Patient Positioning Symposium™

advanced education in patient positioning

Sixth Annual Patient Positioning Symposium

March 27-29, 2014

Disney's Yacht Club Resort

Lake Buena Vista, Florida

Supported by:

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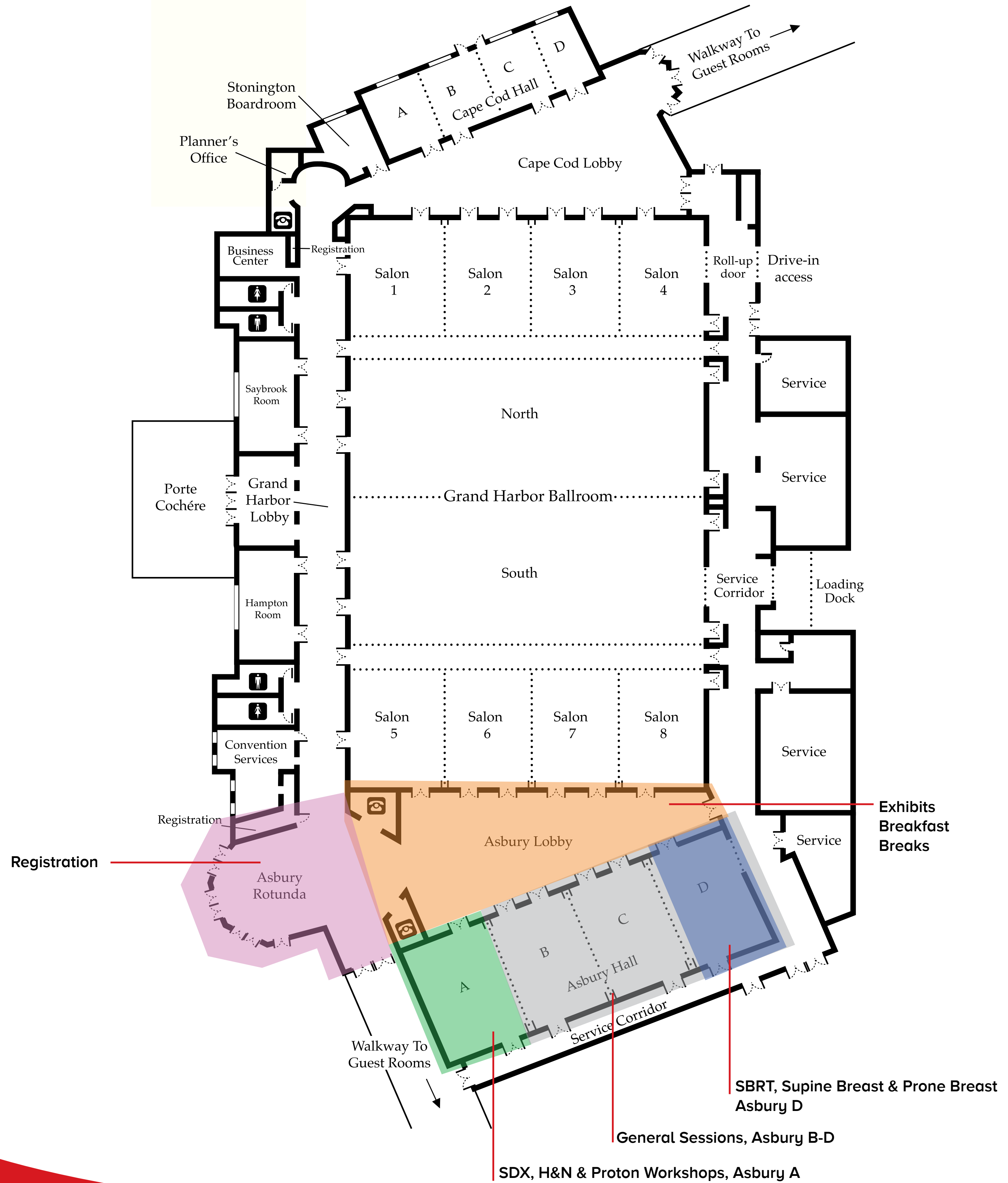
Map of Disney's Yacht Club Resort



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Information

Thank you for joining us for our Sixth Annual Patient Positioning Symposium! We hope you find this symposium enjoyable as well as educational! Here is some general information that you might find useful during your stay:

Hotel Information:

Disney's Yacht Club Resort
1700 Epcot Resorts Boulevard
Lake Buena Vista, Florida 32830-8407
Hotel: (407) 934-7000

* You can find a detailed agenda and schedule on page 6-7.

Summary:

The Patient Positioning Symposium is designed for Radiation Therapy professionals who are interested in learning about the latest practices and future direction of Radiotherapy. CAMPEP, ASRT, and MDCB credits will be awarded after completion of the symposium.

- Present an overview of the current immobilization techniques and technology
- Discuss challenges and issues with current immobilization setup techniques
- Acquire practical knowledge of the basic tools for evolving radiotherapy treatment options

Continuing Education Credits:

Continuing Medical Education Credits
Medical Physicists - Up to 16.5 MPCEC Hours: An application has been submitted to the Commission on Accreditation of Medical Physics Education Program

Radiation Therapists - Up to 15 Credits: An application has been submitted to the American Society for Radiological Technologists for designing of Category A continuing education credits.

Medical Dosimetrists - Up to 10 Credits: An application has been submitted to the Medical Dosimetrists Certification Board for designation of MDCB credit.

Exhibitors

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Symposium Agenda

Thursday, March 27, 2014

11:00am - 12:30pm **Registration (Asbury Lobby)**

1:00pm-2:30pm

DIBH Workshop (Asbury A)
1:00pm - 1:45pm - Group A
1:45pm - 2:30pm - Group B
Wensha Yang, PhD & Jose Martinez, RTT- Facilitator

SBRT Workshop (Asbury D)
1:00pm - 1:45pm - Group B
1:45pm - 2:30pm - Group A
Indrin Chetty, PhD & John Lohmiller- Facilitator

2:30pm-4:00pm

Head & Neck Workshop (Asbury A)
2:30pm - 3:15pm - Group A
3:15pm - 4:00pm - Group B
David Wiant, PhD & David Sterle - Facilitator

Supine Breast Workshop (Asbury D)
2:30pm - 3:15pm - Group B
3:15pm - 4:00pm - Group A
Jennifer Chavez, RT(R)(T) & Nathan Pell- Facilitator

4:00pm-5:30pm

Proton Workshop (Asbury A)
4:00pm - 4:45pm - Group A
4:45pm - 5:30pm - Group B
Andrew Wroe, PhD, D.A.B.R. & Rene Velasquez - Facilitator

Prone Breast Workshop (Asbury D)
4:00pm - 4:45pm - Group B
4:45pm - 5:30pm - Group A
Keith Crowe, Treatment Aide Lead & Tom Miklasz- Facilitator

5:30pm - 6:30pm **Welcome Reception (Asbury Lobby)**

Friday, March 28, 2014

8:00 am Breakfast (Asbury Lobby)

8:45am-9:00am Welcome and Introduction

9:00am-10:00am ***A comprehensive review of technical aspects related to SBRT treatment of thoracic and upper GI tumors***
-Indrin Chetty, PhD - Henry Ford Hospital

10:00am-10:45am ***Immobilization Considerations for Prone Breast Treatments***
-Keith Crowe, Treatment Aide Lead
-Sutter Cancer Center, Radiation Oncology Services - Sacramento

10:45am-11:15am Break

11:15am-12:00pm ***Prone Breast Treatment Update***
-Julia White, MD - Ohio State University

12:00pm-1:00pm ***A New Era of Intra-cranial and Head and Neck Treatment***
-David Wiant, PhD - Moses Cone Health System

1:00pm-2:00pm Lunch (Yacht Club Marina)

2:00pm-3:00pm ***Immobilization Techniques in Proton Therapy***
-Andrew Wroe, PhD, D.A.B.R. - Loma Linda University Medical Center

3:00pm-4:00pm ***Patient Positioning Using an In-Room MR Imaging System***
-Rojano Kashani, PhD - Washington University School of Medicine

4:00pm-4:30pm Break (Asbury Lobby)

4:30pm-5:30pm ***The Clinical Use of a Spirometer based Respiratory Motion Management System for Deep Inhalation Breath-hold Radiation therapy of Left-sided Breast Cancer Treatment***
-Wensha Yang, PhD - Cedars-Sinai Medical Center

5:30pm ***Epcot Center***

Saturday, March 29, 2014

9:00 am Breakfast (Asbury Lobby)

9:45am-10:30am ***Unconventional Immobilization Devices and Setups***

-Tneisha Haddock, BS, RT(R)(T) - Duke University Hospital

10:30am-11:15am ***In Search for the Ideal Proton Therapy Immobilizer - Evaluation Study of Intracranial Immobilizer***

-Omar Zeidan, PhD, D.A.B.R. - UF Health Cancer Center at Orlando Health

11:15am-12:00pm ***Therapist Perspective on Treatment Delivery (Past/Present/Future)***

-Maryse Biron, M.Ed., RTT & Tricia Lamore, RTT - Fletcher Allen Health Care

12:00pm-1:00pm Lunch (GH Salons I & II)

1:00pm-1:45pm ***Eradication of Ambiguity in Radiation Therapy - Start in Simulation Procedures***

-Thomas Jozwiak, RT(R)(T) & Rediet Gebremichael, BSRT(R)(T)(CT

- University of Texas MD Anderson Cancer Center

1:45 pm-2:45pm ***Brachytherapy Workflow in Radiation Oncology***

-Doug Martin, MD - Ohio State University

2:45pm-3:15pm Break (Asbury Lobby)

3:15pm-4:00pm ***"It's More Than Just Doing More With Less"***

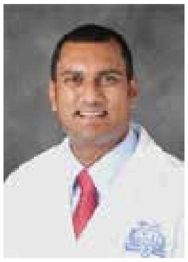
-Jordan Johnson, MSHA, BSRT(R)(T) - Thompson Cancer Survival Center

4:00pm-4:45pm ***Orchestrating Better SBRT Positioning***

-Keith Crowe, Treatment Aide Lead

-Sutter Cancer Center, Radiation Oncology Services - Sacramento

Indrin Chetty, PhD



I am the head of the Radiation Physics Division in the Department of Radiation Oncology and I am responsible for: overseeing routine clinical operations, mentoring junior faculty members, facilitating new clinical and research projects, assisting with writing peer-reviewed publications, assisting with grant writing applications, and routine administrative tasks associated with leading a large group of 40 faculty, 31 physicists and 9 dosimetrists.
My main area of research involves accurate estimation of dose to the tumor and surrounding healthy lung tissue during radiation treatment for patients with lung cancer. More specifically the methodology involves the development and application of an accurate algorithm (the Monte Carlo technique) for computation of dose in the patient tissues, by simulating radiation interactions within the patient. My experience in medical physics has spanned approximately 20 years, and much of my research experience over this time has been associated with the treatment of lung cancer patients. I was the PI of a R01 grant from the NIH investigating better correlation of outcomes with MC dose calculation for lung cancer patients.
I received my BS degree, with high distinction (equivalent of Summa Cum Laude), in Physics and Mathematics at the University of Michigan prior to attending the University of California, Los Angeles, where I earned both an MS and PhD in Medical Physics. After working as a Medical Physicist in California while pursuing my PhD degree, I returned to the University of Michigan (upon completion of my PhD) where I began to apply the clinical aspects of medical physics with research in improving accurate planning and targeting of radiation therapy and assessment of response. My research interests also include the use of image-guided radiation therapy (IGRT), which involves imaging of the patient's tumor site and surrounding normal tissues at the time of treatment, with the goal of improving targeting accuracy.
I am also actively involved in service related to our national organizations, the American Society of Therapeutic Radiation Oncology (ASTRO) and the American Association of Physicists in Medicine (AAPM). This year I am chair of the ASTRO Radiation Physics committee. In 2011 I served as the Scientific Program Chair for the annual meeting of the AAPM. I am actively engaged in education in Radiation Oncology at the national level. I served for 6 years as the physics program chair for the ASTRO Spring Refresher Course, which is a national course focusing on clinical, physics and biology education for residents training in the field of Radiation Oncology. I am also currently serving as the Physics Chair for the ASTRO State-of-the-Art meeting, which focuses on the use of the latest technologies in IMRT, IGRT, SBRT and particle therapies in the routine clinical setting.

Keith Crowe, Treatment Aide Lead

Mr. Crowe is a Treatment Aide Lead at Sutter Cancer Center Radiation Oncology Services – Sacramento California. Responsible for Treatment Aide Department for 25 years, lead development of SRS/SBRT programs, IMRT Head and Neck, Prone Breast. Mr. Crowe has worked with multiple vendors to create many innovative, cutting edge immobilization devices. Mr. Crowe is responsible for patient positioning, is an enthusiastic caregiver and has extensive Clinical training in sterilization techniques.

Julia White, MD

Dr. White is considered the international authority in breast cancer as it pertains to radiation oncology. Her clinical research has helped define the field of breast radiation oncology. Dr. White earned her bachelor's degree in biology at Rosemont College in Rosemont, Penn., and her medical degree from Michigan State University's College of Human Medicine. Dr. White is the new director of breast radiation oncology at The Ohio State University Comprehensive Cancer Center – Arthur G. James Cancer Hospital and Richard J. Solove Research Institute (OSUCCC–James). Prior to joining Ohio State, Dr. White was a professor in the department of radiation oncology at the Medical College of Wisconsin in Milwaukee. She also served as department chair and medical director for the department of radiation oncology at Community Memorial Hospital in Menomonee Falls, Wisconsin. Dr. White holds memberships in almost a dozen professional and honorary societies, including American College of Radiology, American Society of Clinical Oncology and American Society of Therapeutic Radiology and Oncology, while also serving on several editorial boards including Journal of Clinical Oncology and International Journal of Radiation Oncology Biology Physics.

Faculty

David Wiant, PhD

Dr. Wiant Dr. earned his bachelor's degree in physics from the Department of Physics Kenyon College, Gambier Ohio, and received his PHD from the Department of Physics Kent State University, Kent, OH. Dr. Wiant is currently a Senior Physicist, in the Department of Radiation Oncology Cone Health System, Greensboro, NC. Dr. Wiant received the prestige's Otto Lehmann Award in Karlsruhe Germany, one of only two major international dissertation awards in the field of liquid crystal technology; the annual honor recognizes young scientists for outstanding thesis or dissertation work. This is the first time the award has gone to a doctoral candidate in the United States. Dr. Wiant holds Professional Certifications in American Board of Radiology–Therapeutic Medical Physics and the Authorized Medical Physicist, North Carolina.

Andrew Wroe, PhD, D.A.B.R.

As a Medical Physicist and Translational Researcher I seek to bring together physics, medicine, engineering, computer science and biology in developing advancements in radiation medicine. Specifically I am interested in developments in proton therapy including patient immobilization, patient alignment, Monte Carlo simulations, beam delivery, dosimetry and imaging. I obtained my undergraduate and graduate training in medical physics from the University of Wollongong in Australia. This training had a large laboratory and clinical component, which focused on multidisciplinary solutions to overcoming challenges in medical physics. During the course of my PhD studies I spent a total of 18 months in the US completing research at a number of institutions including the US Naval Academy, Brookhaven National Laboratory, Loma Linda University Medical Center, Massachusetts General Hospital and the Harvard School of Medicine. This research was sponsored in part by a Fulbright Scholarship, which I was fortunate enough to be awarded with in 2005.

Since 2007 I have been employed as a Medical Physicist and Associate Director of Translational Research within the Department of Radiation Medicine at the James M. Slater MD Proton Treatment and Research Center. This posting is excellent as it allows me to use a multi-disciplinary approach to progressing proton therapy and in turn pass my knowledge onto students. Additionally I am an Assistant Professor at the Loma Linda University School of Medicine, and Honorary Fellow at the Centre for Medical Radiation Physics at the University of Wollongong.

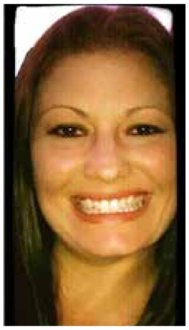
Rojano Kashani, PhD

Dr. Kashani earned her bachelors' degree in Electrical Engineering from the University of Michigan, Ann Arbor, MI, and received her Masters and PhD degrees in Nuclear Engineering and Radiological Sciences. Dr. Kashani completed her Medical Physics Residency in Radiation Oncology at the Washington University School of Medicine; St. Louis, MO. Dr. Kashani is currently an Instructor in Radiation Oncology in the Washington University School of Medicine, St. Louis, MO, while also serving as the Chief of Stereotactic Body Radiation Therapy Service. Dr Kashani is board certified by the Therapeutic Medical Physics (American Board of Radiology), and some of the arrears of clinical interest include Stereotactic Body Radiotherapy, Deformable Image Registration and Adaptive Therapy.

Wensha Yang, PhD

Dr. Yang earned her bachelor's degree in (Chemistry and Materials) from the University of Science and Technology of China, and received her Ph.D. in (Material Chemistry, Minor in Analytical Chemistry) from the University of Wisconsin-Madison. Dr. Yang is currently a Medical Physicist, in the Department of Radiation Oncology at Cedars-Sinai Medical Center, Los Angeles, California. Prior to joining Cedars-Sinai Medical Center, Dr. Yang was an Assistant Professor in the Department of Radiation Oncology at the University of Virginia. Dr. Yang holds memberships in several professional and honorary societies, including ASTRO, AAPM, Sigma Xi, Materials Research Society and American Chemical Society, while also serving on the Head and Stereotactic Body, Radiotherapy SBRT Committee at the Department of Radiation Oncology, Cedars-Sinai.

Faculty

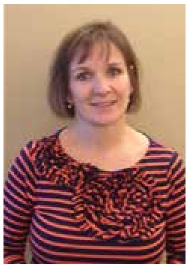


Tneisha Haddock, BS, RT(R)(T)

Tneisha M. Haddock is a radiation therapist Level II at Duke University Hospital in Durham, NC. She graduated from East Carolina University with a Bachelor of Science degree in Exercise and Sport Science with a concentration in Exercise Physiology in 2002. At Pitt Community College, she studied Radiography and graduated with an Associates of Arts degree in 2007 and in 2008 graduated with a diploma in Radiation Therapy. She has been an employee at Duke since August 2008. She is a lead CT Simulation therapist, member of the Falls and Safety Committees, and a departmental preceptor for prospective radiation therapy students.

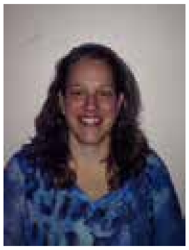
Omar Zeidan, PhD, D.A.B.R.

Omar Zeidan received his doctorate in nuclear physics from the University of Tennessee in 2002. He then joined the Department Of Radiation Oncology, University of FL, as a research associate followed by a residency in radiotherapy physics at the Johns Hopkins Oncology Center in Baltimore. Between 2005 and 2010 he was a staff physicist at M.D. Anderson Cancer Center Orlando. Between 2010 and 2013 he was the Director of Medical Physics and Corporate Radiation Safety Officer for the proton therapy center in Oklahoma City. He recently joined back M.D. Anderson Cancer Center Orlando as Chief of Proton Therapy Physics. His main clinical and research interests include Proton Therapy, Intensity and image-guided radiotherapy (IGRT).



Maryse Biron, M.Ed., RTT

Maryse Biron is a Radiation Therapist at Fletcher Allen Health Care and the Clinical Coordinator for the University Of Vermont in Burlington, Vermont. She received her undergraduate degree from the University of Vermont and her Master's in Education from St. Michael College. Maryse has over 28 years experience in the field radiation oncology. Maryse works in radiation oncology as a senior therapist at Fletcher Allen Health Care. Maryse is also responsible for the radiation therapy student's clinical education and internships. Maryse is currently working with the University of Vermont to establish the use of a Clinical Simulation Lab using a "Vertual" Linac to enhance the clinical education of the radiation therapy students.



Tricia Lamore, RTT

Tricia Lamore is a Radiation Therapist at Fletcher Allen Health Care in Burlington, Vermont. She received her AS degree from the University of Vermont. She has over 20 years of experience in radiation therapy. One of her specialties is CT simulation. She has been a key part of implementing new technologies in her department including new treatment devices and new immobilization. She was on the team that helped bring on SABR and Frameless SRS. She plays a very active role in teaching the students and has been named clinical instructor of the year several times. She loves being a team player and is always up for a new challenge!

Faculty

Thomas Jozwiak, RT(R)(T)

Mr. Jozwiak is a Radiation staff Therapist at UT MD Anderson Radiation Oncology Department. Mr. Jozwiak graduated from UT MD ANDERSON CANCER CENTER SCHOOL OF HEALTH & SCIENCES with a BS Radiation Therapy, and is currently attending ASHFORD UNIVERSITY for his Masters in MHA. During his tenure at UT MD Anderson, he has become very experienced with BAT, CT on rails, 4D console, Primus, Aqusim, PET CT, OBI, Gated breathing treatments. Mr. Jozwiak is a member of the American Registry of Radiologic Technologists and the American Society of Radiologic Technologists.

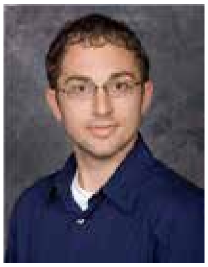
Rediet Gebremichael, BSRT(R)(T)(CT)

Mr. Gebremichael is a Radiation staff Therapist at UT MD Anderson Radiation Oncology Department with eight years of practical clinical experience. Mr. Gebremichael graduated from University of Texas Houston, Texas with a BS Radiation Therapy, and is currently assisting physicians on elaborate and technical procedures such as simulation, ISO center placement for proton treatments and photon treatments. Mr. Gebremichael is a member of the American Registry of Radiologic Technologists and the American Society of Radiologic Technologists.

Doug Martin, MD

Douglas Martin, MD is the Clinical Director, Department of Radiation Oncology at the Arthur G. James Cancer Hospital and Richard J. Solove Research Institute and Associate Professor, The Ohio State University College of Medicine coming to Columbus, OH in 2006. He completed residency training at the University of Iowa in 1995. After residency he served in the U.S. Navy on active duty until 2002. He then joined the Lexington Clinic in Lexington, KY and served as Radiation Oncology Department Head from 2003-2006. At Ohio State, he leads the department's brachytherapy program with a focus on genitourinary and gynecologic malignancies. He is also on the transition task force involved in the design and planning for the "New James Cancer and Critical Care Tower", a 1.1 billion dollar, 1 million square feet facility set to open for patient care in December 2014. The radiation oncology department takes up the entire second floor and has a fully operational brachytherapy suite with direct access to MR imaging during procedures. He will review current and future workflow for radiation therapy brachytherapy procedures performed at his institution.

Jordan Johnson, MSHA, BSRT(R)(T)



Jordan Johnson is the Director of Cancer Center for CMC Regional Hospital as a joint venture with Thompson Cancer Survival Center. He graduated Magna Cum Laude in 2007 with a Baccalaureate in Radiologic Technology from the University of Louisiana and in 2008, received a second Baccalaureate in Radiation Therapy from the University of Texas MD Anderson. Jordan recently completed his Master's degree in Healthcare Administration from the University of St. Francis.

Jordan worked as a radiation therapist at Duke University Hospital for 4 years, in addition to having previously worked in diagnostic imaging, CT, and MRI. He serves as a site visitor for the JRCERT, is an ASRT grassroots member, in 2010 represented North Carolina at RT in DC, is the Vice Chairman, and the Region 6 team leader for the ASRT's CRTA Committee.

Jordan enjoys helping patient's through their journey with cancer, mentoring students and advancing our profession.

Patient Positioning Symposium
advanced education in patient positioning

Index of Slides

Friday, March 28, 2014

9:00am - 10:00am

Indrin Chetty, PhD

A comprehensive review of technical aspects related to SBRT treatment of thoracic and upper GI tumors

Comprehensive review of technical aspects related to SBRT treatment of thoracic and upper GI tumors

Indrin J. Chetty, PhD
Henry Ford Health System

Learning Objectives/Outline

1. What is SBRT?
2. SBRT utilization
3. Clinical Workflow
   - Simulation and Immobilization
   - Treatment Planning
   - Treatment Delivery
4. VMAT planning and delivery considerations
5. Summary

What is stereotactic body radiotherapy (SBRT)?

"stereotactic" describes a procedure during which a target lesion is localized relative to a known three dimensional reference system. Stereotactic body radiation therapy (SBRT) and Stereotactic Radiosurgery (SRS) are specialized forms of cancer treatment whereby high doses of radiation are delivered in large fraction sizes over a short course of treatment, generally limited to 5 or fewer fractions. SRS is defined as treatment delivery to the brain or spine, while SBRT is defined as treatment delivery elsewhere within the body (which can include the spine);...

From: Solberg *et al* "Quality and Safety Considerations in Stereotactic Radiosurgery and Stereotactic Body Radiation Therapy" (Practical Radiation Oncology 2011)

Conventional RT vs SBRT

Characteristic	Conventional RT	SBRT
Dose / Fraction	1.8 – 3 Gy	6 – 30 Gy
No. of Fractions	10 – 30	1-5
Target definition	CTV / PTV gross disease + clinical extension: tumor may not have a sharp boundary.	GTV / CTV / ITV/ PTV well-defined tumors: GTV=CTV
Margin	Centimeters	Millimeters
Physics / dosimetry monitoring	Indirect	Direct
Required setup accuracy	AAPM TG40, TG142	AAPM TG40, TG142
Primary imaging modality used for tx planning	CT	Multi-modality: CT/MR/PET-CT

Courtesy: Stan Benedict (UC Davis)

Conventional RT vs SBRT

Characteristic	Conventional RT	SBRT
Redundancy in geometric verification	No	Yes
Maintenance of high spatial targeting accuracy for the entire treatment	Moderately enforced (moderate patient position control and monitoring)	Strictly enforced (sufficient immobilization and high frequency position monitoring through integrated image guidance)
Need for respiratory motion management	Moderate – Must be at least considered	Highest

Courtesy: Stan Benedict (UC Davis)

Conventional RT vs SBRT

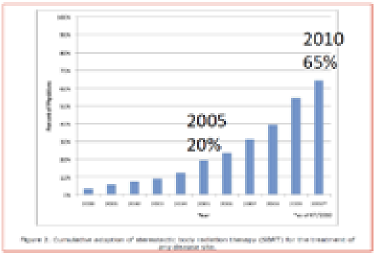
Characteristic	Conventional RT	SBRT
Staff Training	Highest	Highest + special SBRT Training
Technology implementation	Highest	Highest
Radiobiological understanding	Moderately well understood	Poorly understood
Interaction with systemic therapies	YES	YES

Courtesy: Stan Benedict (UC Davis)

SBRT Utilization: A Survey of Stereotactic Body Radiation Therapy Use in the United States

Pan H, et al. Cancer. 2011 Oct 1;117(19):4566-72.

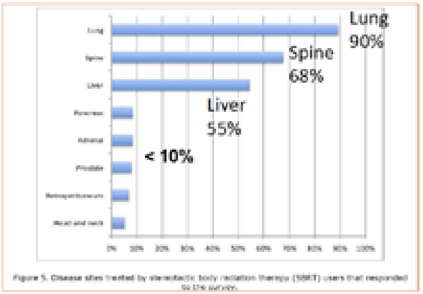
1600 radiation oncologists randomly selected
- >500 analyzable responses



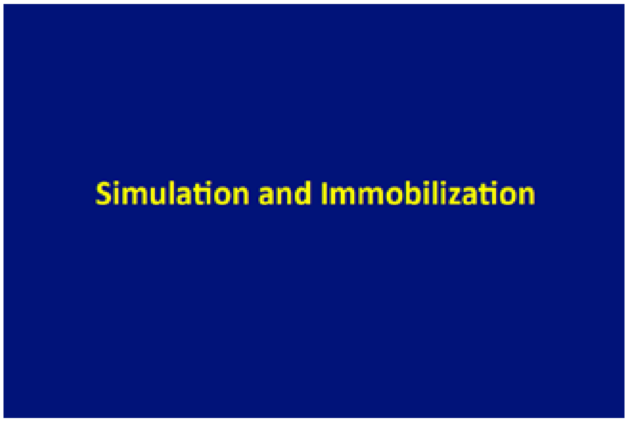
Courtesy: Brian Kavanagh (Univ of Colorado-Denver)

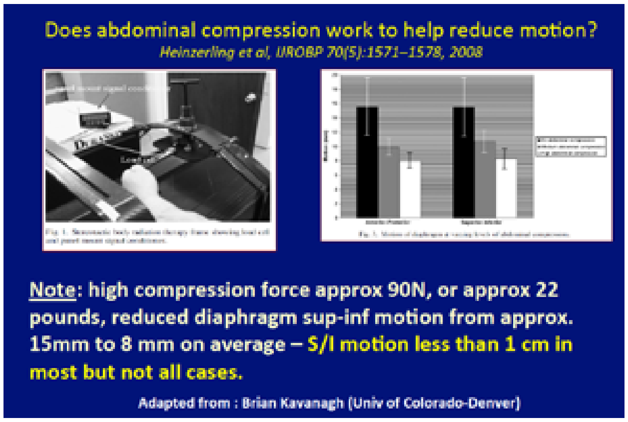
Patient Selection and Treatment Sites: A Survey of Stereotactic Body Radiation Therapy Use in the United States

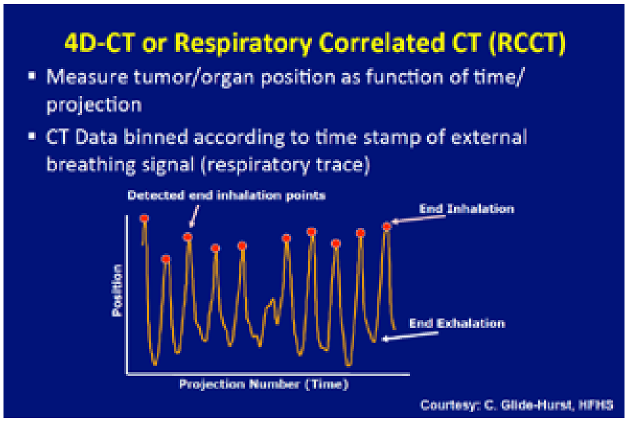
Pan H, et al. Cancer. 2011 Oct 1;117(19):4566-72.

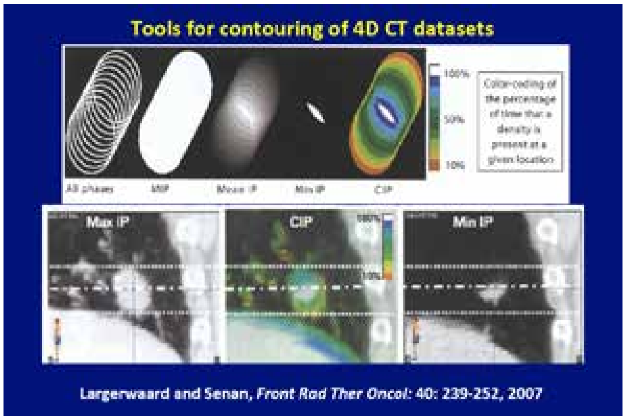


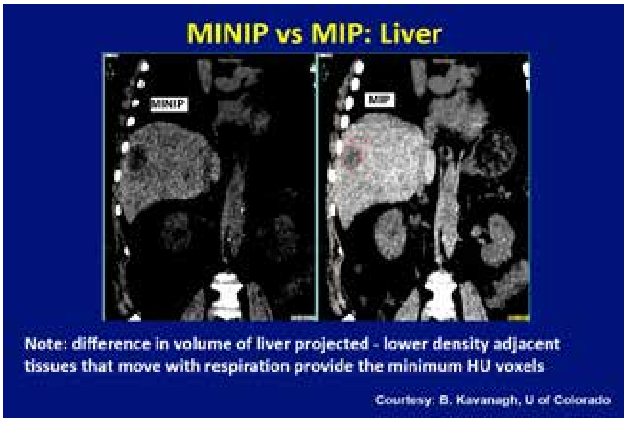
Courtesy: Brian Kavanagh (Univ of Colorado-Denver)

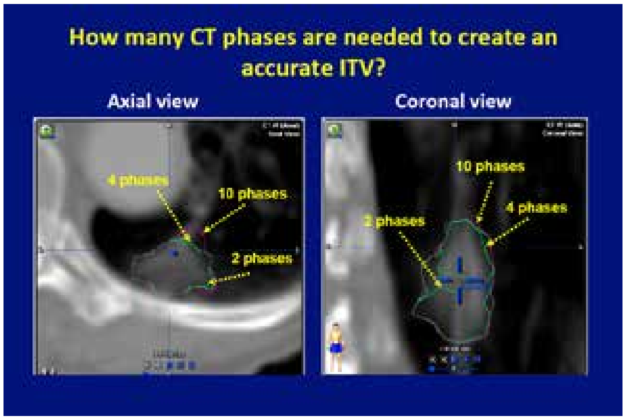












Lung SBRT planning margins

Appropriate planning margins to account for setup uncertainties: follow nationally accepted guidelines e.g. RTOG, and relevant literature

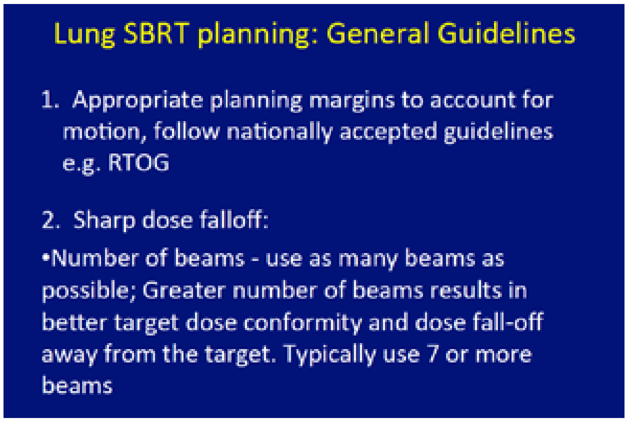
Table 7. Margins used for planning target volume definition for stereotactic body radiotherapy of different targets

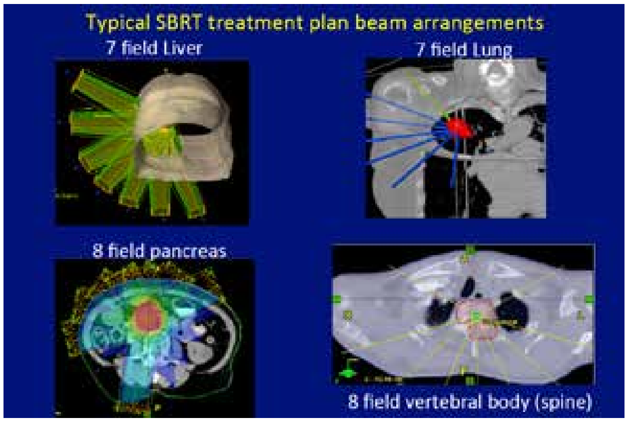
Study	Organ	Margin transverse (mm)	Margin long (mm)	Comment	Method for breathing reduction
Timmerman et al. (89)	Lung	5	10		Different methods
Baumann et al. (66)	Lung	5, 10	10		Abd. comp
Zimmermann et al. (62)	Lung	Individual	Individual		Abd. comp
Joyner et al. (58)	Lung	5	10		
Okunieff (67)	Lung	7	10		Resp. gating
Paludan (68)	Lung	Minimum 5	10		Abd. comp
Høyer et al. (59)	Liver	Minimum 5*	10	*Lateral margin	Abd. comp
Méndez Romero et al. (11)	Liver	5	10		Abdom. comp
Wulf et al. (10)	Liver	5	5, 10		Abd. comp
Kavanagh et al. (48)	Liver	Minimum 5	10		Abd. comp or breath hold
Dawson et al. (40)	Liver	Minimum 5*	min 5*	*Ind. margin	ABC
Svedman (39)	Liver, lung	5, 10	10		Abd. comp
Wurm (70)	Liver, lung	5	5		Adaptive gating
Hodge (71)	Lung	6	6*	*Margin to ITV	Abd. comp
Guckenberger (58)	Lung	5*	5*	*Margin to ITV	Abd. comp
Nagata et al. (18)	Lung	5*	8–10*	*Margin to ITV	Abd. comp
Onishi et al. (52)	Lung	0–5*	0–5*	*Margin to ITV	Different methods

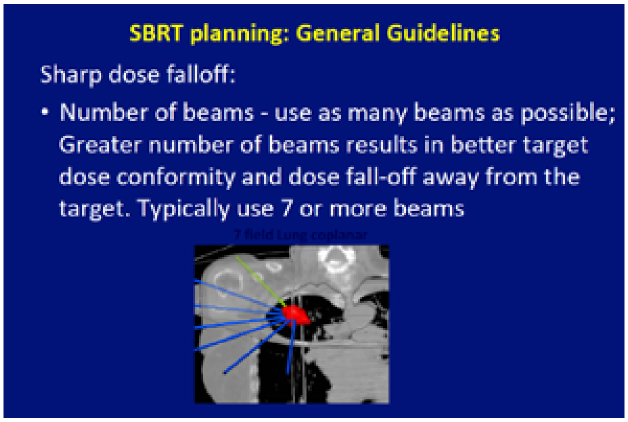
Abbreviations: Resp. = respiratory; Abd. = abdominal compression; ABC = Automatic breathing control.

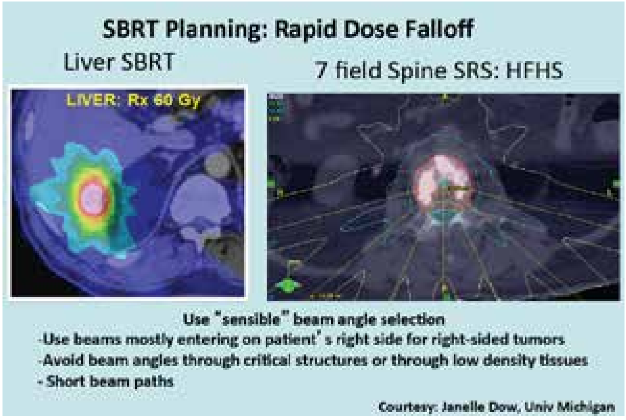
Nagata *et al*: "Stereotactic radiotherapy of primary lung cancer and other targets: results of consultant meeting of the IAEA" **IJROBP: 79: 2011**

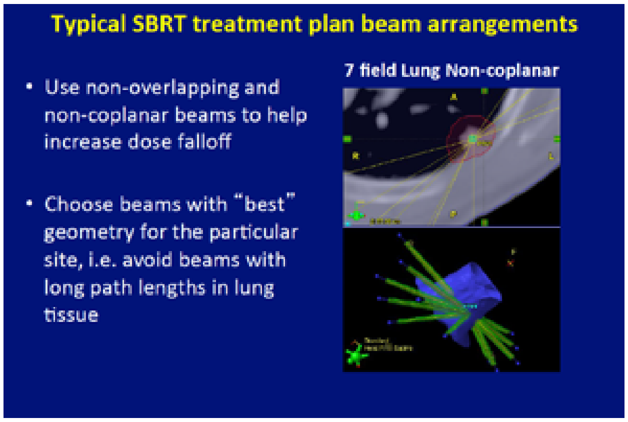
SBRT treatment planning requirements


Lung SBRT planning: General Guidelines
1. Appropriate planning margins to account for motion, follow nationally accepted guidelines e.g. RTOG
2. Sharp dose falloff:
•Number of beams - use as many beams as possible; Greater number of beams results in better target dose conformity and dose fall-off away from the target. Typically use 7 or more beams

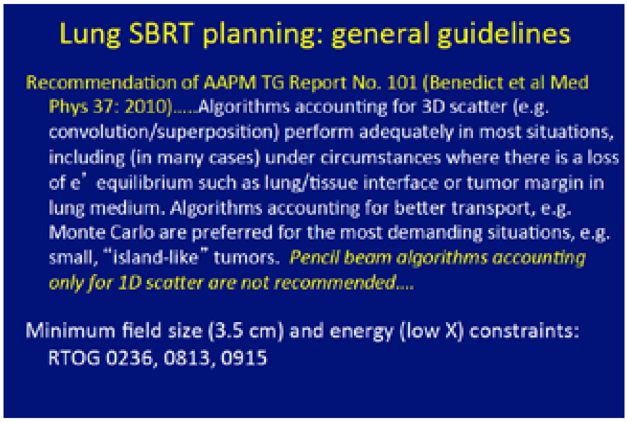

Typical SBRT treatment plan beam arrangements
7 field Liver
7 field Lung
8 field pancreas
8 field vertebral body (spine)

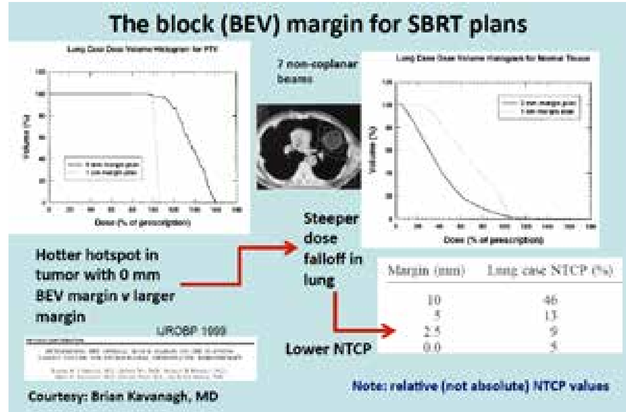

SBRT planning: General Guidelines
Sharp dose falloff:
• Number of beams - use as many beams as possible; Greater number of beams results in better target dose conformity and dose fall-off away from the target. Typically use 7 or more beams

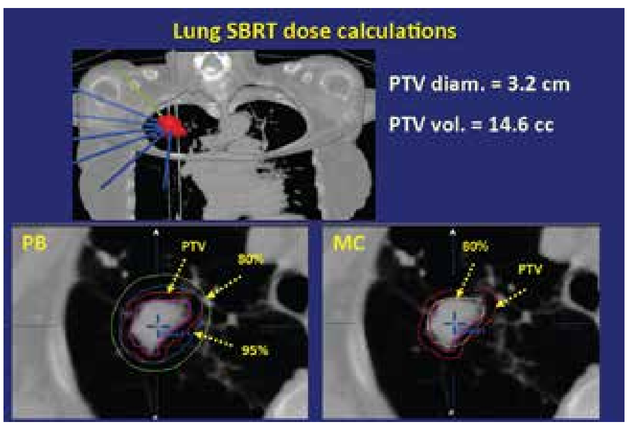

SBRT Planning: Rapid Dose Falloff
Liver SBRT
7 field Spine SRS: HFHS
LIVER: Rx 60 Gy
Use "sensible" beam angle selection
-Use beams mostly entering on patient's right side for right-sided tumors
-Avoid beam angles through critical structures or through low density tissues
- Short beam paths
Courtesy: Janelle Dow, Univ Michigan

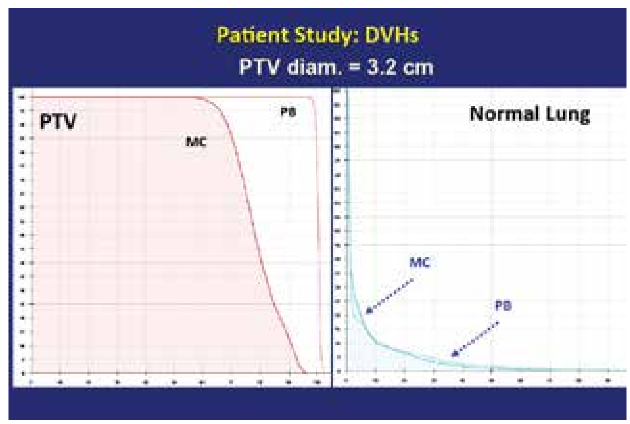

Typical SBRT treatment plan beam arrangements
• Use non-overlapping and non-coplanar beams to help increase dose falloff
• Choose beams with "best" geometry for the particular site, i.e. avoid beams with long path lengths in lung tissue
7 field Lung Non-coplanar

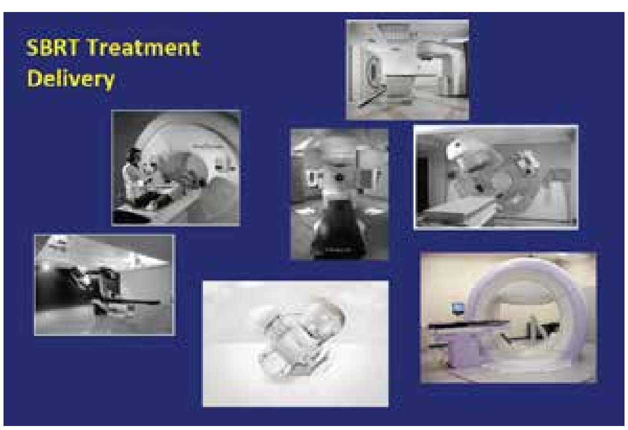

Large number of beams. Failure to use spread out dose results in excessive skin toxicity
Errors in SRS / SBRT
6 months
3 months
12 months
Courtesy: Timothy Solberg, UT Southwestern Medical Center

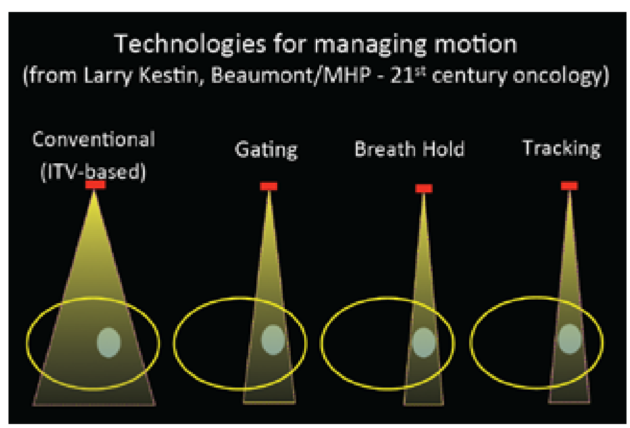

Lung SBRT planning: general guidelines
Recommendation of AAPM TG Report No. 101 (Benedict et al Med Phys 37: 2010)…..Algorithms accounting for 3D scatter (e.g. convolution/superposition) perform adequately in most situations, including (in many cases) under circumstances where there is a loss of e⁻ equilibrium such as lung/tissue interface or tumor margin in lung medium. Algorithms accounting for better transport, e.g. Monte Carlo are preferred for the most demanding situations, e.g. small, "island-like" tumors. Pencil beam algorithms accounting only for 1D scatter are not recommended….
Minimum field size (3.5 cm) and energy (low X) constraints: RTOG 0236, 0813, 0915


The block (BEV) margin for SBRT plans
7 non-coplanar beams
Steeper dose falloff in lung
Hotter hotspot in tumor with 0 mm BEV margin v larger margin
IJROBP 1999
Lower NTCP
Margin (mm)
Lung case NTCP (%)
10 46
5 13
2.5 9
0.0 5
Courtesy: Brian Kavanagh, MD
Note: relative (not absolute) NTCP values


Lung SBRT dose calculations
PTV diam. = 3.2 cm
PTV vol. = 14.6 cc
PB
PTV
80%
95%
MC
80%
PTV

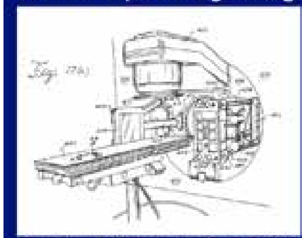

Patient Study: DVHs
PTV diam. = 3.2 cm
PTV
PB
MC
Normal Lung
MC
PB

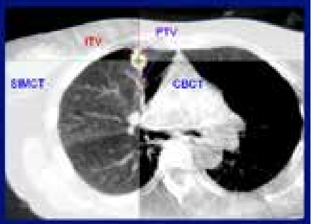

SBRT Treatment Delivery


Technologies for managing motion
(from Larry Kestin, Beaumont/MHP - 21st century oncology)
Conventional (ITV-based)
Gating
Breath Hold
Tracking

Conventional (ITV-based) Localization: CBCT

CBCT image guidance significantly improves positioning and reduces required target margins and normal tissue dose

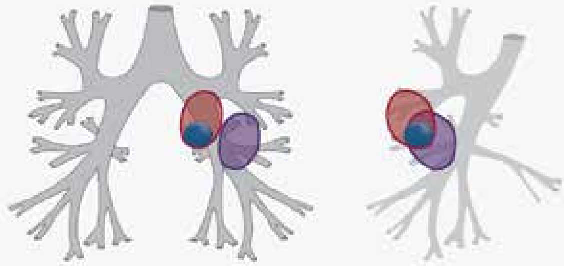




David Jaffray: US Patent, Fig. 17 (a) Jan' 2005

Localization: systematic shift in the ITV: baseline shift

(from Larry Kestin, MHP, 21st century oncology)



Localization: Baseline shift

Mean target position vector was greater than 2 mm and 5 mm in 41% and 7% of fractions, respectively [n=126, from Shah *et al.* (Beaumont) Red Journal, 2011]

MTP (baseline) shift was significantly different based on treatment time and type of immobilization device – stereotactic body frame was most accurate

Baseline shift necessitates daily volumetric imaging (CBCT)

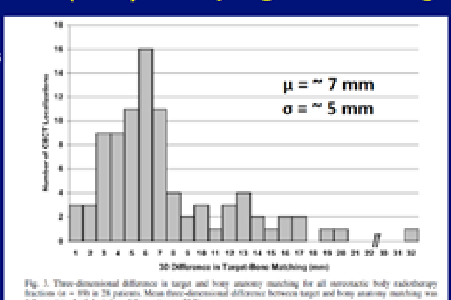
CBCT: Early Stage NSCLC (SBRT)

CBCT-based localization reduces margins significantly relative to conventional (skin-tattoo) alignment
[data from Grills *et al.* (Beaumont) Red Journal, '08] ; [Sonke *et al.* (NKI) Red '09]

	SBF alone/precorrection margin	SBF + CBCT IGRT/postcorrection margin (residual only†)
Lat. (mm)	9.1	1.6
Long. (mm)	12.6	2.4
Vert (mm)	8.7	1.9

Soft-tissue (CBCT) vs Bony Alignment for lung SBRT

28 Patients
89 Fractions



Purdie et al., Red Journal (2006)

Investigation of localization errors using CBCT for SABR-based treatment of lung cancer and impact on planning margins

Essa Mayyas[1], Ning Wen[1], Dezhi Liu[1], Carri Glide-Hurst[1], Sanath Kumar[1], Benjamin Movsas[1], Munther Ajlouni[1] and Indrin J. Chetty[1] (Submitted to PMB)

78 SBRT lung patients (12 Gy x 4) imaged daily with CBCT on the OBI (Trilogy or TrueBeam)

Couch shifts between CBCT (soft tissue) and skin-mark alignment

	A/P	S/I	L/R
$\mu_{interfx}$(mm)	-1.4	2.0	1.0
$\Sigma_{interfx}$(mm)	2.1	4.2	2.9
$M_{interfx}$(mm)	6.8	12.7	9.8

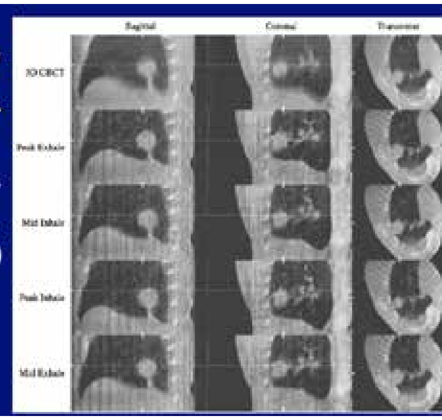
Residual Errors: between CBCT and kV/kV or kV/MV x-rays

$\mu_{residual}$(mm)	-0.3	0.1	0.0
$\Sigma_{residual}$(mm)	0.6	0.6	0.4
$M_{residual}$(mm)	2.4	2.0	1.6
$M_{interfxn}$(mm)	6.8	12.7	9.8

Investigation of localization errors using CBCT for SABR-based treatment of lung cancer and impact on planning margins
Essa Mayyas[1], Ning Wen[1], Dezhi Liu[1], Carri Glide-Hurst[1], Sanath Kumar[1], Benjamin Movsas[1], Munther Ajlouni[1] and Indrin J. Chetty[1] (Submitted to PMB)

Respiratory Correlated 4D-CBCT vs. 3D-CBCT

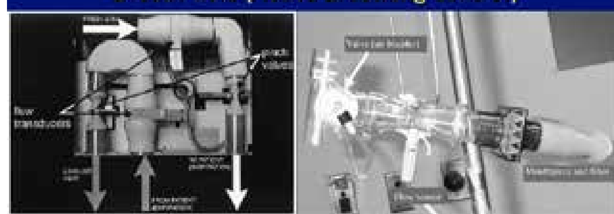
Sonke et al. *Medical Physics:* 32: 1176 (2005)



Considerations: ITV-based w/ volumetric imaging

- Volumetric information is available to correct for systematic uncertainties; one is able to view normal tissues
- Imaging information is "static" and not dynamic, i.e. one cannot account for real-time motion
- Treatment/imaging of the ITV may result in unwanted dose to the normal tissues especially for high amplitude motion
- Matching of the CBCT to a reference dataset may confound the match – 4D CBCT may be helpful here
- Noise can be a real problem and confound proper visualization especially where patient scatter is significant

Alternatives to the ITV approach: Breath-hold (Active Breathing Control)



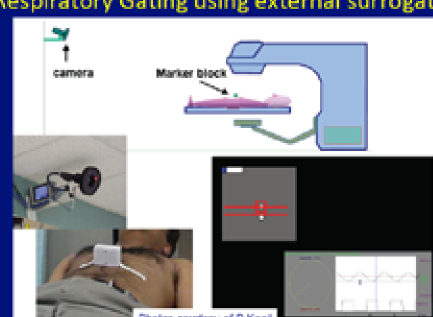
Wong *et al.* The use of Active Breathing Control to reduce margin for breathing motion, Red Journal: 44: 911 (1999)

Balter *et al.* Daily targeting of intrahepatic tumors for radiotherapy, Red Journal: 52: 266 (2002)

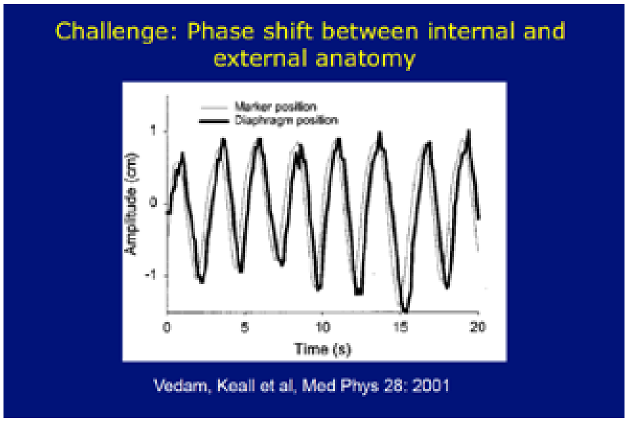
Active Breathing Control

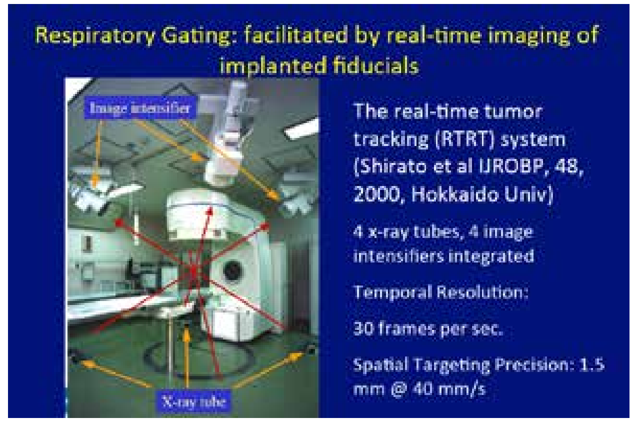
- ABC found to reduce margins by half or more for lung and liver tumors (Wong, Balter, Dawson 2001, etc.)
- Intrafraction (short-term) reproducibility: 1-2 mm (Wong, Balter)
- Interfraction (long-term) reproducibility for lung: ave. deviations were 2-3 mm; max diffs were 3.8 mm in RL, 9.0 mm in SI, and 6.8 mm in AP directions were observed for inhale scans (Kashani, Balter et al)
- Increases Tx time a factor of 3-5; patient tolerability issues

Alternatives to the ITV-based approach: Respiratory Gating using external surrogates

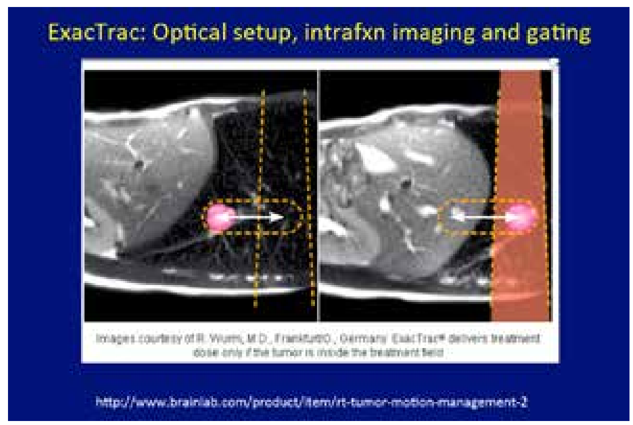


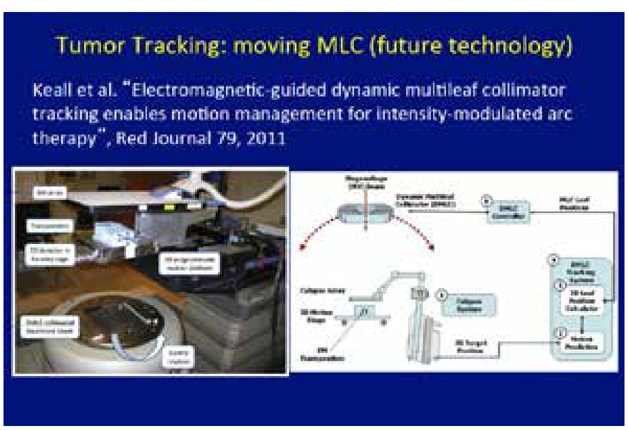
Courtesy: C Glide-Hurst (HFHS)


Challenge: Phase shift between internal and external anatomy
Marker position
Diaphragm position
Amplitude (cm)
Time (s)
Vedam, Keall et al, Med Phys 28: 2001

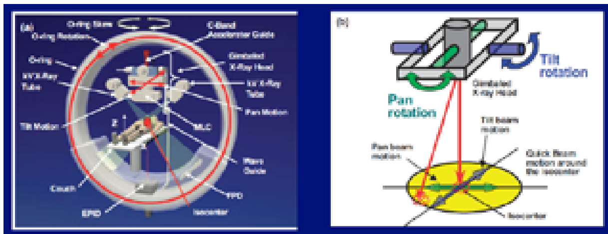

Respiratory Gating: facilitated by real-time imaging of implanted fiducials
Image intensifier
X-ray tube
The real-time tumor tracking (RTRT) system (Shirato et al IJROBP, 48, 2000, Hokkaido Univ)
4 x-ray tubes, 4 image intensifiers integrated
Temporal Resolution:
30 frames per sec.
Spatial Targeting Precision: 1.5 mm @ 40 mm/s


ExacTrac (BrainLab): optical guidance, intrafxn imaging, gating
J-Y Jin, F-F Yin et al. Use of the brainlab exactrac x-ray 6D system in image-guided radiotherapy, Med Dosim 33:124-34, 2008


ExacTrac: Optical setup, intrafxn imaging and gating
http://www.brainlab.com/product/item/rt-tumor-motion-management-2


Tumor Tracking: moving MLC (future technology)
Keall et al. "Electromagnetic-guided dynamic multileaf collimator tracking enables motion management for intensity-modulated arc therapy", Red Journal 79, 2011


VERO system (BrainLAB, MHI)



"6D" motion compensation with the "gimbaled" source

kV planar or volumetric imaging

Gating using fluoroscopy enhanced to visualize soft tissue

"VERO" Kamino et al Red J: 66, 2006

Considerations: Respiratory Gating and Tracking

- Can reduce normal tissue exposure especially for tumors moving with large amplitudes
- Gating increases Tx time considerably (2-5 times) based on the % duty cycle/gating window and patient compliance
- Combination of real time imaging of implanted fiducials can result in very high skin doses, up to 1200 mGy per hour (reported in Jiang 2005 with the RTRT system); Implanting fiducials is invasive
- With gating residual motion behaves unpredictably and could exceed planning margins. Daily image guidance should be performed (Ozhasoglu and Murphy, Red Journal 52, 1389–1399, 2002)

Ozhasoglu and Murphy, Red Journal 52, 1389–1399, 2002

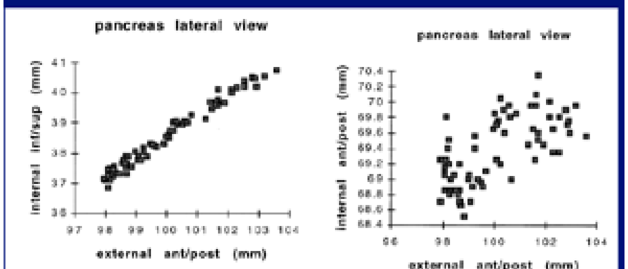


Fig. 8. The relationship between the inferior/superior motion of a pancreas tumor and the anterior/posterior motion of a surface chest marker during free breathing, measured in a lateral fluoroscopic view over a 1-min time period.

Fig. 9. The anterior/posterior displacement of a pancreas tumor vs the anterior/posterior displacement of a surface chest marker measured in a lateral fluoroscopic view.

Ozhasoglu and Murphy, Red Journal 52, 1389–1399, 2002

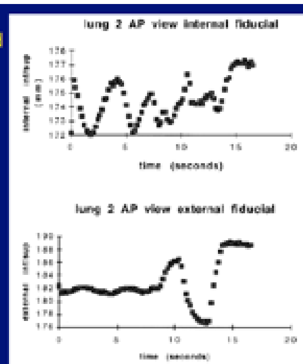
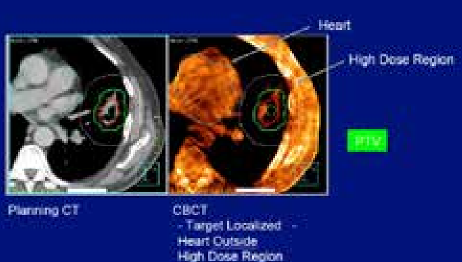


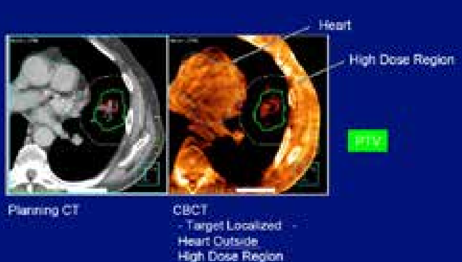
Fig. 13. The motion pattern of the lung tumor (a) and the chest wall (b) for the second lung patient during a period of unstable breathing.

Hitting the Target and Avoiding Organs at Risk

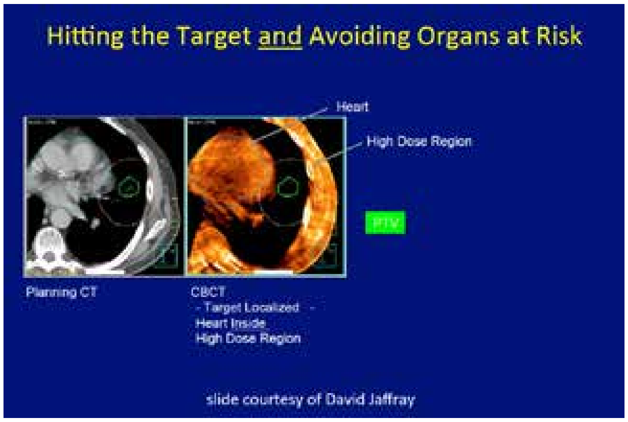


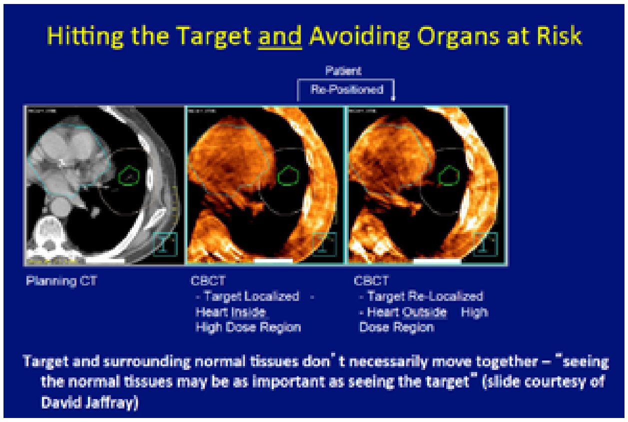
slide courtesy of David Jaffray

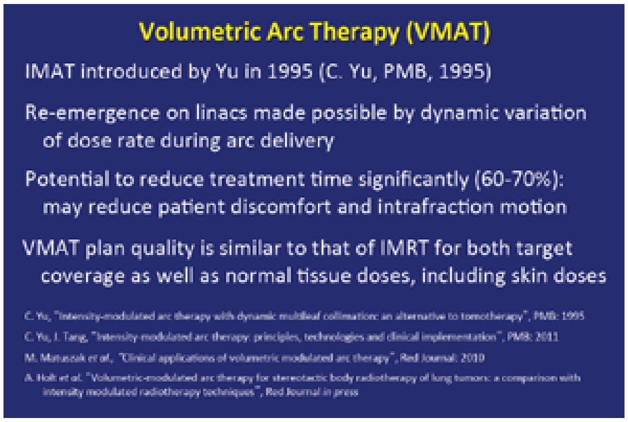
Hitting the Target and Avoiding Organs at Risk

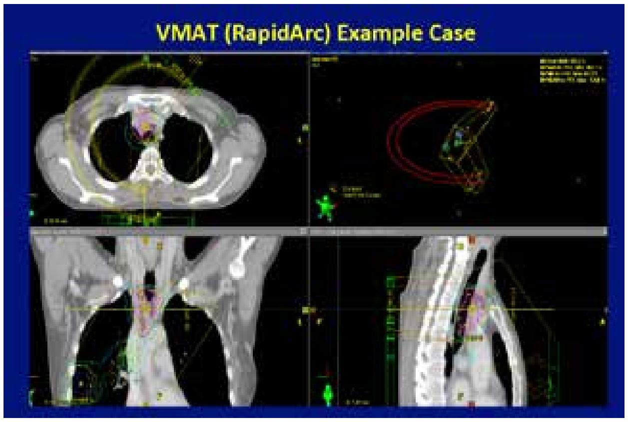


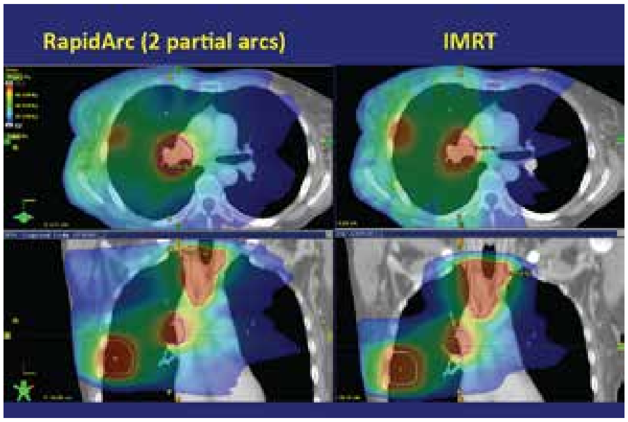
slide courtesy of David Jaffray

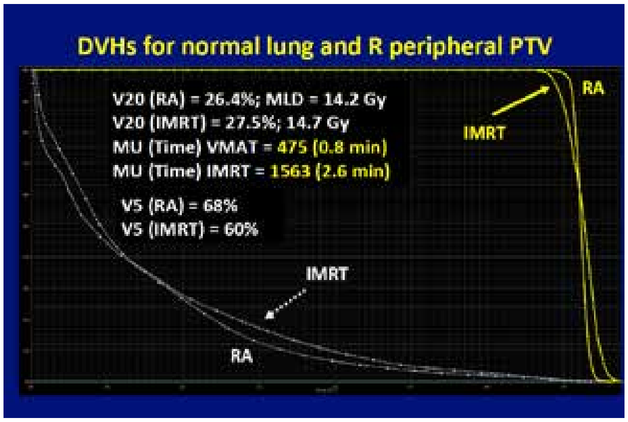

Hitting the Target and Avoiding Organs at Risk
Heart
High Dose Region
PTV
Planning CT
CBCT
- Target Localized -
Heart Inside
High Dose Region
slide courtesy of David Jaffray


Hitting the Target and Avoiding Organs at Risk
Patient
Re-Positioned
Planning CT
CBCT
- Target Localized -
Heart Inside
High Dose Region
CBCT
- Target Re-Localized
- Heart Outside High
Dose Region
Target and surrounding normal tissues don't necessarily move together – "seeing the normal tissues may be as important as seeing the target" (slide courtesy of David Jaffray)


Volumetric Arc Therapy (VMAT)
IMAT introduced by Yu in 1995 (C. Yu, PMB, 1995)
Re-emergence on linacs made possible by dynamic variation of dose rate during arc delivery
Potential to reduce treatment time significantly (60-70%): may reduce patient discomfort and intrafraction motion
VMAT plan quality is similar to that of IMRT for both target coverage as well as normal tissue doses, including skin doses
C. Yu, "Intensity-modulated arc therapy with dynamic multileaf collimation: an alternative to tomotherapy", PMB: 1995
C. Yu, J. Tang, "Intensity modulated arc therapy: principles, technologies and clinical implementation", PMB: 2011
M. Matuszak et al., "Clinical applications of volumetric modulated arc therapy", Red Journal: 2010
A. Holt et al. "Volumetric-modulated arc therapy for stereotactic body radiotherapy of lung tumors: a comparison with intensity modulated radiotherapy techniques", Red Journal in press


VMAT (RapidArc) Example Case

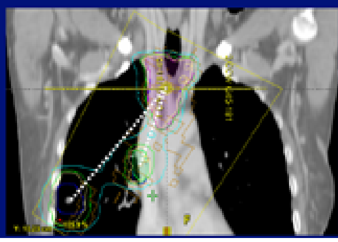

RapidArc (2 partial arcs)
IMRT


DVHs for normal lung and R peripheral PTV
V20 (RA) = 26.4%; MLD = 14.2 Gy
V20 (IMRT) = 27.5%; 14.7 Gy
MU (Time) VMAT = 475 (0.8 min)
MU (Time) IMRT = 1563 (2.6 min)
V5 (RA) = 68%
V5 (IMRT) = 60%
RA
IMRT
IMRT
RA

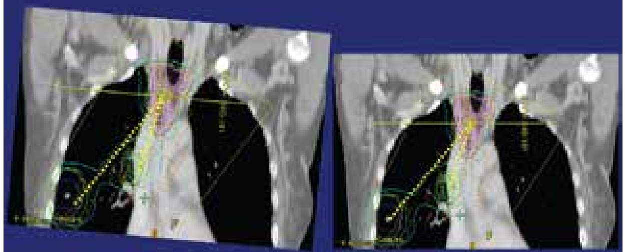
CAVEAT: VMAT for multiple tumors with single isocenter

Accuracy of single isocenter treatments for multiple tumors using VMAT is highly sensitive to patient setup errors

The dosimetric impact on each tumor will depend on the distance of the tumor from the isocenter

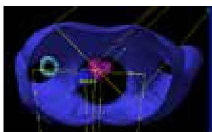


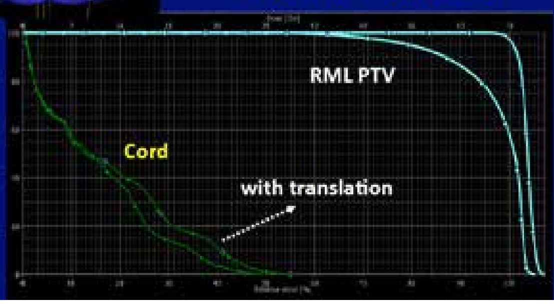
5 deg. rotation setup error: arc length = R x θ



Dosimetric impact of a 0.5 cm translation in each axis

(courtesy Karen Chin (HFHS))





Summary: VMAT

Is dependent on:

- Direction of major tumor motion relative to that of MLC motion
- Amplitude of motion
- Tends to average out over multiple arcs and fractions
- Complexity of intensity modulation

Is similar to the interplay effect observed with IMRT

Overall Summary

Methods for mitigating motion must be applied thoughtfully with careful consideration of the limitations

Margin design must incorporate systematic and random errors, as well as other factors, such as the strength of the surrogate used to image the tumor (recall the *van Herk formalism* for computing the planning margin)

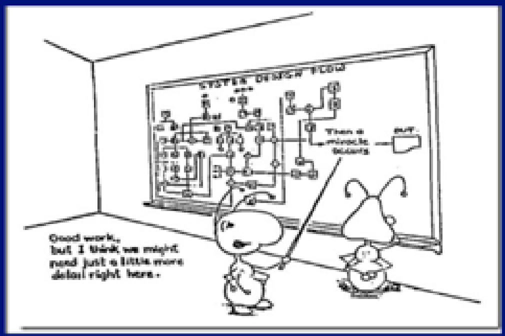
Overall Summary

SBRT planning for different treatment sites, lung, liver, pancreas, spine etc. must incorporate safe tumor doses and normal organ tolerance doses from studies in the literature, and protocols

Lung tissue density impacts tumor dose deposition significantly requiring accurate dose algorithms e.g. convolution/superposition or Monte Carlo; tumor location and size are significant factors

VMAT offers an efficient solution to RT delivery, particularly in the context of SBRT but should be used cautiously with consideration of the impact of setup errors

SBRT: The details are important



http://thenamiracleoccurs.wordpress.com

Acknowledgements

David Jaffray, PhD – Princess Margaret Hospital

Carri Glide-Hurst, PhD - Henry Ford Hospital

Haisen Li, PhD - Henry Ford Hospital

Other colleagues at HFHS

Larry Kestin, MD: Michigan Health Care Professionals: 21st Century Oncology (previously at Beaumont Hospital)

Brian Kavanagh, MD, University of Colorado, Denver

Stan Benedict: UC-Davis

Tim Solberg: Univ of Pennsylvania

Symposium Organizers

Thank you for your attention

Notes

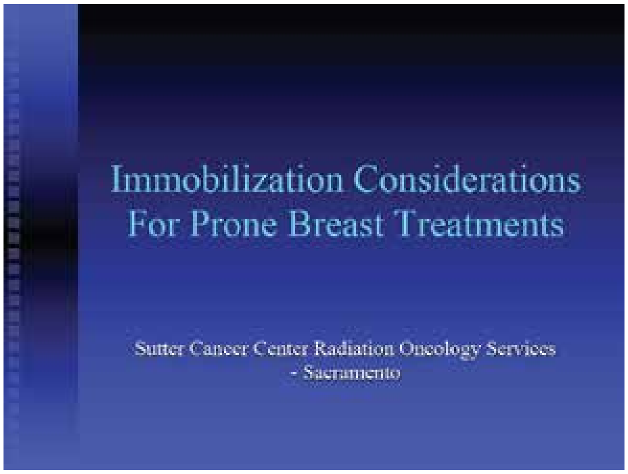
Notes

Friday, March 28, 2014

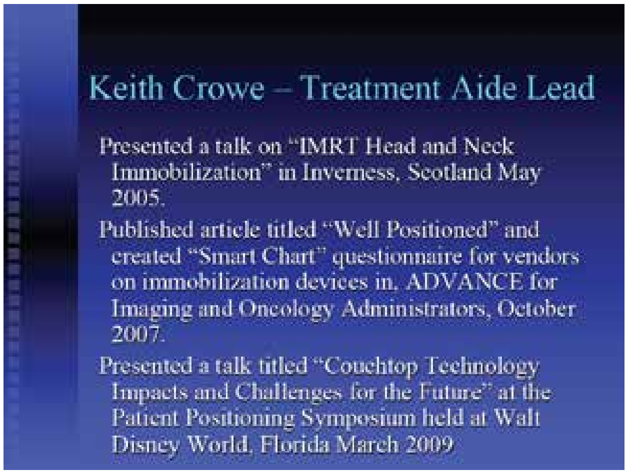
10:00am - 10:45am

Keith Crowe, Treatment Aide Lead

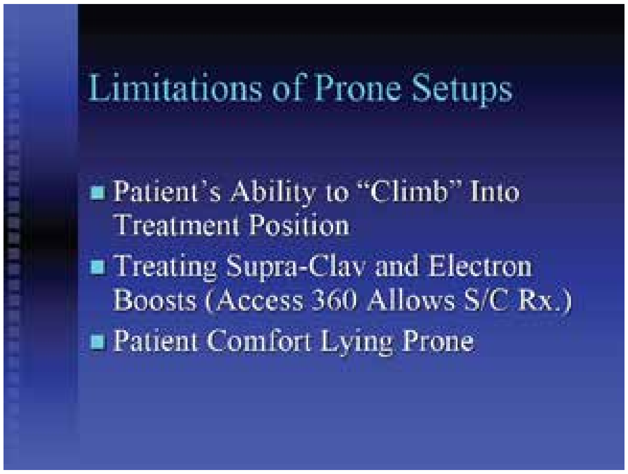
Immobilization Considerations for Prone Breast Treatments


Immobilization Considerations
For Prone Breast Treatments
Sutter Cancer Center Radiation Oncology Services
- Sacramento


Keith Crowe – Treatment Aide Lead
Sutter Cancer Center Radiation Oncology Services – Sacramento
Formerly Radiological Associates of Sacramento (ROC)
25+ Years as a Patient Positioning Expert
Treatment Aide Position Similar to Mould Room Staff in U.K.


Keith Crowe – Treatment Aide Lead
Presented a talk on "IMRT Head and Neck Immobilization" in Inverness, Scotland May 2005.
Published article titled "Well Positioned" and created "Smart Chart" questionnaire for vendors on immobilization devices in, ADVANCE for Imaging and Oncology Administrators, October 2007.
Presented a talk titled "Couchtop Technology Impacts and Challenges for the Future" at the Patient Positioning Symposium held at Walt Disney World, Florida March 2009


Benefits of Prone vs Supine
Little to No Lung in Field
Minimize Skin Fold Reactions
No Heart in Field on Left Sided Treatments
Pendulous Breast is in a More Reproducible Position


Limitations of Prone Setups
Patient's Ability to "Climb" Into Treatment Position
Treating Supra-Clav and Electron Boosts (Access 360 Allows S/C Rx.)
Patient Comfort Lying Prone


Starting Up Prone Program
New Technology Requires Training
Research of Various Techniques
Determining a Simulation Process
Treatment Planning
Feedback From Treatment Machine
Identifying Bottlenecks and Issues on Linac

Difficulties of Setups

- Reproducibility Sup/Inf and Lt/Rt
- Patient Comfort Lying Prone
- Many Prone Patients Are Obese
- Patient Difficulty Getting Into Position
- Contra Lateral Breast Position

Initial Issues Encountered

- Getting the Patient Into Position
- Patient Comfort Lying Prone
- Patient Position Reproducibility
- Patient Movement Due to Discomfort
- Aligning the Patient (Sup/Inf and Lt/Rt)
- Opposite Breast Position Was Inconsistent

Adding a Vacuum Cushion

- One thing was evident to our staff. We needed to use a vacuum cushion with the Access 360 device.
- We considered 3 alternatives.
  - Full Body Cushion
  - Upper Torso Cushion
  - 2 Separate Cushions

Adding a Vacuum Cushion

- Choosing a Cushion Design
  - Full Body and Lower Torso Cushion
    - Full Body is more difficult to use
    - Lower body position had minimal impact on setup reproducibility
  - Upper Torso – Most of the movement we observed was above the waist. Patient was simply not comfortable lying on the padding for a long time

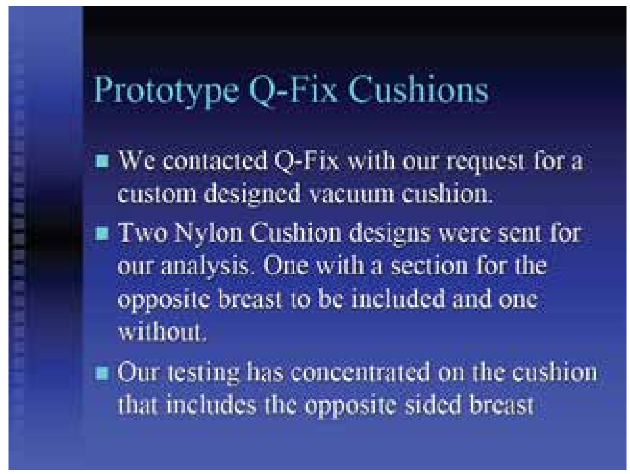
Adding a Vacuum Cushion

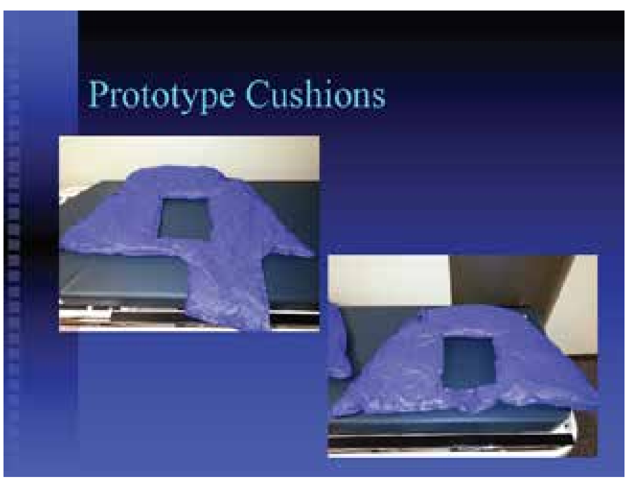
- We remove the upper pink padding on the Access 360 device.

First Cushion Attempt

- Our first cushion was a 100 cm x 70 cm clear Urethane Vac-Loc with the beads pushed out of one quadrant.

Keith Crowe, Treatment Aide Lead





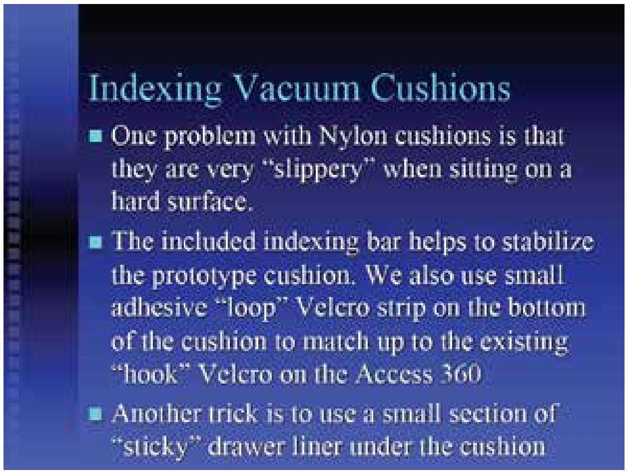

Top View (Embedded Low Face Holder)


Close Up of Low Face Holder

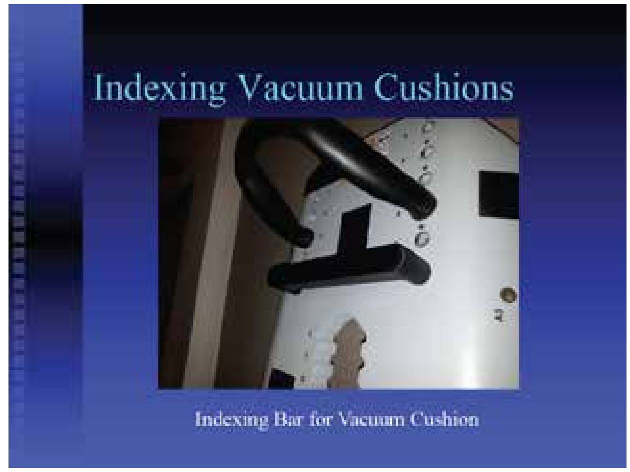

Side View (Patient Left)

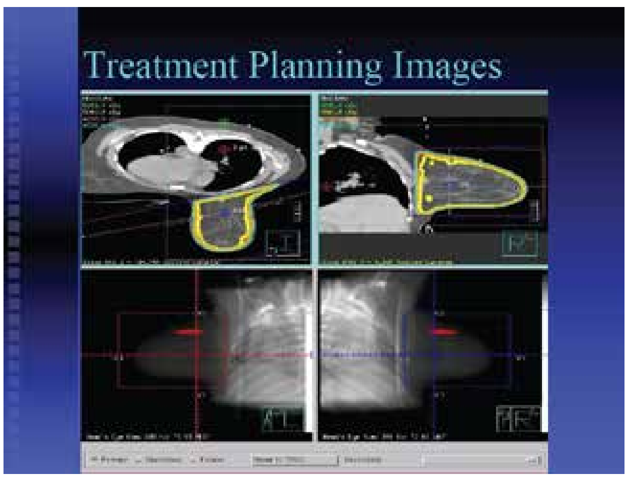

Side View (Patient Right)

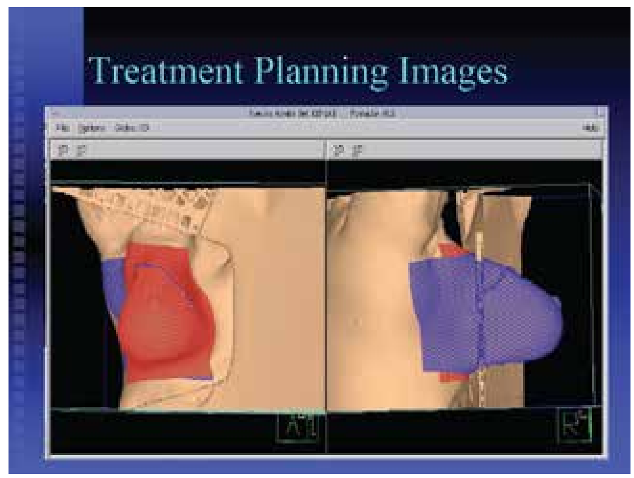

Top View

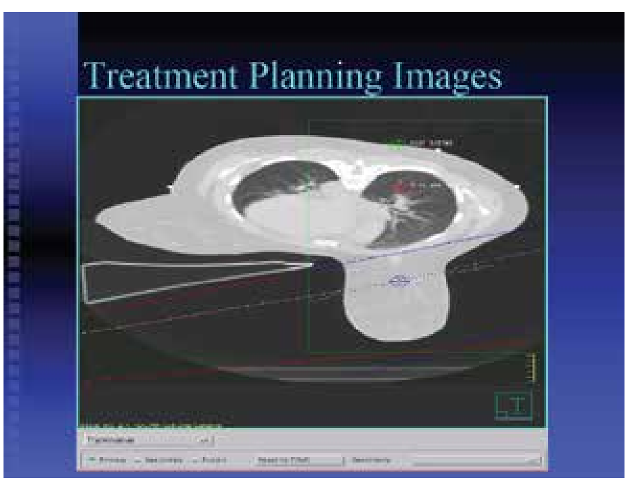

Indexing Vacuum Cushions
One problem with Nylon cushions is that they are very "slippery" when sitting on a hard surface.
The included indexing bar helps to stabilize the prototype cushion. We also use small adhesive "loop" Velcro strip on the bottom of the cushion to match up to the existing "hook" Velcro on the Access 360
Another trick is to use a small section of "sticky" drawer liner under the cushion

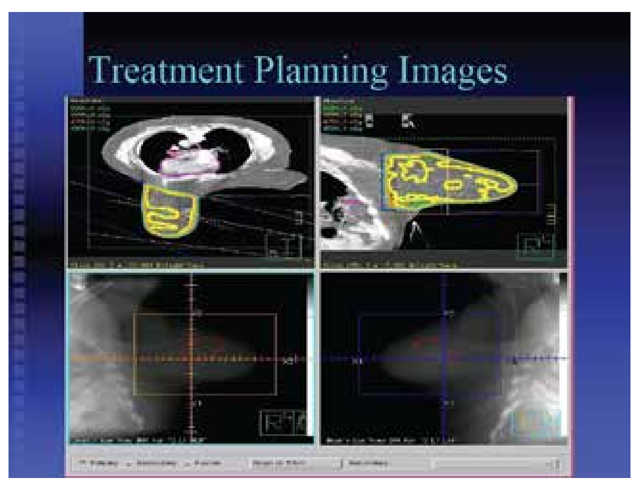

Indexing Vacuum Cushions

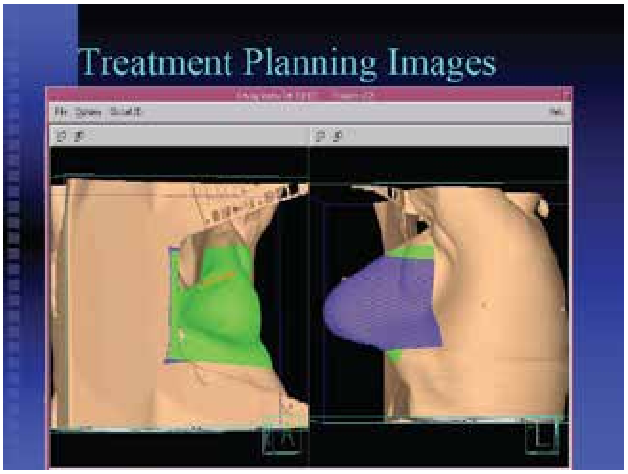

Indexing Vacuum Cushions
Indexing Bar for Vacuum Cushion


Treatment Planning Images


Treatment Planning Images


Treatment Planning Images


Treatment Planning Images



Stable Patient Position

- With the use of an upper immobilization device our patients are able to maintain a very stable position.
- The opposite side breast position has a major impact on daily reproducibility. The patient has an ability to rotate depending on where the opposite breast is positioned.
- The Low Face Holder allows us to vary the height of the Prone pillow to account for larger patients.

Observations

- We have seen a major improvement in patient comfort since using upper torso cushions.
- The patient is able to maintain their position for a longer period.
- Immobilizing the opposite side breast is imperative to reproducibility. It was this daily variation that was causing many issues.

Observations

- The breast must be positioned such that it freely falls into the open area of the Access 360 device. The patient needs to almost “fall” into that area slightly so that there is no beam passing through the center spine area of the device on the Medial tangent field
- The width of the cushion must be closely monitored to avoid gantry collisions.

Observations

- Our clinical trials have shown that an upper body cushion can dramatically improve the daily reproducibility with the Access 360 device.
- It is important that the cushion not raise the patient up and away from the opening.
- We look forward to working with Q-Fix to fine tune the Prone Cushion design.

Notes

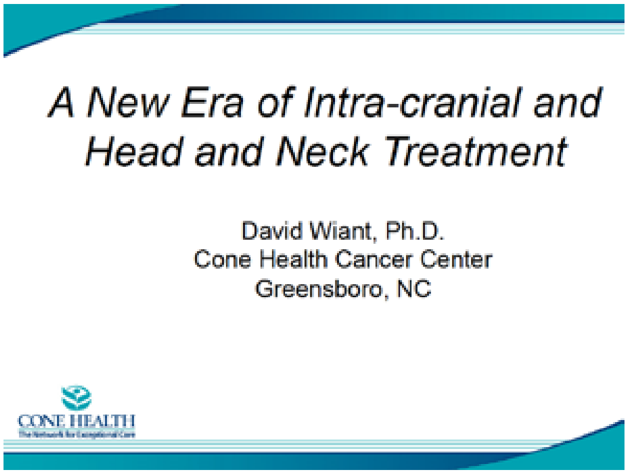
Notes

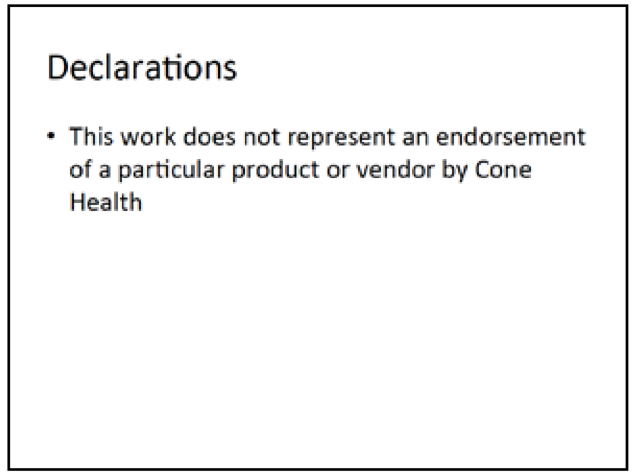
Friday, March 28, 2014

12:00pm - 1:00pm

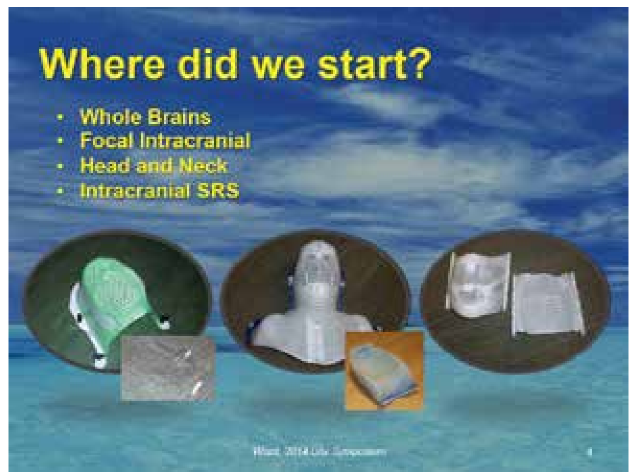
David Wiant, PhD

A New Era of Intra-cranial and Head and Neck Treatment

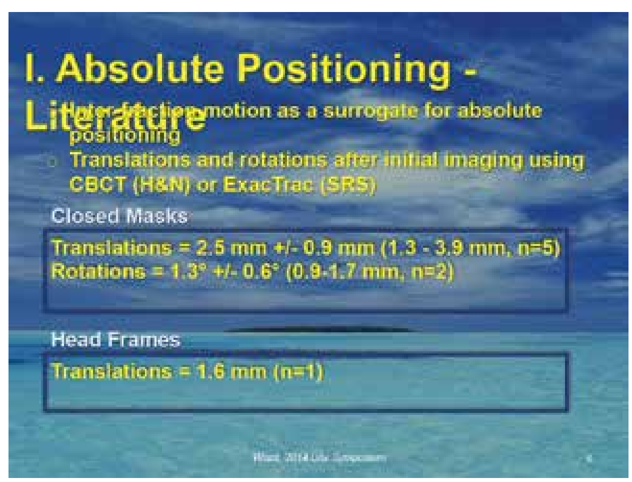

A New Era of Intra-cranial and Head and Neck Treatment
David Wiant, Ph.D.
Cone Health Cancer Center
Greensboro, NC
CONE HEALTH

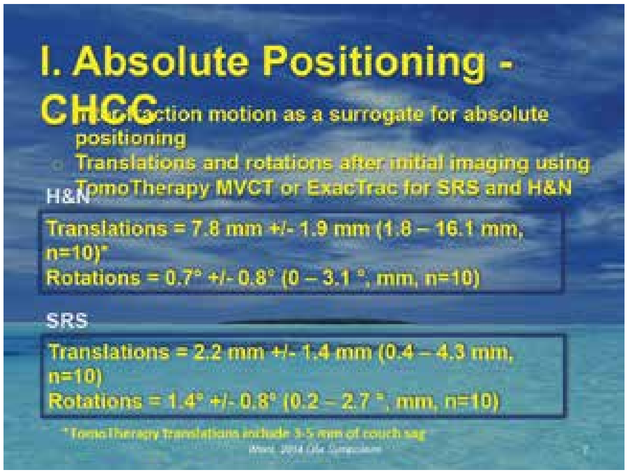

Declarations
• This work does not represent an endorsement of a particular product or vendor by Cone Health


Thanks!
Therapists
• Jehnna Myrick
• Melissa Napier
• Brian Lamonds
• Lenora Sayles
• Crystal Reynolds-Bell
Physicians
• Sarah Squire
• John Moody
• Matt Manning
• Robert Murray
• Stacy Wentworth
• Jim Kinard
Physicists
• Jon Terrell
• Jackie Maurer
• Caroline Vanderstreaten
• Jan Pursley
• BJ Sintay
VisionRT
Qfix
Klarity


Where did we start?
• Whole Brains
• Focal Intracranial
• Head and Neck
• Intracranial SRS

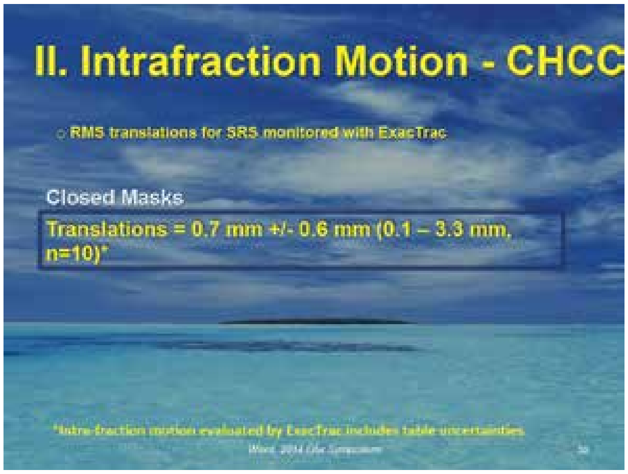

What are the questions?
I. Absolute Positioning
a. Conformation
b. Inter-fraction Motion
II. Intra-fraction Motion
III. Dosimetric Properties
a. Surface Dose
b. Transmission
c. Imaging Artifact
IV. Physical Properties
a. Ease of Use
b. Shrinkage
c. Smell
d. Comfort

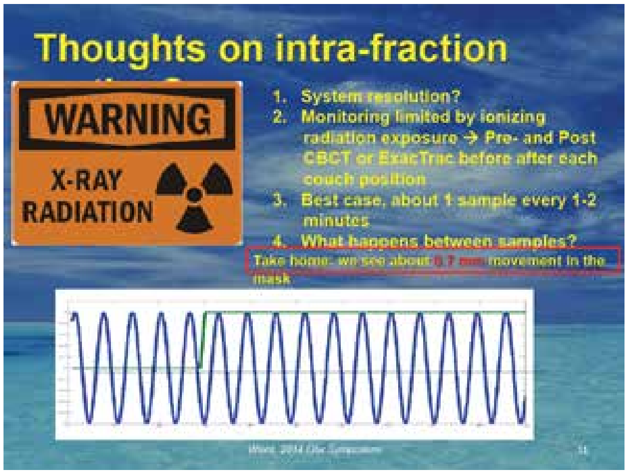

I. Absolute Positioning - Literature
Inter-fraction motion as a surrogate for absolute positioning
Translations and rotations after initial imaging using CBCT (H&N) or ExacTrac (SRS)
Closed Masks
Translations = 2.5 mm +/- 0.9 mm (1.3 - 3.9 mm, n=5)
Rotations = 1.3° +/- 0.6° (0.9-1.7 mm, n=2)
Head Frames
Translations = 1.6 mm (n=1)


I. Absolute Positioning - CHCC
ction motion as a surrogate for absolute positioning
Translations and rotations after initial imaging using TomoTherapy MVCT or ExacTrac for SRS and H&N
H&N
Translations = 7.8 mm +/- 1.9 mm (1.8 – 16.1 mm, n=10)*
Rotations = 0.7° +/- 0.8° (0 – 3.1 °, mm, n=10)
SRS
Translations = 2.2 mm +/- 1.4 mm (0.4 – 4.3 mm, n=10)
Rotations = 1.4° +/- 0.8° (0.2 – 2.7 °, mm, n=10)
*TomoTherapy translations include 3-5 mm of couch sag

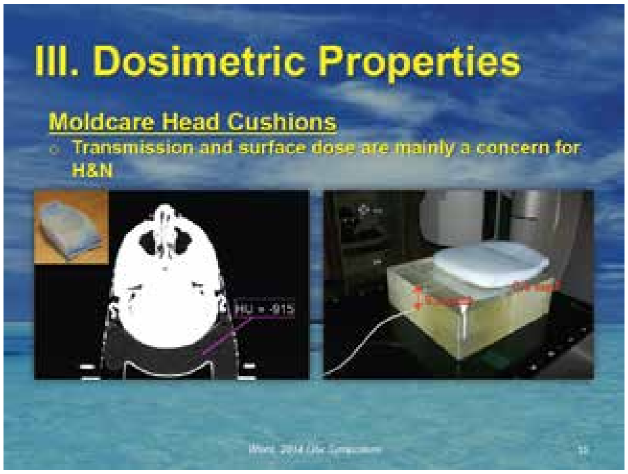

Does this tell us how much the patient is moving in the mask?
SRS: 2-3 mm
H&N: 3-4
We probably see about 2 mm, 1° change in absolute position inside the mask

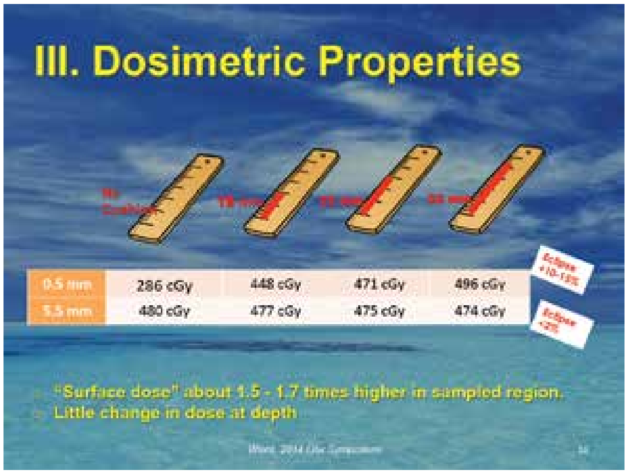

II. Intrafraction Motion - Literature
RMS translations for SRS and H&N monitored with pre- and post- CBCT and ExacTrac
Closed Masks
Translations = 0.8 mm +/- 0.3 mm (0.25 – 1.4 mm, n=13)
Head Frames
Translations = 0.7 mm +/- 0.4 mm (0.25 – 1 mm, n=3)


II. Intrafraction Motion - CHCC
RMS translations for SRS monitored with ExacTrac
Closed Masks
Translations = 0.7 mm +/- 0.6 mm (0.1 – 3.3 mm, n=10)*
*Intra-fraction motion evaluated by ExacTrac includes table uncertainties

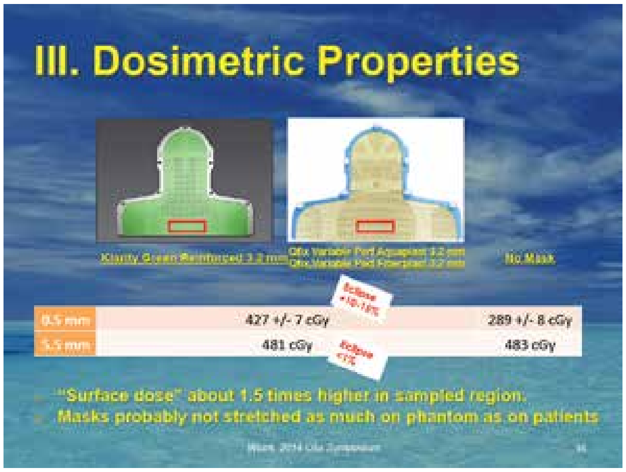

Thoughts on intra-fraction
WARNING
X-RAY RADIATION
1. System resolution?
2. Monitoring limited by ionizing radiation exposure → Pre- and Post CBCT or ExacTrac before after each couch position
3. Best case, about 1 sample every 1-2 minutes
4. What happens between samples?
Take home: we see about 0.7 mm movement in the mask


Positioning/Intrafraction Motion


III. Dosimetric Properties
Moldcare Head Cushions
Transmission and surface dose are mainly a concern for H&N
HU = -915

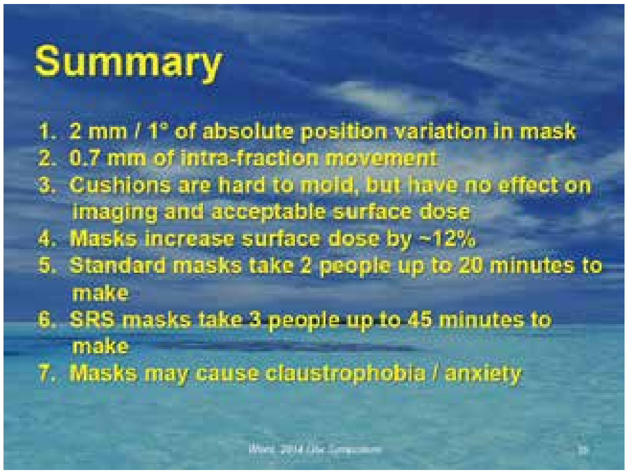

III. Dosimetric Properties
0.5 mm
286 cGy
448 cGy
471 cGy
496 cGy
5.5 mm
480 cGy
477 cGy
475 cGy
474 cGy
"Surface dose" about 1.5 - 1.7 times higher in sampled region.
Little change in dose at depth


III. Dosimetric Properties
Masks
Transmission and surface dose are mainly a concern for H&N

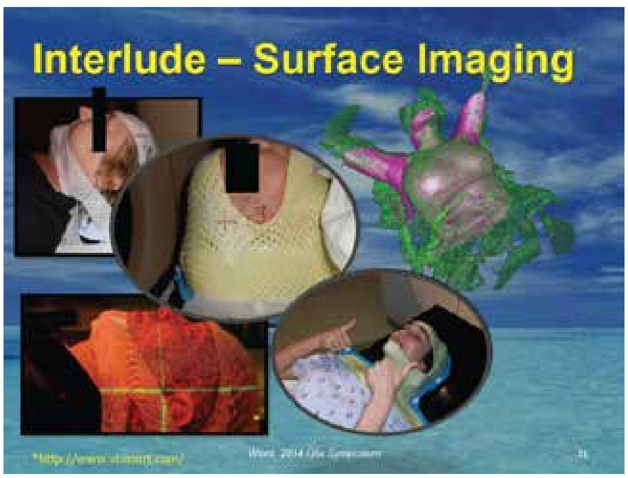

III. Dosimetric Properties
No Mask
0.5 mm
427 +/- 7 cGy
289 +/- 8 cGy
5.5 mm
481 cGy
483 cGy
"Surface dose" about 1.5 times higher in sampled region.
Masks probably not stretched as much on phantom as on patients

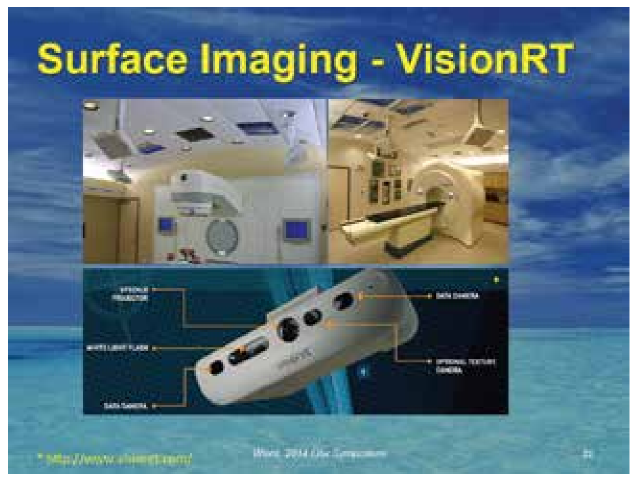

IV. Physical Properties
Head Cushions
Easily moldable when wet
~5 minutes to dry
Not reusable / re-formable
Difficult to mold tightly to head. Need at least 2 people actively involved
Odor when wet

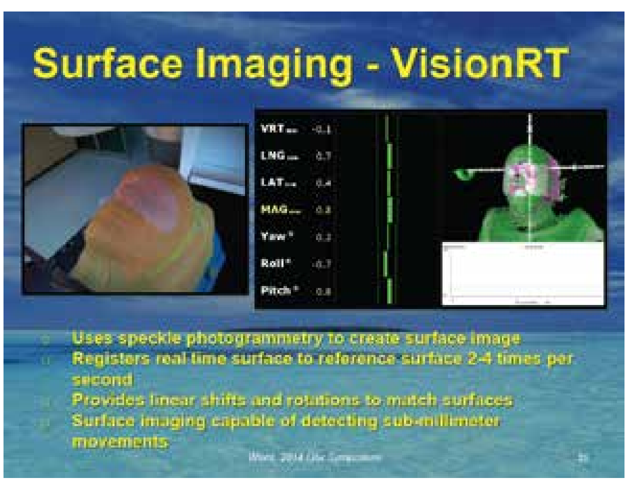

IV. Physical Properties
Masks
Intracranial / H&N
5-10 minutes to dry
Slight shrinkage (may use spacer in sim)
2 people needed for placement
May cause claustrophobia / anxiety
SRS
2-piece mask takes 30 minutes to dry
Minimal shrinkage (always use spacer)
3 people needed for placement
May cause claustrophobia / anxiety

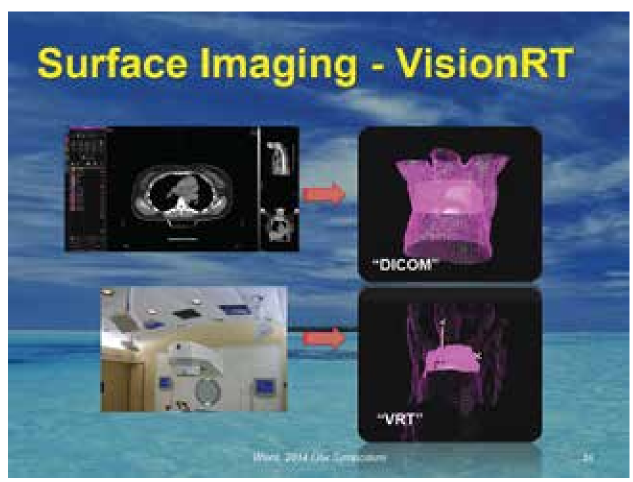

Summary
1. 2 mm / 1° of absolute position variation in mask
2. 0.7 mm of intra-fraction movement
3. Cushions are hard to mold, but have no effect on imaging and acceptable surface dose
4. Masks increase surface dose by ~12%
5. Standard masks take 2 people up to 20 minutes to make
6. SRS masks take 3 people up to 45 minutes to make
7. Masks may cause claustrophobia / anxiety


Where Are We Going?


Interlude – Surface Imaging
*http://www.visionrt.com/

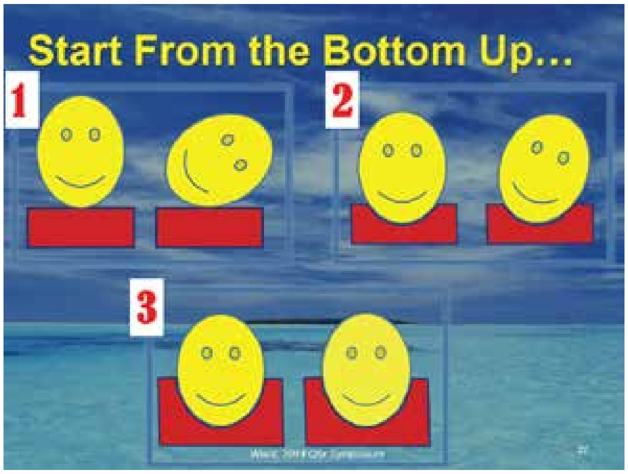

Surface Imaging - VisionRT
* http://www.visionrt.com/


Surface Imaging - VisionRT
VRT
LNG
LAT
MAG
Yaw °
Roll °
Pitch °
Uses speckle photogrammetry to create surface image
Registers real time surface to reference surface 2-4 times per second
Provides linear shifts and rotations to match surfaces
Surface imaging capable of detecting sub-millimeter movements


Surface Imaging - VisionRT
"DICOM"
"VRT"

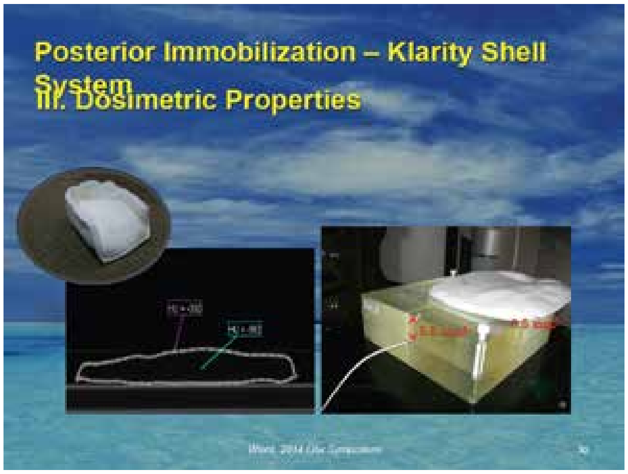

Masks – Do we need them?
Forced Motion
vs.
"Resting Motion"
vs.
Diligence

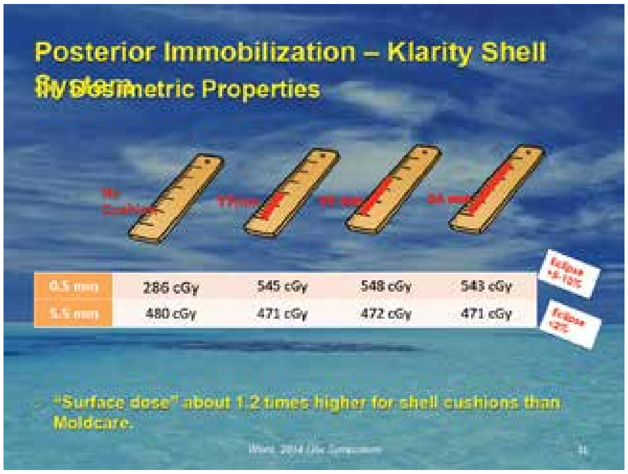

Masks – Do we need them?
Personal Opinions
1 . Whole Brains – No
2. SRS – Probably Not, but I'd use one
3. Definitive Intracranial or H&N - Yes


Start From the Bottom Up…
1
2
3


Posterior Immobilization – Mayo Mold
<0.7 mm motion over 20 minutes*
Comfortable
Logistical difficulties with building and disposal
Not easy to put mask over mold


Posterior Immobilization – Klarity Shell System

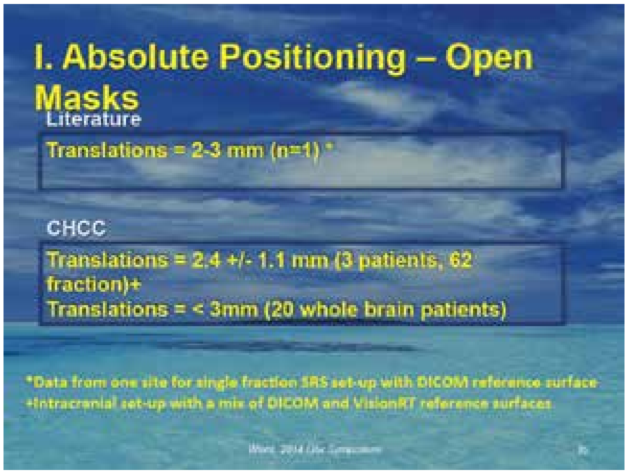

Posterior Immobilization – Klarity Shell System
III. Dosimetric Properties

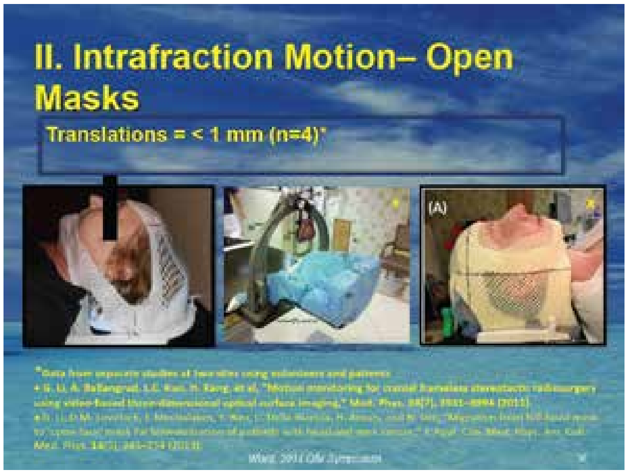

Posterior Immobilization – Klarity Shell
Dosimetric Properties
0.5 mm
286 cGy
545 cGy
548 cGy
543 cGy
5.5 mm
480 cGy
471 cGy
472 cGy
471 cGy
Eclipse +8-10%
Eclipse <2%
"Surface dose" about 1.2 times higher for shell cushions than Moldcare.

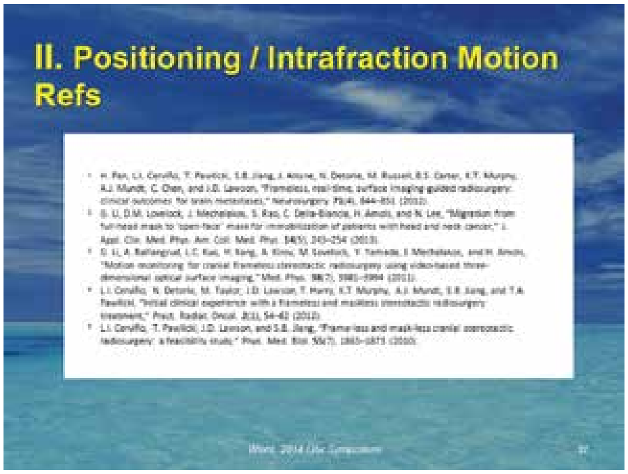

Posterior Immobilization – Klarity Shell
Physical Properties
Allows for tapered top edges for good mask fit
Acceptable dosimetric properties for certain applications
Easy disposal
No odor
Dry heat
Reformable / Reusable
1 person to form mold in about 15 mins
Reasonable fit

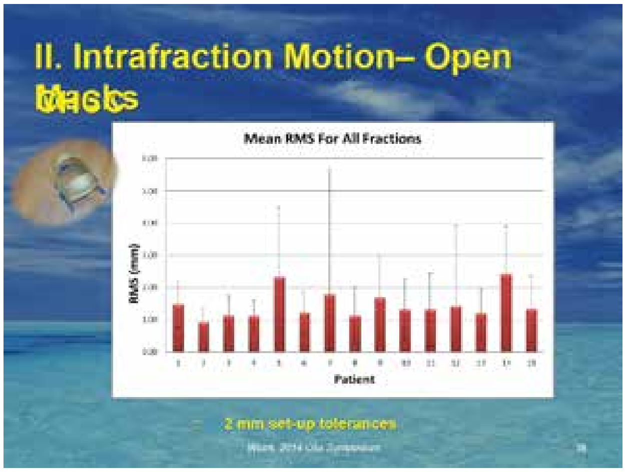

Posterior Immobilization -
Physical Properties
Allows for tapered top edges for good mask fit
Acceptable dosimetric properties
Easy disposal
1 person to form mold in about 10 minutes
Does not always give tight fit
Some odor when wet

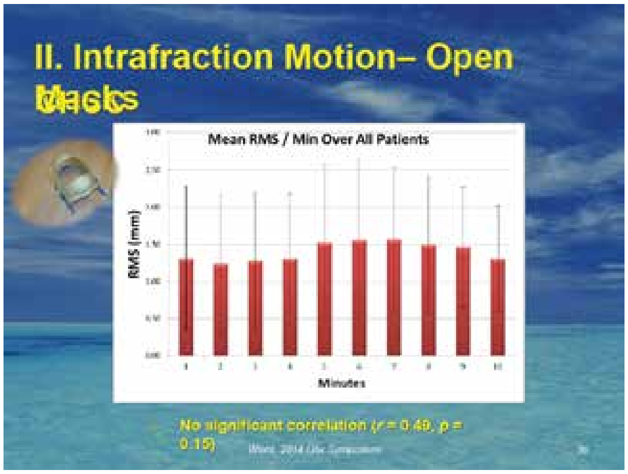

Open Masks

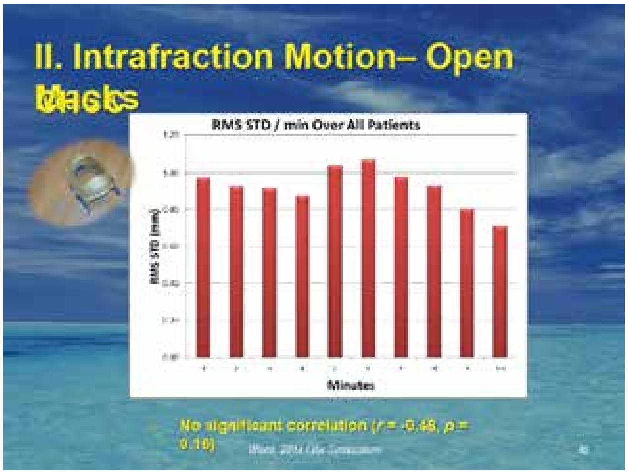

I. Absolute Positioning – Open Masks
Literature
Translations = 2-3 mm (n=1) *
CHCC
Translations = 2.4 +/- 1.1 mm (3 patients, 62 fraction)+
Translations = < 3mm (20 whole brain patients)
*Data from one site for single fraction SRS set-up with DICOM reference surface
+Intracranial set-up with a mix of DICOM and VisionRT reference surfaces

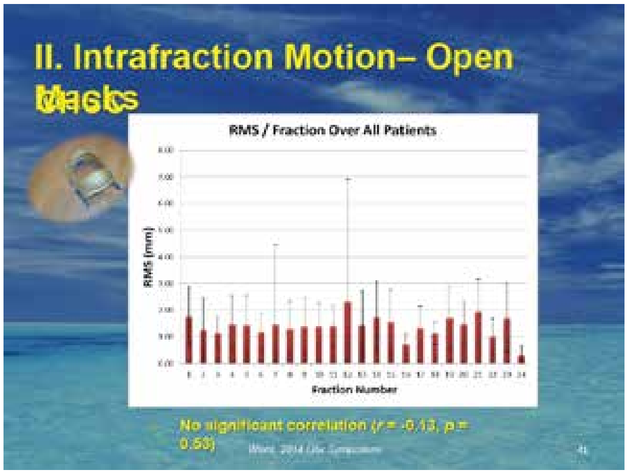

II. Intrafraction Motion– Open Masks
Translations = < 1 mm (n=4)*
(A)

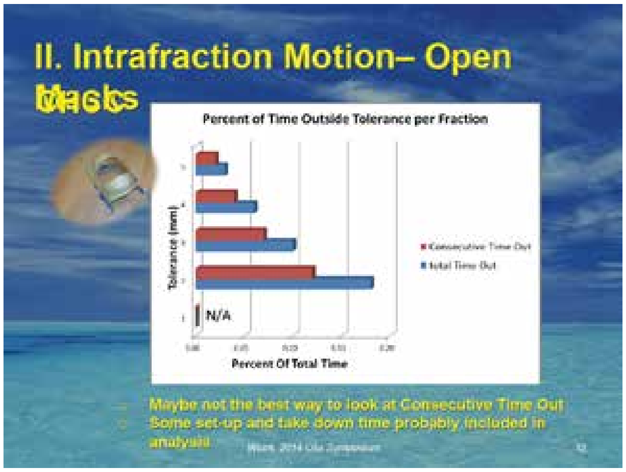

II. Positioning / Intrafraction Motion Refs
H. Pan, L.I. Cervino, T. Pawlicki, S.B. Jiang, J. Alksne, N. Detorie, M. Russell, B.S. Carter, K.T. Murphy, A.J. Mundt, C. Chen, and J.D. Lawson, "Frameless, real-time, surface imaging-guided radiosurgery: clinical outcomes for brain metastases," Neurosurgery 71(4), 844–851 (2012).
G. Li, D.M. Lovelock, J. Mechalakos, S. Rao, C. Della-Biancia, H. Amols, and N. Lee, "Migration from full-head mask to 'open-face' mask for immobilization of patients with head and neck cancer," J. Appl. Clin. Med. Phys. 14(5), 243–254 (2013).
G. Li, A. Ballangrud, L.C. Kuo, H. Kang, A. Kirov, M. Lovelock, Y. Yamada, J. Mechalakos, and H. Amols, "Motion monitoring for cranial frameless stereotactic radiosurgery using video-based three-dimensional optical surface imaging," Med. Phys. 38(7), 3981–3994 (2011).
L.I. Cervino, N. Detorie, M. Taylor, J.D. Lawson, T. Harry, K.T. Murphy, A.J. Mundt, S.B. Jiang, and T.A. Pawlicki, "Initial clinical experience with a frameless and maskless stereotactic radiosurgery treatment," Pract. Radiat. Oncol. 2(1), 54–62 (2012).
L.I. Cervino, T. Pawlicki, J.D. Lawson, and S.B. Jiang, "Frame-less and mask-less cranial stereotactic radiosurgery: a feasibility study," Phys. Med. Biol. 55(7), 1863–1873 (2010).
Wiant, 2014 Ula Symposium

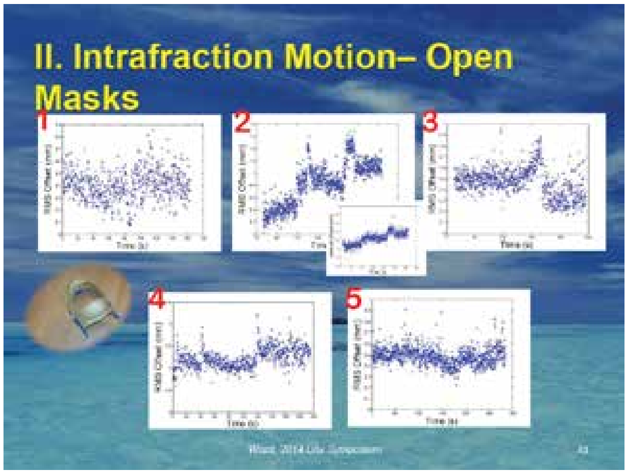

II. Intrafraction Motion– Open Masks
Mean RMS For All Fractions
RMS (mm)
Patient
2 mm set-up tolerances
Wiant, 2014 Ula Symposium

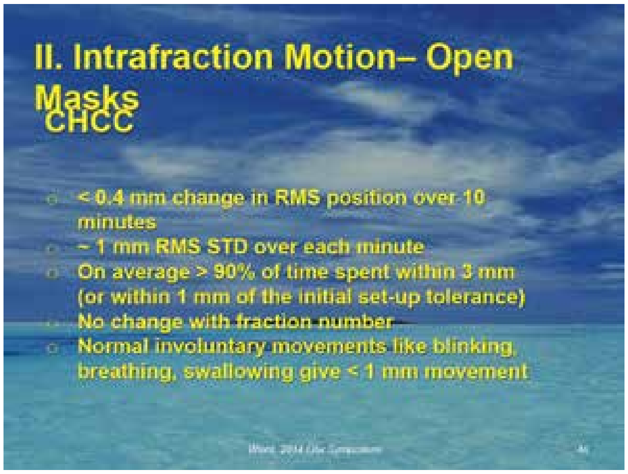

II. Intrafraction Motion– Open Masks
Mean RMS / Min Over All Patients
RMS (mm)
Minutes
No significant correlation (r = 0.49, p = 0.15)
Wiant, 2014 Ula Symposium


II. Intrafraction Motion– Open Masks
RMS STD / min Over All Patients
RMS STD (mm)
Minutes
No significant correlation (r = -0.48, p = 0.16)
Wiant, 2014 Ula Symposium


II. Intrafraction Motion– Open Masks
RMS / Fraction Over All Patients
RMS (mm)
Fraction Number
No significant correlation (r = -0.13, p = 0.53)
Wiant, 2014 Ula Symposium

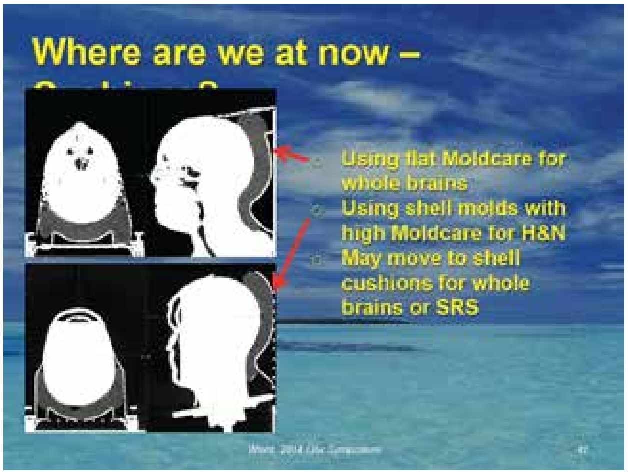

II. Intrafraction Motion– Open Masks
Percent of Time Outside Tolerance per Fraction
Tolerance (mm)
N/A
Percent Of Total Time
Consecutive Time Out
Total Time Out
Maybe not the best way to look at Consecutive Time Out
Some set-up and take down time probably included in analysis
Wiant, 2014 Ula Symposium


II. Intrafraction Motion– Open Masks
1
2
3
4
5


II. Intrafraction Motion– Open Masks
CHCC
< 0.4 mm change in RMS position over 10 minutes
~ 1 mm RMS STD over each minute
On average > 90% of time spent within 3 mm (or within 1 mm of the initial set-up tolerance)
No change with fraction number
Normal involuntary movements like blinking, breathing, swallowing give < 1 mm movement


III. Dosimetric Properties – Open Masks
Qfix Assure Open View 2.4 mm
Qfix Assure Open View 3.2 mm
No Mask
0.5 mm 448 cGy 487 cGy 289 cGy
5.5 mm 481 cGy 480 cGy 483 cGy
Surface dose 4-5% higher for 2.4 mm and 12-13% higher for 3.2 mm than current masks (427 cGy for current masks)


IV. Physical Properties – Open Masks
Intracranial / SRS
2-3 minutes to dry
Slight shrinkage (may use spacer in sim)
2 people needed for placement – easy placement w/ split frame
May reduce claustrophobia / anxiety
H&N
2-3 minutes to dry
Slight shrinkage (may use spacer in sim)
3 people needed for placement – hard to make, no split frame
May reduce claustrophobia / anxiety


Where are we at now –
Using flat Moldcare for whole brains
Using shell molds with high Moldcare for H&N
May move to shell cushions for whole brains or SRS

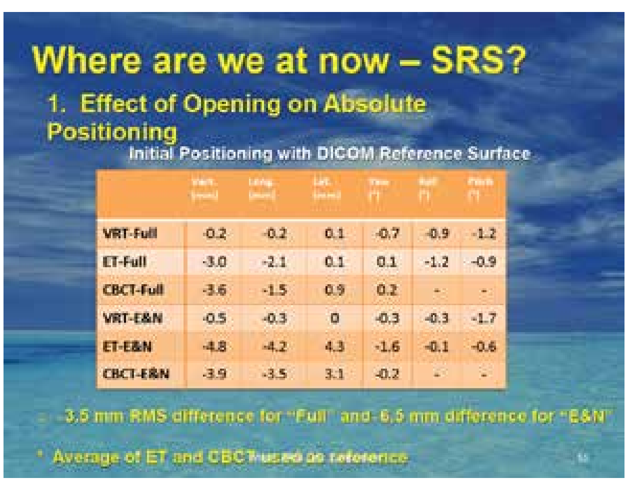

Where are we at now – Whole Brain?
All patients treated with 3.2 mm Assure Open View masks
All patients treated with "flat" Moldcare cushions
All patients monitored with surface imaging


Where are we at now – H & N?
50 patients randomized to 2 groups
Group 1
Current standard of care with closed masks
Weekly survey rating anxiety and claustrophobia
VS.
Group 2
Shoulder length 2.4 mm Assure Open masks
"High" Moldcare with shell mold
Portrait frame with hand grips
Positioning and monitoring with surface imaging


Where are we at now – H & N?
Research Questions
1. Can surface imaging be used to supplement or replace CBCT for daily absolute localization?
2. Do open masks provide adequate intrafraction immobilization over protracted courses of treatment (25+ fractions)?
3. Do open masks show indications of claustrophobia or anxiety reduction?
VS.

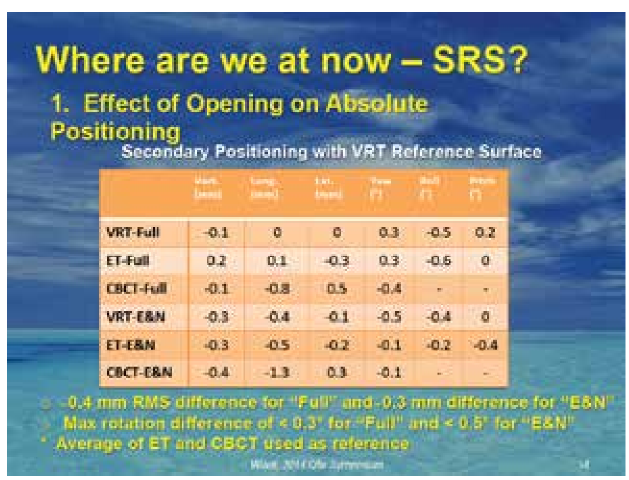

Where are we at now – SRS?
Pre-Clinical Research
1. How does the size of the opening affect absolute positioning?
2. How does the size of the opening affect monitoring at non-zero couch angles?


Where are we at now – SRS?
1. Effect of Opening on Absolute Positioning
"Full Face"
"Eyes and Nose"
VS.


Where are we at now – SRS?
1. Effect of Opening on Absolute Positioning
Initial Positioning with DICOM Reference Surface

	Vert. (mm)	Long. (mm)	Lat. (mm)	Yaw (°)	Roll (°)	Pitch (°)
VRT-Full	-0.2	-0.2	0.1	-0.7	-0.9	-1.2
ET-Full	-3.0	-2.1	0.1	0.1	-1.2	-0.9
CBCT-Full	-3.6	-1.5	0.9	0.2	-	-
VRT-E&N	-0.5	-0.3	0	-0.3	-0.3	-1.7
ET-E&N	-4.8	-4.2	4.3	-1.6	-0.1	-0.6
CBCT-E&N	-3.9	-3.5	3.1	-0.2	-	-

~3.5 mm RMS difference for "Full" and ~6.5 mm difference for "E&N"
* Average of ET and CBCT used as reference


Where are we at now – SRS?
1. Effect of Opening on Absolute Positioning
Secondary Positioning with VRT Reference Surface

	Vert. (mm)	Long. (mm)	Lat. (mm)	Yaw (°)	Roll (°)	Pitch (°)
VRT-Full	-0.1	0	0	0.3	-0.5	0.2
ET-Full	0.2	0.1	-0.3	0.3	-0.6	0
CBCT-Full	-0.1	-0.8	0.5	-0.4	-	-
VRT-E&N	-0.3	-0.4	-0.1	-0.5	-0.4	0
ET-E&N	-0.3	-0.5	-0.2	-0.1	-0.2	-0.4
CBCT-E&N	-0.4	-1.3	0.3	-0.1	-	-

~0.4 mm RMS difference for "Full" and ~0.3 mm difference for "E&N"
Max rotation difference of < 0.3° for "Full" and < 0.5° for "E&N"
* Average of ET and CBCT used as reference

Where are we at now – SRS?

2. VRT versus ET at non-zero couch angles

Where are we at now – SRS?

2. VRT versus ET at non-zero couch angles

Differences Between VRT and ET for Full Mask

Couch Angle [°]	Vert. [mm]	Long. [mm]	Lat. [mm]	Yaw [°]	Roll [°]	Pitch [°]	RMS [mm]
0	0.1	0	-0.1	-0.1	0	0	0.1
30	-0.1	0	0	0.2	-0.1	-0.2	0.2
60	-0.2	0.2	0.5	-0.1	-0.5	0.2	0.6
90	-0.2	0.2	0.6	-0.3	-0.3	0.1	0.6
330	0	0	-0.1	0.2	-0.3	0.2	0.1
300	-0.3	-0.2	-0.4	-0.5	0.2	-0.1	0.5
270	-0.3	-0.2	-0.7	0	-0.1	0.1	0.7

- 36 measurements made at 7 different couch angles
- 0-2 mm offsets were made with the couch

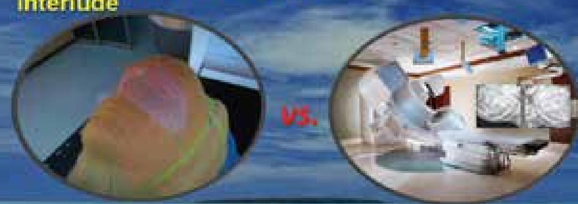
Where are we at now – SRS?

Another Surface Imaging Interlude

- The "full" masks gave more stable surface image readings (+/- 0.1 mm) than the eyes and nose masks (+/- 0.5 mm)
- ET had +/- 0.2 changes in shifts with repeated

Where are we at now – SRS?

Another Surface Imaging Interlude



- Surface imaging and ET were in almost perfect agreement at couch angles within +/- 30°
- The surface imaging system more accurately detected translations at couch angles within +/- 30°

Where are we at now – SRS?

Another Surface Imaging Interlude

- At couch angles outside of +/- 30° surface imaging had a ~0.5-1 mm systematic offset
- It's not clear whether our system is not functioning properly or the system cannot handle couch positions outside 30°

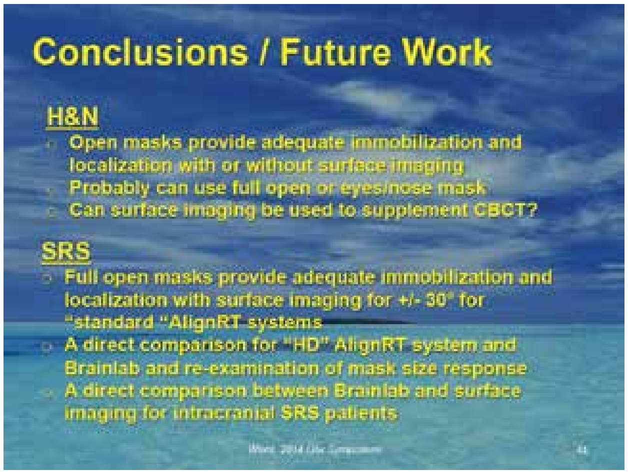
Conclusions / Future Work

Whole Brain

- Open masks provide adequate immobilization and localization with or without surface imaging
- "High" posterior immobilization without mask and with surface imaging is a possibility - Make volunteer motion measurements in this set-up

Intracranial

- Open masks provide adequate immobilization and localization with or without surface imaging
- Can surface imaging be used to supplement CBCT?


Conclusions / Future Work
H&N
Open masks provide adequate immobilization and localization with or without surface imaging
Probably can use full open or eyes/nose mask
Can surface imaging be used to supplement CBCT?
SRS
Full open masks provide adequate immobilization and localization with surface imaging for +/- 30° for "standard "AlignRT systems
A direct comparison for "HD" AlignRT system and Brainlab and re-examination of mask size response
A direct comparison between Brainlab and surface imaging for intracranial SRS patients


Questions?

Notes

Friday, March 28, 2014

2:00pm - 3:00pm

Andrew Wroe, PhD, D.A.B.R.

Immobilization Techniques in Proton Therapy

Proton Therapy Immobilization How is it different to photons?

Andrew Wroe PhD DABR

Department of Radiation Medicine, Loma Linda University Medical Center

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Disclosure

I have not had a personal financial relationship with the manufacturer of products or services discussed in this presentation.

All material discussed is based on experience and scientific merit.

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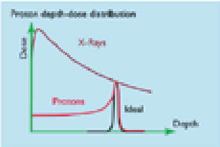
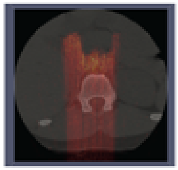
Outline

» Proton Therapy Introduction
- History
- Bragg Peak
- Finite Range



» Proton Therapy Immobilization Considerations
- Range Uncertainty
- Part to Part Variability
- Time Stability
- Edge Effects
- CT Uncertainty
- External Immobilization
- Internal Immobilization



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Outline

» Immobilization Solutions at LLUMC
- POD
- Bite Block
- BoS
- SDX
- Rectal Balloon

» Benefits of Department Wide Solutions
- Standardization for Combo Treatments
- Accuracy
- Cost Effectiveness

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History and LLUMC

» First proposed by Robert Wilson in 1946 and was developed in its first 2 decades at 5 centers world wide

» Slow initial progress because of limited advancements in imaging, treatment planning and dosimetry.

» Improvements in these areas have resulted in an explosion in proton therapy

» LLUMC was the first hospital based proton therapy center in 1990 with almost 18,000 patients treated since opening

» Currently there are over 30 operating proton therapy facilities worldwide with plans for a further 22

» Today over 50,000 patients have been treated with protons world wide

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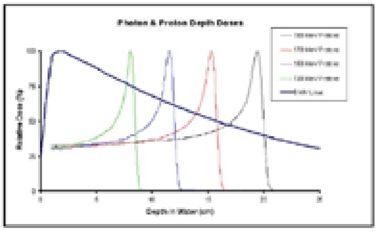
Why Protons?

» Protons are a useful tool in radiation therapy as they produce a high dose region in the patient

» This high dose region can be placed anywhere by varying the protons energy

» Protons stop

» Low entrance dose



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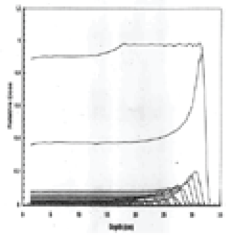
How do you treat with a Bragg Peak?

- A Bragg peak gives a very narrow high dose region
- To treat a volume that may be multiple centimeters thick we spread out the Bragg peak (SOBP)
- Achieved by superimposing many Bragg peaks of different energy and intensity
- The SOBP creates a uniform dose region for treating a volume
- Can be achieved passively or dynamically
- The SOBP width can be made to suit the volume being treated



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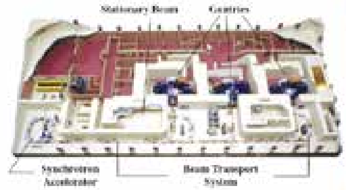
Facility Design

- Built around a central accelerator used to deliver protons of 200-300 MeV
- Gantries allow for beam delivery 360 degrees around the patient providing more treatment options for clinicians
- A precision couch allows for alignment of patients with 6-degrees of freedom
- An onboard imaging device allows for the position of the patient to be verified



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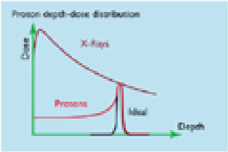
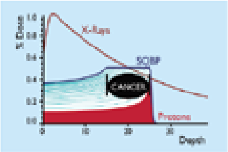
Immobilization Impact

- As with photons both external and internal immobilization effects our ability to hit a specific target
- In proton therapy anything located upstream of the target and in the beam path can impact the depth of the distal edge
- This includes immobilization devices
- **In proton therapy you need to remember the third-dimension!**





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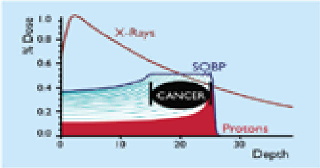
PT Immobilization - Range Uncertainty

- Uncertainty in the Bragg peak position, (or more correctly the SOBP distal edge) is an important issue for proton therapy



- Overestimation in proton range can lead to irradiation of normal tissue
- Underestimation of proton range required can lead to under-dosing of the target volume

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PT Immobilization - Range Uncertainty

- Multiple factors can contribute to range uncertainty including:
  - Errors in conversion of CT # to electron density to proton stopping power
  - Immobilization device part to part variability
  - Changing patient body contour
- Typically the range uncertainty for proton therapy is accepted as 3% of the protons total range.
- Immobilization devices located upstream of the target can contribute to this uncertainty.

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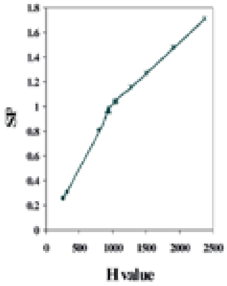
PT Immobilization – CT Uncertainty

- CT imaging is the basis of our dose calculation in photon and proton therapy
- In proton/photon therapy HU are converted to electron density
- For proton therapy an additional conversion of electron density to proton stopping power is complete.
- As the proton range calculation is dependant on this conversion, errors in this calculation can lead to errors in the proton range



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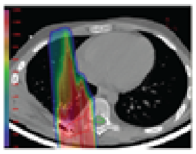
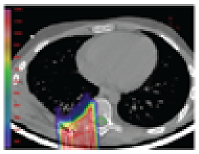
PT Immobilization – CT Uncertainty

- CT scanners are useful at deriving material information a range of tissues
- Materials that do not lie on the CT calibration curve can be difficult to image accurately
- Material choices for immobilization devices are key for accurate imaging
- For all immobilization devices the CT generated proton water equivalent thickness (WET) should be experimentally verified prior to clinical use





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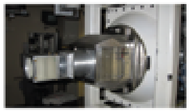
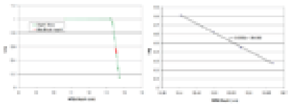
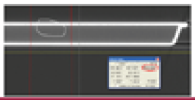
PT Immobilization – CT Uncertainty







- Measuring the water equivalent thickness is completed at LLUMC using precision range shifters
- The shift in the distal edge position with a immobilization device placed upstream of the detector is recorded and the water equivalent thickness determined
- This data is then compared to CT scans and treatment planning data to ensure accuracy

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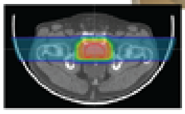
PT Immobilization – Part to Part Variability

- Part to part variability can impact range uncertainty if the patient is scanned using one immobilization device (i.e. a table top) and treated on a different device.
- Loma Linda has overcome this by having a patient specific POD which travelled with the patient.
- As the patient was scanned and treated in the same device any part to part variability was accounted for
- The difficulty with this system is storage space



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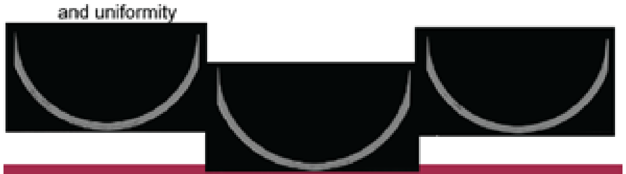
PT Immobilization – Part to Part Variability

- Today we are moving to a modular system where a specific device (i.e. POD, table-top, BoS insert etc) is located in a specific room (i.e. CT, proton etc).
- These devices must be interchangeable such that the patient treatment plan is an accurate representation of delivery.
- Device characteristics to check include dimensions, density, and uniformity



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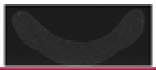
PT Immobilization – Time Stability

- Moldable devices such as the MoldCare cushion offer an increased level of customization to the immobilization process
- In proton therapy such devices should only be scanned once the internal composition has stabilized to minimize range errors
- MoldCare cushions need to dry out to have a uniform internal structure
- Studies at LLUMC suggest this takes 24 hours
- If the CT is completed prior to this, density correction is needed to ensure the treatment plan reflects the conditions on treatment day

0 hr

6 hr



24 hr

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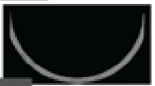
PT Immobilization – Non-uniformity

- Non uniformity in an immobilization device should be avoided
- Device non-uniformity can include low/high density regions in manufactured devices or folds in patient specific devices such as vac-lock bags.
- Non-uniformities can shift relative to the patient daily.
- Shifts in non-uniformities can compromise beam range relative to patient anatomy.



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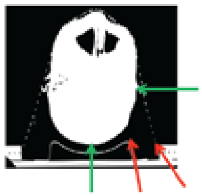
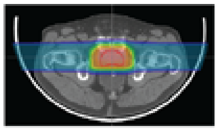
PT Immobilization - Edge Effects

» Edge effects refer to passing the beam across edges or along boundaries

» Shifts in the patient relative to the boundary on a daily basis can impact the proton range





» Beams that pass half through a device are also problematic

» Proton beams should pass entirely through an immobilization device / table top and allow for setup uncertainty

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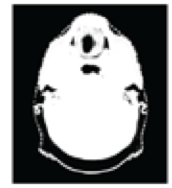
PT Immobilization - Edge Effects

» Edge effects can be minimized through planning guidelines and immobilization design

» Low profile mask frames allow for a wider range of beam angles to be used in patient treatment with minimal impact on range uncertainty



» Beveled edges allow for minimal impact on range uncertainty

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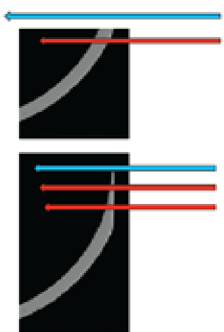
PT Immobilization – Beveled Edges



» A beam which crosses an immobilization boundary can introduce significant range error if the target/patient moves relative to the immobilization structure

» Beveled edges reduce any range uncertainty with patient position relative to the edge. Beams that cross these boundaries can deliver acceptable range uncertainty

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PT Immobilization – External Immobilization

» External proton immobilization should:

- Adequately immobilize the patient
- Place the patient in a reproducible position
- Be accurately represented in the treatment plan
- Be homogeneous in construction
- Have beveled edges to limit edge effects
- Use low density materials where possible
- Place a minimal amount of material in the beam path
- Allow minimal air gap

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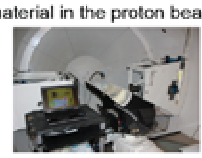
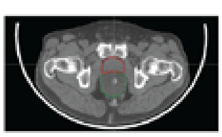
PT Immobilization – Internal Immobilization

» Internal immobilization is also a key component in proton therapy immobilization to limit motion and allow for localization of a specific target

» Where possible such immobilization should not add additional material in the proton beam path





» Where the immobilization device is in the beam path it should be water equivalent or have a density that is imagable by CT and accurately reflected in the dose calculation

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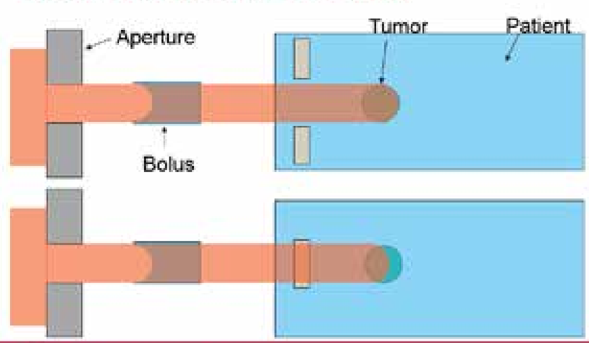
Immobilization Vs Tracking



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Immobilization at LLUMC


- Has been developed and refined through 20+ years of proton experience
- A general breakdown of immobilization device and treatment site:
  - Thorax/Abdomen – POD
  - Head/Neck – Mask
  - SRS/SRT – Bite Block

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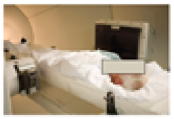
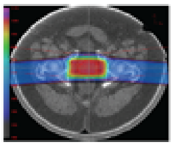
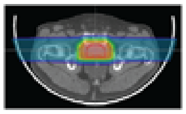
POD Immobilization

- 2 part expansion foam allows us to create a custom mold of the patient with low density material.
- POD immobilization is used extensively at LLUMC as it:
  - Confines larger patients to the CT circle
  - Provides superior body immobilization
  - Provides reproducible patient thickness for lateral and posterior beams
  - Allows for minimal air gaps
  - Provides a stable reference for leveling a patient

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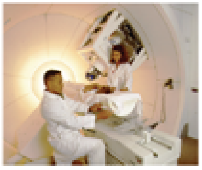
POD Immobilization

- The existing system at LLUMC creates a single custom POD that is used for imaging and treatment.
- Advantages:
  - Same POD for imaging and treatment
  - Superior POD immobilization
- Disadvantages:
  - Storage
  - Transportation



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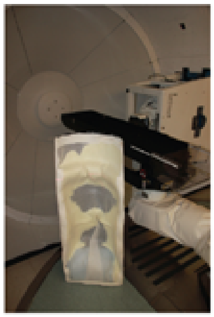
POD Immobilization

- The goal has been to update the POD immobilization to retain all the benefits.
- To do this we are building on "liner" technology
- A POD will be allocated to a specific room while the patient specific liner will be travel with the patient (imaging through treatment)
- The challenge is to create a room specific POD which meets the proton design considerations



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POD Immobilization

- The new design is built on the Q-fix kVue platform and has been designed to maximize the treatable volume
- Features include:
  - Beveled Edges
  - Foam core for homogeneity
  - Adjustable foot plate
  - Removable SDX shelf
  - 42.5 inch uninterrupted treatable length + 14.5 inches


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POD Immobilization

- The new POD system will provide improved treatment flexibility (beveled edges, movable carbon rails)


- Liner technology will provide improved treatment room efficiency and storage

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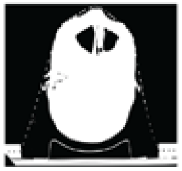
Head / Neck Immobilization

» Aquaplast mask immobilization is the standard immobilization material for head/neck

» The difficulties with standard systems include:

- Large bulky mask frames
- Limited nozzle clearance
- Limited shoulder immobilization



» A new mask system more custom suited to proton therapy was needed that could also be applied to the existing conventional machines with minimal modifications

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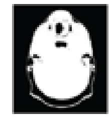
Head / Neck Immobilization

» The BoS system that was designed by MGH physicists in collaboration with Q-fix has been implemented at LLUMC

» It provides:

- Easy implementation onto existing couches
- Head/Shoulder immobilization
- Edgeless" masks
- Minimalist design



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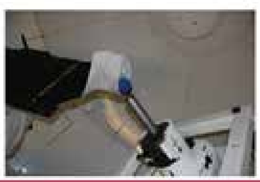
Head / Neck Immobilization

The main advantage of the system is the ability to attain a wide range of treatment angles with minimal material in the beam path



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Bite Block Immobilization

» Proton Therapy has a big advantage for SRS and SRT through the Bragg peak and superior penumbra

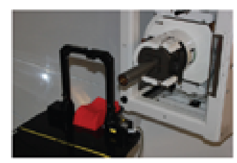
» The challenge is to harness this ability with effective immobilization

» At LLUMC we use vacuum bite block fixation

» Vacuum is used to attach the frame to the table and then the bite block to the patient

» This provides a secure immobilization platform which can be released at the push of a button

» It also adds no additional material to the beam path



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Bite Block Immobilization

» Multiple design elements were incorporated including:

- Compatibility with current bite-block frame
- Vacuum attachment of bite-block frame
- Foam core construction to minimize proton water equivalent thickness
- Bevelled edges to minimize proton edge effects
- Indexed head cushion
- Indexing for body immobilization devices
- Visual and radio-opaque markers for couch QA
- Variable foot rests and knee cushions to customize foot and leg position

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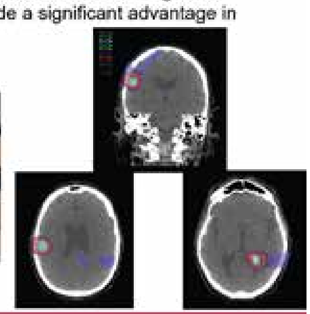
Bite Block Immobilization

» Proton therapy, bite block immobilization and a 6-degree of freedom robotic positioner provide a significant advantage in SRS and SRT



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Breath Hold Monitoring

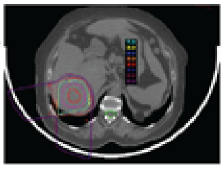
» Localizing the target not only in space but time is also important

» Patient breath hold assists in localization of the target with time allowing for accurate beam delivery.

» Gating is complex and can also lead to technical challenges and long treatment times with pulsed beam delivery

» Belt systems can add extra material in the proton beam path which is undesirable

» Relying on the patient to hold their breath reproducibly can be unreliable



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Breath Hold Monitoring

» Implementation of a spirometric device such as an ABC or SDX device provides real time feedback for the therapist and patient

» This has been implemented at LLUMC and approximately 10 patients have been treated with excellent patient/staff feedback

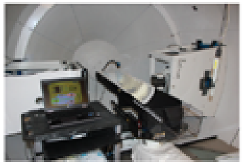
» Unit mounted on self contained cart

» Unit connects wirelessly to control room

» Works well with POD immobilization

» No additional material placed in beam path

» Patient data stored on secure database for future clinical analysis



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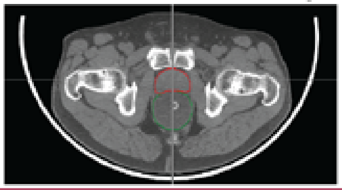
Rectal Balloon

» Rectal balloons provide internal immobilization of the prostate

» By filling the rectum with a known volume of water and ensuring the patient has a full bladder for CT and treatment we create a reproducible prostate position

» This decreases inter- and intrafraction motion significantly



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Rectal Balloon

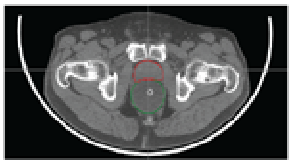
» This decreases inter and intrafraction motion significantly?

» What do I mean……..

» Motion was reduced by approximately 50% *

» Rectal balloon and patient instruction provides prostate position accuracy with bony anatomy alignment that is equivalent to prostate imaging *

* R. Schulte, K. Little, R. Grover, C. Rossi, J. Slater, "Intra- and Interfraction Prostate Motion in the Treatment of Prostate Cancer with Endorectal Balloon," ASTRO Abstract #3104, 2011.



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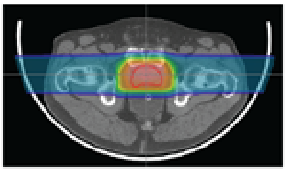
Rectal Balloon

» Rectal balloon also:

~ Fills the rectum with water minimizing range uncertainty due to variation in rectal filling

~ Locates much of the rectum away from the treatment field

~ Is well tolerated by patients



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Multi-Modality Immobilization

» Proton therapy immobilization is specialized

» Not all photon immobilization can be adapted to and used in proton therapy due to inherent differences

HOWEVER, proton therapy immobilization can be used in photon therapy

» Design concepts for proton therapy immobilization does not make it unsuitable for photon therapy

» Using proton therapy immobilization in the photon clinic is a viable solution

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Multi-Modality Immobilization

» Standardizing the immobilization clinic wide has a number of benefits

- **Accuracy:** single scan single plan regardless of modality
- **Flexibility:** allowing physicians to easily transfer patients between modalities reducing the need for re-scans
- **Cost:** supporting only one immobilization system is more cost effective
- **Training:** lessens the burden on training and in-services
- **Efficiency:** No need to re-immobilize based on modality; and staff are more practiced in the use of a single system

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Take Home Message

» **Proton therapy is a useful tool for radiation medicine yet requires specific immobilization design features to reach its full potential**

» **Immobilization is more critical to beam delivery in proton therapy**

» **Care must be taken to understand the effects immobilization is having on beam delivery prior to clinical release**

» **Employing site-wide immobilization solutions has distinct benefits**

» **Make sure the immobilization device immobilizes the patient**

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Acknowledgements

The entire staff in the Department of Radiation Medicine at LLUMC including physicians, physicists and therapists.

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Notes

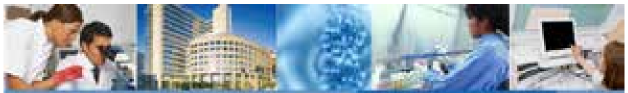
Notes

Friday, March 28, 2014

3:00pm - 4:00pm

Rojano Kashani, PhD

Patient Positioning Using an In-Room MR Imaging System



Patient Positioning Using an In-Room MR Image-Guided Treatment Delivery System

Rojano Kashani, Ph.D., DABR

Outline

- Introduction to in-room MR image-guidance
- Imaging capabilities of first commercially available system
- Patient positioning considerations
- Site specific immobilization and positioning
  - Breast
  - Head-and-neck
  - Spine SRS
  - Pelvis / Abdomen
  - Stereotactic lung and abdomen
- Discussion

Introduction to in-room MR image-guidance

- Existing imaging techniques mostly address the pre-treatment imaging at each fraction
  - 2D-2D match with kV source
  - Conebeam CT
  - Fluoroscopy
  - MVCT
- During treatment delivery, we rely on motion surrogates
  - Varian's RPM which images a small plastic block on patient's abdomen
  - Align-RT which tracks the motion of patient's surface
  - Calypso which tracks the position of implanted electromagnetic transponders

Introduction to in-room MR image-guidance

- Systems that allow for imaging during treatment provide limited information
  - Varian TrueBeam allows for acquisition of kV images
    - Limited planar images, with no soft tissue information
  - CBCT can be repeated during delivery the treatment but adds additional time for image acquisition and increases the dose to the patient.

Introduction to in-room MR image-guidance

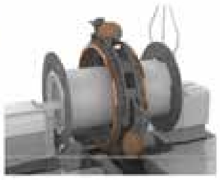
- Benefits of in-room MR
  - Visualization of soft tissue targets instead of surrogates
    - Potential for more accurate patient setup, allowing for margin reduction
  - No additional dose to the patient
  - Ability to image during treatment to monitor tumor motion
  - Capability to track soft tissue targets or OARs for gating
- In-room MR systems currently under development
  - 0.2-T MRI+linac Prototype: Cross Cancer Institute, Canada
  - 1.5-T MRI+Elekta: UMC Utrecht, The Netherlands
  - 0.35-T MRI+Cobalt Sources: ViewRay, Oakwood, OH

First Commercially-Available Solution

- 0.35-T MRI+Cobalt Sources: ViewRay, Oakwood, OH

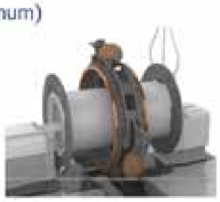
First Commercially-Available Solution

- 0.35-Tesla MRI field
  - Strong enough to produce quality images while reducing dosimetric effect of MR field
- Co-60 sources:
  - Eliminate problems with generating beam in the presence of magnetic field
- Integrated system
  - Monte-Carlo-based treatment planning
  - Imaging
  - Delivery



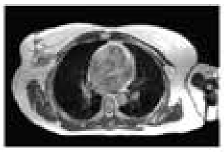
Machine Characteristics

- 3 Co-60 sources: 15,000 Ci each (maximum)
  - Dose rate at isocenter – 600 cGy from all 3
  - Source size: ~2x2.5 cm
- Collimation
  - MLC – 30 pairs of leaves per head
- SSD = 105 cm
- Bore size = 70 cm
- Maximum field size = 27 cm
- Virtual to machine isocenter distance = 155 cm
- Couch – 180 cm long, 50 cm wide



Machine Characteristics

- Typical imaging times:
  - Localizer (Pilot) scan : 15 sec
  - High resolution volumetric scan : 25 sec – 3 min
- Imaging resolution
  - Volumetric images: 1.5x1.5x1.5 mm
  - Planar treatment images: 3.5x3.5x5.0 mm
- Real-time imaging speed:
  - 4 frames per second – Single plane
  - 2 frames per second – Three planes



Patient positioning considerations

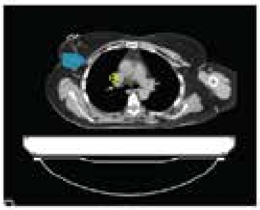
- Bore size – 70 cm
- Treatment couch
- Gradient coils
- MR compatibility of immobilization devices

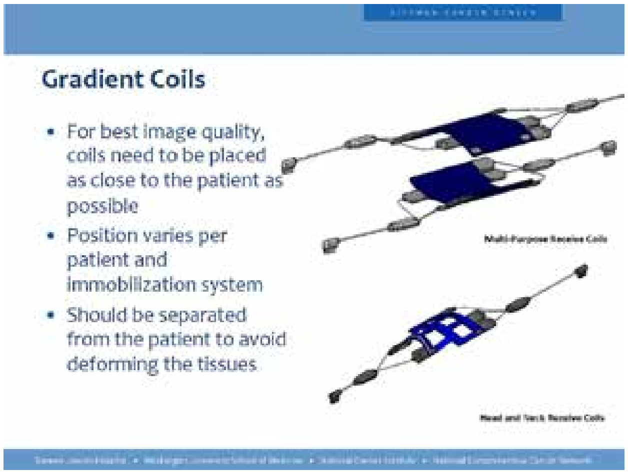
Bore size

- 70 cm diameter bore
  - Limits the use of some of the standard immobilization devices such as slant boards due to clearance
    - Also depends on patient size
  - Consideration of anatomy outside the field of view (FOV)
    - TPS provides an estimate of valid isocenter locations based on external skin defined on planning image.
    - It also uses the skin to verify clearance prior to allowing the user to shift the couch
    - Does not know about anatomy outside of FOV (arms)
    - Most immobilization devices are not visible on the setup MR image.

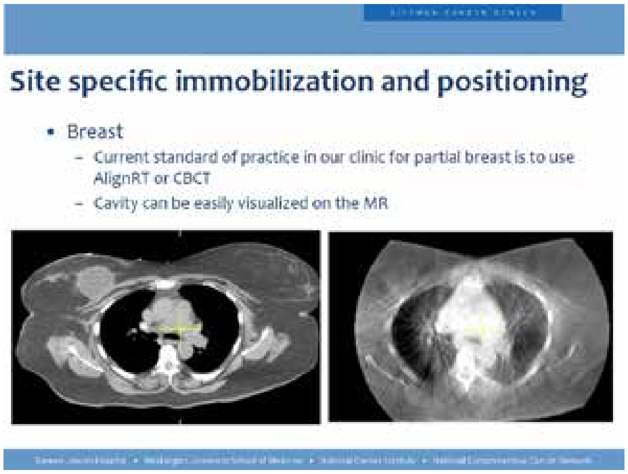
Treatment Couch

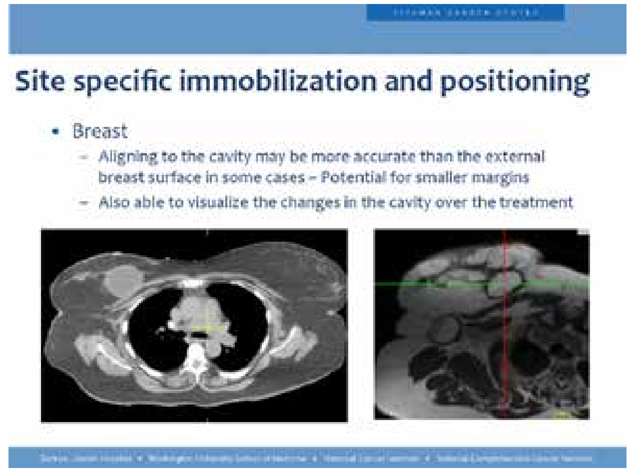
- Fiberglass
  - Highly attenuating compared to carbon fiber
- Indexed
- 50 cm wide
  - Slightly narrower than some other IGRT couches
- Modeled in TPS
  - Modeled in the TPS to within 1% accuracy, however attenuation varies depending on beam angle => Patient position relative to the couch is very important




Gradient Coils
• For best image quality, coils need to be placed as close to the patient as possible
• Position varies per patient and immobilization system
• Should be separated from the patient to avoid deforming the tissues
Multi-Purpose Receive Coils
Head and Neck Receive Coils


Site specific immobilization and positioning
• Breast
– Alpha cradle / Vacloc bag
– Arm up on the affected side
– Coil placement is a concern as it may change the breast tissue shape from fraction to fraction
• Coils were separated from the patient by placing a bridge over the patient to hold the coils


Site specific immobilization and positioning
• Breast
– Current standard of practice in our clinic for partial breast is to use AlignRT or CBCT
– Cavity can be easily visualized on the MR

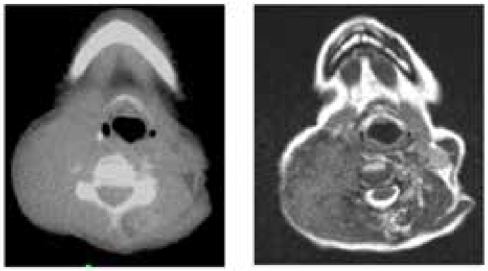

Site specific immobilization and positioning
• Breast
– Aligning to the cavity may be more accurate than the external breast surface in some cases – Potential for smaller margins
– Also able to visualize the changes in the cavity over the treatment


Site specific immobilization and positioning
• Head-and-Neck


Site specific immobilization and positioning
• Head-and-Neck

Site specific immobilization and positioning

- ConeBeam CT vs. MR



Discussion

- Minor modifications were made to immobilization devices as well as actual patient setup
- MR compatible versions of various devices were built
- Ability to monitor patient position during treatment would allow for less rigid immobilization for specific sites.

Acknowledgments

- Olga Green, Ph.D.
- Sasa Mutic, Ph.D.
- James R. Victoria, CMD

Notes

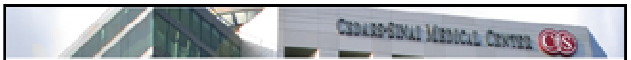
Notes

Friday, March 28, 2014

4:30pm - 5:30pm

Wensha Yang, PhD

The Clinical Use of a Spirometer based Respiratory Motion Management System for Deep Inhalation Breath-hold Radiation therapy of Left-sided Breast Cancer Treatment



Clinical Implementation of a Spirometer based DIBH for left-sided Breast Radiation

Wensha Yang Ph.D.

Medical Physicist and Assistant Professor

Cedars Sinai Medical Center

Disclosure

I have no financial relationship with any of the vendors in this presentation to disclose.

Cedars Sinai Medical Center

Outline

- Clinical needs for breast radiotherapy with respiratory motion control.
- How to control respiratory motion for breast cancer.
- Cedars-Sinai' s experience on a spirometer based respiratory motion control for left-side breast radiotherapy.

The NEW ENGLAND JOURNAL of MEDICINE

MARCH 14, 2013

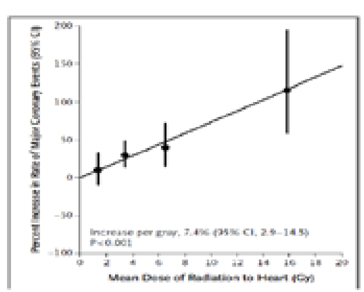
Risk of Ischemic Heart Disease in Women after Radiotherapy for Breast Cancer

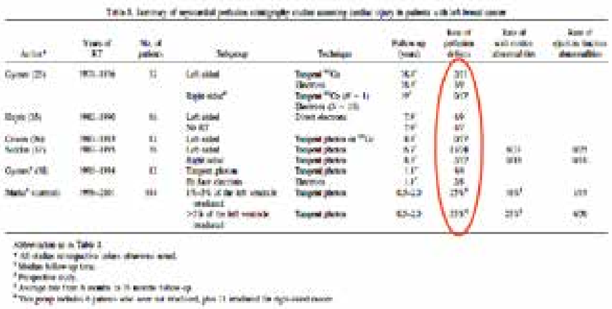
Sarah C. Darby, Ph.D., Marianne Ewertz, D.M.Sc., Paul McGale, Ph.D., Anna M. Bennet, Ph.D., Ulla Blom-Goldman, M.D., Dorthe Brønnum, R.N., Candace Correa, M.D., David Cutter, F.R.C.R., Giovanna Gagliardi, Ph.D., Bruna Gigante, Ph.D., Maj-Britt Jensen, M.Sc., Andrew Nisbet, Ph.D., Richard Peto, F.R.S., Kazem Rahimi, D.M., Carolyn Taylor, D.Phil., and Per Hall, Ph.D.

- 2168 breast cancer patients.
- Rates of major coronary events increased linearly with the mean dose to the heart by 7.4% per gray, with no apparent threshold.
- Begins within a few years after exposure, and continues for at least 20 years.

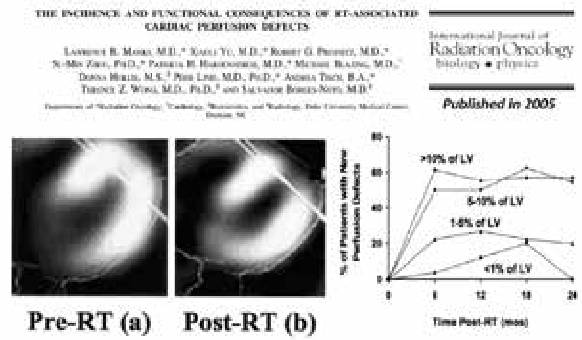
Methods

- 963 with major coronary events and 1205 controls.
- Mean dose to the heart and LAD
- Model: *Bs*(1+KX), where *Bs* was the stratum-specific rate of major coronary events in the absence of radiotherapy, X was the dose of cardiac radiation (in Gy), and K was the percentage increase in the rate of major coronary events per Gy

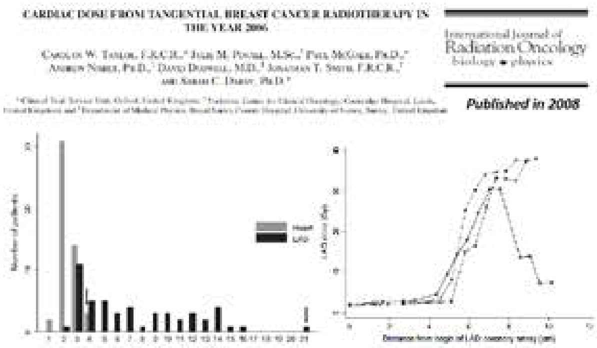




Significant number of patients who underwent radiation had cardiac perfusion defects.



- 114 patients were included in the study.
- Of 114 patients, 94, 69, 41, and 27 has follow-up SPECT 6, 12,18,and 24months post-RT.
- Radiation therapy causes volume-dependent perfusion defects in ~40% of patients within 2 years of RT.



- 50 patients with left-sided breast cancer and 5 patients with right-side breast cancer
- Average mean dose was 2.3 (SD=0.7)Gy to the heart and 7.6(SD=4.5) Gy to the LAD.
- 44% patients have part of the heart receiving >20Gy.
- LAD dose is distance dependent.

There are clinical needs for techniques to reduce in-field cardiac volumes and hence to reduce the cardiac doses!

↓

But how?

Can we do it with prone?

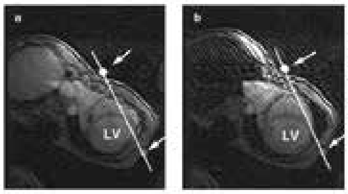
Heart moves anteriorly when patient is setup in prone position.

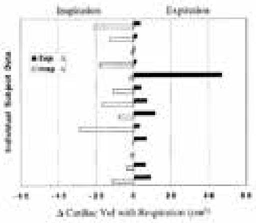
Is there a better breathing phase for critical organ sparing?

Impact of Respiratory Manoeuvres on Cardiac Volume Within Left-Breast Radiation Portals

Ming Hui Chen, Michael L. Chuang, Bruce A. Bornstein, Rebecca Gelman, Jay R. Harris, and Warren J. Manning

Circulation Volume 96(10):3269-3272 November 18, 1997



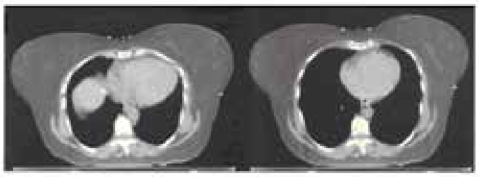


CLINICAL INVESTIGATION

REDUCTION OF CARDIAC VOLUME IN LEFT-BREAST TREATMENT FIELDS BY RESPIRATORY MANEUVERS: A CT STUDY

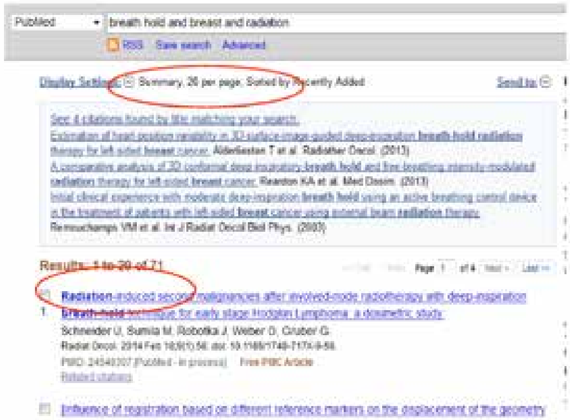
International Journal of Radiation Oncology biology • physics

Published in 2000



- CT study to propose radiotherapy of left-sided breast with breathing maneuver.
- No technique was used to monitor the breath-hold.
- Multiple breath-hold scans were acquired at the same day, showing reproducibility of the breath-hold <2mm using a surface marker as a landmark.
- No breathing monitoring device was used

Can We Utilize Breathing Control to Achieve Reproducible Gating/Breath-hold Position?



Breathing Control Devices for Breast Radiation Therapy

Voluntary Breath-hold

- Self-held breath-hold without respiratory monitoring. CMNR interlock (Varian machine) through a hand-held switch, not commercially available
- Spirometry based.(Dyn'R, Vmax)
- Surface marker based. (Varian RPM system)
- 3D-surface image guided. (Vision RT, C-RAD)

Involuntary Breath-hold

- Active breathing control device. (Elekta)

Gating technique

- 4DCT to decide best gating window for the treatment (Varian RPM system)

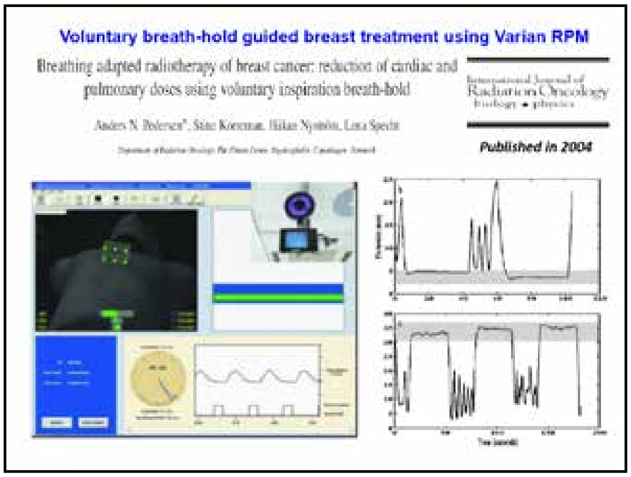
Audiovisual feedback systems are usually used to improve breath-hold reproducibility throughout the treatment course.

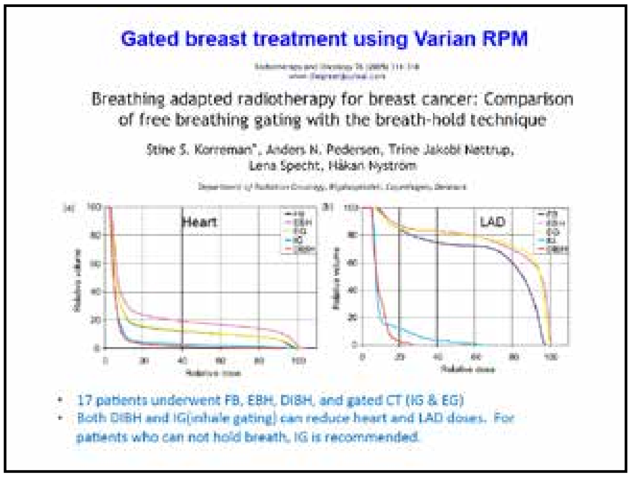
Spirometry Products that are Compatible with DIBH

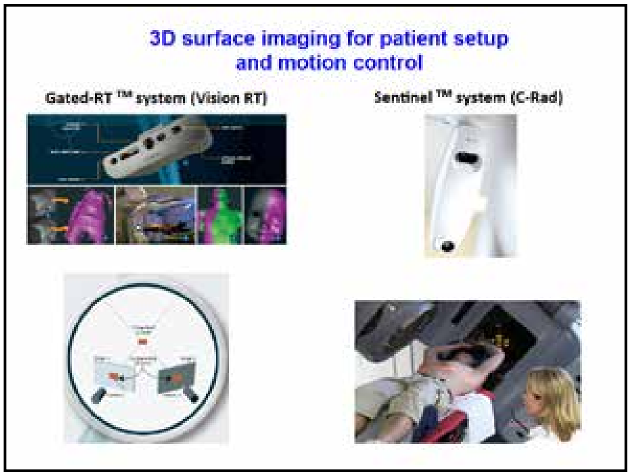
SpiroDyn'RX (Dyn'R, Muret, France)

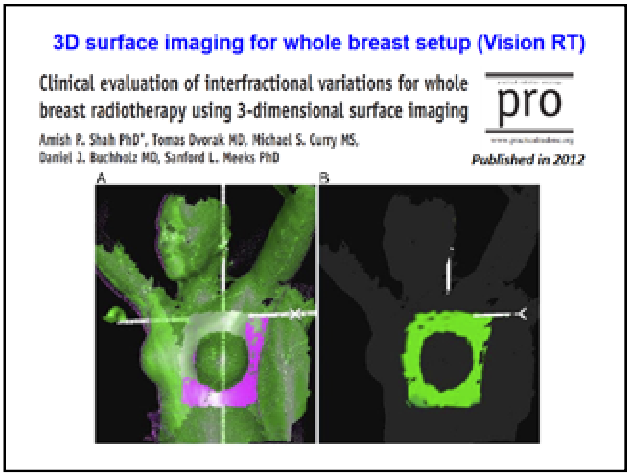
VMAX Spectra 20C (VIASYS Healthcare Inc, Yorba Linda, CA)

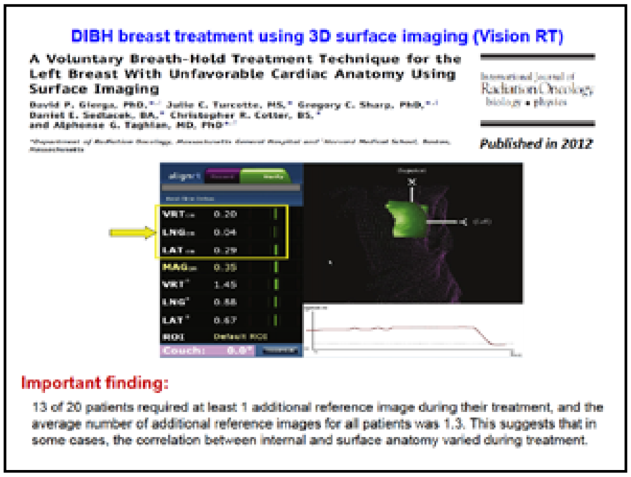
- A reproducible state of deep inspiration breath-hold technique.
- Controls internal anatomy by controlling lung volume

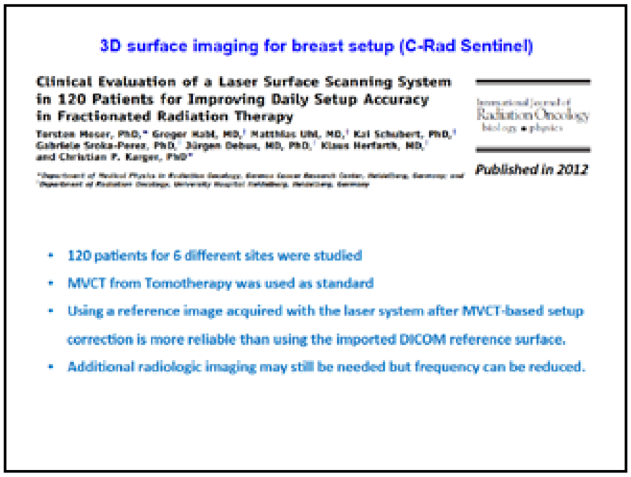

Voluntary breath-hold guided breast treatment using Varian RPM
Breathing adapted radiotherapy of breast cancer: reduction of cardiac and pulmonary doses using voluntary inspiration breath-hold
Anders N. Pedersen*, Stine Korreman, Håkan Nyström, Lena Specht
International Journal of Radiation Oncology biology • physics
Published in 2004


Gated breast treatment using Varian RPM
Breathing adapted radiotherapy for breast cancer: Comparison of free breathing gating with the breath-hold technique
Stine S. Korreman*, Anders N. Pedersen, Trine Jakobi Nøttrup, Lena Specht, Håkan Nyström
Heart
LAD
Relative volume
Relative dose
17 patients underwent FB, EBH, DIBH, and gated CT (IG & EG)
Both DIBH and IG(inhale gating) can reduce heart and LAD doses. For patients who can not hold breath, IG is recommended.

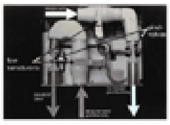

3D surface imaging for patient setup and motion control
Gated-RT ™ system (Vision RT)
Sentinel ™ system (C-Rad)


3D surface imaging for whole breast setup (Vision RT)
Clinical evaluation of interfractional variations for whole breast radiotherapy using 3-dimensional surface imaging
Amish P. Shah PhD*, Tomas Dvorak MD, Michael S. Curry MS, Daniel J. Buchholz MD, Sanford L. Meeks PhD
pro
Published in 2012
A
B


DIBH breast treatment using 3D surface imaging (Vision RT)
A Voluntary Breath-Hold Treatment Technique for the Left Breast With Unfavorable Cardiac Anatomy Using Surface Imaging
David P. Gierga, PhD, Julie C. Turcotte, MS, Gregory C. Sharp, PhD, Daniel E. Sedlacek, BA, Christopher R. Cotter, BS, and Alphonse G. Taghian, MD, PhD
International Journal of Radiation Oncology biology • physics
Published in 2012
VRT 0.20
LNG 0.04
LAT 0.29
MAG 0.35
VRT 1.45
LNG 0.88
LAT 0.67
ROI Default ROI
Important finding:
13 of 20 patients required at least 1 additional reference image during their treatment, and the average number of additional reference images for all patients was 1.3. This suggests that in some cases, the correlation between internal and surface anatomy varied during treatment.


3D surface imaging for breast setup (C-Rad Sentinel)
Clinical Evaluation of a Laser Surface Scanning System in 120 Patients for Improving Daily Setup Accuracy in Fractionated Radiation Therapy
Torsten Moser, PhD, Gregor Habl, MD, Matthias Uhl, MD, Kai Schubert, PhD, Gabriele Sroka-Perez, PhD, Jürgen Debus, MD, PhD, Klaus Herfarth, MD, and Christian P. Karger, PhD
International Journal of Radiation Oncology biology • physics
Published in 2012
120 patients for 6 different sites were studied
MVCT from Tomotherapy was used as standard
Using a reference image acquired with the laser system after MVCT-based setup correction is more reliable than using the imported DICOM reference surface.
Additional radiologic imaging may still be needed but frequency can be reduced.

Involuntary breath-hold guided breast treatment using Elekta ABC



- Active Breathing Coordinator (ABC) from Elekta, developed at William Beaumont Hospital.
- Modified ventilator that has two separate flow monitors and two scissor valves, which are interfaced with computer.
- Valves will be closed when a defined lung volume is set.
- Allow breath-hold in any predefined lung volume.
- Validated on lung and liver patients

THE USE OF ACTIVE BREATHING CONTROL (ABC) TO REDUCE MARGIN FOR BREATHING MOTION

John W. Wong, Ph.D., Michael B. Sharpe, Ph.D., David A. Jaffray, Ph.D., Vijay R. Kini, M.D., John M. Robertson, M.D., Jannifer S. Stromberg, M.D., and Alvaro A. Martinez, M.D.
Department of Radiation Oncology, William Beaumont Hospital, Royal Oak, MI

International Journal of Radiation Oncology biology • physics

Published in 1999

First use of ABC on breast radiation therapy

DEEP INSPIRATION BREATH HOLD TO REDUCE IRRADIATED HEART VOLUME IN BREAST CANCER PATIENTS

Katharina E. Sixel, Ph.D., F.C.C.P.M.,*† Marianne C. Aznar, M.Sc.,* and Yee C. Ung, M.D., F.R.C.P.C.*†
*Toronto-Sunnybrook Regional Cancer Centre, Toronto, Ontario, Canada; †University of Toronto, Toronto, Ontario, Canada

International Journal of Radiation Oncology biology • physics

Published in 2001

Table 1. Absolute and relative cardiac volume irradiated to more than 25 Gy

	Regular tangents		Wide tangents	
Patient	Normal respiration	DIBH	Normal respiration	DIBH
1	0 cc (0%)	0 cc (0%)	23 cc (3%)	14 cc (2%)
2	38 cc (4%)	14 cc (1%)	116 cc (13%)	75 cc (7%)
3	40 cc (5%)	0 cc (0%)	53 cc (7%)	10 cc (1.3%)
4	27 cc (4%)	8 cc (1%)	57 cc (9%)	24 cc (3%)
5	12 cc (2%)	12 cc (2%)	22 cc (4%)	28 cc (5%)

DIBH = deep inspiration breath hold.

Table 2. [illegible]

	Regular tangents		Wide tangents	
Patient	Normal respiration	DIBH	Normal respiration	DIBH
1	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]

DIBH = deep inspiration breath hold.

- 5 patients
- Planned with both regular tangents and wide tangents
- DIBH was able to reduce both cardiac volume and lung V25

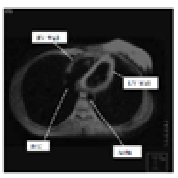
Comparison of MRI defined heart volume with CT defined heart volume

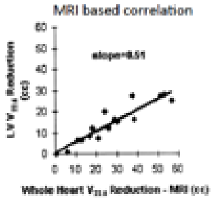
MRI-BASED VOLUMETRIC ASSESSMENT OF CARDIAC ANATOMY AND DOSE REDUCTION VIA ACTIVE BREATHING CONTROL DURING IRRADIATION FOR LEFT-SIDED BREAST CANCER

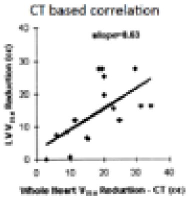
Daniel J. Krauss, M.D.,* Larry L. Kestin, M.D.,* Gilbert Raff, M.D.,† Di Yan, Ph.D.,* John Wong, Ph.D.,* Ralph Gentry, B.S.,† Nicola Letts, B.S.,* Carlos E. Vargas, M.D.,* Alvaro A. Martinez, M.D., F.A.C.R.,* and Frank A. Vicini, M.D.*
Departments of *Radiation Oncology and †Cardiology, William Beaumont Hospital, Royal Oak, MI

International Journal of Radiation Oncology biology • physics

Published in 2005







- LV volumes calculated from MRI and CT are correlated with each other, indicating CT is adequate for determining which patients are likely to benefit from ABC treatments

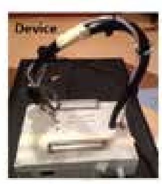
Something here!!!

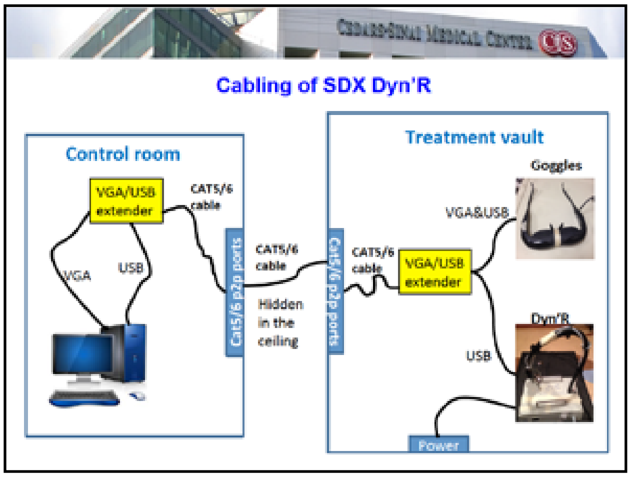
Implementation of at Cedars Sinai Medical Center

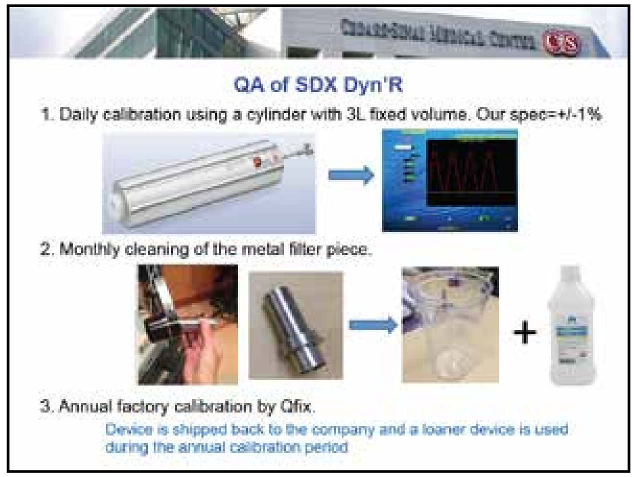
- Purchased SDX Dyn'R about two years ago.
- ~2 months for physics test, training for therapists and setup protocols.
- We started with lung, liver and pancreas SBRT. Later it was used on breast regularly fractionated case. Breast SBRT protocol is in development.

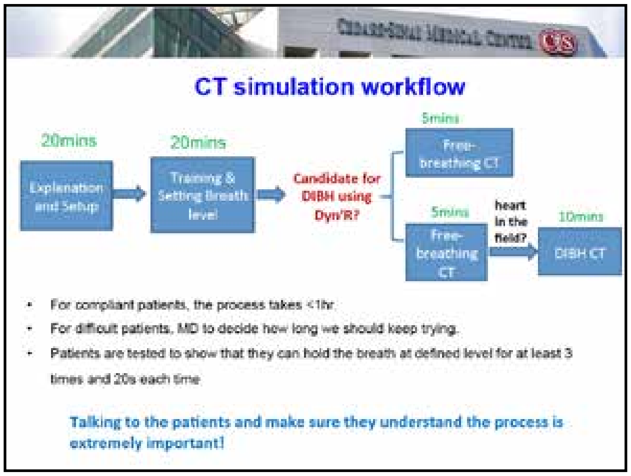
It takes team work to implement a new procedure in clinic!

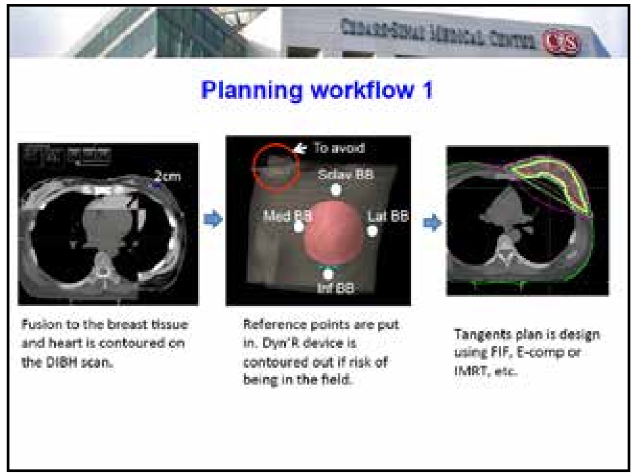
Components of SDX Dyn'R

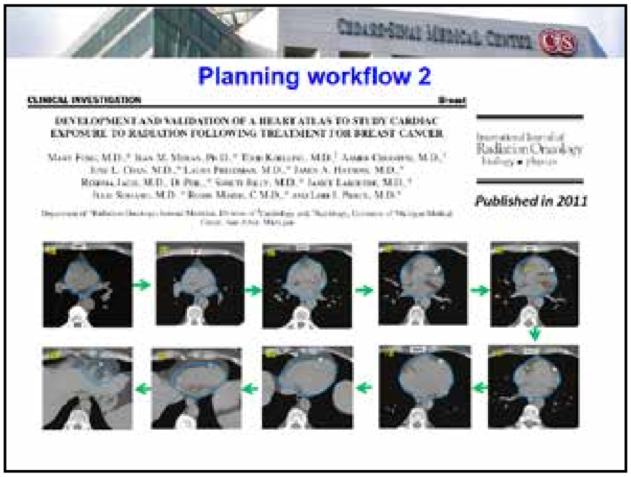


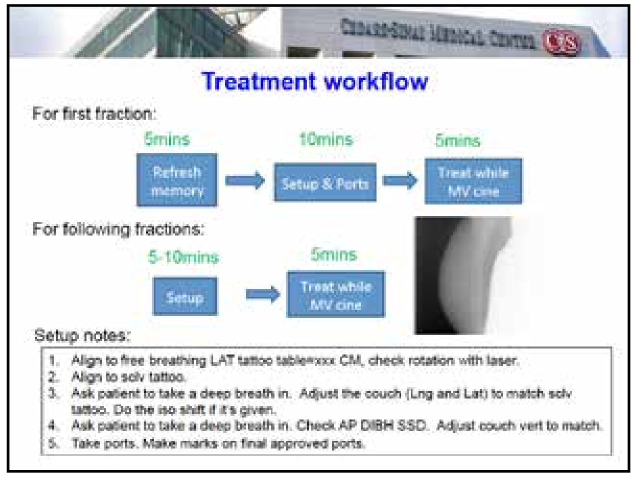

Cabling of SDX Dyn'R
Control room
VGA/USB extender
CAT5/6 cable
VGA
USB
Cat5/6 p2p ports
CAT5/6 cable
Hidden in the ceiling
Treatment vault
Cat5/6 p2p ports
CAT5/6 cable
VGA/USB extender
VGA&USB
Goggles
Dyn'R
USB
Power

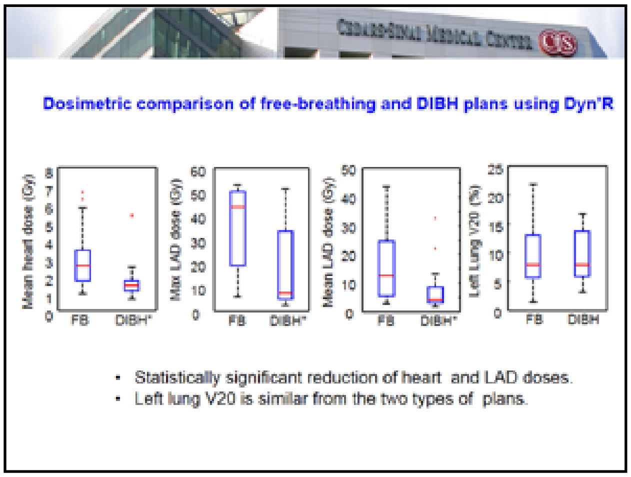

QA of SDX Dyn'R
1. Daily calibration using a cylinder with 3L fixed volume. Our spec=+/-1%
2. Monthly cleaning of the metal filter piece.
3. Annual factory calibration by Qfix.
Device is shipped back to the company and a loaner device is used during the annual calibration period

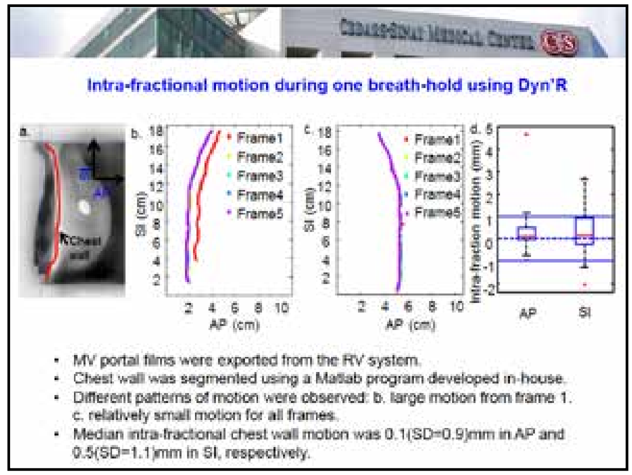

CT simulation workflow
20mins
Explanation and Setup
20mins
Training & Setting Breath level
Candidate for DIBH using Dyn'R?
5mins
Free-breathing CT
5mins
Free-breathing CT
heart in the field?
10mins
DIBH CT
For compliant patients, the process takes <1hr.
For difficult patients, MD to decide how long we should keep trying.
Patients are tested to show that they can hold the breath at defined level for at least 3 times and 20s each time
Talking to the patients and make sure they understand the process is extremely important!

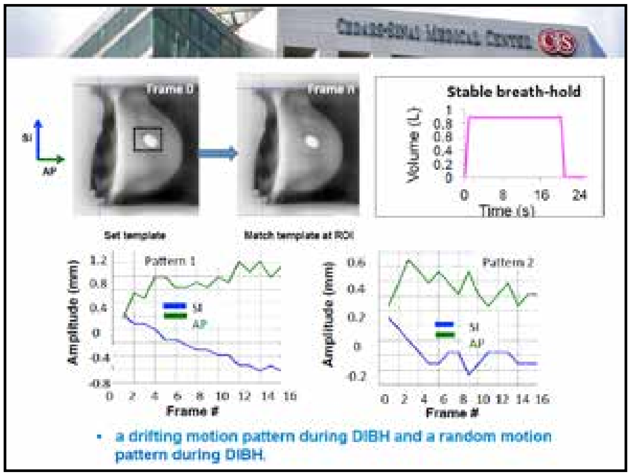

Planning workflow 1
2cm
To avoid
Sclav BB
Med BB
Lat BB
Inf BB
Fusion to the breast tissue and heart is contoured on the DIBH scan.
Reference points are put in. Dyn'R device is contoured out if risk of being in the field.
Tangents plan is design using FIF, E-comp or IMRT, etc.

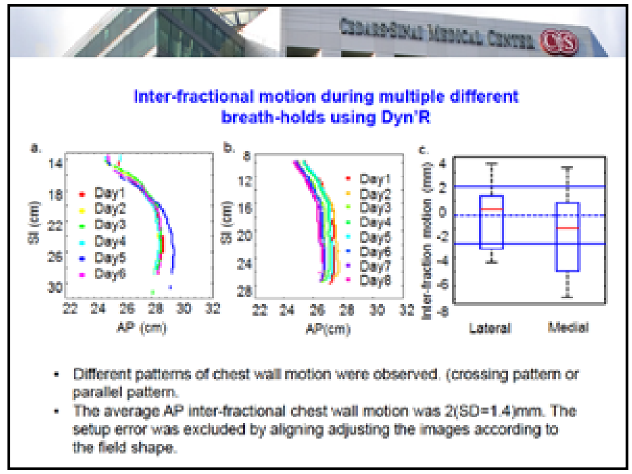

Planning workflow 2
CLINICAL INVESTIGATION
DEVELOPMENT AND VALIDATION OF A HEART ATLAS TO STUDY CARDIAC EXPOSURE TO RADIATION FOLLOWING TREATMENT FOR BREAST CANCER
Published in 2011

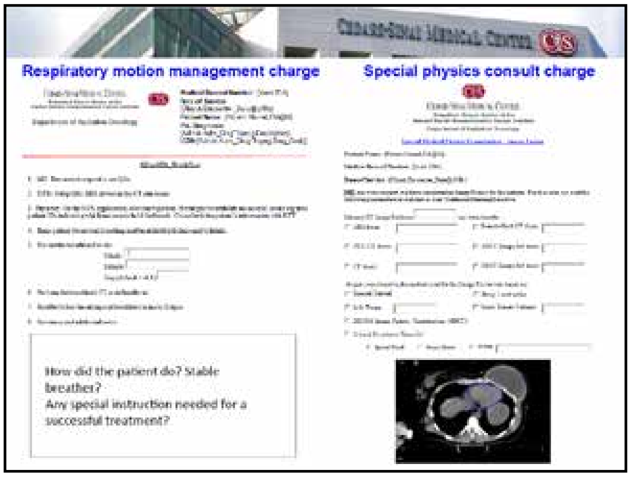

Treatment workflow
For first fraction:
5mins
Refresh memory
10mins
Setup & Ports
5mins
Treat while MV cine
For following fractions:
5-10mins
Setup
5mins
Treat while MV cine
Setup notes:
1. Align to free breathing LAT tattoo table=xxx CM, check rotation with laser.
2. Align to sclv tattoo.
3. Ask patient to take a deep breath in. Adjust the couch (Lng and Lat) to match sclv tattoo. Do the iso shift if it's given.
4. Ask patient to take a deep breath in. Check AP DIBH SSD. Adjust couch vert to match.
5. Take ports. Make marks on final approved ports.

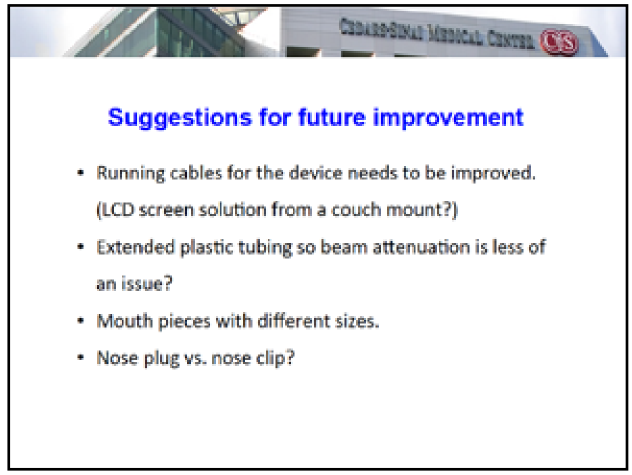

CEDARS-SINAI MEDICAL CENTER
Dosimetric comparison of free-breathing and DIBH plans using Dyn'R
Mean heart dose (Gy)
Max LAD dose (Gy)
Mean LAD dose (Gy)
Left Lung V20 (%)
FB
DIBH*
DIBH
• Statistically significant reduction of heart and LAD doses.
• Left lung V20 is similar from the two types of plans.


CEDARS-SINAI MEDICAL CENTER
Intra-fractional motion during one breath-hold using Dyn'R
Chest wall
Frame1
Frame2
Frame3
Frame4
Frame5
SI (cm)
AP (cm)
Intra-fraction motion (mm)
AP
SI
• MV portal films were exported from the RV system.
• Chest wall was segmented using a Matlab program developed in-house.
• Different patterns of motion were observed: b. large motion from frame 1. c. relatively small motion for all frames.
• Median intra-fractional chest wall motion was 0.1(SD=0.9)mm in AP and 0.5(SD=1.1)mm in SI, respectively.


CEDARS-SINAI MEDICAL CENTER
Frame 0
Frame n
Stable breath-hold
Volume (L)
Time (s)
Set template
Match template at ROI
Pattern 1
Pattern 2
Amplitude (mm)
Frame #
SI
AP
• a drifting motion pattern during DIBH and a random motion pattern during DIBH.


CEDARS-SINAI MEDICAL CENTER
Inter-fractional motion during multiple different breath-holds using Dyn'R
Day1
Day2
Day3
Day4
Day5
Day6
Day7
Day8
SI (cm)
AP (cm)
Inter-fraction motion (mm)
Lateral
Medial
• Different patterns of chest wall motion were observed. (crossing pattern or parallel pattern.
• The average AP inter-fractional chest wall motion was 2(SD=1.4)mm. The setup error was excluded by aligning adjusting the images according to the field shape.


CEDARS-SINAI MEDICAL CENTER
Respiratory motion management charge
Special physics consult charge
How did the patient do? Stable breather?
Any special instruction needed for a successful treatment?


CEDARS-SINAI MEDICAL CENTER
Suggestions for future improvement
• Running cables for the device needs to be improved.
(LCD screen solution from a couch mount?)
• Extended plastic tubing so beam attenuation is less of an issue?
• Mouth pieces with different sizes.
• Nose plug vs. nose clip?

Conclusions

- There are clearly clinical needs for left-side breast radiation with respiration control.
- Different technologies are available on the market to achieve similar goal.
- Different factors are considered in choosing a technique for your center. (accuracy, external vs. internal, how easy to use, budget, etc.)

Acknowledgement

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Steven Shiao
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Robert Reznik

Therapist group:
Troy Gustafson
Tai Nguyen
Sinead Hochberg
Bob Alagala
Tim Labelle

Thank you!

Notes

Notes

Saturday, March 29, 2014

9:45am - 10:30am

Tneisha Haddock, BS, RT(R)(T)

Unconventional Immobilization Devices and Setups

Unconventional Immobilization Devices & Setups

Tneisha M. Haddock

BS, RT (R)(T)

Duke University Hospital

Presentation Topics…

- Pre-simulation and simulation process
  - Overall steps
- Communication between Doctors and Simulation Therapists
- Unconventional set-ups and devices, including some rare diseases
  - Main point of interest
- Department Communication
  - Simulation therapists, treatment therapists, and other involved patient care providers

Pre-simulation process

- Communication between Doctors & Simulation Therapists
  - MD Order
- Room preparation
  - Necessary supplies
- Call other necessary personnel
  - Dosimetry, physics, treatment therapists
- Patient education
  - What is to take place at time of simulation

Simulation process

- Set patient up & construct device
  - MD Order
- Mark patient appropriately
- Scan patient with approved parameters
  - MD Order
- Planning Documentation
  - Treatment checklist & planning pictures

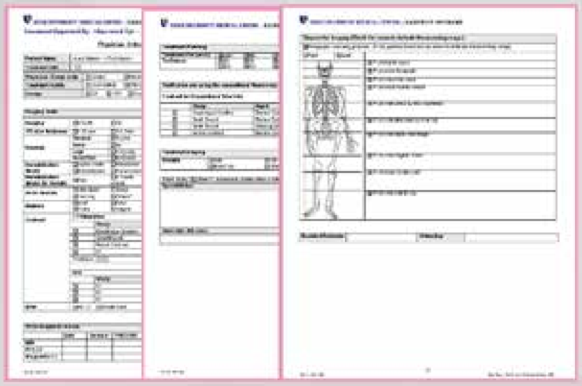
Communication Between Doctors and Simulation Therapists

- Electronic Medical Record (EMR)
  - Two Used in Radiation Oncology
    - Aria– Departmental
      - MD Order
      - Treatment Checklist
      - Planning Pictures
      - Journal
      - Alerts
    - Epic – Duke University Health Systems

Communication Between Doctors and Simulation Therapists

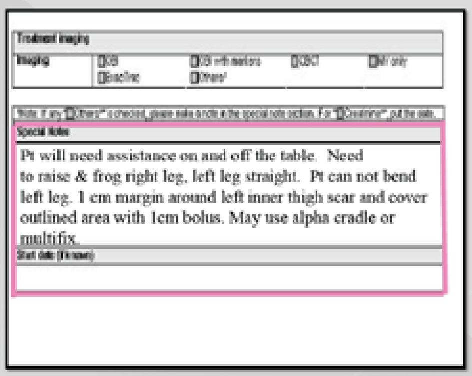
- Electronic Medical Record (EMR)
  - MD Order
    - Located in Aria
    - Detailed physician's prescription for the patient's setup to achieve optimal treatment and patient care
    - Additional detailed setup comments can be added to the notes section
    - Resident, Attending, or Physician's Assistant can enter the form
    - Attending must approve before simulation
    - Part of the Pre-simulation & simulation processes
    - Key form of departmental communication

MD Order Document



Immobilization Choices

Special Notes


Treatment Imaging

Special Notes

Pt will need assistance on and off the table. Need to raise & frog right leg, left leg straight. Pt can not bend left leg. 1 cm margin around left inner thigh scar and cover outlined area with 1cm bolus. May use alpha cradle or multifix.

Start date (if known)

Unconventional Devices and Setups

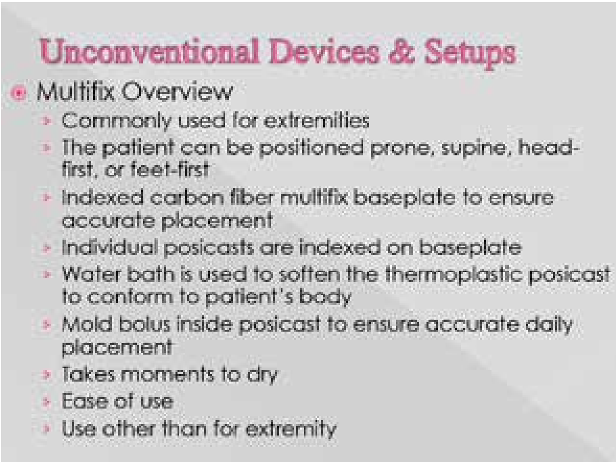
- Goal
  - Show and discuss immobilization devices that have been created for certain types of diseases, body types, body areas
  - Unfamiliar Devices
  - Combination devices
  - Interchangeable devices

Unconventional Devices & Setups

- Anatomy/Areas Covered
  - Extremities
  - Breast
  - Body (upper, mid, & lower)
  - Head & Neck

Unconventional Devices & Setups

- Types of devices used
  - Multifix
  - Moldcare
  - Alpha Cradle, Body Fix, and Vacloc
  - Orfit
  - Aquaplast sheets
  - Styrofoam


Unconventional Devices & Setups
Multifix Overview
Commonly used for extremities
The patient can be positioned prone, supine, head-first, or feet-first
Indexed carbon fiber multifix baseplate to ensure accurate placement
Individual posicasts are indexed on baseplate
Water bath is used to soften the thermoplastic posicast to conform to patient's body
Mold bolus inside posicast to ensure accurate daily placement
Takes moments to dry
Ease of use
Use other than for extremity


Multifix
03/04/2013
03/04/2013


Unconventional Devices & Setups
Multifix-Forearm


Unconventional Devices & Setups
Multifix + Styrofoam - Right Leg (Darire's Disease)


Unconventional Devices & Setups
Multifix + Aquaplast + Moldcare + Styrofoam-Left leg with left foot immobilization


Unconventional Devices & Setups
Multifix + Bolus + Styrofoam – Right Lateral Knee

Unconventional Devices & Setups

- Multifix + Breastboard - S'clav Chin Strap/Breast

Unconventional Devices & Setups

- Multifix + Breastboard - S'clav Chin Strap/Breast

Unconventional Devices & Setups

- Moldcare Overview
  - Commonly used for head and neck set-ups, for customized head support
  - Used to hold bolus in place
  - Can be constructed to be a customized headholder
  - Takes longer to dry
  - Ease of use
  - Use other than for head & neck set-ups

Unconventional Devices & Setups

- Moldcare - Typical Head & Neck

Unconventional Devices & Setups

- Moldcare – Left Leg/Inner Thigh

Unconventional Devices & Setups

- Moldcare + Bolus – Left Leg/Inner Thigh


Unconventional Devices & Setups
Moldcare + Styrofoam – Right Pelvis & Leg


Unconventional Devices & Setups
Moldcare + Styrofoam – Right Pelvis & Leg


Unconventional Devices & Setups
Moldcare + Bolus – Left Upper Elbow/Arm
BOLUS


Unconventional Devices & Setups
Moldcare – Right Bicep/Upper Arm


Unconventional Devices & Setups
Moldcare + Orfit – CSI (craniospinal irradiation)


Unconventional Devices & Setups
Orfit + Styrofoam – CSI (craniospinal irradiation)

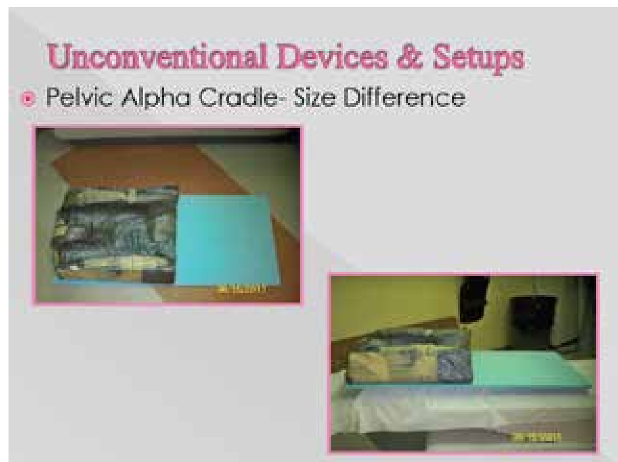
Unconventional Devices & Setups

- Alpha Cradle, Body Fix, & Vacloc Overview
  - Commonly used for patient's body immobilization
  - Use other than for body set-ups
  - Can use same device on different anatomical areas
  - Stable & precise mold for patient's position
  - Alpha Cradle is not re-usable, uses chemicals
  - Body fix & Vacloc are environmentally friendly, easy to clean, re-usable, easier on patient's and therapists to make, uses a vacuum


Unconventional Devices & Setups
T-Bodyfix +15 Degree Styrofoam Wedge, Clear Wingboard - Breast


Unconventional Devices & Setups
T-Bodyfix – Pelvis/Sacrum


Unconventional Devices & Setups
Pelvic Alpha Cradle – SBRT Prostate


Unconventional Devices & Setups
Pelvic Alpha Cradle- Size Difference


Unconventional Devices & Setups
Short Bodyfix - Right Groin/Pelvis


Unconventional Devices & Setups
Short Bodyfix - Anal Treatment


Unconventional Devices & Setups
Pelvic Alpha Cradle – Anal Treatment


Unconventional Devices & Setups
Pediatric Cradle – Pediatric Abdomen


Unconventional Devices & Setups
Short Bodyfix - Pediatric Abdomen


Unconventional Devices & Setups
Decubitus Cradle – Right Abdomen/Appendix


Unconventional Devices & Setups
Decubitus Cradle – Right Abdomen/Appendix


Unconventional Devices & Setups
Vacloc + Wingboard – Esophagus & Thoracic Spine


Unconventional Devices & Setups
Vacloc + Wingboard – Esophagus & Thoracic Spine


Unconventional Devices & Setups
Vacloc + Prone Face Positioner – Right Bicep/ Arm


Unconventional Devices & Setups
Arm Alpha Cradle – Right Forearm


Unconventional Devices & Setups
Arm Alpha Cradle – Right Forearm


Unconventional Devices & Setups
Arm Alpha Cradle – Right Bicep

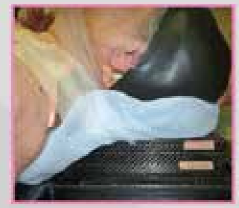

Unconventional Devices & Setups
Orfit Overview
Commonly used for head & neck immobilization
Used to hold bolus in place
Can be prone or supine

Unconventional Devices & Setups

- Bolus + Swim cap – Supine Scalp

Unconventional Devices & Setups

- Orfit + Bolus + Swim cap + Moldcare – Supine Scalp



Unconventional Devices & Setups

- Moldcare – Supine Scalp Headrest

Unconventional Devices & Setups

- Orfit + Bolus + Swim cap – Prone Scalp

Unconventional Devices & Setups

- Orfit + Bolus + Swim cap + Prone Face rest – Prone Scalp

Unconventional Devices & Setups

- Aquaplast Sheets + Bolus + Accufix – Supine Posterior Scalp

Unconventional Devices & Setups

- Aquaplast Sheets + Bolus – Supine Posterior Scalp

Unconventional Devices & Setups

- Aquaplast Sheets + Bolus + Orfit – Left Neck/ Mastoid Process

Unconventional Devices & Setups

- Orfit + Bolus – Right Forehead

Unconventional Devices & Setups

- Orfit + Bolus – Right Nose & Left Lateral Neck

Department Communication

- Planning Documentation
  - Treatment Checklist
  - Planning Pictures
- Alerts
- Journal Notes

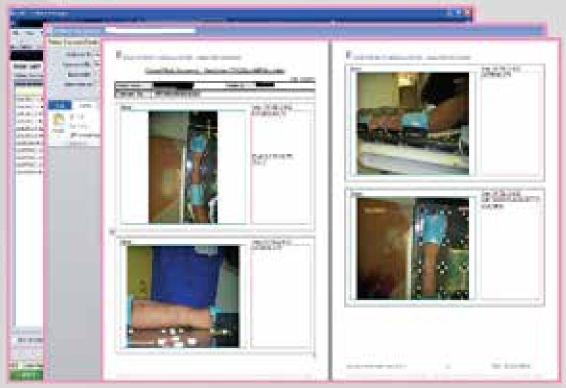
Department Communication

- Planning Documentation
  - Treatment Checklist
    - Detailed simulation set-up notes
    - Extra notes concerning the setup are written here in additional notes
    - Who completed the simulation if questions arise
    - Found under the "Documents" section
    - Dosimetrists & Physicists may also use this for planning purposes and to enter information into RT Chart for treatment set-up

Department Communication

- Planning Documentation
  - Planning Pictures
    - CT 0 pictures
    - All pictures that may be needed for set-up
    - Other notes can be added separately to the pictures if needed

Planning Documentation

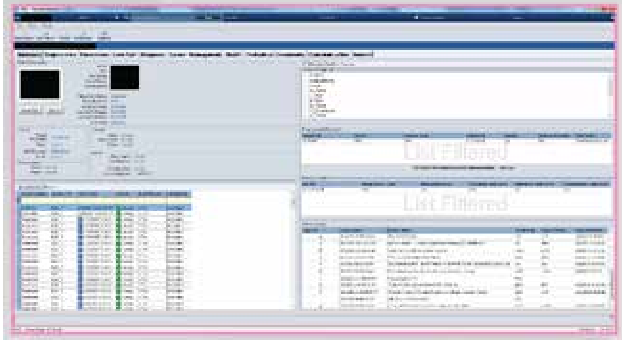


Department Communication

- Alerts
  - Entered by anyone
  - Reminders
  - Part of set-up notes

Department Communication

- Alerts



Department Communication

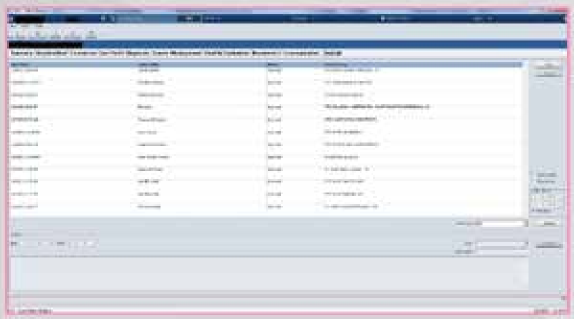
- Alerts

Department Communication

- Journal Notes
  - Entered by anyone
  - Reminders
  - Location of immobilization device made at simulation
  - Notes pertaining to patient care
  - Treatment comments

Department Communication

- Journal Notes



Take Away Messages

- These are not typical setups and will not work for every patient
- Not all setups are universal
- Patient centered
- Tailored to treat affected body area and patient condition
- Orfit – doctors main choice but can use others
- Don't be afraid to think outside the box ☺

Thank You For Your Attention

Any Questions?

Notes

Saturday, March 29, 2014

10:30am - 11:15am

Omar Zeidan, PhD, D.A.B.R.

In Search for the Ideal Proton Therapy Immobilizer - Evaluation Study of Intracranial Immobilizer

In Search for The Ideal Proton Therapy Immoblizer – An Evaluation Study of Intracranial Immoblizer

UFHealth
CANCER CENTER
ORLANDO HEALTH

Omar Zeidan, PhD, DABR

Chief, Proton Therapy Physics

Disclosures

- No financial disclosures
- The material presented in this talk is based on clinical experience at the ProCure Proton Therapy Center – Oklahoma City
- Feel free to contact me about the material presented in this talk:

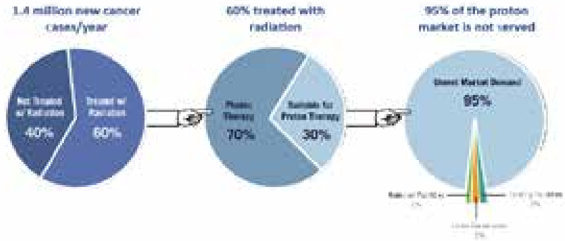
Omar Zeidan, Ph.D., DABR
Chief, Proton Therapy Physics
UF Health Cancer Center – Orlando Health
Omar.Zeidan@Orlandohealth.com

Outline

- Status of proton therapy in the US
- Treatment room design and the impact of imaging capability on immobilization
- Importance of good immobilization in PT for intracranial treatments
- How to do an independent evaluation of immobilization and recommendations on improvements

Significant and unmet need for protons

Using existing protocols, protons would benefit >250,000 patients/year
This requires a proton therapy center in every major U.S. city



Proton Centers - 2014

The National Association for Proton Therapy

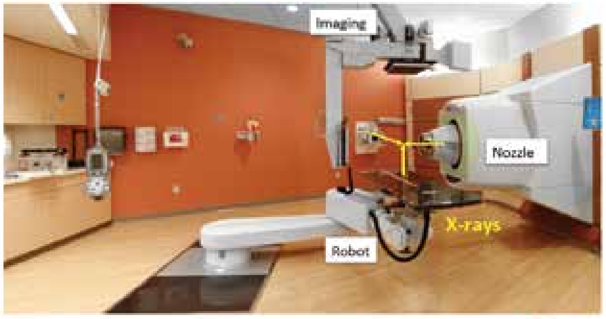
Multi-room Centers

Single-room Centers (compact gantry)

No beam sharing – one Cyclo/room

UFHealth

Treatment Room Components



UFHealth

Variations of room Design

UFHealth

In room Imaging Capabilities

kV/kV, CT

kV/kV, CBCT

In Development

UFHealth

Operational Challenges

Differences

Single-Room Center	Multi-room Center
Operates like a conventional linac – beam preparation time is relatively small (no beam sharing)	Beam preparation is long – could be several minuets due to beam sharing
Requires more robotic couch kicks – more imaging	Full gantry rooms require less couch kicks and less imaging
Less imaging degrees of freedom (2-axis imaging)	More imaging degrees of freedom (3-axis imaging)

UFHealth

Operational Challenges

Similarities

Single-Room Center	Multi-room Center
Robot, Gantry, Snout motions are relatively slow	Robot, Gantry, Snout motions are relatively slow
Volumetric imaging is a challenge (technology & workflow)	Volumetric imaging is a challenge (technology & workflow)

UFHealth

The ideal treatment requires precise, accurate, and reproducible positioning at all times

Localization ⟷ Immobilization

Can only be quantified in a snapshot of time

Should be quantified at all times: intra- and inter-fraction

Imaging & Immobilization

- Less imaging means more efficient treatment – a robust immobilization system is needed
- More imaging – more accurate localization but longer time for patient on couch
- Throughput is an issue in proton therapy centers- on average 10 minutes/beam
- Goal: image once at setup and trust that immobilizer system to keep the integrity of localization for the rest of the treatment – should not be that hard for intracranial treatments…! **or is it?**

Evaluation of Immobilization Quality in PT

Basic assumptions:

- Robotic couch motion has sub-millimeter accuracy
- Imaging and radiation isocenter congruency is sub-millimter for all couch/gantry/snout positional combinations
- Image fusion quality and reproducibility is user independent

Perfect Positioning & Localization

Importance of Intracranial Immobilization in PT

Mask intra-fraction monitoring

Mask inter-fraction monitoing

Immobilization is only part of the equation. What about localization technology in PT?

- [x] In-room lasers
- [ ] CT
- [ ] CBCT
- [ ] Portal Imaging
- [ ] Fluoroscopy
- [ ] MVCT
- [x] Digital X-rays
- [ ] Surface motion tracking
- [ ] Internal tumor tracking
- [ ] Gating (active and passive)

✔ : currently existing & reliable technology

UFHealth CANCER CENTER

Welcome to the Era of Personalized Immobilization

UFHealth CANCER CENTER

References

UFHealth CANCER CENTER

Acknowledgements

- Wen Hsi, PhD - McLaren Proton Therapy Center, Flint, MI
- Therapist and Physicists at the ProCure Proton Therapy Center, Oklahoma City, OK

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Thank You

Questions?

UFHealth CANCER CENTER

Notes

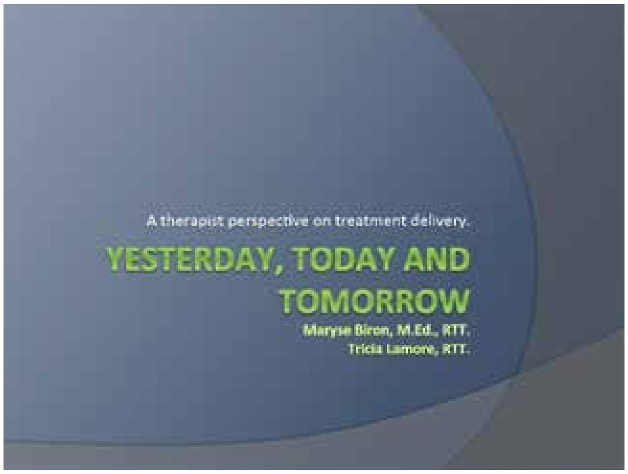
Notes

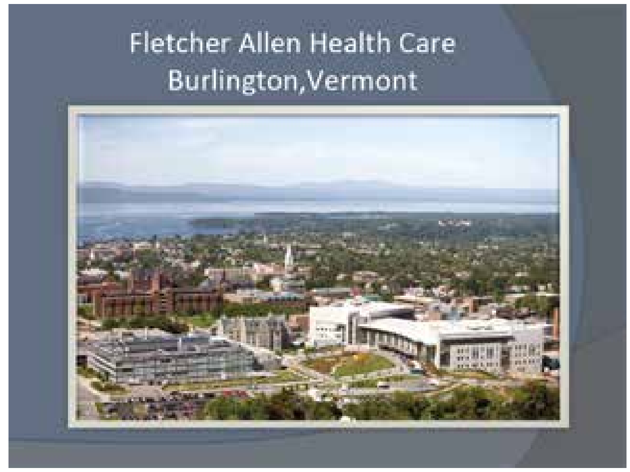
Saturday, March 29, 2014

11:15am - 12:00pm

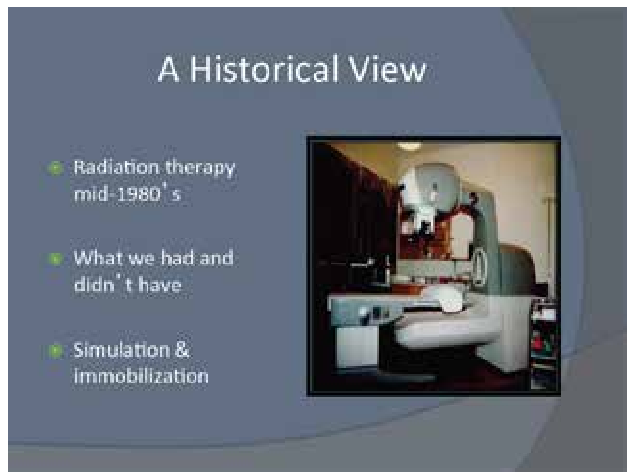
Maryse Biron, M.Ed., RTT & Tricia Lamore, RTT

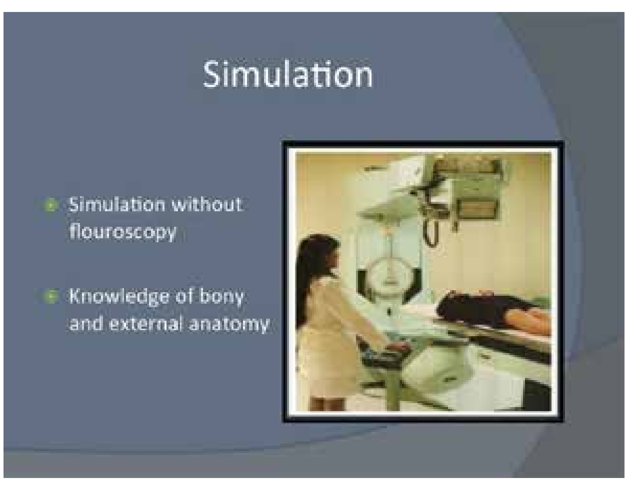
Therapist Perspective on Treatment Delivery (Past/Present/Future)

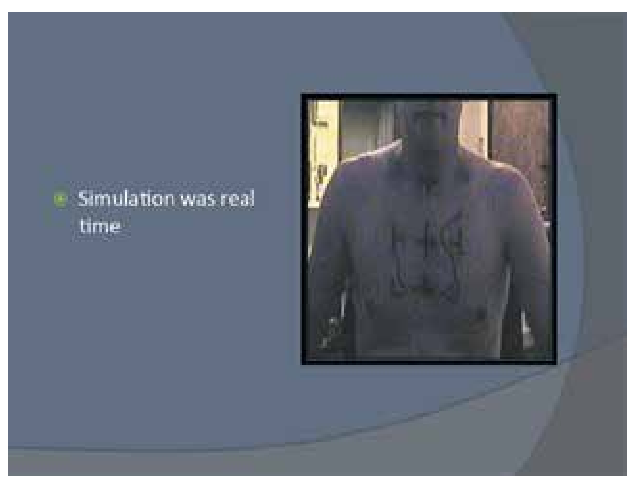

A therapist perspective on treatment delivery.
YESTERDAY, TODAY AND TOMORROW
Maryse Biron, M.Ed., RTT.
Tricia Lamore, RTT.

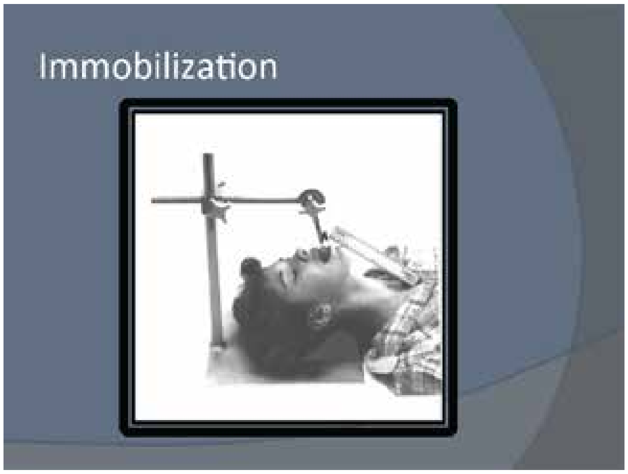

Fletcher Allen Health Care
Burlington,Vermont

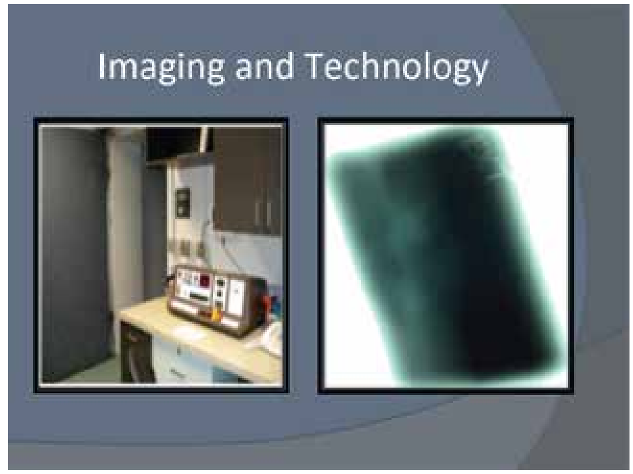

Goals and Objectives
Historical review of Radiation Therapy
Immobilization, technology and treatment delivery
Industry changes and new technology


A Historical View
Radiation therapy mid-1980's
What we had and didn't have
Simulation & immobilization

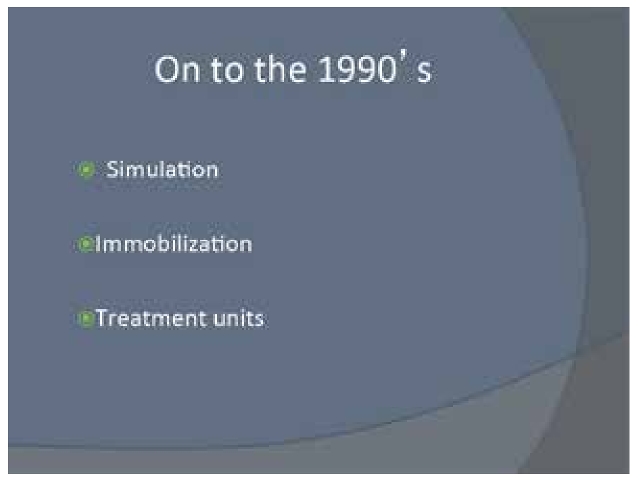

Simulation
Simulation without flouroscopy
Knowledge of bony and external anatomy

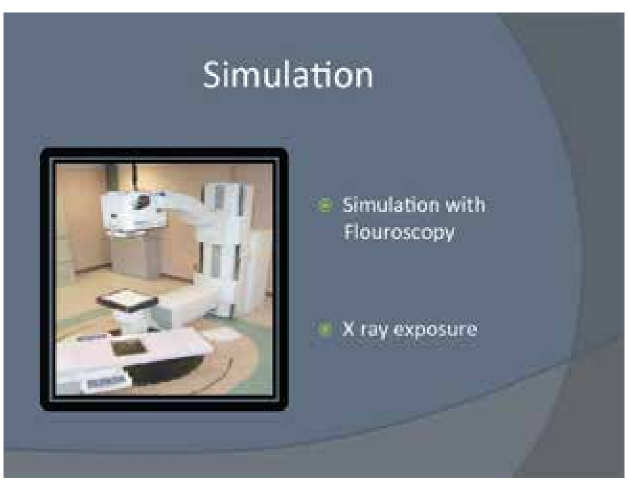

Simulation was real time

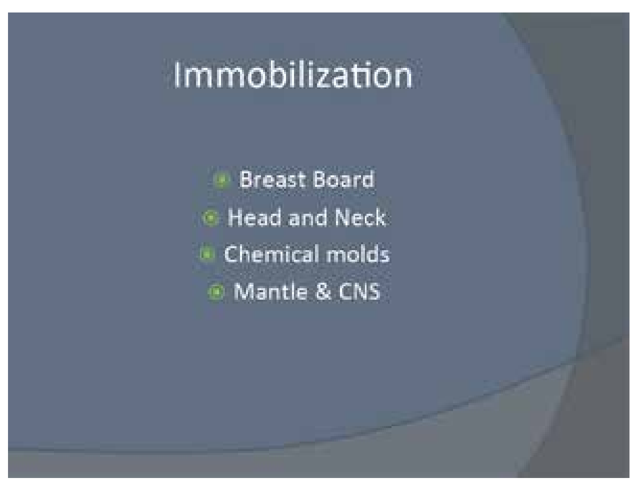

Immobilization


Imaging and Technology

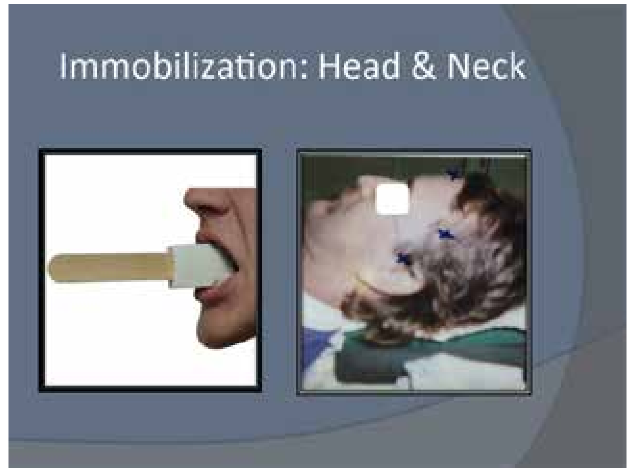

Treatment Delivery
Hand Blocks
Sandwich trays
Exposure


On to the 1990's
Simulation
Immobilization
Treatment units


Simulation
Simulation with Flouroscopy
X ray exposure


Immobilization
Breast Board
Head and Neck
Chemical molds
Mantle & CNS


Breast Board
One size fits all
Not indexed


Immobilization: Head & Neck


Immobilization: Alpha Cradle


Prone CNS


Treatment delivery
Beamstopper
Cerrobends
Imaging ..MV only
Heustis film holder


Upgrades to Linear Accelerator
MLC
Independent Jaws


Imaging and Technology
Record and verify
Imaging

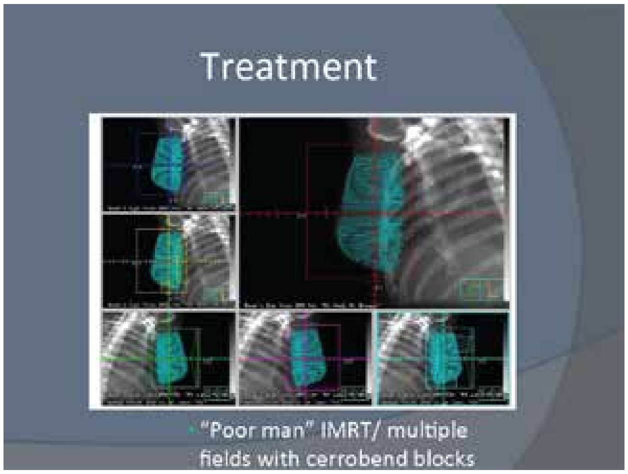

NEW MILLENIUM

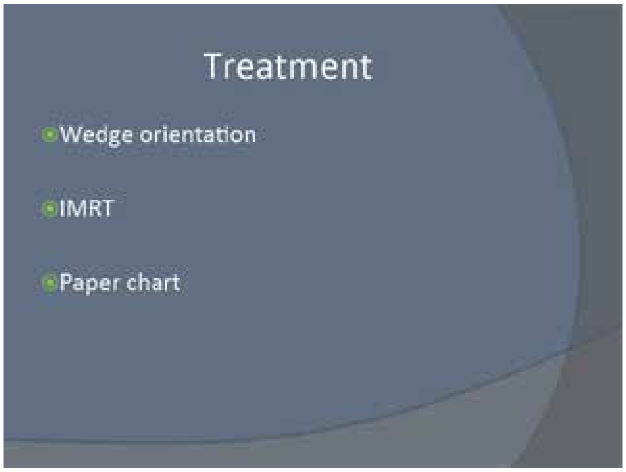

Simulation 2000's
Simulation
Visit to CT

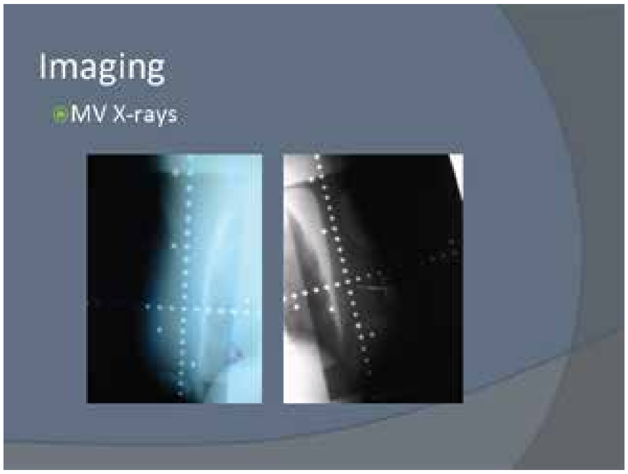

Immobilization devices 2000's
Wingboards
Vac loks


HEAD POSITIONING


BREAST BOARDS

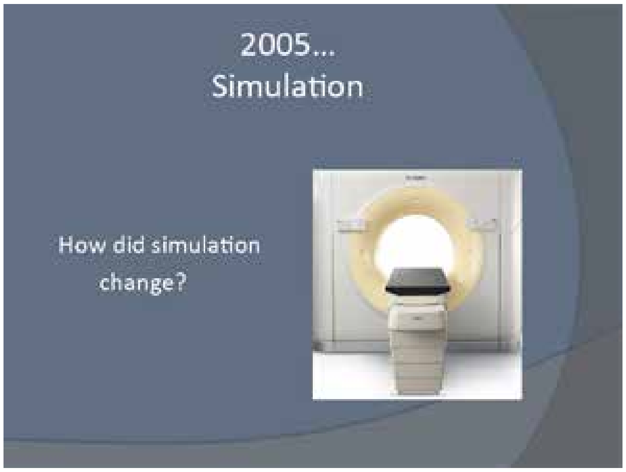

Treatment
"Poor man" IMRT/ multiple fields with cerrobend blocks


Treatment
Wedge orientation
IMRT
Paper chart


Imaging
MV X-rays

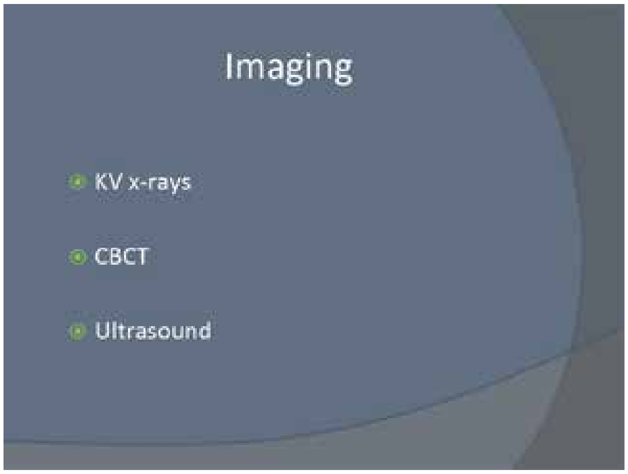

Technology: Framed SRS
Immobilization
Simulation
Treatment

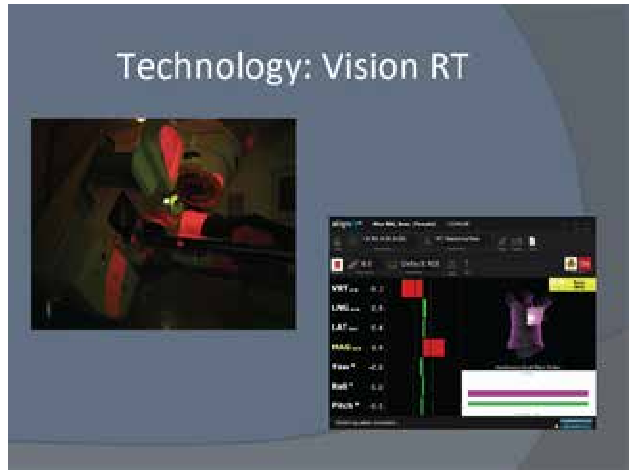

Quality Assurance
Simple
Energy output
Door interlocks


2005...
Simulation
How did simulation change?


Immobilization
Custom headrests
Belly board
Vac loks


Treatment
Electronic charting
"golden moment"
New facility


Imaging
KV x-rays
CBCT
Ultrasound


Technology: Vision RT


Technology: SABR
Immobilization
Simulation
Treatment


Technology: Frameless SRS
Immobilization
Simulation
Treatment

Quality Assurance

- Complex
- Energy output
- Door interlocks
- Ultrasound
- Imaging & isocenter confirmation
- Vision RT

Tomorrow- Where are we headed?

Tomorrow

- Immobilization
- Treatment
  - Agility MLC
  - VMAT
  - 4D CBCT/ Adaptive therapy
  - SABR body/VISION RT
  - TPUS
- Treatment planning

Acknowledgments

Thank you to the Radiation Oncology staff at Fletcher Allen Health Care including physicians, physicists, dosimetrist and therapists.

Fletcher Allen Health Care | The University of Vermont

Vermont's Academic Medical Center

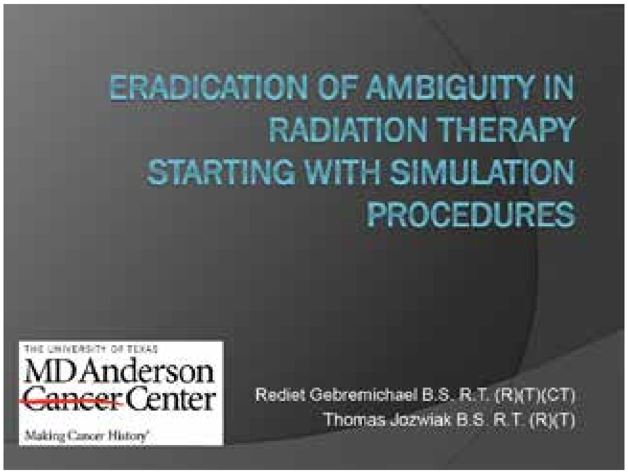
Notes

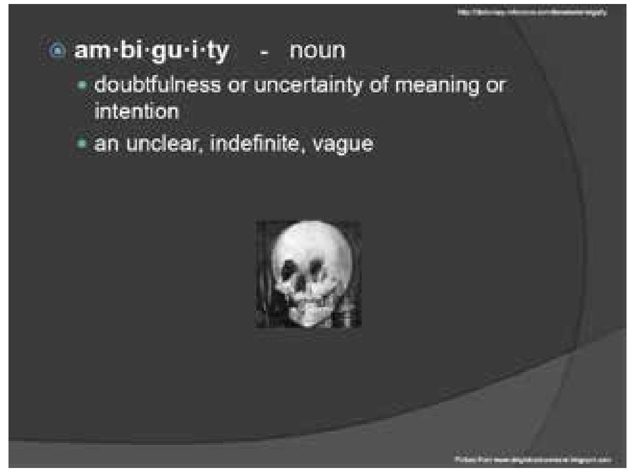
Saturday, March 29, 2014

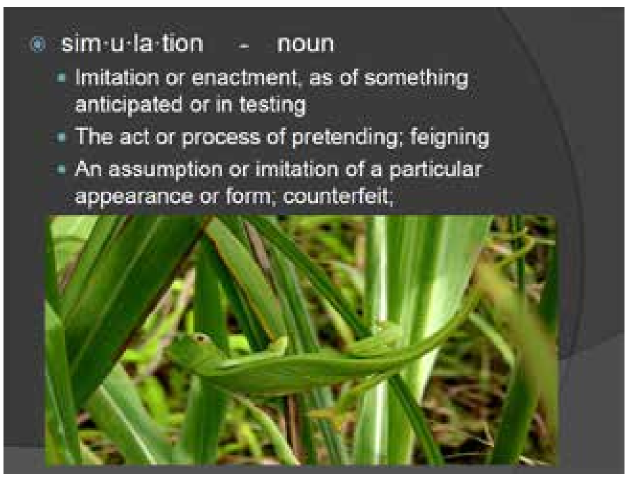
1:00pm - 1:45pm

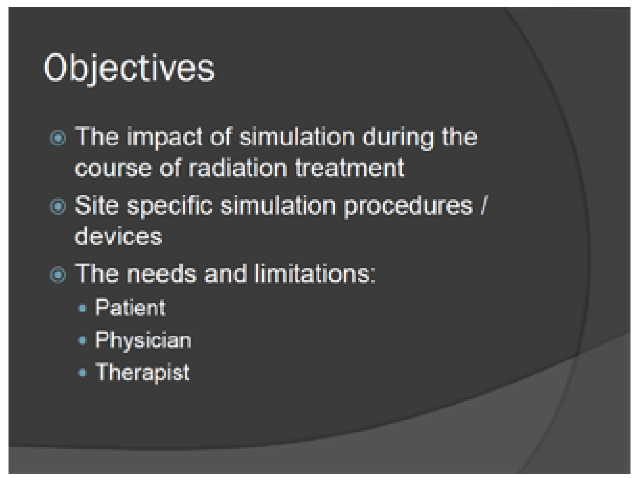
Thomas Jozwiak, RT(R)(T) & Rediet Gebremichael, BSRT(R)(T)(CT)

Eradication of Ambiguity in Radiation Therapy – Start in Simulation Procedures


ERADICATION OF AMBIGUITY IN RADIATION THERAPY STARTING WITH SIMULATION PROCEDURES
THE UNIVERSITY OF TEXAS
MD Anderson Cancer Center
Making Cancer History
Rediet Gebremichael B.S. R.T. (R)(T)(CT)
Thomas Jozwiak B.S. R.T. (R)(T)


am·bi·gu·i·ty - noun
doubtfulness or uncertainty of meaning or intention
an unclear, indefinite, vague


sim·u·la·tion - noun
Imitation or enactment, as of something anticipated or in testing
The act or process of pretending; feigning
An assumption or imitation of a particular appearance or form; counterfeit;

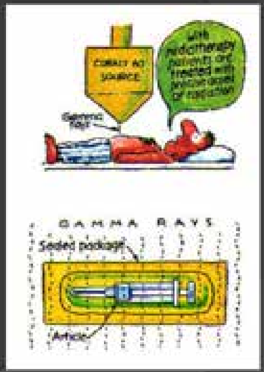

Objectives
The impact of simulation during the course of radiation treatment
Site specific simulation procedures / devices
The needs and limitations:
Patient
Physician
Therapist


How is radiation understood

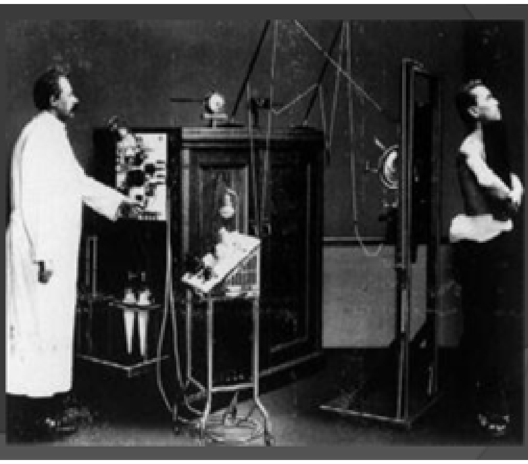

The old delivery of XRT
Fig. 2. Photograph of the ward for continuous irradiation of the entire body at long distances.

Era of Cobalt-60

- As early as the era of Cobalt-60, image quality was poor
  - owing to low contrast
    - resulting from the higher beam energy and poor resolution due to the large source size



- Early systems had problems
  - stability
  - lack of coincidence of the imaging
  - treatment sources locations



The current expectations for the delivery of XRT

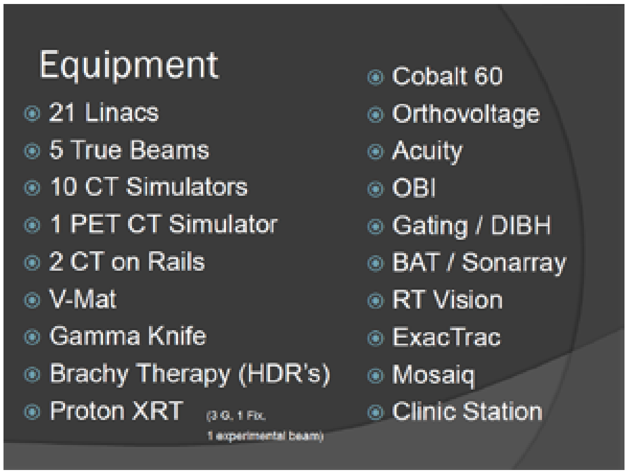
- Tighter treatment margins
  - Daily kV
  - CBCT
  - CT on Rails
  - VMAT
  - Ultrasound
  - Breath hold
- 4D CT
- PET CT
- MRI's for Gamma Knife

Little Info about UTMDACC

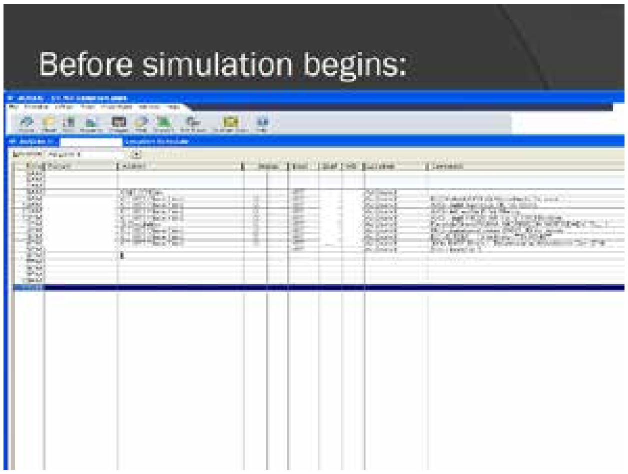
- Radiation Oncology Division
  - 62 Radiation Oncologists
  - 26 Radiation Oncology Residents
  - 27 PA's / APN
  - 49 Radiation Oncology Nurses
  - 66 Medical Physicists (70% PhD)
  - 50 Certified Medical Dosimetrists
  - 112 Radiation Therapists

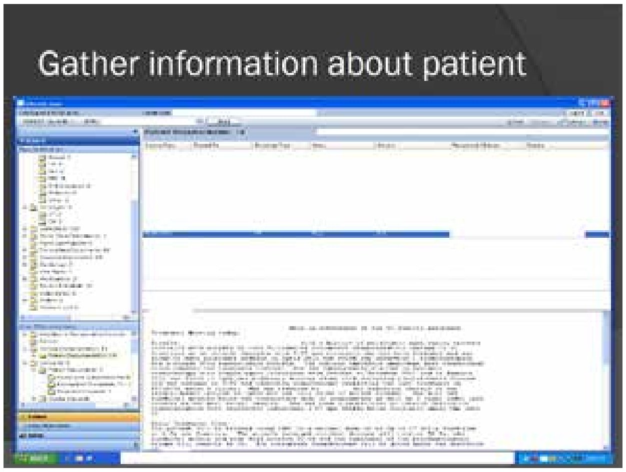
Patient Care

- New Patient Census (PTC & RCCs included): 8,110
- Daily External Beam Treatments 750 (+/-)
- Total External Beam Treatments 154,250

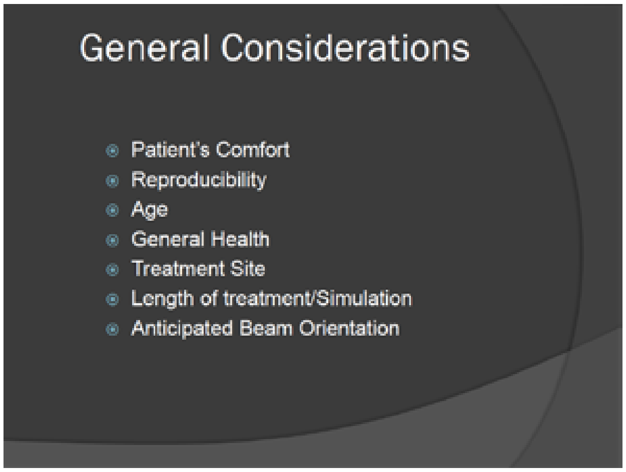

Equipment
21 Linacs
5 True Beams
10 CT Simulators
1 PET CT Simulator
2 CT on Rails
V-Mat
Gamma Knife
Brachy Therapy (HDR's)
Proton XRT
(3 G, 1 Fix, 1 experimental beam)
Cobalt 60
Orthovoltage
Acuity
OBI
Gating / DIBH
BAT / Sonarray
RT Vision
ExacTrac
Mosaiq
Clinic Station


One more type of simulation
Clinical set-up


Before simulation begins:


Gather information about patient


Disclosure and Consent
For Radiation Oncology
External Beam
Brachytherapy
Intraoperative Radiotherapy
ALL FEMALES MUST COMPLETE:
I Am Pregnant
I Could Be Pregnant
I Am Not Pregnant

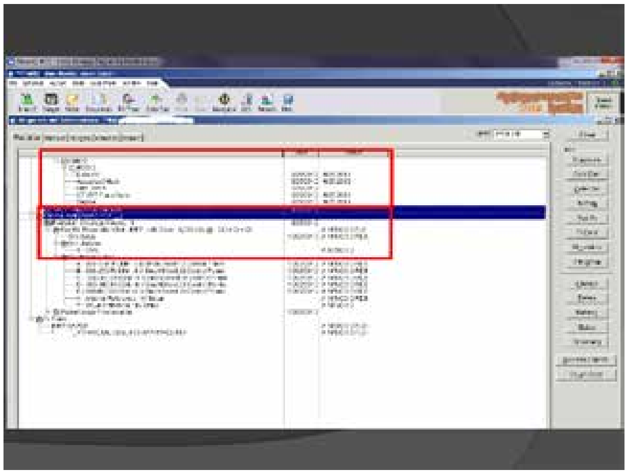

General Considerations
Patient's Comfort
Reproducibility
Age
General Health
Treatment Site
Length of treatment/Simulation
Anticipated Beam Orientation

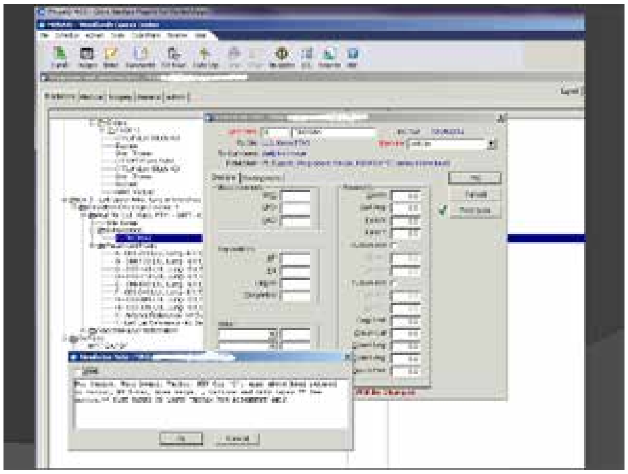
Patients Condition

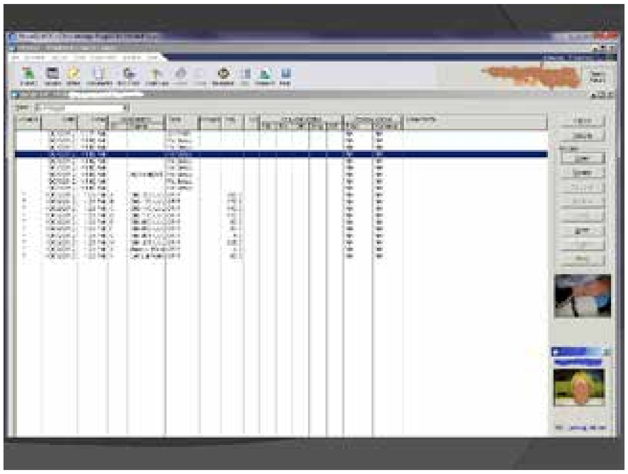
- In-Patient and Out-Patient
  - ICU
  - Sedation
  - Anxious
  - Fear
  - Paralyzed

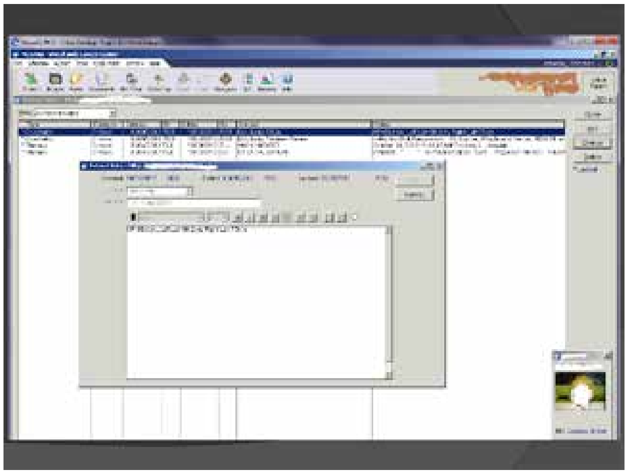
Patient Preparation

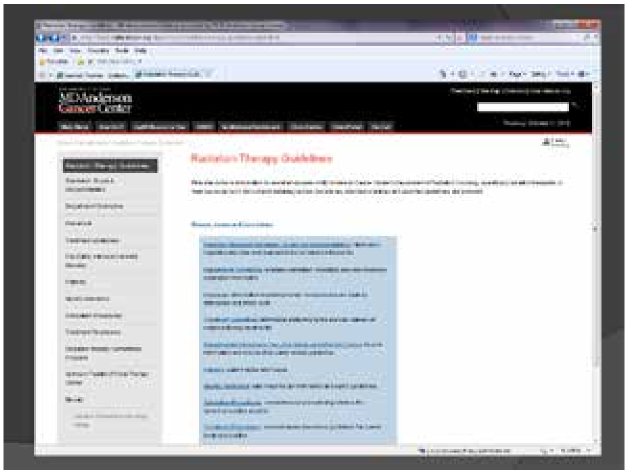
1. Obtain Patient's Medical Record Card
2. Face photo
3. Contact numbers
4. Time of treatment preference
5. Explanation of procedure
6. Question and answers

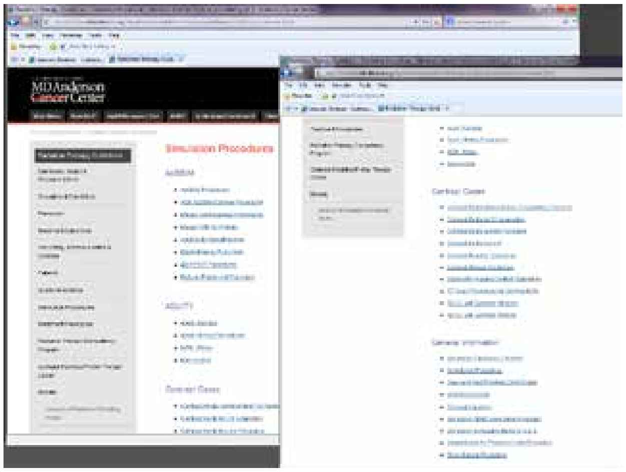


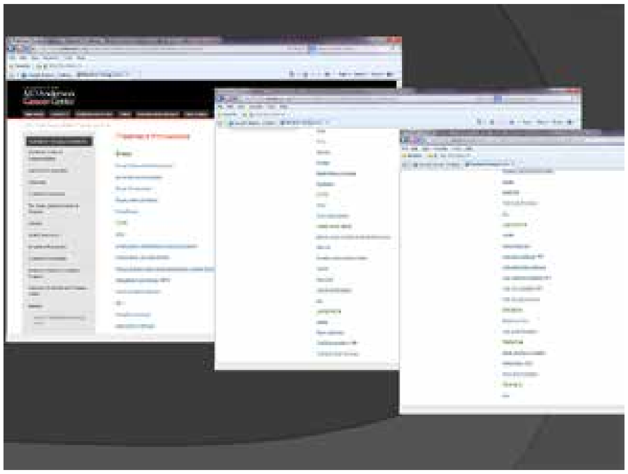












Site specific immobilization devices

- CNS
- Head and Neck
- Thoracic
- GU
- Gyn
- Breast
- Other

Room Preparation

1. Have all possible materials available for quick access
2. Each set-up is sight specific and depends upon physician's preference and patient limitations
3. Make sure the laser system is on
4. Ensure patient is properly gowned, jewelry / dentures / hearing aids, etc. removed for specific treatment

CNS – Alignment

1. Patient supine, pad on table, reg hh, clr B(neutral), mask, arms across chest holding A bar, wedge knees.
2. Align head – use lasers to dissect face sagittally at glabella, nasion, and mental protuberance. Transversely, align laser to the orbital margin. Coronally, raise table to level of EAM.
3. Use a marker to dot in the 3 points on face.

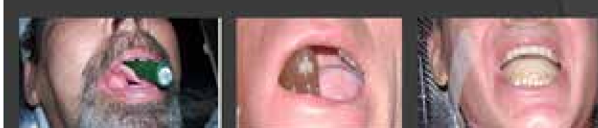
CNS – Making Mask and Scanning

1. Drop mask and do the scout film.
2. While waiting for mask to soften, (4 min) make sure patient's head and neck are in alignment and repeat if necessary
3. Place mask over patient, clamp down securely, and contour around face and head.
4. Fan, dry with facecloth, using lasers place tape and 3 bb's- 1st at the glabella, then in alignment with the center bb at mid-depth.
5. Scan vertex to clavicles, make sure bb's are in same plane (slice) and mark patient's mask.

HEAD AND NECK

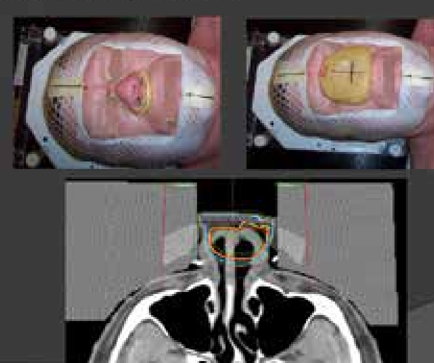
HEAD AND NECK

Custom Devices



- Some patients require special devices to fill cavities,
- position the tongue for treatment,
- or create larger distance between normal tissue and treatment volume.

Bolus- Bees wax



H/N Alignment for IMRT Treatment

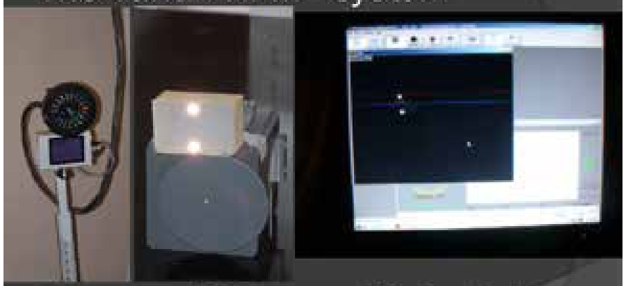
1. Patient supine on table, specific device system/mask, headrest to fit patient, arms at side with footboard set at ??,(Orfit footboard for sim only) wedge knees, (stent/bolus if used), marks for alignment, tegaderm.
2. Align patient same as CNS patient, but more attention must be given to get the body in alignment with head and neck.

H/N – Making Mask and Scanning

1. Drop mask and perform scout.
2. While mask is softening (approx 7 min), ensure patient alignment and repeat as necessary.
3. With physician's assistance, place mask over head and neck, contouring mask onto patient without any wrinkles and secure it to the frame. Realign patient with his marks.
4. Allow time for drying, wipe surface dry, ask physician where to mark iso center, then, using room's lasers, place all 3 bb's in the same plane at that point.
5. Repeat scout, get physician's ok, then scan as directed (usually from vertex to carina).
6. Using room's lasers, mark patient at bb's and draw in bolus placement if used - mark patient's abdomen for alignment and place tegaderm over marks.

4D CT

The Varian RPM® system

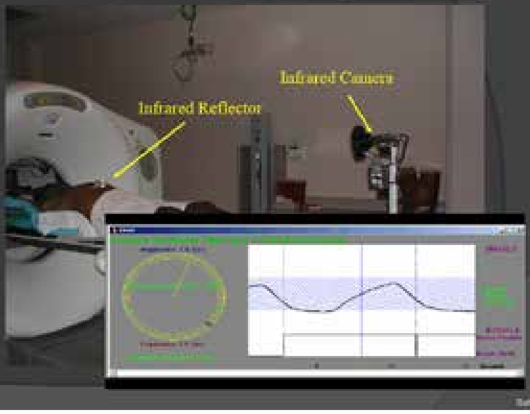


IR Camera

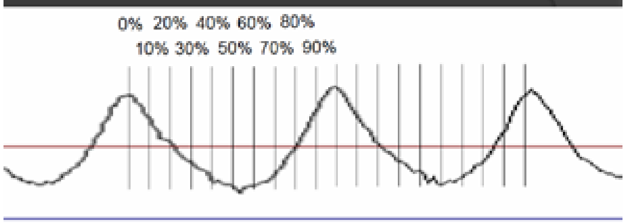
IR Reflectors

RPM software tracks the markers
Intended to gate treatments
Can be used to monitor patient breathing and for patient feedback

The RPM system for respiratory monitoring



Definition of respiratory phases



0% = End Inspiration

50% = Near End Expiration

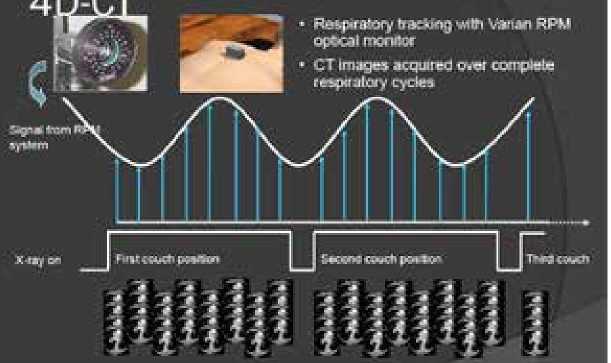
General approach to 4-D image acquisition

- Acquire image data continuously during respiration
- Reconstruct the image data at specific phases in the respiratory cycle for each patient location.
- Combine image data at same phase from several respiratory cycles.
- Result: A series of 3-D CT scans each representing a different phase in the respiratory cycle.

4-D image acquisition

- Several companies are developing options improving the acquisition of 4-D CT image data sets. Including both cine and helical acquisition modes.
- We use both cine and helical approaches at MDACC

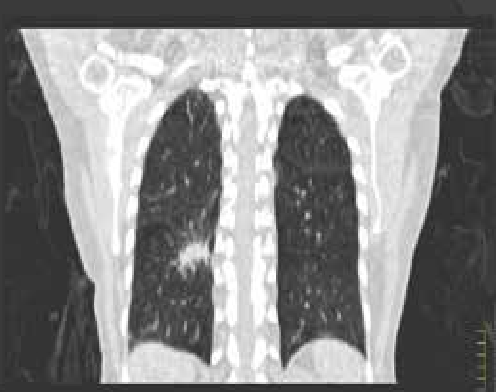
4D-CT



Slide courtesy of Tinsu Pan Ph.D., UTMDACC

Example: a 4D dataset shown at three planes through the GTV

Result of 4DCT

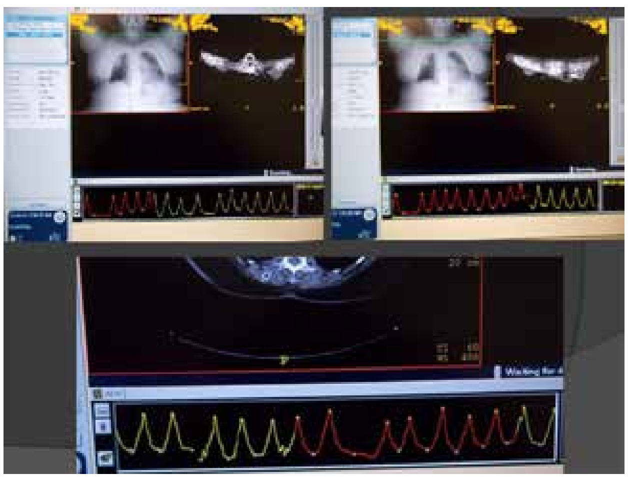


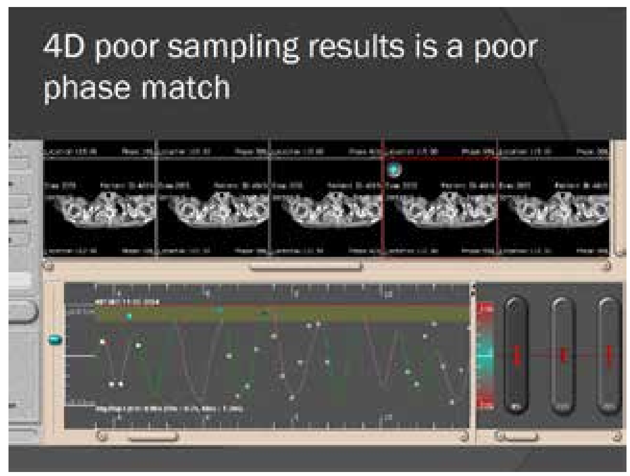
Patient breathing requirements for good 4D imaging

- Breathing must be regular – uniform in time and amplitude from cycle to cycle to ensure phase consistency.
- Respiratory cycle must be shorter than:
  - Helical: the time it takes the table to move the detector array width
  - Cine: the acquisition time at each couch position.

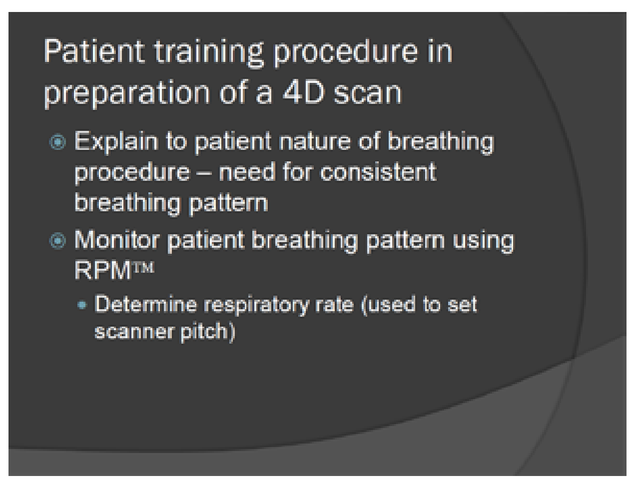

Bellows


ISO placement




4D poor sampling results is a poor phase match


4D poor sampling results in missing data
For either cine or helical:
Phase-based binning assumes reproducible displacement
Note slight displacements in patient anterior surface


Patient training procedure in preparation of a 4D scan
Explain to patient nature of breathing procedure – need for consistent breathing pattern
Monitor patient breathing pattern using RPM™
Determine respiratory rate (used to set scanner pitch)

Patient coaching (4 approaches)

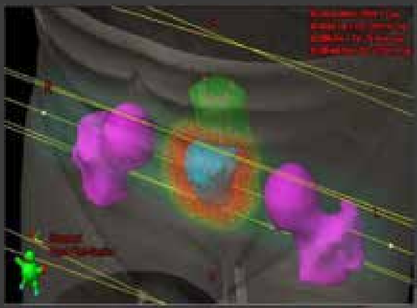
1) Do nothing – many patients breath best by being relaxed and not thinking about breathing.
2) Pre-imaging relaxation and coaching – works for many nervous patients.
3) Audio prompting: Works best to modify breathing rate, but makes nervous patient more nervous. (nonverbal audio device shows promise for these patients)
4) Video prompting: Helps patients who breath irregularly in amplitude.

Patient Video Feedback Devices

The patients breathing motion can be fed-back to the patient along with a target amplitudes to help improve the quality of 4DCT imaging.

CT-on-Rails

GU



Important - full bladder/empty rectum

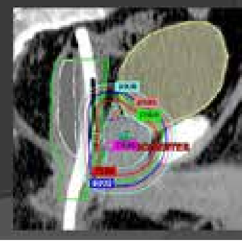
- Hydrate Body
- Eat light meals
- Avoid fresh fruits, vegetables, beans and dairy products
- 30cc Milk of Magnesium
- Fleet Enema
- Expel all gas prior to simulation/treatment

- Immobilization
  - Med-Tec Device
- Mini-CT Scan
  - 2.5mm slice thickness
  - Bladder volume
  - Rectum volume & position
    - Rectal balloon
  - Prostate/fossa position
    - Fiducials
  - Iso-center placement

- Bladder Scanner
  - Volume recorded in mosaiq
- Full-CT Scan
  - L2-mid femur
  - Verify iso-center
- Skin Markings
  - Tattoos

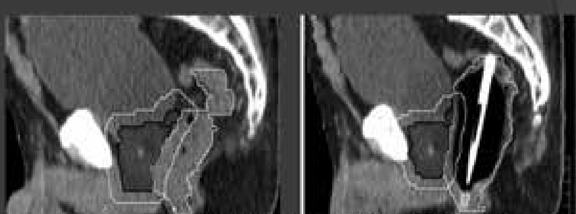
Prostate balloon immobilizers

- Immobilizes and conforms to the size of the prostate
- Localizes the prostate and push bowel and sigmoid away from it
- Balloons are inserted rectally
  - Blue line must face anterior to the patient
  - Filled with 60cc to 100 cc of H2O
- One use only



PROTOCOL

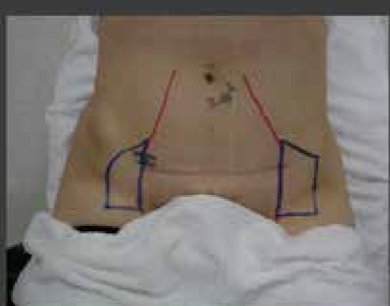
Evaluation of a rectal insert as a potential internal immobilization device to improve dosimetry in prostate cancer radiotherapy (LAB05-0546)

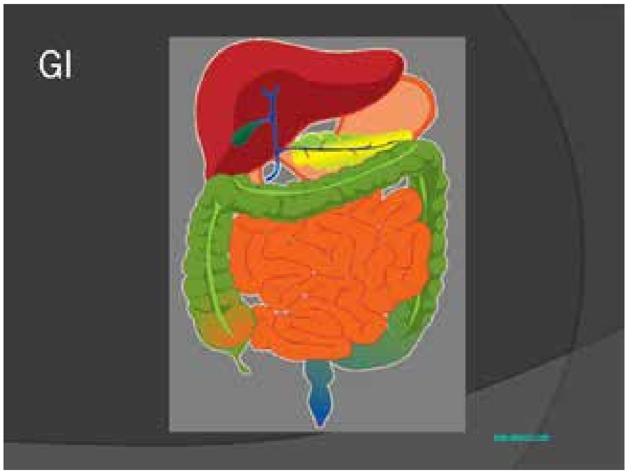


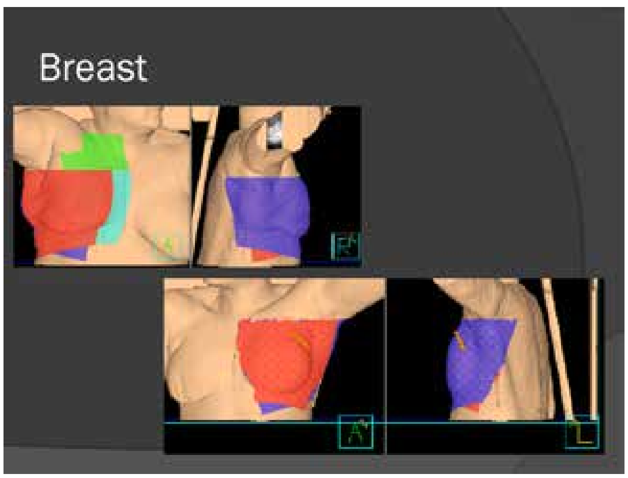
van Lin et al, IJROBP, 63 (2), 2005. pp565-576

Gyn

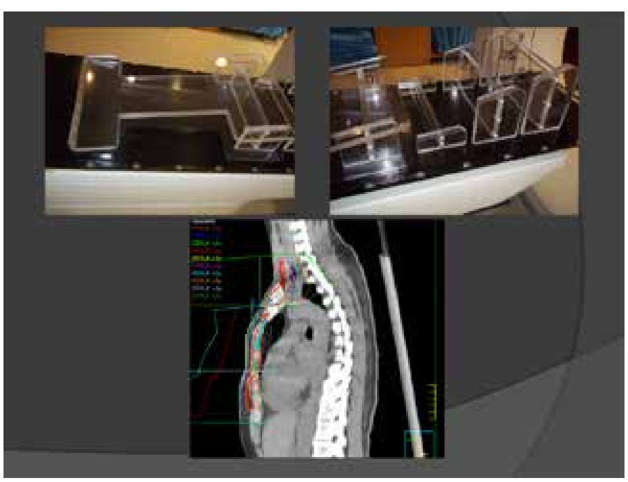
Inguinals



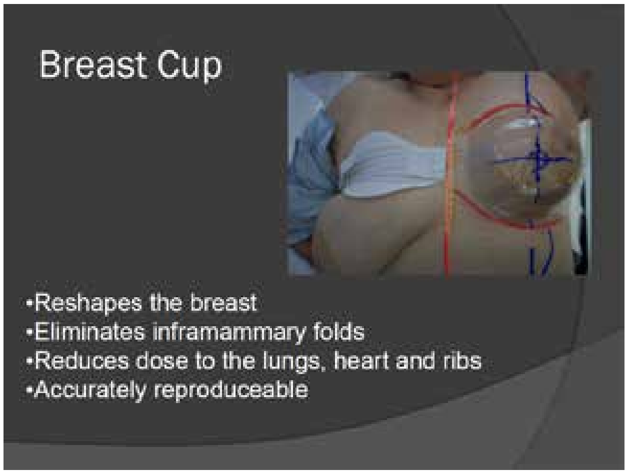

GI

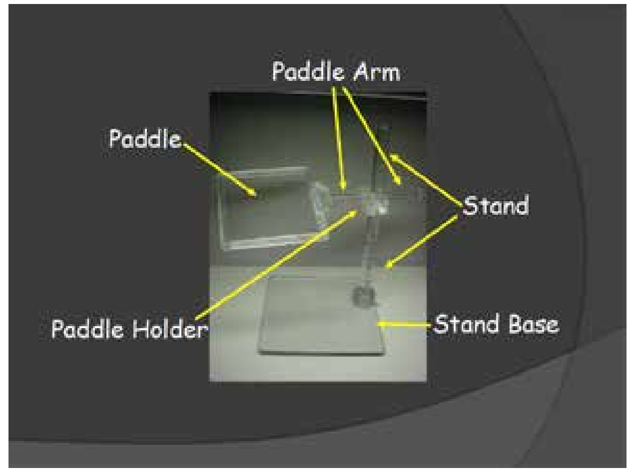

Breast

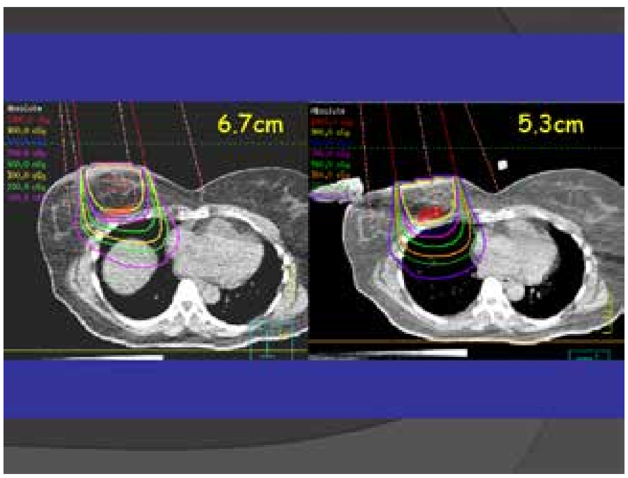

Simulation:
Set-Up and Equipment
Patient positioned in a Vac-lok™ immobilization device and on an angle board
Angle slants of 5°-20°:
prevent breast tissue from riding above clavicle
decrease skin fold at inframammary sulcus
Patient's arm on affected side raised above head
Patient's head turned away from affected side

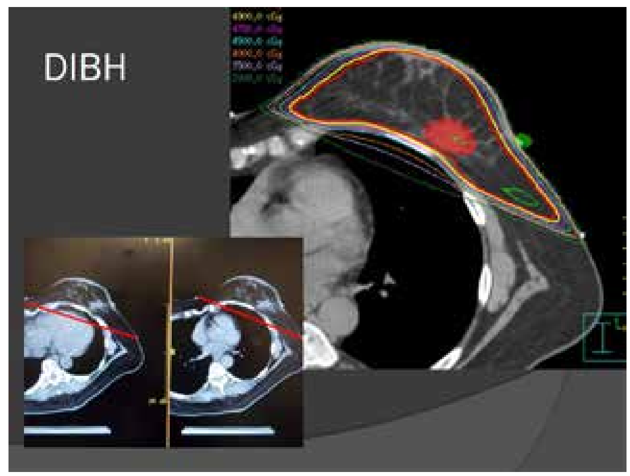


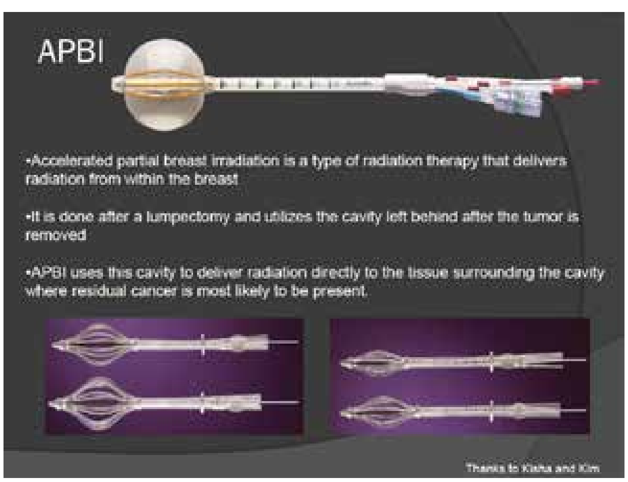

Prone Breast Radiation Treatment

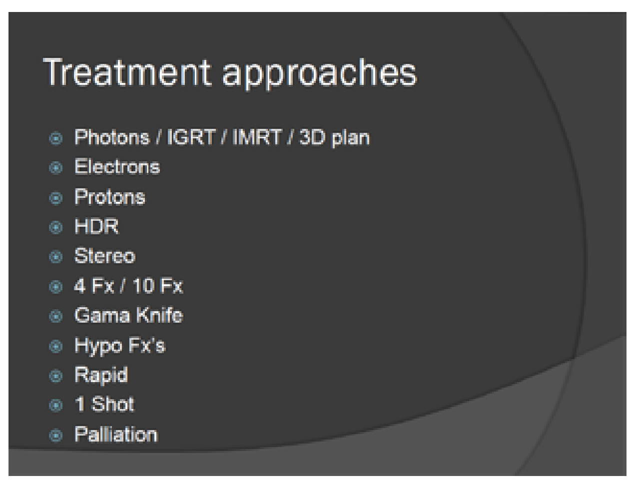

Breast Cup
•Reshapes the breast
•Eliminates inframammary folds
•Reduces dose to the lungs, heart and ribs
•Accurately reproduceable

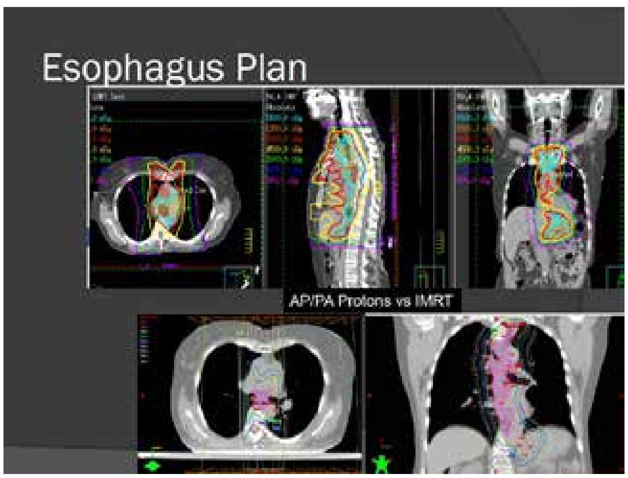

Paddle Arm
Paddle
Stand
Paddle Holder
Stand Base

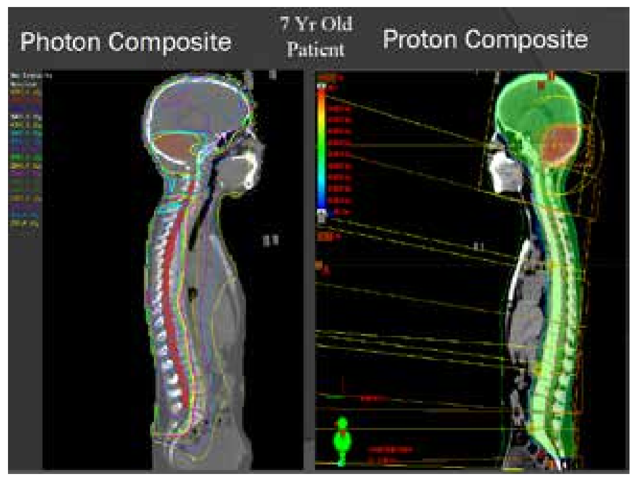

6.7cm
5.3cm


DIBH


APBI
•Accelerated partial breast irradiation is a type of radiation therapy that delivers radiation from within the breast
•It is done after a lumpectomy and utilizes the cavity left behind after the tumor is removed
•APBI uses this cavity to deliver radiation directly to the tissue surrounding the cavity where residual cancer is most likely to be present
Thanks to Kisha and Kim


Treatment approaches
Photons / IGRT / IMRT / 3D plan
Electrons
Protons
HDR
Stereo
4 Fx / 10 Fx
Gama Knife
Hypo Fx's
Rapid
1 Shot
Palliation





Physician needs and limitations for the patient treatment

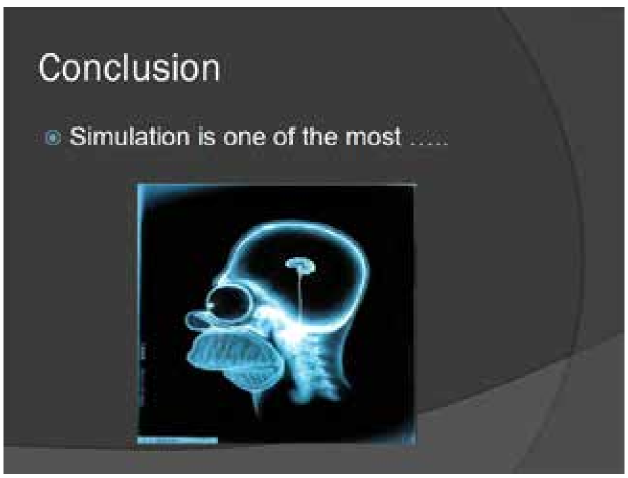
- Dose escalation
- Easy access
- Larger target volumes vs tighter treatment margins
- Sparing more of healthy tissues
- Multiple ISO's

Patient needs and limitations for the treatment

- Comfort
- Modesty
- Easy way of getting in or on to the immobilization device


Therapist needs and limitations for the treatment
Time constrains
Set-up note to complex
Manageable reproducibility of set-ups
On occasions working alone


Ultimate and poor immobilization


Conclusion
Simulation is one of the most …..

Notes

Saturday, March 29, 2014

1:45pm - 2:45pm

Doug Martin, MD

Brachytherapy Workflow in Radiation Oncology

BRACHYTHERAPY WORKFLOW RADIATION ONCOLOGY

Doug Martin, MD
Clinical Director
Radiation Oncology
James Cancer Hospital and Solove Research Institute

The James

INTRODUCTION

- Review the history of brachytherapy
- Review of types of brachytherapy
  - Diseases treated
  - Types: HDR, LDR, pulsed rate
- Teams involved
  - Rad onc team members
  - Surgical team members
  - Hospital: Inpt, Anesthesia

The James

INTRODUCTION

- Imaging
  - Types of imaging used
  - Benefit of each type of imaging
    - MRI, CT, and US
- Pt positioning
  - Critical for applicator placement
  - Critical to minimize changes, ensure tx delivery accuracy

The James

INTRODUCTION

- Most common brachytherapy cases
  - Prostate implant
  - Gyn Onc intracavitary
  - Gyn Onc interstitial
- Improved/modified procedures in new department
- Summary
- Questions

The James

CANCER CENTER OVERVIEW

- 1 of 40 institutions with NCI-CCC designation
  - Held since 1976
  - Original 8 in 1973
  - Midwest's first and Ohio's only freestanding cancer hospital
- OSU is the largest university in the country
- One of 7 NCI-designated Phase I Centers

The James

DEPARTMENT OVERVIEW

- 15 physician faculty
  - 5 physician scientists
- 10 medical physicists
- 10 research faculty
- Training programs:
  - Radiation Oncology medical residency
  - Medical Physics residency
  - Radiation therapist program

The James

Radiation Oncology Resources

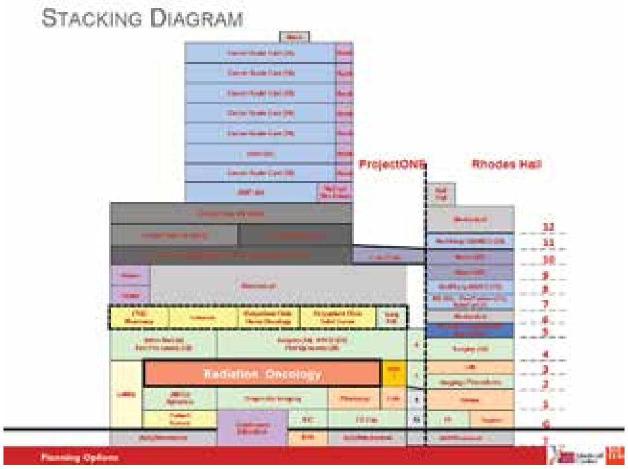
Current Department:

1. Linear Accelerators x 4 (3 Siemens, 1 Truebeam/STX)
2. Gamma Knife
3. Simulators: CT x 1
4. Operating room – BRACHY Suite

New Department:

1. Linear Accelerators x 7 Truebeams
2. Simulators: PET/CT, CT, MRI, shelled space for ?MRI/PET
3. Operating room – BRACHY Suite
4. Gamma Knife stays in same location

The James



BRACHYTHERAPY

- Brachios (Greek) = "short distance"
- Implantation of encapsulated radioactive sources inside/close tumor
  - 'interstitial' placing sources within tissue
  - 'intracavitary' within normal anatomic cavities

The James

Brachytherapy

- Long history, first cases in early 1900's
- Utilization has been like a pendulum
- Prostate cancer and Gynecologic malignancies continue to benefit from brachytherapy and make up the majority of cases in most institutions
- Partial breast irradiation with brachytherapy applicators also in common practice

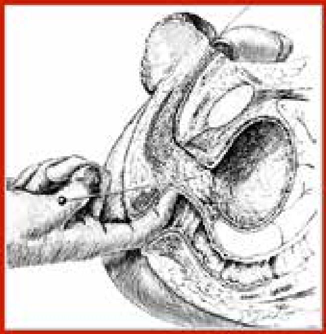
The James

It's often assumed that prostate brachytherapy was first performed in the second half of the 20th century. In fact, radium sources were used in the treatment of prostate cancer many decades earlier by several prominent urologists. The leading innovator was Benjamin Barringer, who performed hundreds of transperineal implants beginning in 1915.[2]

1915

From ONCURA website

Insertion of an Emanation-Tipped Needle using a Transperineal Approach, Under Guidance of a Finger in the Rectum



Young initially reported dramatic results, with "amazing resorption of extensive carcinomatous involvement of prostate and seminal vesicles in the majority of cases," resulting in the "disappearance of pain and obstruction...which is indeed remarkable."[2-4]

From ONCURA website

Gold Radon-Bearing Seeds

Radiograph of pelvis demonstrating the position of intraprostatic gold-sheathed radon ("emanation") seeds. This patient had undergone several implants.[1]

1926

From ONCURA website

Brachytherapy

- Disease sites (almost any site):
  - GU: prostate, female urethra, penis
  - GYN: cervix, uterus, vagina, vulva
  - EYE: ocular melanoma
  - Breast: partial breast irradiation
  - Head & Neck: primary or recurrent disease
  - Sarcoma, Thoracic, Skin, Rectal, CNS, GI

The James

Types of Brachytherapy

- Intracavity implants
  - Radioactive sources are placed near the tumor (cervix, trachea)
- Interstitial implants
  - Sources placed directly into the tissue (prostate, vagina)
- Intraoperative implants
  - Surface applicator is in direct contact with the surgical tumor bed (soft tissue sarcoma) done at the time of surgery

The James

Brachytherapy delivery

- Low-Dose-Rate (LDR)
  - Radiation delivered over the course of 48 to 120 hours or longer - Gynecologic, breast, head and neck, and prostate cancers may be treated with low-dose-rate brachytherapy
- High-Dose-Rate (HDR)
  - High energy source delivers the dose in a matter of minutes rather than days - Gynecologic, breast and some prostate implants may use use high-dose-rate brachytherapy

The James

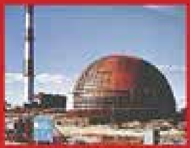
Brachytherapy Implant Duration

- Permanent or Temporary
  - Temporary implants are left in the body for minutes up to several days
    - Patient may require hospitalization during the implant depending on the treatment site (e.g., cervix)
    - Examples include low or high dose rate gyn implants and high dose rate prostate or breast implants
  - Permanent implants release small amounts of radiation over a period of several months
    - Patients receiving permanent implants may be minimally radioactive and should avoid close contact with children or pregnant women
    - Example permanent seed prostate implants

The James

Brachytherapy Source Production

- Radium was only naturally occurring radioactive material used for brachytherapy
- Most brachytherapy isotopes used today are man made:
  - A stable isotope is taken and bombarded with neutrons (activation) or protons (transmutation) to create a radioactive element
- Source production typically happens in a Nuclear Reactor or Cyclotron



Nuclear Reactor

Cyclotron

Brachytherapy Sources

Isotope	Half-Life $T_{1/2}$	Mean Energy (keV)	Predominant Mode of Decay
Iridium-192	74.3 days	598	-β, EC
Cesium-137	30.0 years	662	-β
Iodine-125	59.5 days	35	EC
Gold-198	2.7 days	412	-β
Radium-226	*1622 years*	*830*	*α*
Cobalt-60	5.3 years	1250	-β
Palladium-103	17.0 days	21	EC
Phosphorous-32	14.29 days	695 (β)	-β

Team Approach

- Radiation Oncology Department
  - Radiation Oncologist
  - Radiation Physicist
  - Brachytherapy trained Radiation Therapist
  - Brachytherapy trained Nurses
  - PCAs
- Surgical Team – Urology, Gynecologic Oncology, etc.
- Anesthesiologist
- Surgical Nurse and Scrub tech
- Inpatient nursing, pain team

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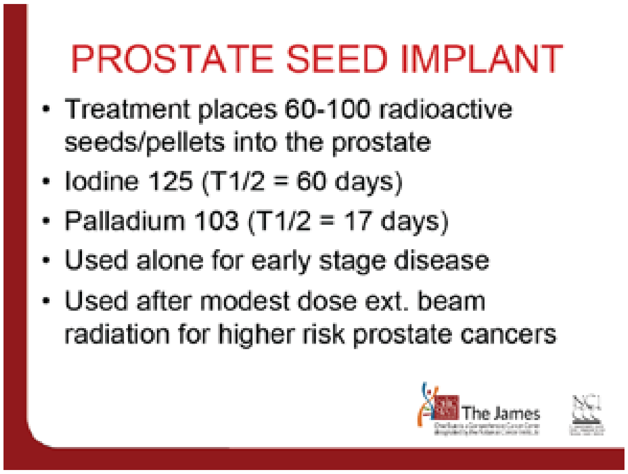
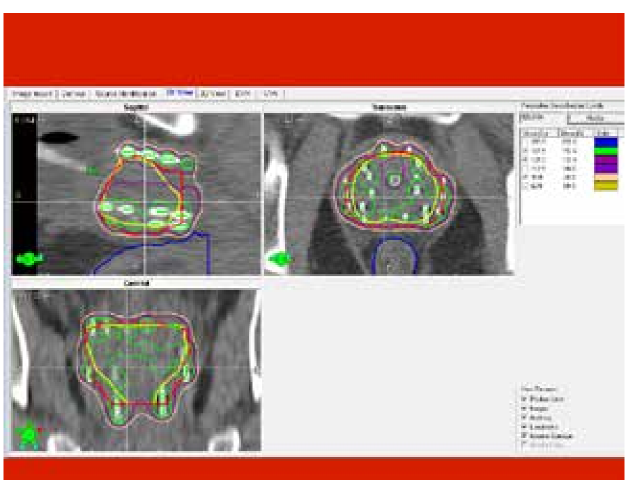
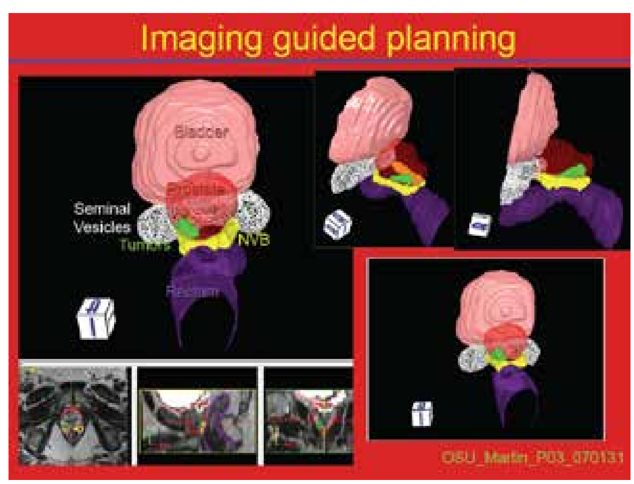

PROSTATE SEED IMPLANT
• Treatment places 60-100 radioactive seeds/pellets into the prostate
• Iodine 125 (T1/2 = 60 days)
• Palladium 103 (T1/2 = 17 days)
• Used alone for early stage disease
• Used after modest dose ext. beam radiation for higher risk prostate cancers
The James

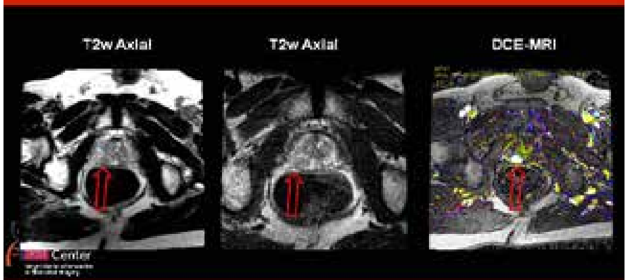

The James


Needle, delivering seeds into prostate
Catheter in urethra
Ultrasound probe in rectum for needle guidance
Template to aid accurate placement of the needles delivering the seeds
The James




Imaging guided planning
Bladder
Prostate
Seminal Vesicles
Tumors
NVB
Rectum
OSU_Martin_P03_070131

Imaging guided planning



GYNECOLOGIC CA

- CERVICAL CANCER
- VAGINAL CANCER
- ENDOMETRIAL CANCER
- URETHRA- RARE

The James

TANDEM AND RING 45 DEGREE

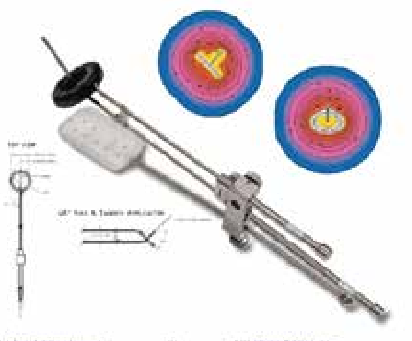
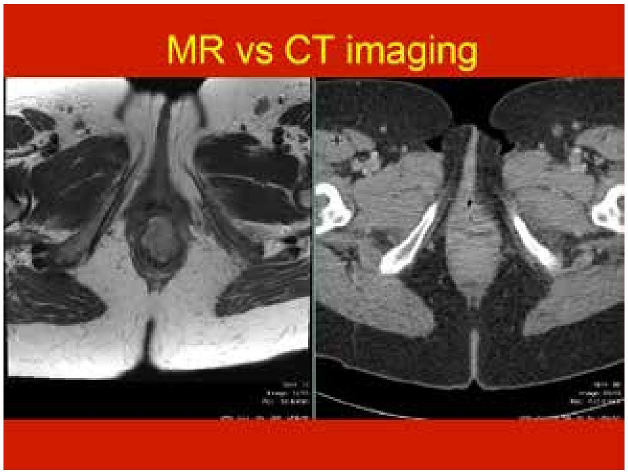
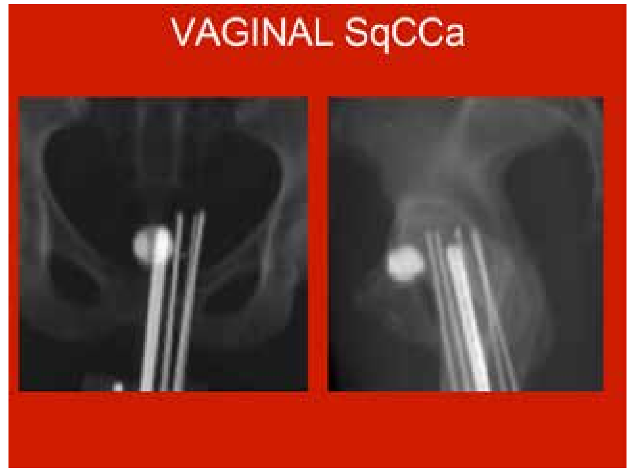
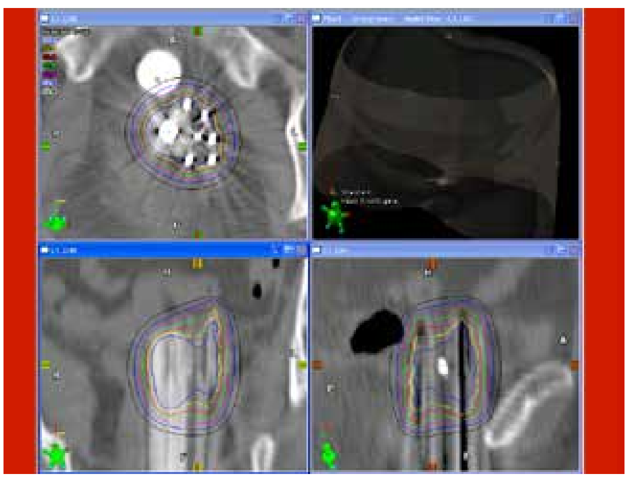


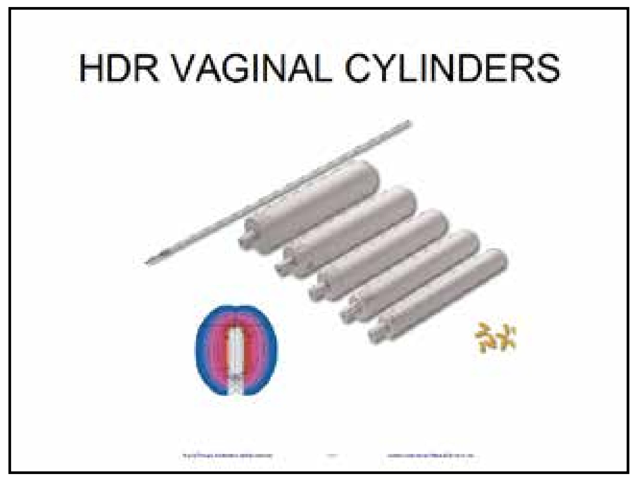
Image-based Brachytherapy for Women's Cancer

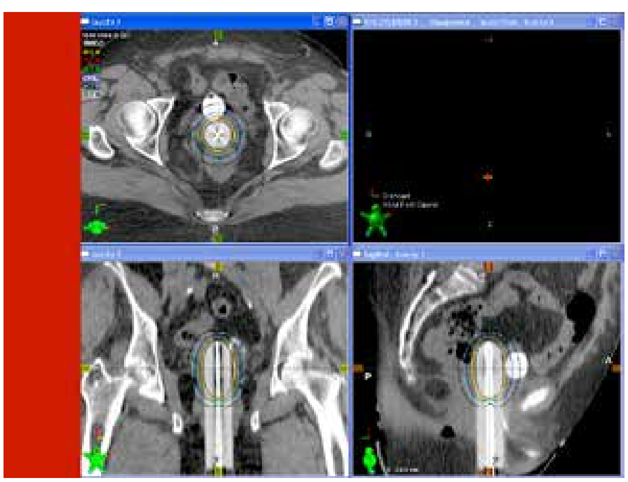
Multi-Modality Imaging in Cervical Cancer Brachytherapy

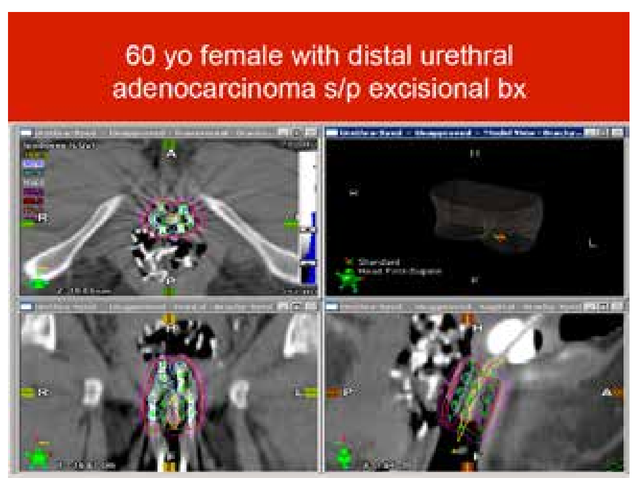

MR vs CT imaging

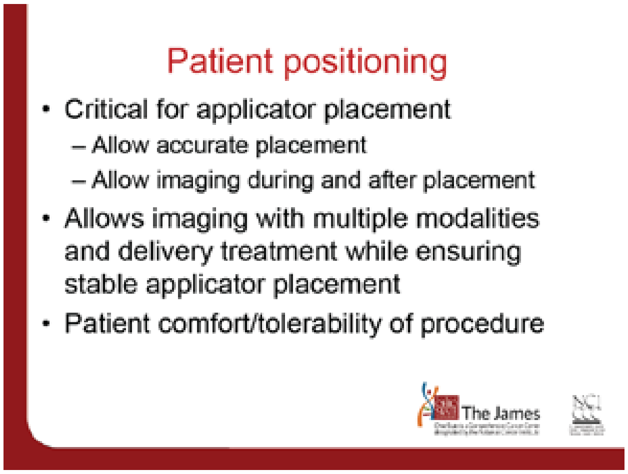

VAGINAL SqCCa

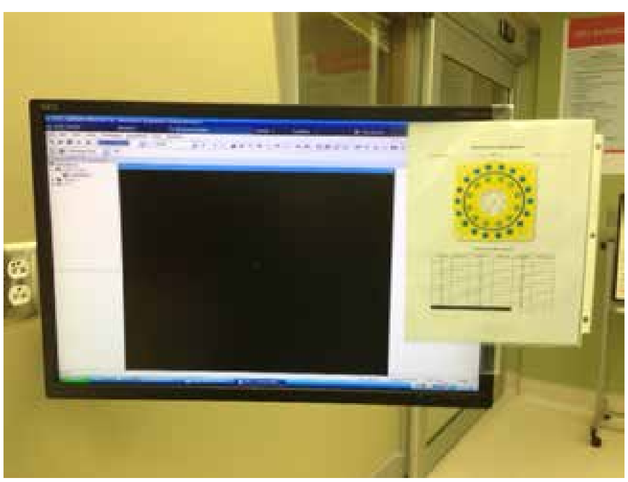



HDR VAGINAL CYLINDERS




60 yo female with distal urethral
adenocarcinoma s/p excisional bx


Patient positioning
• Critical for applicator placement
– Allow accurate placement
– Allow imaging during and after placement
• Allows imaging with multiple modalities and delivery treatment while ensuring stable applicator placement
• Patient comfort/tolerability of procedure
The James




QUESTIONS?
The James

Notes

Saturday, March 29, 2014

3:15pm - 4:00pm

Jordan Johnson, MSHA, BSRT(R)(T)

“It’s More Than Just Doing More with Less”

IT'S MUCH MORE THAN JUST DOING MORE WITH LESS

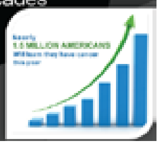
Jordan Johnson, MSHA, BSRT RT

Overview

- Changes in Radiation Oncology
- Staffing
- Productivity
- Management
- Billing and Coding
- Marketing
- Legislation

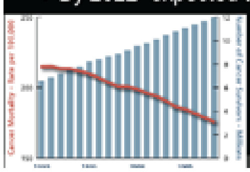
Radiation Oncology

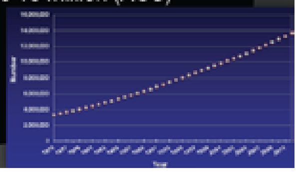
- At the core we are all in it for patient care
  - Quality, accurate care **Every Time**
- Incidence
  - Cancer rates are expected to grow
    - 2010 to 2030 rates expected to grow 45% (US)
    - 1.6 million to 2.4 million
    - 2013- 1.66 million new cases
    - WHO- 57% increase worldwide
    - 14 million in 2012 to 22 million in 2 decades
- Why the Growth
  - Screening
  - Testing
  - Aging population



Radiation Oncology

- Survivors
  - Death rates have decreased 20% from their peak in 1991
  - World wide- predicted growth over 20 yrs 8 to 13 million
  - January 1, 2012- 13.7 million survivors (ACS)
    - Males- 6.44 million
    - Females- 7.24 million
  - By 2022- expected to grow to 18 million (ACS)





Dilemma

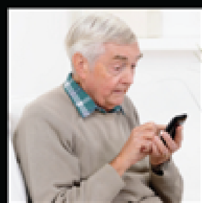
- We have better outcomes
- We have more patients that need treatment
- Costs are increasing
- Capital is being contained
- Budgets being dialed back
- Reimbursement is decreasing
- Patient access to care
- We all hear: maximize productivity, cut costs, cut expenses, watch hours……We have to be **PROFITABLE**

What is Being Profitable

- Definition has changed
  - 5 to 10 years ago
    - Hiring staff / Locums
    - Travel
    - Purchasing
    - Overtime
  - Now
    - Minimize purchases
    - Maximize life of equipment
    - Meeting the budget
    - Not sacrificing quality or safety
    - Productivity models
    - LEAN & Six Sigma

Patients Struggle

- Ability to get insurance
  - Understanding insurance
- Access to care
- Medicare
- Uncertainty
- Entitlement
- The best care
- Don’t want to wait
- Increased deductibles/ copays

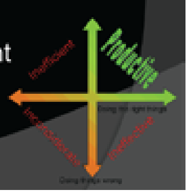


Provider’s Struggle

- Continue to provide quality care
- Reimbursement
- Volumes
- Staffing
- Medical equipment costs
- Outpatient Services- operation hours
- Providers retiring and fewer coming onboard
- Patient accountability
- Educate patients

The Change

- Staffing
- Productivity
- Management
- Billing and coding
- Marketing
- Legislative updates / involvement
- Patient input/ opinion



Staffing

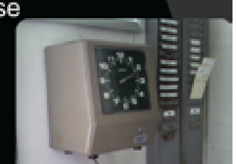
- Who works in our department
- Evaluate how they all work
  - Teams
  - solo
  - shifts
  - floats
  - 8’s vs 10’s
- Clinic Hours

Staffing

- FTE Calculations- constant review
  5.7 x (30 or 31)= Divide that into your productive hours
- Hiring
  - Full time/ part time
  - Locums?
- Staggering shifts
- Cross Utilization

Staffing

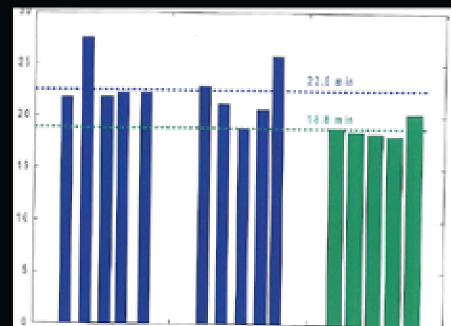
- Overtime- does it make sense
  - Why?
- PRN’s
  - Amount of time they work
  - Using them more- trend
- Staying focused on the dept.
- Exempt Vs. Non Exempt
- Types of Treatment- IMRT, SBRT, SRS



Staffing

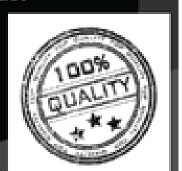
- Utilization of technology and techniques
  - Rapid Arc / VMAT
  - SBRT
  - AFS
  - Dosimetry- segments, couch kicks, contouring tools
- Centralization
- Many of the linacs and R&Vs have time saving features
  - May need licensing or commissioning
  - End Result is to maximize use of productive hours

Staffing



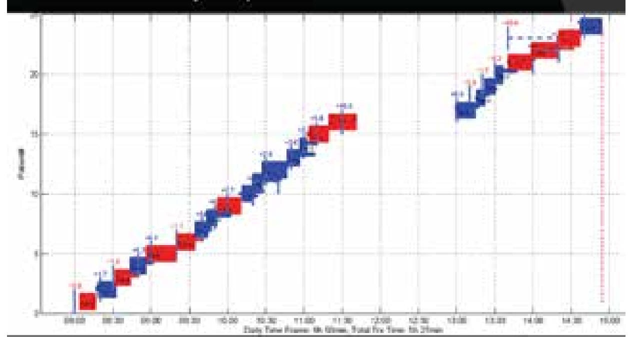
Staffing

- Referral patterns- front desk / scheduling
  - New specialty physicians
  - Extended vacations
- Quality of Your Hire
  - Don't want someone just doing the least
  - Screening- ask the tough questions
  - Let them work and observe
    "Breathing is not a qualification"
  - Hiring Freezes
- Productivity Reports
  - Only as good as the data you capture

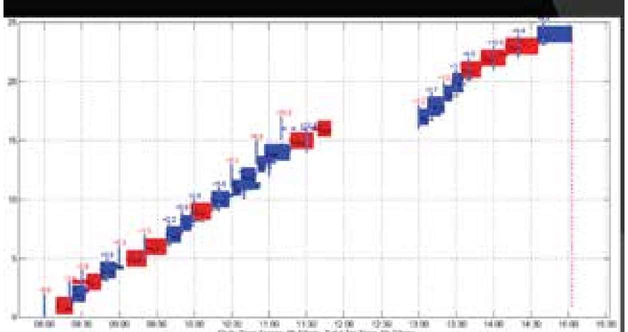


Productivity

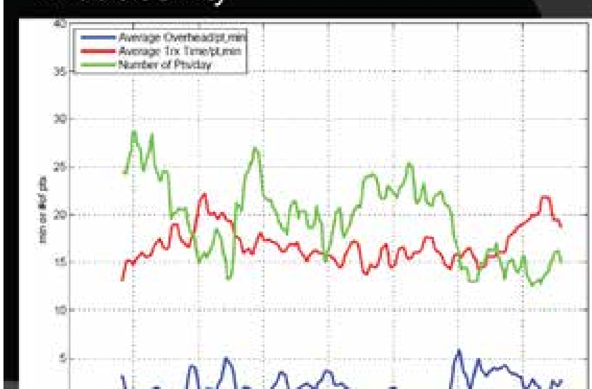
- Productivity Reports



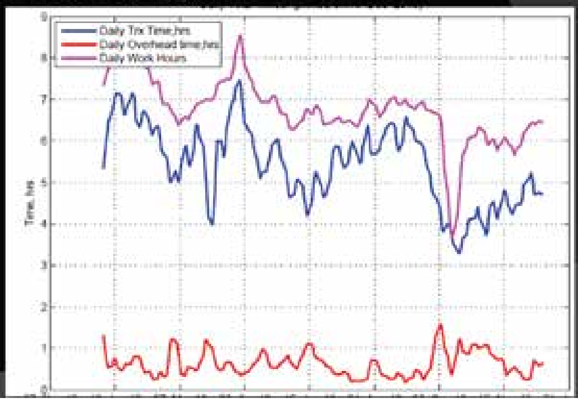
Productivity



Productivity



Productivity



Productivity

- Graph Indicators
  - Spikes may indicate patient issues
    - Patient set ups
    - Patient prep- prostate
    - Inpatient wait time
    - Chemo
  - Overhead time increase
    - May indicate lighter volumes
    - Change in patient treatment types
  - Can define normal ranges
  - Annual patterns
    - You can’t staff for what might happen

Productivity

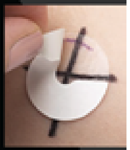
- Patient Process
  - Consult
    - Paperwork
    - Time spent with patient
  - Sim
    - Patient Instructions
    - Streamline set ups
  - Treatment
    - Treatment types
    - Inpatients
    - Transport
    - Gowns / patient attire
    - Patient arrival times

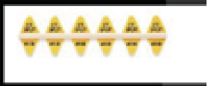
Productivity

- Departmental Design
  - Logistical locations
    - Minimize distances
  - Distraction free areas
    - Nursing
  - Patient waiting rooms
    - On treatment
    - Consults
  - Ex. Department & CT

Management

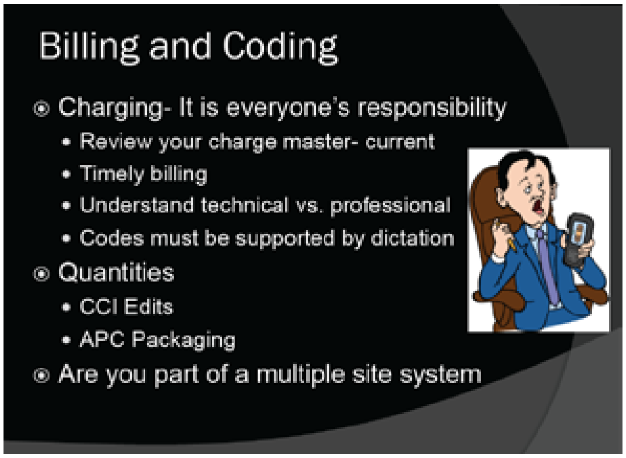
- Resources
  - Do you have excess amounts of products
  - “I’ve always bought it”
  - Waste
    - It may be cheaper, but how much are you using
    - Do you get better results
      - Masks, breastboards, vac lok…ect
  - Processes- looking for supplies
- Donations or sample programs
  - Nutrition
  - Skin care products
  - Patient information
- Foundation
- Could things be done locally
  - Fabrications

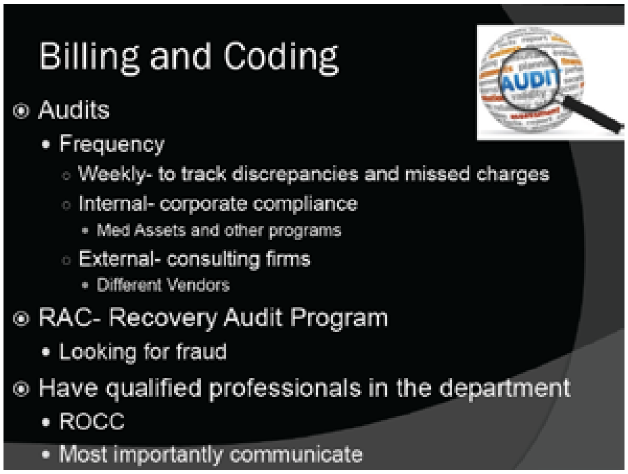




Management

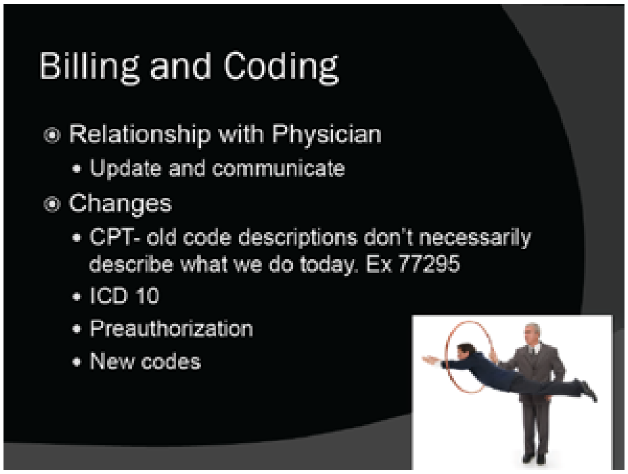
- Contracts
  - Review them…By line item
    - Aspects you aren’t using
  - Are there competitors?
  - Multi facility discounts
- Length of contract
  - Single year Vs. Multi Year
  - Contract renewal?
  - Lease Vs. Buy (up front capital)
- Could contracts or aspects be done away with?
  - Downgrade to parts only

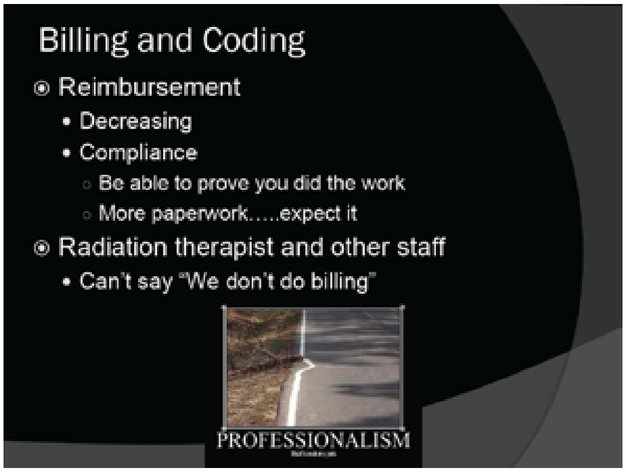




IMRT

Established patient visit	99211-99215	
New patient visit	99201-99205	
CT Sim	77280-77290	
CT Sim	77014-TC	if in your department
Tx devices	77332-77334	vac lok, bite block
radiology treatment planning	77261-77263	Professional Code Only
Special Tx Procedures	77470	if applicable require documention
Special physics consult	77370	physics must do (image fusion)
IMRT Tx Planning	77301	
Basic Radiation Dos Calc	77300	x - number of gantry angles
Multileaf devices	77338	once per course
Sim Verification	77280	iso verification
Daily Tx	77418	
Daily IGRT	77014	
Weekly Physics	77336	
Weekly TX management	77427	Professional Code Only





Marketing

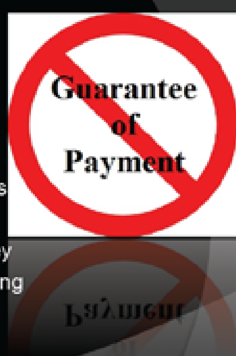
- Strategy
  - Know your market
  - Know your surrounding market
- Analysis
- What Sets You Apart
  - Something or a Someone
  - Create a difference
- Educate Community
  - Services
  - Changes

Legislation

- Several Fronts
  - Departmental
  - Hospital
  - Physician
- Departmental
  - CARE Bill & MARCA
    - Federal and State level
    - Patient safety and minimum standards

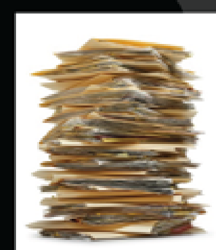
Legislation

- Hospital
  - Meaningful Use
  - Affordable Care Act
    - State- coverage
  - Sequestration- spending cuts
  - CMS Reimbursement Cuts
    - Benchmarks to recoup money
  - Hospital based vs freestanding
- Insurance
  - Pre authorization rules
  - Bundle/ packaging Coverage



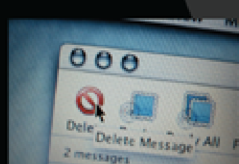
Legislation

- Physician
  - Affordable Care Act
    - Increased volumes
    - Paper work
    - Delayed payment
    - Physicians leaving
  - Reimbursement
- Does this affect the way we care for our patients?

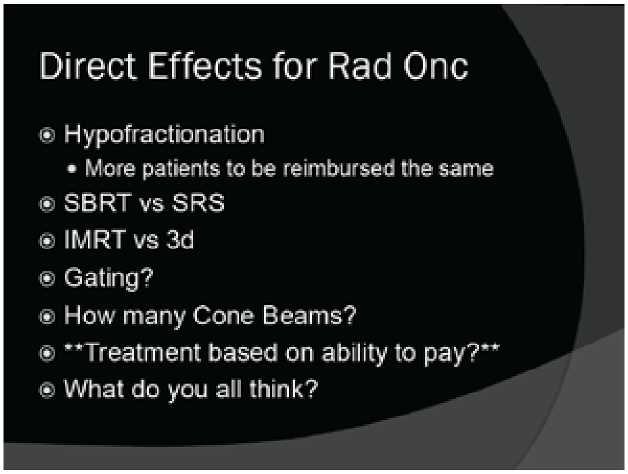


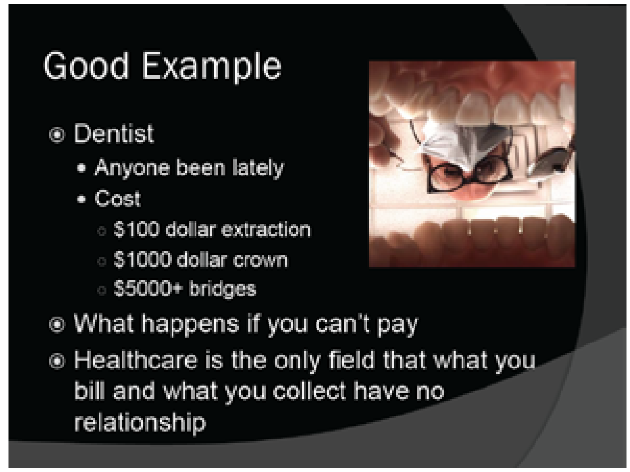
Legislation

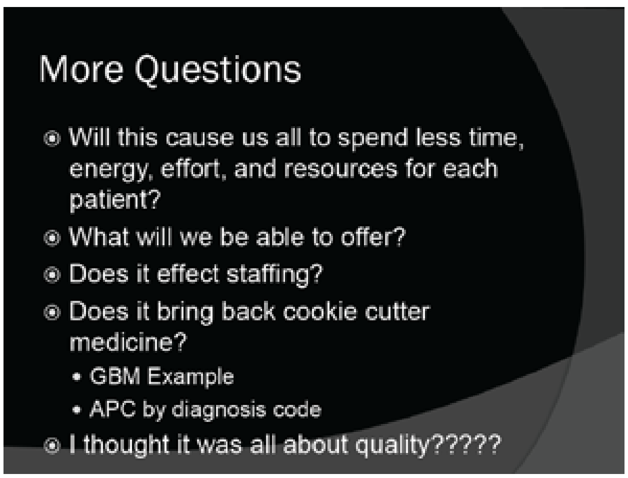
- Getting involved
  - Read the emails
  - Listen
    - Media
    - Patients
  - Ask questions
- Let Patients Know
  - Local articles
  - Handouts



So does all of this effect the way we do things in our clinic?

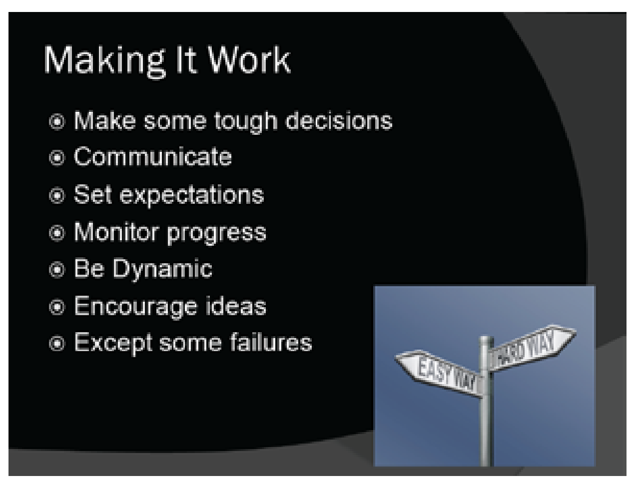

Direct Effects for Rad Onc
Hypofractionation
More patients to be reimbursed the same
SBRT vs SRS
IMRT vs 3d
Gating?
How many Cone Beams?
Treatment based on ability to pay?
What do you all think?


Good Example
Dentist
Anyone been lately
Cost
$100 dollar extraction
$1000 dollar crown
$5000+ bridges
What happens if you can't pay
Healthcare is the only field that what you bill and what you collect have no relationship


More Questions
Will this cause us all to spend less time, energy, effort, and resources for each patient?
What will we be able to offer?
Does it effect staffing?
Does it bring back cookie cutter medicine?
GBM Example
APC by diagnosis code
I thought it was all about quality?????


Direct Effects for Rad Onc
One thing will be for sure
The importance of immobilization
Accuracy and precision
Will tape and velcro make a comeback?
Paid by devices we use
Simple, Intermediate and Complex
It is all part of the plan
CT
Vendors become dynamic with us


What we do costs money?
Staff
Equipment
Contracts
Facility
Bottom line…… quality costs money!!!
The government seems to mandate it
Our patients deserve it and demand it


Making It Work
Make some tough decisions
Communicate
Set expectations
Monitor progress
Be Dynamic
Encourage ideas
Except some failures
EASY WAY
HARD WAY

Making It Work

- Communication
  - Prompt
  - Effective
  - It's ok to ask questions
  - Teaching opportunities
- Physician
  - Make them a part
  - Management should not be just the messenger
  - Build rapport

Making It Work

- Increases efficiency
- Increases productivity
- Saves money due to increased focus
- Saves Clinic Time
  - Allows for more time on the other PROFITABLE aspects
- Increases patient safety
  - Reportable events and near misses

Ahead of the Curve

Regardless of what is going on, one thing remains…..our patients and their families need us and have quality expectations.

Through breaking the cycle, innovative thinking, and effective communication we can deliver and remain viable.

Notes

Notes

Patient Positioning Symposium
advanced education in patient positioning

Saturday, March 29, 2014

4:00pm - 4:45pm

Keith Crowe, Treatment Aide Lead

Orchestrating Better SBRT Positioning

Orchestrating Better SBRT Patient Positioning

Sutter Cancer Center
Radiation Oncology Services - Sacramento

Keith Crowe – Treatment Aide Lead

- Sutter Cancer Center Radiation Oncology Services – Sacramento
- Formerly Radiological Associates of Sacramento (ROC)
- 25+ Years as a Patient Positioning Expert
- Treatment Aide Position Similar to Mould Room Staff in U.K.

Background

- Presented a talk on "IMRT Head and Neck Immobilization" in Inverness, Scotland May 2005.
- Published article titled "Well Positioned" and created "Smart Chart" questionnaire for vendors on immobilization devices in. ADVANCE for Imaging and Oncology Administrators, October 2007.
- Presented a talk titled "Couchtop Technology Impacts and Challenges for the Future" at the Patient Positioning Symposium held at Walt Disney World, Florida March 2009

Current Naming Approach

Stereotactic ABlative Radiotherapy – SABR

SBRT	SRS
Stereotactic Body Radiation Therapy	Stereotactic RadioSurgery*

* Linac - based

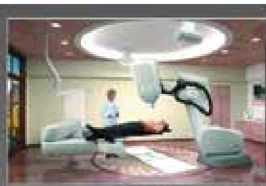
Terminology

- **SBRT** – Stereotactic Body Radiation Therapy
- **SABR** – Stereotactic ABlative Radiotherapy
- **SRS** – Stereotactic RadioSurgery

SBRT

- Enhanced radiation therapy technique that enables high radiation doses to be precisely delivered to primary tumors and metastasis
- Emerging technology in cancer treatment offering less invasive therapy compared to surgery with comparable outcomes (site specific results pending).
- Often used for patients that are not surgical candidates
- Treatment sites: lung, prostate, liver, spine, pancreas, …

SBRT technology



- "Specialty Linacs" (Cyberknife®)
- High quality "Regular Linacs" with advanced imaging systems

Experience

- We started up our SBRT program in May 2008
- Since then we have treated more than 400 cases.
- The vast majority of these are SBRT Lung cases
- In addition to Lung cases we have also treated Spine, Liver and Pancreas
- These numbers do not include 2000+ Gamma Knife patients.

Starting Up Our Program

- When we started out in 2008 there were very few SBRT immobilization options. We looked at the Body Fix system but our staff were not happy with the process. There were other new systems being developed but we needed to get creative and come up with something in the interim.
- We started by designing our own in-house "Split System" using ABS plastics and Nylon materials.
- The use of plastic material would allow us to use Calypso and possible future MRI considerations.

Split System (Upper)

The upper piece consists of a square plate with 2-pin indexing and a clear Silverman mounted using plastic screws. This is indexed using an adjustable 2-pin bar. This allows for Left/Right adjustment. A 100 cm x 70 cm Clear Urethane Vacuum Cushion is formed over the plate (patient arms up). The device is taped together using duct tape.

Upper Vacuum Cushion

Split System (Lower Section)

Split System (Lower Section)

- Constructed with ABS and Nylon. It is designed to "ride" along the couchtop surface.
- We also use PVC gutter pipe sections filled with Polyurethane foam. These are held in place with Velcro. The gutter pipe indexes the cushion to the plate.
- A 100 cm x 70 cm Clear Urethane Vacuum Cushion (lengthwise) is formed to immobilize the patient's lower torso.

Split System Vacuum Cushions

Abdominal Compression

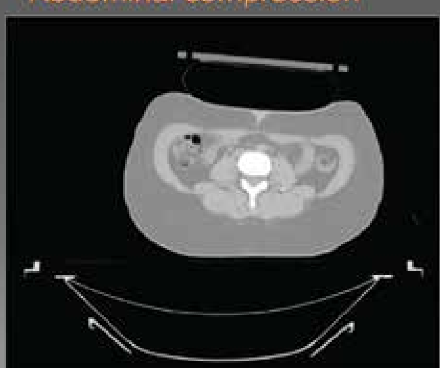
- We designed our own Abdominal Compression device using a blood pressure cup and a plastic plate to restrict patient breathing. The blood pressure cup alone did not work and we needed to be able to attach the device around the patient so Velcro strap was chose to get the job done.
- We had to find a someone able to sew a scale to the Velcro strap material. We went to local sewing shops until we found someone able to do the work

Abdominal compression

- Applied when needed to reduce tumor motion (< 1 cm)
- Plastic board with belt
- Blood pressure cuff under board
- Needed pressure determined during sim and recorded for treatment

ROC Compression Belt

Abdominal compression



Belt in axial planning CT

Abdominal compression

Belt in sagittal planning CT

Early Lessons Learned

- Lung tumors are rarely along the central axis of the couchtop. Often they are 5 cm to 7 cm or more off midline. If the patient is positioned in the center of the treatment couch gantry collisions can occur.
- It is important to build any offset needed into the SBRT immobilization device prior to simulation.
- Our Split System was designed to account for these shifts by moving the adjustable 2-pin bar (upper) and positioning the gutter pipe sections (lower).
- As a general rule the couchtop can me moved laterally up to 5 cm to account for tumor location before it creates collision issues.

Search For a Better System

- We looked at several different SBRT systems and all of them failed to account for the need to position the patient off center for treatment. The breathing compression devices if included were all stationary in the central axis and not adjustable laterally.
- All of the devices were overlay designs. This creates a extremely high "Build Up" effect.
- We liked the idea of a "flared out" whole body cushion because the rectangular design of the Body-Fix didn't allow for "arms up" positioning. Most SBRT designs used only lower torso immobilization with a simple wingboard for upper body.

Search For a Better System

- We shared this information with some vendors but none were willing to work with us to make any design changes to their existing SBRT systems.
- Working with Q-fix they incorporated all of these improvements into their Stradivarius SBRT System design.
  - These include an adjustable breathing compression plate and our idea for a Flared Full Body Cushion.
  - Q-Fix also adopted our Abdominal Compression design.

SBRT patient immobilization

- Stradivarius SBRT System.
- CT Overlay (Right) >
- kVue Insert (Below) v

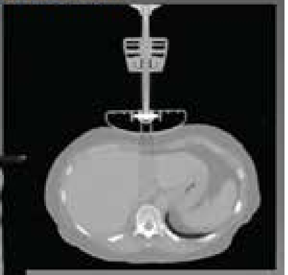
SBRT patient immobilization

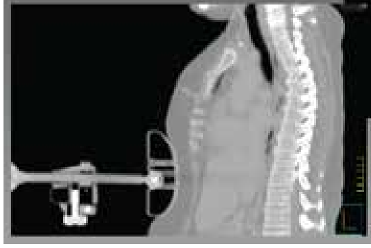
Stradivarius board (WFR)

- Breathing compression (Shown in off-center position)
- Flared Full Body Cushion >

SBRT patient immobilization

Stradivarius Compression Arch (CT Images)





Adjusting Patient Positioning in the Stradivarius Device

- In order to avoid collision issues with the gantry it is important to build in any offsets into the Full Body Cushion.
- The key adjustment is to position the Silverman Headrest correctly on the Wingboard. This will move the patient approximately 4cm in any direction for each hole location selection. (SUP/INF and LT/RT)
- Think of the Stradivarius device as a stationary rectangle that does not move and position the patient within that box.
- There is approximately 5 cm of lateral couchtop adjust available but it is better to build this offset into the immobilization device itself.

Wingboard with a "B" Silverman Headrest in the normal starting position (#3)

Wingboard with a "B" Silverman Headrest in the (#4) position

This will shift the patient 4 cm left of midline

Silverman Headrest Adjustments

- The previous slide will move the patient approximately 4cm to the left of midline
- The patient should also have their position checked to ensure that if the Compression Arch is used it will be able to be clamped onto the kVue Insert below the cutout area.
- Move the Silverman Sup/Inf to position the patient in the desired position
- The full Body Cushion can now be constructed

Constructing the Full Body Cushion

- The upper part of the cushion should be kept INSIDE of the Wingboard area. Exceeding this width will create issues with possible gantry collision
- The key here is what we call
- "LONG AND LEAN"
- This is important to minimize possible gantry collisions.
- Using this technique we have used a stand alone Q-fix full body cushion in an MRI scanner on 2 different occasions
- We have also used the Stradivarius SBRT System on our PET/CT scanner with great results (Minus the Compression Arch)

Constructing the Lower Extremity Cushion

- Prior to pulling a vacuum on the full body cushion the Compression Arch and Lower Extremity Arch should be placed into position
- This ensures that the arches have a clear area to attach to the Insert.
- The Full Body Cushion can now be evacuated.
- The final step is to make the Lower Extremity Cushion. We simply embed the lower arch into the cushion (no clips) It will easily press into position on the Linac

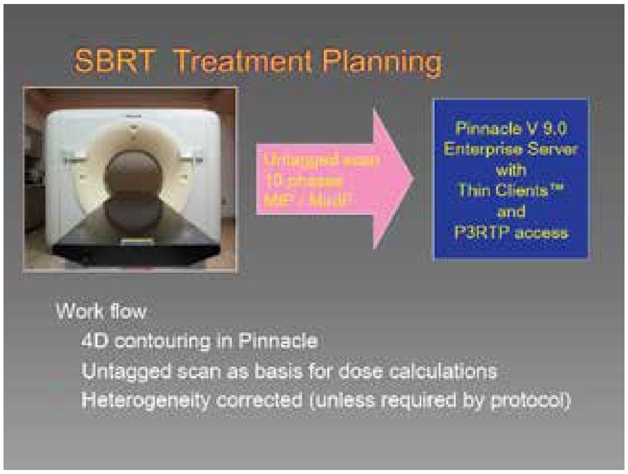

Patient Immobilization – SRS (Head)
CDR system – Mayo Mold
Single use mold
Optional mask


Patient Immobilization – SRS (Head)
CDR system – Mayo Mold
Single use mold
Optional mask
– Couch attachment with option for 2 rotations (roll and yaw)
view under the CDR system attached to the couch


Patient Immobilization – SRS (Head)
CDR system – Mayo Mold
Single use mold
Optional mask


SBRT Treatment Planning
4D large bore CT
Gated scan with breathing belt
10 phases, MIP / MinIP


SBRT Treatment Planning

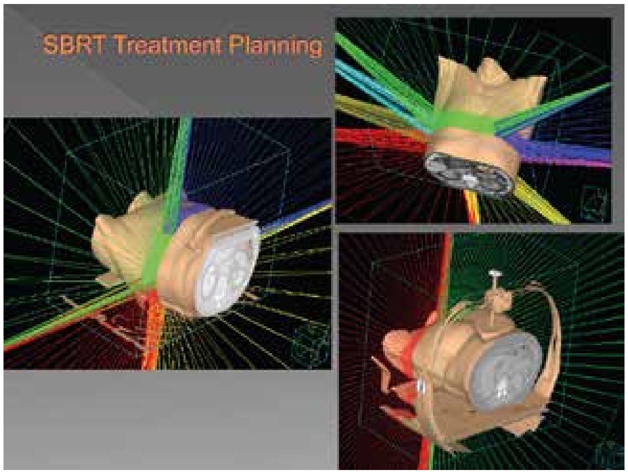

SBRT Treatment Planning
Untagged scan
10 phases
MIP / MinIP
Pinnacle V 9.0
Enterprise Server
with
Thin Clients™
and
P3RTP access
Work flow
4D contouring in Pinnacle
Untagged scan as basis for dose calculations
Heterogeneity corrected (unless required by protocol)


SBRT Treatment Planning
Tumor motion


SBRT Treatment Planning
Tumor motion


SBRT Treatment Planning
Tumor motion


SBRT Treatment Planning
Tumor motion


SBRT Treatment Planning


SABR for Prostate CA
Stereotactic ABlative Radiation
→ aka Stereotactic Body Radiation Therapy (SBRT)

SABR for Prostate CA

- Ultra precise stereotactically delivered radiation
- Uses VMAT for delivery of radiation
- Uses Calypso for localization and tracking
- Uses Cone Beam CT for 3D localization


SABR for Prostate CA

Clinical trial done with:
- RAS Radiation Oncology Centers
- University of Michigan
- Washington University
- Fox Chase Cancer Center
- Cedar Sinai

Why SABR for Prostate CA?

→ Five Treatments!

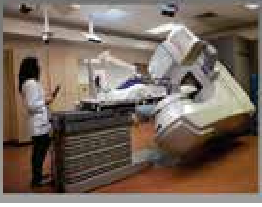
Who can have SABR for Prostate CA?

- Stage T1 to T2b
- Gleason score 7 or less
- PSA 15 or less

SABR vs. Cyberknife for Prostate CA

- VMAT
- True Real Time Tracking
- 3D Image Guidance Confirmation
- Fast—15 min
- OK name

- Open Circle
- Intermittent tracking in 2D
- No independent targeting confirmation
- Slow—60 to 90 min
- Cool Name




SABR vs. IMRT/Calypso

SABR
- Ultra precise
- 5 treatments
- Some patients

IMRT/Calypso
- Highly Precise
- 43 Treatments
- All patients


Summary
SBRT is an opportunity for patients that did not have any treatment options before
SBRT is much more than fewer fractions and more MU → quality assurance is critical on all levels
Treatment strategies are still under investigation → ongoing and future studies will determine optimal dose levels and approaches
SBRT should be a team effort involving Physicians, Physicists, Dosimetrist's, Therapists, Treatment Aides, engineers, nurses and administrators
Quality SBRT treatment requires highly accurate patient positioning
In order to minimize gantry collisions immobilization devices need to be "Long and Lean"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Thank you!

Notes