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ADVANCED MULTIMODAL NANOSYSTEM : THE FUTURE MEDICINE

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Nanomedicine, a rapidly developing branch of medicine, has the potential to overcome major drawbacks of modern medicine [1]. Nano-modules have invaded in all field of medicine from pharmaceuticals to treatment; medical imaging to diagnostics; and material implantation to tissue regeneration. Moreover, one nano-system can also assimilate several modules for multifunctional aspect. For example, gold nanoparticles can be used simultaneously for drug delivery, cancer detection as well as thermotherapy [2]. Due to its unique potentiality nanomedicine has been heralded for incurable diseases such as cancer [3], immunodeficiency diseases [4] and neurodegenerative diseases [5].

Perhaps nanomedicine is the next revolution to mankind[2]. Nanoparticles as drug or drug delivery modules is drawing attention due to its physicochemical properties such as, high drug loading, protection of drugs from degradation, avoidance of multidrug resistance, prolong drug release, reduced non-target area cytotoxic, enhancing drug adherence at the disease target area, slow degradation into non-toxic byproducts [6].

Despite having such potential, there are various limiting factors that need to be addressed to make a foolproof nano-module [7]. Therefore prior to setting up a nanomedicine application strategy various critical issues need to be considered such as the nanosystem should be able to witstand the micro-environmental condition at administration root, should be loaded with molecules that guides them to reach disease areas and formulated to easy drug unloading. Also for proper elimination, nanomaterials characteristics is very essential (detailed in video). And incase nanomaterials are retained in body, it should act like complete inert compound [8].

Future approaches to formulate efficient nanomedicine should focus on: (see, Fig.1)

Prolonging drug adherence. Most of the drug needed daily intake regime due to its non-adherence [9]. To overcome this, one strategy could be to develop drug loaded NPs depot at or near disease site, leading to gradual release of NPs over time. This will maintain high drug concentration at the disease site, consequently reducing adverse high drug-dosage side effects. Therefore, patient will need to take the medicine less frequently than daily dosing. Thus it could virtually mimic vaccines. In this state nano-drugs could be termed as *"Nanoccines"*.

Next prime drawback of conventional drugs or drug delivery system is toxicity and non-specificity [10]. There are various potential drugs that get rejected by Food and Drug Administration (FDA), due to their adverse drug reactions (ADR). Nano-drug delivery can

potentially overcome those drawbacks and lead to reconsideration by FDA for approval. To achieve this multilayered NP system can be strategically designed to avoid entry site degradation, systemic elimination, enhanced target tissue uptake, and enhanced functional efficacy.

Another major drawback is non-target and eliminatory organ toxicity [11,12]. Presently nanomaterials have shown inflammatory responses, non-specific binding lead to oxidative stress, and accumulation at non-specific areas leading to systemic toxicity. The nano-material should biodegrade into non-toxic byproducts, if it doesn't reach the disease area or are not taken up by the diseased tissue. The byproducts should be such that it acts as building block components for body or easily and quickly eliminated from the body.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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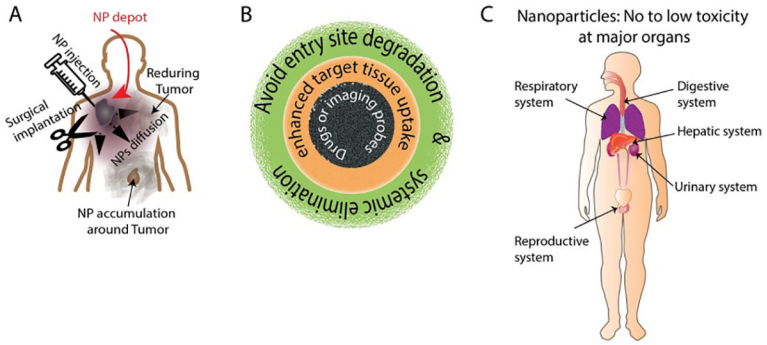

Figure 1.

Future approaches to formulate efficient nanomedicine |A| Drug loaded NPs depot or an inert depot, prolonging drug adherence. |B | Multilayered NP system can be strategically designed to avoid toxicity and non-specificity. |C| Nanomaterials byproducts should be non-target and eliminatory organ toxicity.