

# Liquid Biopsies in Oncology: Transforming Cancer Diagnosis and Treatment

Zhang Li\*

Department of Oncology, National Cancer Center, Beijing, China

## DESCRIPTION

Cancer remains one of the most formidable health challenges globally, with millions of lives affected by its incidence and mortality rates. Traditionally, cancer diagnosis and monitoring have heavily relied on invasive tissue biopsies, which come with inherent risks, discomfort, and limited accessibility. In recent years, liquid biopsies have emerged as a groundbreaking innovation in the field of oncology. This non-invasive approach offers a promising alternative to traditional tissue biopsies by detecting and analyzing cancer-related genetic material and biomarkers in bodily fluids, primarily blood. Liquid biopsies hold the potential to transform cancer diagnosis, treatment selection, and monitoring, providing a wealth of information about the disease's progression and response to therapy. In this comprehensive essay, we will delve into the world of liquid biopsies, exploring their principles, applications, advantages, limitations, and the impact they have on the landscape of cancer care.

## Principles of liquid biopsies

Liquid biopsies primarily focus on the analysis of Cell-Free DNA (cfDNA) and, more specifically, Circulating Tumor DNA (ctDNA). CfDNA refers to fragmented DNA molecules found in bodily fluids, including blood, urine, and cerebrospinal fluid, that originate from cells undergoing apoptosis or necrosis. CtDNA, a subset of cfDNA, is derived from cancer cells and carries genetic mutations specific to the tumor. By isolating and analyzing ctDNA from a blood sample, liquid biopsies can reveal crucial insights into the genomic alterations driving the cancer's growth.

## Extracellular vesicles

Extracellular vesicles, including exosomes and microvesicles, play a pivotal role in intercellular communication. These tiny membrane-bound vesicles carry various bioactive molecules, such as proteins, nucleic acids, and lipids, which can serve as valuable biomarkers for cancer detection and monitoring. Liquid biopsies can isolate and analyze the contents of these EVs, providing information about the tumor's molecular characteristics.

## Applications of liquid biopsies

**Early cancer detection:** One of the most significant advantages of liquid biopsies is their potential to detect cancer at an early stage, often before symptoms manifest or conventional imaging techniques can detect the tumor. By identifying ctDNA or cancer-related biomarkers in the bloodstream, liquid biopsies enable clinicians to diagnose cancer at a more treatable and curable stage, improving overall patient outcomes.

**Monitoring disease progression:** Liquid biopsies can be used to monitor the progression of cancer over time. Serial blood samples can track changes in ctDNA levels, mutations, and other biomarkers, providing real-time insights into how the disease is evolving. This information can guide treatment decisions and help identify resistance mechanisms as the cancer adapts to therapy.

**Treatment selection and personalization:** Liquid biopsies offer a non-invasive means of identifying specific genetic mutations or alterations within a tumor. This information is invaluable for tailoring cancer treatment to the individual patient, ensuring that they receive the most appropriate targeted therapies or immunotherapies. Personalized treatment plans based on liquid biopsy results have the potential to increase treatment efficacy and reduce unnecessary side effects.

**Monitoring minimal residual disease:** After cancer treatment, it is crucial to monitor for the presence of Minimal Residual Disease (MRD), which refers to small amounts of cancer cells that may remain in the body even after successful treatment. Liquid biopsies can detect low levels of ctDNA associated with MRD, allowing for early intervention if cancer recurrence is suspected.

## Advantages of liquid biopsies

**Non-invasiveness:** The non-invasive nature of liquid biopsies is a significant advantage over traditional tissue biopsies. Patients undergoing liquid biopsy procedures experience minimal discomfort and reduced risk of complications, making it a safer and more accessible diagnostic option.

**Correspondence to:** Zhang Li, Department of Oncology, National Cancer Center, Beijing, China, E-mail: liang@yahoo.com

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**Accessibility:** Unlike tissue biopsies, which may require invasive procedures and specialized equipment, liquid biopsies are relatively easy to perform and can be conducted in most healthcare settings. This accessibility broadens the reach of cancer diagnostics, particularly in regions with limited medical resources.

**Real-time monitoring:** Liquid biopsies enable real-time monitoring of cancer progression and treatment response. Traditional imaging techniques, such as CT scans or MRIs,

provide snapshots of the disease but may not capture its dynamic changes as effectively as serial liquid biopsy measurements.

**Heterogeneity assessment:** Cancer is known for its intratumoral heterogeneity, where different regions of a tumor may have distinct genetic profiles. Liquid biopsies, by sampling DNA shed from various parts of the tumor, offer a more comprehensive assessment of this heterogeneity, aiding in treatment decisions and understanding resistance mechanisms.