

Nanotechnology in Anesthesia and Pain – A Review



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Abstract

Nanomedicine is monitoring, repair, construction, and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures. Nano-robots (Nanobots) are nanosized, artificially fabricated, controllable devices. They freely travel in human body and interact with specific cells at molecular level. Its benefits include disease prevention, imaging, prenatal, virtual reality, individual medicine, emergency medicine, anaesthesia & ICU, research, medical monitoring, medical records, nano-biopharmacy, drug delivery and cancer treatment. It would be applicable to general anaesthesia, regional anaesthesia, pain, cancer therapy and insight into consciousness.

Introduction

A nanometer is a billionth of a meter (10^{-9}). A size of 0.1- 100 nm is used for this technology. *Richard Feynman* (Nobel laureate) hypothesized the concept in his book- *There's Plenty of Room At the Bottom* (1959). Eric Drexler described nanotechnology in *Engines of Creation: The coming Era of Nanotechnology* (1986). The term Nano technology refers to research & development at the atomic, molecular, or macromolecular level (0.1 – 100nm) to create structures, devices and systems with novel function (NNI). Nanomedicine is monitoring, repair, construction, and control of human biological systems at the molecular level, using engineered nanodevices and nanostructures. Nano-robots (Nanobots) are nanosized, artificially fabricated, controllable devices. They freely travel in human body and interact with specific cells at molecular level. They can perform multiple cellular level functions, including replacing, repairing DNA that is damaged in the cell as we age and may also be diseased. They are self-replicating and could even be programmed to build other nanobots. Types of nanobots include - Single action nanobots, Disease specific nanobots, Drug carrier nanobots, Inhaled drugs nanobots, Chromalloyocytes, Vasculoids - blood like, Respirocytes - RBC like, Clottocytes - platelets like, Microbivores – virus/bacteria killers and cancer curers.

Advantages of Nanobots

- Nano-robots are non-biological entities with no side effects.
- Being highly specific and target oriented, it reduces morbidity.
- Since they reach specific receptors, lesser drug is required.
- They bind to terminal receptors.
- No peaks and troughs in effect.

- They do not follow first order kinetics as other injectables.

Medical use of nanotechnology

Prevention, Diagnosis and Treatment

It includes disease prevention, imaging, prenatal, virtual reality, individual medicine, emergency medicine, anaesthesia & ICU, research, medical monitoring, medical records, nano-biopharmacy, drug delivery and cancer treatment.

Regenerative Medicine

It includes cell repair, bone repair, ageing, stem cells, reproduction of new organs, heart disease, diabetes, seizures, sensory feedback, limb control surgery, dental and ophthalmology.

Possible advances of Nanotechnology in Anaesthesiology

General Anaesthesia

At Canary Islands they developed an Automatic controlled anesthesia system which detects hypnotic state based on EEG & BIS and supplies appropriate dose of antiesthetic. It is a computer software program which saves time, an aesthetic drug and their doses [1]. Examples include Nano formulated drugs like anesthetic drugs and diclofenac, Biosensor for monitoring depth of anesthesia, Nanotube capnograph sensor, Real time non invasive glucose and electrolyte monitoring.

Regional Anaesthesia

With nanotechnology, an antidote to bupivacaine overdose is possible. There is a formation of pi-pi complexes between bupivacaine and a pi-electron-rich injectable nanoparticle. This complex would be devoid of clinical effects of bupivacaine and would thus render toxic bupivacaine harmless. So, it could be possible to counteract high spinal as soon as it is realised.

Local Anesthesia

Lidocaine-loaded poly (carpo-lactone)-poly (eethylene glycol)-poly (carpo-lactone) (PCL-PEG-PCL) Nano particles in hydrogel was prepared of size 200 nm. This has been shown to be superior in terms of onset of anesthesia and efficacy. Once drug is injected, it is directed through Nano-computer to the specific site where action is required. It is kept at that site for wanted time and removed from body when not required.

Future advances in super specialities of anaesthesiology- Nano-Technology in Pain

Chronic pain affects 1.5 billion people worldwide. Problems in pain management include economic burden, subjective scale of pain measurement, side effects of opioids, drug interaction, sedation and GI problem. Biomarker for pain is an objective scale. Examples include-

- TNF nanoplates- Gold nanorods decorated with small inhibitor RNA that target TNF mRNA. Primary intermediary in neuropathic pain [2].
- Tramadol hydrochloride –Loaded PLGA Nano particles
- Intrathecal Gold-Coated Fe₃O₄
- Polymeric Nanocarriers for Spinal Cord Injury – Associated Pain
- Nanofluidic Membrane Technology for Next –Generation Pain Therapies
- Loperamide HCL- Encapsulated Anti- ICAM- 1 are immunoliposomes for peripheral pain and inflammation. They target specific peripheral opioid receptors and have no side effects of opioid. They are very helpful in acute post operative pain, arthritics and neuropathic pain [3].
- Citronellal / β -CD Complex: Effects on Noninflammatory Chronic Muscle Pain and have antihyperalgesic effect [4].
- Oral Transmucosal Fentanyl Citrate(OTFC) for cancer pain- Selectively target opioid receptors in brain, spinal cord, smooth muscle and bypass GI tract. Thus, they have no side effects and are helpful in opioid tolerant individuals [5].
- Saxitoxin- potent anesthetic, bundled with liposomes.

Vasculoids

Single, multisequence nanobot capable of all transport function of blood including circulation of respiratory gases, glucose, hormones, cytokines, waste products & cellular components. They conform to the shape of natural blood cells and do not need heart pump. It can be a complete replacement of blood [6].

Colonocytes

They are artificial platelets that control bleeding 100 to 1000 times faster. The number required is very less for desired activities. Specifically programmed motile colonocytes would even be able to detect internal bleeding and spontaneously seal the site. Thus,

giving the hope for avoiding emergency surgeries, reduces the ICU mortality, no bleeding diathesis and no DIC syndrome [7].

Respirocytes (RBC)

These nanostructures transport O₂ in human body similar to erythrocytes but 256 times faster. They also transport CO₂ [8].

Nano-Atropine

Oregano phosphorous poisoning is commonly encountered in ICUs and atropine is one of the primary therapeutic drugs. Nanotechnology has enabled formulation of inhaled atropine in form of dry powder which can be used in field conditions even by lay man. It can be supplied with pesticide and can be used in case of accidental poisoning [9].

Microbivores

Microbivores would mimic white cell and perform phagocytoses of specific bacteria, viruses and fungi [10].

Disadvantages of Nanotechnology

It includes high cost, complicated fabrication, toxicity, terrorism, practical implementation and uncontrolled self-replicating nanobots will consume earthly resource.

Conclusion

Nanotechnology will continue to have profound and positive impact on humanity. Will serve as cornerstone in this ongoing & noble endeavor of safe anesthesia and pain relief. It would be applicable to general anaesthesia, regional anaesthesia, pain, cancer therapy and insight into consciousness. Disadvantages include high cost, complicated fabrication, toxicity, terrorism and practical implementation.

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