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Nanomedicine: why it still taking long from "bench to bedside"?

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Abstract

The nanoscale materials biomedical applications have exponentially increased from last few decades. It has been estimated that globally around 1300 nanomaterials are produced every year. Their wide applications include automobiles, aerospace, energy, electro-mechanical engineering, textiles, environmental scavenger, food additives and biomedical industry applications. The produced materials are mostly from the bench of chemists, chemical or materials scientists. The nano-bio interface is more challenging due to two different disciplines marriage i.e. engineering and biology. For instance, the intended nanoscale materials biomedical applications especially nano therapeutics and nano drug delivery system, only initial in vitro cytotoxicity assays or in vivo simple murine models applications are performed. The in vitro studies focusing on cell cultures are simple and no complex interfering system is involved i.e. blood pressure, colloidal osmotic pressure, hormonal homeostasis, reticuloendothelial cells and immunity etc. Therefore, the in vitro studies can evaluate the nanoscale materials biocompatibility up to some extent but not completely. Similarly the murine models, guinea pigs or even advance primates cannot represent the human model due to genetic variations.

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The nanoscale materials studies mainly focus on the desired applications rather than complete pharmacokinetics and pharmacodynamics [1]. The nanoscale materials fate after desired therapy is needed to be extensively investigated. Most of the studies with nanoscale therapeutic or drug delivery system do not focus on the vital organs functionality e.g. liver, kidney, spleen, lung etc. Hence, it is quite possible that the nanoscale materials having good anti-cancer or antibacterial efficacy may be hazardous to vital organs and have severe adverse effects. Similarly, the size of nanoscale materials is inevitable for in vivo applications i.e. less than 10 nm is screened by reticuloendothelial system within the body and above 300 nm may cause severe embolism. Moreover, the robustness and survival of the nanoscale materials system without mimicking autoimmunity within the circulatory system in vivo are also matter of serious concern for nanoscale materials translation.

Likewise, the medical professionals have subtle to none knowledge regarding nanoscale materials and their biomedical translation. The nanoscale materials interaction at cellular level is unique and complex than other drugs. Therefore nano-bio interface is of prime importance, since most of the cell organelles, ligand receptors, genetic materials (DNA, mRNA, miRNA, siRNA etc.) and proteins are ranged from 2-20 nm[2]. Therefore nanoscale materials can interact more efficiently with intracellular contents for desired applications. For the approval of any therapeutic modality the regulating bodies[3] either regional (United States Food and Drug Administration, European Medicines Agency, Medicines and Healthcare Products Regulatory Agency of United Kingdom, China State Food and Drug Administration, Ministry of Health & Welfare Japan etc.) or international (World Health organization, Pan American Health Organization, World Trade Organization, International Conference on Harmonization, and World Intellectual Property Organization) need extensive trial and studies for public safety that can be closely monitored by the medical scientist and practitioners. In case of nanomedicine, the close collaboration between material and medical scientists is highly desired. The collaboration of nanoscale material laboratories and hospitals in this regard can accelerate the nanomedicine “bench to bedside” journey.

The recent organ on chip concept[4, 5] is of scientific value and can reduce the gape between the bench to bed due to; 1) The cells from human model with 3D structure and maximum possible influencing factors can produce “pseudo-real” model for nanoscale biomedical applications especially in theranostics, drug uptake and biocompatibility trials. For instance, the in vogue blood brain barrier in vitro model is simple with only several layers of endothelial cells, basement membrane and astrocytes. If the same system is implicated on the microchip with stimulated influencing factors may perform more precisely. Likewise the kidney, liver and spleen as organ on chip may accelerate the drug toxicity trials. 2) The nanoscale materials fabricating scientists may be benefited with simple but more efficient than in vitro system currently in vogue for in initial drug trials. 3) Certain specific disease models are not cost effective and higher budget allocation be may cut off via organ on chip modality.

In summary, the close collaboration of nanoscale material fabricating and life science or medical scientists is highly desired for accelerating the nanomedicine applications from “bench to bedside”. Moreover, the detailed biocompatibility trials including vital body organs and circulatory system in addition to desired therapeutic effect may also benefit the scrutiny of clinical candidate nanoscale materials.

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