Chapter 47

Nanoparticles: Reshaping the Future of Breast Cancer Therapeutics

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ABSTRACT

Breast cancer is the most prevalent cancer globally, particularly in women, and has significant side effects from therapy. A potential substitute for the treatment of breast cancer is nanomedicine. Good clinical results have previously been obtained from the widespread usage of nanomedicine products like Doxil® and Abraxane® as additional treatments for breast cancer. Potential therapeutic nanocarriers having the capacity for targeting, imaging, and tracking include both organic and inorganic nanomaterials. Nanoparticles have the potential to revolutionize breast cancer gene therapy by decreasing the likelihood of immune system-based identification, boosting bioavailability, increasing the circulation period, and supplying the gene regulator precisely. Herein, we discuss the potential of nanotechnology, current obstacles in breast cancer therapy, and the targeted medication delivery strategy of nanoparticles, nanoparticles-based imaging, biosensing, two types of gene therapy for breast cancer: one based on nanoparticles and the other using nanoparticles and targeted death.

KEYWORDS
Nanoparticles, Breast cancer, Drug delivery, Gene therapy, imaging, Biosensing

Received: 22-Jun-2024
Revised: 26-Jul-2024
Accepted: 20-Aug-2024

A Publication of Unique Scientific Publishers

Cite this Article as: Hanif K, Khan KQ, Ashraf S, Fatima A, Hassan SU, Tahir UB and Imran M, 2024. Nanoparticles: reshaping the future of breast cancer therapeutics. In: Rubio VGG, Khan A, Altaf S, Saeed Z and Qamar W (eds), Complementary and Alternative Medicine: Nanotechnology-I. Unique Scientific Publishers, Faisalabad, Pakistan, pp: 398-405. https://doi.org/10.47278/book.CAM/2024.414

INTRODUCTION

A group of disorders known as cancer are brought on by unchecked cell proliferation, which gives these aberrant cells the ability to proliferate and invade other bodily regions. Due to inadequate techniques for early cancer detection, cancer claimed the lives of approximately 9.6 million people worldwide in 2018 (Bray et al., 2018). According to American Cancer Society statistics, the most prevalent invasive cancer found in women worldwide is breast cancer (BC). In 2018, there were 266,120 newly identified cases of invasive BC with a possible death toll of 40,920. However, if discovered early enough, especially before metastasis, it is believed to be treatable (Liyanage et al., 2019). It is necessary to use novel and creative perspectives in order to handle breast cancer efficiently.

Current Obstacles in Breast Cancer Treatment

The disease's great biological diversity (tumor heterogeneity) in how it presents amongst cases, each case's rapid evolution (clonal evolution of cancer stem cells), the multiple canonical pathways driving the disease's progression, the serious side effects of the traditional treatment cocktail (chemo and adjuvant therapies), and the onset of therapy resistance make breast cancer a difficult disease to control (Tanaka et al., 2009). Managing recurrence and treatment resistance are two difficulties in the treatment of BC. In fact, metastases account for 30% of recurrent illness in early-stage BC (Pisani, 2002).

Therefore, in order to properly treat each BC subtype, new strategic medicines must be developed. Since different habitats coexist at the metastatic location, controlling BC in metastatic cases is a far more difficult task. The standard therapeutic approach was excising the tumor by surgery, followed by radiotherapy and chemotherapy, which frequently had a great deal of negative side effects on healthy tissues. Not driven by the HER2 protein or the hormones progesterone or estrogen, ten to twenty percent of cases of breast cancer are triple negative (TNBC) and is an aggressive form that is not

well responsive to chemotherapy or hormone treatments. TNBC is also associated with BRCA1 mutations. Patients with TNBC often have a worse prognosis due to medication resistance, unfavorable side effects, and possibly cancer recurrence (Foulkes et al., 2010).

Potential of Nanotechnology

The multidisciplinary field of nanotechnology, which has applications in medicine including targeted thermal ablation, gene therapy, nanoparticle-based drug delivery, imaging, diagnostics, and bio sensing, is founded on ideas from physics, biochemistry, chemistry, and materials science. Nanotechnology is the manipulation of cellular and molecular components of matter. The use of nanotechnology has expanded over the past few decades, and drug-loaded nanoparticles have a high loading capacity and are a promising tool for cancer treatments since they are less toxic, stable, efficacious, selective, and tolerable than conventional chemotherapy medicines. During BC therapies, anticancer drugs can be delivered to tumors either actively or passively using nanoparticles laden with the drugs. (Singh et al., 2017). Some of the most significant cancer therapy approaches have been made possible by the quick development of nanotechnology. (Tran et al., 2020). In cancer and reconstructive surgery, nanotechnology has great promise. Underlying conditions related to breast cancer recurrence through implants may benefit greatly from modified Nano medicine (Alshareeda et al., 2023).

Nanoparticles

Nanoparticles are extremely small crystals with a size of less than 100 nm, meaning they are limited to the Nano scale in all three dimensions. An integrated interfacial layer surrounds the nanoparticles, which is usually made up of ions or other inorganic or organic molecules. Since nanoparticles are used in Nano medicine to improve drug delivery and activity, they are of great scientific interest (Mirza and Karim, 2021). Because of their unique coating and typical tiny size, hydrophobic anticancer medicines are easier to administer to specific body locations with less immune system opsonization (Tang et al., 2017). Many nanoparticles that selectively target metastasized breast tumors have been developed, including those made of Carbon nanotubes, quantum dots, fullerene, gold, silica, and magnetic materials. Due to the conjugation of semiconductor fluorescent Nano crystals, like quantum dots, to antibodies, these target proteins can be accurately quantified and simultaneously labeled in a single section of breast tumor (Yezhelyev et al., 2005). The simultaneous detection and quantification of multiple proteins on small tumor samples will be made possible by the use of nanoparticles, including gold-containing nanoparticles (i.e., Raman probes) and quantum dots of various sizes and emission spectra. This will ultimately enable the customization of a particular anticancer treatment to a patient's unique tumor protein profile. Carbon nanotubes, fullerenes, grapheme, and Nano diamond-based nanostructured materials are the main carbon-based Nano systems being developed for cancer theranostics (Augustine et al., 2017).

Nanocarriers

The medical and/or therapeutic goals guide the multi-component architecture of nano-carriers. (Bolhassani and Saleh, 2013). The size, shape, and surface properties of the nanomaterials used in cancer research can be altered to treat particular tumor types. Size plays a crucial role in how well the nano carriers enter the bloodstream and reach the tumor tissue (Bregoli et al., 2016). Optimizing the size of nanoparticles could enhance their selective uptake into tumor tissue. The fluid dynamics and subsequent uptake of the Nano carriers can be affected by their form. Due to difficulties in manufacturing and testing, it seems that spherical Nano carriers are utilized more often than nonspherical ones (Truong et al., 2015).

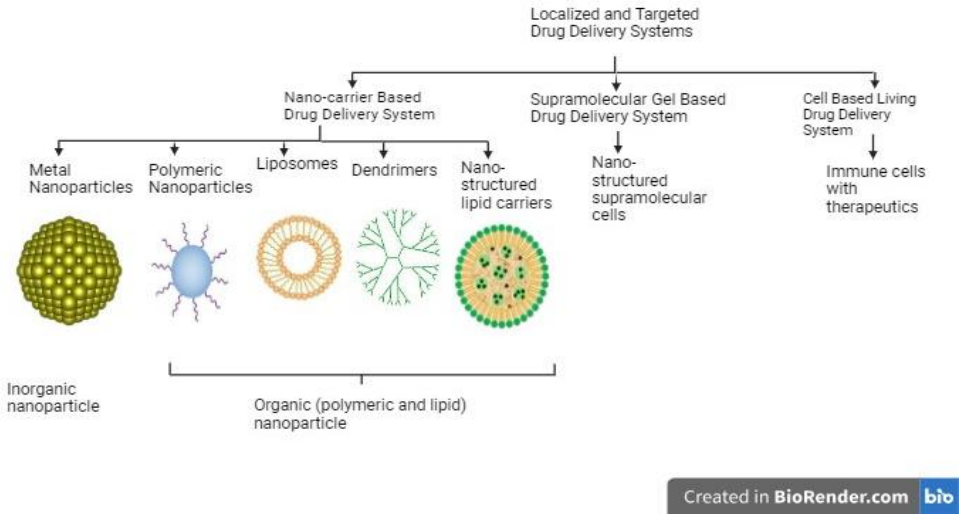


Fig. 1: Structure and classification of a system of nanocarriers.

By delivering the active ingredients to the intended tissue, the idea of a Nano carrier promises to lessen the harmful effects that would otherwise affect healthy tissues. Utilizing nanoparticles could enable tumor cells to receive tailored

medicine delivery. Using active or passive targeting raises the drug's concentration in the cancer cells. Given these benefits, patients with metastatic disease may have better results if nanoparticle medicines continue to go in the correct direction. However, the main obstacle to treating cancer is treatment resistance (Shapira et al., 2011). The composition of Nano carriers can be made sensitive to stimuli (such as pH or temperature changes) so that they release their cargo appropriately. Additionally, ligands that are recognized by receptors overexpressed in cancer cell tissues can be used to functionalize nano carriers. Finally, Polymers (such polyethylene glycol, or PEG) can be coated on nano carriers to increase their circulation time and remain invisible to the immune system (Viseu et al., 2018). The versatility of Nano carrier systems has been further investigated in relation to the development of theranostic (therapeutic + diagnostic) cancer treatment tools, which integrate many therapies with imaging techniques to track the body's distribution of therapeutic substances (Tabish et al., 2018).

Breast Cancer Treatment using Nanotechnology

The fast-moving clinical translation of effective breakthroughs based on nanotechnology has completely transformed the field of cancer treatment (Ferrari, 2005). Pharmacological uses of rapidly developing nanotechnology are available to identify and manage a range of illnesses, particularly cancer. The primary goals of Nano technological breakthroughs in cancer treatment include improved diagnostics, more effective medication delivery to tumor cells, and the development of targeted therapies (fig.2). The physio-biochemical characteristics of nanoparticles for therapeutic application are the focus of innovative Nano therapy, which is followed by targeted nanoparticle drug delivery aimed at reducing antitumor drug side effects with a promising fall in traditional treatment costs, a major barrier to cancer treatment (Mirza and Karim, 2021).

Nanoparticles-based Drug Delivery

Clinical trials are currently underway for a number of Nano particulate-based chemotherapeutic delivery systems for the treatment of BC, including liposome-, polymeric-, and nanoparticle albumin-bound paclitaxel formulations that have already received US FDA approval. With a unique coating that prevents immune system attack, Doxil® and Abraxane®, Two US FDA-approved drugs based on nanotechnology currently on the market, represent significant advances in cancer treatment. This allows for the precise medication administration to cancerous cells with a reduced risk of side effects compared to current chemotherapies.

Global experts in cancer treatment have become interested in Nano particulate drug delivery systems (NDDS) and, in particular, lipid nanoparticles (which have a increased level of biocompatibility and adaptability) because of their size-dependent features and prospective benefits. It is possible to create lipid Nano particulate formulations with a variety of characteristics that are pertinent to different disease states and administration routes. Additional specialized formulation criteria, such as affordability, stability in terms of chemicals and biology, decreased poisoning, and increased effectiveness, can also be met by customizing the product. Furthermore, lipid-based Nano carriers are seen to be attractive options for the formulation of both immunotherapeutic medicines and conventional chemotherapeutic drugs due to their safety and efficacy profiles (Mizrahy et al., 2017). Trans membrane glycoprotein HER2 is encoded by the human ErbB2 gene and is a target for immunotherapy against breast cancer (Lee and Muller, 2010). To target breast cancer that is HER2-positive, vaccines and other Nano medicines may be developed using overexpression of HER2, which induces an immunological response (Savas et al., 2016).

The FDA approved albumin Nano particle chaperones of paclitaxel for treatment in recurrent and metastatic BC ten years after approving liposomally encapsulated (pegylated) doxorubicin (anthracycline) for use in metastatic cancer in 1995. The latest generation of liposomal dox is safer and less cardio toxic than conventional dox, while yet having efficacies comparable to those of the former (Hortobagyi, 1997). Specifically, the proteins expressed on cancer cells are not targeted by first-generation classified vectors (Ferrari, 2008). Active targeting, or the ability to identify and focus on certain biological substances found on the surface of cancer cells, is what has allowed the "second generation" of therapeutic nanovectors to develop. Applying this method has the potential to decrease potentially fatal systemic cytotoxicity and increase the therapeutic window for delivering larger concentrations to sick lesions (Tanaka et al., 2009). High affinity ligands, including folate (Gabizon et al. 2004), prostate-specific membrane antigen (Farokhzad et al. 2006a), and Arg–Gly–Asp (RGD) (Pasqualini et al. 1997), can be chemically coupled to the surface of nanoparticles to achieve this. This enhances the interaction between the cancer cells and the nanoparticles, leading to a significant advancement in the bio distribution of nanoparticles in comparison to non-targeted first-generation Nano vectors.

Using a multi-stage approach, According to Tasciotti et al. (2008), the "third generation" of nano vectors is characterized by a greater degree of multi-functional integration and as a carrier for nanoparticles. First stage biodegradable mesoporous silicon micro particles can be loaded with one or more second stage nanoparticle types carrying various payloads for imaging and therapy. Since the first stage of the third-generation vectors' delivery method directs the particles towards the vascular endothelium and the second stage particles pass via the fenestrations, it does not depend on the EPR effect. Third-generation vectors' modularity offers a potent tool for addressing a variety of unmet medical needs, with an emphasis on the creation of multifunctional and multimodal medicines (Tasciotti et al., 2008).

DNA nanostructures are carefully built and developed to have controllable size, shape, function, surface, and chemistry. DNA nanostructures have been effectively loaded with two powerful anticancer drugs, doxorubicin (Dox) and CpG oligonucleotides, to increase their cellular absorption effectiveness (drug payload) (Hu et al., 2018).

Nanoparticles-based imaging

Using common imaging modalities including computer topography, positron emission tomography, magnetic resonance imaging, and near-infrared fluorescence imaging, both active and passive targeting NPs can be utilized to target

and scan breast cancer and metastases (Mu et al., 2017). Tracking the course of cancer and the effectiveness of used therapy requires both qualitative and quantitative imaging. Receptors, anchoring proteins, transporters, enzymes, and other cell membrane protein indicators are often targeted for imaging because of their 2- to 100-fold higher amounts on tumor cells. Because of its extreme overexpression in tumor cells (HER2 is one of the most expressed membrane proteins) and its low expression in healthy cells, HER2 is a perfect biomarker for cancer. For the treatment of metastatic BC with HER2 overexpression, the FDA-approved anti-HER2 monoclonal antibodies trastuzumab and pertuzumab have previously been produced (Cai et al., 2008).

Table 1: Chemotherapeutic agents including nanomaterials in cancer clinical trialss (Jin et al., 2020)

	Year	Drugs	Disease	Findings
Liposome	2015	Doxorubicin	Platinum-Sensitive Ovarian Cancer	beneficial risk-benefit ratio
		Paclitaxel	Non-Small Cell Lung Cancer	significant resection rate and disease response, with manageable toxicity
		Ursolic acid	Advanced Solid Tumors	reasonable, controllable toxicity, increasing the rate of patient remission
		Mitomycin C	advanced cancer	lengthy half-life, bearable, and efficient
	2016	miR-34a Mimic	Advanced Solid Tumors	efficient
		Vincristine Sulfate	Refractory Solid Tumors or Leukemias	lacking neurotoxicity with a dosage limit
		5-fluorouracil and Leucovorin	Advanced Solid Tumors	extended half-life, reduced peak plasma concentration, and greater area
		Cytarabine	Childhood Acute Lymphoblastic Leukemia	no long-term detrimental neurological effects
	2017	Amphotericin	Acute Lymphoblastic Leukaemia	efficient
		Irinotecan	Recurrent High-Grade Glioma	nothing atypically poisonous
	2018	Cytarabine and Daunorubicin	Newly Diagnosed Secondary Acute Myeloid Leukemia	notably higher survival rate
		Curcumin	Locally Advanced or Metastatic Cancer	resilient
		Daunorubicin	Pediatric Relapsed/Refractory Acute Myeloid Leukemia	well-accepted and exhibited high rates of reaction
		Lipovaxin-MM	Malignant Melanoma	safe and devoid of harmful side effects that are scientifically noticeable.
		Vincristine Sulfate	Acute Lymphoblastic Leukemia	offered a significant clinical advantage and safety
		Oligodeoxynucleotide	Refractory or Relapsed Haematological Malignancies	tolerant, efficient
	2019	Eribulin	Solid Tumours	well-accepted with a pleasant pharmacokinetic profile
polymeric Micelles	2017	Epirubicin	Solid tumors	demonstrated less toxicity than conventional epirubicin formulations and was well tolerated in patients with a variety of solid malignancies
	2018	Genexol-PM plus carboplatin	Ovarian Cancer	Well-tolerated toxicity and superior efficacy
	2019	Paclitaxel (PTX)	Breast cancer	NK105 had a better PSN toxicity profile than PTX

The poly(d,l-lactide-co-glycolide) (PLGA) polymer, which has FDA approval for therapeutic use in humans, served as the basis for the development of the majority of polymeric nanoparticles. For preclinical research in TNBC tumor models, nontargeted polymeric nanoparticle drug carriers have been developed. One such example is an active metabolite of irinotecan (SN38) encapsulated in polymeric nanoparticle that demonstrated anticancer effectiveness in the 4T1 mouse mammary tumor model (Sepehri et al., 2014). For the purpose of tracking medication administration, Certain polymeric nanoparticles have had a variety of imaging agents added to them. Because NIR imaging is easy to use, quick to detect when drugs are delivered via nanoparticles, and can be used to optically image tumor cells that are resistant to treatment before excision, it has been fully studied (Miller-Kleinhenz et al., 2015).

One non-invasive method of medical diagnosis is magnetic resonance imaging (MRI). Certain exogenous contrast agents are used to boost contrast and provide improved resolution and sensitivity in magnetic resonance imaging (MR) since it can be challenging to distinguish between normal and diseased tissues in these images. A measurable magnetic

resonance (MR) signal is produced by the metal nanoparticles' enormous surface area and size, which exhibit super paramagnetic phenomena. Specifically, a great deal of research has been done on super paramagnetic iron oxide nanoparticles (SPIONs) as T2 contrast agents in magnetic resonance imaging (MRI). This is due to the fact that phantom pictures' negative contrast (darkness) can be enhanced by the T2 relaxivity of water protons (Núñez et al., 2018). There is a development underway to create "smart" Nano probes that can sense changes at the molecular level and interact in vivo with natural systems. Systematically administered, ligand-biomarker-accumulated Nano probes provide deep diagnostic imaging by relaying signals from malignancies (Ferrari , 2005).

Using imaging probes specific to biomarkers for image-based diagnosis and therapy monitoring is a promising way to improve cancer imaging's sensitivity and specificity (Weissler, 2006). Despite having a high sensitivity, nuclear imaging methods need complex and costly radiochemistry and have poor resolution and anatomic localization of the tumor lesion. Injectable nanoparticles have proven to be useful imaging probes for cancer detection in animal experiments because they attach to specific proteins on cancer cells, such BC cell mammaglobin. In addition to enabling non-invasive therapies such employing infrared light to kill cancer cells, an imaging contrast ant with nanoparticles can reach a tumor site and help identify cancerous cells. It is anticipated that widespread adoption will happen during the next five to 10 years. Though confusing, adaptable Nano medicine will play a significant role in providing superior alternatives to conventional cancer treatments.

Nanoparticles-based gene therapy

When it comes to breast cancer gene therapy, nanoparticles have the potential to be a game-changer since they can be an efficient carrier of a particular medicine or gene by increasing bioavailability, decreasing the likelihood of recognition based on the immune system, and precisely supplying the gene regulator (Mirza and Karim, 2021). Gene therapy aims to substitute a malfunctioning gene with a functional one, healthy variation. Prosperous gene delivery requires the crossing of both extracellular and intracellular barriers. Immune reaction is deliberately dodged or reduced, and immunologically inert minicircles are also employed for effective systemic delivery of gene. Usually, lipid bilayer membranes are disrupted to allow for the methodical delivery of naked pDNA using laser irradiation, sonoporation, or electroporation (McCrudden and McCarthy, 2013). A magnetic field can be used to drive gene editing in vivo in Zhu et al.'s prospective translation approach for CRISPR-Cas9 therapeutic systems. In tumor-bearing mice models, they used recombinant baculovirus vectors multiplexed with Nano magnets to maximize efficiency, reduce genotoxicity, and improve transduction in target cells and targeted tissue distribution (Mirza and Karim, 2019).

In triple negative breast cancer, TP53 is the most often altered or deleted gene. One neighboring gene that is a potential collateral susceptible target of TP53 is POLR2A (RNA polymerase II subunit A). Cancer cells are extremely vulnerable to additional TP53 suppression or inhibition since nearly Every TNBC with a decrease in TP53 copy number also has hemizygous POLR2A deletion. It's interesting to note that TNBC has partial deletion of this specific crucial gene, which may provide a targeted treatment alternative. POLR2A is the target of a recently developed and patented low pH-triggered Nano bomb (Xu et al., 2019). Upon delivery to a TNBC cell, with a controlled release, this POLR2A inhibitor-containing Nano-bomb multiplied 100 times its initial size and killed cancer cells specifically.

In addition to offering great promise for the creation of multimodality agents with imaging and therapeutic properties, nanoparticles are also highly promising as diagnostic imaging agents. However, some of the most promising nanoparticles have heavy metals and show extended tissue preservation. There are significant toxicity concerns with this. By minimizing the time of exposure to these compounds, the production of nanoparticles with appropriate clearance properties will reduce the risks associated with toxicity (Longmire et al., 2008). Therefore, creating nanoparticles with the best possible clearance or biodegradability is a necessary requirement before using them in a clinical setting.

Nanoparticles-based Diagnosis

By using fluorescent in-situ hybridization, fluorescent nanoparticles can be used in cancer diagnostics to identify a variety of genes and matrix RNA, as well as to multiplex simultaneous profile of tumor indicators (Yezhelyev et al., 2006). The quality of life and survival rates of BC patients are severely impacted by late diagnosis; therefore, earlier cancer detection and more accurate diagnosis are desperately needed. Recently, a number of Nano-based techniques, such as aptamers, QDs, and organic and inorganic NPs, have shown promise as methods for detecting and screening HER-2+ BC (White et al., 2020). The majority of targeted agents take advantage of mAbs, Fabs, scFv, and anti-HER-2 humanized monoclonal antibodies (Trastuzumab and Pertuzumab). The dual benefit of labeling NPs with these targeting moieties is that it stabilizes the targeting agent and loads many contrast agents onto a single vector, greatly enhancing the signal's specificity and intensity. Additionally, the ability to alter the constructs' physico-chemical characteristics offers far more control over the bio distribution and clearance kinetics, which enhances tumor retention and permits longer imaging times for the tumor tissue (Sitia et al., 2022).

In the past few years, molecular diagnostic techniques based on nanotechnology have advanced very quickly, and in the future, they will become a vital possibility for the diagnosis of cancer. Aptamer-guided silver–gold bimetallic nanostructures have a notable cytotoxic effect on the BC cell line MCF-7. The highly active surfaces of these nanostructures enhanced Raman scattering, allowing for the potential treatment of BC cells using near-infrared photothermal therapy (Wu et al., 2012). Concurrently doing clinical breast examination, breast imaging, and biopsy is known as a triple test, which increases diagnosis accuracy and lowers the amount of false negative results. As a cutting-edge method for breast cancer early detection, iron oxide nanoparticles offer a lot of promise. The latest goal of Google Inc. is to create wearable detectors

and iron oxide NP diagnostics, which will be included in the upcoming Google Wear operating system and device versions (Nounou et al., 2015).

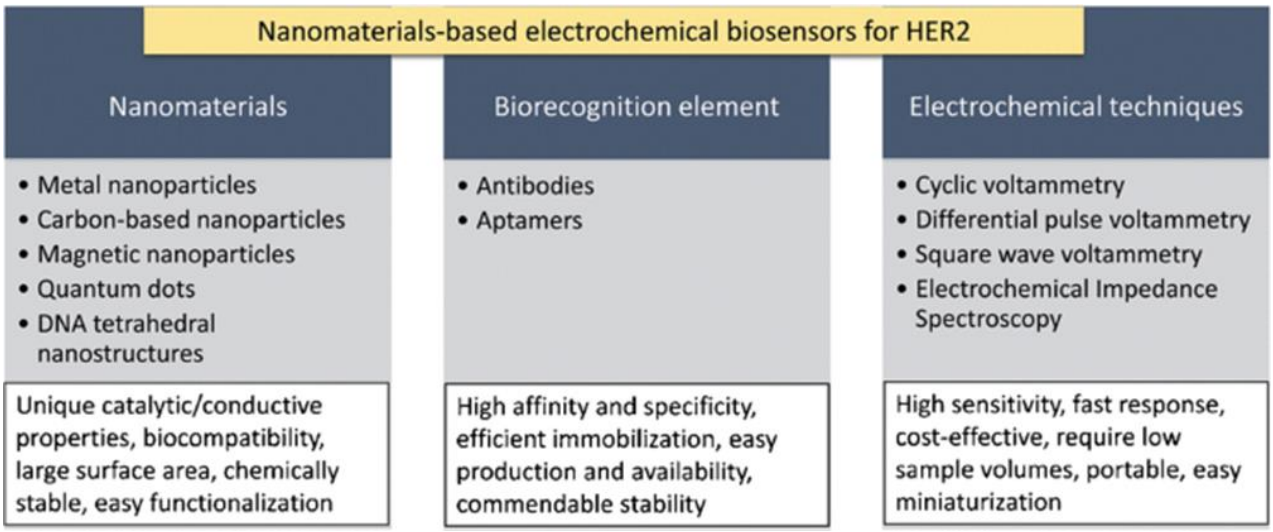
Since miRNA can either restore or repress miRNA expression, they appear to be a promising diagnostic biomarker with the potential to be employed for early identification of BC. Enhanced clinical relationship between the illness type and stage can be achieved by mining the regulation mediated by miRNA. As an alternative, nanotechnology offers a strict and sensitive miRNA detection method with significant implications for cancer theranostics. Strongly targeted therapeutic miRNA for tumor targets has also been demonstrated to be delivered noninvasively using nanoparticles and Nano pores (Cai et al., 2015).

Nanoparticles-based Thermoablation

Though it is thought to be the greatest option for treating confined tumors, surgical resection is ineffective for treating heterogeneous cancer, metastases, and small tumors (less than 3 cm in size). Tumor ablation therapy is a minimally invasive local treatment approach that has unique benefits for treating tumors that are difficult to surgically remove. Nevertheless, ablation therapy is unable to entirely eradicate all tumor tissues and cells at once due to its physical and chemical makeup as well as the limitations of equipment technology. Not only that, but the ablation process invariably causes some normal tissues nearby to be damaged. According to recent research, certain types of ablations can kill tumor tissues by physically inducing an immune response. This can then produce a large number of immune cells that kill tumor tissues and cells again. Metal nanoparticles coated with immunological medicines can enhance the effectiveness of this anti-tumor immunotherapy. Consequently, there is a lot of room for research on the use of metal nanoparticles in conjunction with ablative treatment (Xie et al., 2023).

Nanoparticles-based Biosensing (immunosensing)

Electrochemical biosensors that utilize nanomaterial, antibodies, and aptamers have gained significant traction as effective and efficient methods for detecting HER2-ECD. These biosensors take advantage of the distinct conductive characteristics, large surface area, chemical stability, and high affinity and specificity of aptamers and antibodies, as well as the unique properties of nanomaterial to assess HER2 in a selective and sensitive manner (Ahirwar , 2021). As bio recognition elements or detection probes, (Peng et al., 2014).



According to reports, aptasensors and electrochemical immunosensors for HER2 have been developed utilizing label-free and label-based detection methods. The label-free methods make use of HER2's inherent properties, which impose electrode impedance fluctuations and permit label-free detection. On the other hand, the label-based approaches increase test sensitivity by producing an enhanced signal by attaching labels to biomolecules or electrode surfaces, such as fluorescent tags, enzymes, and nanoparticles (Bogomolova et al., 2009). Improved bio recognition element immobilization increased electrochemical signal output, and decreased background noise (i.e., a rise in the signal-to-noise ratio) have all been made possible by the use of nanomaterial in bio sensing applications (Shan et al., 2020).

Breast cancer gene therapy via nanoparticle-mediated targeted death

This type of treatment aims to cause malignant cells to die by expressing genes whose protein products trigger several death pathways. Typically, pDNA is used to administer these genes. When compared to the protein itself, pDNA has a number of benefits. For example, even when purified on a large scale, pDNA does not cause an immune response, and tumor cells do not become resistant to it. Three main methods are used in gene therapy to cause cell death: a) Gene-directed enzyme prodrug treatment (GDEPT); b) Toxin-induced; and c) Induced apoptosis (Vago et al., 2016). A series of genetic mutations and aberrations discovered in BC are excellent for gene therapy, which involves giving cancer cells a nucleic acid-based drug to either correct the genetic defects or kill the malignancies. The goal of death-induced gene therapy is to completely

eradicate malignant cells, so its difficulty is to cause death only in diseased tissues while sparing healthy ones. One of the main challenges in gene therapy is creating the ideal transfection vector, and for breast cancer gene therapy, nanoparticles seem to be a promising fit(Roacho-Perez et al., 2018).

Conclusion

Nanomaterials are being carefully chosen to change the objectives of breast cancer medication and examination by reducing the discomfort associated with conventional chemotherapy, overcoming present clinical challenges and influencing the therapy landscape going forward. A summary of the latest advancements Systems for delivering drugs or genes against cancer, particularly breast cancer, using nanoparticles have been developed, focusing on the drug delivery method and strategy design utilized in nanomedicine. Nanoparticles-based drug delivery systems provide superior stability, pharmacokinetics, biocompatibility, and tumor targeting in contrast to traditional drug. Moreover, they reverse medication resistance and greatly reduce systemic toxicity. Notwithstanding moral and security issues, nanotechnology offers a useful arsenal in the fight against cancer.

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