

Liquid Biopsy: A Minimally Invasive Approach to Disease Detection

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Introduction

Liquid biopsy is an innovative diagnostic technique that analyzes biological material circulating in body fluids, most commonly blood, to detect and monitor diseases. Unlike traditional tissue biopsies, which require invasive procedures, liquid biopsy offers a minimally invasive alternative that can be performed repeatedly with minimal risk to patients. It primarily focuses on the detection of circulating tumor cells, circulating tumor DNA, RNA fragments, and extracellular vesicles. Liquid biopsy has gained significant attention in oncology, where it enables real-time insights into tumor biology, disease progression, and treatment response.

Discussion

One of the major advantages of liquid biopsy is its ability to capture tumor heterogeneity. Tumors often consist of multiple subclones with distinct genetic profiles, and a single tissue biopsy may not represent the entire tumor landscape. Liquid biopsy samples genetic material shed from different tumor sites, providing a more comprehensive view of the disease. This makes it particularly valuable for monitoring cancer evolution and identifying emerging resistance mutations during treatment.

Liquid biopsy plays a crucial role in early cancer detection and diagnosis. Advances in molecular technologies, such as next-generation sequencing and digital PCR, have improved the sensitivity and specificity of detecting tumor-derived genetic alterations from blood samples. In clinical practice, liquid biopsy is increasingly used to guide targeted therapy selection by identifying actionable mutations without the need for repeated tissue biopsies.

Another important application of liquid biopsy is disease monitoring. Changes in biomarker levels over time can reflect treatment effectiveness or disease recurrence. Liquid biopsy enables early detection of minimal residual disease after surgery

or therapy, allowing timely clinical intervention. It also facilitates longitudinal monitoring, which is essential for adapting treatment strategies in response to tumor dynamics.

Despite its advantages, liquid biopsy faces several challenges. Low concentrations of tumor-derived material, especially in early-stage disease, can limit detection accuracy. Standardization of testing methods, data interpretation, and clinical validation remains an ongoing concern. Additionally, biological factors such as tumor type and location influence the amount of detectable circulating material. Continued research and technological refinement are needed to address these limitations.

Conclusion

Liquid biopsy represents a significant advancement in modern diagnostics, offering a non-invasive, dynamic approach to disease detection and monitoring. Its applications in oncology, particularly in early detection, treatment guidance, and real-time monitoring, highlight its transformative potential. While technical and biological challenges persist, ongoing improvements in molecular technologies and clinical validation are expanding its reliability and clinical utility. Liquid biopsy is poised to become an integral component of personalized medicine, enhancing patient care through earlier diagnosis and more precise treatment strategies.