MINI REVIEW

Nanorobot's environmental and health risks: A preliminary assessment

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ABSTRACT

During the last decade, nanorobots for biomedical applications have undergone intensive study and rapid development, to the point where they can currently carry cargos to specific areas in organisms under laboratory settings. Despite this advancement, studies on nanorobot dangers and talks regarding prospective nanorobot regulation have been limited thus far. This preliminary assessment of nanorobot dangers begins with a quick summary of the present status of the technology. Helixes, nanorods, and DNA nanorobots are the three primary forms of nanorobots described in the overview. Each of these categories has several distinct designs. Second, early warning signs of possible dangers are examined and addressed. Two possible dangers are highlighted: (i) the use of hazardous materials and UV light in nanorobots, and (ii) the loss of control over propulsion and aiming. Third, present rules are examined in relation to nanorobots. Current medical device rules are plainly unsuitable for nanorobots, and it's even unclear whether specific restrictions would apply. To get the most out of nanorobots, we advocate conducting wide, risk-related research as well as discussions with stakeholders and the general public regarding the definition, purpose, and controllability of nanorobot applications.

Key Words: *Nanorobots; Hazardous; Nanomaterials*

INTRODUCTION

Roco differentiated a number of generations of nanotechnology in a fundamental study, the two earliest being passive and active nanostructures. Passive nanotechnology is described as when "the nano component accomplishes nothing especially elaborate," according to Tour. "The nano entity performs something complicated such as absorbing a photon and releasing an electron, so operating a device, or moving in a precise and specified pattern over a surface," according to the definition. Although distinguishing between passive and active nanotechnology can be difficult, most typical nanoparticles and nanotubes now employed in nanoproducts fall under the passive nanomaterials category [1]. During the 2000s, this is where the majority of risk-related research took place, particularly for a small number of nanomaterials such as silver nanoparticles, titanium dioxide nanoparticles, silica nanoparticles, cerium dioxide nanoparticles, zinc oxide nanoparticles, iron nanoparticles, quantum dots, fullerenes, carbon nanotubes, and graphene. Active nanomaterials have received far less attention, owing to their restricted manufacturing and use in society. One sort of active nanomaterial, on the other hand, is obviously on the rise. Nanorobots, which are sometimes referred to as science fiction, are now being widely investigated and developed, particularly for medical purposes in which an effort is being made to blend nanotechnology with medicines. The most common use stated is medication delivery, namely for site-specific cancer therapy via tumor-killing drug delivery. Environmental monitoring and water treatment are two more potential uses, in addition to medical [2]. Despite this advancement, study on the dangers of nanorobots has been limited thus far. Several examples in history demonstrate how the introduction of new technology that first provided significant benefits to society eventually turned out to have significant environmental and health consequences. Regulation was often enacted late in the game, after the first symptoms of detrimental side effects had shown. Ionizing radiation, which was discovered about 1900 and gave substantial diagnostic and therapeutic benefits through X-rays and radioisotopes, is a good example from medicine. There were early concerns that radiation exposure may cause significant harm at the time, but they were widely ignored. In the 1930s and 1940s, X-rays were also utilised in beauty salon

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to fit shoes and remove unsightly hair. Because there was no legislation insuring the safety of ionising radiation, such abuses were feasible. Such laws have only progressively evolved as our understanding of radiation dangers has grown, allowing for the beneficial use of radiation while limiting risks to a minimum. Antimicrobials, another significant medical breakthrough probably the most significant of all time have saved millions of lives by eradicating harmful microorganisms. Antimicrobials have also been utilised as a growth promoter in industrialised animal husbandry, in addition to its primarily beneficial functions. Animals administered sub-therapeutic doses of antimicrobials over extended periods of time demonstrated improved growth rates, food conversion, egg production, and milk supply. Antimicrobial resistance emerged in the 1940s as a result of such widespread usage, posing a danger to the use of antimicrobials in medicine. Antimicrobials as growth promoters were not prohibited until the mid-1980s [3].

TECHNOLOGICAL DEVELOPMENT OF NANOROBOTS

From Richard Feynman's renowned address "There's Plenty of Room at the Bottom" in 1959 until now, the technical development of both micro and nano-sized robots has been entwined with the development of other technologies such as magnetic control and nanostructure synthesis.In 2005, the first nanorobots were described, including a nanocar constructed primarily of fullerene molecules. Three types of nanorobots appeared in the 2010s helices (also known as nanoswimmers), nanorods (also known as nanoswimmers, nanomotors, or, if longer, nanowires), and DNA nanorobots.

Helices

A variety of robots have been built with screw-like helix tails for locomotion, which resemble bacterial flagella or other biological phenomena. The majority of them, including the MagnetoSperm and the MOFBOTS, should be classified as micro-sized robots. There are, however, examples of helix-like robots that are on the verge of being nanometer-sized

Nanorods

Although alternative forms are also employed for the same purpose, nanorods are generally cylindrical rods with varied metal segments. Garcia-Gradilla constructed a 250 nm broad and 1800 nm long rod of gold-nickel-gold segments, which is particularly noteworthy from a medical standpoint. Ultrasound vibrations cause these nanorods to move at around 50 m-s1 in serum and about 10 m-s1 in saliva, but at a slower rate. These nanorods may be directed along specified paths thanks to the magnetic characteristics of nickel.

DNA nanorobots

DNA nanorobots are made up of deoxyribonucleic acid molecules, allowing for the use of DNA as a building material for nanoscale machines. They are sometimes based on DNA origami, which involves folding DNA molecules to produce patterns and structures. The DNA walker, invented by Gu is a nanorobot that consists of a trigonal arrangement of double helices that resembles a symmetrical three-legged wheel with 'feet' that function as ligands. These DNA 'feet' can link to a broader 'landscape' of DNA origami sheets, through which the DNA walker may 'walk' by rotating 120 degrees and binding to a new bioreceptor with each step. The DNA walker carrying numerous 5 nm gold nanoparticles across the DNA sheet landscape to a predetermined spot is an example of this capability.

POTENTIAL NANOROBOT HAZARDS

Several of the nanorobot designs have the potential to enhance health-related outcomes, such as cancer treatment. However, as can be shown from prior late lessons with promising technologies that bring significant societal advantages, such as the X-rays and antimicrobials hazards might exceed benefits in some cases. Only a few references to environmental and health issues have been identified in the nanorobot literature thus far. Nanorobots "will need to be toxicologically inert, degradable, or ejected from the body," Kostarelos said in a brief post regarding their safety. Some safety considerations may be discovered in studies about DNA nanorobots. The I-creators switches said that the injected worms were "viable and healthy," implying that the I-switch is not hazardous to nematodes at the quantities used. An assessment of the safety of the DNA nanosheet/tubular nanorobot was undertaken by Li in their work. At relevant concentrations, the nanorobots did not cause any thrombi or enhanced blood coagulation in non-tumor-bearing animals. There were also no immunological or cytotoxic reactions. They also had no effect on thrombi or blood coagulation in Bama miniature pigs, who are anatomically and physiologically comparable to humans [4].

REGULATING NANOROBOTS

There is presently no legislation addressing the use of nanorobots particularly, as there was in the early development of X-rays and antimicrobials. Meeting the current approval standards for medical items and devices is undoubtedly one of the most time-consuming, rigorous, and costly regulatory procedures available, involving many rounds of clinical testing, safety, and benefit evaluation. However, when it comes to more sophisticated pharmaceuticals, laws in the EU and elsewhere have been criticised as being inadequate. It's also uncertain whether nanorobots should be classified as a medical device or a medicinal product, which are regulated differently in the EU under the Regulation of Medical Devices and the Medicinal Products Directive.

RECOMMENDATIONS

The major uses for nanorobots that have been proposed are for them to be administered directly to the human body or the environment. Such exposure-prone applications, such as pharmaceutical and pesticide applications, necessitate a study of the dangers associated with nanorobots. At this early stage, we recognised two major possible risks associated with nanorobots (i) the usage of traditional hazards, such as toxic compounds and UV radiation, and (ii) the loss of propulsion and navigation control. Furthermore, we emphasise that there is a lack of nano-specific regulation, making it unclear if present regulations will be able to detect and govern nanorobot dangers at an early stage of development. The first recommendation, based on lessons (i) and (ii), is to perform research of the environmental and human health concerns of various nanorobot designs before they are widely used, moving away from the belief that risk assessment and regulation are only needed for nanoparticles. Discussions regarding the dangers of nanoparticles began early in the development of nanotechnology. Since then, we've learnt how critical it is to give adequate funds for risk-related research and to start studies early in order to map distinct hazards. Although it is presently unknown if nanorobots pose a threat to human health or the environment, it is conceivable to begin the process of investigating this.

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