CT-Guided Transthoracic Percutaneous Needle Biopsy: A Retrospective Audit at a Tertiary Referral Centre

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Abstract

Purpose: The purpose of this audit was to determine the success and complication rates from computed tomography (CT)-guided transthoracic percutaneous needle biopsies (PNBs) in a tertiary referral centre and compare these with the Society of Interventional Radiology (SIR) standards of practice.

Materials and methods: Using the Picture Archiving and Communication System (PACS), all CT-guided transthoracic PNBs were isolated at St. Joseph's Healthcare Hamilton (SJHH) for the year of 2010. Reports, images, or both, were reviewed to determine lesion size, lesion site, needle size, number of core biopsies obtained, and complication rates. Post biopsy chest radiograph reports, images, or both, were reviewed in some cases. Pathology, microbiology, and surgical reports were also reviewed. Complication and diagnostic rates were then compared with published SIR standards of practice.

Results: Two hundred and fifty-eight CT-guided transthoracic PNBs were performed at SJHH in 2010, of which 224 (86.8%) were successful. One hundred and twenty nine (50.0%) had minor complications, while none resulted in major complications. Thirty-two (12.4%) biopsies were non-diagnostic. Five (1.9%) non-diagnostic biopsies were shown to be malignant by repeat biopsy or surgery. Two (0.8%) biopsies showed benign tissue but were proven malignant by repeat biopsy or surgery.

Conclusion: CT-guided transthoracic PNB is a safe and effective technique to obtain tissue diagnosis, however regular audits are necessary to improve outcomes and minimize complications.

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Introduction

St. Joseph's Healthcare Hamilton (SJHH) is located in Hamilton, Ontario, Canada. It serves as a thoracic and respiratory tertiary referral centre for the Central West Region of Ontario, with a population of 2.3 million people. Computed tomography (CT)-guided transthoracic percutaneous needle biopsy (PNB) is offered by the Department of Diagnostic Imaging at SJHH.

Transthoracic PNB is a minimally invasive diagnostic tool that is primarily used for tissue diagnosis of lesions in the lung parenchyma, hilum, or mediastinum.[1,2] It is also useful in establishing the cause of multiple pulmonary nodules, abscesses, and focal areas of consolidation.[3] Although several imaging modalities are feasible, CT has become the most commonly used imaging modality for guidance throughout these procedures.[4] In part, this is because CT allows for visualization and biopsy of lesions as small as 0.5 cm in diameter.[5] Furthermore, its safety has been optimized with the use of contrast enhancement to avoid vascular structures and a coaxial technique to avoid multiple punctures.[6]

The purpose of this audit is to ensure a high standard of care and to recognize institution-specific rates of complications and diagnoses. This data may also be used to provide a more appropriate and accurate informed consent to patients at SJHH and similar institutions.

Materials and Methods

Research ethics board approval was obtained for this study. All CT-guided transthoracic PNBs performed at SJHH in 2010 were retrospectively isolated using the Picture Archiving and Communication System (PACS) and included in this study. These biopsies were undertaken to examine lesions within the lung parenchyma, pleura, mediastinum, or chest wall, with indications following the Society of Interventional Radiology (SIR) guidelines. Exclusion criteria were the following: significant coagulopathy which could not be corrected, severely compromised cardiopulmonary function, hemodynamic instability, and lack of a safe pathway to the lesion.[7]

All biopsies were performed by five radiologists (three interventional radiologists and two diagnostic radiologists trained to perform CT-guided lung biopsies). The biopsies were performed with CT guidance under local anesthetic, with a minority requiring intravenous sedation. The patients recovered in

the day surgery area following the procedure for two to three hours to ensure stability and the absence of pneumothoraces. A follow-up chest radiograph was performed at one and two hours post-procedure to rule out pneumothorax.

Biopsy reports, images, or both, were reviewed to determine rates and types of complications, lesion size (in long-axis dimension), lesion site, needle size, and number of core biopsies performed. Pathology, microbiology, and in certain cases, post-biopsy chest radiographs, clinical notes, and operative reports were reviewed. Complication and success rates were compared with published SIR standards of practice, with success being defined as a diagnostic biopsy result which was confirmed by repeat biopsy or surgery.[7] Repeat biopsies were performed in cases where the lesion was concerning for malignancy on imaging but described as non-diagnostic or benign on the pathology report.

The performance of CT-guided transthoracic PNB as a diagnostic test was also assessed. A true positive was considered a biopsy confirmed to be malignant on most recent pathologic analysis (from the initial biopsy, from a repeat biopsy, or from subsequent surgery). A true negative was considered a biopsy confirmed to be benign on most recent pathologic analysis. A false positive was considered a biopsy shown to be malignant on initial biopsy, but benign on repeat biopsy or subsequent surgery. A false negative was considered a biopsy shown to be benign or non-diagnostic on initial biopsy, but malignant on repeat biopsy or subsequent surgery. Sensitivity, specificity, positive predictive value, and negative predictive value were then calculated.

Results

In 2010, a total of 258 CT-guided transthoracic PNBs were performed. One hundred and ninety seven (76.4%) PNBs were performed for disease that was ultimately proven malignant, either by biopsy or subsequent surgery, while 34 (13.2%) PNBs were performed on lesions proven to be benign. Figures 1 and 2 show images from two representative cases included in this study.

In total, 224 (86.8%) biopsies were considered to be successful, while 32 (12.4%) were non-diagnostic. A repeat CT-guided PNB was required for 8 (3.1%) patients. Five (1.9%) non-diagnostic biopsies were shown to be malignant by repeat biopsy or surgery. Two (0.8%) biopsies showed benign tissue but were proven malignant by repeated biopsy or surgery.

One hundred and twenty nine (50.0%) biopsies performed had minor complications. Specifically, the number of occurrences of pneumothorax, thoracostomy tube placement, and mild haemorrhage were 48 (18.6%), 24 (9.3%), and 57 (22.1%), respectively. Of note, 11 of the 24 patients requiring a tube thoracostomy had no clinically or radiologically detectable pneumothorax after the biopsy. One patient was discharged home with a small stable pneumothorax and returned the next day with an enlarging pneumothorax requiring a tube thoracostomy. None of the biopsies performed resulted in major complications. There were no deaths resulting from CT-guided transthoracic PNB in our study.

Discussion

Quality improvement (QI) guidelines for PNB have been produced by the SIR Standards of Practice Committee. According to these guidelines, 95% of PNBs should be performed to establish the benign or malignant nature of a lesion, to obtain material for microbiologic analysis in patients with known or suspected infections, to stage patients with known or suspected malignancy when local spread or distant metastasis is suspected, or to determine the nature and extent of certain diffuse parenchymal diseases. The suggested QI threshold for success rates of thoracic/pulmonary PNB is 75%.[7]

Complications occurring as a result of transthoracic PNB are not uncommon. The SIR guidelines classify complications as either minor or major based on clinical outcome (Table 1). QI thresholds for specific complications are also provided (Table 2).[7] Other complications such cardiac tamponade, malignant seeding along the needle tract, and massive haemothorax are not discussed as they are very rare and only described in case reports.[8-10]

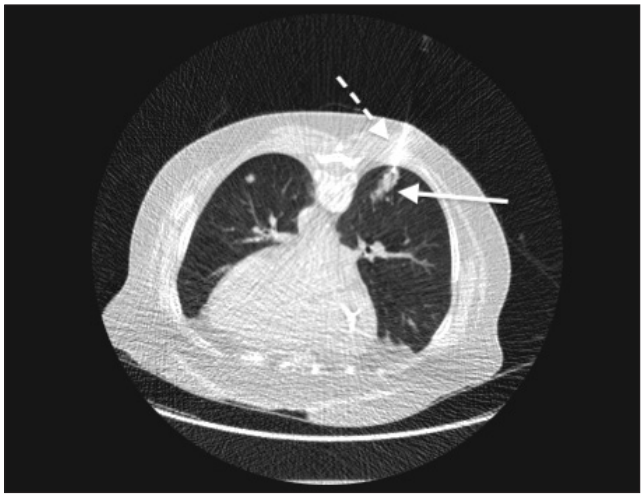

Figure 1. Axial CT imaging of the thorax demonstrating the tip of the transthoracic biopsy needle (broken arrow) entering a lesion in the right lower lobe (solid arrow).

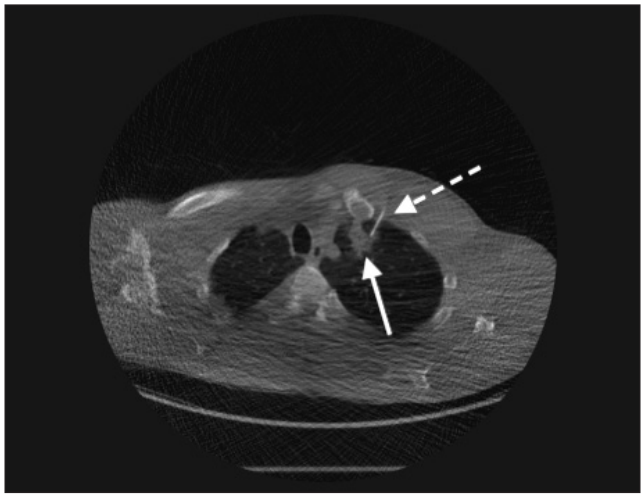

Figure 2. Axial CT imaging of the thorax demonstrating the tip of the transthoracic biopsy needle (broken arrow) entering a lesion in the left upper lobe (solid arrow).

Table 1. SIR classification of complications by clinical outcome.[7]

Minor Complications
No therapy, no consequence
Nominal therapy, no consequence; includes overnight admission for observation only
Major Complications
Require therapy, minor hospitalization (<48 hours)
Require major therapy, unplanned increase level of care, prolonged hospitalization (>48 hours)
Permanent adverse sequelae
Death

Table 2. Complications and suggested QI thresholds for transthoracic PNB.[7]

	Suggested QI Threshold
Minor Complications	
Pneumothorax	45%
Thoracostomy tube placement	20%
Mild haemorrhage*	Not reported
Major Complications	
Haemoptysis requiring hospitalization or specific therapy	2%
Thoracostomy tube placement requiring prolonged admission, catheter exchange, or pleurodesis	3%
Air embolism	<0.1%

*This is not considered a complication in the SIR guidelines; however it was considered a minor complication in our study.

The performance of this diagnostic test at our institution in 2010 is outlined in Table 3. Several other studies have also demonstrated the diagnostic power of transthoracic PNB.[11-19] Multiple factors may contribute to the occurrence of a non-diagnostic biopsy. Li and colleagues found that lesion size has a considerable effect on diagnostic accuracy, with accuracies of PNB for small (<1.5cm in long-axis dimension) and large nodules of 74% and 96%, respectively.[15] Other contributing factors may include location of the lesion and operator experience.[20]

Table 3. Statistical measurement of performance of CT-guided transthoracic PNBs at SJHH.

True positives (TP)	190
True negatives (TN)	34
False positives (FP)	0
False negatives (FN)	7
Sensitivity = TP / (TP + FN)	96.4%
Specificity = TN / (TN + FP)	100.0%
Positive predictive value = TP / (TP + FP)	100.0%
Negative predictive value = TN / (TN + FN)	82.9%

As expected, the diagnostic performance of CT-guided transthoracic PNB demonstrates a high specificity and positive predictive value. This makes it an ideal test for confirmation of suspected malignant disease in the thorax. Patients undergoing this procedure have a high pre-test probability, based on lesion characteristics on previous imaging. Therefore, the lower sensitivity and negative predictive value are not concerning.

Success rates are compared to the SIR standards in Table 4. Note that the QI guidelines do not suggest a threshold for rates of non-diagnostic or benign biopsies that are ultimately shown to be malignant. These are important outcomes following PNB that have a significant impact on patient care. It may therefore be prudent to include these possible outcomes in future QI guidelines.

Table 4. Success rates of CT-guided transthoracic PNB.[7]

	Success Rates	Suggested QI Threshold
Biopsy success rate	86.8%	75%
Non-diagnostic biopsies which were proven to be malignant by repeat biopsy or surgery	1.9%	Not reported
Benign biopsies which were proven to be malignant by repeat biopsy or surgery	0.8%	Not reported

Complication rates are compared to the SIR standards in Table 5. The most common minor complication in our study was mild haemorrhage, occurring in 22.1% of cases. While this is a high occurrence rate, the patients suffering this complication did not have longer hospital admissions, require specific therapy, or have any increase in morbidity or mortality. Further, this complication is not mentioned in the SIR guidelines, presumably because of a lack of effect on measurable patient outcomes. A number of minor complications did occur in our study; however the complication rates were well within the suggested QI thresholds.[7] Nevertheless, the possibility of such complications arising must be discussed with patients when they are considering the risks, benefits, and alternatives of CT-guided transthoracic PNB.

No major complications occurred in our study, nor did any of the biopsies undertaken result in death. Because of the paucity of cases actually resulting in death, the literature discussing the association with mortality is limited. However, one large study in the United Kingdom estimated a mortality rate of 0.15%.[21] Possible causes of death include massive haemorrhage and large venous air embolism.[10, 22]

The success and complication rates in our audit were well within the acceptable QI thresholds suggested by the SIR.[7] As equipment and methodology continue to improve the practice of PNB, it is important for centres offering this procedure to fulfill an appropriate standard of care. This audit demonstrates that such a standard is being met at our institution.

Table 5. Complication rates of CT-guided transthoracic PNB.[7]

	Complication Rates	Suggested QI Threshold
Minor Complications		
Pneumothorax	18.6%	45%
Thoracostomy tube placement	9.3%	20%
Mild haemorrhage	22.1%	Not reported
Major Complications		
Haemoptysis requiring hospitalization or specific therapy	0%	2%
Thoracostomy tube placement requiring prolonged admission, catheter exchange, or pleurodesis	0%	3%

In conclusion, the success and complication rates at our institution exceeded the standards suggested by the SIR.[7] Therefore, CT-guided transthoracic PNB has been reinforced as a safe and effective method for obtaining a tissue diagnosis. This is a retrospective single centre study and, thus, there are limitations in the applicability of its results. Nevertheless, institution-based data can now be offered to patients when providing informed consent. The results can also be used for the same purpose at other similar institutions. Institution-specific clinical audits are most informative and valuable for patients undergoing this procedure. Regular audits are necessary at all centres providing this service to monitor for complications and improve outcomes.

Acknowledgments

We would like to thank the radiologists who participated in this study and the rest of the staff in the Department of Diagnostic Imaging at Saint Joseph's Healthcare Hamilton.

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