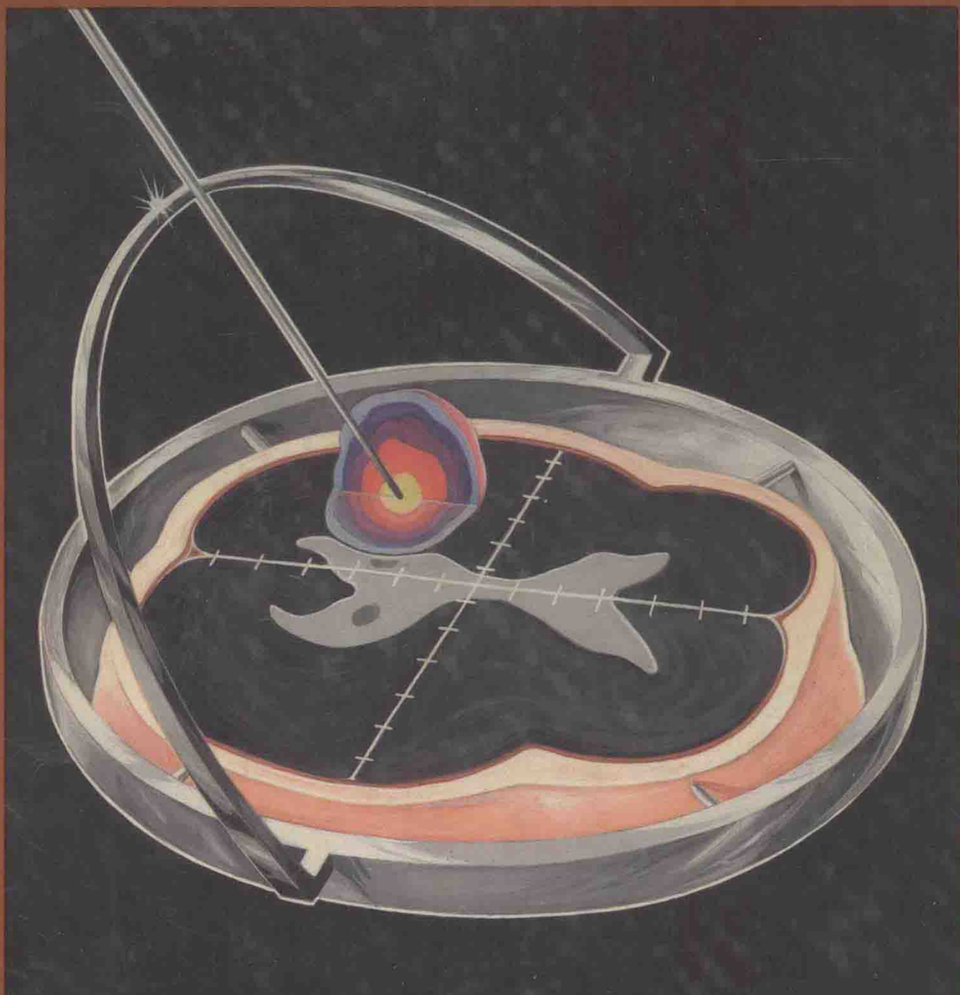
Peter Dyck

Stereotactic Biopsy and Brachytherapy of Brain Tumors

Introduction by Fritz Mundinger



University Park Press • Baltimore

Stereotactic Biopsy and Brachytherapy of Brain Tumors

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University Park Press • Baltimore

University Park Press
International Publishers in Medicine and Human Services
300 North Charles Street
Baltimore, Maryland 21201

Sponsoring Editor: Larry W. Carter
Production Manager: Berta Steiner
Design: Caliber Design Planning, Inc.
Cover illustration by Ted Bloodhart

Typeset by Kingsport Press
Manufactured in the United States of America by Halliday Lithograph

Library of Congress Cataloging in Publication Data
Main entry under title:

Stereotactic biopsy and brachytherapy of brain tumors.

Includes index.
1. Brain—Tumors—Radiotherapy. 2. Radioisotope brachytherapy. 3. Brain—Biopsy, Needle. 4. Stereoencephalotomy. I. Dyck, Peter James. [DNLM: 1. Brain neoplasms—Radiotherapy. 2. Brachytherapy—Methods. 3. Stereotaxic—Methods. 4. Brain—Radiography. 5. Biopsy —Methods. WL 358 S838]
RC280.B7S8 1983 616.99′2059 83–14500
ISBN 0–8391–1926–7

Stereotactic Biopsy and Brachytherapy of Brain Tumors

This book is dedicated to the patients whose hope against overwhelming odds brought about this endeavor.

Introduction

In spite of the many great strides in medicine in recent decades, neurosurgeons have continued to express trepidation when approaching deep-seated intracranial lesions, even when they are cystic. Similar pessimism prevails towards recurrent cerebral neoplasms, particularly those that have failed teletherapy. Olivecrona, among many others, was of the opinion that nothing more could be done at this point.

Palliative shunting of obstructed ventricular systems caused by midline tumors is widely available, and modern anesthesia, microsurgical technics, and corticosteroid therapy have improved overall the prospects of brain tumor patients. However, the prognostic outlook for patients with deep-seated, recurrent tumors remains unfortunately poor. It was not too long ago that Paul Bucy said that cerebral gliomas in general are incurable. Nevertheless, a handful of neurosurgeons have not been dissuaded by the prevailing pessimism, and they continued to explore various avenues that might improve the dismal lot of these unfortunate patients with midline or recurrent neoplastic lesions.

Shortly after Roentgen's discovery of X-rays, the salutary effects of irradiation of brain tumors became apparent. In 1922 Tönnis implanted radium needles or paraffin capsules containing radium into residual gliomas after subtotal resection. By 1935, Harvey Cushing drew attention to this technic in North America, while Kroll, Jäger and Kessel rigorously pursued this eventually disappointing endeavor in Germany.

Resurgence of interest in interstitial radiation grew in the early 1950s. Artificially produced radioisotopes with favorable clinical and physical characteristics and the ability to deliver high radiation doses to a tumor without injury to surrounding brain became widely available.

Georg von Hevesy, from the University of Freiburg im Breisgau, was among the pioneers in this field. A radioactive source was administered orally or intravenously in an attempt to concentrate the radionuclide within a tumor by taking advantage of the disrupted blood-brain barrier produced by the pathologic process. Iodine-121 and its therapeutic role in thyroid neoplasia served as the therapeutic leit motif of this endeavor.

In 1949, Selverstone and Ericson, and two years later Sweet, advocated the use of radiophosphorus (P-32) as a therapeutic adjunct. Sodium-24 and potassium-42 were proposed by Locksley in 1949; Tipser and Freedberg advocated rubidium-86; I proposed wismut-106 in 1958; and finally in 1961 Browell suggested the use of dysprosium-165 EDTA. A number of other isotopes were also tried. Although an increased concentration of the isotope within the neoplasm could be proven, it could not be verified that the regional interstitial radiation was not detrimental to surrounding healthy structures. Hence, these early endeavors were abandoned.

It appeared logical that direct interstitial radiation with an implanted radionuclide might prevent injury to surrounding normal brain, yet deliver therapeutic range of radiation to the offending lesion. Now arose the question of whether interstitial radiotherapy (curietherapy) should be protracted or short lived (brachycurietherapy). The answer in part lay in the cell kinetics of the neoplasm.

How best to adapt the principles of radiobiology and hence arrive at an acceptable teletherpeutic dosimetry for a brain tumor has been a long-standing topic of discussion in neurosurgical circles. Cystic gliomas and craniopharyngiomata were treated with intracavity instillation of phosphorus-32 by Klar (1953) and by Obrador, Spiegel and Wycis (1956). Colloids of gold-198 and yttrium-90 were also recommended for this purpose.

In 1951, Phillip and I utilized phosphorus-32-molybdenum compound, encased in a plexiglass capsule, as intracavity radiotherapy following radical excision of the lesion. In 1955, a graphite macrosuspension of gold-198 was employed subsequent to reoperation on a tumor; it was deposited into the cavity.

In 1957, we began using tantalum-182. I also introduced iridium-192 as an interstitial radioimplant. Fragmented cobalt-60 wire was also employed by me as well as by Klar and Scheer in 1952. Brachytherapeutic principles only were applied in this instance, for obvious reasons.

When cesium-157 and especially iridium-192 came on the market, interstitial radiation concentrated over a short period of time gained a foothold in the treatment of brain tumors. The Gamma-Med® developed by Sauerwein and myself in 1963 remains an available brachycurietherapeutic tool at our institution to the present day. With it, high-intensity regional radiation is delivered to a highly anaplastic lesion within minutes.

In spite of the fact that interstitial radiation of brain tumors has been hesitantly accepted, our results and the data of others support a basis for optimism. Yet it must be underscored that not all institutions offer a favorable environment for the development of modern stereotaxis and present day interstitial radiotherapy.

It was soon learned that radionuclides inserted intraoperatively at craniotomy did not necessarily remain where they were placed, and it was difficult to arrive at dosimetric computations. Also, when cobalt-60 or cesium-157 were employed, the radiation precautions to the hospital crews proved extremely costly. Such undertakings were soon abandoned.

Radiotherapists who handle radioisotopes are constantly aware of the environmental dangers. In order to minimize this danger, Henschke, after extensive personal experience, developed a sophisticated radionuclide application technic for iridium-192. Hilaris then developed an iodine-125 application technic in 1975.

The utilization of stereotaxis for interstitial radiotherapy greatly enhanced targeting accuracy. Although stereotaxy, as introduced by Spiegel and Wycis in 1947, occupied itself then primarily with functional neurological disorders, today it emphasizes localization of nonfunctional intracranial mass lesions. Traugott Riechert and I performed the first stereotactically guided radioimplant of a cerebral cyst in 1953.

In the early 1950s, it was not the deep-seated intracerebral lesions, but rather pituitary neoplasms that received most of the curietherapeutic attention. We were involved in such an endeavor for more than two decades. At first we used phosphorus-32. Then in 1959, Molinatti advocated the use of yttrium-90 seeds. Two years later Joplin proposed the use of gold-182; that same year, 1961, I suggested the use of iridium-192 wires. In February, 1979, I employed iodine-125 to irradiate the tumor of an acromegalic patient. Excellent short- and long-term results have been reported all over the world with this form of interstitial radiotherapy of pituitary tumors.

Rediscovery of the transphenoidal surgical approach to the pituitary fossa, advocated by Jules Hardy and presently in vogue, has modified indications for interstitial radiotherapy of pituitary tumors as well. Yet, interstitial radiotherapy of other cerebral neoplasms has recently received greater attention, albeit in only a few institutions in the world.

The advent of microsurgery, laser technic, modern teletherapy, and high voltage, neutron and proton therapy, combined with corticosteroids and chemotherapy, at first appeared to offer a ray of hope for patients suffering from malignant intracranial lesions. Yet in the past few years, regional and international studies suggest that this is not necessarily the case. In fact, when compared with data from the period 1941–1978, present survival is only slightly improved and useful survival may actually be decreased.

With the introduction of CT-aided stereotaxy and modern radiodosimetric computations, more encouraging prognostic results are in the offing. As of May 19, 1983, we have interstitially radiated 1502 intracranial lesions. Most of our experience is with iridium-192, but iodine-125, made available to us by Hilaris in 1979, also has been widely utilized. Favorable physical properties, including a steep drop in the radiation radius of iodine-125, make it a desirable isotope in the therapeutic armamentarium. And both iridium-192 and iodine-125 comply with national guidelines for radiation safety. Present clinical experience and dosimetric standardization based on CT data, volume reformat and neuropathologic data will inevitably lead to further refinements. Basic research in this field, assimilating available data and further expanding investigation, is needed.

Clinically it is stereotaxy coupled to the CT scanner that has brought about the resurgence of interest in interstitial radiotherapy of nonresectable intracranial lesions. This optimism has been supported by a low complication rate and a high degree of accuracy in diagnosis.

The contemporary spectrum for therapy of brain tumors includes total resection, excision biopsy, curietherapy, teletherapy, and a combination of the latter two. The aggressiveness of the lesion and its histologic type determine the mode of treatment.

After a long period of professional dormancy, interstitial radiation of brain tumors is again receiving its due attention. And with meticulous attention to modern stereotaxis and radiotherapeutic principles, interstitial radiotherapy will find its rightful niche, to the benefit of some patients.

This book is a forum for national and international expression by experts in stereotaxy. Its purpose is to gather pertinent data that impact on modern interstitial radiotherapy of brain tumors. Peter Dyck has taken on not only the arduous task of editing, but also of contributing from his own experience in this field. Thanks to his far-sightedness, neurosurgeons, neurologists, radiotherapists, oncologists and students now have a competent guide to CT-aided stereotaxic biopsy and brachytherapy of brain tumors.

Prof. Dr. Fritz Mundinger
Freiburg im Breisgau
West Germany
May, 1983

Preface

The current renaissance of interest in human stereotaxy is due to new developments primarily in three areas of medicine: computerized tomography of the brain, computer processing of stereotactic data, and increasing awareness of inadequacies of chemotherapy and teletherapy.

Of foremost importance is the modification of CT targeting systems to allow artifact-free, CT-guided stereotaxis. But even with the current precision and expediency of computerized tomography, our contemporary stereotaxic systems approach an accuracy that challenges the resolution capabilities of the CT scanner itself. Professor Dr. Fritz Mundinger of the University of Freiburg, West Germany, has remained one of the forerunners of this frontier. Much of his experience, as well as that of Leksell and others, is covered in these pages. A completely new development is stereotaxis performed with the patient in the CT-scanner.

Computer processing of stereotaxic data is now readily available. Armed with a hand-held calculator and an appropriately programmed magnetic card, the stereotactician is able not only to plan a precise trajectory to the lesion, but also to compute the iodine-125 or iridium-192 dosimetry before the patient leaves the operating theatre. Armand Bouzaglou explains the details of making these calculations in his chapter on radiotherapy.

These technical developments would have dubious value to the surgery of brain tumors were it not for a clinical need. We live in a period of *Sturm und Drang* of brain tumor therapy. Doubt has been expressed recently about the role of chemotherapy in useful survival. Even more alarming is the fact that chemotherapy may potentiate teletherapeutic injury to surrounding normal brain.

It is well known that radiation is not selectively injurious to neoplasms only, but affects also healthy brain tissues. In this therapeutic circumstance, is teletherapy without tissue diagnosis ever justified? It would seem that the answer is no since modern stereotaxis allows biopsy of almost any lesion of the brain with an acceptable risk to the patient.

A substantial body of knowledge suggests that in certain circumstances, interstitial radiation is equal to if not superior to teletherapy. However, a great deal of prospective data-gathering is needed, preferably on a national or global basis. The immediate future of modern stereotaxy is very exciting because it fills an urgent clinical need. At the same time, it offers the stereotactician a chance to take a step forward in the twentieth century with Aesculapius at his side.

In compiling this book, I endeavored to make this step forward less troublesome for the reader than it was for me. In bringing together existing knowledge from so many sources, it has become clear that several areas of our knowledge of this procedure are decidely inadequate. I anticipate that the reader will encounter some controversial issues in these pages; these are due not to bias or imperiousness, but possibly to incomplete fact.

My ultimate hope is that this book will not only inform the reader, but will stimulate the acquisition and publication of new information that will bring about improved results in our treatment of brain tumors. Time will tell.

Peter Dyck, M.D., F.A.C.S.
La Cañada-Flintridge, California
17 May 1983

Acknowledgments

According to John Donne, "No man is an island entire of itself." This becomes apparent early when one endeavors to edit a book.

First I express my gratitude to my colleagues, Armand Bouzaglou, M.D., Livia Solti-Bohman, M.D., and Philip Gruskin, M.D. They comprise the primary team.

I express my gratitude to Robert J. McKenna, M.D., President-Elect of the Society of Surgical Oncology and Barry Sakulsky, M.D., Cancer Research Director, St. Vincent Medical Center, for sharing my dream.

I thank John Gardner, President of Queen of Angels Medical Center and that institution's research foundation and the Cosler Cancer Fund. The same gratitude is extended to Vincent F. Guinan, President, St. Vincent Medical Center, and its public relations staff.

The CT-scanner and operating room crews' industry and loyalty will not be forgotten.

It was the graciousness of Robert Sloane, President, Los Angeles Orthopaedic Hospital, that allowed photographic and audiovisual recording of this project under the directorship of Alfred Benjamin, the SLR camera of Eloise Smith and the video mastery of Abe Thomas.

I would like to thank Franz Isak for his friendship and uncanny capacity to make tangible precision built objects from casual sketches.

My deepest gratitude goes out to Larry Carter, Senior Editor of University Park Press for his indefatigable patience and faith in me.

Yet I suspect this entire project would have come to naught were it not for Martha Aparicio who rolled with the punches and kept the whole project together, with a smile.

My family will see more of me!

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