IMPROVED DESTRUCTION OF COLON POLYPS UNDER COMBINED COLONOSCOPY AND CRYOGENIC SURGERY

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Abstract

Along with development of modern imaging techniques in cancer biology, cryosurgery is emerging as minimally invasive surgical technique in treatment of some specific tumors (kidney, breasts, and bones, liver). Colon polyps/cancers are second largest cancers among humans with high death rate. They are diagnosed under various endoscopic methods/CT/MRI scans, and treated with surgical resection. Here, an alternative approach is proposed for the destruction of colon polyps under cryosurgery with colonoscopy probes. To increase the accurate freezing and destruction, nanoparticles are loaded in cryo probes. Thermal heat capacity equation is determined by PENNE’S bio heat equations. This procedure is relatively safe and long term survival rate may be increased, with fewer side effects compared with normal surgical resection and radiotherapies.

KEYWORDS: Cryoprobe, Colonoscopy, Polyps, Surgical resection.
INTRODUCTION:

Incidence of cancers of colon is low in India, being 5.9 and 5.3 per 1,00,000 in males and females, respectively as compared to 32.9 and 29.4 per 1,00,000 in U.S [7]. Cancers that start in the cells that line the inside of the colon (the longest part of the large intestine) and rectum the last few inches of the large intestine before the anus are called colorectal cancers. The colon and rectum form the large intestine (large bowel), which is the last portion of the digestive system. The digestive system, which is made up of the esophagus, stomach, and small and large intestines, extracts and processes nutrients (vitamins, minerals, carbohydrates, fats and proteins) from food and helps pass waste material out of the body. The important news about colorectal cancer is that it usually starts from a pre-cancerous growth called a polyp and grows slowly, usually in a predictable way. It therefore can be preventable with screening, and when diagnosed at an early stage [7].

Localized cancer of colon is a highly treatable with surgery and about 50% of patients are curable [7]. Recurrence following surgery is a major problem and often it is an ultimate cause of death. Radiation therapy and chemotherapy are by themselves only of palliative value, but, when used as adjuvants, have marginally improved the survival rates.

Here an alternative approach is proposed with theoretical design for the improved destruction of colon polyps under combined colonoscopy and cry probe induced cryogenic surgery. This technique is minimally invasive with efficient destruction of polyps.

COLONOSCOPY DIAGNOSIS:

Colonoscopy is a type of laparoscopic instrument used to view entire colon for diagnosis. The whole colon can be visually inspected, through fiber optic flexible colonoscopy before surgery to rule out multiple poly-poses or a synchronous second primary. Polyps can be respected and specimens for cytological and histological examinations can be obtained from suspicious lesions through colonoscopy. A through bowel preparations is necessary to eliminate intestinal gases and minimize the risk of explosion during electrosurgical usage. Colonoscopy is useful in evaluation of patients with familial polyposis and screening high risk patients with ulcerative colitis. Colonoscopy may be difficult in patients with diverticulitis, inflammatory structures, post radiation changes, and bowel fixation by previous abdominal and pelvic surgery.
Here, colonoscopy is combined with cryogenic probes for targeted freezing polyps, under monitoring of colonoscopy camera lens.

**CRYOGENIC PROBES:**

Cryo-probe technology was used to design the cryogenic probe, and the same was analyzed [5]. Penne’s Bio-heat equations are used to solve heat transfer mechanism [2]. 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 cryo-spray or cryo-jet with different types of cryo-probes, till ice ball is formed. Various caliber probes give better ice volume and surface area of heat transfer. Here cryoprobes are combined with colonoscopy to enhanced freezing of polyps, and the theoretical design of combined cyoprobes and colono-scopic probes are shown in fig.1a)

![Cryogenic Probes Diagram](image)

**BIO HEAT EQUATIONS:**

Bio heat model of Penne’s, is widely used one which describes the tissue freezing process [2]. Thermal capacity equation can be written as
where \( f \) is frozen mixture and \( u \) is unfrozen mixture. Where \( \rho \) is the density of the tissue, \( b \) is the density of the blood; \( h \), enthalpy; \( t \), time; \( \omega b \) the blood perfusion rate (ml·s\(^{-1}\)·ml\(^{-1}\), the volumetric blood flow rate per unit volume of tissue); \( Tb \), the blood temperature \( T \), the tissue temperature; \( cb \), the specific heat capacity of blood; and \( q_{met} \), the metabolic heat generation.

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.

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 \(-89°C\).

**BIO PHYSICS OF COLON CRYOSURGERY:**

Cryosurgery or cryoablation is a technique involving the use of extremely low temperatures to destroy tumors that are left in place to be reabsorbed. The initial approach involved the application of liquid nitrogen at the surface of polyps and the vacuum insulated, recirculated nitrogen cryoprobes combined with colonoscopy. Since the developing the ice ball or cryolesion and the marginal of the normal tissue frozen around the tumor can be seen under colonoscopy [4].

**THE MECHANISMS OF CRYOSURGERY**

The main mechanisms of the cryosurgery involve the following three major process

1. The effect of cooling.
2. The effect of freezing.
3. Thawing and warming.

**PHYSICAL ASPECTS:**
Cryosurgery destroys cells directly by affecting the physiochemical properties and indirectly affecting the structure of vascular channels. The process begins when liquid nitrogen circulates at -196 deg [6]. Celsius through a vacuum probe combined with colonoscopy. The probe is placed in the direct contact of the polyps under guidance of colonoscopy. Ice crystals are formed both inside and outside of the tissues, when the cells are exposed to temperatures below the melting point. As ice forms, the electrolytic compounds are excluded from the crystals, an hyperosmolar environment is created in the extracellular compartment that draws water from inside of the cells. As a result, the tissue shrinks, the cell membranes are disrupted, and the intra cellular proteins in denatured, thus destroying the cell function [4]. Freezing propagates from one cell to another through communication channels. As more tissue crystallizes when small ice crystal grows together with large crystals, a grinding action is created that mechanically disrupts the tissue.

A cycle of freezing is completed; the thawing process occurs. Rapid freezing and slow thawing leads to further tissue damage. As the treated area warms, water passes into the cells and increases in volume, thus bursting the cell membranes. This process is repeated with a second or third cycle until any remaining viable tumors cells are destroyed. Once cryosurgery is performed, the tumor undergoes necrosis and is left in place. A cellular repair process begins immediately and may last several months. Some lesions, particularly small ones, may undergo full resorption and disappear completely.

**TECHNICAL ASPECTS:**

The freezing process involves hollow metallic probes through which liquid nitrogen circulates. The probes are insulated except at the end of the shaft, which comes in contact with the tumor. The size and shape of the ice ball produced depends on the diameter of the probes. The process of ice ball formation can be effectively monitored with less invasive colonoscopy. Colonoscopy combined this type of cryosurgery involves a local anesthesia.

The size of the lesions determines the size of cryoprobe to be used. As the ice forms from the centre outward, the central area freezes rapidly, intermediate area freezes at a moderate rate, and the periphery cools slowly. Thermal gradients can range from 10 deg. Celsius for every millimeter of a tissue, depending on the efficiency of the probe. After the freezing process ends up, two or three thaw cycles are recommended which is followed by
rewarming of tissues. Necrosis of the tumor is demonstrated by gas bubbles in the tumor [4], which may be of no clinical significance.

**NANOCRYOSURGERY FOR COLON POLYPS:**

The concept of cryonano surgery gives new opportunities for future tumor treatment. Advanced nanotechnology is cryonano surgery [1]. The nano cryosurgery is deeply rooted in the test advancement of a nontechnology, 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 [3]. 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. Nano particles 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. This may also be induced in combined cryogenic surgery under colonoscopy for efficient cellular level destruction of polyps with limiting the damage of unwanted freezing of nearby healthy cells. Meanwhile, the introduction of nanoparticles during colon polyps destruction, it could also help a better image the edge of the tumor as well as the margin of ice ball with highly safe , targeted and accurate freezing therapy in future tumor clinics.

**COMPLICATIONS AND CONTRADICTIONS:**

Cryosurgeries for colon polyps have side effects, although they may be less severe than those associated with surgery or radiation therapy. The effects depend upon the location of the tumor. For benign types of polyps or any precancerous polyps the side effects are less severe, it may cause cramping, or any abdominal pain that too lasts for few weeks, until the necrosis of the tissue occurs. For malignancy, the cryosurgical reactions may cause constipation or diarrhea, with abdominal pain along with bloating effects. Although the side effects of cryosurgery may be less severe than those associated with conventional surgery on radiation, more studies are needed to determine the long term effects.
IMPACT OF CRYOSURGERY FOR FUTURE OF COLON POLYPS:

Additional studies are needed to determine the effectiveness of the cryosurgery in controlling colon polyps and improving survival. Data from these studies or novel idea will allow physicians to compare cryogenic surgery with standard treatment options in colon polyps. Moreover, physicians continue to examine the possibility of using cryosurgery in combinations with other treatments.

The major problem in cryosurgery for colon polyps 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. Cryonanosurgery is very simple, flexible, indispensable and relatively comfortable and also gives better results. It is just a beginning to investigate cryonano-surgery but a lot of work is needed to understand nano-cryosurgery 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.

CONCLUSION:

The theme of this paper is not only to eradicate the local type of tumors but also to improve the survival rate of patients with additional years of life, not months. The preliminary study demonstrated the efficient destruction of colon polyps under combined colonoscopy and cryogenic surgery with limiting the regrowth of the tumors arising from the treated tissue. Even though, a theoretical model of surgical procedure has been discussed, the work needs additional molecular-based mechanism of enhancement of freezing destruction. These types of combined endoscopic cryogenic surgical techniques can offer a reasonable hope to the patient.

The nano cryosurgery may lead to advancement in solid tumor therapy by increasing treatment efficiency through carefully planned combinations of a minimally invasive cryosurgical procedure and combined endoscopic techniques. However, a comprehensive understanding of cryosurgery still needs a tremendous work in near future. Since, what has been presented above is not a conclusive. It is just a beginning to investigate the combined endoscopic and cryosurgery for internal cancers. This paper has a preliminary outline for promising future of this emerging physical smarter therapy. To reduce the high costs of these methods, the cryogenic units should be made under indigenous. Future efforts should be made
to perform these types of efficient and flexible way of surgeries to clinically available to all patients at rural with low cost. And finally technology cures and heals

REFERENCES:


