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Short Communication

The Increasing Application of Nanotechnology and Nanomedicine in Urological Oncology

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Abstract

In current urological oncological clinical practice nanotechnology and nanomedicine are being increasing used in radiological imaging, gene and drug therapy, thermal ablation techniques for tumours and helping increasing biology of urological malignancies. We present a short communication of these new developments in nanotechnology and nanomedicine that are currently taking place and the potential great benefits that these techniques will deliver to improving patient care and clinical outcomes in patients with urological malignancies.

In current clinical practice, nanotechnology and nanomedicine are increasingly being used to enhance patient care and improve current management and treatment strategies. The potential application of nanotechnology and nanomedicine ranges across all stages of urologic oncology from the initial diagnosis, radiological imaging, surgical techniques (including robotic urological surgery and thermal ablation), drug delivery and new research [1].

Nanoparticle based tumour targeted contrast agents are used to enhance the sensitivity and specificity of current non-invasive tumour imaging modalities such as CT and MRI scans. Urologic malignancies have higher surface area to volume ratios and are therefore affected by the tumour ligands and type of nanoparticle tracer used, which allows further characterization of specific types of tumour [2]. The application of target specific MRI agents such as Magnetic Nanoparticles (MNPs) and Quantum Dots (QDs) are being evaluated in the enhancement of diagnostic imaging tools in urological malignancy.

The presence of malignant metastatic lymph nodes directly affects a patient's survival rate; hence advances in methods of detection of metastatic malignant nodes pre-operatively will improve management of these patients. Magnetic Nanoparticles (MNPs) can travel into the interstitial space and be transported into lymph nodes, where they are taken up by macrophages. On entry of theMNPs into lymph nodes this process triggers changes in the particle's magnetic properties, which are detected by MRI [3]. Quantum dots, nanoscalelight-emitting particles with simultaneous optical and electronic properties, are also being used to enhance the diagnosis of prostate cancer on both MRI and CT scan imaging [3]. A4 study by Shi et al. [5] showed QD probes are highly sensitive in detecting human prostate cancer micromets in mice. Jain et al [6] discuss the idea of Doxorubicin loaded with nanoparticles that are altered so that they remain in the circulation longer to reach tumour tissue, given to a patient over two weeks. These nanoparticles with dual functions- used not only for imaging applications, but also for drug delivery show a promising avenue for further research.

Nanocarriers can similarly be employed to envelop anti-cancer drugs and transport them to tumour specific sites for controlled release. The advantages are that delivery can be targeted to tumour tissue, thereby allowing more precise administration and reducing the harmful effects caused by destruction of normal tissue. The nanocarriers method of delivering drugs to tissue can be categorised as either active or passive targeting. They exploit two properties of tumour tissue (leaky blood vessels and poor lymphatic drainage); modified to have enhanced permeability and retention, nanocarriers can accumulate specifically in tumour tissue and release the drugs focally. Winquist et al [7] report a study where patients with unresectableurothelial carcinoma were treated with pegylated-liposomal doxorubicin; despite a population of patients with poor prognosis, the nanocarrier showed significant activity, warranting further study.

Research shows that surgical techniques will equally benefit from nanomedicine. Treatment of prostate cancer is diverse:

from conservative to radical prostatectomy, radiotherapy and cryotherapy. Thermal therapy is one method offered to patients presenting with recurrence of prostate cancer. The concept of the treatment is that exposing tumour tissue to high temperatures will impair the cell structure, thus destroying the cell [8]. In current clinical practice the thermal techniques used for the treatment and management of urological malignancies include radio frequency ablation (RFA) and high intensity focused ultrasound (HIFU). Both techniques involve the introduction of a probe into the tissue either radiologically or surgically (e.g. laparoscopic). The advantage of using nanotechnology and nanomedicine for the delivery of thermal therapy to urological malignancies is attributed to direct delivery to the tissue contrasted with the need for the placement of a probe to deliver thermal ablation, which can potentially lead to damage of surrounding structures. Two such innovative nanotechnology based ideas being developed are Gold Nanoshells (GN) and carbon nanotubes (CNT). Fisher et al and others have shown that multiwalled carbon nanotubes are efficient laser induced thermal therapy transducers, although suspicion has arisen with regards to toxicity [9]. Both these agents have shown tissue specificity for urological malignancy cell lines and are being comprehensively investigated further for clinical trials [10].

Technology, urology and oncology have always had a symbiotic relationship. The advent of robotic surgery has led to innovative progress. Robotic Surgery is also following the trend to downscale, with nanorobots being a credible future prospect. These could allow for fewer port sites, as multiple robots are introduced through one incision. Other suggested advances include improved views, lighting and tissue retraction. The lack of haptic feedback during robotic urological surgery is a clinical issue [10-12]. Nanotechnology and nanomedicine are being used in robotic urological surgery for the development of haptic feedback sensors and tissue handing biofeedback sensors to enhance robotic urological surgery.

n conclusion, nanotechnology and nanomedicine are being increasing used for the successful diagnosis and treatment for both localized and advanced urological malignancy. The field is seeing rapid progression from the laboratory into clinical medicine and the ensuing decade will see the amalgamation of data collected from invitro studies, which will now be used to set up clinical trials. The main aim of all international research in nanotechnology and nanomedicine is the development of new technologies for the treatment of urological malignancy, aiming for effective tumour treatment with minimal side effects to the patient.

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