

Abstract

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Quantum Sensing for Early Cancer Detection: A Literature Review of Diagnostic Techniques

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ABSTRACT

Introduction: Quantum medicine is an emerging field that employs the principles of quantum mechanics to revolutionize cancer care. Quantum sensing is a diagnostic technique that uses atomic-scale sensors to detect magnetic signals that indicate the presence of cancer. It offers a powerful route to detect cancer at earlier and more treatable stages by exploiting nanoscale quantum phenomena. This systematic review aims to evaluate the effectiveness of current quantum sensing techniques in oncology, with a focus on quantum dot-based and nanosensors.

Methodology: A literature search using PubMed and Scopus was performed and identified investigations using quantum dots and quantum biosensors for early cancer detection across blood, serum, and cellular samples. Eligible works included primary experimental studies and reviews reporting analytical performance and diagnostic potential.

Results: Across literature, quantum dot sensing techniques demonstrated high analytical sensitivity for the detection of tumors and cancer-associated proteins in liquid and tissue biopsies. Several studies also depicted low analyte concentrations and showed potential in recognizing malignant from benign or healthy samples. However, problems were reported associated with

heterogeneity in assay design or sample preparation and only a minority of studies progressed to early clinical or near-clinical validation.

Conclusion: In conclusion, quantum sensing stands as promising technology for cancer detection. While preclinical data suggest enhanced sensitivity and multiplexing capabilities compared with established diagnostic tools, translation into routine oncology practice is limited by small sample sizes and methodological variability. Future research should prioritize standardized protocols and clinical validation into existing diagnostic workflows."

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