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Review

Vaccines in Breast Cancer: Challenges and Breakthroughs

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Abstract: Breast cancer is a problem for women's health globally. Early detection techniques come in a variety of forms ranging from local to systemic and from non-invasive to invasive. The treatment of cancer has always been challenging despite the availability of a wide range of therapeutics. This is either due to the variable behaviour and heterogeneity of the proliferating cells and/or the individual's response towards the treatment applied. However, advancements in cancer biology and scientific technology have changed the course of the cancer treatment approach. This current review briefly encompasses the diagnostics, the latest and most recent breakthrough strategies and challenges, and the limitations in fighting breast cancer, emphasising the development of breast cancer vaccines. It also includes the filed/granted patents referring to the same aspects.

Keywords: breast cancer; diagnostics; biomarkers; therapeutics; vaccine strategies; antigens; adjuvants; challenges; patents

1. Introduction

Cancer is a heterogeneous disease [1–6] with a poor median survival rate [3]. According to the WHO, it is the second-leading cause of death worldwide [5,6], with breast cancer (BC) being the most common form diagnosed in females [7]. About 5–10% of patients diagnosed with BC exhibit its metastatic form [8]. Moreover, it is highly challenging to forecast the prognosis of the illness with high certainty [3]. BC is classified as invasive or non-invasive [9,10]. The invasive form includes infiltrating ductal carcinoma (IDC) and invasive lobular carcinoma (ILC), while the non-invasive form includes ductal carcinoma in situ (DCIS) and lobular carcinoma in situ (LCIS) [10]. BC is further categorised depending upon the expressing hormone receptor such as the estrogen receptor (ER+), the human epidermal growth receptor 2 (HER2+), the progesterone receptor (PR+) and triple-negative breast cancer (TNBC), i.e., ER, PR, and HER2-all negative [11]. TNBC makes up 10–30% instances of BC [12] and is distinguished by a higher rate of relapse, higher potential for metastasis, and a shorter overall survival [13]. Additionally, cases of male BC, which may be either congenital, developmental, or acquired [14], have recently increased by about 40%, outpacing female cases by 25% of the affected population and by 18% in terms of mortality [15,16], though accounting for fewer than 1% of total BC diagnoses [14,17–19].

The article discusses at length the principle, approaches, and types of vaccines; and the routes of administration, antigens, and adjuvants used in the development of a BC vaccine, including combination therapeutic approaches and the clinical trials taking place in the field, along with a brief discussion on the diagnostics and the treatment strategies.

2. Diagnostics and Treatments in BC

In the recent past, various diagnostics have been developed for the detection of cancer in human subjects. The review briefly presents the diagnosis and its advancements, especially in BC detection. These include computer aided diagnosis (CAD), magnetic resonance imaging (MRI), tomography, Raman imaging, mammography, biopsy, radiomics, pathomics, and the use of artificial intelligence (AI), exosomes, and biomarkers.