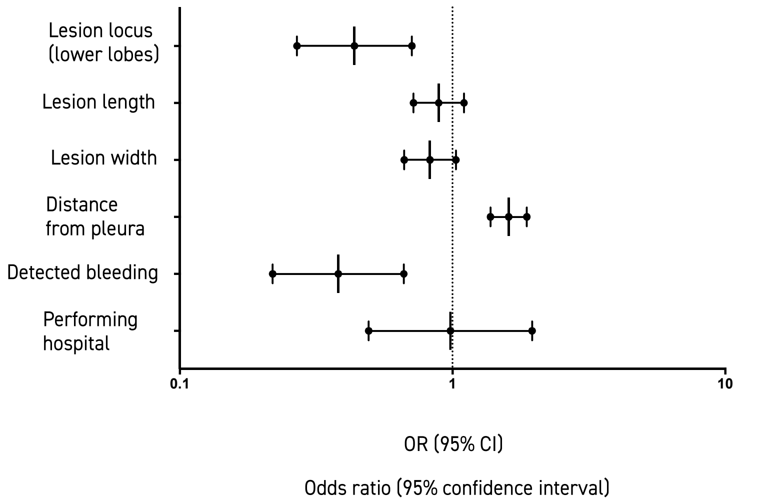


Figure 2. The yield of post-lung biopsy computed tomography in predicting pneumothorax on chest x-ray 2-hours post-procedure in the Barzilai Medical Center cohort

The clustered bar chart shows the percentage of patients diagnosed with pneumothorax on chest X-ray 2 hours post-procedure within patients diagnosed with (positive) and without (negative) pneumothorax on immediate computed tomography. P-value was calculated by achi-square test CT = computed tomography,
CXR = chest X-ray, PNX = pneumothorax

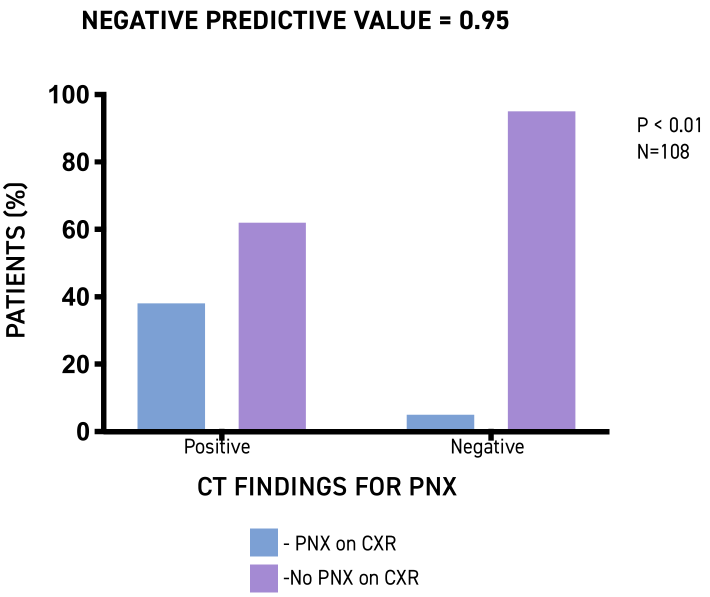


Table 2. Univariate and multivariate analysis to predict pneumothorax diagnosis on chest X-ray combining cohorts from Barzilai Medical Center and Tel Aviv Sourasky Medical Center

	Univariate				Multivariate			
	Odds ratio	95% confidence interval		*P* value	Odds ratio	95% confidence interval		*P* value
		Lower	Upper			Lower	Upper	
Lesion locus (lower lobes)	0.45	0.28	0.70	< 0.01	0.44	0.27	0.71	< 0.01
Lesion length	0.76	0.65	0.89	< 0.01	0.89	0.72	1.10	0.28
Lesion width	0.75	0.64	0s.88	< 0.01	0.83	0.67	1.03	0.09
Distance from pleura	1.11	1.01	1.22	0.03	1.61	1.38	1.87	< 0.01
Detected bleeding	1.09	0.69	1.70	0.71	0.38	0.22	0.66	< 0.01
Performing hospital (Tel Aviv Sourasky Medical Center)	0.58	0.31	1.08	0.09	0.98	0.49	1.96	0.96

= 0.2, 95%CI 0.03–1.1, $P = 0.06$) [Figure 1A], strengthening the statistically significant result in the TLVMC cohort.

When combining the two cohorts, risk factors for pneumothorax were upper lobe location, absence of pulmonary bleeding at biopsy site and a longer distance from pleura [Table 2] [Figure 1B].

DISCUSSION

The main result of this study is that characteristics and rates of complications in CT guided lung biopsies do not differ between rural and urban hospitals. Rural residents are at higher risk for major diseases, considering both burden of disease and the severity of their complications [8]. For example, hypertension affects 27% more US rural residents compared with urban residents, with an increased risk of stroke and cerebrovascular disease [9], and rural patients exhibit worse control of diabetes and its associated cardiovascular endpoints than their urban counterparts [10]. Trauma patients in rural communities are known to have higher rates of mortality and complications than their peers in urban centers [11]. The differences are due to delay in transit time, less access to trauma centers and severity of illness [12]. Nevertheless, unlike trauma and chronic diseases, no study has reported on the relationship between residence and procedural outcomes in patients undergoing CT guided lung biopsy. We found that there are no clinical or statistical significant differences in complications between rural and urban hospitals, and no dissimilarities in patients' and lesions' characteristic. Well trained health care providers and the fact that CT guided biopsy is performed only in optimal technical setting, elucidates the lack of significant differences between cohorts. The incidence of pneumothorax in our cohort (12%) is similar to previous reports regarding lung biopsy complication rates recently reviewed [3]. The lower but not statistically significant incidence of pneumothorax was observed in BMC cohort, can be explained by the shorter distance from pleura in this cohort, a parameter that is known to be a risk factor for pneumothorax.

Studies comparing between urban and rural population in Israel showed an increased prevalence of genu varum and valgum among adolescents [13], Parkinson's disease [14] and rheumatic fever [15] in rural areas in Israel compared to urban population. However, rural/urban comparisons of medical procedures in Israel are infrequent. To our knowledge our study is the first study in Israel that shows that pulmonary medical services in Israel do not differ significantly between medical centers in different resident.

Our second significant finding is the consolidation of our previous results [5]. An ICT cannot replace a chest X-ray performed 2 hours post-lung biopsy in detecting iatrogenic pneumothorax. Combining these two centers experience, ICT detected only 79% of pneumothorax seen on the follow-up chest X-rays with a 6% rate of false negative test results, demonstrating the limited yield of ICT in predicting one of the major complications of percutaneous lung biopsy. Since pneumothorax is a life-threatening complication our data supported preserving the routine follow-up chest X-ray as the gold standard for detecting post procedure pneumothorax, as well as the routine ICT.

Another important observation, which reinforces our previous report, is the protective effect of bleeding on ICT against the development of pneumothorax. In BMC cohort this effect didn't get to statistical significance, whereas a trend toward protective effect was shown, probably due to the low number of patients.

Limitations

Our study has several limiting aspects. Primarily, this is a retrospective analysis and is hence subject to residual confounding effects. And yet, our major complication rates are in-line with previous reports and thus provide support to the external validity of our findings. Furthermore, this study supports our previous results nearly exclusively, strengthening the validity of our observations. A second limitation of our study is the definition of Barzilai as a rural hospital. Due to variances in Israel population and the small size of the country, classification of hospitals as rural or urban is difficult, thus our finding of similar characteristics of CT-guided lung biopsies may be considered as similarities between two different medical centers and not as resemblances among different residences. Two other confounding factors include the physician experience and the patient volume per year at the center. The physician experience and the volume of biopsies in Barzilai are inferior and may influence the results; however, they should inflict the results toward a significant difference between centers and not vice a versa, thus consolidating our results.

CONCLUSIONS

Regarding procedure characteristics and complication rates, results of CT-guided percutaneous lung biopsies are comparable between rural and urban hospitals.

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Capsule

Magnitude, demographics, and dynamics of the effect of the first wave of the COVID-19 pandemic on all-cause mortality in 21 industrialized countries

The coronavirus disease-2019 (COVID-19) pandemic has changed many social, economic, environmental, and healthcare determinants of health. **Kontis** et al. applied an ensemble of 16 Bayesian models to vital statistics data to estimate the all-cause mortality effect of the pandemic for 21 industrialized countries. From mid-February through May 2020, 206,000 (95% confidence interval 178,100–231,000) more people died in these countries than would have had the pandemic not occurred. The numbers of excess deaths, excess deaths per 100,000 people, and relative increase in deaths were similar between men and women in most countries. England and Wales and Spain experienced the largest effect: approximately 100 excess deaths per 100,000 people, equivalent to a 37% (30–44%) relative increase in England and Wales and 38% (31–45%) in Spain. Bulgaria, New Zealand, Slovakia, Australia, Czech Republic, Hungary, Poland, Norway, Denmark, and Finland experienced mortality changes that ranged from possible small declines to increases of 5% or less in either sex. The heterogeneous mortality effects of the COVID-19 pandemic reflect differences in how well countries have managed the pandemic and the resilience and preparedness of the health and social care system.

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