ISSN- O: 2458 - 868X, ISSN –P: 2458 - 8687

International Journal of Medical Science and Innovative Research (IJMSIR)

IJMSIR : A Medical Publication Hub

Available Online at: www.ijmsir.com

Volume – 3, Issue –1, January - 2018, Page No. : 342 - 345

Use of Nanotechnology in Surgical Care Of cancer: A Narrative Review

Thamer Hassan Mobarki, Faculty of Medicine, Jazan University

Correspondence Author: Thamer Hassan Mobarki, Faculty of Medicine, Jazan University

Type of Publication: Original Research Paper

Conflicts of Interest: Nil

Abstract

Introduction: The nanotechnology is rapidly progressing field in cancer diagnosis. Cancer treatment depends on the good diagnostic tool. Thus, nanotechnology can be used in several diagnostic procedures include organ imaging, cellular imaging and cancer microenvironment.

Objective: This review aimed to explore the medical literature that studied use of nanotechnology in surgical oncology.

Conclusions: Surgery is currently the main therapeutic modality in treating human cancers, and the leading predictor of survival rate is a complete surgical excision. The promising applications of nanotechnology in diagnosis and surgical treatment of cancer include tumor demarcation, imaging of lymph nodes, and recognition of residual cancerous cells. A main obstacle is to develop nanoparticle that targeted tumor cells without adjunct harmful effect on healthy tissues. Regarding clinical use, the long-term safety of nanoparticles need further researches.

Keywords: Nanotechnology, Surgery, Treatment, Diagnosis, Accuracy, Safety

Introduction:

The knowledge about very small subjects is called Nanotechnology. These tiny materials came in a size of 0.1 to 100 nm. It is also known that when these particles are of this size the physical properties such as electrical conductance chemical reactivity, magnetism and optical effects, became different than the particles of the original size for example the hard turns into liquids at room temperature (gold).(1) Nanotechnology deals with the transformation of atoms, molecules, or compounds into new product of materials and devices that has unique characteristics.(2)

The field of the nano technology that deals with medicine is called nano medicine, it is a new area in science. The interaction between biological entities and nano devices expands the prospective of research and application. This interaction is already tested in the detection and treatment of cancer in mice using gold nano shells and the use of liposome for drug transport.(3) Nano medicine gives early discovery and prevention with suitable treatment and follow-up of diseases that have been burden to the human kind such diabetes, cancer, multiple sclerosis and also various types of severe transmittable diseases (e.g. HIV). The use of gold nano particles in finding the genetic sequence after being marked with short segments of DNA so damaged tissues can be fixed, thus help in organ transplantation. Biosensors of Carbon nano tubes are used in the study of astrobiology (origins of life), also used in cancer detection.(1) Diagnosing and treating cancer is one of the slowest developing areas in the health sector despite the need of nourishment. Luckily, the nanotechnology is rapidly progressing in the field of diagnosis since cancer treatment depends on the good diagnostic tool used. It can be used in all diagnosis procedures include organ imaging, cellular imaging also in cancer microenvironment.(4) The newly manufacturer lanthanides-based nanoparticles, that characterized by distinguishable luminescent aspects of photons, extended to deep penetration without noise from autofluorescence [5].

Nanotechnology in cancer detection

Conventionally, is done through detecting the physical growth/changes in the tissues by x rays and/or CT Scans this is confirmed by tissue removal through culture. The drawback of this procedure is that it is not very accurate as a result a delay in the treatment may occur.[2] Since nanoparticles are small they can penetrate to the cell into the Genes and discovered the defect. DNA molecules can be detected in their incipient stage in test tubes or in tissues.[2] Google company declared the interest to produce smart magnetic nanoparticles which circulate in blood vessels to detect early malignant signs, however long procedures should be followed to get accreditation of food and drug agency FDA. Many aspects should be studied in advance include nanoparticles such as effectiveness and safety, cost-effectiveness and feasibility of usage.[6] Surgery by taking out the affected organ, is one of the treatment alternatives. But, the drawback is the organ removal, disease recurrent can occur and it's not suitable for all cancer types. The other alternative is radiotherapy. It burns the cancerous cells, and also the healthy ones, the damaged tissues may become non-functional. The third option is chemotherapy, by using drugs they stop cellular division. The problem is that drugs have side effects, however if the cancer in early stages it's fruitful. Just like radiotherapy there are NP that introduce heat to the affected organ. In addition, it can be used to transport drugs to the malignant cells [2]. They are highly cancer specific agents [7]. Unfortunately they have some limitations just like any other agent used in health field for example toxicity (for healthy cells), break down like so many devices, the change in the physical properties during manufacturing and the high cost of materials and personnel [8].

Nanotechnology in cancer surgery

The chemical and physiological characteristics of nanoparticles, allow them to take advantage over the conventional medications. Medications have usually the risk of causing cell toxicity, acquiring poor biocompatibility and initiating high immunogenicity.

Their zeta potential, size, and solubility will all affect the way in which they are cleared from the body (biliary or renal clearance), how they will be transported to the diseased tissue (EPR effect, mononuclear phago- cyte system or other active targeting), as well as the reactivity of nanoparticle surface and cytotoxicity. Due to their relatively large surface area to volume ratio, small changes in their dimensions, surface functions or chemical components can result in huge changes in the interactions with the surrounding environment. Their small size can lead to the disruption of vital cellular functions. These new biocompatible polymeric materials have lower toxicity than earlier generations of polymers, often degrade into products which are biocompatible and can easily be cleared from the system. Nanoparticles made from these polymers may be of less toxicity concern than nanoparticles composed of less innocuous materials. Immunogenicity of nanomaterials is also an important concern. Advancements in nanomaterials have improved their half-life circulation, available for much longer time periods. allows for exposure and accumulation of the particles in organs not previously accessed by the drug, as they may not be cleared from the body for days. In some cases, there is the potential for nanoparticles to remain in the body indefinitely. Inflammatory responses have been found in association with the accumulation of such long lasting nanoparticles in tissues. Fortunately, the toxicity of nanomaterials can be managed through careful design with attention to the particle's size, shape, surface area, charge, state of aggregation, crystallinity, and potential to generate reactive oxygen species. It is also important to verify the stability of the compounds for storage. Due to the significance of proper characterization of nanoparticles, the Nanotechnology Characterization Laboratory (NCL) was formed in 2004 to perform preclinical efficacy and safety testing of nanoparticles (8).

The combination of simultaneous cancer diagnosis and treatment approach has been called ‘‘Theranostics’’. This approach is established to assist in diagnosis, target-drug transportation and oservation of responses (9, 10). The nontechniques aim to improve cancer surgical care include anterior and cervical mediastinoscopy, video-guided thoracoscopy and assessment of mediastinal lymph node associated with nodal dissection. The future applications of surgical nanotechnology will focus mainly in screening and visualization, with minimally invasive and robotics nanotechnology (11). As a surgical tool, a “bloodless scalpel,” high-intensity focused ultrasound (HIFU) is considered as one of the most initiative and least invasive therapeutic means in cancer surgery. The typical strategy to improve the HIFU ablation efficiency is to increase the doses of HIFU irradiation. However, such an increased HIFU-irradiation dose may bring with the danger of injuring the normal tissues in the acoustic propagation channels. Fortunately, this contradiction can be partially resolved by introducing the elaborately engineered organic/ inorganic nanoparticles (NPs) within tumor tissues to change the acoustic environment of cancer tissues. Focused ultrasound (FUS)-Nanobiotechnology has been successfully introduced into the noninvasive HIFU-based cancer surgery to solve two critical issues of HIFU: the precise positioning of therapeutic targets and the synergistic enhancement of HIFU therapeutic efficiency. By introducing either fluorocarbon-encapsulated organic nanoemulsions or inorganic hollow mesoporous silica nanocapsules, the acoustic environment of tumor tissues can be significantly changed to intensify the acoustic energy deposition within tumors. Importantly, the unique intensified thermal, mechanical, and cavitation effects of HIFU by the (synergistic agents) SAs will promote the vaporization of the encapsulated. This nanoemulsion was composed of (hydrophobic liquid per fluorohexane (PFH) core and hydrophilic shells of phosphati-Dylcholine) PFH and the consequent generation of microbubbles to achieve the high acoustic responsiveness. Thus, these nanosized SAs can concurrently realize the high accumulation amounts of SAs due to their nanodimensions and strong synergistic effects for HIFU therapy based on the post-generated microbubbles by phase transition. (12) In thoracic surgery, the ability to integrate novel imaging techniques, drug delivery strategies and minimally invasive ablative and image-guided surgical approaches offers real hope to those patients diagnosed with thoracic cancers. Recent advances in nanotechnology promise to improve the surgical management of lung and oesophageal cancers (13) . NP-based therapeutics and imaging platforms have been evaluated in the preclinical arena, and early results suggest these technologies have potential to improve rates of curative resection in thoracic malignancies. Interestingly, multiple NP-based imaging platforms have recently emerged that could enable thoracic surgeons to perform real-time intraoperative tumour localization, sentinel lymph node (SLN) mapping and image-guided nanosurgery to achieve complete oncological resection of thoracic malignancies in the near future. Recent advances in nanotechnology are also enabling the evolution of several techniques in NP-mediated selective tumour ablation. Complex NP formulations possessing unique physical and chemical properties are created with the capacity to interact with a variety of external energy sources. Exposure of these NPs to radiofrequency, ionizing radiation, light or ultrasound energy sources mediates thermal, chemical and mechanical effects and ultimately allows for the selective ablation of tumour tissue. Particularly relevant is the discovery that the use of heat to activate the release of drug payloads from nanocarriers leads to increased antitumour cytotoxicity. This approach has shown clinical applicability in the treatment of several different tumour types, including breast, ovarian and hepatocellular cancers. (14)

Conclusion

Surgery is currently the main therapeutic modality in treating human cancers, and the leading predictor of survival rate is a complete surgical excision. Applications of nanotechnology in diagnosis and surgical treatment of cancer include tumor demarcation, imaging of lymph nodes, and recognition of residual cancerous cells. A main obstacle is to develop nanoparticle that targeted tumor cells without adjunct harmful effect on healthy tissues. Regarding clinical use, the long-term safety of nanoparticles need further researches.

References

1. Nikalje AP. Nanotechnology and its applications in medicine. Med chem. 2015;5(2):185-9.
2. Singh OP, Nehru R. Nanotechnology and cancer treatment. Asian J Exp Sci. 2008;22(2):6.
3. Boisseau P, Loubaton B. Nanomedicine, nanotechnology in medicine. Comptes Rendus Physique. 2011;12(7):620-36.
4. Ji T, Zhao Y, Wang J, Zheng X, Tian Y, Zhao Y, et al. Tumor Fibroblast Specific Activation of a Hybrid Ferritin Nanocage‐Based Optical Probe for Tumor Microenvironment Imaging. Small. 2013;9(14):2427-31.
5. Gu Z, Yan L, Tian G, Li S, Chai Z, Zhao Y. Recent advances in design and fabrication of upconversion nanoparticles and their safe theranostic applications. Advanced materials. 2013;25(28):3758-79.
6. Li J. Nanotechnology-based platform for early diagnosis of cancer. Science Bulletin. 2015;60(4):488-90.
7. Gao Y, Xie J, Chen H, Gu S, Zhao R, Shao J, et al. Nanotechnology-based intelligent drug design for cancer metastasis treatment. Biotechnology advances. 2014;32(4):761-77.
8. Hull L, Farrell D, Grodzinski P. Highlights of recent developments and trends in cancer nanotechnology research—View from NCI Alliance for nanotechnology in cancer. Biotechnology advances. 2014;32(4):666-78.
9. Aleassa EM, Xing M, Keijzer R. Nanomedicine as an innovative therapeutic strategy for pediatric cancer. Pediatric surgery international. 2015;31(7):611-6.
10. Sumer B, Gao J. Theranostic nanomedicine for cancer. 2008.
11. Catarino P, Goldstraw P. The future in diagnosis and staging of lung cancer. Respiration. 2006;73(6):717-32.
12. Chen Y, Chen H, Shi J. Nanobiotechnology Promotes Noninvasive High‐Intensity Focused Ultrasound Cancer Surgery. Advanced healthcare materials. 2015;4(1):158-65.
13. Singhal S, Nie S, Wang MD. Nanotechnology applications in surgical oncology. Annual review of medicine. 2010;61:359-73.
14. Hofferberth SC, Grinstaff MW, Colson YL. Nanotechnology applications in thoracic surgery. European Journal of Cardio-Thoracic Surgery. 2016;50(1):6-16.