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INSIDE STORIES

Prof. Arun Chougule
Editor

I am happy to bring out the second issue of AFOMP newsletter after my becoming editor of newsletter. In this newsletter an article on **"The Linear-Quadratic Model : A Primer " by Prof. C.G. Orton** renowned Medical Physicist cum radiobiologist & great teacher speaks about the importance and applicability of linear quadratic models. I hope this preview will create an interest in application of ERD concept in day to day situations in radiotherapy

Another article by Dr. S. D. Sharma gives the present status of **Medical Radiation Physics Courses in India**

I appeal through this newsletter to office bearers of the member countries of AFOMP to provide articles/write up about the medical physics education status in their country.

The article on "Physical Basis and Recent Technological Trend of Carbon-ion Radiotherapy" by Dr. Kitagawa of Chiba, Japan also gives an insight to modern radiotherapy gadgets.

I have introduced a column "Know your AFOMP officer bearers". In this column I am planning to give the short biography of each one and will add up slal warts-leading medical physicist of AFOMP countries in future newsletters.

I appeal to all AFOMP medical physicists to provide information on activities in medical physics in their country, articles etc. so as to improve the quality and enrich the newsletter.

The forthcoming AFOMP & SEACOMP meeting is going to be held at Ho-Chi-Min city, Vietnam during 23-25 Oct. 2014. Organisers are making all effort to make this conference memorable, I hope large number of medical physicist will attend this meeting and get benefited.

Further I would like to inform all the readers that Jaipur, the pink city of India, is hosting an **"International Conference on Medical Physics, Radiation Protection & Radiobiology ICMPRPR-2K15" during 20-22 February, 2015**. I invite you all to participate in this conference and visit the Pink city.

Your feedback and comments are highly appreciated.

Prof. Arun Chougule

WELCOME

INTERNATIONAL CONFERENCE ON MEDICAL PHYSICS, RADIATION PROTECTION & RADIOBIOLOGY-2015

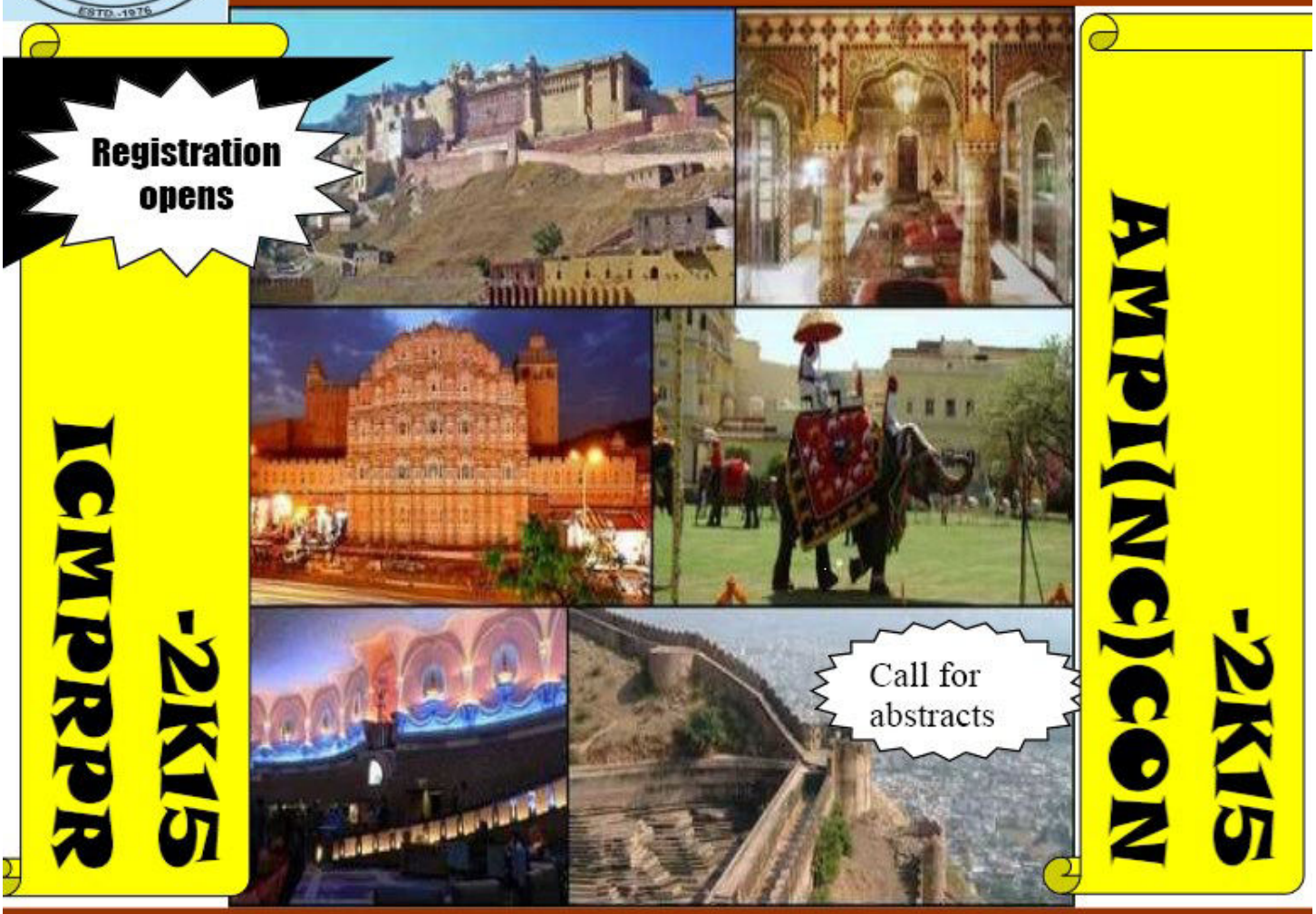
&

ANNUAL CONFERENCE OF ASSOCIATION OF MEDICAL PHYSICISTS OF INDIA (NORTHERN CHAPTER)

20th , 21st ,22nd February 2015

Venue:- SMS Medical College Auditorium, Jaipur (Rajasthan) India

FIRST ANNOUNCEMENT



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The Linear-Quadratic Model: A Primer

Colin G. Orton, PhD, Professor Emeritus, Wayne State University, Detroit, Michigan, USA

For the analysis, comparison, or revision of different fractionation or dose rate schemes in radiotherapy, it has become common practice to use the linear-quadratic (L-Q) bio effect dose model. Following is a brief review of the various equations used for different applications.

Simple fractionation schemes

The following basic Biologically Effective Dose (BED) equation (Eq. 1) is used when the time to deliver each fraction is short, and the time between fractions is long, compared to the cellular repair half time, and the overall time to deliver the course of radiotherapy is short compared to the cellular doubling (or repopulation) time:

$$BED = Nd\left(1 + \frac{d}{\alpha/\beta}\right) \qquad \text{Eq. 1}$$

where N = number of fractions, d = dose/fraction (in Gy), and α/β (Gy) is a tissue-specific radiobiological parameter that represents how well cells repair radiation damage (the lower α/β the better the repair). Note that α/β represents the ability of cells to repair not the speed of repair (which is denoted by the repair half time). Typically, unless we know better values, α/β is assumed to be 10 Gy for tumors and about 3 Gy for late-reacting normal tissues. Some exceptions might be prostate and breast cancers, for which α/β ratios are reportedly about 1.5 Gy and 4 Gy, respectively.

What about repopulation during long courses of radiotherapy?

When the course of radiotherapy is long enough for cells to repopulate during the treatments, we need to reduce the BED accordingly using Eq. 2:

$$BED = Nd\left(1 + \frac{d}{\alpha/\beta}\right) - kT \qquad \text{Eq. 2}$$

where T (days) is the overall time of the course of radiotherapy, including any rest periods, and k is the reduction in BED per day of treatment due to repopulation. Some people believe that a period of time passes after the start of a course of therapy before repopulation (sometimes called "accelerated repopulation") begins, the so-called "kick-off" time T_k, which is often assumed to be about 28 days. Then T in Eq. 2 needs to be replaced by $(T—T_k)$ for courses of radiotherapy when $T > T_k$. For courses when $T < T_k$, k is assumed to be 0. Another format for the above equation is often used which incorporates the potential doubling time, T_{pot}, of the cells. The BED equation then becomes:

$$BED = Nd\left(1 + \frac{d}{\alpha/\beta}\right) - \frac{0.693T}{\alpha T_{pot}} \qquad \text{Eq. 3}$$

The problem here is that repopulation is represented by two biological parameters (α and T_{pot}) instead of one (k). Personally, I prefer the simpler form of the equation, since it is difficult enough to determine one extra biological parameter, let alone two. Unless more accurate values are known, I use the values of k shown in Table 1.

Table I: typical values assumed for k

Type of cell	*k* (BED units/day)
Late-responding normal tissue	about 0
Acutely-responding normal tissue	0.2 – 0.3
Slowly-growing tumor	about 0.1
Typical tumor	about 0.3
Rapidly-growing tumor	about 0.6

Note that, strictly, *k* is in BED units/day since it is a linear-quadratic term, although you will often see it quoted as Gy/day.

Correction for repair *during* each fraction

Sometimes fraction times can be quite long, especially for the large doses/fraction used for hypofractionation. For such cases when there is time during each fraction for some repair to occur, a repair factor, *G*, is introduced and the BED equation (without repopulation) becomes:

$$BED = NRt\left(1 + \frac{GRt}{\alpha/\beta}\right) \qquad \text{Eq. 4}$$

where *R* is the dose-rate in Gy/h and *t* is the time for each fraction in h. Hence the dose/fraction is *Rt* Gy. *G* is a function of the repair-rate constant (μ) of the cells and the time to deliver each fraction. The full equation for BED is:

$$BED = NRt[1 + \frac{2R}{\mu(\alpha/\beta)}\left\{1 - \frac{1-e^{-\mu t}}{\mu t}\right\}] \qquad \text{Eq. 5}$$

Note that the repair-rate constant = 0.693/ $t_{1/2}$, where $t_{1/2}$ is the half-time for repair. There is little consensus on what $t_{1/2}$ values to use but typically I like to use 0.5 h for tumor and 1.5 h for late-reacting normal tissue cells (μ = 1.4 h^{-1} and 0.46 h^{-1}, respectively).

Low dose-rate brachytherapy

Equation 5 is also used for low dose-rate brachytherapy since there is repair during each fraction of treatment. However, since low dose-rate brachytherapy treatments are often very long compared to cellular repair half-times, the equation can be simplified considerably since $e^{-\mu t}$ approaches zero for large values of *t*.

For 10h < *t* >100h the BED equation becomes:

$$BED = NRt[1 + \frac{2R}{\mu(\alpha/\beta)}\left\{1 - \frac{1}{\mu t}\right\}] \qquad \text{Eq. 6}$$

and, for *t* >100h the BED equation becomes simply:

$$BED = NRt[1 + \frac{2R}{\mu(\alpha/\beta)}] \qquad \text{Eq. 7}$$

Permanent implants

For brachytherapy using short half-life radionuclides for permanent implants, the dose-rate decreases as the treatment progresses, so account must be taken both of the repair-rate of the cells and the decay-rate of the sources. If the decay constant of the radionuclide is λ (in h^{-1}), and the initial dose-rate is R_0 (Gy/h), the BED reached at a time *t* after implantation is:

$$BED = \frac{R_0}{A\lambda}\left[1 + \frac{2R_0\lambda}{(\mu-\lambda)(\alpha/\beta)}\{A(B-C)\}\right] \qquad \text{Eq. 8}$$

where:

$$A = 1/(1 - e^{-\lambda t}) \qquad \text{Eq. 8a}$$

$$B = (1 - e^{-2\lambda t})/2\lambda \qquad \text{Eq. 8b}$$

$$C = \left[1 - e^{-(\mu+\lambda)t}\right]/(\mu + \lambda) \qquad \text{Eq. 8c}$$

For permanent implants, if repopulation can be ignored (for late-responding normal tissue cells, for example), the BED after complete decay is obtained by letting t go to infinity in the above equations, which gives:

$$BED_{\infty} = \frac{R_0}{\lambda}\left[1 + \frac{R_0}{(\mu+\lambda)(\alpha/\beta)}\right] \qquad \text{Eq. 9}$$

For permanent implants when repopulation cannot be ignored (for most tumors and acutely-responding normal tissues, for example), because the rate of cell killing decreases with time after implantation due to decay of the radionuclide sources, after a time t_{eff} the rate at which cells repopulate exceeds the rate at with they are being killed, where t_{eff} is a function of the rate of decay of the radionuclide represented by the decay constant λ, and the rate of repopulation represented by repopulation parameter k. The BED calculated at this time will be the maximum achieved. An approximate equation for t_{eff} (in h) is:

$$t_{eff} \approx -[ln(k/24R_0)]/\lambda \qquad \text{Eq. 10}$$

where $k/24$ is the repopulation parameter in BED units/h, R_0 is the initial dose rate in Gy/h, and λ is in h^{-1}. Then, in order to calculate the maximum BED reached (at time t_{eff}), all you need to do is replace t in Eqs. 8a, 8b and 8c by t_{eff}.

Examples

1. *Comparison of different fractionation schemes*

When comparing the biological effectiveness of different treatment regimes you need to consider the effect on both tumor and normal tissues. To do this you should not simply use the same dose and dose/fraction for these two tissues since, with modern highly-conformal radiotherapy techniques, the effective dose to normal tissues will be lower than that to the tumor. There is geometrical sparing of the normal tissues which might be represented by a "geometrical sparing factor" f where:

$$f = \frac{effective\ dose\ to\ normal\ tissues}{effective\ dose\ to\ tumor}$$

Here, by "effective dose" we mean the dose that would produce the same biological effect if delivered uniformly to the tissue as the inhomogeneous dose actually delivered. A good example would be the Equivalent Uniform Dose (EUD) that many treatment planning computers can calculate. The following example illustrates the use of the geometrical sparing factor:

Question: *A radiation oncologist wishes to change a conventional breast cancer fractionation schedule of 60 Gy delivered in 30 fractions over 6 weeks, to a hypofractionated regime delivered in 6 fractions, also over 6 weeks. What dose/fraction should be used to keep tumor effects the same, and how will this affect late -reacting normal tissues?*

Firstly, we can neglect repopulation since the overall treatment times are the same. Secondly, let us assume that highly conformal techniques are used for both standard and hypofractionated treatments and that the geometrical sparing factor $f = 0.7$ for both.

Parameters: assume that α/β for breast cancer is 4 Gy and for late-reacting normal tissues is 3 Gy.

Solution: using Eq1,the tumor BED for the conventional treatment is :

$$BED_{t,conv} = 60\left(1 + \frac{2}{4}\right) = 90.0$$

Then the dose/fraction *d* required for the same BED using hypofractionation is given by:

$$90 = 6d\left(1 + \frac{d}{4}\right)$$

This is a quadratic equation for which:

***d* = 6.0 Gy**

Now consider the late-reacting normal tissues for which the BED for conventional fractionation, using f = 0.7 and α/β = 3 Gy is:

$$BED_{l,conv} = 60 \times 0.7\left(1 + \frac{2\times0.7}{3}\right) = \mathbf{61.6}$$

For the hypofractionated treatments at tumor dose 6.0 Gy/fraction, the late-effect BED is:

$$BED_{l,hypo} = 6 \times 6.0 \times 0.7\left(1 + \frac{6.0\times0.7}{3}\right) = \mathbf{60.5}$$

Hence one would expect the effect on late-reacting normal tissues to be relatively unchanged (60.5 vs. 61.6).

2. ***Change from LDR to HDR***

Question: *It is required to replace an LDR cervix cancer treatment of 60 Gy at a dose rate R = 0.6 Gy h^{-1} by a six fraction HDR implant. What dose/fraction should be used to keep the effect on the tumor the same, and will this increase or decrease the effect on surrounding normal tissues assuming that the geometrical sparing factor f = 0.7 for the LDR and 0.6 for the (more dosimetrically versatile) HDR treatments?*

Solution: since the overall time for the LDR treatments t = 100 h we can use the simplified version of the BED equation (Eq. 7), so:

$$BED = Rt\left[1 + \frac{2R}{\mu(\alpha/\beta)}\right]$$

Assume: μ = 1.4 h^{-1} and α/β = 10 Gy for tumor, then:

$$BED_{LDR} = 60[1 + 1.2/(1.4 \text{ x } 10)] = 65.1$$

Then, if d is the dose/fraction required for equivalence, using Eq.1 gives:

$$65.1 = 6d\left(1 + \frac{d}{10}\right)$$

This is a quadratic with solution

***d* = 6.55 Gy**

Now consider normal tissues. All LDR doses and dose rates need to be multiplied by the geometrical sparing factor 0.7. Then, again using Eq.7, and assuming that μ = 0.46 h^{-1} and α/β = 3 Gy for normal tissue late reactions, the LDR BED to normal tissues is:

$$BED_{LDR} = 60 \times 0.7[1 + (1.2 \times 0.7)/(0.46 \times 3)] = \mathbf{67.6}$$

The HDR BED to normal tissues at tumor dose 6.55 Gy/fraction, using Eq.1 and f = 0.6 is:

$$BED_{HDR} = 6 \times 0.6 \times 6.55\left(1 + \frac{6.55\times0.6}{3}\right) = \mathbf{54.5}$$

This is somewhat lower than for the LDR treatments, so the HDR treatments are likely to be better tolerated.

3. *Correction for breaks in treatment*

Question: *A patient is planned to receive 60 Gy in 6 weeks at 2 Gy/fraction. After 28 days there is an unplanned 14 day break. What dose/fraction should be used if the treatment is to be completed in 12 more fractions over 16 days if tumor control is not to be compromised?*

Solution: the physician states that this is neither a rapidly growing or slowly growing tumor, so we will assume an average repopulation rate with $k = 0.3$ (Table I) with $\alpha/\beta = 10$ Gy.

The BED planned is, using Eq. 2:

$$BED_{planned} = 60\left[1 + \frac{2}{10}\right] - 0.3 \times 42 = 59.4$$

The BED delivered before the break is 2/3rds of this i.e. 39.6, which reduces to 39.6 – 0.3 x 14 = 35.4 by the end of the break.

To complete the treatment we need to give an additional BED of 59.4 – 35.4 = 24.0. Then, again using Eq. 2 with 12 fractions of dose *d*/fraction over 16 days:

$$24.0 = 12d\left[1 + \frac{d}{10}\right] - 16 \times 0.3$$

This is a quadratic with solution:

***d* = 2.0 Gy/fraction**

Note that this will keep the effect on tumor as originally planned. Late-reacting normal tissues, however, will not benefit much from the break, if at all, if the treatment is completed this way. Rather than putting normal tissues at too much risk of complication, the physician might want to compromise and give just one extra 2 Gy fraction instead of two.

3. **How accurate are these calculations?**

The reliability of these calculations depends on two things: (a) the accuracy of the L-Q model itself and, (b) the accuracy of the parameters assumed. Clearly, the complex radiobiological changes that take place in tissues when they are irradiated cannot possibly be represented by such a simple model. Decades of experience using this model in clinical practice, however, have demonstrated that it seems to give fairly reliable results, despite its simplicity, even though we have not been particularly confident about the values of the parameters we have been using. Fortunately, people have been collecting data on tumor control and complication risks and using these to estimate better parameters. Based on these, things will continue to improve and, maybe we will develop a better model. In the meantime, it is best to use the L-Q model with caution as a guide to practice and to remain vigilant when using it so as to detect any obvious errors. Like all models, it is wrong, but it is useful. For a more complete discussion of this topic readers are referred to AAPM Report 166 “The Use and QA of Biologically Related Models for Treatment Planning” which is available open access at http://aapm.org/pubs/reports/RPT_166.pdf.

Medical Radiation Physics Courses in India

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Introduction

Medical Radiation Physics is an applied branch of physics that deals with the application of physical principles, concepts and methods to the diagnosis and treatment of diseases. Historically, medical physics has been concerned with the uses of ionizing radiation in radio-diagnosis and therapy. About three decades ago, medical physics activities were restricted primarily to the dosimetry of ionizing radiation. In the recent years, this concept has changed considerably and now the medical physicist is involved in physics of imaging, quality assurance of radiological equipment, administration of radiation protection, radiobiological modeling, biomedical instrumentation, bioelectrical investigations of brain and heart, thermography, ultrasound, laser and nuclear magnetic resonance techniques. A number of developments have taken place in the recent time in India for improving the quality of medical radiation physics courses. This communication describes briefly the current status and recent developments in this direction.

Types of medical physics courses

On the basis of entry level qualification requirements, two types of medical radiation physics courses are conducted in the country, namely (i) one year post M. Sc. Diploma in Radiological Physics (Dip. R.P.)/ one year post M. Sc. Diploma in Medical Physics (Dip. M.P.), and (ii) two years post B. Sc. Master Degree in Medical Physics [M. Sc. (Med. Phys.)]. These two courses are thought to be equivalent to each other. Historically, medical radiation physics education and training in India started with the introduction of one year Certificate Course in Radiological and Hospital Physics in 1962 by the Radiological Physics & Advisory Division (the then Division of Radiological Protection), Bhabha Atomic Research Centre, Mumbai in collaboration with World Health Organization (WHO) and International Atomic Energy Agency (IAEA). Later, this course was affiliated to University of Bombay and renamed as Diploma in Radiological Physics (Dip.R.P.). Since 2007, the Dip. R. P. programme is conducted under the aegis of Homi Bhabha National Institute (HBNI, a deemed to be University). So far 904 students have successfully completed the Dip.R.P. course and the 52nd course with 26 students is in progress. In 1981, Department of Physics, Anna University started two years Master Degree course in Medical Physics. Subsequently, a number of university/ institution started either one year Post M. Sc. Diploma in Radiological/Medical Physics course or two years M. Sc. Medical Physics course. Currently, six institutions are conducting Dip. R.P./Dip. M.P. course and seven universities are conducting M. Sc. (Med. Phys.) course. A few institutions/universities are also in process to start the either Dip. R. P./Dip. M.P. course or M. Sc. (Med. Phys.) course. About 130 candidates are passing out from these courses every year.

Harmonized syllabus

Traditionally, medical physics curriculum was worked out by a group of faculty from the university/ institution conducting the programme. This concept has changed now and it requires the input from the faculties of all the involved disciplines, clinical medical physicists and radiation safety experts. The HBNI constituted a coordination committee for revising and restructuring the Dip. R .P. programme involving faculties and experts from research/ teaching institutions, hospitals and regulatory body. This committee prepared a revised syllabus for Dip.R.P. programme which was later adopted by the Atomic Energy Regulatory Board (AERB) as standard syllabus for medical physics course in the country. The AERB standard syllabus is applicable for one year Post M. Sc. programme and 2nd year of two years M. Sc. (Med. Phys.) course. The elaborate syllabus prescribed by University Grants Commission of India on Nuclear Physics, Radiation Physics, Solid State Physics, Electronics and Instrumentation and Mathematical Physics was also recommended for the 1st year of two years M. Sc. (Med. Phys.) course. Now, all the institutions/ universities conducting medical physics courses in the country are using this harmonized syllabus.

Internship

With the advancement in technology and complexity in techniques of medical imaging and radiation therapy, it is felt necessary that medical physicists should have sufficient clinical and technological experience prior to practicing as clinical medical physicist. As per current trends of medical physics service requirements in the country, majority of medical physicist find employment in radiation oncology departments of the hospitals. Accordingly, AERB in its safety code for radiotherapy included the mandatory requirement of at least one year internship at a well equipped recognized radiotherapy centre for a medical physicist. A committee of experts worked out the criteria for recognizing the radiotherapy centers of the country and 86 radiotherapy centers on their willingness have been accredited to conduct the internship in medical physics. In addition, the committee also prescribed an internship syllabus and format of certification after successful completion of the internship programme. The internship in medical physics in the country was implemented with effect from 2013.

Competency certification of medical physicist

College of Medical Physics of India (CMPI), an academic wing of Association of Medical Physicists of India (AMPI), started competency test and certification of academically and clinically qualified medical physicists in the country in the year 2010 in the specialty of Radiation Oncology Physics. The CMPI certification examination consists of two parts namely written and oral examinations. The written examination consists of three papers, namely (i) General Medical Physics, (ii) Radiobiology and Radiation Protection, and (iii) Radiation Oncology Physics (the specialty paper). The oral examination is a comprehensive evaluation of the candidate which comprises a scientific presentation by the candidate on the topic of his/her choice in presence of all the examiners and comprehensive evaluation by five different examiners in the different aspects of the specialty paper. The candidates who obtain at least 50% marks separately and at least 60% marks in aggregate are declared successful by the CMPI Board and are enrolled as CMPI certified member. So far four certifications examinations have conducted by the CMPI.

Certification in Medical Radiation Protection

Candidates passing out of the AERB recognized institutions/ universities are eligible for appearing in Radiological Safety Officer (RSO) certification examination. This examination consists of two parts, namely written and oral evaluations. The written paper is of 100 marks and a syllabus has been prescribed by the AERB for this paper. Oral examination is also of 100 marks which includes comprehensive evaluation of the candidate by a team of examiners including representative of regulatory body. The candidates who obtain at least 50% marks separately and at least 60% in aggregate are declared successful and certified as eligible RSO. This examination is conducted by the Radiological Physics and Advisory Division of Bhabha Atomic Research Centre.

Summary

The medical physics education and training in India is now well structured. However, the quality of teaching and training at majority of institutions/ universities needs further improvement. In this direction, it is planned to conduct training of trainers (ToT) programme periodically. The first ToT programme for medical physics teachers is being organized this year. It is also required to modulate the existing course content and training modality so that medical physicist trained in India should also contribute towards innovations in this field.

ESR's Euro Safe Imaging campaign promotes Radiation Protection

By *Madan M. Rehani, PhD,*
Director of Radiation Protection, European, Society of Radiology. VIENNA

Madan M. Rehani

The mission of Euro Safe Imaging is to support and strengthen medical radiation protection across Europe following a holistic, inclusive approach. Europe is unique and it has the potential for coordinated radiation safety actions in medical imaging. So what makes Europe unique? In Europe, the European Atomic Energy Community (EURATOM) Directive is binding on European member states, and EURATOM has regulated medical radiation protection, including x-rays, since the 1990s. No other region, or country, has something similar. In the U.S., each state has its own regulatory mechanism for x-rays, as federal laws regulate the use of radioisotopes in medicine (nuclear radiation), through the Nuclear Regulatory Commission (NRC), but not x-rays. The requirements issued by the International Atomic Energy Agency (IAEA) are not binding on IAEA member states, They are voluntary international standards. In the 1990s, when the Maastricht Treaty was signed, there was a vision to have something like a standardized European xray image, such that when the patient travels from one European country to another, there could be validity of the image and thus avoiding repeat imaging. This led to the development of quality criteria for image quality that included patient dose as well. Europe also established diagnostic reference levels (DRLs) that became one of the most important tools for optimization in patient radiation protection. The European Commission has supported these developments through a variety of projects. While the directives need to be incorporated into national regulatory systems by European member states, Europe's largest radiological society, the European Society of Radiology (ESR) can play an important role as a promoter to support the implementation of the directives through professional channels. The need for this has never been greater than today with patient radiation exposure rising.

Why do we need Euro Safe Imaging?

Not since x-rays were first used in medical imaging has there been such an interest in radiation protection for patients. The cumulative patient radiation doses have been reaching levels never seen before. There have been some reports of overexposure, resulting in visible radiation induced skin injuries to patients. There have been reports of overuse of CT, which has become a more patient friendly and clinically valuable imaging technique, with the prospect of it becoming used like a simple radiograph (e.g., chest x-ray). Much of the use is justified, but a number of publications indicate that, typically, a quarter or more of examinations may not meet appropriateness criteria. Euro Safe Imaging is a campaign designed to meet the needs of the present, but with the roots of vision that began few decades ago. The purpose is to promote the appropriate and safe use of imaging, as well as the utilization of features in dose efficient equipment, through the cooperation of stakeholders.

What will Euro Safe Imaging do?

The ESR has already taken part in a number of EC projects in the area of medical radiation protection. A steering committee for Euro Safe Imaging has just been established. Recently, a consortium led by the ESR was awarded a project by the EC to establish diagnostic reference levels for pediatric examinations. The ESR has previously pursued a number of projects and actions in cooperation with the European Federation of Organizations for Medical Physics (EFOMP), European Federation of Radiographer Societies (EFRS), Heads of the European Radiological Protection Competent Authorities (HERCA), European Association of Nuclear Medicine (EANM), European Society for Radiotherapy & Oncology (ESTRO), and subspecialty radiological societies, such as the Cardiovascular and Interventional Radiological Society of Europe (CIRSE), the European Pediatric Radiology Society (ESPR), the European Society of Urogenital Imaging (ESUR), and the European Society of Gastrointestinal and Abdominal

The ESR has also worked with major international organizations such as the European Commission, International Atomic Energy Agency (IAEA), World Health Organization (WHO), and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), and the International Commission on Radiological Protection (ICRP). Collectively approaching the implementation of radiation protection, motivating countries to translate guidelines into their own languages, creating mechanisms for feedback and providing certifi-

cation, later on, will meet the ESR's vision of safe imaging for patients. Steps already taken include the following:
Publication of a European Society of Radiology statement on radiation protection: ESR statement on radiation protection: globalization, personalized medicine and safety (the GPS approach), *Insights into Imaging*, December 2013, Vol. 4:6, pp. 737739, DOI 10.1007/s132440130287z
Training actions with chairs and senior radiologists on orienting them toward radiation protection at the Management in Radiology (MIR) annual meeting in October 2013 in Barcelona, Spain
Establishment of a website on Euro Safe Imaging Posters from various countries depicting the current status of safety in imaging made available at the Euro Safe Imaging website Cooperation with Image Gently and Image Wisely from the U.S. is envisaged.
[Originally published in ECR Today on 6 March 2014 reproduced with permission]

PHYSICAL BASIS AND RECENT TECHNOLOGICAL TREND OF CARBON-ION RADIOTHERAPY

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In order to treat a deep-seated tumor by the radiotherapy (RT), it is important to decrease the damage to normal organs surrounding the tumor as low as possible level. The good localized physical dose distribution given by charged particles, especially heavy ions, has been known since the 1940's. In addition, many biological experiments showed another promising advantage of heavy ion radiotherapy for a deep-seated tumor (HI-RT), i.e. a good relative biological effectiveness (RBE) even for radio-resistant tumors. This advantage comes from the high linear energy transfer (LET) of heavy ions[1]. Based on physics, lighter ion species cause larger multiple scattering in the deep side, and heavier ion species give unexpected dose over the end-point due to the projectile fragmentation. Carbon or neon ions were viewed as the most promising ion species for RBE, but silicon or argon ions were also considered favorably since they give the highest gain factor for radio-resistant tumors. The best ion species principally depends on the depth and thickness of the tumor, the tumor type, and other conditions of the individual patient. Although lighter ions like lithium or beryllium show a better performance as decreasing of a thickness of tumor, comparable as 10 times larger than the width of Bragg peak shown in Figure 1 (a), carbon is one of the best candidates for the typical conditions, a depth of 10 – 25 cm and a thickness of several centimeters shown in Figure 1 (b).

The pioneering work of HI-RT was carried out by the Lawrence Berkeley Laboratory, University of California (LBL; the present abbreviation is LBNL) between 1975 and 1992. Although about 440 clinical results for 17 years were insufficient and LBNL had to break off the clinical trials due to the closure of the accelerator facility, many biological experiments confirmed its promising possibility[2]. The Heavy Ion Medical Accelerator in Chiba (HIMAC) at the National Institute of Radiological Sciences (NIRS) in Chiba, Japan is the first medical dedicated heavy ion accelerator complex and had an aim to develop HI-RT as a safe and secure irradiation technologies[3]. This national research project was conducted under the Japanese government's 'The 1st (1984 – 1993), 2nd (1994 - 2003), and 3rd (2004-2013) Comprehensive 10-year Strategy for Cancer Control'. The clinical data have been accumulated under prescribed clinical protocols since 1994. At present, the total number of patients exceeded 8000. All of clinical protocols and its results have been reported routinely through the evaluation committee at NIRS. The summaries have been published and have clearly demonstrated the advantages of C-RT[5,6].

Regarding toxicities, from the systematic phase-I/II dose-escalation studies for many kinds of tumors, the safe doses have been determined and irradiation techniques have been improved with the observation of no further severe side effects than have been already observed. The dose fractionations have also been determined as optimal in the same dose-escalation studies. Clinical results are evaluated by two measured clinical statistics, i.e. local control and survival ratios. Good local control ratios have been achieved for some intractable tumors, such as inoperable bone and soft tissue tumors, postoperative pelvic recurrence of rectal cancer, and so on. In these diseases, even if the case is operable, HI-RT gave a large benefit to prevent a great reduction of the organ function due to the resection and to keep the survival ratio comparable to that obtained by the

resection. In addition, the benefit of HI-RT over other modalities has been demonstrated in terms of a significant reduction in overall treatment time with acceptable toxicities. The peripheral-type no-small-cell lung cancer has also been very effectively treated by low-LET RT, but usually low-LET RT must divide the dose into 20-30 fractions and a few months are needed for the treatment period. In the case of HI-RT, the number of fractions and treatment period were carefully reduced step by step from 18 fractions over 6 weeks to one single fraction, thus one day treatment. The respiratory-gated irradiation method[8,9] for target organs with respiratory movement and multi-port irradiation from 3- or 4-field directions were utilized for all patients to reduce toxicities. For hepatocellular carcinoma, 2 fractions over 2 days have been adopted without severe side effects.

At present seven C-RT facilities are under operation worldwide. Four of the seven facilities are located in Japan. Others are in Germany, Italy, and China. In addition, five facilities are under construction. More detailed history and status have been described in the references[10,11]. Almost facilities consist of a synchrotron with an injector accelerator system, ion sources, and the most important key-technology i.e. irradiation system. The role of the irradiation system is to realize uniform dose distribution on the target volume. Although there are historically various beam-delivery systems[9], the present methods to obtain a large uniform irradiation volume from the pencil shaped and mono-energetic heavy ion beam are roughly divided into two categories shown in Figure 2.

The first category includes a wobbler method (Figure 2.I.a) which was developed at LBNL and has been utilized for daily clinical treatment at HIMAC[12], The system consists of a pair of orthogonal bending magnets and a beam scatterer to spread the beam size in the lateral direction and it is used in association with a ridge filter as a range modulator. This method requires a beam collimator and a range compensator and both items are usually patient-specific hardware. RBE is assumed in the water equivalent target volume[13]. The disadvantage is that an unwanted dose will be deposited on the entrance path of target; that dose is of the same level as the dose to the target volume. In order to reduce this deposited dose, the layer-stacking wobbler method (Figure 2.I.b) has been utilized for several tumor types[14].

The second category includes pencil-beam scanning methods (Figure 2.II.a), such as spot scanning and raster scanning. The first spot-scanning system for proton radiotherapy (p-RT) was developed at NIRS. [15] The Paul Scherrer Institute (PSI) in Villigen, Switzerland has routinely utilized the one-dimensional spot -scanning method with the movement of the patient couch for pion RT at first, then for p-RT.[16] For HI-RT, the Gesellschaft fur Schwerionenforschung (GSI) in Darmstadt, Germany has developed the three-dimensional raster-scanning method with variable beam-energy acceleration, and is utilizing it for daily clinical treatment.[17] This method realizes a better dose distribution without an unexpected dose on normal tissues. In addition, the beam intensity efficiency is better than the wobbler method, and patient-specific hardware is not necessary. However, it is difficult to make a uniform dose distribution with a reasonable margin, acceptable irradiation efficiency, and reliable quality assurance in a trunk organ without respiratory-gated irradiation (Figure 2.II.b). Therefore the pencil-beam scanning methods have mostly been utilized for treatments of head and neck tumors only. On the other hand, the wobbler method is able to cover almost trunk organs like lung, liver, and pancreas.

In the case of the usual external-beam radiotherapy with an electron linac (X-RT), the technique is simpler than p-RT and C-RT. The edge of beams of X-RT is able to be aligned with the outline of the target shown in Figure 3 (a). The varying of the irradiation dose deposited in the target volume is small. However, in the case of p-RT and HI-RT, the distorted shape and the varying of the density cause the range modification shown in Figure 3 (b). It is almost impossible to chase the moving organs. The respiratory gated irradiation is one solution for the pencil-beam scanning method with p-RT and HI-RT. It was difficult to achieve the uniform dose distributions by the previous scanning methods. The reason was errata during the slow scanning speed. Two new treatment rooms with the scanning system have been constructed at HIMAC [18,19]. The key-technology is the fast multi-repaint scanning to equalize errata. In addition, an algorithm has been developed to take account of biological effectiveness for the new irradiation method[20]. The clinical trial for the still organs like prostate and head-and-neck started since 2011. After the careful verification, the clinical trial for the moving organs will start in 2014.

Another frontier of the development is the C-RT rotating gantry. In X-RT and p-RT, the flexibility of the irradiation direction is usually realized by the rotating gantry. However the C-RT gantry become huge and is still not suitable for the hospital specified facility. The development of the compact C-RT gantry system with the superconducting-magnets technology is now in progress at HIMAC[21]. The construction of an additional treatment room will be finished in 2016. We expect to report the result soon.

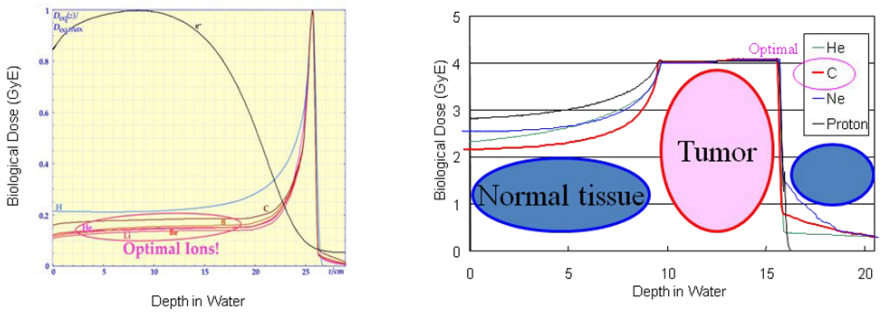

Figure 1. Biological depth-dose distributions of a single Bragg peak with a depth of 26cm (a, presented by A. Brahme in private communication), and 6cm Spread-Out Bragg Peak with a depth of 16cm (b).

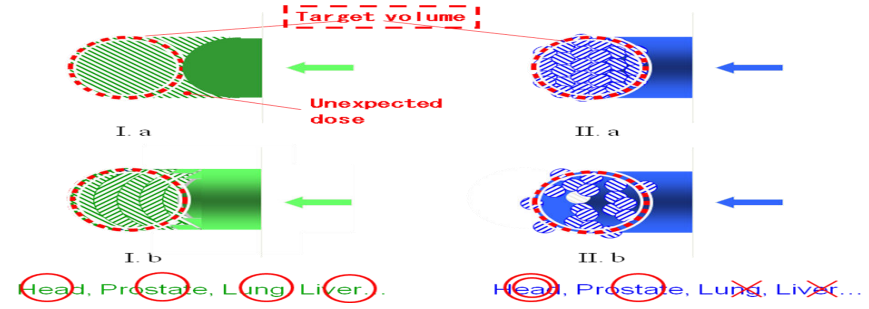

Figure 2. Summary of irradiation methods. I. a Wobbler method. I.b Layer-stacking wobbler method. II.a Pencil-beam scanning method. II.b Pencil-beam scanning method without respiratory gate.

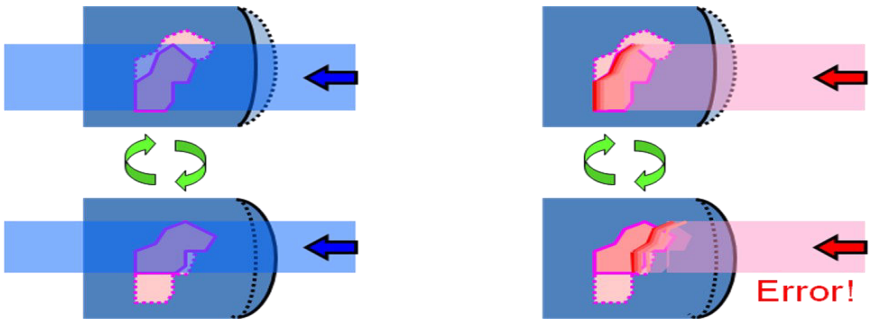

Figure 3. Moving organs due to the respiration. (a) Irradiation by X-rays with the usual external-beam radiotherapy with an electron linac. (b) Irradiation by proton or heavy ions without considerations of the distortion and the density varying.

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Travel Grant Awardee report for Attending 13th AOCMP & 11th SEACOMP Congresses , Singapore 12-14 December 2013

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It is a great pleasure of me to wish my acknowledgement to the travel fund from Asia-Oceania Federation of Organizations for Medical Physics to enable me to attend the 13th AOCMP & 11th SEACOMP Congresses in Singapore from 12 to 14 December 2013.The congress consisted of plenary lectures, keynote addresses, proffered papers and poster presentations.

The meeting began with pre-congress lectures by two distinguished medical physicists; Tomas Kron (PhD) and Raymond K. Wu (PhD) about "Implementing Stereotactic Body Radiotherapy for Physicists, The challenges and issues" and "Stereotactic Radiotherapy using Cyber knife" respectively. In addition to these sessions, Arun Chougule (PhD) was presented "Radiobiology for Medical Physicist" to general audiences of which is fundamental subject in Medical Physics field. In the afternoon sessions, the meeting was continued with series of lectures namely "Radiotherapy Incidents", "NCRP 151-IAEA 1223 Radiotherapy shielding", "Adaptive Radiotherapy" and " 3D Brachytherapy" as a platform for the participants to refresh the basic knowledge among the topics of the lectures given. In honor of the late Prof. John Cameron, the inaugural John Cameron Lecture was delivered by David Townsend, a Professor of Medicine, University of Tennessee. His lecture was titled "From Evolution to Revolution-Multi Modality Imaging Comes of Age". This is followed with various presentation from other faculty members with topics such as "Motion management in radiotherapy: from imaging to treatment, A Role for Molecular Imaging in Therapy Planning, Medical Physics Education and IAEA Special Project in Asia-Oceania, History of Medical Physics in Asia -Oceania, IAEA Lecture: The Important Role of the Medical Physicist in the Clinic, Digital Imaging: Working towards Best Practices, Past, Present and Future of Computer Assisted Radiology and Surgery" and lastly "PET and CT in Cancer management: A match made in heaven" In the first and second day of the congress. In addition to these sessions, oral presentations of interest and poster were arranged concurrently. About 35 proffered papers with 8 minute each were selected on the basis of their significance and timeliness and session chairs within each subject area.

My work was chosen for an oral presentation and that was quite an experience. I believe that medical physicists or postgraduate students should attend and present their work to treasure their routine works and the research in the field of medical physics meaningfully. It is probably worth attempting to take opportunities the excellent facilities and supports within the faculty members to approach some relevant issues especially in the latest technology of radiotherapy. Moreover, more developments such as advancements in radiation treatment technology, safety protocols and workflow improvements were the key topics discussed during the 3 days congress which offering a new treatment options and hope to patients with even the most complex tumors. The major components in adaptive radiotherapy which incorporated into IMRT planning using highly skilled of dose delivering such as image-guided stereotactic techniques is the utmost challenging part. The main thing I learned from this congress was about the importance of basic knowledge of each component and consolidates it to have successful outcomes. One of the useful sessions I attended was SABR or Stereotactic Ablative Body Radiotherapy. The speaker helps the participant to figure out answers to the SABR. The participant can learn to engage and focus on the technological features required and explore the clinical scenarios and challenges in commencing the SABR programme. Although the dose escalation of ablative dose remain elusive, the application for SABR is effective non-invasive treatment modality with low toxicity in patients with small inoperable of some types of metastases.

Following are the summary of a few lectures that I have attended which interest me the most.

Radiotherapy incidents by Brendan Healy

Incident reporting schemes are divided into two; mandatory and voluntary schemes. As the accidents and incidents still tend to repeat therefore we need be better at learning from previous learning. An event reporting plays important role in to identifying system design flaws and critical steps in radiotherapy processes. It also helps in spreading the knowledge on new risk and at the same time promoting safety culture and the awareness among the workers. It is required for the events to be reported in two ways;mandatory

and voluntary reporting systems. Mandatory reporting system should trigger an investigation and the release of information should occur only after incident has been investigated thoroughly. The reporting information should be accurate and verified. Voluntary reporting system however, should include unintended errors that results in little or no harm to patients. The report should be disseminated where the learning component can be delivered effectively.

Stereotactic Ablative Body Radiation Therapy by Tomas Kron

Stereotactic body radiation therapy is a targeted cancer treatment uses advanced technology to deliver a potent ablative dose that highly focused and accurate radiation to deep-seated tumors such as in the lung, liver, spine, pancreas, kidney and prostate. The presentations were based to the practice at Peter Mac Callum Cancer Centre and the experiences of the speaker himself. The objectives of the presentations were to introduce and explore the clinical scenarios and challenges in commencing the SABR programme. Most of the cases in stereotactic procedures involve the brain lesions however the technique is also applied to extra cranial lesions in the body.

The general features in delivering SABR are the tumor should be a small lesions with margins set up and motion margin ITV. The radical treatment includes non-operable patients, lung, liver, renal, pancreas and palliative treatments are bone pain and oligo metastases.

SBRT is characterized by the following essential components such as:

- Thickness and the resolution of the MLC. These are useful for irregular lesions to avoid the tolerance doses of the surrounding normal tissue.
- The immobilization is essentially used during the processes to avoid patient movement. Accurate repositioning of the patient for proper accounting of internal organ motion including breathing motion consistently which requires the lesions to be defined as Internal Target Volume or mid breathing position to assess in planning. To generate the ITV, It is based on the maximum intensity projection (MIP) image set derived from 4D CT. However these images cannot be used for dose calculation. SABR also requires the access to PET and MR for the fusion of the images which affect the ability of target definition and the critical structures contouring.
- The dose dosimetry distributions that conform to tumors volume in relation to the prescription isodose line but may allow very heterogeneous target dose ranges. In a feasibility of this technique, IMRT or VMAT is taking into considerations especially for the concave tumors
- Registration of the patient's anatomy for treatment delivery to a 3D coordinate system are based on fiducial markers. It can be positioned to correlate both to the tumor target and the treatment delivery device.
- Dose prescriptions using a few (i. e, 1-5) fractions of very high dose. AAPM SBRT Task Group (2006) has recommended the number of fractionation of less than 5 with dose per fraction more than 5 Gy. In related consideration, Peter Mac Callum is using conformity index of CI100 (Vprescribed /PTV) and CI50 (V50%dose/PTV) as a guide to optimize the proton plan.

The above characterizations should be followed thoroughly to avoid accident/incidents related to SABR. In most patients, the side effects found are posterior lesions, build-up immobilization and the overlap of radiation beams originated from fields divergence.

Brachytherapy; Past, present and future. Moving from 2D to 3D planning by Arun Chougule

Brachytherapy is one of the oldest form of radiation therapy that treated with radioactive source. The background of the brachytherapy was detailed explained. The presentation focuses on the background and brachytherapy application procedures, brachytherapy planning options and associated simulation procedures. Information will include the utilization of the types of brachytherapy applicator for various types of brachytherapy procedures such as bronchus implants, MammoSite and seed implants which presented and are designed to assist the attendee in applying the information in the clinical setting.

Physics of Proton Beam Therapy by Shigekazu Fukuda

The presentation was also focused on the proton facilities, accelerator system, irradiation methods and associated simulation procedures used to deliver the proton treatment. Proton beam radiation therapy is a type of high-energy, external radiation therapy that targets tumors with streams of protons (small, positively charged particles). There are 36 proton therapy centers and 6 carbon ion therapy (PTCOG 2012) facilities running in world wide.

Protons are directly ionizing radiation that uses Bragg Peak as a principle of particle beam interaction. Protons are large particles with a positive charge that penetrate matter (in this case, tissue) to a limited depth, based on the energy of the beam, and deposit most of their energy at the end of the beam. The particles have an ability to enter the patient with high velocity and a very short interaction time on the entrance side of the body and travel straight through and exiting out on the tumors with slow velocity and long of interaction time. In turn, the Bragg Peak principle resulting in superior to tumors localization with lower entrance dose and the absence of exit dose which make its optimal for used in deep-seated tumors. This ability to spare healthy tissue is the main difference between x-rays and protons. Research has shown that the biologic effect, or the damage to exposed tissues, is essentially the same for both therapies. This means the therapies will destroy tumor cells in the same manner, but protons should result in less toxicity to healthy tissues.

The flow patient procedure involves the immobilization of the patients and transported through the treatment process which includes the imaging and gantry equipment. This processes are done following to CT scanning of the patient prior each treatment. The patient is imaged to ensure precise delivery of radiation landmarks are placed to aid in the correct delivery of radiation beams. The target delineation and calculation of dose helps to obtain the desirable dose distribution of the patient.

Compensators made of polyethylene were ordered to be fabricated and collimator was designed to adjust the beam ranges to the shapes of distal edges of the target for all beam ports. The shape of the delivered bolus was verified for acceptance using a coordinate measuring machine.

Before irradiation, a rehearsal was carried out for the patient in the irradiation room or the CT simulation room. Image guidance is used to verify the patient setup. At the rehearsal, patient registration was done and compare the digital radiographs with digitally reconstructed radiographs allows correction of the patient positioning relative to the treatment planning position. The coincidence of x ray field and the corresponding proton field guarantees that the patient setup is correct for dose delivery. Finally the patients receive radiation from multiple beam angles for 15 to 25 minute per session.

Yimin Hu

Yimin Hu was the leading pioneer of medical physics in China and is now acknowledged as one of the profession's most significant contributors. Today, after a career spanning almost 50 years, Yimin Hu has earned the reputation as the father of medical radiation physics in China.

Yimin Hu is the chair professor at the Cancer Institute & Hospital, Chinese Academy Medical Science and Peking Union Medical College. He is chairman of CSMP, president of AFOMP, the AC member of IUPESM and a council member of IOMP. He is a visiting professor at Tsinghua University and University of Science and Technology of China.

Professor Hu has been engaged in both clinical practice and research in medical radiation physics, specializing in radiation oncology physics in China. He designed and supervised the manufacture of the first manual-controlled multi-leaf-collimators for Co-60 unit and for Betatron electron beams in 1960s. In the1970s he established China's first clinical dosimetry system and proposed "four dosimetric principles" of guiding the treatment planning for radiation oncologist and radiation physicist. Since 1980s, he has focused on establishing and promoting quality assurance and quality control programs as well as the adoption of contemporary techniques. In the early 1990s he pioneered linac-based X-ray stereotactic irradiation using implanted gold-markers for image guiding. He designed the CREAT X-ray Stereotactic System including associated treatment planning system. He also designed planning software for the first generation China-made rotational γ- knife.

Professor Hu was appointed as the chair in medical physics in China and has trained numerous students, many of whom later became leaders in their respective clinics world-wide. Since 1980s he has been pursuing the exchange ideas and innovations in the field by developing medical radiation physicist joint training, academic exchange programs and by chairing multiple national and international conferences. He is the chief editor of various textbooks, "Radiation Oncology Physics", "Radiation Oncology Technology", "Radiation Therapy Treatment Planning" and is the co-editor in chief of "Radiation Oncology" as well as the associated editor of various international journals.

Currently Professor Hu is focusing on completing the next generation of IMRT system, which features three heads delivering three cross-firing-beams. This design integrates the clinical functions of various existing systems: C-arm based Linear Accelerators, TomoTherapy unit, X-ray SRS/SBRT systems, Elekta γ-knife, Cyber knife and Vero unit. This system is capable of doing coplanar and non-coplanar real-time imaging- and dose-guided IMRT/SBRT.

Professor Hu has had enormous influence on the development of radiation physics in China, and on the global physics community as well, that encourages not only sound clinical practices and the adoption of modern techniques, but also ensures that his passion is passed down to a new generation of professionals.

Know Your Secretary

Howell Round

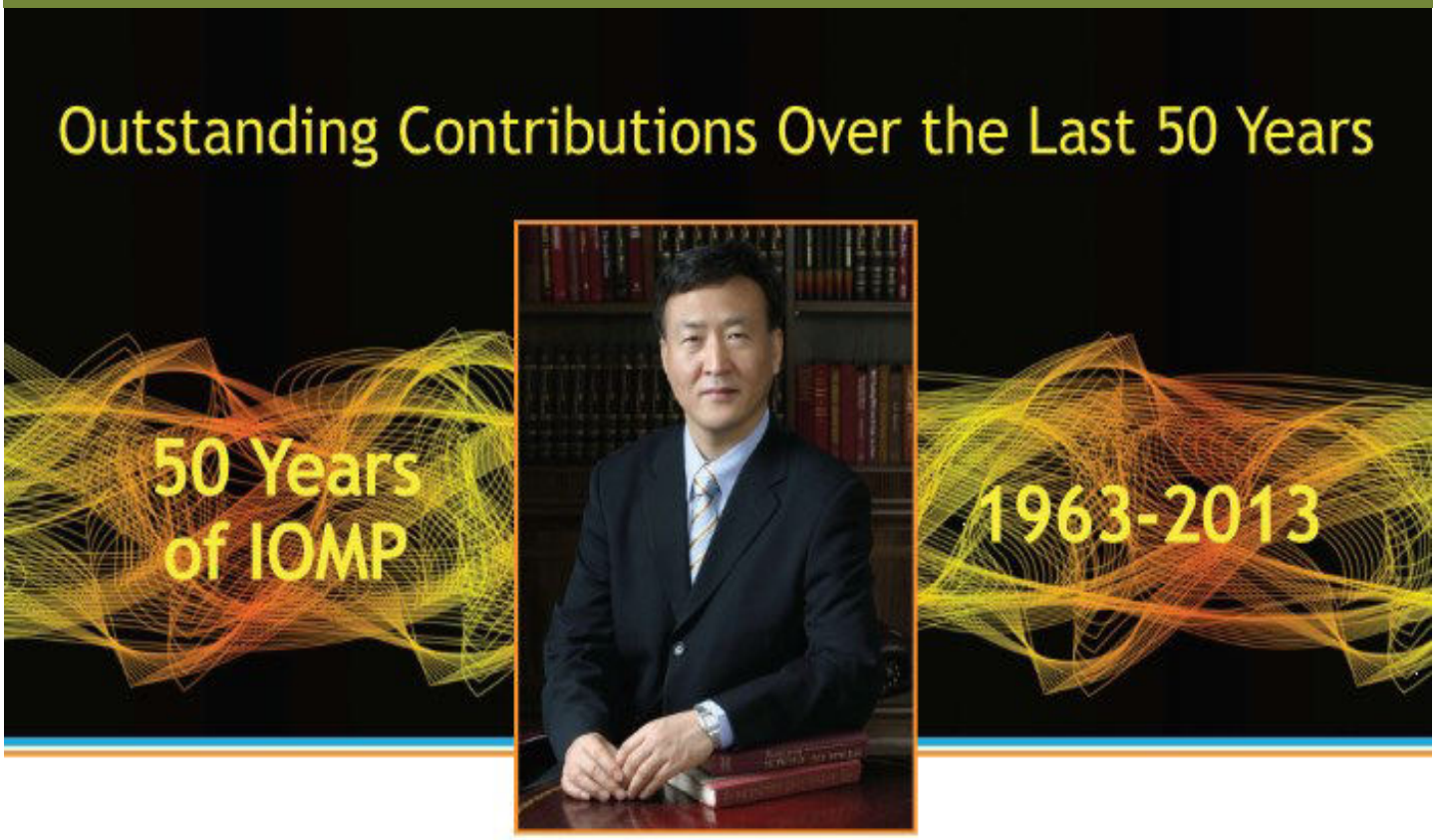
Howell Round is an associate professor in the School of Engineering at the University of Waikato in New Zealand. He originally did a BSc(Tech) degree in physics at the University of Waikato. As part of the degree program he spent several months working with the physicists at the local hospital. Having decided on a career in medical physics he did an MSc in medical physics at the University of Surrey, UK, and later a PhD in engineering on a medical ultrasound project at the University of Canterbury, New Zealand.

After a few years as a clinical physicist, he embarked on an academic career returning to the Physics Department at the University of Waikato. He headed the Department for seven years in the 1990s, after which he developed his interests in medical physics education, professional matters, workforce issues and medical physicist certification. As part of this, he co-developed with John Drew the Australasian College of Physical Scientists and Engineers in Medicine's (ACPSEM) Training, Education and Accreditation Program for training clinical medical physicists. He has also chaired the AFOMP Professional Development Committee and led the development of AFOMP's Policies 2 – 4, and is currently its Secretary General.

He has held many positions in medical physics professional societies and has served on several committees of the IOMP, AFOMP and ACPSEM. He was president of the ACSPEM from 2006 – 2007 and now chairs its Professional Standards Board. In 2010 he was presented with the Distinguished Service Award of the ACPSEM.

He is a Fellow of the New Zealand Institute of Physics, a Fellow of the ACPSEM and a Fellow of the Institution of Professional Engineers of New Zealand.

From a personal point of view, he is married to a radiation oncologist (Glenys) and has two sons: Gareth (a lawyer) and Mitchell (an architect). In his free time he enjoys restoring classic British sports cars such as his Caterham Super Seven in the photograph.



Tae Suk Suh

Dr. Tae Suk Suh, Professor of Medical Physics at the Catholic University of Korea is known for his work with his colleagues on the development of radiotherapy planning, multi-modality imaging, and, in particular, the radiosurgery system.

Tae Suk Suh contributed greatly towards the development at University of Florida radiosurgery system using unique bearing system as one of US Teams during 1987-1992.

Professor Suh's career has spanned more than 30 years, a period which has witnessed huge advances in radiosurgery hardware and planning systems. He has contributed greatly towards the development of radiosurgery optimization techniques; and in 1998 at Kangnam St.Mary's hospital in Seoul, he was the first to undertake flattening filter free (FFF) beam-based radiosurgery in a clinical setting. He also pioneered many other technologies, including the development of the radiation treatment planning system and 3T active shield magnetic resonance imaging.

Having established his academic career in Korea, Professor Suh has served as an editor and editorial board member for many international journals of medical physics. During his leadership of the Korean Society of Medical Physics, he was well appreciated for his many contributions, including his promotion of medical physics in the Asia-Oceania region, and he organized the World Congress on Medical Physics and Biomedical Engineering in 2006 (WC 2006, Seoul) and the Asia-Oceania Congress of Medical Physics three times in Asia (AOCMP 2002, 2006, 2012).

In 2001, the Korean Ministry of Science and Technology acknowledged Professor Suh's Radiation Biomedical Engineering Laboratory (RBEL) at the Catholic University of Korea as a National Research Laboratory. In 2009 the RBE Laboratory and Molecular Imaging Program at Stanford jointly established the Advanced Research Center for Medical Physics, as a center for international research. In 2006 and again in 2012, Professor Suh was honored with the Korean Government's Award for the Best Academic Achievement.

Tae Suk Suh organized the WC 2006 in Seoul, Korea, in 2006. (Opening ceremony)

Calendar of Events

July 2014	20-24 July 2014 **AAPM 56th Annual Meeting, Austin, TX USA** American Association of Physicists in Medicine, http://www.aapm.org/meetings/
August 2014	20 - 22 August 2014 **2nd International Conference on Medical Physics in Radiation Oncology and Imaging (ICMPROI-2014)** Dhaka, Bangladesh , mail:- rupama_5@hotmail.com , http://bmps-bd.org/icmproi2014/
September 2014	07-10 September 2014 **Joint Conference of SGSMP,DGMP and OGMP,** Zurich, Switzerland ,http://www.medphys-kongress.de/ 11-13 September 2014 **8th European conference on Medical Physics (ECMP),** Athens, Greece, Hosted by the Hellenic Association of Mecical Physics (HAMP) together with the European Federtion of Organizations for Medical Physics (EFOMP) , http://www.efomp-2014.gr/
October 2014	**23– 25 October 2014** **14th Asia-Oceania Congress of Medical Physics (AOCMP) and the 12th South East Asia Congress of Medical Physics (SEACOMP) ,** Hochiminh City, Vietnam Asia Oceana Federation of Medical Physics [AFOMP],www.afomp.org
November 2014	20– 22 November, 2014 **AMPICON2014, *35th Annual conference* of Association of Medical Physicists of India** www.ampi.org.in 30Nov-5Dec2014 **RSNAA nnualMeeting**, Chicago USA Radiological Society of North America, http://rsna.org/Annual_Meeting.aspx
February 2015	20-23 rd February 2015 International conference on Medical Physics, Radiation Protection and Radiobiology **"ICMPRPR 2K15"** and Annual Conference of Association of Medical physicists of India–Northern Chapter— **"AMPI-NC-CON 2015** " SMS Medical College, Jaipur, India www.ampi-nc.org icmprpr2k15@gmail.com

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