Liquid biopsy-based detection and characterization of minimal residual disease in solid tumor patients: A new window of opportunity for post-adjuvant therapy

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Liquid Biopsy has been defined as the analysis of tumor cells or products released from primary or metastatic tumor tissues into the blood or other body fluids. Over the past ten years, CTCs, ctDNA and extracellular vesicles have received enormous attention as new biomarkers and subject of translational research (Alix-Panabieres & Pantel, Cancer Cell and Cancer Discovery 2025). In particular, CTC and ctDNA research has opened new avenues for a better understanding of tumor biology in cancer patients, including intra-patient heterogeneity and evolution towards resistance to therapy. Although both biomarkers are already used in numerous clinical trials, their clinical utility is still under investigation with first promising results. Clinical applications include early cancer detection, improved cancer staging, early detection of relapse and minimal residual disease (MRD), real-time monitoring of therapeutic efficacy and detection of therapeutic targets and resistance mechanisms. In particular, ultrasensitive ctDNA and CTC assays are now able to detect minute amounts of tumor signals in the blood of patients with completely resected solid tumors (Pantel & Alix-Panabieres, Nature Rev. Clin. Oncol. 2025), indicating the presence of MRD. This opens a new avenue for interventional clinical studies in the post-adjuvant setting which are aimed to demonstrate which therapy will be able to eradicate or control MRD and thereby prevent overt metastatic relapse. To achieve this important goal, assay harmonization and standardization as conducted by international consortia like the European Liquid Biopsy Society (ELBS; www.elbs.eu) and GUIDE-MRD (www.guidemrd-horizon.eu) are essential. Here, I will discuss the potential and current challenges of liquid biopsy for implementation of MRD diagnostics into precision medicine with emphasis on solid tumors.