CRYONANO PROBE DESIGN & DEVELOPMENT WITH CRYOGENIC TECHNIQUES APPLICATION

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ABSTRACT

Cryoprobe technology was used to design the cryogenic probe, and the same was analyzed. Penne’s Bioheat equations are used to solve heat transfer mechanism. To optimize the freezing and to enhancement in the freezing heat transfer and to increase freezing effects and more ice nucleation and there by minimize the surrounding healthy tissues being frozen the nanoparticles are loaded, which are very much required for the successes cryosurgery. This was done with the help of a device called cryospray or cryojet with different types of cryoprobes, till ice ball is formed. Various caliber probes gives better ice volume and surface area of heat transfer. Cryosurgery techniques and equipment was successfully applied in the fields of engineering and in many branches of medicine such as Cardiology, Oncology, dermatology, gynecology, urology, neurology, pulmonary medicine. It is also used in veterinary medicine.

1. INTRODUCTION

Cryosurgery is an important ablation technique for tumors and destroys tumors by cycles of freezing and thawing. Cryosurgery's destructive effects on tumors are due to two major mechanisms, one immediate, the other delayed. Cryosurgery is low temperature application to treat cancer and is often used to treat cancer 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. The mechanisms of cryosurgery are the effect of cooling, the effect of freezing, thawing and warming. Cryosurgery is accepted and approved by many countries. Applications of cryogenic techniques have been used in cryosurgery.

The Mechanisms of Cryosurgery

The effect of cooling.
The effect of freezing.
Thawing and warming

2. LOW TEMPERATURE SURGERY (FREEZING)

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. The technique is used to treat tumors where conventional surgery would be difficult. The Cryosurgery has a typical success rates compared to those of traditional open surgery.

3. THE JOULE-THOMSON PRINCIPLE

The joule-thomson principle is used in cryoprobe technology. Freezing of the cryoprobe's tip is achieved with the Joules-Thomson effect: liquid nitrogen during triggering by cryogun generates immediate cooling of the tip of the probe, theoretically to -89°C.

4. NANOTECHNOLOGY

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 Nanotechnology has the potential impact to surgical practice. 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. It has wider applications in all the field and one of its important application of nontechnology is Cryonics.

5. 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) can produce exceptional images of tumor.
GOVERNING (BIO HEAT) EQUATIONS

\[ \begin{align*}
\text{Cf} &= C_f t(1 - \eta) + C_p \eta \\
\text{Cu} &= C_u t(1 - \eta) + C_p \eta
\end{align*} \]

Where \( f \) is frozen mixture and \( u \) is unfrozen mixture.

\[ \frac{\partial T}{\partial t} + \nabla \cdot (k \nabla T) = q \]

7. OBJECTIVE OF DESIGNING THE CRYOPROBE

The primary objective of designing the cryoprobe is

a) To obtain a low cryogenic temperature of range -80 to -100 \( \text{c} \) at the tip of the cryoprobe
b) Diameter as small as possible to have minimal invasive surgery

METHODOLOGY

A new thermal model probe was designed and analysed to solve the problems in cryogenic surgery. To increase the tissue conductivity, significant freezing effects and more efficient ice formation, alumina alpha (Al₂O₃) nanoparticle solution is loaded for administrating the cryonano surgery. Cryosurgical treatment 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.

8. RESULTS & DISCUSSION

Using various caliber probes or using different diameter probes or simultaneous placement of more probes and Using different cryogen also gives better results. Different diameter of cryoprobes and materials minimize the freezing/thawing cycle. Cryonanosurgery is very simple, flexible, indispensable and relatively comfortable and also gives better results.
<table>
<thead>
<tr>
<th>parameter</th>
<th>Unit</th>
<th>value</th>
</tr>
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<tbody>
<tr>
<td>Blood perfusion rate</td>
<td>ml.s⁻¹ ml</td>
<td>≤0.011</td>
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<tr>
<td>Metabolic heat generation</td>
<td>KWm⁻³</td>
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<tr>
<td>latenheat</td>
<td>MJ.m⁻³</td>
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<tr>
<td>specific heat of frozen tissue</td>
<td>MJ.m⁻³°C⁻¹</td>
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<tr>
<td>specific heat of unfrozen tissue</td>
<td>MJ.m⁻³°C⁻¹</td>
<td>3.6</td>
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<tr>
<td>Thermal conductivity of frozen</td>
<td>w.m⁻¹°C⁻¹</td>
<td>0.5</td>
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<tr>
<td>Thermal conductivity of unfrozen</td>
<td>w.m⁻¹°C⁻¹</td>
<td>2</td>
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<tr>
<td>Blood temperature</td>
<td>°C</td>
<td>37</td>
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</table>

9. CONCLUSION

By increasing outputs or adding cryoprobes ice ball can be expanded to kill nearly any size of tumor any number of probes can be inserted and cooled simultaneously and the process of cooling can be monitored with ultrasound which gives (hypo echoic) a dark image when the tissue is frozen. It is just a beginning to investigate cryonanosurgery but a lot of fundamental understanding of the mechanisms of tissue damage is required during cryosurgery. Many critical and complex factors still not clear are to be studied and investigated. Further study and investigations would be on both improved cryosurgical device technology and mathematical cryosurgery optimization techniques. Further study is to develop improved imaging techniques. It is anticipated that cryosurgery will become a standard technique in the minimally invasive surgeon armamentarium.
Lesions and Effectiveness
CRYOPROBE THERMAL DESIGN
10. ACKNOWLEDGMENT

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11. REFERENCES


[5] M. Chandran, Dr. P. Senthil Kumar “cryonanoprobedesign & cryogenic techniques was published in the International Journal of International Journal of Mechanical Engineering Research and Development (IJMERD), ISSN 2248 – 9347 (Print) ISSN 2248 – 9355 (Online), Volume 3, Number 2 April - May (2013), pp.01-04