My Journey and Challenges in becoming a Medical Radiation Physicist

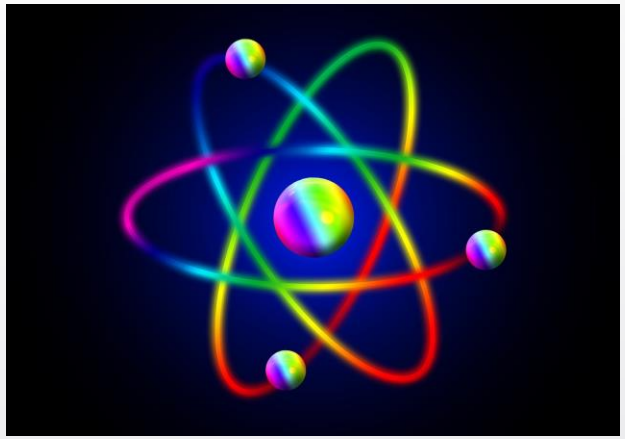
By

Dr. Summer R. (Chaudhari) Ahmad, Ph.D.

9th Annual Qur'an and Science Symposium

OVERVIEW

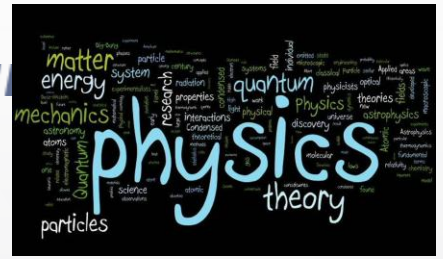
- Introduction
- What is Medical Radiation Physics?
- Training
- Quran and Research
- Challenges



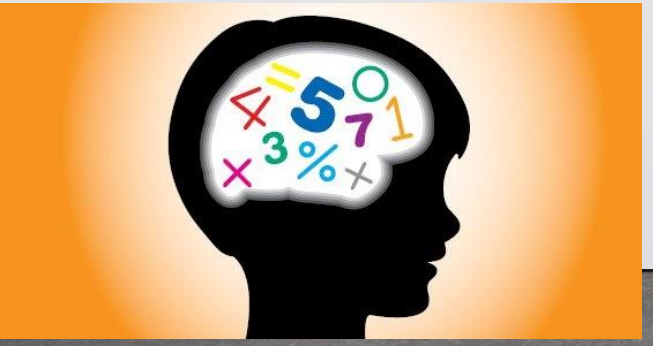
MY CAREER TIMELINE

- 2002: BS (Cum Laude with Honors) in Biochemistry from the University of Missouri-Columbia
- 2008: PhD (MS, 2005) in Medical Radiation Physics, Rosalind Franklin University of Medicine and Science, North Chicago, IL
- 2005-2008: Dissertation work Washington University in St. Louis School of Medicine
- 2008-2010: Medical Physics Residency Training Program, University of Minnesota Medical School, Department of Radiation Oncology , Masonic Cancer Center
- 2010: Faculty: Assistant Professor, University of MN Physicians, clinic and teaching
- June 2011: Married and moved to Broad Brook, CT. Northampton, MA (Cooley Dickenson Hospital) as a solo clinical Medical Radiation Physicist in the Department of Radiation Oncology
- January 2015 : Began working remotely as a medical physicist for Crux Quality Solutions

REQUIREMENTS FOR ADMISSION



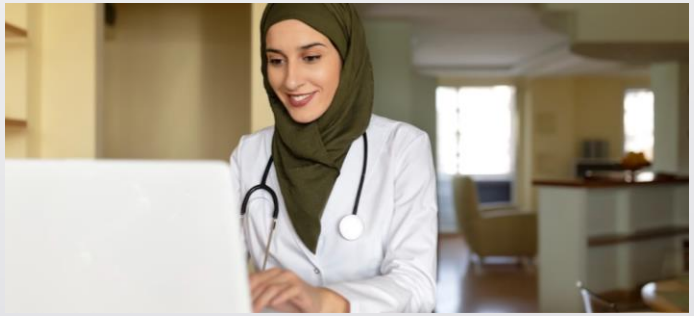
- A strong foundation in physics and mathematics is essential for graduate study in Medical Physics.
- Students applying to a Graduate Program in Medical Physics are expected to have completed an undergraduate degree in physics or a degree in another physical science or engineering discipline with coursework equivalent to that required for a minor in physics and proficiency in mathematics.



What does a medical radiation physicist do?

- A medical radiation physicist **studies the use of radiation for medical purposes.**

- A few aspects of the broad range of our work includes:
  - Working within the health care industry to maintain proper operation and calibration of radiation equipment (external beam delivery systems such as linear accelerators, treatment planning computers, etc.)
  - Ensuring that the equipment delivers the appropriate amount of radiation to patients.
  - Teaching
  - Research



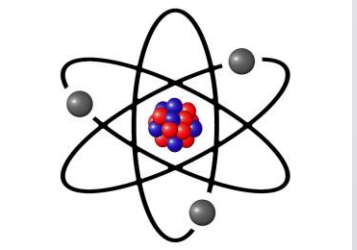
- Medical Physics includes areas such as:

  Radiotherapy physics

  Diagnostic Radiology physics

  Nuclear Medicine Physics

  Radiation Protection



SOME OF MY RESEARCH WORK

Phys Med Biol. 2009 Apr 21;54(8):2315-22. doi: 10.1088/0031-9155/54/8/004. Epub 2009 Mar 20.

The validation of tomotherapy dose calculations in low-density lung media

Summer R Chaudhari [1], Olga L Pechenaya, S Murty Goddu, Sasa Mutic, Dharanipathy Rangaraj, Jeffrey D Bradley, Daniel Low

Affiliations + expand

PMID: 19305040 DOI: 10.1088/0031-9155/54/8/004

Abstract

The dose-calculation accuracy of the tomotherapy Hi-Art II(R) (Tomotherapy, Inc., Madison, WI) treatment planning system (TPS) in the presence of low-density lung media was investigated. In this evaluation, a custom-designed heterogeneous phantom mimicking the mediastinum geometry was used. Gammex LN300 and balsa wood were selected as two lung-equivalent materials with different densities. Film analysis and ionization chamber measurements were performed. Treatment plans for esophageal cancers were used in the evaluation. The agreement between the dose calculated by the TPS and the dose measured via ionization chambers was, in most cases, within 0.8%. Gamma analysis using 3% and 3 mm criteria for radiochromic film dosimetry showed that 98% and 95% of the measured dose distribution had passing gamma values < or =1 for LN300 and balsa wood, respectively. For a homogeneous water-equivale test. It was found that for the interface between

Phys Med Biol. 2009 Oct 7;54(19):5663-74. doi: 10.1088/0031-9155/54/19/001. Epub 2009 Sep 1.

Enhanced efficiency in helical tomotherapy quality assurance using a custom-designed water-equivalent phantom

S Murty Goddu [1], Sasa Mutic, Olga L Pechenaya, Summer R Chaudhari, Jose Garcia-Ramirez, Dharanipathy Rangaraj, Eric E Klein, Deshan Yang, James Grigsby, Daniel A Low

Affiliations + expand

PMID: 19724101 DOI: 10.1088/0031-9155/54/19/001

Abstract

Tomotherapy is an image-guided, intensity-modulated radiation therapy system that delivers highly conformal dose distributions in a helical fashion. This system is also capable of acquiring megavoltage computed-tomography images and registering them to the planning kVCT images for accurate target localization. Quality assurance (QA) of this device is time intensive, but can be expedited by improved QA tools and procedures. A custom-designed phantom was fabricated to improve the efficiency of daily QA of our Tomotherapy machine. The phantom incorporates ionization chamber measurement points, plugs of different densities and slide-out film cartridges. The QA procedure was designed to verify in less than 30 min the vital components of the tomotherapy system: static beam quality and output, image quality, correctness of image registration and energy of the helical dose delivery. Machine output, percent depth dose and off-axis factors are simultaneously evaluated using a static 5

Phys Med Biol. 2009 Apr 21;54(8):2541-55. doi: 10.1088/0031-9155/54/8/019. Epub 2009 Apr 6.

Dosimetric variances anticipated from breathing-induced tumor motion during tomotherapy treatment delivery

S R Chaudhari [1], S M Goddu, D Rangaraj, O L Pechenaya, W Lu, E Kintzel, K Malinowski, P J Parikh, J D Bradley, D A Low

Affiliations + expand

PMID: 19349658 DOI: 10.1088/0031-9155/54/8/019

Abstract

In their classic paper, Yu et al (1998 Phys. Med. Biol. 43 91) investigated the interplay between tumor motion caused by breathing and dynamically collimated, intensity-modulated radiation delivery. The paper's analytic model assumed an idealized, sinusoidal pattern of motion. In this work, we investigate the effect of tumor motion based on patients' breathing patterns for typical tomotherapy treatments with field widths of 1.0 and 2.5 cm. The measured breathing patterns of 52 lung- and upper-abdominal-cancer patients were used to model a one-dimensional motion. A convolution of the measured beam-dose profiles with the motion model was used to compute the dose-distribution errors, and the positive and negative dose errors were recorded for each simulation. The dose errors increased with increasing motion magnitude, until the motion was similar in magnitude to the field width. For the 1.0 cm and 2.5 cm field widths, the maximum dose-error magnitude exceeded 10% in some simulations, even with breathing-motion magnitudes as small as 5 mm and 10 mm, respectively. Dose errors also increased slightly with increasing couch speed. We propose that the errors were due to subtle drifts in the amplitude and frequency of breathing motion, as well as changes in baseline (exhalation) position, causing both over- and under-dosing of the target. The results of this study highlight potential breathing-motion-induced dose delivery errors in tomotherapy. However, for conventionally fractionated treatments, the dose delivery errors may not be co-located and may average out over many fractions, although this may not be true for hypofractionated treatments.

Int J Radiat Oncol Biol Phys. 2008 Aug 1;71(5):1511-7. doi: 10.1016/j.ijrobp.2008.03.070. Epub 2008 Jun 4.

Estimation of setup uncertainty using planar and MVCT imaging for gynecologic malignancies

Lakshmi Santanam [1], Jacqueline Esthappan, Sasa Mutic, Eric E Klein, S Murty Goddu, Summer Chaudhari, Sasha Wahab, Issam M El Naqa, Daniel A Low, Perry W Grigsby

Affiliations + expand

PMID: 18538499 DOI: 10.1016/j.ijrobp.2008.03.070

Abstract

Purpose: This prospective study investigates gynecologic malignancy online treatment setup error corrections using planar kilovoltage/megavoltage (KV/MV) imaging and helical MV computed tomography (MVCT) imaging.

Methods and materials: Twenty patients were divided into two groups. The first group (10 patients) was imaged and treated using a conventional linear accelerator (LINAC) with image-guidance capabilities, whereas the second group (10 patients) was treated using tomotherapy with MVCT capabilities. Patients treated on the LINAC underwent planar KV and portal MV imaging and a two-dimensional image registration algorithm was used to match these images to digitally reconstructed radiographs (DRRs). Patients that were treated using tomotherapy underwent MVCT imaging, and a three-dimensional image registration algorithm was used to match planning CT to MVCT images.

Dev Dyn. 2003 Nov;228(3):451-63. doi: 10.1002/dvdy.10429.

Neurogenic phenotype of mind bomb mutants leads to severe patterning defects in the zebrafish hindbrain

Stephanie Bingham [1], Summer Chaudhari, Gary Vanderlaan, Motoyuki Itoh, Ajay Chitnis, Anand Chandrasekhar

Affiliations + expand

PMID: 14579383 PMCID: PMC2219915 DOI: 10.1002/dvdy.10429

Free PMC article

Abstract

Failure of Notch signaling in zebrafish mind bomb (mib) mutants results in a neurogenic phenotype where an overproduction of early differentiating neurons is accompanied by the loss of later-differentiating cell types. We have characterized in detail the hindbrain phenotype of mib mutants. Hindbrain branchiomotor neurons (BMNs) are reduced in number but not missing in mib mutants. In addition, BMN clusters are frequently fused across the midline in mutants. Mosaic analysis indicates that the BMN patterning and fusion defects in the mib hindbrain arise non-cell autonomously. Ventral midline signaling is defective in the mutant hindbrain, in part due to the differentiation of some midline cells into neural cells. Interestingly, while early hindbrain patterning appears normal in mib mutants, subsequent rhombomere-specific gene expression is completely lost. The defects in ventral

Clinical Trial > Int J Radiat Oncol Biol Phys. 2008 Nov 15;72(4):1134-9.
doi: 10.1016/j.ijrobp.2008.02.063. Epub 2008 May 9.

Prospective clinical trial of positron emission tomography/computed tomography image-guide intensity-modulated radiation therapy for cervica carcinoma with positive para-aortic lymph nodes

Jacqueline Esthappan [1], Summer Chaudhari, Lakshmi Santanam, Sasa Mutic, Jeffrey Olsen, Dusten M Macdonald, Daniel A Low, Anurag K Singh, Perry W Grigsby

Affiliations + expand

PMID: 18472358 DOI: 10.1016/j.ijrobp.2008.02.063

Abstract

Purpose: To describe a more aggressive treatment technique allowing dose escalation to posit para-aortic lymph nodes (PALN) in patients with cervical cancer, by means of positron emissio tomography (PET)/computed tomography (CT)-guided intensity-modulated radiation therapy Here, we describe methods for simulation and planning of these treatments and provide objec for target coverage as well as normal tissue sparing to guide treatment plan evaluation.

Methods and materials: Patients underwent simulation on a PET/CT scanner. Treatment plans generated to deliver 60.0 Gy to the PET-positive PALN and 50.0 Gy to the PALN and pelvic lym

Radiother Oncol. 2009 Oct;93(1):64-70. doi: 10.1016/j.radonc.2009.07.013. Epub 2009 Sep 3.

Dosimetric consequences of uncorrected setup errors in helical Tomotherapy treatments of breast-cancer patients

S Murty Goddu [1], Sridhar Yaddanapudi, Olga L Pechenaya, Summer R Chaudhari, Eric E Klein, Divya Khullar, Issam El Naqa, Sasa Mutic, Sasha Wahab, Lakshmi Santanam, Imran Zoberi, Daniel A Low

Affiliations + expand

PMID: 19733408 DOI: 10.1016/j.radonc.2009.07.013

Abstract

Background and purpose: The Tomotherapy Hi-Art II system allows acquisition of pre-treatment MVCT images to correct patient position. This work evaluates the dosimetric impact of uncorrected setup errors in breast-cancer radiation therapy.

Materials and methods: Breast-cancer patient-positioning errors were simulated by shifting the patient computed-tomography (CT) dataset relative to the planned photon fluence and re-computi the dose distributions. To properly evaluate the superficial region, film measurements were compar against the Tomotherapy treatment planning system (TPS) calculations. A simulation of the integrat dose distribution was performed to evaluate the setup error impact over the course of treatment.

Med Phys. 2009 Feb;36(2):329-38. doi: 10.1118/1.3049594.

Deformable registration of abdominal kilovoltage treatment planning CT and tomotherapy daily megavoltage CT for treatment adaptation

Deshan Yang [1], Summer R Chaudhari, S Murty Goddu, David Pratt, Divya Khullar, Joseph O Deasy, Issam El Naqa

Affiliations + expand

PMID: 19291972 PMCID: PMC5148039 DOI: 10.1118/1.3049594

Free PMC article

Abstract

In adaptive radiation therapy the treatment planning kilovoltage CT (kVCT) images need to be registered with daily CT images. Daily megavoltage CT (MVCT) images are generally noisier than the kVCT images. In addition, in the abdomen, low image contrast, differences in bladder filling, differences in bowel, and rectum filling degrade image usefulness and make deformable image

DOI: 10.1016/j.ijrobp.2008.11.004 • Corpus ID: 21609714

Helical tomotherapy planning for left-sided breast cancer patients with positive lymph nodes: comparison to conventional multiport breast technique.

S. Goddu, S. Chaudhari, +7 authors D. Low • Published 15 March 2009 • Medicine, Physics • International Journal of radiation oncology, biology, physics

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Effect of dose prescription and block margin on small field treatment planning

Published online by Cambridge University Press: **23 November 2011**

Summer R. Chaudhari, Margaret Reynolds and Patrick D. Higgins

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Abstract

Background and purpose: We evaluated the effect of block margin on small fields when point dose prescription (ICRU) or isodose line prescription (RTOG) formats are used.

Material and methods: A total of 11 clinical SBRT cases, one 4-field prostate case and 2 phantom cases using 0, 0.5 or 1 cm block margins were analysed. Integral dose and target coverage were compared using DVHs and isodose volumes for either isodose line prescription (100% Rx dose to 95% PTV volume) or isocenter point prescription (100% Rx dose to the isocenter) were calculated.

MULAQAT WITH BELOVED HUZOOR (ABA)

- Family Mulaqat with Huzoor (aba) in Zion, IL, Fateh-e-Azeem Masjid
- I asked Beloved Huzoor, *"As the theme is 100 Abdus Salaams, can you please tell me how women can also reach the highest levels of excellence despite the significant sacrifices that might be needed with regards to children and family life?"*
- Huzoor (aba) asked me what my degree is
- Beloved Huzoor (aba) said, *"So why not, why can't you do all that, if you have already come this far, then why not?"*
- *I think it is a very positive and encouraging message from beloved Huzoor (aba) encouraging women to excel in academics. This message encourages us all to strive harder in our prayers, studies and work towards academic excellence.*

INSPIRATION: *DR. MOHAMMAD ABDUS SALAAM*

- **Awarded the 1979 Nobel Prize along with Steven Weinberg and Sheldon Glashow**
    - ***they realized that weak nuclear forces and electromagnetic forces were components of the same force, termed the electroweak force.***
- **He spoke of his faith in his banquet speech**
- **He was passionate about promoting science in developing countries**
- **He donated all the money he received from his Nobel Prize to setting up a fund in Pakistan to promote educational opportunities.**
- **He recalled there had once been a golden age of Islamic science, when for hundreds of years Islamic scientists had led the world. He urged Muslims to regain the spirit of free enquiry that existed in those times.**

Dr. Salaam retired from his chair at Imperial College in 1994, age 68. Abdus Salam died peacefully, age 70, at home in Oxford on November 21, 1996. He was buried four days later in the Ahmadi city of Rabwah, Pakistan. Pakistan's Nobel prize winner's gravestone defaced in Rabwah.

The Abdus Salam International Centre for Theoretical Physics

THE HOLY QUR'AN: A TRUE SOURCE OF GUIDANCE

LET'S KEEP THE TORCH BURNING

- Seven hundred and fifty verses of the Quran (almost one-eighth of the Book) exhort believers to study Nature, to reflect, to make the best use of reason in their search for the ultimate, and to make the acquiring of knowledge and scientific comprehension a part of the community's life.
- The Holy Prophet of Islam (saw) emphasized that the quest for knowledge in sciences is obligatory upon *every* Muslim, man and woman.

- Hazrat Abu Huraira, may Allah be pleased with him, narrates:
  I heard the Prophet of Allah(saw) say:
  The word of wisdom is the lost property of a Muslim, so that, wherever he finds it, he should take it, as he is most entitled to it. (Tirmidhi)

THE HOLY QUR'AN AND SCIENCE

- "Can they not look up to the clouds, how they are created; and to the Heaven how it is upraised; and the mountains how they are rooted, and to the earth how it is outspread?" (88:17)
- "Verily in the creation of the Heavens and of the earth, and in the alternation of the night and of the day, are there signs for men of understanding. They who, standing, sitting or reclining, bear Allah in mind and reflect on the creation of the Heavens and of the earth, saying: '*Oh our Lord! Thou has not created this in vain.*'" (3:189-190).
- The Quran emphasizes the superiority of the alim-the man possessed of knowledge and insight, asking: *How can those, not possessing these attributes, ever be equals of those who do?* (39:10)

GOALS AND CHALLENGES

- Remain attached to faith, prayers, Holy Qur'an, Islamic way of life
- Determined to use my training to make the world around me a better place
- Want to make progress in field of specialization
- Keep Huzoor's (a.b.a.) desire to produce the best scientists, Nobel Laureates in Jamaat in view at all times
- Stay involved in kids' lives, school volunteer activities, etc.
- Kids' homework, encourage them to set high standards
- Extracurricular activities (after school, weekends)
- *Time management*

JazakhAllah!!!