CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
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Project Number
31513

Project Title
Nanophotothermolysis: IPL Treatment with Targeted AuNP for Colorectal Cancer Therapy Modeled by Monte Carlo Simulations

Abstract

Objectives/Goals
Chemotherapy causes harmful side effects by destroying healthy cells in addition to cancerous ones. Attaching cancer seeking ligands to nanoparticles can direct drugs to cancer sites to boost drug efficacy and reduce toxicity. Since the folate receptor is upregulated in cancer with limited distribution in normal cells, folate conjugated gold nanoparticles (AuNP) can be synthesized for cancer targeting. AuNP also have a unique surface plasmon resonance property which converts light photons to heat for cancer cell destruction in a new process called nanophotothermolysis. I hypothesize that IPL treatment will be effective in destroying significantly more colon cancer cells than normal fibroblast cells when incubated with optimal sized folate conjugated AuNP.

Methods/Materials
I created a computer modeling algorithm with Monte Carlo Simulations to determine optimal AuNP kinetics for endocytosis by testing 9 parameters in 1000 simulation runs. I synthesized gold nanospheres with inversely proportional amounts of sodium citrate to HAuCl4 in 13nm, 26nm, 52nm and 104nm sizes. After characterizing uptake of nanospheres in Rat-2 fibroblast cells using UV-Vis spectra and TEM, I prepared samples for ICP-MS. I developed a method to create optimal sized folate-AuNP . I applied IPL treatment to GPC-16 cells and Rat-2 fibroblast cells with folate-AuNP using a filtered xenon flash lamp of wavelengths between 400 to 1100 nm and fluence of 6 joules/cm2. I prepared Trypan blue cell viability assays measuring cell counts with a hemocytometer and recorded the results.

Results
In silico molecular docking and bending energy modeling predicted AuNP size dependent endocytosis with optimal uptake of nanoparticles size in the 40-60nm range. In vitro analysis with UV-Vis spectra and ICP-MS measured greatest gold concentration uptake of gold AuNP with diameters of 52 nm. IPL treatment targeting cancers cells with overexpression of folate receptors destroyed 80% cancers cells with folate conjugated AuNp and only 20% of the normal fibroblast cells.

Conclusions/Discussion
A new energy transfer model simulating size dependent endocytosis accurately predicted optimal size range and correlated with in vitro results. The combination of folate conjugated AuNP with nanophotothermolysis treatment effectively destroyed cancer cells with little effect on normal cells demonstrating great potential for targeted cancer therapy.

Summary Statement
I created a new molecular modeling algorithm, developed a one-step synthesis for folate-AuNP incubated with normal and cancer cells, and measured the effect of nanophotothermolysis on cancer cell viability.

Help Received
Dr. Ron Birrell and Mark Kent advice on cell culture techniques/chemicals, David Shimmin, Nanocraft grant/advice on TEM cell prep, Dr. Thomas Fister, EAG lab grant/advice on ICP-MS sample prep, Joseph Muskin, University of Illinois Nano-CEMMS advice on AuNP synthesis and my parents.