Article type: General Commentaries

Home Page URL: https://www.alliedacademies.org/clinical-pathology-laboratory-medicine/

The evolution of diagnostic techniques in anatomical pathology: From microscopy to molecular profiling.

Michael Nguyen*

Department of pathology and Laboratory Medicine, University of Texas, USA.

***Correspondence to:** Michael Nguyen, Department of pathology and Laboratory Medicine, University of Texas, USA. E-mail: mnguye@stanfordmed.edu

Received: 10-Jun-2025, Manuscript No. AACPLM- 25-166919; **Editor assigned:** 11-Jun-2025, Pre QC No. AACPLM- 25-166919 (PQ); **Reviewed:** 20-Jun-2025, QC No. AACPLM- 25-166919; **Revised:** 21-Jun-2025, Manuscript No. AACPLM- 25-166919 (R); **Published:** 28-Jun-2025, DOI: 10.35841/ aacplm-7.2.259

Introduction

Anatomical pathology, the branch of pathology that studies structural changes in tissues and organs, has undergone significant transformation over the past century. Traditionally reliant on microscopic examination of stained tissue sections, diagnostic techniques have evolved to incorporate advanced molecular technologies, vastly improving diagnostic accuracy, prognostication, and personalized treatment strategies. [1].

The cornerstone of anatomical pathology has been light microscopy. Since the 19th century, the examination of Hematoxylin And Eosin (H&E) stained tissue sections has enabled pathologists to identify cellular morphology, tissue architecture, and pathological alterations such as inflammation, dysplasia, and malignancy. The development of special stains and Immunohistochemistry (IHC) further enhanced diagnostic precision by allowing identification of specific cell types and proteins. For decades, histopathology combined with IHC has been the gold standard for cancer diagnosis and classification.[2].

Immunohistochemistry revolutionized pathology by enabling the detection of antigens within tissues using specific antibodies. This technique has been essential in subclassifying tumors, determining cell lineage, and identifying prognostic markers. However, despite its advances, IHC is limited by antibody availability and semi-quantitative interpretation. [3]

The advent of molecular diagnostics in the late 20th century marked a paradigm shift. Techniques such as Polymerase Chain Reaction (PCR), Fluorescence In Situ Hybridization (FISH), and Next-Generation Sequencing (NGS) allowed detection of genetic mutations, chromosomal rearrangements, and gene expression profiles. Molecular profiling supplements morphological data, providing insights into tumor biology, therapy targets, and resistance mechanisms. Despite advances, challenges remain in integrating molecular data into routine practice, standardizing techniques, and ensuring cost-effectiveness. Future innovations such as single-cell sequencing and spatial transcriptomics may provide unprecedented insights into tissue heterogeneity and microenvironment.[4].

Next-generation sequencing enables comprehensive genomic analysis from small tissue samples, facilitating detection of actionable mutations.This has been particularly transformative in oncology, where molecular profiling guides targeted therapies and immunotherapy selection, improving patient outcomes. Digital pathology, involving the scanning of glass slides into high-resolution digital images, has enhanced diagnostic workflows and enabled remote consultations. Coupled with Artificial Intelligence (AI) and machine learning algorithms, it promises to improve diagnostic accuracy by identifying subtle patterns beyond human recognition [5].

Conclusion

Anatomical pathology has evolved from traditional microscopy to a multi-modal discipline integrating molecular profiling and digital technology. This evolution not only enhances diagnostic precision but also paves the way for

Citation: Nguyen M. The evolution of diagnostic techniques in anatomical pathology: From microscopy to molecular profiling. J Clin Path Lab Med.2025;(7)2:259

personalized medicine, fundamentally transforming patient care.

References

1. Robboy SJ, Weintraub S, Horvath AE, et al. Pathologist workforce in the United States: I. Development of a predictive model to examine factors influencing supply.Arch Path Lab. 2013;137(12):1723-32.
2. Ausseil J, Desmaris N, Bigou S, et al. Teaching genomic pathology: translating team-based learning to a virtual environment using computer-based simulation.Arch Path Lab. 2019;143(4):513-7.
3. Chen W, Zheng R, Baade PD, et al. Cancer statistics in China.CA Cancer J Clin. 2016;66(2):115-32.
4. Ramalingam SS, Vansteenkiste J, Planchard D, et al. Overall survival with osimertinib in untreated, EGFR-mutated advanced NSCLC.N Engl J Med. 2020;382(1):41-50.
5. Solomon BJ, Kim DW, Wu YL, et al. Final overall survival analysis from a study comparing first-line crizotinib versus chemotherapy in ALK-mutation-positive non–small-cell lung cancer.J Clin Oncol. 2018;36(22):2251-8.

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