Handbook of Cryosurgery

Edited by
Richard J. Ablin

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Foreword

For far longer than a century before the development of modern cryosurgical techniques, there was both interest and practical application in the physiological and destructive effects of cold upon the function and structure of various organ systems of the human body. However, I believe that the modern era of cryogenic surgery can be said to have begun in 1961 with the development of a practical, controllable system for the use of extreme cold as a physiological and surgical tool. In 1967, Balthasar, producing cold injuries in cerebral cortex of cat, concluded that the use of cold was the most physiologic method for creating lesions in the brain. Haas and Taylor, as a result of a pathologic investigation of lesions produced by extreme cold in various organs, recommended that surgeons study the instrumental application of cold as a surgical technique. Bory suggested that as a surgical agent, the use of cold offered the advantage of anesthetic, coagulant, and destructive properties.

The various advantages that might be offered by the use of cooling and freezing in surgical techniques was, therefore, evident for many years. Openchowski developed an instrument which employed the principle of rapid evaporaton of ether. Haas and Taylor developed an apparatus which contained carbon dioxide snow and which cooled tissue by creating a negative thermal gradient from the tissue contiguous to the cooling instrument. They unequivocally demonstrated the ability of extreme cold to produce discreet, circumscribed, relatively hemostatic, biologic lesions in various organs of animals. Weil, Chanteur, and Dondey developed a cooling cannula, which employed butane or propane as a refrigerant, in order to produce transitory nervous function blockade in the brain of a cat. Dondey, Rey, and LeBeau recommended the use of a similar cannula for surgical coagulation in the nervous system, and Ries and Tytus also reported rapid freezing as an experimental surgical technique in animals.

For many years prior to the development of the modern cryosurgical instruments, I was engaged in neurosurgical techniques which required physiological inhibition of nervous function prior to the infliction of a permanent therapeutic lesion. It occurred to me that the use of cooling, followed by the use of extreme cold, might be the ideal way to achieve both inhibition and lesion formation within the nervous system. It was this which led me to investigate the use of extreme cold as a physiological or surgical tool.

My first experiments were carried out with Arnold Lee. We developed a system which employed liquid nitrogen as the refrigerant, but could not, in my opinion, successfully develop a completely satisfactory method of insulating the cannula. Therefore, I decided to investigate the possibilities of employing vacuum insulation, in a relatively tiny probe, to make possible the use of liquid nitrogen as a refrigerant. This proved to be a practical and successful method.

The first liquid nitrogen system was developed in collaboration with the Sage Instrument Company, employing an active vacuum pump to satisfactorily insulate our cryosurgical probe. Ultimately, it became obvious that we would have to employ a system in which the cannula was permanently insulated by a vacuum sheath, and this was developed in collaboration with Arthur Rinfret and his associates at the Lindy Corporation.

The source of refrigeration (and still the principal cryosurgical instrument used today in various disciplines) is liquid nitrogen, the temperature of which is dependent upon the pressure. At 22 lb/in.^{2}, liquid nitrogen is stored in the system at −196°C. An insulated withdrawal sheath carries the liquid nitrogen under pressure to the cannula. This withdrawal tube must be precooled for approximately 2 min before allowing the liquid nitrogen to enter the surgical probe. When the discharge through the precooling valve changes from liquid and gas to liquid only, indicating that the withdrawal tube has been cooled to the temperature of liquid nitrogen, the refrigerant is then allowed to pass into the surgical probe, which has been placed in the tissue to be cooled or frozen. Only the tip of the cooling cannula in the case of the system employed for use in the brain, is not insulated. In this noninsulated tip, liquid nitrogen withdraws heat from the adjacent tissue in a predictable manner according to known physical parameters. The liquid nitrogen is rapidly transformed into gas, which escapes through the outer portion of the cooling cannula. The temperature of the freezing tip is automatically controlled, and is recorded by a copper-constantine thermocouple located within the tip and visibly monitored. This system has been modified for use in various organs, and other techniques have been devised which will be described within various chapters of this handbook.

We have found that cryogenic surgery offers the ideal characteristics for physiological and clinical testing and lesion infliction with deep brain structures. Our use of cryogenic brain surgery has been reported many times and does not require elaboration in this instance. In fact, one of my neurosurgical colleagues has contributed a chapter on the use of cryogenic surgery within the central nervous system to this handbook. I would like to say that I believe, even though this method has been widely employed throughout the world, that cryogenic surgery has been underutilized within my own specialty. For example, employing a rather large cryosurgical probe, a large hemorrhagic tumor within the brain can be rapidly frozen and turned into a ball of ice which neither bleeds nor presents any difficulty in removal once it has been transformed in this matter. In addition, this frozen tissue may be manipulated by the cryosurgical probe, as though the tumor had a handle upon it. It can be then dissected free from the surrounding brain tissue without the employment of retractors or any other undue pressure upon the normal brain tissue.

The first successful use of the modern cryosurgical system was carried out on our service in 1961. It immediately became apparent that the possible usefulness of this tool extended far beyond its employment in physiologic neurosurgery. One of the most obvious was the cryogenic congelation of the necrosis of cancer. Arnot, in 1851, had attempted to treat cancer by the employment of cold rind solution to tumors of the breast. A century later, in collaboration with Grisman, Gorek, and Williams, we applied our new method of cryogenic surgery to malignant growths in differe nt parts of the body. It was demonstrated the extreme cold could produce necrosis of cancer tissue in vivo, that the method could be used with a great margin of safety, and that it was a relatively simple technique. Gage and others will report on the elaboration of the usefulness of extreme cold for the cryogenic congelation and necrosis of cancer in this handbook.

One of the remarkable things about the use of extreme cold as a method of tissue destruction is that it does not cause necrosis of arterial tissue or thrombosis within arteries. Rather, it freezes the artery, and the frozen blood is then lysed. In collaboration with Samra, in laboratory experiments, I found and reported that experimental thromboses within arteries could be frozen and lysed, reestablishing blood flow within arteries. This was an experiment which has not been followed up clinically, but which deserves consideration as a therapeutic tool.

Another remarkable fact about the use of extreme cold is that it does not produce scarring when employed on superficial tissues such as the skin. Therefore, carcinomas of the skin and mucous membranes can be frozen and destroyed, even at mucoid-epidermal borders such as the lip, without fear of scar tissue production.

I congratulate the authors and the editor of this *Handbook of Cryosurgery*. I recommend it to a wide readership among all surgical disciplines, since it describes in detail safe and efficacious techniques for temporarily interrupting physiologic and chemical functions of various organs as well as producing therapeutic lesions within these organs. Its contribution to the development of an immunologic response to malignant tissue within the body is still one of the most exciting and interesting possbilities being explored.

Like all other modalities which we consider to be new, we now know that the use of extreme cold has been encouraged as a therapeutic tool of the art of therapy for many centuries. In my view, it is still in its formative stage. I am certain that this handbook will help to define its role and to induce those who have yet realized its potential to investigate the usefulness of cryogenic surgery as an investigative and therapeutic tool.

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Preface

The past decade has witnessed a rapidly growing literature in the various disciplines of cryosurgery, accompanied by an increasing number of conferences being held on this subject. Notable examples have included, among others, the International Congresses of Cryosurgery in Vienna, Austria (1972), Turin, Italy (1974), and Valencia, Spain (1977); an International Symposium on Cryosurgery in Urology, Stuttgart, Germany (1973); a Workshop on Cryosurgery, Washington, D.C. (1975); an International Conference on Cryoimmunology, Dijon, France (1976); and, most recently, a Symposium on the Immunological Aspects of Cryosurgery held in Tokyo, Japan (1978). These, together with the organization of a national and international cooperative study group, the Group d'Etudes de la Cryochirurgie and the Cryoimmunotherapeutic Study Group, and the founding of the International Society of Cryosurgery in 1974 and the American College of Cryosurgery in 1977, testify to the interest in the continued development and application of cryosurgery for the controlled cryogenic destruction of abnormal tissues.

An integral part of this development and application has lain not only in advances in instrumentation and sophistication of technique for attainment of improved methods of palliation and treatment, but also in increased knowledge of the biochemical, physiological, immunological, and morphological alterations following freezing.

This *Handbook of Cryosurgery* was conceived following an extensive telephone conversation in late November 1976 with Doctor Maurits Dekker. Rather than a conventional review of the state of the art of the various disciplines of cryosurgery, it was thought that a text on what opportunities cryosurgery may contribute to the treatment of disease from a *how to do* and *why* point of view would prove more useful. To this end, it is I believe fair to state that not since publication of *Cryosurgery* in 1968, edited by Doctors Robert W. Rand, Arthur P. Rinfret, and Hans von Leden, has there been assembled a more knowledgable and experienced group of authors than those contributing to this handbook.

The outstanding feature of this handbook is to provide a comprehensive treatise on the practical application of cryosurgery for the treatment of benign and malignant disease in humans with exemplary consideration of the use of cryosurgery in experimental oncology and veterinary medicine.

While I am the editor, this text obviously represents the cooperative and dedicated efforts of my contributors to whom I remain appreciative for making what I hope will provide illuminating and invaluable information for present and future applications of cryosurgery. Equally, my appreciation and gratitude to my editorial assistant, Mrs. Barbara Saunders, for her diligent assistance and patience to the very end. A special note of my appreciation and indebtedness must be given to Professors Ernst H. Beutner and the late Ernest Witebsky, my principal mentors in the discipline of immunology, whose introduction and encouragement led me to my initial and intriguing collaborative studies with Doctors Maurice J. Gonder and Ward A. Soanes, on the immunological aspects of freezing. I wish to express my appreciation to my wife, Lynn, and son, Michael, for their patience and understanding, particularly during my anxious hours of editing and writing.

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