

Potential of nanoparticles in cancer therapeutics: An insight

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Cancer is the second major cause of death, exceeded only by cardiovascular diseases. It is characterized by uncontrolled cell proliferation and an absence of programmed cell death. While surgery and radiotherapy are the primary treatments used for local and nonmetastatic cancers, anti-cancer drugs (chemotherapy, hormone and biological therapies) are the choice currently used in metastatic cancers. Unfortunately, chemotherapy also affects normal cells especially those with fast proliferation rates, such as the hair follicles, bone marrow and gastrointestinal tract cells, generating the characteristic side effects of chemotherapy. The indiscriminate destruction of normal cells, the toxicity of conventional chemotherapeutic drugs, as well as the development of multidrug resistance, support the need to find new effective targeted treatments based on the molecular targets of the tumor cells. These novel targeted therapies includes nanoparticle mediated targeted drug delivery in order to specifically deliver chemotherapeutic agents to the cancer cells, vis a vis minimizing the undesirable side effects.

Nanoparticles (NPs) are a group of nano-sized vehicles devised to deliver drugs to target malignant tissues or organs and have provided remarkably improved therapeutic efficacy for cancer therapy. A variety of NPs have been developed to accommodate efficient loading and release of drugs with a wide spectrum of chemical and physical characteristics. In addition, physicochemical modifications of the surface or interior of NPs allow for modulation of pharmacokinetic features as per clinical demands. However, cancer-related mortality still remains high and drug-mediated cancer treatment a challenging research field despite the remarkable advances in targeting efficiency and therapeutic efficacy demonstrated and resulted from NPs. In this review, we focus on typical approaches and recent trends in NP-mediated drug delivery and their potential for targeted cancer therapy.

1. INTRODUCTION

Cancer is one of the most devastating diseases that it is typically characterized by uncontrolled proliferation, replicative immortality and resistance to cell death. A report indicates that more than 10 million cases annually worldwide are being diagnosed further it is estimated that by 2030, there will be 15 million new cases every year which calls for the sincere concern of scientific community [1-3]. The major reasons for poor patient survival is mainly due to attributable to widespread metastasis, lack of effective treatment strategies and multiple drug resistance [4]. The conventional chemotherapeutic drugs are distributed in non-specific manner where they affect cancer as well as normal cells; they fail to accumulate specifically in the cancerous cells; hence induce severe undesirable toxic effects on healthy cells. The therapeutic effectiveness of formulation directly correlates to its ability to selectively target to and preferentially accumulate in the cancer cells, overcome biological barriers, “smartly respond” and provide controlled and sustained release of the drug payload. Thus, there is a need to develop some novel drug delivery strategies based on nanocarrier(s) that could provide specific targeting of the drug(s) to tumour cells and cause minimum toxicity to healthy cells. Over the last three decades remarkable efforts have been made by oncologists, bioengineers in the area of cancer chemotherapeutics; however absolute treatment could not be developed and achieved [5, 6]. Although only a limited number of nanomedicine(s) have been approved for human use, majority of them are in the developing stages and yet to prove the concept preclinically. In recent

years, significant progress has been made applying nanotechnology based approaches that target specifically the tumour cells and improve the localized delivery. Although these approaches could improve the therapeutic efficacy with minimum systemic toxicity of bioactive(s), much attention on effective delivery strategies is still needed focusing on chemotherapy related side effects and patient compliance [7-9].

2. LIMITATIONS OF EXISTING CANCER THERAPIES

Chemotherapy, surgery and radiotherapy are well known main curative treatments for local and non-metastatic cancers, generally successful if the cancer is detected at an early-localized stage, however these mode of treatment turn to be inefficient when the cancer spreaded throughout the body as a result of metastasis and thereby progressed to a locally advanced cancer. The current choice for the treatment of metastatic cancers is chemotherapy, hormonal therapies and biological therapies; since the bioactive(s) could reach each organ or body parts through the bloodstream. The current treatments of cancer still have many unmet needs and have major limitations as shown in Figure 1. In spite of important progresses in the cancer treatment adjuvant and combinatorial therapies are more effective but only for a defined period of time. Obviously, more effective and specific alternative options for the cancer continue to be a therapeutic need. The effective treatments of cancer should effectively address the chemotherapy associated severe side effects, drug resistance and circumvent and prevent the tumour evasion [10, 11].

