CRYONANO PROBE DESIGN & CRYOGENIC TECHNIQUES

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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 the 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 give 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.

Keywords: Cryosurgery, cancer, freezing, thawing and warming

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. Cryo surgery is accepted and approved by many countries. Applications of cryogenic techniques have been used in cryosurgery.

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. 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 element of molecular nanotechnology is molecular assemblers and nano robot. It has wider applications in all the field and one of its important application of nontechology is Cryonics.

4. GOVERNING (BIO HEAT) EQUATIONS

\[ C_f = C_f t(1 - f) + C_p \]
\[ C_u = C_u t(1 - u) + C_p \]

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

\[ \frac{\partial (\rho_b)}{\partial t} = \nabla \cdot (\rho_b C_{b-b}(T_b-T))+q \]

5. METHODOLOGY

A new thermal model probe was designed and analyzed to solve the problems in cryogenicsurgery. To increase the tissue conductivity, significant freezing effects and more efficient ice formation, alumina alpha (Al2 O3)nanoparticle solution is loaded for administrating the cryonanosurgery. 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.
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>
</thead>
<tbody>
<tr>
<td>Blood perfusion rate</td>
<td>ml.s⁻¹ ml</td>
<td>≤0.011</td>
</tr>
<tr>
<td>Metabolic heat generation</td>
<td>kW.m⁻³</td>
<td>33.8</td>
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<tr>
<td>Latent heat</td>
<td>MJ.m⁻³</td>
<td>250</td>
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<tr>
<td>Specific heat of frozen tissue</td>
<td>MJ.m⁻³°C⁻¹</td>
<td>1.8</td>
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<tr>
<td>Specific heat of unfrozen tissue</td>
<td>MJ.m⁻³°C⁻¹</td>
<td>3.6</td>
</tr>
<tr>
<td>Thermal conductivity of frozen</td>
<td>W.m⁻¹°C⁻¹</td>
<td>0.5</td>
</tr>
<tr>
<td>Thermal conductivity of unfrozen</td>
<td>W.m⁻¹°C⁻¹</td>
<td>2</td>
</tr>
<tr>
<td>Blood temperature</td>
<td>°C</td>
<td>37</td>
</tr>
</tbody>
</table>

7. 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 (hypoechoic) 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. The mechanisms of cryosurgery are the effect of cooling, the effect of freezing, thawing and warming.

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9. REFERENCES


