

A Study of cryogenic probe design, analysis and Heat transfer

M.Chandran , P.Senthil kumar

Abstract— Cryogenic probe(or) cryoprobe are generally used for the treatment of diseased tissue in cryotherapy or cryosurgery. A new model cryoprobe was designed and simulation of was done with the help of analysis software. The cryogen Liquid nitrogen at a very low temperature was used as the working fluid .Many heat transfer mechanisms occur during cryosurgery Penne s Bioheat equations are used to find the heat transfer .Results show a significant enhancement in the freezing heat transfer. Both ice volume and surface area of heat transfer can be increased using cryobrobes with large diameter and also an increase in hydraulic diameter, there was a delay in the saturation boiling of the working fluid .A new technique called cryonanosurgery is introduced to solve the main problem in cryosurgery. In cryonanosurgery nanoparticle are injected with cryogenic surgery to maximize the freezing and there by minimize the surrounding healthy tissues being frozen. This was done with the help of a tool called cryospray (or) cryojet (or)cryogun with different types of cryoprobes, till ice ball is formed.Nanoparticles are loaded with functional solution and injected into the target tissue. Addition of nanoparticle into biological environment increases the tissue conductivity and significantly increases freezing effects and results in more ice nucleation and also helps to get better image at the edge of tumorwhich are very much needed for the successes cryosurgery.

Index Terms— Cryodestruction, . liquid nitrogen, tissue, freezing

I. INTRODUCTION

Cryosurgery, also known as cryodestruction and currently is the most widely used cryogen. Liquid nitrogen, which boils at -196°C (-320.8°F), is the most effective cryogen for use in a clinical setting. To destroy diseased tissue, the tissue is cooled to -20°C to -30°C (-4°F to -22°F). Temperatures of -25°C to -50°C (-13°F to -58°F) can be achieved within 30 seconds if a sufficient amount of liquid nitrogen is applied by spray or probe Cryosurgery is a minimally invasive procedure, and is often preferred to more traditional kinds of surgery because of its minimal pain ,scarring and cost.

Cryosurgery is used to treat several types of cancer, and some precancerous or non-cancerous conditions. Cryosurgery is also used to treat some types of low-grade cancerous and non-cancerous tumors of the bone. It may reduce the risk of joint damage when compared with more extensive surgery, and help lessen the need for amputation. The treatment is also used to treat AIDS-related Kaposi's sarcoma or cryotherapy, is the removal of abnormal or diseased tissue by freezing, usually with liquid nitrogen. The technique is used to treat cancerous tumors, control pain, control bleeding, and reduce brain tumors. Cryosurgery has been used to treat skin lesions for approximately 100 years. The first cryogens were liquid air and compressed carbon dioxide snow. Liquid nitrogen became available in the 1940's.

II. NANOTECHNOLOGY

A. Nanotechnology has the potential impact to surgical practice. Nanomedicine is the medical application of nanotechnology. Nano medicine ranges from the medical applications of nanometer's to nonelectric biosensors, and even possible future applications of molecular technology . Current problems for nano medicine involve understanding the issues related to toxicity and environmental impact of Nano scale materials .Molecular nanotechnology is speculative subfield of nanotechnology. Molecular nanotechnology is highly theoretical one. The proposed elements of molecular nanotechnology is molecular assemblers and nano robot. Nanotechnology is nothing but a technology which uses atom with a view to creating desired product. Ithas wider applications in all the field .The important application of nontechnology is Cryonics .Nanotechnology will enable manipulation of matter at the molecular level. Nano nephrology is a branch of nano medicine and nanotechnology that seeks to use nano-materials and nanodevicesfor the diagnosis, therapy, and management of renaldiseases.

II. NANOPARTICLES

Nanoparticles are promising tools for advancement of drug delivery, medical imaging and as diagnostic sensors .nanoparticles are stable, solid colloidal particles consisting of biodegrade polymer or lipid materials Nanoparticles are sized between 100 and 1 nanometers and they're used to treat cancer. The small size of nanoparticles endows them with properties that can be very useful in oncology, particularly in imaging. Quantum dots (nanoparticles with quantum confinement properties, such as size-tunable light emission), when used in conjunction with MRI (magnetic resonance imaging a successes of cryogenic engineering), can produce

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exceptional images of tumor sites. These nanoparticles are much brighter than organic dyes and only need one light source for excitation. This means that the use of fluorescent quantum dots could produce a higher contrast image and at a lower cost than today's organic dyes used as contrast media. Nanomedicine is the medical application of nano technology. Nano medicine ranges from the medical applications of nanometer's to nonelectric biosensors, and even possible future applications of molecular technology . Current problems for nano medicine involve understanding the issues related to toxicity and environmental impact of nano scale materials.

III. CRYOSURGERY(FREEZING)

Cryosurgery is also called cryotherapy or cryodestruction or cryoablation is a surgical technic that employs freezing at cryogenic temperatures to destroy undesirable tumor cells. cryosurgery is effected by means of a cryosurgery **device** called cryoprobes either by placing its continuously cooled tip on or into the tissues to be destroyed .Cryosurgery can also be done with the help of swab and spray. Cryo surgery is accepted and approved by many countries. This technique is used to treat cancerous tumors ,control pain ,control bleeding, and reduce brain tumors. Cryosurgery has been used to treat skin lesions for approximately 100 years. The first cryogens were liquid air and compressed carbon dioxide snow. Liquid nitrogen became available in the 1940's and currently is the most widely used cryogen. Liquid nitrogen, which boils at -196°C (-320.8°F), is the most effective cryogen for the use in clinical setting to the destroy diseased tissue, the tissue is cooled to -20°C to -30°C(-4°F to -22°F). Temperatures of -25°C to -50°C (-13°F to -58°F) can be achieved within 30 seconds if a sufficient amount of liquid nitrogen is applied by spray or probe Cryosurgery is a minimally invasive procedure, and is often preferred to more traditional kinds of surgery because of its minimal pain ,scarring, and cost. Cryosurgery has a typical success rates compared to other success rates for traditional open surgery. Imaging technology is one of the major developments in cryosurgery. Apart from the practical and economic advantage , it has physiological advantages also..

IV. CRYOSURGERY FOR THE TREATMENT OF CANCER

Cryosurgery is used to treat several types of cancer such as Bladder cancer, liver cancer, bone, breast, colon, esophageal, bladder, gastric, liver, lung, nasopharyngeal, ovarian, pancreatic, prostate, rectal, renal, skin, testicular, thyroid, uterine, head and neck cancer.. Some precancerous or non-cancerous conditions .Cryosurgery is also used to treat some types of low-grade cancerous and non-cancerous tumors of the bone. It may reduce the risk of joint damage when compared with more extensive surgery, and help lessen the need for amputation. The treatment is also used to treat AIDS-related Kaposi's sarcoma.

III. CYRO NANOSURGERY

The concepts of cryonanosurgery may offer new opportunities for future tumor treatment. cryonanosurgery is closely related to the advanced Nano-technologies. The Nanocryosurgery is deeply rooted in the test advancement of experiments and theoretical analysis indicate that, once nano particles are implanted into target area, not only the maximum freezing rate inside the target could be increased during cryosurgery compared with the conventional approach, but most importantly, the possibilities of ice nucleation could also **be significantly improved which would induce an enlarged death of tumor cells. Such innovation is quite beneficial** to raise the curative effectiveness of conventional cryosurgery and decrease the recurrence rate of post-cryosurgery. In addition, introduction of nanoparticles during cryosurgery could also help better image the edge of tumor as well as the margin of the ice ball. This is very important in guaranteeing a successful cryosurgery. Such merits may lead to a highly "green" therapy on tumor. Nanoparticles would further improve the effective killing rate of tumor cell with the combination of cryosurgery, except for adopting the highly conductive nano materials. Nano particles with lowered thermal conductivity can also have unique virtue in cryosurgery.

IV. BIO HEAT EQUATIONS

$$\frac{\partial(\rho h)}{\partial t} = \nabla \cdot (\nabla k t) + \rho_b C_b \dot{T}_b (T_b - T) + q_{met}$$

Where ρ is the density of the tissue, and where ρ_b is the density of the blood; h , enthalpy; t , time; \dot{T}_b the blood perfusion rate (ml·s⁻¹·ml⁻¹, the volumetric blood flow rate per unit volume of tissue); T_b , the blood temperature and T , the tissue temperature; c_b , the specific heat capacity of blood; q_{met} , the metabolic heat generation (w·m⁻³). The second and the third terms of Equation are the heat source contributions from blood perfusion and metabolic heat generation respectively. The sum of the two terms is the total heat source, marked as "Q". Equation is based on the assumption that blood in the biological tissue is supplied with an isotropic capillary network and it enters the tissue at the blood temperature of the major supplying artery and leaves the tissue at tissue temperature..

V. METHODOLOGY

Cryosurgical treatment for cancer is performed with mini cryogun or cryojet (model Inc-196) liquid nitrogen storage devices adapted to different types of cryoprobes used in the

cryosurgery till ice ball is formed (AUGold)solution is loaded for administrating the cryonanosurgery that is .nanoparticles are mixed with functional solution and injected into the target tissue. Depends on the type of tumor. Addition of nanoparticle into a wetbiological environment will increase the tissue conductivity ,good biological compatibility and thus significant freezing effects and more efficient ice formation. Cryonanosurgery can be tested with mice and human trails will also be held.

PROCESS OFCRYO (NANO)SURGERY

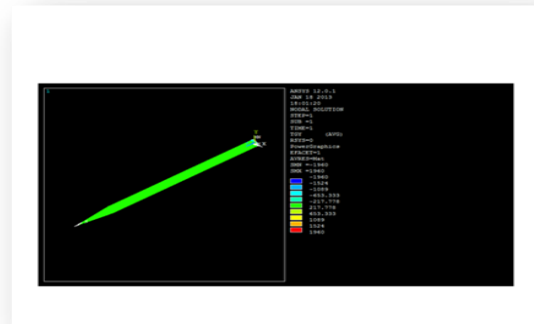
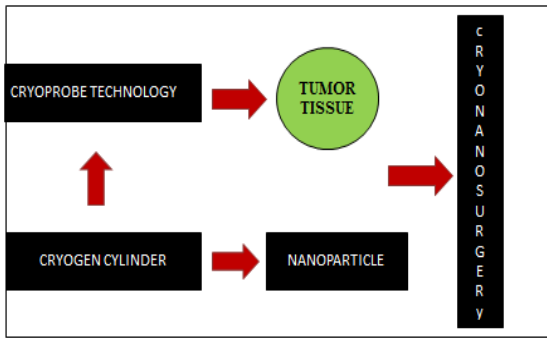


Figure 1 Thermal analysis

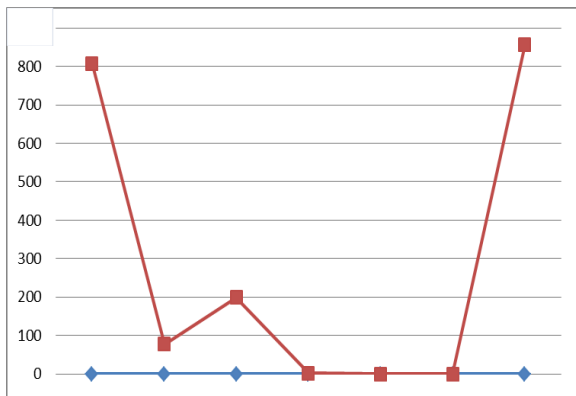


Figure 2 Property of LN₂ vs Value

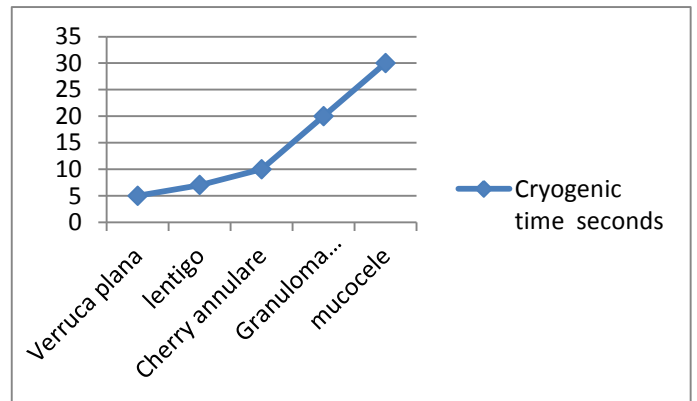


Figure 3 Cryogenic Time vs Lesion

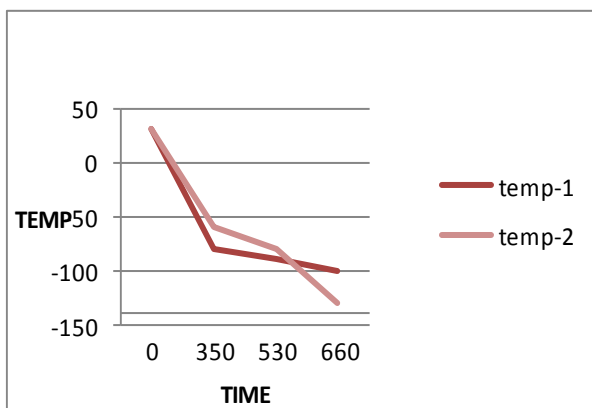


Figure 4 Time vs Temp

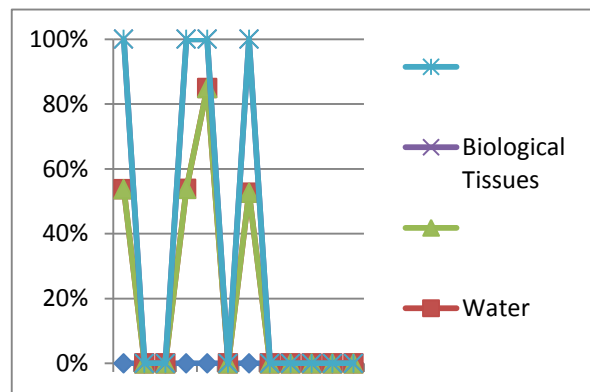


Figure 5 Biological tissue vs water

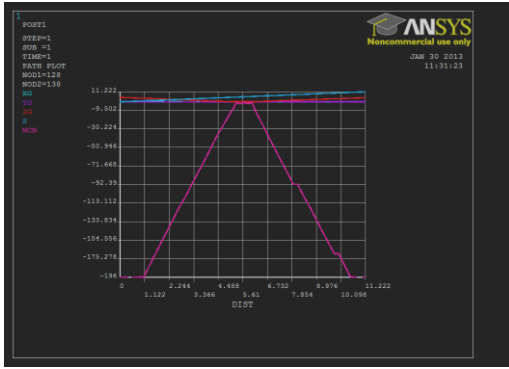


Figure 6 Thermal analysis

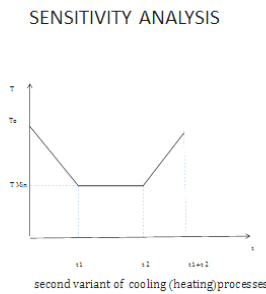


Figure 7 sensitivity analysis



Figure 8 cryo sprays and Adopter

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RESULTS &DISCUSSION

Ice volume and surface area of heat transfer can be increased using cryobrobes with large diameter. An increase in hydraulic diameter, there was a delay in the saturation boiling of the working fluid. The problem of in appropriate freezing in cryosurgery is minimized by the introduction of nanoparticles into target tissue area and it also improves image contrast and gives a better image guidance for the cryosurgical operation.

CONCLUSION

Common skin lesions normally require treatments that are lengthy, painful and require post-operative care. They may be time consuming and complicated but cryonanosurgery is very simple, flexible, indispensable and relatively comfortable and also gives better results .It is just a beginning to investigate cryonanosurgery but a lot of work is needed to understand nanocryosurgery in future since many critical and complex factors still not clear are to be studied and investigated ..Further study and investigations would be on both the basic mechanisms and practical issues.

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