Nanobiosensors as a Revolutionizing Technique for Diagnosing Parasitic Infection Diseases

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Abstract- Parasitic infections, including malaria, hydatid cysts, leishmaniasis, and schistosomiasis, remain a significant cause of mortality and morbidity worldwide. In addition to their severe public health impacts, parasitic diseases impose a heavy economic burden on health systems. Control and treatment of zoonotic parasitic infections depend mainly on early and accurate diagnosis. Traditional diagnostic techniques, such as microscopic examinations, immunological methods, such as enzyme-linked immunosorbent assay (ELISA), and molecular tests, such as polymerase chain reaction (PCR), are standard tools for parasite identification. However, these methods are time-consuming and expensive and rely on sophisticated equipment; however, their application has many challenges. Nanobiosensors are novel devices that use nanotechnology and biology to provide new approaches for rapid and accurate diagnosing techniques, and they can detect many biomarkers. Hence, the current review aims to introduce nanobiosensors and their types and review their specific applications in diagnosing parasitic diseases. These sensors use the unique properties of nanomaterials to detect parasite biomarkers with high sensitivity and accuracy. Nanobiosensors can directly detect parasites or their metabolic products, enabling early disease detection. In conclusion, nanobiosensors could be essential in controlling and eradicating parasitic diseases.

Keywords: Nanotechnology, Nanobiosensors, Parasites, Helminth, Protozoa

INTRODUCTION

Parasitic diseases, such as malaria, cystic echinococcosis (CE), leishmaniasis, and schistosomiasis, remain a significant cause of mortality and morbidity worldwide. In addition to their severe public health impacts, parasitic diseases impose a heavy economic burden on health systems. Control and treatment of parasitic diseases depend mainly on early and accurate diagnosis [1].

Traditional diagnostic techniques, such as microscopic examinations, immunological methods, such as enzyme-linked immunosorbent assay (ELISA), and molecular tests, such as polymerase chain reaction (PCR), are standard diagnostic tools for parasite identification. However, these methods are time-consuming, expensive, and require sophisticated equipment. Furthermore, in many resource-limited settings, such tools are difficult to access [2].

Nanobiosensors are novel devices that combine nanotechnology and biology to provide new approaches for rapid and accurate disease diagnosis. They use the unique properties of nanomaterials to detect parasite biomarkers with high diagnostic and analytical performances, such as sensitivity, specificity, and accuracy [3]. Nanobiosensors can also be used to detect parasites or their metabolic products directly. Hence, the current review aims to introduce nanobiosensors and their tools and review their specific applications in diagnosing parasitic diseases [4].

NANOBIOSENSORS

Nanobiosensors are advanced devices that combine nanomaterials and biological elements such as antibodies, DNA, and enzymes to detect specific molecules such as proteins, parasite DNA, and other biomarkers [5]. Nanobiosensors operate in three main steps: first, the target

molecule is recognized by the biological element, then the signal produced is amplified using nanomaterials, and finally, the signal is converted into a measurable output.

The most important types of nanobiosensors include electrochemical, optical, and magnetic sensors [6]. Electrochemical nanobiosensors measure electrical changes resulting from the interaction of the target molecule with the biological element and use gold nanoparticles and carbon nanotubes to increase sensitivity [7]. In contrast, optical nanobiosensors take advantage of changes in optical properties such as absorption and fluorescence, and quantum dots and metal nanoparticles play a crucial role in this technology [8]. Magnetic nanobiosensors are also designed based on the magnetic properties of nanomaterials and are used to detect molecules at very low concentrations.

APPLICATION

Nanobiosensors have provided new opportunities for the early detection of parasitic diseases. Nanobiosensors have numerous applications in diagnosing parasitic diseases and can provide a novel and accurate solution for rapidly identifying parasites. For example, in malaria, researchers developed gold nanobiosensors and specific antibodies to detect surface proteins of *Plasmodium falciparum* accurately [9]. Regarding CE, electrochemical nanobiosensors sensitive to the parasite's DNA have detected the genetic material of *Echinococcus granulosus* in body fluids [10]. Moreover, optical nanobiosensors using quantum dots detect *Leishmania*-specific antigens with high sensitivity in leishmaniasis [11]. In schistosomiasis, magnetic nanobiosensors have also been successfully used to detect *Schistosoma* antigens in blood and urine samples, improving the accuracy and speed of diagnosis [12].

CONCLUSION

Nanobiosensors are revolutionary tools for rapid and accurate detection of parasitic diseases. Nanobiosensors, using advanced nanomaterials and biological elements, have increased the sensitivity and accuracy of diagnostic methods. Although nanobiosensors are promising, further research on cost, safety, and feasibility for widespread use in global health systems is needed. In the future, nanobiosensors could be an essential support in controlling and eradicating parasitic diseases.

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