Using Proton Therapy For Re Irradiation

Re-irradiation for Recurrent Head and Neck Cancer
Proton Beam Radiotherapy

MONITORING AND MANAGEMENT OF ANATOMICAL VARIATIONS DURING PROTON THERAPY TREATMENTS IN PEDIATRIC PATIENTS
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Proton and Charged Particle Radiotherapy

Re-irradiation for Recurrent Head and Neck Cancer

This book, now in its second edition, provides a comprehensive overview of current re-irradiation strategies, with detailed discussion of re-irradiation methods, technical aspects, the role of combined therapy with anticancer drugs and hyperthermia, and normal tissue tolerance. In addition, disease specific chapters document recent clinical results and future research directions. All chapters from the first edition have been revised and updated to take account of the latest developments and research findings, including those from prospective studies. Due attention is paid to the exciting developments in the fields of proton irradiation and frameless image-guided ablative radiotherapy. The book documents fully how refined combined modality approaches and significant technical advances in radiation treatment planning and delivery have facilitated the re-irradiation of previously exposed volumes, allowing both palliative and curative approaches to be pursued at various disease sites. Professionals involved in radiation treatment planning and multimodal oncology treatment will find it to be an
invaluable aid in understanding the benefits and limitations of re-irradiation and in designing prospective trials.

Proton Beam Radiotherapy

The pediatric head and neck cancer patient necessitates a multidisciplinary team of specialists to provide an optimal continuum of care. This A-Z guide provides practical, in-depth information for all medical professionals involved in the evaluation and treatment of these patients. Written in an easy to follow format, each entry contains illustrative figures to aid in pathological and radiographical diagnosis, as well as structured discussion of evaluation and multimodality management. The alphabetical layout eliminates redundancy and allows the busy physician to quickly locate relevant information. Pediatric Head and Neck Tumors is ideal for young physicians as well as attending physicians seeking to expand their knowledgebase to the various subspecialties involved in the multidisciplinary care of their patients.

MONITORING AND MANAGEMENT OF ANATOMICAL VARIATIONS DURING PROTON THERAPY TREATMENTS IN PEDIATRIC PATIENTS

The results of decades of research and development are providing compelling evidence about the efficacy of radiation therapy with proton and carbon ion beams to achieve superior complication free tumor control leading to a world-wide rapid growth in their clinical use. This book contains comprehensive reviews of the state of the art of the technology and physics of heavy charge particle therapy by the experts from the leading cancer centers of world that will be valuable as a practical guide for radiation therapy professionals interested in these modalities.

Prediction of Risks of Cardiac Mortality and Secondary Cancers After Thoracic Radiotherapy in Adolescents and Young Adults

At the Normandy particle therapy center, patient treatments began in July 2018 using the ProteusOne (IBA) for robust optimized (RO) plan calculated via a Monte Carlo dose engine within the RayStation treatment planning system (RaySearch). Comparisons of planning strategies with MFO/SFO-IMPT delivery, with planning on PTV or robust on CTV were performed. Robust evaluation (RE) (taking into account uncertainties to the stopping power conversion and patient position, e.g. 3%/3mm) of plans under different clinical scenario, stemming from the patient immobilization analysis during the treatment course (for further details see poster: Intracranial immobilization evaluation at the Normandy Particle Therapy Center), including the uncertainty on the spot position (maximum tolerance or mean error from QA protocol), were analyzed. RO shows promise in fully exploiting the benefits of proton-therapy with an optimal treatment quality. However in some cases classic PTV optimization could be foreseen for large tumors if treated in SFO-IMPT. Systematic RE (3%/3mm) were performed for all cases treated so far at the proton center with SFO-IMPT to validate the planning with clinicians. New RE strategies are being discussed to be more representative of clinical scenario during the treatment courses.

Practical Radiobiology for Proton Therapy Planning
Purpose
Re irradiation (Re RT) for rectal cancer (inpatients with prior pelvic RT has been shown to be safe and effective. However, limited data exists with the use of proton therapy. We hypothesize that PT is a safe and feasible for re treatment and may allow for decrease in toxicity or treatment escalation. Methods and Materials
We performed a single-institutional retrospective IRB approved analysis of all RC patients with any prior pelvic RT re irradiated with Pencil Beam Scanning proton therapy. We collected patient and treatment characteristics, including prior diagnosis, re irradiation records, and toxicities. Outcomes, including overall Survival (and Local Control (were estimated using Kaplan Meier.

Results
Twenty six patients (median follow up 15.3 months) received PBSPT Re RT from 2016-2018. 16 patients w/ recurrent RC [median prior dose 52.2 Gy, 63.0 and 16 patients w/ de novo RC and variable prior RT (9 for prostate, 1 for ovarian)]. Median Re RT dose was 44.4 Gy 16.0 20.0 (BID), and 22 received concurrent chemotherapy. Five underwent surgical resection (all R 0). Three patients experienced grade 3 acute toxicities, and no acute Grade 4-5 toxicities were observed.

Early Results of Reirradiation for Rectal Cancer Using Pencil Beam Scanning Proton Therapy Are Promising
Two patients had grade 3+ late toxicities, including one grade 5 toxicity occurring in a patient with history of significant injury from prior RT. One year LC and OS were 76.5% (95% CI 66.0-86.9%) and 77.7% (95% CI 68.8-86.6%), respectively. Conclusion: In this largest such series, early results of PT for Re RT for RC are promising, with longer follow up needed.

Accelerated Partial Breast Irradiation
In recent years, interest in the management of anterior skull base tumors has been fostered by the introduction and subsequent rapid expansion of indications of transnasal endoscopic techniques. In parallel, extraordinary progress has been made in all the other disciplines which are involved in the complex process of managing anterior skull base tumors, leading to substantial improvements in diagnosis and treatment. The anterior skull base can be involved in a large variety of tumors of a varying nature and histology, which in the majority of cases originate from adjacent anatomic sites. In fact, primary lesions of the anterior skull base mainly include osteoma and other tumors originating from bone and cartilage. Tumors involving the anterior skull base have their origin prevalently in the sinonasal tract, but lesions developing on the intracranial site, such as meningiomas, may also extend caudally to encroach upon this area. All these lesions are rare, which means that the pertinent literature does not include prospective studies or treatment guidelines based on a high level of evidence. In view of the extreme histological variability of lesions involving the anterior skull base, much emphasis has been placed on addressing the different nuances of treatment in relation to histology, especially for malignant tumors. The chapters focusing on surgery provide divergent views on selection criteria for a specific surgical technique, which is the aim of this publication.

New Technologies in Radiation Oncology
Meningiomas, the second most frequent of intracranial tumors, are characterized by a protean range of possible locations and appearances, due to their origin from the extensive and intricately formed meninges. As such, a wide variety of differential diagnoses is typical, and the therapies chosen are necessarily highly variable. The introductory chapters of this book cover the pathology of these tumors, the evolution of special surgical methods, instrumentation, intraoperative monitoring, and the role of...
radiosurgery. Ten surgical chapters cover the individual regions of occurrence, including the sphenoid wing, olfactory groove, cerebellopontine angle, etc., all of which require a specialized approach and therapeutic strategy. Key Features: Discussion of pathology and therapy organized by anatomic location of the lesions with the goal of providing best patient outcomes New WHO meningioma classification system based on most recent research in growth patterns, gene sequencing, and molecular patterns of development Important updates on the newest developments in treatment modalities for meningioma, including the lesser invasive radiotherapy and radiosurgery for the smaller lesions and to avoid the necessity of performing radical surgery Meningiomas of the Skull Base: Treatment Nuances in Contemporary Neurosurgery is an essential reference guide for neurosurgeons and neurologists (in training and in practice) and will also be welcomed by skull base surgeons and otolaryngologists.

**Elucidating Uncertainties In Radiobiological Parameters In Proton Beam Irradiation By A Global Fit**

The relative biological effectiveness (RBE) is known to increase towards the end of the proton range as the linear energy transfer (LET) of the proton beam increases. A generic RBE factor of 1.1, as often applied to proton therapy treatment plans, may be inadequate in predicting the tumour response and the toxicity to the peripheral normal tissues. Better understanding of RBE as a function of LET is therefore crucial in ensuring the safety and efficacy of proton therapy treatments. Recently, Abolfath et al. (Sci Rep 7: 8340, 2017) proposed a global fit to cellular survival curves across different LETs to reduce uncertainties in the fit and elucidate unphysical fluctuations of alpha/beta ratio in the function of LET. Our study used published datasets of V79 Chinese hamster lung fibroblasts and AG01522 normal human skin fibroblasts under proton beam irradiation and re-analyzed them with a single global fit across all LETs. The R2 for V79 and AG01522 are 0.9760 and 0.9787, respectively. Our results showed that the global fit technique could be applied to other cell lines. Similar smooth transitions in RBE could be observed. Furthermore, the u03b1/u03b2 ratio for V79 was calculated in the high LET region that was not established in the original work. This can lead to a better understanding of biological response of tissue towards the end of the proton range.

**Breast Cancer Survivorship Care**

Purpose/ObjectivesTo evaluate the dosimetric impacts of IMPT as compared with VMAT using photon on early stage left-sided breast cancer.Materials/ MethodsSix early stage left-sided breast cancer patients treated by post-lumpectomy irradiation with 4 partial arcs VMAT were retrospectively re-optimized using IMPT. One single left anterior oblique IMPT field was used for optimization using Varian Eclipse proton TPS. In both IMPT and VMAT planning, simultaneous integrated boost technique was used to give 58 Gy(RBE) to GTV (tumour bed) and 50 Gy(RBE) to PTV (whole left breast) in 25 fractions, assuming RBE of 1.1 and 1 for proton and photon, respectively. GTV and PTV coverage, dose conformity and homogeneity were reported by dose received by 95% and 98% target volumes (D95, D98), conformity number (CN) and homogeneity index (HI). Mean dose (Dmean), near-maximum dose (D2), percentage organ volume receiving more than 5, 10, 20 Gy(RBE) (V10,V20,V30) of heart, contralateral breast, left and right lungs were compared. Dmean, D2, V30, V40 and V50 of skin (a layer structure of 2mm inward from
the body contour on irradiated side) were also evaluated. Statistical analysis was performed using Wilcoxon-signed rank test. A two-tailed p

Carbon-Ion Radiotherapy

Background: Re-irradiation in the scalp area can be challenging given proximity to the organs at risk (OAR) like the eye and underlying brain. Our aim is to evaluate the dosimetric differences of volumetric modulated arc therapy (VMAT) and electron beam therapy (EBT) in comparison to 3-D proton beam therapy (PBT). Methods: We evaluate a case of recurrent angiosarcoma of left temporal scalp status post prior tomotherapy overlapping treatments to 60 Gy in 30 fractions. VMAT, EBT and PBT plans were generated using Pinnacle. Both VMAT and EBT plans used a skin bolus versus no bolus used for the proton plan. Doses to the OARs including cochlea, eyes, lens, lacrimal glands, optic nerves, optic chiasm, pituitary gland and underlying brain were compared. Results: Re-irradiation treatment dose was 60 GyRBE. Representative comparison of the plan images is shown in Figure 1. Target volume coverage was comparable in all plans. Compared to VMAT and EBT, PBT plan showed significant reductions in mean and max doses to all OARs (Table 1). Without the use of protons several OARs would have exceeded dose tolerance utilizing VMAT or electrons. Dose reduction of up to 100% was achieved for central and contralateral OARs. Conclusions: PBT as compared to VMAT and EBT resulted in meaningful dose reductions to all OARs, while maintaining excellent target coverage. PBT shows a significant advantage in treating superficially located skin cancers like angiosarcoma without need for a bolus. PBT could be considered in the upfront treatment and certainly in the re-irradiation setting.

Optimization Techniques and Systematic Robustness Evaluation in Proton-therapy

This book offers a comprehensive, practical guide to understanding the physical and biological characteristics of proton beam radiotherapy. The application of proton beams to the treatment of solid cancers has expanded exponentially over the last decade due to their physical properties, which make it possible to administer higher doses of radiation to lesions with only a minimum dose to the surrounding healthy tissues. Accordingly, understanding the basic aspects of proton beam radiotherapy is a primary concern not only for medical physicists and radiation biologists, but also for all physicians involved in cancer treatment using proton beams. The major aspects discussed include the technique’s development background, the generation and delivery system for proton beams, physical characteristics, biological consequences, dosimetry, and future prospects in both medical physics and radiation biology in terms of effective cancer treatment. Gathering contributions from experts who provide clear and detailed information on the basics of proton beams, the book will greatly benefit not only radiological technicians, medical physicists, and physicians, but also scientists in cancer radiotherapy.

Meningiomas of the Skull Base

Carcinoma of the prostate increasingly dominates the attention of urologists for both scientific and clinical reasons. The search for an explanation and the prediction of the
variable behaviour of the malignant prostatic cell continues unabated. The search for more precise tumour staging and more effective treatment is equally vigorous. Editors Andrew Bruce and John Trachtenberg have assembled acknowledged leaders in prostate cancer to present those areas of direct interest to the clinician. There are a number of other topics that might have been considered but most of these, such as experimental tumour models or biochemical factors affecting cell growth, still lack immediate application for the clinician. Carcinoma of the prostate continues to have its highest incidence in the western world, and the difference in comparison with the incidence in the Far East appears to be real and not masked by diagnostic or other factors. A number of other epidemiological aspects need careful analysis: Is the incidence increasing? Is the survival improving? Is the prognosis worse in the younger patient? Epidemiological data are easily misused and misinterpreted so that a precise analysis of the known facts makes an important opening chapter to this book.

**Early Results Of Re-Irradiation For Rectal Cancer Using Pencil-Beam Scanning Proton Therapy Are Promising**

**Objectives:** Proton therapy (IMPT) may represent a superior option compared to photon therapy (IMRT) for preserving the balance between treatment-related toxicities and local control for curative head and neck re-irradiation (re-RT).

**Materials and Methods:** We conducted a retrospective analysis of prospectively collected toxicity data for head-and-neck cancer (HNC) patients treated with re-RT using IMPT and IMRT. All patients had at least one prior curative radiation course to the head-and-neck region. Acute toxicity within 3-months of re-RT was recorded using CTCAE version 4.3. Statistical analysis was performed using Fisher Exact and Wilcoxon rank sum tests.

**Results:** Our cohort included 31 HNC patients treated with re-RT between April 2013 and December 2018 using IMPT (n=14) and IMRT (n=17). Average follow-up was 16 months. 77% (n=24) received definitive intent re-RT, while 23% (n=7) received adjuvant re-RT. Median re-RT dose was 66 Gy whereas median total dose was 130 Gy. IMPT used conventional fractionation and stereotactic body radiotherapy (SBRT) in 7 patients each (50%). IMRT used hyperfractionation in 76% (n=13) and conventional in 18% (n=3) and one SBRT. IMPT had lower rates of grade-3 acute toxicity for any given outcome when compared to IMRT (36% vs 71%, p=0.05), this effect was also seen in conventional IMPT compared to IMRT hyperfractionation (43% vs 69%), although statistically not significant (p=0.25). Some of the toxicities assessed included dysphagia (7.1% vs 41.2%, p=0.03), mucositis (14.3% vs 35.3%, p=0.01), and dermatitis (14.3% vs 29.4%, p=0.02). Breakdown of these toxicities is shown in Figure 1 below.

**Conclusion:** IMPT reduced rates of grade u22653 toxicity in HNC re-irradiation compared to IMRT, despite differences in fractionation schedules. These encouraging results warrant further exploration through larger prospective studies.

**Acute Toxicity Profile in Head and Neck Cancer Patients Treated with Re-Irradiation Using Proton Therapy Versus Intensity Modulated Radiotherapy**

After radical treatment of head and neck cancer about 20-50% of patients are diagnosed with the locoregional recurrence during first two years. The main treatment for recurrent disease is salvage surgery, but in most cases, surgery is not feasible due to the high risk of complications and morbidity, and only 20% of patients are suitable for surgical salvage. Reirradiation is an effective treatment method with acceptable toxicity, but this
treatment method is limited to normal tissue tolerance to a total dose. When chemotherapy is administered for recurrence, the response rate is up to 40%, so with the advancement of technical measures, after introduction of intensity-modulated radiotherapy, fractionated stereotactic body radiation therapy, high-dose-rate brachytherapy, proton beam reirradiation, a reirradiation is increasingly more often used for head and neck cancer relapse treatment. In this chapter, we will discuss about reirradiation with curative intent using new different radiation techniques (intensity-modulated radiotherapy (IMRT), stereotactic body radiation therapy (SBRT), high-dose-rate brachytherapy (HDR-BRT) and proton beam reirradiation (PBRT) for previously irradiated head and neck cancer and present recommendations for retreatment of head and neck cancer relapse using reirradiation alone or with systemic chemotherapy/biologic therapy.

**Adenocarcinoma of the Prostate**

Radiation therapy is a complex process where a given target volume receives a given dose of radiation divided over one or multiple treatments. Every step in this process can introduce some types of uncertainties into the problem which may compromise the quality of the treatment. Typically, a volume larger than the actual tumor is irradiated to make the treatment more robust against these uncertainties. This comes at the cost of normal tissue irradiation and an increased risk of toxicity. In this dissertation, we investigate approaches to managing uncertainties in radiation therapy treatments for lung cancer patients. In the first part of the dissertation, we focus on the process of designing a treatment plan which involves selecting appropriate beam angles and deciding the right amount of radiation dose to the tumor cells, while sparing the normal tissue surrounding the tumor. Selecting the optimal set of treatment beam angles, called beam angle optimization (BAO), involves a very large-scale combinatorial optimization problem with many local minima. In order to identify an efficient approach to obtain high quality beam angles, we first examine the strengths and weaknesses of some existing BAO optimization methods including both global and local search algorithms. We then propose a hybrid framework to overcome some of the weaknesses observed in these methods. Next, we perform an in-depth study into the impact of interplay effect, which results from relative motion of the tumor and proton beam, on the dose distribution in the patient with lung cancer. The dynamic dose distribution, that provides an estimation of delivered dose under the influence of interplay effect, is calculated by simulating the machine delivery processes on the moving patient described by 4D computed tomography (4DCT) during the dose delivery process by linking timestamps of each on/off switch of proton spots, spills, energies, and fields to patient respiratory cycles. We introduce a clinically applicable metric for clinicians to use for determining the magnitude of the uncertainties caused by interplay effects. We then explore the techniques of fractionation and iso-layered re-scanning for mitigating these interplay effects. In the last part of the dissertation, we develop a robust adaptive optimization framework for intensity modulated radiation therapy (IMRT) for lung cancer, where temporal variation of tumor volume and its associated uncertainties throughout the course of the treatment are accounted for to re-optimize the treatment plan for the following sessions. This framework gives an insight into the trade-off between sparing the healthy tissues and ensuring that the tumor receives a sufficient dose. With this trade-off in mind, we demonstrate that our robust adaptive solution outperforms a non-adaptive solution and a nominal (no uncertainty) solution on a clinical case.
Proton Therapy Physics

Practical Radiobiology for Proton Therapy Planning covers the principles, advantages and potential pitfalls that occur in proton therapy, especially its radiobiological modelling applications. This book is intended to educate, inform and to stimulate further research questions. Additionally, it will help proton therapy centres when designing new treatments or when unintended errors or delays occur. The clear descriptions of useful equations for high LET particle beam applications, worked examples of many important clinical situations, and discussion of how proton therapy may be optimized are all important features of the text. This important book blends the relevant physics, biology and medical aspects of this multidisciplinary subject.

Stereotactic Body Radiation Therapy

Breast Cancer Survivorship Care.

Anterior Skull Base Tumors

Radiographer Led Daily Cone Beam CT (CBCT) Anatomical Match and Online Correction for Adult Tumour Sites treated with Proton Beam Therapy.

Introduction

The use of Cone Beam CT (CBCT) as an Image Guided Radiotherapy (IGRT) method enables visualisation of treatment volume prior to treatment delivery, giving confidence to clinicians that the dose distributions planned are a fair representation of actual CTV coverage daily [1]. CBCT had also been proven to minimise doses to Organs at Risk (OARs) [2], as well as able to reduce CTV to PTV margins [3]. In UK radiotherapy centres, radiographer-led or radiographer alone daily CBCT matches across megavoltage photon treatments is the standard of care. In the first UK high energy Proton Beam Therapy centre, Rutherford Cancer Centres, treating non-paediatric cancers, radiographer alone daily CBCT and u2018on-lineu2019 correction has also been implemented for Proton treatments. We compared the u2018on-lineu2019 daily cone-beam CT matches and shifts performed by radiographers during clinical treatments with u2018off-lineu2019 reviews carried out by clinical oncologists.

Materials & Methods

Our centre is equipped with IBA Proteusu00a0One proton therapy machine incorporating large field of view kilovoltage CBCT and 6D robotic table. Every patient undergoes daily CBCT imaging with on-line 6D patient position corrections, matching to planning CT scan carried out by treatment radiographers using IBAu2019s adaPT Insightu00ae software. As per Rutherford Cancer Centres (RCC) protocol, the treating oncologist will review every patientsu2019 first fraction CBCT u2018off-lineu2019 within the first three fractions of treatment and approve if they either completely agree or deem the match acceptable to proceed with treatment. If the CBCT quality or match is not acceptable then this will be disapproved, and the radiographer team notified. We reviewed daily matches and corrections made by radiographers with u2018off-lineu2019 reviews by oncologists to: compare radiographer matches with those made by oncologists to determine the magnitude and range of changes (if any), adequacy of image quality to determine anatomical matches, anatomical changes that would prevent daily proton beam delivery or require re-planning. A retrospective, independent offline image match was also carried out by a Clinical Oncologist planning and treating with Proton Beam therapy to review all 15 patients.

Results

The first 15 non-paediatric cancer patients treated on Proteusu00a0One in our centre since commencing treatments in April 2018 have been reviewed. Centre
policy is to have the first fraction images reviewed and assessed by the treating Oncologist. The treating oncologist reviewed their patients' images offline in Mosaiq at the time of treatment and all agreed with the radiographers' online match and correction by approving the image, authorising treatment to proceed. The independent review was carried out offline in Mosaiq image review platform and not IBA adapt Insight as with online image match and correction. A 2mm tolerance was given to allow for user variability, differences in the auto match algorithms between Mosaiq and Adapt Insight and to allow for factors such as online time pressures. The review found no images to be out of tolerance. Anatomical changes that would prevent or delay proton treatment were all detected correctly by treating radiographers and the patient either counselled on appropriate preparation for treatment before re-imaging and treatment delivery, or referral back to the treating oncologist for discussion and decision on re-planning made. 4 out of 15 patients required a re-plan during their course of treatment, 3 of which were a reaction to the CBCT imaging by the treating radiographers in conjunction with the dosimetry and physics team resulting. 1 was a proactive replan due to a delay between planning and treatment start. Discussions & Conclusion In the UK, treatment radiographers who are suitably trained are regularly reviewing online treatment images and patient setups. This include applying daily corrections using CBCT images. Best practice would utilise defined protocols for individual anatomical sites in conjunction with dosimetrists, physicists, oncologists and even radiologists to ensure consistency and reproducibility between radiographers and clinicians. Radiographers should have deep understanding of the treatment modalities, anatomical sites, awareness of potential issues that could affect the treatment plan (e.g., weight loss, rectal filling). Suitably trained radiographers at Rutherford Cancer Centres will continue to match daily CBCT images in collaboration with Dosimetry and Physics utilising defined treatment protocols.

**Pediatric Radiation Oncology**

**[Purpose]** To quantify the effect of interfractional movements of the prostate, seminal vesicles (SVs) and rectum on prostate proton treatment using full sets of in-room CT images. **[Methods]** We analyzed 1483 sets of daily CT images acquired throughout the proton therapy treatment for 40 patients with four times higher statistics than the one of our published results [1]. We evaluated daily movements of pelvic anatomies by simulating image-matching strategies, and estimated means, systematic and random errors of each anatomies. The change of the mean and errors were also studied by referring daily CT-images as a reference to evaluate the optimum period of re-acquiring the CT-images for re-planning. **[Results]** The data confirmed our previous results and the prostate-rectum matching showed the smaller errors. The mean and systematic errors of the anterior and posterior sides of SVs decreased, when the daily CT-images acquired around 10 days after the first irradiation were used as a reference in comparison to the simulator CT-images, as did the rectum's anterior region. Figure 1 shows the mean and errors of the rectal daily movement over the superior-inferior (SI) position by referring sequential daily CT-images for each image matching method. The positive mean values around SVs region, which means the movement toward the anterior side, decreased gradually as the reference CT number increases. The re-planning with the reference CT after 10 days might reduce the rectal dose around SV region. The effect of daily movement on proton dose will be presented based on several planning scenarios. [1] Y. Maeda, et al. Medical Physics, 45(5), 1844(2018).
Radiographer Led Daily Cone Beam CT Anatomical Match and Online Correction for Adult Tumour Sites Treated with Proton Beam Therapy

Established since 1986 as the definitive text and reference on use of radiation therapy for childhood cancer, Pediatric Radiation Oncology is now in its thoroughly revised and updated Fifth Edition. This edition reviews all significant recent clinical trials—including, for the first time, significant European clinical trials—and provides increased coverage of international and Third World issues. The latest cancer staging guidelines are included. New chapters cover psychosocial aspects of radiotherapy for the child and family and medical management of pain, nausea, nutritional problems, and blood count depression in the child with cancer. This edition also has full-color illustrations throughout. A companion website includes the full text and an image bank.

Radiation Therapy Optimization Under Uncertainty for Lung Cancer

The task of choosing the right prostate cancer treatment is daunting. It is further complicated by conflicting information the patient receives from physicians and the Internet. This book is written by a prostate cancer survivor who now runs an international prostate cancer support group. It’s about his journey and the important things he learned along the way. It is the book the author wishes had been available when he was diagnosed 6 years ago. It is intended to provide specific information for men who are at risk or have been recently diagnosed with prostate cancer. All major treatment options are examined and the pros and cons of each are summarized. A relatively new, non-invasive, highly effective treatment is highlighted. It is an option that cures cancer as well as any other option, but generally leaves the patient with a higher quality of life and fewer, if any, side effects. This book has been endorsed by several physicians as well as other highly respected people from all walks of life.

Practical Radiation Oncology

"Intensity modulated proton therapy (IMPT) is believed to improve the therapeutic ratio by reducing the dose to normal tissue as compared to three dimensional conformal (photon) radiotherapy (3D-CRT). This hypothesis is investigated in this work by predicting the risks of late radiation-induced effects for young patients receiving radiotherapy for Hodgkin’s and non-Hodgkin’s lymphoma (HL and NHL) or breast cancer (BC) using radiobiological modeling. The late effects considered were cardiac mortality and secondary cancer in the lungs and breasts (for female patients). Patient data was acquired for twenty-eight patients who were under thirty years of age and were treated with radiotherapy for HL, NHL, or BC in Quebec in 2010. The original computed tomography simulation images were used to re-plan the patients with IMPT using Eclipse treatment planning software (version 10, Varian Medical Systems, Palo Alto, CA). The dose-volume data of the original photon plans and the new proton plans were analyzed using the relative seriality model to assess the risks of late effects. The relative seriality model was utilized to predict excess risk of cardiac mortality. The Schneider1 modified linear quadratic model was used to predict the excess absolute risk for induction of lung cancer and breast cancer. Parameters for each model were derived from retrospective studies in the literature. Dosimetric plan comparison revealed IMPT reduced dose to the organs at risk of interest as compared to 3D-CRT. Overall the excess risk of cardiac mortality and the excess absolute risks for lung and breast
Prostate Cancer

This edited volume Prostate Cancer is a collection of reviewed and relevant research chapters, offering a comprehensive overview of recent developments in the field of urologic oncology. The book comprises single chapters authored by various researchers and edited by an expert active in the urologic oncology research area. All chapters are complete in themselves but united under a common research study topic. This publication aims at providing a thorough overview of the latest research efforts by international authors and opens new possible research paths for further novel developments.

Proton and Carbon Ion Therapy

INTRODUCTION Lateralized tonsil cancer is a common head and neck cancer that is often irradiated to only one side of the neck. IMPT can help spare midline organs such as the brainstem and larynx from exit dose, but it is difficult to spare the ipsilateral parotid gland from entrance dose. This is the first known study of unilateral neck irradiation to evaluate potential dosimetric improvements beyond IMPT using SPArc.

MATERIALS AND METHODS Five patients undergoing high dose (66-70 CGE) IMPT using single-field uniform dose (SFUD) optimization to tonsil cancer and the unilateral neck were re-planned using SPArc in RayStation ver. 6.2. The same worst-case-scenario robust optimization parameters were used (3.5% range and 3 mm setup uncertainties with total 21 scenarios). Clinical IMPT plans using 2 to 3 fields were compared to SPArc plans utilizing one partial arc with 2.5 degree arc sampling frequency. RESULTS Mean dose levels (in GyE) for organs at risk were as follows with IMPT versus SPArc, respectively: Parotid Gland 54.8 vs. 21.8, Pharyngeal Constrictors 43.4 vs. 33.6, Larynx 23.8 vs. 14, Ipsilateral Cochlea 11.6 vs. 2.4, Esophagus 19.5 vs. 12, and Oral Cavity 19.5 vs. 17.1. Similarly, the average Brainstem maximum was reduced from 25.8 to 15.1 CGE with SPArc. Differences were statistically significant (p

Re-Irradiation: New Frontiers

Novel Prospects in Oxidative and Nitrosative Stress

Oxidative stress plays a crucial role in the pathophysiology of various diseases when there is a disruption of the intracellular redox balance and the homeostatic balance between cellular oxidants and antioxidants. Reactive oxygen species (ROS) and reactive nitrogen species (RNS) react with molecular targets including proteins, lipids, and nucleic acids contributing to mitochondrial injury and cellular dysfunction. This book intends to provide the readers with an extensive overview of the novel approaches and prospects based on oxidative and nitrosative stress in the pathophysiology of various diseases and in the current treatment strategies with antioxidants.

Pediatric Head and Neck Tumors

The best and most concise single source for state-of-the-art diagnosis and treatment of
Lung cancer – newly revised, updated, and expanded. Lung cancer has long been the number-one cause of death from cancer every year and the third most frequently diagnosed after breast and prostate cancers. In 2010, about 15% of all cancer diagnoses and 30% of all cancer deaths were due to lung cancer. Needless to say, there is a great need for more rapid advancements in diagnosis and treatment of this devastating disease. Here is the comprehensively revised, updated, and expanded edition of the well-established, evidence-based reference book that deals with the most recent advances in lung cancer prevention, screening, diagnosis, research, and treatment for the clinician. Edited and authored by leading authorities in the field, this Fourth Edition of the highly regarded Lung Cancer is better than ever – featuring nine new chapters along with seven re-formatted ones that are nearly brand new in content and approach. It covers Smoking Prevention and Cessation; Molecular Profiling; Somatic Genome Alterations in Human Lung Cancers; Management of Multi-Focal Bronchioloalveolar Carcinoma (BAC); Primary Tracheal Tumors; Predictive Tumor Biomarkers for EGFR Inhibitors; Non-Small Cell and Small-Cell Lung Carcinoma; and more. This Fourth Edition of Lung Cancer: Provides the very latest research in the identification of biomarkers to predict a high risk for developing lung cancer – vital for implementing screening, diagnosis, and prevention strategies. Presents the newest lung cancer staging system, as well as updated and cutting-edge surgical and radiation therapy techniques that make local tumor control more effective and less invasive while sparing normal tissues. Discusses combined modality therapy and new chemotherapeutic agents which are yielding higher response rates and improved survival when used in the adjuvant setting or concurrent with highly sophisticated radiation or proton treatment. Offers novel and emergent approaches to preventative, diagnostic, and therapeutic modalities with an emphasis on the best evidence available from the latest studies and clinical trials. With almost half of the revised and updated content being brand new, Lung Cancer, Fourth Edition, is an important and vital resource for all medical professionals and students involved in the care and treatment of those struck with this catastrophic illness.

**Managed Beam Service (MBS) Provided by Muir PT - a Novel Way of Delivering Proton Beams Utilizing Mechatronics**

Proton and Carbon Ion Therapy is an up-to-date guide to using proton and carbon ion therapy in modern cancer treatment. The book covers the physics and radiobiology basics of proton and ion beams, dosimetry methods and radiation measurements, and treatment delivery systems. It gives practical guidance on patient setup, target localization, and treatment planning for clinical proton and carbon ion therapy. The text also offers detailed reports on the treatment of pediatric cancers, lymphomas, and various other cancers. After an overview, the book focuses on the fundamental aspects of proton and carbon ion therapy equipment, including accelerators, gantries, and delivery systems. It then discusses dosimetry, biology, imaging, and treatment planning basics and provides clinical guidelines on the use of proton and carbon ion therapy for the treatment of specific cancers. Suitable for anyone involved with medical physics and radiation therapy, this book offers a balanced and critical assessment of state-of-the-art technologies, major challenges, and the future outlook of proton and carbon ion therapy. It presents a thorough introduction for those new to the field while providing a helpful, up-to-date reference for readers already using the therapy in clinical settings.

**Lung Cancer**
Radiotherapy plays a key role in the treatment of many cancer types. This book is intended to bring forward the recent advancements in the field of radiation oncology. It presents the experience of several researchers who dedicate many hours a day to not only treat patients but also assess the physical aspects of newer radiotherapy facilities. This book contains many valuable contributions from radiation oncology physicians and medical physicists who are experts in their fields.

Radiotherapy

Introduction
Proton therapy (PT) is increasingly being used for pediatric tumors. This is mainly due to the advantages with respect to conventional therapy in terms of organs at risks (OAR) sparing. It is known that PT is more sensitive to anatomical/density modifications. Aim of this study is to present our experience in monitoring and managing anatomical variations in cranial and spinal pediatric lesions.

Materials and Methods
Five cases, with different histology and location, were studied: 1 Skull base chordoma, 1 supratentorial glial neoplasm with hygroma, 1 craniopharyngioma with cystic component, 1 glial tumor of the posterior cranial fossa with vermian residue and 1 atypical meningioma with residual disease in close proximity with the cervical cord. Each patient underwent several CT and MR scans over the treatment course. The following MR sequences were acquired: T2 (study of the cystic and hygromatous component), 3D Flair (study of the edemigenous component), 3D T1 (OAR anatomical definition), DWI (study of cellularity). MR imaging was used to outline target and OAR on the control CTs, then the nominal plan was re-calculated on the CT. In case of target under dosage or OAR constraints violation a re-planning occurred in order to recover the initial dose prescription/constraints.

Results
A total of 9 CT and 15 MR were acquired in this study. Only in 1 case the re-planning was needed due to the increase of the cystic component in a craniopharyngioma.

Conclusions
Monitoring and management of anatomical variations via repeat imaging is feasible in pediatric patients and in some cases it was used to trigger replanning.

Radiation Therapy for Genitourinary Malignancies

This book addresses the most relevant aspects of radiation oncology in terms of technical integrity, dose parameters, machine and software specifications, as well as regulatory requirements. Radiation oncology is a unique field that combines physics and biology. As a result, it has not only a clinical aspect, but also a physics aspect and biology aspect, all three of which are inter-related and critical to optimal radiation treatment planning. In addition, radiation oncology involves a host of machines/software. One needs to have a firm command of these machines and their specifications to deliver comprehensive treatment. However, this information is not readily available, which poses serious challenges for students learning the planning aspect of radiation therapy. In response, this book compiles these relevant aspects in a single source. Radiation oncology is a dynamic field, and is continuously evolving. However, tracking down the latest findings is both difficult and time-consuming. Consequently, the book also comprehensively covers the most important trials. Offering an essential ready reference work, it represents a value asset for all radiation oncology practitioners, trainees and students.

Upgraded Analyses for the Effect of Organ Motion on Proton Prostate
Treatment Using Full Sets of Daily CT Images

This book is a comprehensive guide to the use of modern radiation therapy techniques for prostate cancer and other common and rare genitourinary malignancies. It will be an ideal resource for clinicians and trainees wishing to delve more deeply into the practical and technical aspects of radiotherapy for these malignancies and will serve to enhance day-to-day management in clinical practice. The first section is devoted to prostate cancer and includes coverage of low dose rate and high dose rate brachytherapy, conventionally fractionated, moderately hypofractionated, and ultra-hypofractionated external beam radiotherapy, and proton therapy. The second section focuses on radiotherapy considerations in relation to bladder cancer, testicular cancer, renal cell carcinoma, and rare malignancies such as penile cancer and urethral cancer. Radiotherapeutic treatment of patients with genitourinary malignancies now involves unprecedented precision and complexity, and this book will enable readers to exploit fully the exciting advances that have been achieved in recent years.

Proton Therapy

Developments in radiation oncology have been key to the tremendous progress made in the field in recent years. The combination of optimal systemic treatment and local therapy has resulted in continuing improved outcomes of cancer therapy. This progress forms the basis for current pre-clinical and clinical research which will strengthen the position of radiation oncology as an essential component of oncological care. This book summarizes recent advances in radiotherapy research and clinical patient care. Topics include radiobiology, radiotherapy technology, and particle therapy. Chapters cover a summary and analysis of recent developments in the search for biomarkers for precision radiotherapy, novel imaging possibilities and treatment planning, and advances in understanding the differences between photon and particle radiotherapy. Advances in Radiation Therapy is an invaluable source of information for scientists and clinicians working in the field of radiation oncology. It is also a relevant resource for those interested in the broad topic of radiotherapy in general.

Dosimetric Comparison of Intensity Modulated Proton Therapy (IMPT) Versus Volumetric Modulated Arc Therapy (VMAT) on Early Stage Left Breast Cancer

This text is a concise handbook designed to assist the clinician in the implementation of Accelerated Partial Breast Irradiation (APBI). It includes a review of the principles that underlie APBI, a practical and detailed description of each technique for APBI, a review of current clinical results of APBI, and a review of the incidence and management of treatment related complications. The book encompasses a number of different techniques and approaches that include brachytherapy, intraoperative, and external beam techniques. There is currently no single source that describes these techniques and their clinical implementation.

Advances in Radiation Therapy

Stereotactic body radiation therapy (SBRT) has emerged as an important innovative treatment for various primary and metastatic cancers. This book provides a
comprehensive and up-to-date account of the physical/technological, biological, and clinical aspects of SBRT. It will serve as a detailed resource for this rapidly developing treatment modality. The organ sites covered include lung, liver, spine, pancreas, prostate, adrenal, head and neck, and female reproductive tract. Retrospective studies and prospective clinical trials on SBRT for various organ sites from around the world are examined, and toxicities and normal tissue constraints are discussed. This book features unique insights from world-renowned experts in SBRT from North America, Asia, and Europe. It will be necessary reading for radiation oncologists, radiation oncology residents and fellows, medical physicists, medical physics residents, medical oncologists, surgical oncologists, and cancer scientists.

Spot-Scanning Proton Arc Therapy (SPARC) Versus Intensity Modulated Proton Therapy (IMPT) For Parotid Sparing In Unilateral Tonsil Cancer

This volume is the first comprehensive and practical clinical reference on proton and charged particle radiotherapy. The first half of the book explains the treatment delivery systems used, offers detailed guidance on treatment planning techniques, examines key clinical issues in proton radiotherapy, and reviews recent experience with heavier charged particle radiotherapy. The second half of the book offers "how-to" information on treatment of pediatric tumors, lymphomas, and tumors of the central nervous system, eye, skull base, cervical spine, bone and soft tissue, paranasal sinus, nasal cavity, nasopharynx, oropharynx, oral cavity, salivary glands, prostate, lung, gastrointestinal tract, female reproductive tract, and breast. More than 100 full-color illustrations complement the text.

Re-irradiation for Recurrent Scalp Angiosarcoma - Dosimetric Advantage of Proton Therapy Over VMAT and Electron Therapy

PROBLEM-COST OF CURRENT PTMUIR Managed Beam Services (MBS) can deliver a system with a minimum of 250 patients per annum and expand to 2,000 patients per annum in normal working hours. MUIR Managed Beam Services (MBS) is the first system to design in 2 Accelerators with the second accelerator added to the standard configuration after 1,000 patients per annum. DOUBLES PATIENT CAPACITY MUIR multiple treatment rooms system Other multiple treatment rooms system8 Gantry 4 Gantry 24 Patients per hour 12 Patients per hour 2 Accelerators 1 Accelerator u20ac80,000 Energy cost per annum u20ac4,000,000 Energy cost per annum Zero Decommissioning u20ac68,000 Decommissioning 4,000 Sq M 40,000 Sq M Zero Capital Cost $400,000,000 Capital Cost Note: As curent max capacity is a 4 gantry system, and we have assumed 2 systems for cost comparaisons.COMPARABLE METRICSMUIR is offering the first Managed Beam Services (MBS) using a new mechatronics concept to re-engineer the proton therapy delivery system, in an 8 room modular configuration. All equipment is factory-assembled and delivered to hospital site pre-certified, shortening the lead time from delivery on site to a fully functioning and commissioned solution providing treatment to patients. SOLUTION-ENGINEERED INNOVATION HOW-COMMERCIAL INNOVATION MUIR aims to make the Proton Therapy Managed Beam Services (MBS) available to Healthcare Providers on an all inclusive pay-per-treatment basis. The cost per patient will be very significantly below current costs and closer to current costs for standard radiotherapy. MUIR Managed Beam Services (MBS) delivers assured outcomes in a manner that avoids upfront capital strain for the
You Can Beat Prostate Cancer: And You Don’t Need Surgery to Do It

Proton Therapy Physics goes beyond current books on proton therapy to provide an in-depth overview of the physics aspects of this radiation therapy modality, eliminating the need to dig through information scattered in the medical physics literature. After tracing the history of proton therapy, the book summarizes the atomic and nuclear physics background necessary for understanding proton interactions with tissue. It describes the physics of proton accelerators, the parameters of clinical proton beams, and the mechanisms to generate a conformal dose distribution in a patient. The text then covers detector systems and measuring techniques for reference dosimetry, outlines basic quality assurance and commissioning guidelines, and gives examples of Monte Carlo simulations in proton therapy. The book moves on to discussions of treatment planning for single- and multiple-field uniform doses, dose calculation concepts and algorithms, and precision and uncertainties for nonmoving and moving targets. It also examines computerized treatment plan optimization, methods for in vivo dose or beam range verification, the safety of patients and operating personnel, and the biological implications of using protons from a physics perspective. The final chapter illustrates the use of risk models for common tissue complications in treatment optimization. Along with exploring quality assurance issues and biological considerations, this practical guide collects the latest clinical studies on the use of protons in treatment planning and radiation monitoring. Suitable for both newcomers in medical physics and more seasoned specialists in radiation oncology, the book helps readers understand the uncertainties and limitations of precisely shaped dose distribution.

Proton and Charged Particle Radiotherapy

- Summarizes the state of the art in the most relevant areas of medical physics and engineering applied to radiation oncology - Covers all relevant areas of the subject in detail, including 3D imaging and image processing, 3D treatment planning, modern treatment techniques, patient positioning, and aspects of verification and quality assurance - Conveys information in a readily understandable way that will appeal to professionals and students with a medical background as well as to newcomers to radiation oncology from the field of physics

Particle Radiotherapy

This book serves as a practical guide for the use of carbon ions in cancer radiotherapy. On the basis of clinical experience with more than 7,000 patients with various types of tumors treated over a period of nearly 20 years at the National Institute of Radiological Sciences, step-by-step procedures and technological development of this modality are highlighted. The book is divided into two sections, the first covering the underlying
principles of physics and biology, and the second section is a systematic review by
tumor site, concentrating on the role of therapeutic techniques and the pitfalls in
treatment planning. Readers will learn of the superior outcomes obtained with carbon-
ion therapy for various types of tumors in terms of local control and toxicities. It is
essential to understand that the carbon-ion beam is like a two-edged sword: unless it is
used properly, it can increase the risk of severe injury to critical organs. In early series
of dose-escalation studies, some patients experienced serious adverse effects such as
skin ulcers, pneumonitis, intestinal ulcers, and bone necrosis, for which salvage
surgery or hospitalization was required. To preclude such detrimental results, the
adequacy of therapeutic techniques and dose fractionations was carefully examined in
each case. In this way, significant improvements in treatment results have been
achieved and major toxicities are no longer observed. With that knowledge, experts in
relevant fields expand upon techniques for treatment delivery at each anatomical site,
covering indications and optimal treatment planning. With its practical focus, this book
will benefit radiation oncologists, medical physicists, medical dosimetrists, radiation
therapists, and senior nurses whose work involves radiation therapy, as well as medical
oncologists and others who are interested in radiation therapy.