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Aptameric Fluorescent Biosensors for the Detection of Liver Cancer

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Abstract

With a low 5-year survival rate after diagnosis, liver cancer is a major worldwide health concern. The current diagnostic approaches combining ultrasound, CT scans, MRI, and biopsy have the limitation of finding detectable liver cancer when the tumour has already advanced to a specific size, frequently resulting in late-stage diagnoses and dismal clinical treatment outcomes. To this purpose, there has been a great deal of interest in developing highly sensitive and selective biosensors to examine relevant cancer biomarkers in the early stage diagnosis and provide suitable treatment alternatives. Aptamers are a perfect recognition element among the many methods since they can bind to target molecules with great affinity and specificity.

Keywords: Aptamer • Biosensors • Liver cancer • Forster resonance energy transfer • Metal-enhanced fluorescent

Introduction

Over the past few decades, cancer has become a serious global health threat. Lung, liver, and stomach cancers kill the most lives each year, despite the fact that breast, lung, and prostate cancers have greater incidence rates. The high death rate for liver cancer in comparison to the incidence rate is particularly worrisome. While routine exams are required to identify cancer risk factors, monitor the prognosis, and detect recurrences, liver cancer is frequently discovered in its advanced stages, when the likelihood of survival and cure is minimal. The liver cancer's stealthy onset, lack of early indicators, difficulty in early identification, quick progression, and dearth of targeted therapy all contribute to the dismal prognosis and low patient survival rates [1].

Literature Review

On the other hand, the onset of cancer entails numerous molecular biological alterations, such as DNA, RNA, and protein mutations and aberrant expressions that lead to malignancy. As a result, accurate molecular quantification of these alterations is thought to be a crucial parameter for diagnosis and prognosis. A receptor, a component of the target molecule that recognises the target molecule, is essential for accurate and sensitive cancer biomarker detection due to the variety of properties of cancer biomarkers, including their expression level and binding moiety based on structural differences. In this regard, an aptamer has evolved and has been widely used to construct biosensors for early monitoring of various diseases. It can recognise a range of targets, including oligonucleotides, proteins, tiny molecules, even exosomes and complete cells.

Aptamers are made up of brief single-stranded DNA or RNA molecules and are created using the SELEX process. Aptamers are able to recognise a biological target with high specificity and affinity through weak interactions such as hydrogen bonds, van der Waals forces, electrostatic interactions, and shape complementarities, which function similarly to antigen-antibody interactions. Additionally, aptamers are good target recognition molecules for creating biosensors since they are simple to synthesise for a variety of biological targets and functionalized with chemical functional groups like fluorophores. While many evaluations focus on cancer diagnosis platforms, the development of biosensors for accurate liver cancer diagnosis merits a detailed, in-depth review due to its high death rate. Therefore, we will thoroughly review recent developments and research, with a particular emphasis on fluorescent-based aptameric biosensors for diagnosing liver cancer [2].

Discussion

Proteins have drawn a lot of interest among the numerous biomarkers as a key indicator for cancer diagnosis and prognosis. Alpha-Fetoprotein (AFP), for instance, is frequently utilised as a diagnostic marker for people with liver cancer. Elevated levels of AFP are frequently associated with chronic liver disease and Hepatocellular Carcinoma (HCC). Patients with liver cancer have higher blood AFP levels than healthy people, who have AFP levels below 25 ng/mL, upto 400 ng/mL. Identification of AFP is of major relevance for the early diagnosis and clinical treatment of liver cancer because the amount of AFP is also connected to the stage of the disease. A very sensitive aptamer-based biosensor to detect AFP using the Forster Resonance Energy Transfer (FRET) mechanism [3].

The high mortality rate of liver cancer is a result of the difficulties of early identification, which poses a significant challenge to medical personnel everywhere. The latest developments in the powerful FRET and Metal-Enhanced Fluorescent (MEF) biosensing systems, which use aptamer-based nanotechnology to find biomarkers linked to liver cancer, have been highlighted in this review. The sensitive and targeted detection of numerous liver-cancer-related biomarkers, including proteins and miRNA, has demonstrated encouraging results using these fluorescent-based techniques. The road to the development of aptamer-based biosensors is still being travelled, despite the fact that the proof-of-concept methods are surely interesting. The aptamer selection method must be optimised if this journey is to be successful. The regulation of the spacing between molecules, as well as the choice of aptamers, are two key elements that must be taken into consideration [4].

Even though FRET and MEF were the main topics of this review, other optical technologies like resonance and colorimetric methods can also help diagnose common cancers like breast, lung, and prostate cancer. The rapid, real-time analysis capabilities of resonance-based methods, such as Surface Plasmon Resonance (SPR) and Localized Surface Plasmon Resonance (LSPR), are well-liked. However, they are constrained by issues like a lack of specificity and the need for intricate instrumentation. However, despite requiring bulky optical components, Surface-Enhanced Raman Spectroscopy (SERS) has

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superior specificity and excellent photophysical properties. Finally, colorimetric procedures are basic and don't need exorbitant separate investigation gadgets however experience the ill effects of low awareness. The diverse and ever-evolving landscape of optical biosensing can be seen in each of these optical technologies' distinct advantages and disadvantages. In conclusion, in order to fully utilize their potential in the fight against cancer, they require ongoing improvement and refinement [5,6].

Conclusion

In addition, the microfluidic chip's incorporation of suggested biosensing strategies reduced reaction time and reagent quantity, enhancing sensitivity and streamlining the entire procedure. In their work, Shi et al. also designed a signal amplification strategy using Functionalized Ordered Mesoporous Nanoparticles (FOMNs) based on Boolean logic "AND" and assembled a dual-signal analysis (fluorescence and Raman signals). The double signals must be seen under the presence of both telomerase and miR-21. To put it succinctly, the release of the DNA-ROX (carboxy-X-rhodamine)-BHQ hairpin complex from sFOMNs was initiated by the presence of telomerase. The HCR process followed after DNA-Ag and DNA-ROX-BHQ hybridized with miR-21 as the second input to amplify Raman and fluorescence signals. The LSPR mechanism that AgNPs developed also enhanced Raman and fluorescence signals. Dual signals derived from suggested strategies were relevant to the levels of telomerase and miR-21 expression in living cells, as evidenced by the results of the experiment.

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Conflict of Interest

There are no conflicts of interest by author.

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