

Biomarkers: Driving personalized, precise, non-invasive medicine.

Isabelle Laurent*

Department of Genomic Science, Sorbonne University, Paris, France

Introduction

Liquid biopsy, involving the analysis of circulating tumor cells, circulating tumor DNA, exosomes, and other biomarkers from bodily fluids, shows immense potential for non-invasive cancer detection, monitoring, and prognostication [1]. Its ability to provide real-time insights into tumor evolution offers a significant advantage over traditional tissue biopsies, especially for early diagnosis and tracking treatment response.

Recent advancements in Alzheimer's disease research highlight novel biomarkers, including blood-based tests for amyloid and tau pathologies, which are transforming early diagnosis and disease monitoring [2]. These less invasive approaches offer significant promise for clinical trials and routine practice, enabling more precise patient stratification and treatment development.

Artificial intelligence and machine learning are revolutionizing biomarker discovery by identifying complex patterns in large datasets that traditional methods often miss [3]. This accelerates the identification of novel diagnostic and prognostic markers and improves their clinical utility, paving the way for more personalized medicine.

The gut microbiota plays a crucial role in inflammatory bowel disease, and various microbiota-derived metabolites and microbial signatures are emerging as powerful biomarkers [4]. These biomarkers offer new avenues for understanding disease pathogenesis, predicting treatment response, and developing personalized therapeutic strategies.

Circulating microRNAs are stable, non-coding RNA molecules found in blood that act as crucial regulators of gene expression [5]. Their specific expression patterns in various cardiovascular conditions make them promising non-invasive biomarkers for early diagnosis, risk stratification, and monitoring of disease progression and treatment efficacy.

Exosomes, small extracellular vesicles, carry a diverse cargo of proteins, lipids, and nucleic acids, reflecting the physiological and pathological state of their parent cells [6]. In neurological disorders, exosomal contents serve as valuable biomarkers for diagnosing neu-

rodegenerative diseases, monitoring disease progression, and even predicting therapeutic responses, offering a less invasive alternative to cerebrospinal fluid sampling.

Saliva, an easily accessible biofluid, contains a rich array of biomarkers including proteins, DNA, RNA, and metabolites that mirror systemic health and disease [7]. Its non-invasive collection makes it an ideal source for developing diagnostic tools for various conditions, supporting personalized medicine strategies from oral cancers to systemic diseases.

Metabolomics, the large-scale study of small molecules (metabolites) within cells, biofluids, or tissues, offers a comprehensive snapshot of cellular physiology [8]. In oncology, it's instrumental in discovering novel biomarkers for early cancer detection, prognosis, and predicting treatment response, moving towards a more individualized approach to cancer therapy.

Immunotherapy has revolutionized cancer treatment, but predicting patient response remains a challenge [9]. Immunological biomarkers, such as PD-L1 expression, tumor mutational burden, and specific immune cell profiles, are critical for identifying patients most likely to benefit, thereby guiding treatment decisions and optimizing clinical outcomes.

Single-cell RNA sequencing (scRNA-seq) offers unprecedented resolution by analyzing gene expression at the individual cell level, uncovering cellular heterogeneity often masked by bulk RNA sequencing [10]. This technology is invaluable for identifying novel disease biomarkers, pinpointing specific cell types involved in pathology, and understanding complex disease mechanisms, leading to more targeted diagnostic and therapeutic strategies.

Conclusion

Biomarker discovery and application are changing medicine. For example, liquid biopsy analyzes bodily fluids for cancer detection, offering a non-invasive edge over traditional tissue methods for early diagnosis and treatment monitoring. Similarly, new blood-based tests for amyloid and tau pathologies are transforming Alzheimer's disease diagnosis and monitoring, making clinical tri-

*Correspondence to: Isabelle Laurent, Department of Genomic Science, Sorbonne University, Paris, France. E-mail: isabelle.laurent@sorbonne.fr

Received: 03-Nov-2025, Manuscript No. aacbc-229; Editor assigned: 05-Nov-2025, Pre QC No. aacbc-229 (PQ); Reviewed: 25-Nov-2025, QC No. aacbc-229; Revised: 04-Dec-2025, Manuscript No. aacbc-229 (R); Published: 15-Dec-2025, DOI: 10.35841/aacbc-9.4.229

als and patient stratification more precise.

Artificial Intelligence and Machine Learning are speeding up biomarker discovery, finding complex patterns in large datasets to identify diagnostic and prognostic markers for personalized medicine. The gut microbiota's role in inflammatory bowel disease is revealing new biomarkers, like metabolites and microbial signatures, helping us understand disease and predict treatment responses.

Circulating microRNAs in blood show promise for cardiovascular disease diagnosis, risk stratification, and monitoring. Exosomes, small extracellular vesicles, offer valuable biomarkers for neurological disorders, serving as a less invasive alternative to cerebrospinal fluid sampling. Even saliva, an easily accessible biofluid, is a rich source of biomarkers for various conditions, supporting personalized medicine.

Metabolomics provides a detailed view of cellular physiology, helping discover oncology biomarkers for early cancer detection and individualized therapies. Immunological biomarkers, like PD-L1 expression, are crucial for predicting immunotherapy responses, guiding treatment decisions in cancer. Meanwhile, Single-cell RNA sequencing provides unprecedented resolution, uncovering cellular heterogeneity to identify novel disease biomarkers and understand complex disease mechanisms for targeted strategies. Overall, these advancements are pushing medicine towards more personalized, precise, and less invasive diagnostics and treatments.

References

1. Dong L, Yumei L, Qing L. *Liquid biopsy as a promising tool for cancer detection and prognosis*. *Sig Transduct Target Ther*. 2024;9:23.
2. Kajsa EM, Erik S, Oskar H. Biomarkers in Alzheimer's disease: *Recent advances and future perspectives*. *J Intern Med*. 2023;294:708-726.
3. Junyan L, Jianzhuang L, Jun J. *Artificial intelligence in biomarker discovery and clinical application*. *Med Sci Monit*. 2023;29:e940242.
4. Jessica MH, Mark SS, Clara EL. Gut microbiota-derived biomarkers in inflammatory bowel disease. *Inflamm Bowel Dis*. 2022;28:1283-1294.
5. Yanan W, Qing L, Yanfei Y. *Circulating microRNAs as biomarkers for cardiovascular diseases*. *J Cardiovasc Transl Res*. 2021;14:669-680.
6. Yuhui H, Xiaojing F, Yang G. Exosomal biomarkers in neurological disorders: *Current status and future prospects*. *Mol Neurobiol*. 2021;58:1461-1478.
7. David TW, Wan-Ling W, Eric JL. *Saliva as a source of biomarkers for precision medicine*. *Mol Diagn Ther*. 2020;24:511-523.
8. Xiaoyan Z, Jingjing F, Kaiyan Y. Metabolomics in oncology: *From biomarker discovery to clinical application*. *Front Oncol*. 2020;10:597148.
9. Jie L, Xueying L, Wen-Quan C. *Immunological biomarkers for predicting immunotherapy response in cancer*. *J Hematol Oncol*. 2019;12:121.
10. Feng L, Fan Y, Jing W. *Single-cell RNA sequencing for biomarker discovery in disease*. *Trends Biotechnol*. 2019;37:994-1004.

Citation: Laurent I. Biomarkers: Driving personalized, precise, non-invasive medicine. *aacbc*. 2025;09(04):229.