Immunohistochemistry in clinical pathology: A tool for precision diagnosis.

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Introduction

Immunohistochemistry (IHC) is a widely utilized laboratory technique that allows for the identification and localization of specific antigens in tissue sections using antibodies tagged with detectable markers. In clinical pathology, IHC plays a crucial role in the diagnosis and classification of various diseases, particularly cancers, by providing valuable information on the molecular characteristics of tumors and aiding in differential diagnosis. The advancement of IHC has significantly contributed to precision medicine by allowing pathologists to tailor treatment strategies based on the unique immunoprofile of a disease [1].

IHC works by using antibodies that bind to specific proteins or antigens present in tissue samples. These antibodies are linked to a detectable marker, such as an enzyme (e.g., horseradish peroxidase), or a fluorescent dye, allowing for visualization under a microscope [2]. The ability to identify and visualize the precise location of specific proteins or biomarkers within the tissue can provide essential insights into the pathogenesis and progression of diseases, enabling a more accurate and individualized diagnosis [3].

One of the most significant applications of IHC in clinical pathology is in oncology. Tumors can have distinct patterns of protein expression, which can guide the diagnosis and classification of cancer subtypes. For example, breast cancer can be characterized by the expression of estrogen receptors (ER), progesterone receptors (PR), and human epidermal growth factor receptor 2 (HER2), with IHC being used to assess the presence of these markers [4]. The detection of HER2 amplification in breast cancer, in particular, helps in determining the use of targeted therapies, such as trastuzumab, offering a personalized treatment plan. Similarly, in non-small cell lung cancer (NSCLC), IHC is crucial for identifying driver mutations, such as epidermal growth factor receptor (EGFR) mutations and anaplastic lymphoma kinase (ALK) rearrangements, to guide targeted therapy decisions [5].

In addition to oncology, IHC is invaluable in the diagnosis of infectious diseases and autoimmune disorders. For instance, IHC can be employed to detect bacterial or viral antigens directly within tissue samples, helping to confirm infections such as tuberculosis, viral hepatitis, or HIV. In autoimmune diseases, IHC can identify tissue-specific autoantibodies or immune complexes that help differentiate between conditions such as systemic lupus erythematosus (SLE) or rheumatoid arthritis [6].

IHC also plays a critical role in the classification of hematological malignancies. The identification of cell surface markers, such as CD markers in lymphoid malignancies (e.g., CD20 in B-cell lymphomas and CD3 in T-cell lymphomas), aids in distinguishing between different types of leukemias and lymphomas, which is essential for determining prognosis and appropriate treatment [7].

Moreover, IHC has proven invaluable in improving diagnostic accuracy by allowing for better differentiation of tumors with overlapping histological features. For example, the use of IHC to distinguish between benign and malignant melanocytic lesions, such as using HMB-45 or S100 in the diagnosis of melanoma, enhances diagnostic certainty and reduces the risk of misclassification [8].

Despite its numerous benefits, IHC does have limitations. Variability in antibody quality, differences in laboratory protocols, and subjective interpretation can affect the reliability and reproducibility of results. Standardization efforts and the development of automated IHC systems aim to minimize these issues [9]. Additionally, while IHC provides valuable information, it is often used in conjunction with other techniques, such as molecular profiling and genetic testing, to achieve a comprehensive understanding of the disease [10].

Conclusion

In conclusion, IHC is an indispensable tool in clinical pathology that has revolutionized precision medicine. It allows for the identification of specific biomarkers, aiding in the accurate diagnosis, prognosis, and treatment of various diseases, particularly cancers. As technology advances, the application of IHC in combination with molecular profiling is expected to further enhance its role in personalized medicine, providing more effective and targeted treatment strategies.

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