NANOONCOLOGY:
DRUG DELIVERY IN NEUROLOGICAL CANCERS

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BME281
Introduction

• Nano-oncology is the application of Nanomedicine to cancer diagnosis and treatment.

• Has the potential to alter clinical oncology for a multitude of different cancers.

• Has the ability to create novel drug delivery systems that can specifically target the tumor sites.
Introduction

• Nano-oncology/nanomedicine is a branch of nanotechnology.

• Nanotechnology is the design of small devices on the nanometer scale (nm), from 1 to 100 nm.
  • This miniscule scale allows these devices to reach places in the body that conventional treatment methods cannot.
Introduction – How Small Is “nanometer”
Understanding nanomedicine

NANOMEDICINE: THE FUTURE OF MEDICINE

Nanomedicine, refers to highly specific medical intervention at the molecular level for curing disease or repairing damaged tissues. Though in its infancy, could we be looking at the future of medicine? Early clinical trials certainly look promising.

HOW NANOMEDICINE WORKS

Nanomedicine works by *injecting nanoparticles* into the body.

**CAN BE USED TO:**
- Deliver medicine
- Find and treat disease
- Repair damaged cells

- One human hair is approximately 80,000 nanometers wide
- Nanoparticles are between 1 and 100 nanometers in diameter
Understanding nanomedicine

**APPLICATIONS OF NANOMEDICINE**

**DRUG DELIVERY**
Using nanotechnology to deliver medicine, diabetic rats kept stable blood sugar levels for 10 days after injection.

**CANCER DIAGNOSIS AND TREATMENT**
- Using microRNA from a patient’s blood plasma and nanotechnology:
  - Medical professionals can determine if lung cancer is present and begin treatment the same day.
- Using Nano-Therm therapy to overheat brain cancer cells helps to destroy them:
  - In clinical trials, those with recurrent glioblastoma survived a median of 13 months.
  - More than double the survival rate of those who did not receive Nano-Therm therapy.

**FLU TESTING**
Today’s flu tests are:
- Time consuming
- Inaccurate

**NANOMEDICINE GOLD FLU TESTING:**
- Instant results
- Immediate treatment to prevent spreading to others
- Commercial nanotech testing
- No more than 5 years away
Understanding nanomedicine

**CELL FEEDBACK**
- Nanomedicine can be used to test cell response to drugs
- Instant feedback on how cells respond to medicine
- Can save years and millions of dollars on testing and clinical trials
- More effective than current medications

In a 1956, Arthur C. Clarke first wrote of the nanotechnology concept in a short story, *The Next Tenants*

**ADVANTAGES OF NANOMEDICINE**
- Faster diagnosis of many ailments
- More precise treatments of conditions such as cancer
- Repair tissue deep within the body
- Target only diseased organs without destroying healthy tissue
Neurological Cancers

- Central nervous system (CNS) tumor malignancies have a high mortality and morbidity rate.
  - Five year survival rate is at around 35%.
  - An excess of 50% of patients with CNS tumors in 2013 were expected to die.
    - Median survival rate of one year.
- For example, Glioblastoma Multiforme (GBM) is a primary brain tumor and a major challenge for neurosurgery and oncology.
  - Lack of knowledge of pathophysiology of GBM.
  - Limited access of chemotherapeutic agents at the tumor site.
How is nanooncology helping treat GBM?

• New innovations in nanooncology allow for a more precise target of the tumor due to:
  • The nanoparticle’s has the ability to pass the blood brain barrier (BBB)
    • Via optimization of elemental processes in engineering, physics, biology, chemistry and pharmacology.

• Hone in on the specific tumor site
  • No leakage of anti-cancer drug
  • Spares healthy tissue of cytotoxicity in the drugs.
GBM Treatment via MNPs

- MNPs or Magnetic Nanoparticles, are used in “Nano-therm” treatment methods.
  - These nanoparticles can induce hyperthermia via alternating magnetic fields (AMFs)
- Hyperthermia induction in the tumor tissue leads to:
  - Protein denaturation, DNA cross linking w/ nucleus → apoptosis
  - Rising oxygenation levels are cause for more susceptibility to chemoagents.
GBM Treatment via MNPs
Drawbacks

- Nanomedicine/nano-oncology faces many obstacles:
  - Safety of nanoparticle’s usage in the body
    - Biodegradable shells and easy distribution to the tumor site
    - No “lost” particles in healthy tissue/organs
    - Possible undesirable toxic properties in other parts of body.

- Improvement of “targeting efficacy” of nano-vectors to specific cancerous microenvironments.

- Development of effective triggers for release of drug agents.

- More physiological barriers including:
  - The Blood-Brain Barrier, drug resistance, etc.
Future Direction

- Development of a multifunctional nanoparticle that can carry:
  - 1) one or more drugs
  - 2) specific targeting moiety
  - 3) an imaging agent
  - 4) cell-penetrating agent
  - 5) a stimulus-sensitive element for controlled release
  - 6) Stabilizing polymer for biocompatibility

- European Union recognized the importance of research in nanomedicine and established the “Nanosafety Network” that:
  - brings in additional reports for additional knowledge on nanosafety.
  - will eventually lead to newer nanomedicine products for healthcare.
<table>
<thead>
<tr>
<th>TRADE NAME</th>
<th>DESCRIPTION OF NANO PARTICLE</th>
<th>CANCER TARGETED BY THE NANO PARTICLE</th>
<th>PHASE OF DEVELOPMENT</th>
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<tbody>
<tr>
<td>Doxil</td>
<td>Liposomal doxorubicin</td>
<td>HIV-related Kaposi sarcoma, metastatic breast and ovarian cancer[25]</td>
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<td>Liposomal muramyl tripeptide phosphatidyl ethanolamine</td>
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<td>ThermoDox</td>
<td>Liposomal nanoparticle with thermal release of doxorubicin</td>
<td>Hepatocellular carcinoma[42]</td>
<td>Phase 3</td>
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References


• “Nanobiotix: nanomedicine for cancer treatment”<https://www.youtube.com/watch?v=vg4b7WztpmQ>


• Apatow et al. (2013) Nanomaterials: Cancer Treatment and Imaging, University of Rhode Island

• “Nanomedicine: Application of Nanotechnology in Medicine: Great Infographic”, http://internetmedicine.com/2014/01/01/22575/