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Personalized Pleural Biopsies: Advancing Precision in Pleural Disease Diagnosis

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A B S T R A C T

The diagnosis of pleural disease, particularly in cases of malignant pleural effusion, remains a clinical challenge due to the limitations of traditional fluid analysis. Emerging evidence supports the use of pleural biopsies, with thoracoscopic biopsy recognized as the gold standard, offering superior diagnostic sensitivity. However, image-assisted needle biopsies, such as ultrasound-guided procedures, provide a valuable alternative for patients who cannot undergo thoracoscopy, achieving similar diagnostic yield in select cases. This personalized approach to biopsy selection - guided by imaging findings and molecular diagnostics - allows for enhanced diagnostic precision, especially in the era of precision oncology, where molecular profiling is increasingly essential for treatment planning. Future research will focus on optimizing biopsy strategies to further refine pleural disease diagnostics, ensuring individualized patient care.

Keywords: Chest Diseases; Pleural Effusion; Diagnosis; Biopsies

Introduction

The diagnosis of pleural disease continues to challenge clinicians, with a broad spectrum of over 50 known causes of pleural effusion, ranging from benign to malignant etiologies.[1] Traditional diagnostic methods, such as pleural fluid cytology, have demonstrated suboptimal sensitivity for malignant diseases, particularly in more complex cases like mesothelioma, where diagnostic sensitivity may be as low as 5%.[2] This growing recognition of the limitations of fluid analysis has led to a shift toward pleural biopsies as a first-line diagnostic tool.[3] However, the choice of biopsy method must balance diagnostic yield, patient safety, and resource availability - factors that are crucial in guiding optimal clinical decision-making.

Several biopsy techniques are available, each with its advantages and limitations. Closed pleural biopsies utilizing Abrams or cutting needles, with or without image guidance, remain common in many settings. However, thoracoscopic pleural biopsy, either through medical thoracoscopy (MT) or video-assisted thoracoscopic surgery (VATS), is widely regarded as the gold standard for pleural biopsy, offering a diagnostic sensitivity exceeding 95% in large-scale studies.[4] Yet, this approach requires specialized expertise and access to surgical facilities, which are not universally available. For patients who cannot tolerate thoracoscopy due to their clinical status or logistical limitations, ultrasound-guided cutting needle biopsies offer an attractive alternative, providing increased diagnostic yield and lower complication rates compared to Abrams biopsy, with a smaller procedural burden for both the patient and the clinician.[5,6]

Balancing Diagnostic Precision and Accessibility

Recent data further underscore the importance of image guidance in enhancing diagnostic outcomes for pleural biopsies. Studies comparing image-assisted Abrams needle biopsy (IA-ANPB) to MT in patients with pleural effusions and pleural lesions suggest a nuanced approach to biopsy selection. For patients with visible pleural abnormalities, IA-ANPB has shown comparable diagnostic sensitivity to MT, making it a viable alternative in centers with appropriate expertise. However, in cases of effusion without visible pleural lesions, MT remains superior, with significantly higher diagnostic sensitivity and negative predictive value, cementing its role as the preferred modality.[7]

This growing body of evidence presents clinicians with an important diagnostic decision-making framework: in patients with targetable pleural lesions on imaging, IA-ANPB offers a reasonable balance between diagnostic efficacy and procedural safety. In contrast, when no pleural abnormalities are seen apart from effusion, thoracoscopic evaluation remains essential. This recommendation aligns with current international guidelines that advocate for the early use of pleural biopsies in suspected malignant cases.[8]

Emerging Trends: The Role of Molecular Markers

A key consideration in pleural biopsies, especially in the context of malignancy, is the increasing role of molecular diagnostics. Advances in targeted therapies and immunomodulating treatments for cancers, particularly lung cancer, demand not only accurate diagnosis but also molecular profiling to guide therapy.[9] Medical thoracoscopy has demonstrated superior tissue yield for molecular markers compared to needle biopsies, further solidifying its role in the era of precision oncology.[10] Future studies focusing on the molecular outcomes of pleural biopsies across various techniques will provide essential insights into optimizing biopsy strategies for personalized cancer care.

Future Directions and Clinical Application

While the results from randomized trials like those by Lee et al[7] are promising, broader validation across multiple centers and patient populations is necessary before fully incorporating these findings into routine clinical practice. Additionally, the introduction of cutting-edge imaging techniques, such as real-time ultrasound-guided cutting needle biopsies, could further refine the diagnostic pathway, particularly in patients with difficult-to-access pleural lesions.

The challenge of balancing patient tolerance, procedural safety, and diagnostic accuracy remains central to pleural disease management. Personalized biopsy approaches, informed by patient-specific imaging findings and clinical context, offer the best opportunity to enhance diagnostic precision while minimizing patient risk. As more data emerge, clinicians will be better equipped to tailor pleural biopsy strategies to individual patients, ultimately improving outcomes in pleural disease diagnostics.

Conclusion

The integration of image-guided techniques and personalized biopsy methods marks an important evolution in the management of pleural disease. While thoracoscopic biopsy remains the gold standard for many patients, advancements in image-assisted needle biopsy techniques offer viable alternatives for select cases. Moving forward, a more personalized approach to pleural biopsies, driven by both imaging findings and molecular diagnostics, will undoubtedly shape the future of pleural disease management, ensuring that each patient

receives the most appropriate and effective care.

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