

Intraoperative Radiation Therapy

INTRAOPERATIVE RADIATION THERAPY

Proceedings of the Third International Symposium
on Intraoperative Radiation Therapy

Edited by

Mitsuyuki Abe, M.D.

Professor and Chairman
Department of Radiology
Kyoto University
Kyoto, Japan

Masaji Takahashi, M.D.

Professor
Department of Oncology
Chest Disease Research Institute
Kyoto University
Kyoto, Japan

PERGAMON PRESS

Member of Maxwell Macmillan Pergamon Publishing Corporation

New York • Oxford • Beijing • Frankfurt
São Paulo • Sydney • Tokyo • Toronto

Pergamon Press Offices:

U.S.A.	Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, New York 10523, U.S.A.
U.K.	Pergamon Press plc, Headington Hill Hall, Oxford OX3 0BW, England
PEOPLE'S REPUBLIC OF CHINA	Pergamon Press, Xizhimenwai Dajie, Beijing Exhibition Centre, Beijing, 100044, People's Republic of China
GERMANY	Pergamon Press GmbH, Hammerweg 6, D-6242 Kronberg, Germany
BRAZIL	Pergamon Editora Ltda, Rua Eça de Queiros, 346, CEP 04011, Paraiso, São Paulo, Brazil
AUSTRALIA	Pergamon Press Australia Pty Ltd., P.O. Box 544, Potts Point, NSW 2011, Australia
JAPAN	Pergamon Press, 8th Floor, Matsuka Central Building, 1-7-1 Nishishinjuku, Shinjuku-ku, Tokyo 160, Japan
CANADA	Pergamon Press Canada Ltd., Suite 271, 253 College Street, Toronto, Ontario M5T 1R5, Canada

Copyright © 1991 Pergamon Press, Inc.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means: electronic, electrostatic, magnetic tape, mechanical, photocopying, recording or otherwise, without permission in writing from the publishers.

Library of Congress Cataloging in Publication Data

International Symposium on Intraoperative Radiation Therapy (3rd :
1990 : Kyoto, Japan)

Intraoperative radiation therapy : proceedings of the Third

International Symposium on Intraoperative Radiation Therapy / edited
by Mitsuyuki Abe and Masaji Takahashi.

p. cm.

The symposium was held in Kyoto, Nov. 12-15, 1990.

Includes bibliographical references and index.

Cancer--Intraoperative radiotherapy--Congresses. I. Title.

[DNLM: QZ 263 J6165j]

RD54I58 1990

616.99'40642--dc20

DNLM/DLC

for Library of Congress

91-2311

CIP

Printing: 1 2 3 4 5 6 7 8 9 Year: 1 2 3 4 5 6 7 8 9 0

Printed in the United States of America



The paper used in this publication meets the minimum requirements of American National Standard for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48-1984

.....
**INTRAOPERATIVE
RADIATION
THERAPY**
.....

Pergamon Titles of Related Interest

Bentel, Nelson, Noell: TREATMENT PLANNING AND DOSE CALCULATION IN RADIATION ONCOLOGY, Fourth Edition

Turner, Bogard, Hunt, Rhea: PROBLEMS AND SOLUTIONS IN RADIATION PROTECTION

Cember: INTRODUCTION TO HEALTH PHYSICS, Second Edition

Bragg, Rubin, Youker: ONCOLOGIC IMAGING

Hilaris, Nori, Anderson: AN ATLAS OF BRACHYTHERAPY: Principles, Techniques, and Clinical Applications

Mizer, Scheller, Deye: RADIATION THERAPY SIMULATION WORKBOOK

Related Journals

(Free sample copies available upon request)

European Journal of Cancer & Clinical Oncology

Cancer Communications

Health Physics

Medical Dosimetry

International Journal of Radiation Oncology-Biology-Physics

PREFACE

The advent of megavoltage radiotherapy made it possible to deliver a sufficient dose to deep-seated tumors. However, a cancericidal dose of external beam irradiation cannot be given if the tumors are located near radiosensitive critical structures. On the other hand, in surgery, the possibility always exists that microscopic lesions will be left behind, even after what is believed to be a curative operation. To overcome these limitations of radiotherapy and surgery, intraoperative radiation therapy (IORT) was developed. The benefit of IORT results from direct visualization of the site to be irradiated and physical removal of potentially dose-limiting normal tissues from the field. IORT has opened the way to new treatment of radioresistant or unresectable tumors. This new form of radiotherapy has also widened the scope of radiotherapy by permitting curative treatment of radioresistant tumors without affecting normal structures.

Because of the encouraging results obtained through IORT, its use has spread in Japan and the number of institutions where this radiotherapy is performed has continued to increase, to a total of 61 in 1990. To date, about 3,500 patients have been treated with IORT. It has spread in the United States, Europe, and Asia. The number of papers on IORT has increased markedly since 1984 and a total of about 100 papers were published in international journals in 1988.

Because of the increasing enthusiasm for IORT, the first international symposium was organized by R. R. Dobelbower in Ohio in 1986. At this meeting 38 papers were presented. The second symposium was organized by E. Bodner, K. Glaser, and H. Frommhold in Innsbruck in 1988 and 93 papers were presented.

The Third International Symposium on Intraoperative Radiation Therapy was held in Kyoto, Japan from November 12 to 15, 1990. The purpose of this symposium was to provide an update on IORT, the state of the art,

and to discuss recent fundamental and clinical results in IORT from the viewpoints of biology, physics, engineering, and clinical medicine.

This symposium brought together about 300 active scientists, medical doctors, and engineers from 21 countries and 170 papers were presented. It is my hope that this book will serve as a comprehensive reference for institutions planning to perform IORT and to give those who are interested in IORT updated information on this field.

I would like to thank all the authors for their contributions. I would also like to express my sincere gratitude to the foundations and many Japanese companies which have financially supported this symposium.

A handwritten signature in black ink, reading "Mitsuyuki Abe". The signature is fluid and cursive, with the first name "Mitsuyuki" and the last name "Abe" clearly distinguishable.

Mitsuyuki Abe, M.D.
President, Third International
Symposium on Intraoperative Radiation Therapy

ACKNOWLEDGMENT

The symposium is financially supported by the Commemorative Association for the Japan World Exposition, the Japan Federation of Economic Organizations, Inoue Foundation for Science, the Murata Science Foundation, and many Japanese companies which have an understanding of intra-operative radiation therapy.

CONTENTS

Preface	xxiii
Acknowledgment	xxv

Part I. BIOLOGICAL ASPECTS

1	The Rationale of Intraoperative Radiotherapy <i>Frank Ellis</i>	3
2	Radiobiological Aspects and Data to Improve Intraoperative Radiotherapy <i>Christian Streffer</i>	6
3	Intraoperative Radiation Therapy: Future Prospects With Radiation Protectors and Radiation Sensitizers <i>F. E. Halberg, T. L. Phillips, S. M. La Rue, E. L. Gillette, M. R. Harrison</i>	9
4	Potential for a Therapeutic Gain for IORT Combined With EBRT <i>E. L. Gillette, S. McChesney Gillette, B. E. Powers, H. D. Thames, Jr.</i>	12
5	Experimental and Clinical Approach to the Use of Total-Body Gas Hypoxia During Intraoperative Irradiation <i>S. P. Yarmonenko, A. Vacek, T. Tacev</i>	15
6	Safe Single Dose of Irradiation Followed by Broncoplasty in Dogs <i>Y. Takahashi, K. Inui, H. Wada, S. Hitomi, M. Takahasi</i>	18

Contents

7	Fundamental Study of Efficacy of Intraoperative Radiotherapy on Pancreatic Carcinoma Transplanted Into the Pancreas of Hamsters <i>S. Ito, H. Yoshimura, T. Tamada, K. Iwata, N. Horikawa, N. Tsuji, H. Ohishi, H. Uchida, Y. Konishi</i>	20
8	Long-Term Effects of Combined Partial Hepatectomy and Intraoperative Radiation Therapy in Rat Liver <i>G. B. Doglietto, R. Bellantone, V. Valentini, A. Crucitti, M. Bossola, A. G. Morganti, N. Cellini, P. Marano, F. Crucitti</i>	22
9	The Effects of Intraoperative Radiation on Mechanical Properties of Bone in Rabbit Tibia <i>M. Sugimoto, S. Takahashi, Y. Kotoura, T. Yamamuro, Y. Shibamoto, K. Sasai, M. Abe, M. Takahashi, M. Oka</i>	24
10	Tolerance of Articular Cartilage in Experimental Intraoperative Radiation on Rabbit Knee Joints <i>S. Takahashi, M. Sugimoto, Y. Kotoura, T. Yamamuro, Y. Shibamoto, K. Sasai, M. Abe, M. Takahashi, M. Oka</i>	26
11	Radiation Reaction of BGC-823 Cell Line to β -Ray Single Dose Irradiation <i>Y. X. Wang, S. R. Luo, D. W. Zheng</i>	28

Part II. PHYSICAL ASPECTS

12	Intraoperative Radiation Therapy: Technique, Dosimetry and Dose Specification <i>J. R. Palta</i>	33
13	Intraoperative Radiation Therapy in France: Technical and Dosimetric Aspects <i>I. Sentenac, P. Aletti, J. J. Bard, F. Bidault, J. Bloquel, J. Bonnet, G. Brunet, R. Delard, R. Garcia, H. Kharrati, S. Landriaux, B. Lavigne, G. Puel</i>	36
14	Intraoperative Radiation Therapy Quality Assurance Program in the United States <i>J. C. H. Chu, P. Kennedy, J. D. Hazle, G. E. Hanks</i>	39

15	Design and Dosimetric Data of an Air-Dock Electron Applicator With Video Camera System for Intraoperative Radiotherapy <i>A. Hess, Th. Block, A. Krüll, K.-H. Hübener</i>	42
16	A Collimation System for Accurate and Easy Docking in Intraoperative Radiotherapy <i>Ingmar Lax, Marie Lundell, Bengt-Inge Rudén, Anders Bergman, Björn Cedermark, Tom Häggmark, Göran Lundell, Nils Wilking</i>	45
17	CT Simulator: A New Treatment Planning System in Intraoperative Radiation Therapy Planning <i>Yasushi Nagata, Kaoru Okajima, Takehiro Nishidai, Manabu Nakata, Masaji Takahashi, Mitsuyuki Abe</i>	48
18	Intraoperative Radiation Therapy: Dosimetry of a Specialized Electron Beam Applicators System <i>A. Valentini, G. Fellin</i>	51
19	Electron Dosimetry for Intraoperative Radiation Therapy in Japan <i>T. Nishidai, K. Kawashima</i>	53
20	Dosimetric Properties for a Pentagonal Applicator With a Bevel End Evaluated by Monte Carlo Calculations <i>Y. Onizuka, S. Uehara, S. Joh, N. Akeda, K. Fukurono, H. Ohtake</i>	55
21	Development of IORT System at San Raffaele Hospital in Milan: Physical Aspects <i>G. M. Cattaneo, V. Fossati, A. Ardesi, C. Fiorino, B. Longobardi, P. Signorotto, R. Calandrino</i>	57
22	Television Monitoring System for Verification of Radiation Field in Intraoperative Radiation Therapy <i>Y. Honke, M. Kawaguchi, N. Sasaki, M. Kawamoto, K. Murata, Y. Takano</i>	59
23	The Design of a Dedicated IORT Table <i>H. J. Hoekstra, H. V. van Hooydonk, J. Vermeij, J. Oldhoff</i>	61
24	The Microselectron HDR IR-192 Used in Intraoperative Radiation Therapy <i>M. W. Gurtler</i>	63

Part III. CLINICAL TRIALS

25	Overview of the RTOG Effort in IORT 1984-1990 <i>G. Hanks</i>	69
26	Intraoperative Radiation Therapy in France <i>A. Roussel, J-P. Gérard, Th. Schmitt, L. Malissard, J-C. Cuillière, J-B. Dubois</i>	71
27	Future of IORT in China <i>Liu Tai-fu</i>	73
28	Clinical Experience With Intraoperative Radiotherapy at the University Clinic of Navarra: 1990 Update <i>F. A. Calvo, M. Santos, D. Ortiz de Urbina, O. Abuchaibe, I. Azinovic, J. Aristu, E. Tangco, R. Martínez, L. Escudé</i>	75
29	Intraoperative Radiation Therapy (IORT) With 100 kV X Photons: Experience on 170 Patients <i>J. B. Dubois, S. D. Gu, M. H. Hay, S. Gely, R. Delard, H. Joyeux, Cl. Solassol, H. Pujol</i>	78
30	Electron Beam Intraoperative Radiotherapy at M. D. Anderson Cancer Center: Preliminary Results <i>T. A. Rich, T. Ochrán, A. Boyer, F. Ames, D. Ota, D. Evans, J. Ajani</i>	81
31	IORT for Locally Advanced Cancer <i>GuoXiong Chen, ShaoBai Song</i>	84
32	Intraoperative Radiation Therapy (IORT) For Abdominal and Pelvic Tumors: Experience of the Institut Jules Bordet, Brussels <i>G. Y. Popowski, A. Piron, P. Ewalenko, J. C. Pector, J. M. Nogaret, R. Van Velthoven, P. Van Houtte, A. Gerard</i>	87
33	The Groningen IORT Experience <i>H. J. Hoekstra, D. M. Mehta, R. T. M. Wijffels, J. Vermey, J. Oldhoff</i>	90
34	Adjuvant Intraoperative Radiation Therapy in Cancer of the Pancreas <i>F. Crucitti, G. B. Doglietto, R. Bellantone, M. Bossola, D. Frontera, V. Valentini, N. Cellini, A. Crucitti, L. Trodella, P. Marano</i>	93

35	Experience With IORT During Its Installation and Establishment Within the Department of Surgery of the University Clinic in Freiburg, Germany <i>H. Frommhold, K. Kuphal, R. Kirchner, R. Salm, P. Stoll, K. Geiger</i>	96
36	Preliminary Experience With Intraoperative Radiation Therapy (IORT) for the Treatment of Brain Tumors <i>H. Fritsch, N. Willich, B. Fink</i>	99
37	The New IORT Facility at the Essen University <i>W. Sauerwein, E. Kotsch, A. Hoederath, J. Rassow, F. W. Eigler, H. Suck</i>	102
38	Intraoperative Radiation Therapy for Cancer of the Digestive Organs <i>T. Ogata, K. Matsuura, M. Kobayashi, K. Araki, T. Maeda, T. Inomata</i>	105
39	Clinical Experience Using Intraoperative Radiation Therapy With a Non-Docking Electron Applicator System <i>W. Grizos, M. Mohiuddin, J. Palta</i>	108
40	IORT: Lyon Intraoperative System <i>F. N. Gilly, G. Braillon, J. P. Gerard, P. Romestaing, M. Mahe, I. Sentenac, N. Salerno, F. Rocher, A. C. Sayag, P. Y. Carry</i>	111
41	Intraoperative Radiation Therapy With Orthovoltage: The University of Arizona Approach <i>Wendell Lutz, J. Robert Cassady, Hugo Villar</i>	113
42	Optimized Installation for Intraoperative Therapy Including Electron Beam, Remote High Dose Rate (HDR) Brachytherapy, Hyperthermia, and Radioimmunoguided Surgery <i>Reinhard A. Gahbauer, Subir Nag, Cristos Kanellitsas, Richard Pieters, Edward Martin, Chen Su, Joseph Goodman</i>	114
43	The Intraoperative Radiotherapy in East-Central Europe <i>Danczak Ginalska Z.</i>	116
44	Intraoperative Radiation Therapy and Local Hyperthermia for Gastric and Colorectal Cancer <i>B. Berdov, V. Skoropad, N. Senokosov</i>	119

45	Shielding Design for a Dedicated Intraoperative Radiation Therapy Facility <i>R. A. Dahl, E. C. McCullough</i>	121
46	Intraoperative Radiation Therapy (IORT) in Korea: Clinical Experience of Yonsei University Hospital <i>John J. K. Loh, Sung Sil Chu, Sun Rock Moon, Gwi Eon Kim, Chang Ok Suh, Kyong Sik Lee, Hung Kun Oh, Byung Soo Kim</i>	123
47	A Seven-Year Experience of Intraoperative Radiation Therapy With 264 Patients <i>Taisuke Inomata, Tomoho Maeda, Yasuhiro Ogawa, Akihito Nishioka, Takuro Ogata, Kyojiro Araki</i>	125
48	Experience of Intraoperative Radiotherapy in Kobe University <i>Toshinori Soejima, Kazufumi Imanaka, Takahisa Hashimura, Kazuyuki Yonezawa, Toshiya Sakaguchi, Takeyuki Kushima, Masao Sako, Michio Kono</i>	127
49	Institutional Experience of IORT by Electron Beam at San Raffaele Hospital in Milan: Clinical Results <i>V. Fossati, G. M. Cattaneo, P. Pessina, M. Carlucci, G. Ferla, L. Olmi, D. Parolini, C. Staudacher, A. Zerbi, A. Bissi, R. Calandrino, V. Di Carlo, E. Galli, G. Torri, F. Volterrani, C. Martinenghi</i>	129
50	Intraoperative Radiation Therapy (IORT) for Carcinomas of the Stomach and Pancreas <i>J. B. Dubois, S. D. Gu, M. H. Hay, S. Gely, H. Joyeux, Cl. Solassol, H. Pujol</i>	131
51	Intraoperative Radiation Therapy for Cancer in the Abdomen <i>T. Inamoto, K. Honda, N. Kobayashi, K. Sasai, M. Takahashi, M. Abe, K. Ozawa</i>	133
52	Fractionated Intraoperative Radiotherapy in Pancreatic Cancer: First Experiences <i>A. Krüll, K.-H. Hübener, T. Block, A. Hess, D. Heyer, M. Baumann, K. Sommer, H.-W. Schreiber, J. Schulte am Esch, S. Schröder</i>	135

Contents

53	The Regional Intraoperative Electron Beam Program at the Catharina Hospital, Eindhoven, The Netherlands <i>Mariad Crommelin, Hendrick Martijn, Piet v.d. Linden, Wim Dries, Marnix Lybeert, Jacques Ribot</i>	137
54	Intraoperative Brachytherapy (IOBT) Using Iodine-125-Seeds <i>W. Sauerwein, M. Busch, I. Heselmann, B. Müller, M. Meyer-Schwickerath, F. W. Eigler, H. Sack</i>	139
55	Intraoperative Brachytherapy: An Old Technique of Therapy That Can Be Interesting to Remember <i>Mario Gallo</i>	141
56	Prevention of Radiation Damage by the Pedicled Omentoplasty <i>A. N. v. Geel, Th. Wiggers, H. Rutten, J. v. Garderen, A. J. Wijnmaalen</i>	143

Part IV. CLINICAL RESULTS:

Brain, Head and Neck and Intrathoracic Malignancies

57	Intraoperative Radiation Therapy (IORT) for Cerebral Glioblastoma <i>Masao Matsutani, Osamu Nakamura</i>	147
58	The Effect of Intraoperative Radiation Therapy (IORT) on Malignant Glioma <i>N. Sakai, H. Yamada, T. Andoh, Y. Nishimura, S. Yanagawa</i>	150
59	Boron Neutron Capture Therapy for Brain Tumors <i>Hiroshi Hatanaka, Hiroshi Yasukochi, Keiji Sano</i>	153
60	Gadolinium Atom on Neutron Capture Therapy <i>Y. Oda, M. Takagaki, S. Miyatake, H. Kikuchi</i>	156
61	Gadolinium Neutron Capture Therapy for Brain Tumors: In Vitro Study <i>M. Takagaki, Y. Oda, H. Kikuchi, T. Kobayashi, K. Kanda, Y. Ujeno</i>	159

62	Intraoperative Radiation Therapy (IOR) Stopped Repeated Recurrence of Anaplastic Ependymoma: A Case Report <i>Junkoh Yamashita, Mitsuyuki Abe, Seiji Takahashi, Yuta Shibamoto, Haruhiko Kikuchi</i>	161
63	New Treatment Protocol by Intraoperative Radiation Therapy for Metastatic Brain Tumors <i>O. Nakamura, M. Matsutani, Y. Tanaka</i>	163
64	Treatment of Radiation Angiopathy With Superoxide Dismutase (SOD) <i>M. Kurisaka, P. O. Eghwrudjakpor, M. Arimitsu, K. Mori, T. Maeda, Y. Niwa</i>	165
65	The Use of intraoperative Radiotherapy (IORT) in the Treatment of T3-T4 Carcinomas of the Base of the Tongue <i>T. Schmitt, N. Barbet, G. Puel, J. M. Prades, C. Martin, N. Pinto</i>	167
66	Intraoperative Radiation for Advanced or Recurrent Head and Neck Malignancies <i>P. Garrett, W. Rate, R. Hamaker, M. Singer, N. Pugh, D. Ross, T. Dugan, R. Haerr, S. Freeman, G. Charles</i>	170
67	Intraoperative Radiation Therapy of Head and Neck Cancer <i>Y. Takizawa, H. Sueyama, M. Nakano</i>	173
68	Intraoperative Radiotherapy of Lung Cancer: Preliminary Report of 18 Cases <i>Di-wen Zheng, Qing-sen Chang, Xiao-mai Huang, and Yu-e Sun</i>	175
69	Intraoperative Radiation Therapy (IORT) in Non Small-Cell Lung Carcinomas (NSCLC) <i>J. B. DuBois, S. D. Gu, M. H. Hay, S. Gely, H. Joyeux, Cl. Solassol, H. Pujol</i>	177
70	Intraoperative Radiotherapy With Esophageal Resection for Esophageal Carcinoma <i>William Grizos, Dan Calloway, Francis E. Rosato</i>	179
71	IORT for Upper Mediastinum in the Treatment of Esophageal Carcinoma <i>A. Takamura, T. Arimota, G. Irie, M. Hosokawa, T. Kawamura, Y. Kaneko</i>	181

- 72 Combined Surgery and Intraoperative Radiation Therapy (IORT) for Thoracic Esophageal Cancer 183
T. Ogata, K. Matsuura, M. Kure, T. Maeda, T. Inomata

Part V. CLINICAL RESULTS:

Gastric, Biliary Tract and Pancreatic Malignancies

- 73 The Basic and Clinical Studies of Intraoperative Radiation Therapy for Gastric Cancer 187
Y. Y. Jiang, J. Q. Liu, G. X. Chen, S. B. Song
- 74 Evaluation of Intraoperative Radiotherapy for Gastric Carcinoma: Analysis of 247 Patients 190
Guoxiong Chen, Shaobai Song, et al
- 75 Prospective Randomized Study on IORT for Resectable Gastric Carcinoma 192
H.-J. Krämling, N. Willich, H. Denecke, J. Grab, F. Schildberg
- 76 Intraoperative Radiotherapy (IORT) for Carcinoma of the Stomach With the Lyon Intraoperative System (L.I.S.): A Series of 27 Patients 195
J. P. Gérard, I. Sentenac, F. Gilly, P. Romestaing, F. Rocher, N. Salerno, L. Descos, J. Vignal, G. Brailon
- 77 Intraoperative Radiation Therapy in Korea 197
M. S. Kim, S. K. Kim, S. K. Song, K. B. Kwun, H. D. Kim, M. K. Chung
- 78 Intraoperative Radiation Therapy for Carcinoma of the Stomach: A Five Year Experience Pilot Study 199
F. Guillemin, L. Malissard, P. Aletti, P. Bey, J. L. Verhaeghe, P. Y. Godfrin
- 79 Intraoperative Radiation Therapy of Extrahepatic Biliary Carcinoma: A Report of RTOG-8506 201
H. Wolkov, G. Graves, M. Won, W. Sause, R. Byhardt, G. Hanks
- 80 Intraoperative Radiotherapy of Cancers of the Biliary Tract 204
H. Uozumi, C. Takada, R. Nishimura, S. Morishita, M. Sumi, M. Takahashi, T. Hiraoka, A. Misumi, K. Mori, T. Yasunaga