CHAPTER 8

CHALLENGE AND FUTURE PROSPECT OF NANOMEDICINE

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8.1 INTRODUCTION

Nanotechnology can be defined as an area in science and engineering that deals with phenomena occurring at the nanoscale dimension, which is the fundamental concept for innovative design in various areas such as medicine, communications, genomics, and robotics. For the past decade, nanotechnology has shown significant potential to stimulate economic growth and improve capacity and quality in various research and development sectors. Moreover, nanotechnology has positively impacted society's welfare and shaped the nature of modern living through its various applications (Marchant, 2016). This technology is said to bring about significant changes in economic conditions and human life, particularly within the healthcare system. The application of nanotechnology in medicine can be termed nanomedicine, as it defines the use of any nanomaterials in the prevention (immunotherapy, vaccines), detection (biosensor), and treatment of diseases (drug delivery, regenerative medicine) as tabulated in Table 8.1 (Saxena et al., 2020).

Table 8.1 Application of nanotechnology in medicine (Source: Saxena et al., 2020)

Area	Application
Therapeutics	Antidiabetic therapy Antimicrobial nanoparticles Cancer therapy
Drug delivery system.	Hybrid nanoparticles Micelles Liposomes Polymeric nanoparticles
Regenerative medicine	Nano-hydroxyapatite AuNp-blended polycaprolactone (PCL)
Diagnostic	Positron emission tomography Computed tomography Magnetic resonance

Nowadays, a wide range of nanomaterials have been thoroughly studied in clinical studies and given approval for usage in practice. Their distinct physicochemical characteristics, such as their high surface area and surface functionalisation, have led to better bioavailability, reduced toxicity, and enhanced pharmacokinetic effects (Zhao, 2018). These advantages arise from nanoparticles' distinctive physical and chemical attributes (NPs), including their chemical composition, customisable shape, expansive surface area, morphology, and small size. Therefore, nanomaterials can serve as alternative or novel materials that overcome the limitations exhibited by conventional drugs, possessing the capability to meet the current market demands in the treatment of diseases.

While nanomedicine has demonstrated its capacity to transform the pharmaceutical industry completely, its progress and development face greater challenges compared to other nanoproducts (Saxena et al., 2020). For instance, thorough pre-clinical research, clinical trials, and clinical indications are necessary for a successful drug translation. But it could take years to finish, and errors or unfavourable outcomes could

negatively impact the development. Furthermore, the toxicity of nanomaterials must also be carefully addressed, as a toxicity assessment is required to fully understand and mitigate any potentially harmful effects on the human body (El-Kady et al., 2023).

Moreover, the biocompatibility of nanomaterials is also an issue as it may interfere with the physiological, pharmacological, and immunological processes of the human body. In addition to their impact on humans, concerns about the toxicity of nanomaterials to the environment have also become a major focus for researchers and authorities (El-Kady et al., 2023). Ethical considerations surrounding the use of nanomedicine are also a major concern that must be carefully addressed, as privacy concerns related to the collection and use of personal data must be fully protected (Wasti et al., 2023). Finally, nanomaterials' safety and regulatory issues require additional considerations compared to traditional drugs. Therefore, a comprehensive understanding of the state of nanotechnology today is necessary to improve the effectiveness of clinical translation. At the same time, the existing challenges and future demands must be thoroughly understood. This chapter discusses the current challenges and limitations during the development of nanomedicines and the future direction to accelerate the growth of nanomedicine, as shown in Figure 8.1.

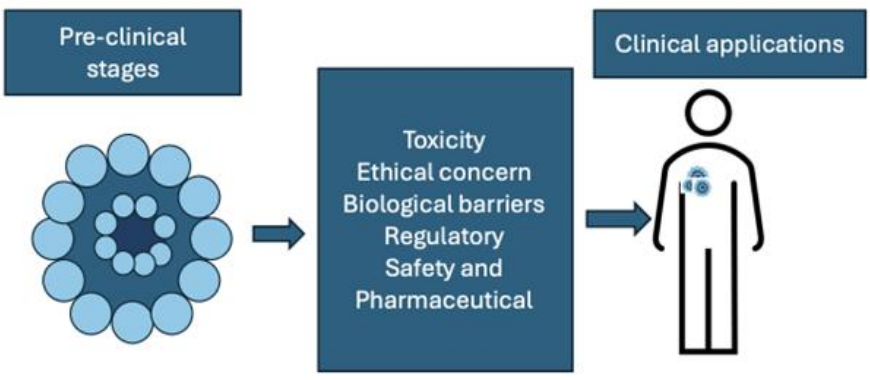

Figure 8.1 Challenges of nanomedicine