Raman-based biochemical fingerprinting of plasma extracellular particles in breast cancer

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Biological fluids contain a heterogeneous population of circulating biogenic nanoparticles that differ in size, density, and molecular composition. Among these, lipoproteins (LPs) are essential for transporting hydrophobic lipids such as cholesterol and triglycerides [1]. Extracellular vesicles (EVs), are lipid bilayer particles released under physiological and pathological conditions, that serve as critical mediators of intercellular communication by transporting biological macromolecules such as lipids, proteins, and nucleic acids. Over the past decade, EVs have gained considerable attention as promising liquid biopsy–based biomarkers for cancer, particularly breast cancer (BC) [2]. Despite encouraging evidence, the reliable use of EVs as disease biomarkers requires rigorous isolation and characterization procedures to ensure an accurate assessment of their biological nature and clinical relevance, as LPs are frequently co-isolated with EVs.
Here, we propose Raman spectroscopy (RS) as a tool to characterize the biochemical composition of circulating extracellular particles (EPs)—including LPs and EVs [3,4]. First, we assessed the ability of RS to detect compositional differences among EPs obtained from human plasma by ultracentrifugation. Then we evaluated whether RS could provide quantitative information on major biomolecular classes by comparing RS data with traditional biochemical assays. Lastly, we investigated biochemical differences in plasma-derived EVs between healthy controls (HC, n=30) and BC patients (BC, n=34) to identify disease-associated spectral signatures
Our results show that consistent Raman bands can be detected across circulating EPs and that their intensities enable an effective discrimination of EVs from LPs and also among the main subtypes of both groups. Good agreement was also observed between RS and biochemical assays for all biomolecules, confirming that RS can rapidly and cost-effectively provide structural information on EPs composition, complementing traditional assays. At last, RS identified a distinct biochemical signature associated with BC, characterized by increased signals from nucleic acids and lipids, underscoring its potential as a valuable diagnostic tool.

References

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