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Nanotechnology: Advancing the translational respiratory research

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Abstract: Considering the various limitations associated with the conventional dosage forms, nanotechnology is gaining increased attention in drug delivery particularly in respiratory medicine and research because of its advantages like targeting effects, improved pharmacotherapy, and patient compliance. This paper provides a quick snapshot about the recent trends and applications of nanotechnology to various translational and formulation scientists working on various respiratory diseases, which can help paving a new path in developing effective drug delivery system.

Keywords: nanotechnology, respiratory, translational, nanoparticulate, drug delivery

Introduction

Chronic respiratory diseases, including asthma, chronic obstructive pulmonary disease (COPD), and cystic fibrosis (CF), are the leading cause of morbidity and mortality worldwide [1]. This is primarily because of the aging population and increasing prevalence of cigarette smoking globally [2]. Thus, it is very crucial for an effective drug delivery system to deliver the therapeutic moiety to the target site at the right time and in an appropriate amount especially with various chronic respiratory diseases, such as asthma where an immediate therapeutic action is needed. Most of the conventional dosage forms have various limitations such as dose dumping, non-targeted effects, multiple administration of drug leading to lesser patient compliance, which lead to the emergence and trends of novel drug delivery systems where nanotechnology is one of the key role players [3]. Nanotechnology is an area in which the drug is incorporated into a nanosystem that provides a new dimension to the pharmacotherapy and have cell-targeted drug delivery approach [4, 5], which is required in majority of the chronic respiratory conditions such as lung cancer, COPD, and pulmonary fibrosis.

Advancements in Translational Respiratory Research (TRR)

With the recent advancements in the area of TRR, various new therapeutic moieties have been identified such as microRNAs [6, 7], monoclonal antibodies [8], and short-interfering RNAs [9]. Moreover, translational research also plays a crucial role in finding solutions to various problems that interfere with the therapeutic effectiveness of active moieties in treating various respiratory conditions such as biofilms [10]. All such recent developments involve the application of nanotechnology in the modern era so as to ensure better patient compliance. The main potential applications in respiratory medicine include drug delivery, gene delivery, regenerative medicine and tissue engineering, and tumor destruction [4]. Some of the recent

translational studies using nanotechnology in different respiratory diseases are listed below:

Asthma

The intravenous administration of antigen-conjugated polystyrene nanoparticles (NPs) can inhibit Th2 responses in mouse model of allergic airway disease [11]. Similarly, targeting IL4Rα using biocompatible NPs containing anti-IL4Rα antibody has also shown decreased inflammation in Bronchoalveolar lavage fluid (BALF) and airway lung tissue of the allergic (ovalbumin-sensitized) mice [12]. Various other advancements in allergen-specific immunotherapy include strontium-doped hydroxyapatite porous spheres [13], exploring the potential of protein corona [14].

COPD

Muralidharan et al. [15] have shown the development and therapeutic potential of microparticulate/nanoparticulate powders containing a novel Nrf2 activator using particle engineering technology in the form of aerosol with excellent aerosol dispersion performance, which can reach the lower airways and can reduce the inflammation in various conditions like acute lung injury, pulmonary hypertension, and pulmonary endothelial diseases including COPD by targeting Nrf2/Keap-1 pathway. Similarly, another study has shown reduced lung inflammation in murine models of obstructive lung diseases using the PEGylated immunoconjugated poly(lactic-co-glycolic acid) (PLGA) NP containing non-steroidal anti-inflammatory drug (ibuprofen) by targeting neutrophils [16].

Pulmonary fibrosis

Biofilms is one of the major problems in pulmonary fibrosis, and to combat this problem, Türeli et al. [17] successfully prepared ciprofloxacin-loaded PLGA NPs for pulmonary delivery using the design of experiment to have an optimized formulation. Also, the intratracheal administration of gadolinium-based NPs in bleomycin-induced mouse model along with the application of magnetic resonance imaging have shown a great deal in understanding the pathophysiology of pulmonary fibrotic process including the monitoring of drug response in various predinical studies [18]. Sodium colistimethate-loaded lipid NPs (Colist-SLNs) and nanostructured lipid carriers (Colist-NLCs) have also been investigated to understand pulmonary infection associated with the patients with CF, where the Colist-NLCs have shown stability studies compared with Colist-SLNs [19].

Respiratory infections

Qiao and co-workers recently employed NPs (nanobioprobes) biosynthesis inside the *Staphylococcus aureus* cells for rapid detection of viral antibodies. This approach seems to have better sensitivity and robustness and can be employed in understanding various respiratory viral infections [20]. Marasini et al. [21] have shown the effectiveness of PLGA-based lipopeptide delivery in intranasal Group A *Streptococcus* vaccine, which results in mucosal IgA response where they found to be effective and patient compliant.

Another recent development includes the fusion of respiratory syncytial virus (RSV) nanorings with palivizumab-targeted neutralizing epitope in the form of NPs RSV vaccine, which have shown protection against the virus replication in mice, particularly in the upper airways. Notably, this nano-delivery system had a combination of cellular immunity and fusion protein antibodies [22]. Guo et al. [23] have shown that intravenous administration of citrated-coated silver NPs has better efficiency to be taken up by the vascular endothelial cells leading to increase in the reactive oxygen species, which can disrupt the integrity of the endothelial layer helping in mediating the inflammation in lungs and various other organs like liver and kidneys.

Lung cancer

Zhang et al. [24] have shown the efficiency of albumin-based delivery system containing gambogic acid, which has low toxicity, enhanced solubility, chemical stability, and anti-tumor efficacy in lung cancer in A549-bearing mice. The use of photodynamic therapy being non-invasive and non-surgical approach in blend with the NPs demonstrate a promising way to treat lung cancer, where hypocrellin B as a novel photosensitizer along with paclitaxel as the anticancer drug NPs have shown to be efficient both *in vitro* and *in vivo* [25]. Various other reviews and research attempts also have shown the potential of NPs in lung cancer [26–30].

Conclusions

Nanotechnology has provided a new platform to transport a wide range of therapeutic moieties to a target-specific cellular site in various respiratory conditions, which is quite evident with various above-cited recently published advancements in the respiratory medicine. Nanotechnology as a novel drug delivery system may open new vistas in the pulmonary clinic by providing maximum efficacy, targeted effects, and improved patient compliance.

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