Chapter 6
Nanomedicine

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ABSTRACT

Nanomedicine deals with the usage of nanotechnology for medical purposes. Due to their identical size to the majority of biological molecules, nanomaterials utilized in nanomedicine are advantageous for in vivo applications. The aim of applying nanotechnology in medicine is to effectively diagnose and treat diseases. Although nanomedicine remains in its early stages, many analytical tools, diagnostic devices, biosensors, drug delivery vehicles, and physical therapy applications are being developed under this branch of medicine to treat diseases. It is anticipated that a growing number of medicines will use nanotechnology in the coming years as a result of the progress in the field. However, as nanotechnology develops, it is essential to consider both benefits and limitations of the technology including its potential risks. Current problems in the development of nanomedicine involve the toxicity and environmental effects of nanoscale compounds, but as the field develops, its impact on the economy is expected to be significant in the future.

INTRODUCTION

The area of medicine known as "nanomedicine" deals with using nanotechnology for medical purposes (Tinkle et al., 2014). Nowadays, nanomedicine is acknowledged as a significant field for developing cutting-edge treatments for unmet medical requirements (Pita, Ehmann, & Papaluca, 2016). Nanomaterials are being used in clinics for diagnosis, control, monitoring and treatment of diseases (Soares, Sousa, Pais, & Vitorino, 2018). For the application of nanomaterials in medicine, the physicochemical properties of the nanoformulation needs to be considered such as distribution, absorption, metabolism and elimination, crossing biological barriers, persistence in body and toxicity (Tinkle et al., 2014).

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Physicochemical properties of nanomaterials differ from other chemical counterparts mainly because of their size that makes them more suitable to be used in drug development (Soares et al., 2018). Their size provides increased particle surface energy because of increased surface area compared to volume that makes them more reactive (Pino et al., 2014). Nanoparticles thus have the ability to adsorb biomolecules and are designed based on where they enter the body and the kind of bodily fluids they come into contact with (Louro, 2018).

Nanomaterials can be made to engage with certain biological targets by adjusting their shape, size, chemical composition and surface (B. Y. Kim, Rutka, & Chan, 2010). A careful nanoparticle design is thus required for a desired biological outcome. This calls for in-depth understanding of the interaction of nanomaterials with living systems, which requires a better understanding of the pathophysiological nature of disease to design particles that can reach the target site (Albanese, Tang, & Chan, 2012).

To understand the performance of nanoparticle in the body, it is necessary to characterize it. Nanoparticle characterization offers recommendations for process control and safety evaluation. The characterization should ideally be performed at various stages throughout the lifecycle of nanoparticle starting from its design to *in vivo* performance as the different steps of the lifecycle can modify some properties of the nanoparticle and thereby, interfere with measurements. The characterization also helps in informing the potential risks caused by nanoparticles to the human body (Lin, Lin, Wang, & Sridhar, 2014).

Nanomaterials are applied in medicine for nanodiagnosis, nanotherapy and regenerative medicine. They are introducing positive developments in clinical practice because of the following advantages: 1) they allow the use of multiple mechanisms of action. 2) they integrate molecules that could otherwise be highly toxic. 3) they maximize efficacy by reducing dose and therefore toxicity. 4) they have better passage across biological barriers. 5) they provide site specific drug release (Ramalingam & Rana, 2015; Soares et al., 2018). Even though nanomedicine is still in its beginning, there are a wide variety of nanomedicines in market, in clinical trials, or under development (E. M. Kim & Jeong, 2017). Bringing these nanomedicine-based technologies in use will supply strong means for treating diseases. However, there is potential of nanomaterial toxicity and the unique challenges brought by nanomaterials require ethical standards and legal regulations (Zor, Selek, Orlando, & Williams, 2019).

CLINICAL APPLICATION OF NANOTECHNOLOGY

The health sector is currently working to increase output, accessibility, and treatment quality while lowering costs. Nanotechnology has revolutionized the healthcare approaches in recent years that provides hope for a strong influence on offering improved medical services. Nanomedicine involves regulation, fabrication, design and use of treatments and devices with size range in nanoscale (1–100 nm) in this context (Minakshi Prasad et al., 2018). Exclusive countrywide and global organizations and pharmaceutical companies are investing in developing new gene therapies, *in vivo* imaging tools, and drug delivery methods using this technology (M. Prasad et al., 2018). Nanotherapeutics offers fresh opportunities to increase the effectiveness and safety of conventional therapies (Kaspar & Reichert, 2013). Cancers, blood disorders, neurological diseases, orthopaedic issues, infectious diseases and diabetes are among the conditions for which nano-based drug delivery methods hold promise. These methods also hold promise for infectious diseases which present difficulty because the traditional antimicrobial drugs used to treat them have negative impacts and drug resistance. The primary difficulty in achieving the anticipated treatment efficiency from conventional drugs is target specificity. Nanoparticles have demonstrated to