BENEFICIOS DE LAS NUEVAS TECNOLOGÍAS EN LA PROTECCIÓN RADIOLÓGICA DEL PACIENTE ONCOLÓGICO

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HISTORIA DE LA RADIOTERAPIA

- 1895 Descubrimiento de los rayos X
- 1896 Descubrimiento de la Radioactividad
- 1898 Descubrimiento del Radium
- 1920's mejoras en los tubos de RX (150-300Kv)
- 1950's Cobaltos (1Mv or million volt)
- 1960's Acelerador Lineal (4 - 25 million)
- 1970's computadoras y TAC
- 1980's Radioterapia 3D
- 1990's Radioterapia conformada 3D
- 2002 IMRT
- 2002+ IGRT

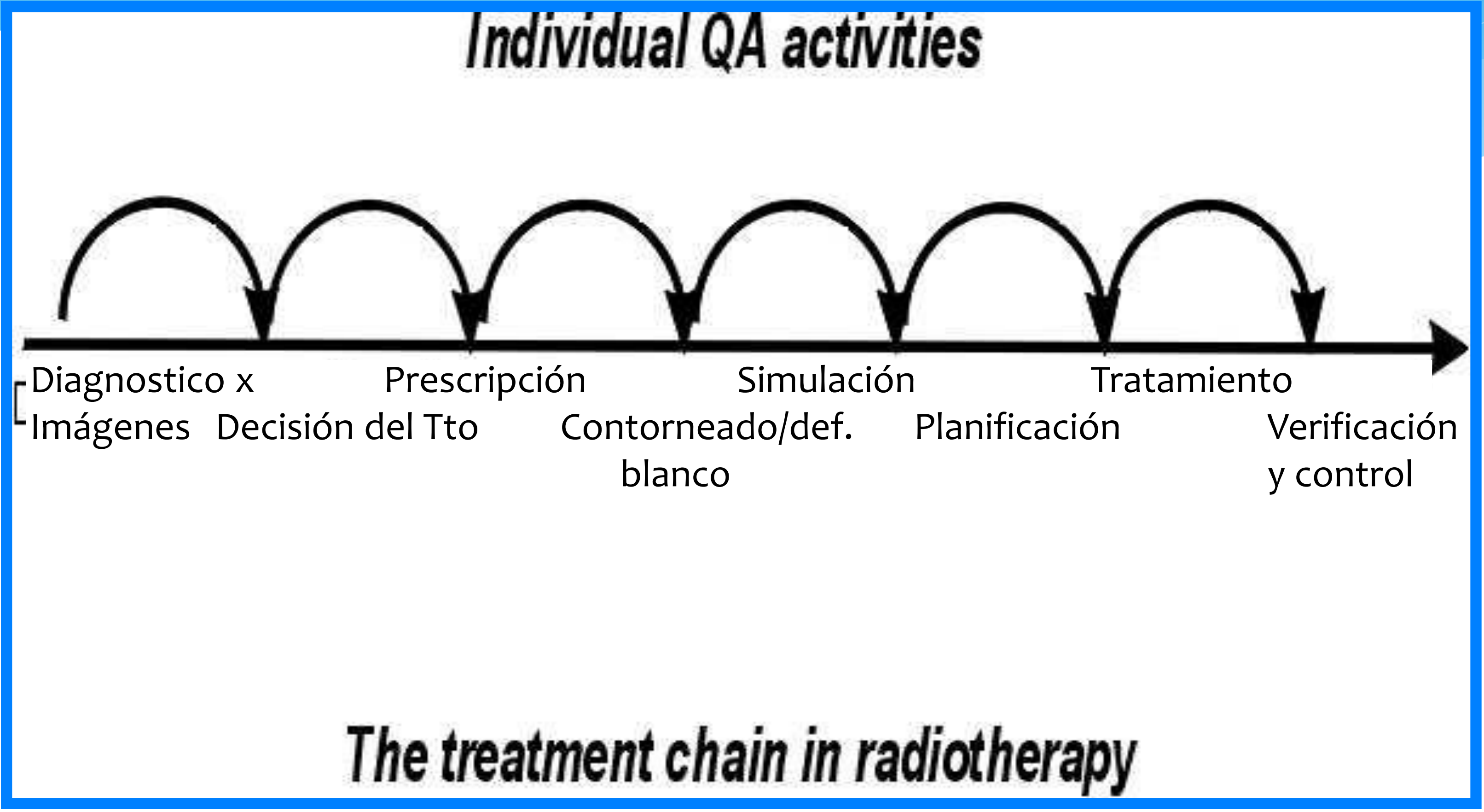
OBJETIVOS DE LA RADIOTERAPIA

- Administrar dosis suficiente para lograr control tumoral
- Disminuir la dosis al máximo en los tejidos vecinos para evitar complicaciones
- Aumentar dosis aumenta el control local
- Aumentar dosis aumenta complicaciones

PROTECCON RADIOLOGICA DEL PACIENTE

- Oncólogo radioterapeuta.
- Físico Medico
- Tecnólogo en radioterapia.
- Experto en radioprotección. (OPR)

CADENA DE TRATAMIENTO


Individual QA activities
The treatment chain in radiotherapy

Diagnostico x Imágenes
Decisión del Tto
Prescripción
Contorneado/def. blanco
Simulación
Planificación
Tratamiento
Verificación y control

GARANTIA DE CALIDAD EN RADIOTERAPIA

- En todos los procesos y procedimientos en radioterapia (diagnóstico, prescripción del tratamiento, preparación y administración del tratamiento, seguimiento).

- En todas las áreas de la radioterapia incluyendo a todos los grupos profesionales (oncólogos radioterapeutas, físicos, técnicos, administrativos).

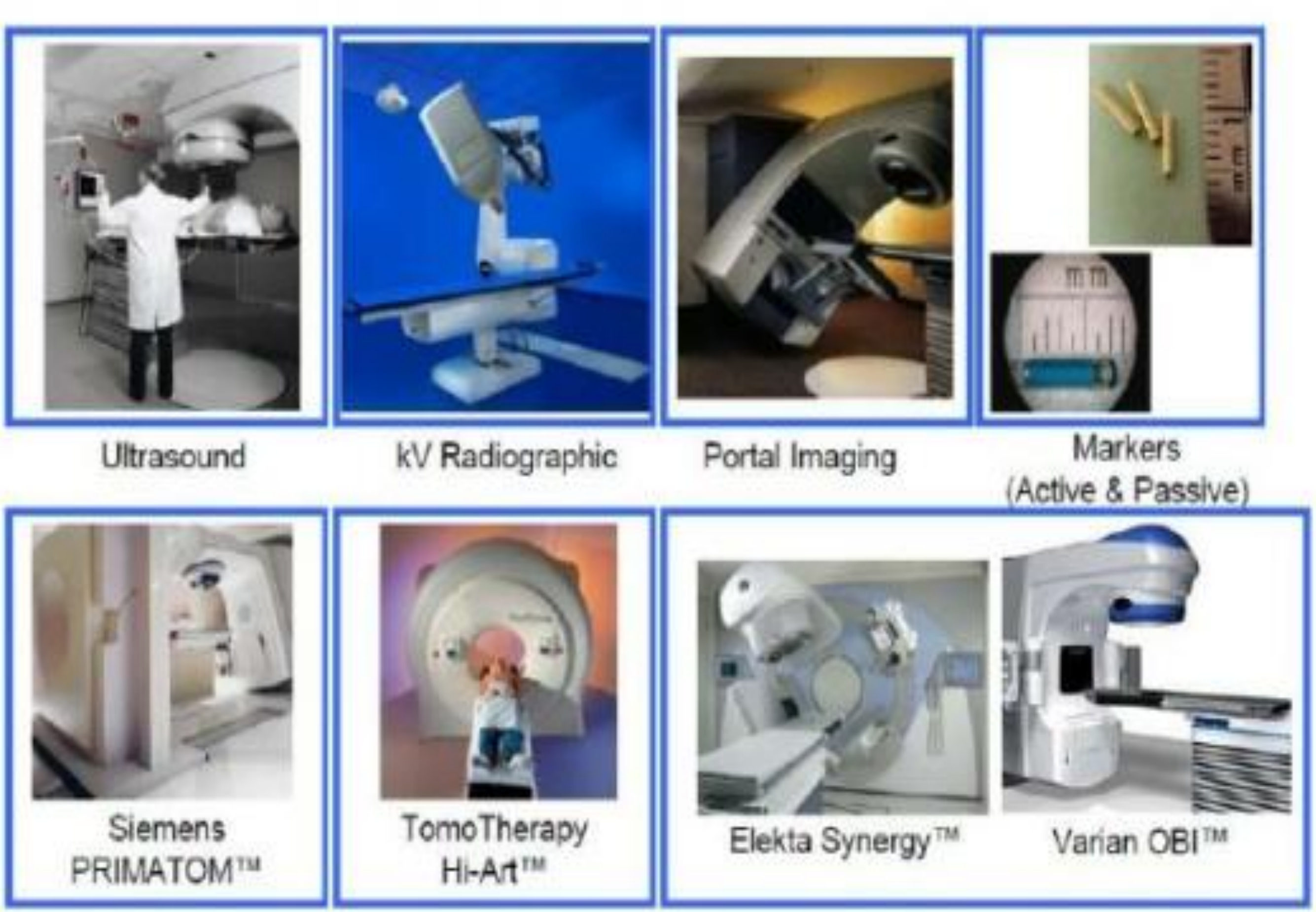
OBJETIVOS DE LA PROTECCIÓN RADIOLOGICA

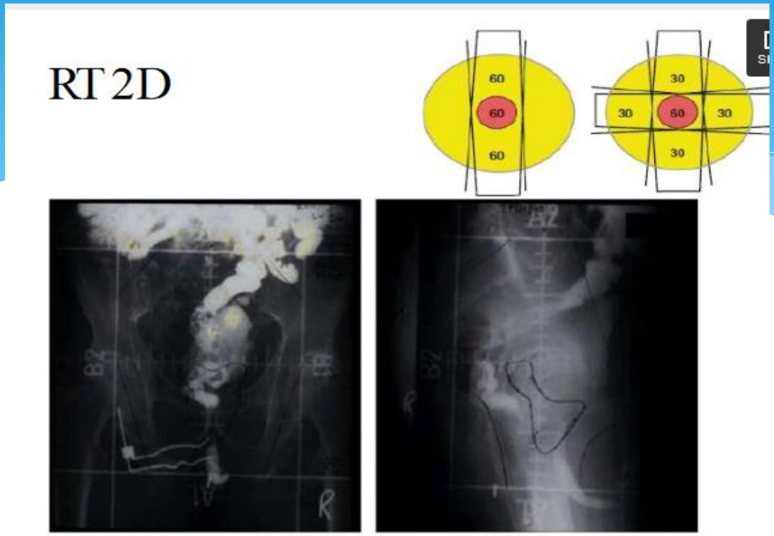
- Evitar que ocurran efectos determinísticos,
- Reducir al máximo la probabilidad de aparición de efectos estocásticos.
- Proporcionar un adecuado nivel de protección a las personas sin limitar indebidamente las prácticas beneficiosas que dan lugar a la exposición a las radiaciones ionizantes.

- **Efectos estocásticos:**
  - probabilidad de ocurrencia incrementa con la dosis
  - severidad es independiente de la dosis
  - Sin umbral de dosis
  - **Ej. Carcinogénesis**

- **Efectos determinísticos (non-estocásticos) :**
  - severidad incremente con la dosis
  - Frecuentemente con umbral de dosis
  - **Ej. O pacificación de cristalino.**

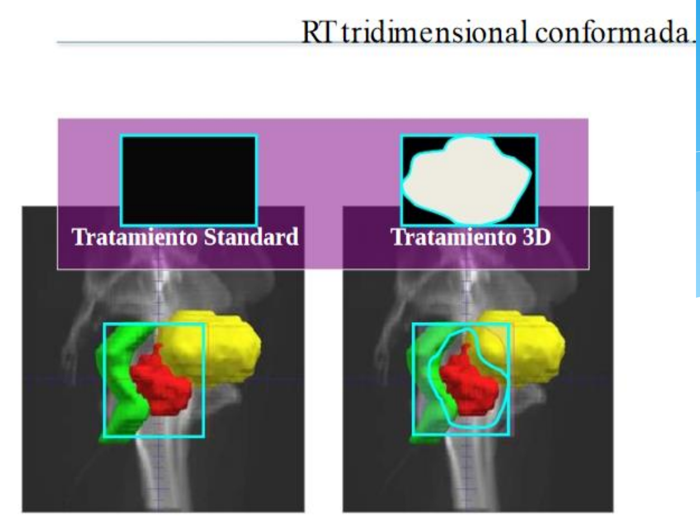
AVANCES TECNOLOGICOS


Ultrasound
kV Radiographic
Portal Imaging
Markers
(Active & Passive)
Siemens
PRIMATOM™
TomoTherapy
Hi-Art™
Elekta Synergy™
Varian OBI™



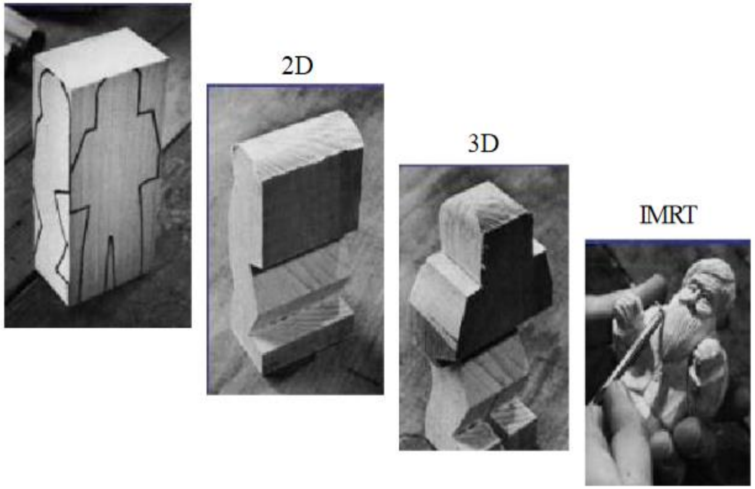
RT 2D

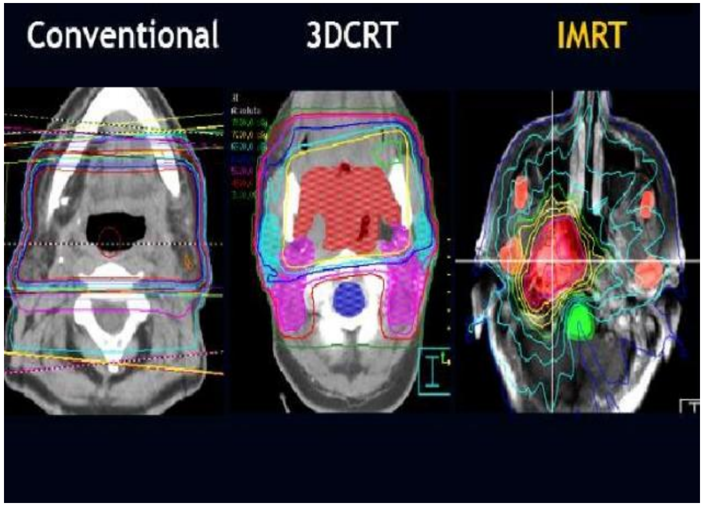
60
60
60
30
30
60
30
30
B2
B2
R
R



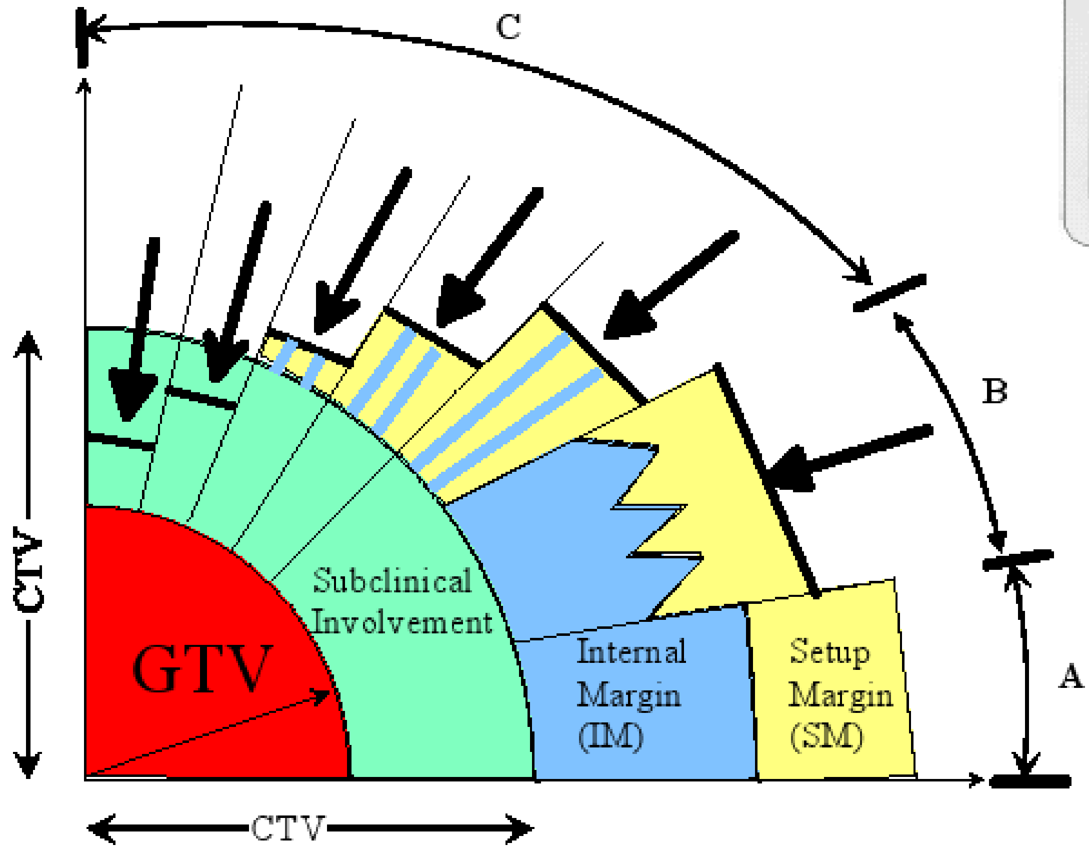
RT tridimensional conformada.

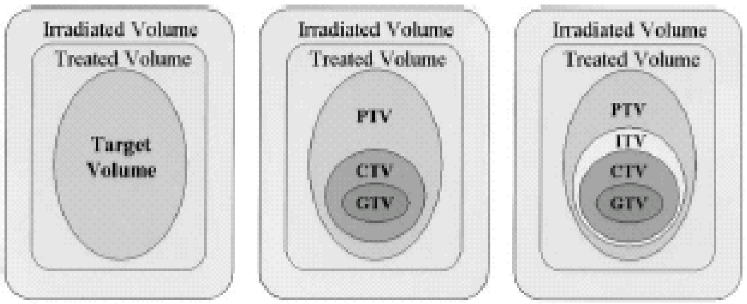
Tratamiento Standard
Tratamiento 3D





Conventional
3DCRT
IMRT

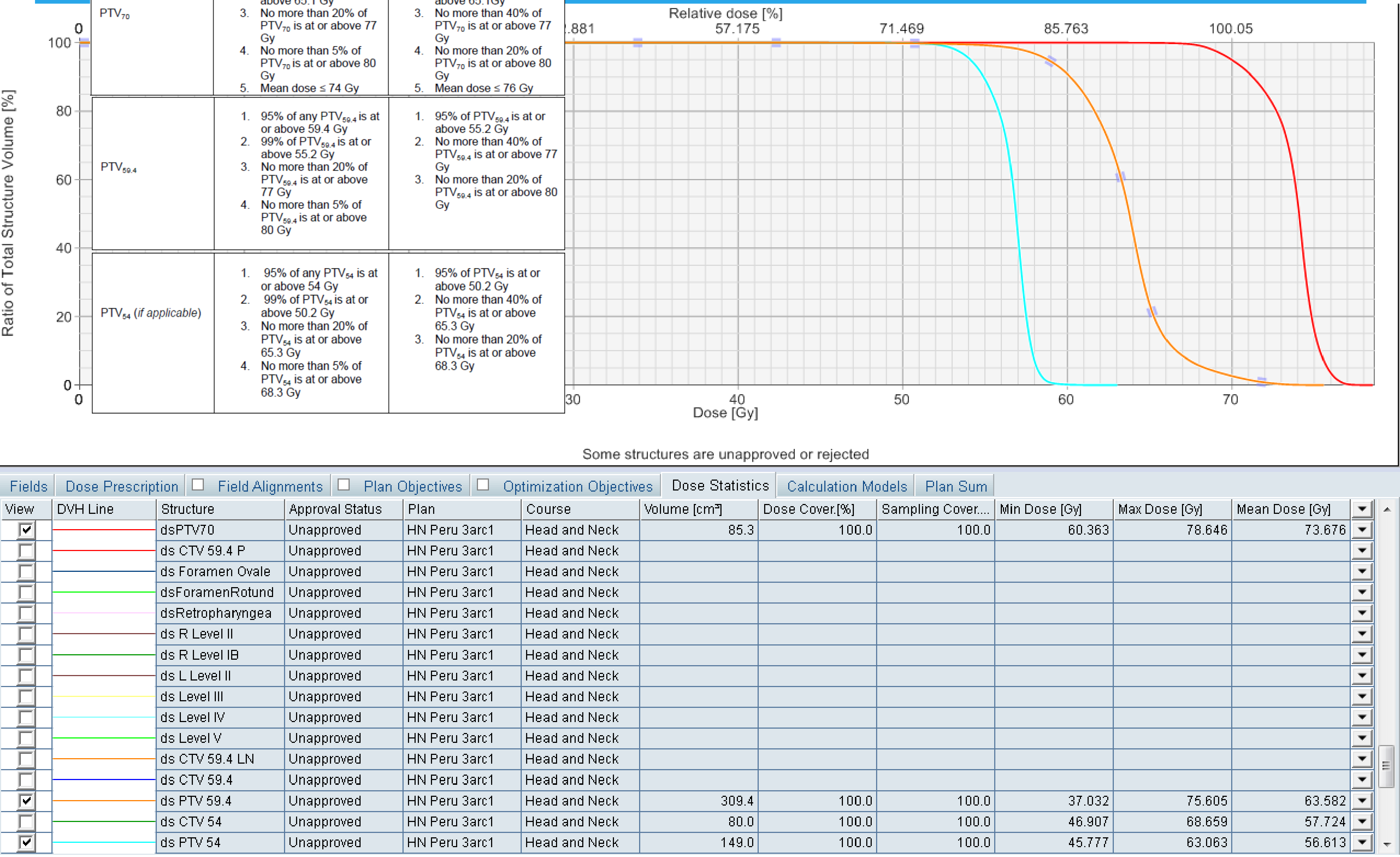

C
B
A
GTV
Subclinical
Involvement
Internal
Margin
(IM)
Setup
Margin
(SM)
CTV
CTV


Irradiated Volume
Treated Volume
Target
Volume
Irradiated Volume
Treated Volume
PTV
CTV
GTV
Irradiated Volume
Treated Volume
PTV
ITV
CTV
GTV

(A) ICRU 29 (B) ICRU 50 (C) ICRU 62

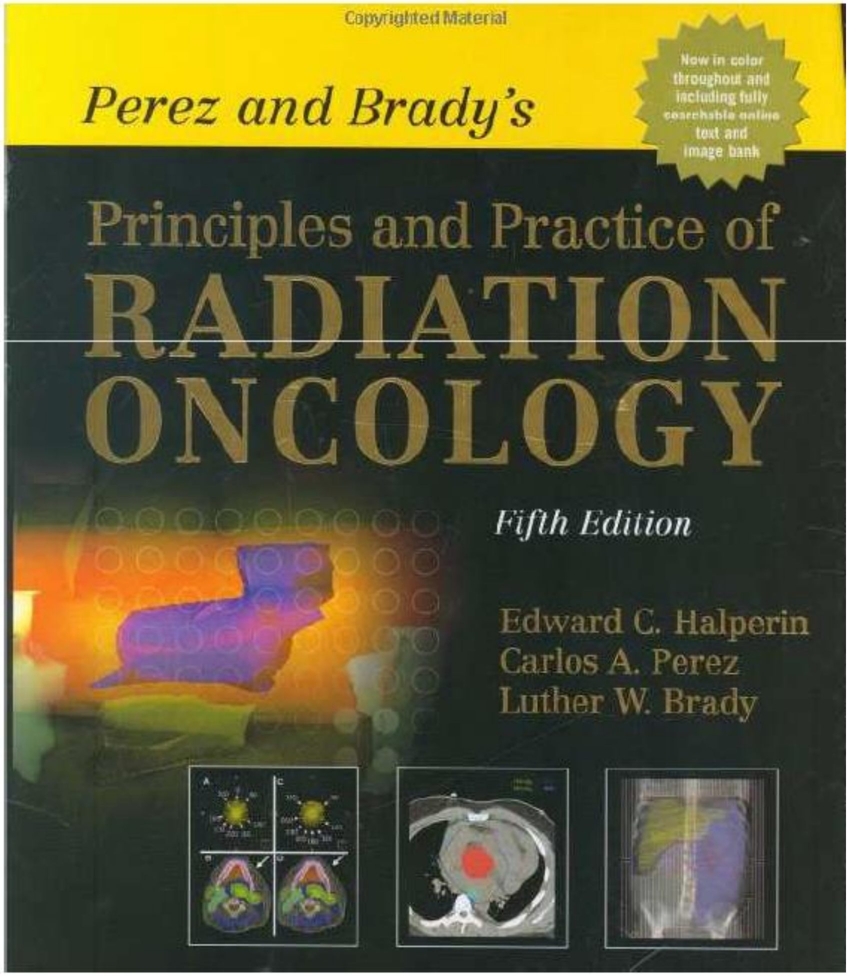
DVH - PTVs

PTV	No Variation	Minor Variation
PTV_{70}	1. 95% of any PTV_{70} is at or above 70 Gy 2. 99% of PTV_{70} is at or above 65.1 Gy 3. No more than 20% of PTV_{70} is at or above 77 Gy 4. No more than 5% of PTV_{70} is at or above 80 Gy 5. Mean dose ≤ 74 Gy	1. 95% of PTV_{70} is at or above 70 Gy 2. 97% of PTV_{70} is at or above 65.1Gy 3. No more than 40% of PTV_{70} is at or above 77 Gy 4. No more than 20% of PTV_{70} is at or above 80 Gy 5. Mean dose ≤ 76 Gy
$PTV_{59.4}$	1. 95% of any $PTV_{59.4}$ is at or above 59.4 Gy 2. 99% of $PTV_{59.4}$ is at or above 55.2 Gy 3. No more than 20% of $PTV_{59.4}$ is at or above 77 Gy 4. No more than 5% of $PTV_{59.4}$ is at or above 80 Gy	1. 95% of $PTV_{59.4}$ is at or above 55.2 Gy 2. No more than 40% of $PTV_{59.4}$ is at or above 77 Gy 3. No more than 20% of $PTV_{59.4}$ is at or above 80 Gy
PTV_{54} (*if applicable*)	1. 95% of any PTV_{54} is at or above 54 Gy 2. 99% of PTV_{54} is at or above 50.2 Gy 3. No more than 20% of PTV_{54} is at or above 65.3 Gy 4. No more than 5% of PTV_{54} is at or above 68.3 Gy	1. 95% of PTV_{54} is at or above 50.2 Gy 2. No more than 40% of PTV_{54} is at or above 65.3 Gy 3. No more than 20% of PTV_{54} is at or above 68.3 Gy


Relative dose [%]
0
.881
57.175
71.469
85.763
100.05
Ratio of Total Structure Volume [%]
100
80
60
40
20
0
0
30
40
50
60
70
Dose [Gy]
Some structures are unapproved or rejected
Fields
Dose Prescription
Field Alignments
Plan Objectives
Optimization Objectives
Dose Statistics
Calculation Models
Plan Sum

View	DVH Line	Structure	Approval Status	Plan	Course	Volume [cm³]	Dose Cover.[%]	Sampling Cover....	Min Dose [Gy]	Max Dose [Gy]	Mean Dose [Gy]
☑	—	dsPTV70	Unapproved	HN Peru 3arc1	Head and Neck	85.3	100.0	100.0	60.363	78.646	73.676
☐	—	ds CTV 59.4 P	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds Foramen Ovale	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	dsForamenRotund	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	dsRetropharyngea	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds R Level II	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds R Level IB	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds L Level II	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds Level III	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds Level IV	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds Level V	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds CTV 59.4 LN	Unapproved	HN Peru 3arc1	Head and Neck						
☐	—	ds CTV 59.4	Unapproved	HN Peru 3arc1	Head and Neck						
☑	—	ds PTV 59.4	Unapproved	HN Peru 3arc1	Head and Neck	309.4	100.0	100.0	37.032	75.605	63.582
☐	—	ds CTV 54	Unapproved	HN Peru 3arc1	Head and Neck	80.0	100.0	100.0	46.907	68.659	57.724
☑	—	ds PTV 54	Unapproved	HN Peru 3arc1	Head and Neck	149.0	100.0	100.0	45.777	63.063	56.613

Referencias Bibliograficas para Contorno de Volumenes de Blancos y de Organos de Riesgo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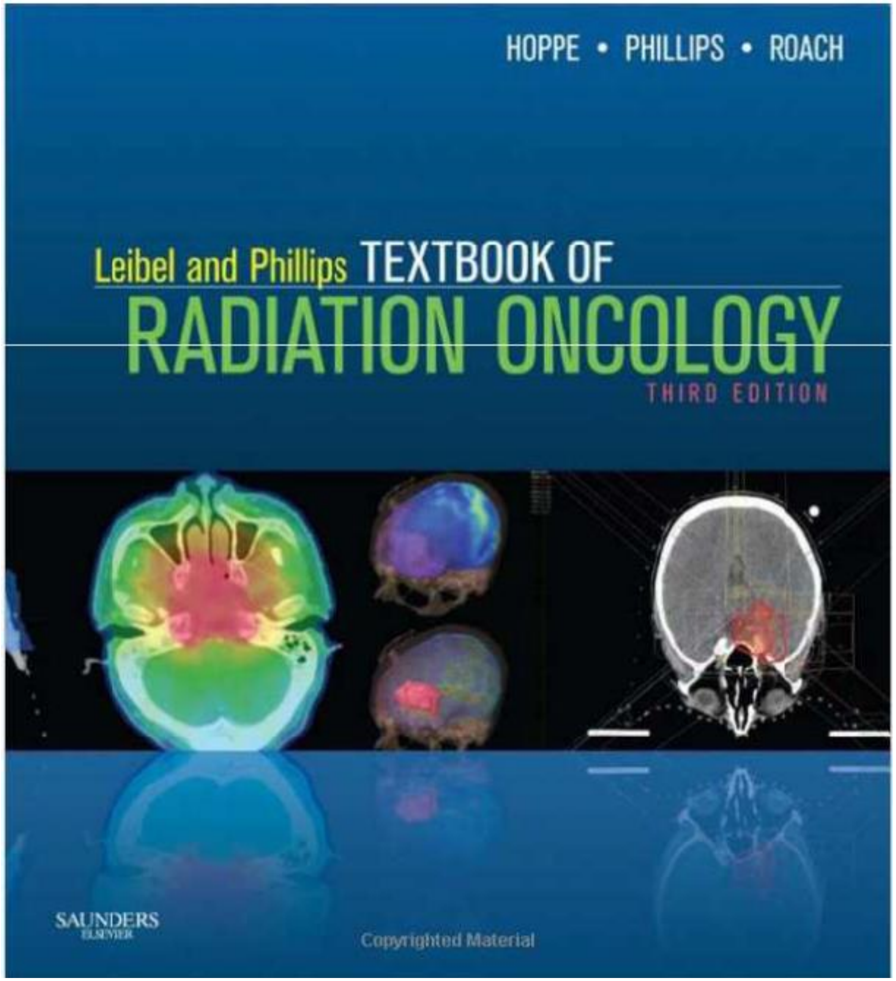
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Prescribing, Recording, and Reporting Photon-Beam Intensity-Modulated Radiation Therapy (IMRT)

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BIOLOGY•PHYSICS

VOLUME 76, NUMBER 3, SUPPLEMENT 2010

QUANTITATIVE ANALYSES OF NORMAL TISSUE EFFECTS IN THE CLINIC

Guest Editors:
Lawrence B. Marks, M.D.
Randall K. Ten Haken, Ph.D.

Associate Guest Editor:
Mary K. Martel, Ph.D.

Official Journal of
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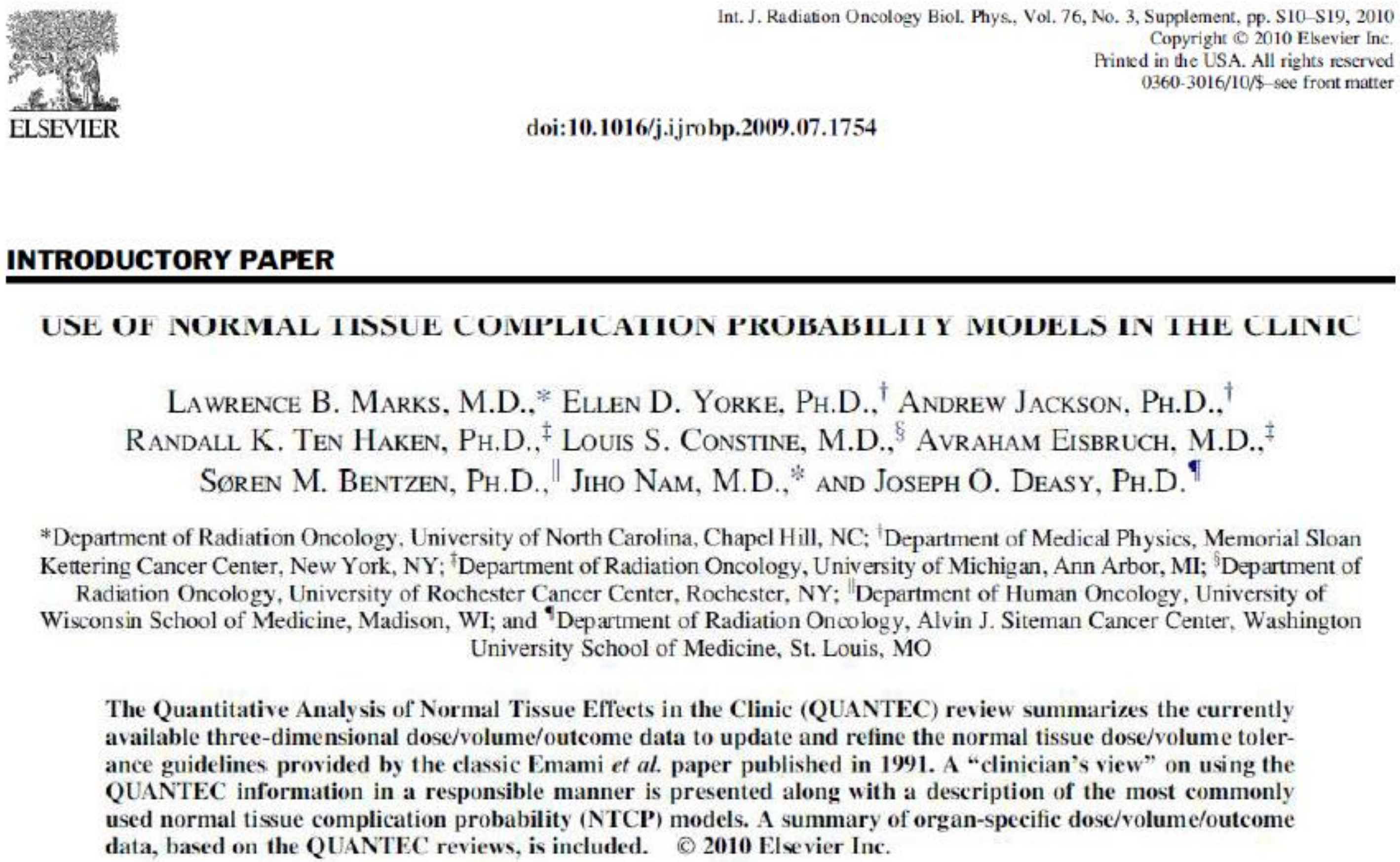

Int. J. Radiation Oncology Biol. Phys., Vol. 76, No. 3, Supplement, pp. S10–S19, 2010
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0360-3016/10/$–see front matter

doi:10.1016/j.ijrobp.2009.07.1754

INTRODUCTORY PAPER

USE OF NORMAL TISSUE COMPLICATION PROBABILITY MODELS IN THE CLINIC

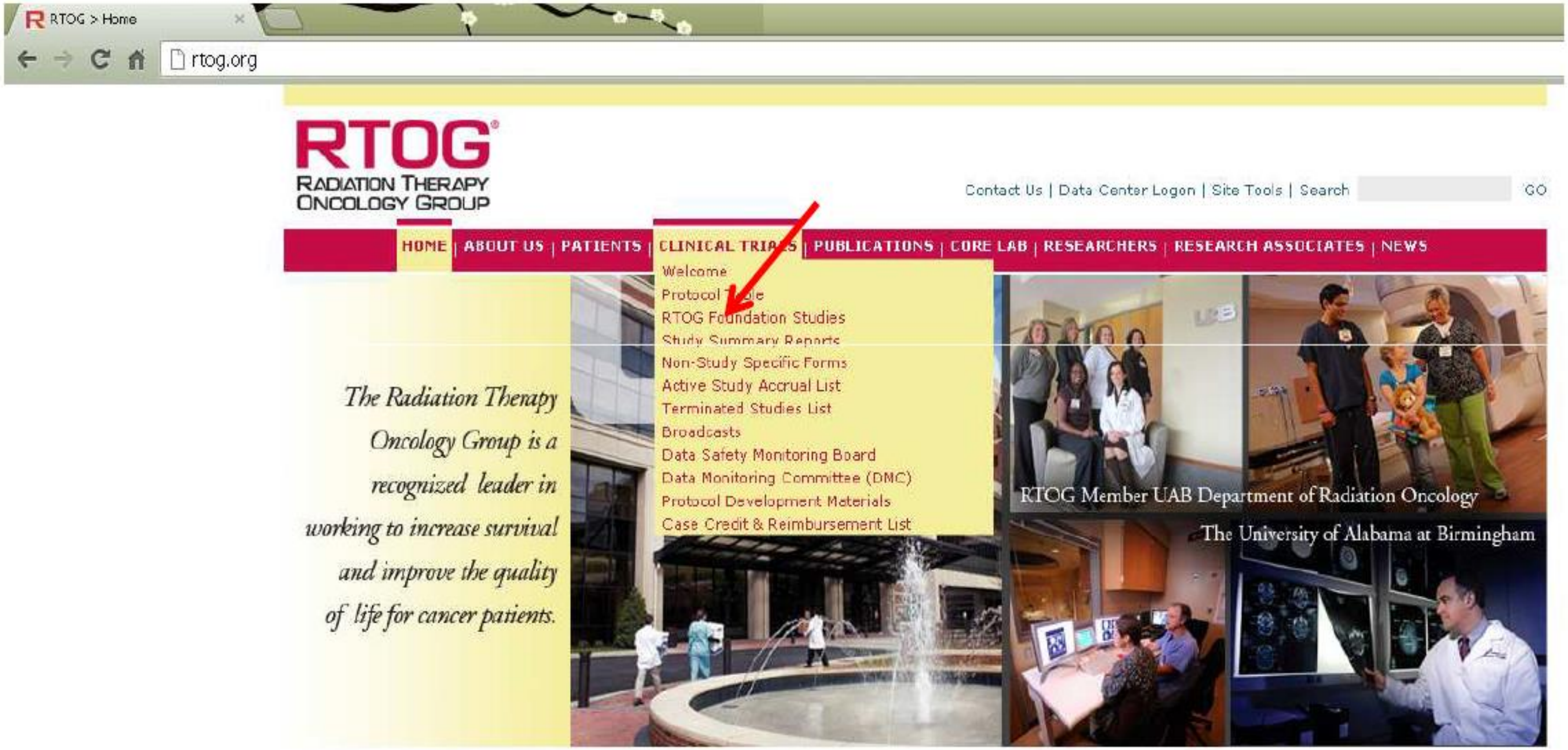
Lawrence B. Marks, M.D.,[*] Ellen D. Yorke, Ph.D.,[†] Andrew Jackson, Ph.D.,[†]
Randall K. Ten Haken, Ph.D.,[‡] Louis S. Constine, M.D.,[§] Avraham Eisbruch, M.D.,[‡]
Søren M. Bentzen, Ph.D.,[||] Jiho Nam, M.D.,[*] and Joseph O. Deasy, Ph.D.[¶]

[*]Department of Radiation Oncology, University of North Carolina, Chapel Hill, NC; [†]Department of Medical Physics, Memorial Sloan Kettering Cancer Center, New York, NY; [‡]Department of Radiation Oncology, University of Michigan, Ann Arbor, MI; [§]Department of Radiation Oncology, University of Rochester Cancer Center, Rochester, NY; [||]Department of Human Oncology, University of Wisconsin School of Medicine, Madison, WI; and [¶]Department of Radiation Oncology, Alvin J. Siteman Cancer Center, Washington University School of Medicine, St. Louis, MO

The Quantitative Analysis of Normal Tissue Effects in the Clinic (QUANTEC) review summarizes the currently available three-dimensional dose/volume/outcome data to update and refine the normal tissue dose/volume tolerance guidelines provided by the classic Emami *et al.* paper published in 1991. A "clinician's view" on using the QUANTEC information in a responsible manner is presented along with a description of the most commonly used normal tissue complication probability (NTCP) models. A summary of organ-specific dose/volume/outcome data, based on the QUANTEC reviews, is included. © 2010 Elsevier Inc.

QUANTEC

PROTOCOLOS DE RTOG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Welcome
Protocol Table
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Non-Study Specific Forms
Active Study Accrual List
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Broadcasts
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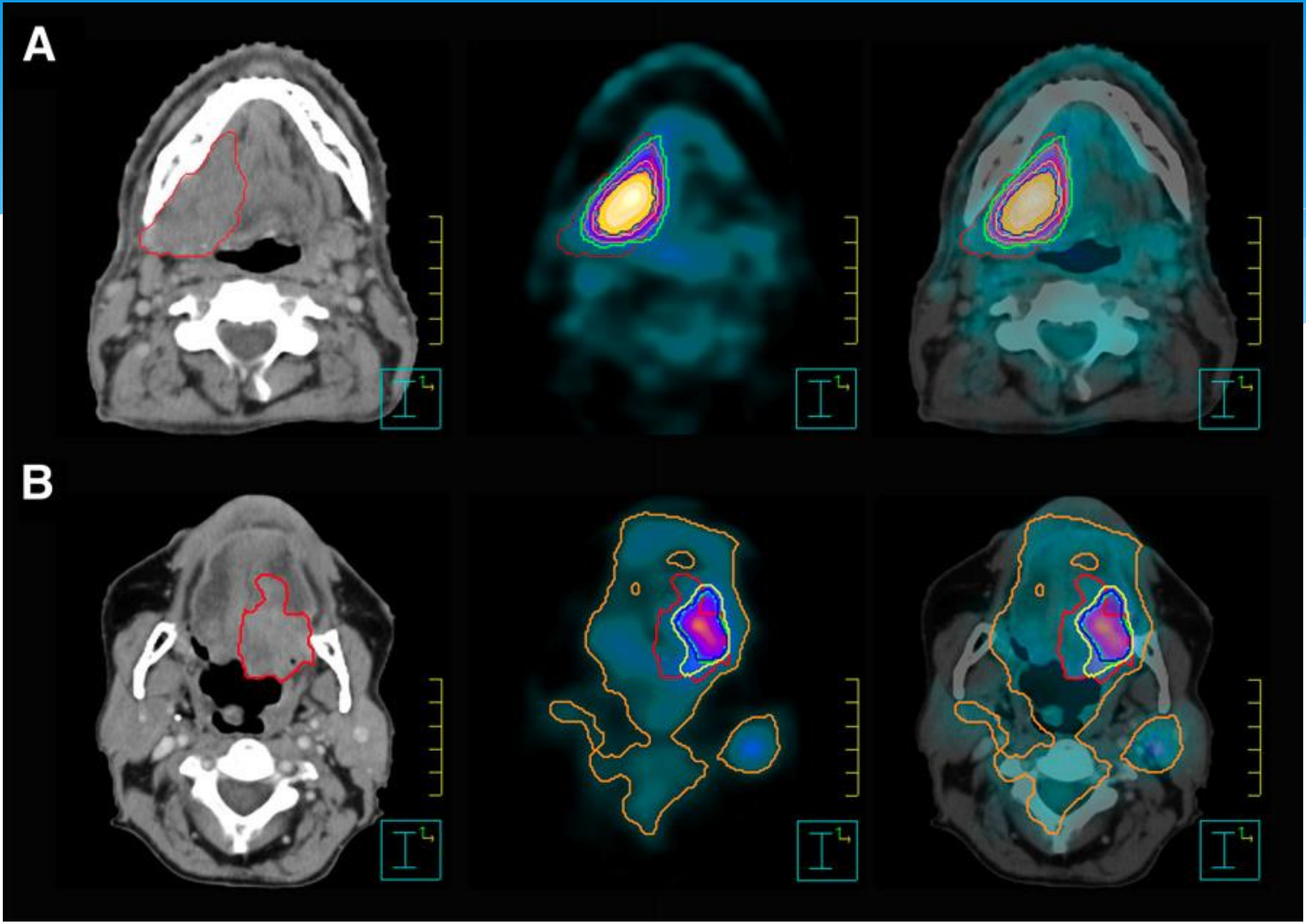
The University of Alabama at Birmingham

The Radiation Therapy Oncology Group is a recognized leader in working to increase survival and improve the quality of life for cancer patients.

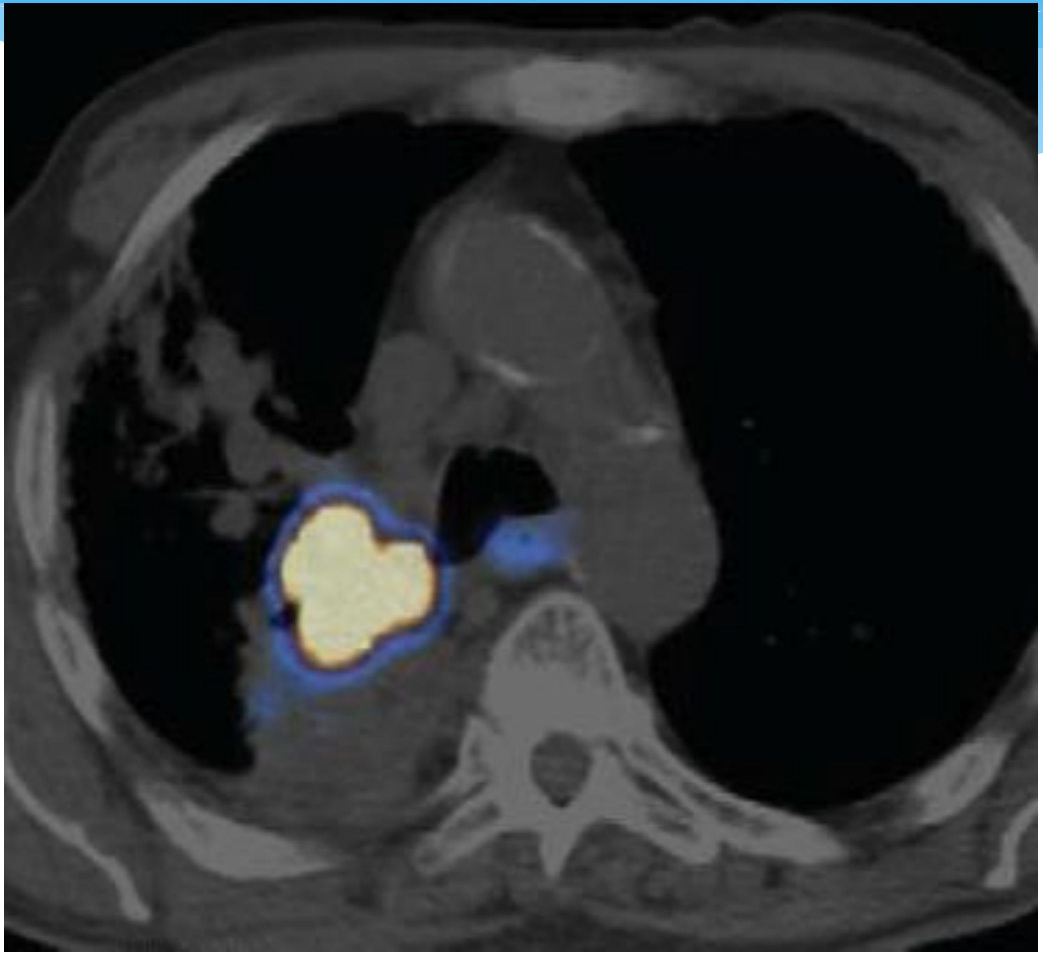
rtog.org
RTOG 0522 and 0615
Standard (not experimental)



Int. J. Radiation Oncology Biol. Phys., Vol. 69, No. 4, pp. 1282–1289, 2007

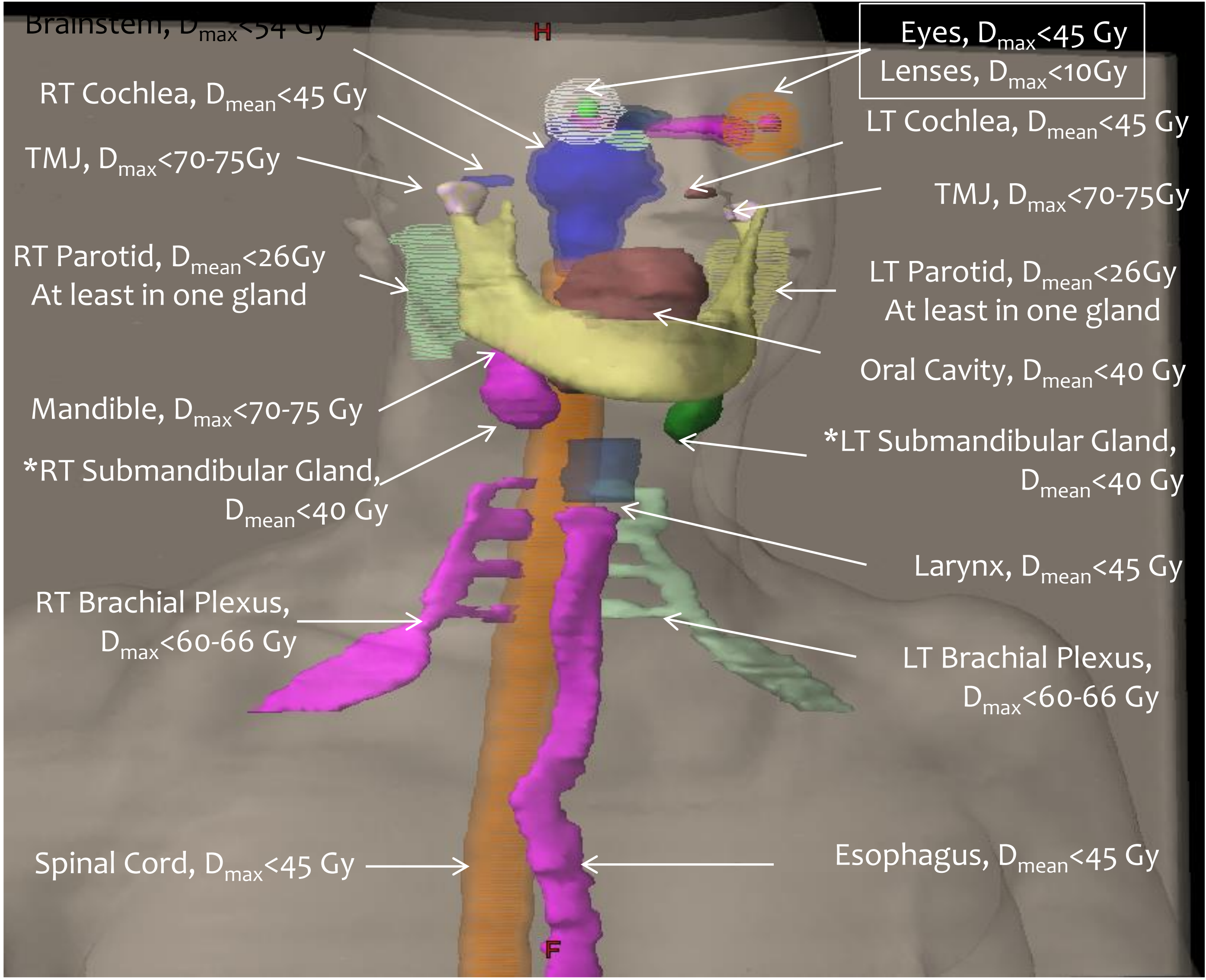
DELIMITACION DEL TUMOR

34 pacientes
17 componente atelectásico
9 cambios en los campos con FDG
6 disminuyó el campo
17 Sin atelectasias (3 sufrieron cambios)



Nestle U et al. Int J Radiat Oncol Biol Phys 1999; 44:593-7

OARs Delineados con Objetivo de Dosis de RTOG 0615 & Quantec



Brainstem, $D_{max}<54$ Gy

RT Cochlea, $D_{mean}<45$ Gy

TMJ, $D_{max}<70\text{-}75$Gy

RT Parotid, $D_{mean}<26$Gy
At least in one gland

Mandible, $D_{max}<70\text{-}75$ Gy

*RT Submandibular Gland,
$D_{mean}<40$ Gy

RT Brachial Plexus,
$D_{max}<60\text{-}66$ Gy

Spinal Cord, $D_{max}<45$ Gy

Eyes, $D_{max}<45$ Gy
Lenses, $D_{max}<10$Gy

LT Cochlea, $D_{mean}<45$ Gy

TMJ, $D_{max}<70\text{-}75$Gy

LT Parotid, $D_{mean}<26$Gy
At least in one gland

Oral Cavity, $D_{mean}<40$ Gy

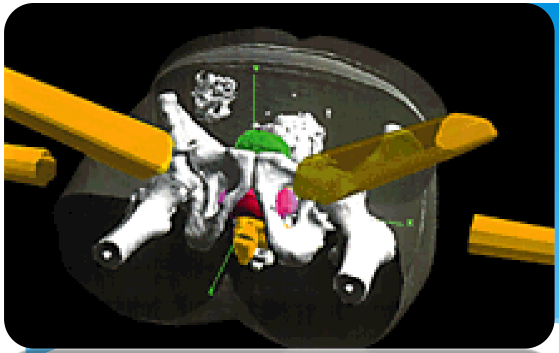
*LT Submandibular Gland,
$D_{mean}<40$ Gy

Larynx, $D_{mean}<45$ Gy

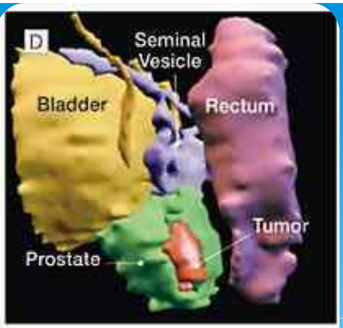
LT Brachial Plexus,
$D_{max}<60\text{-}66$ Gy

Esophagus, $D_{mean}<45$ Gy

*If Gland is not part of the target volume



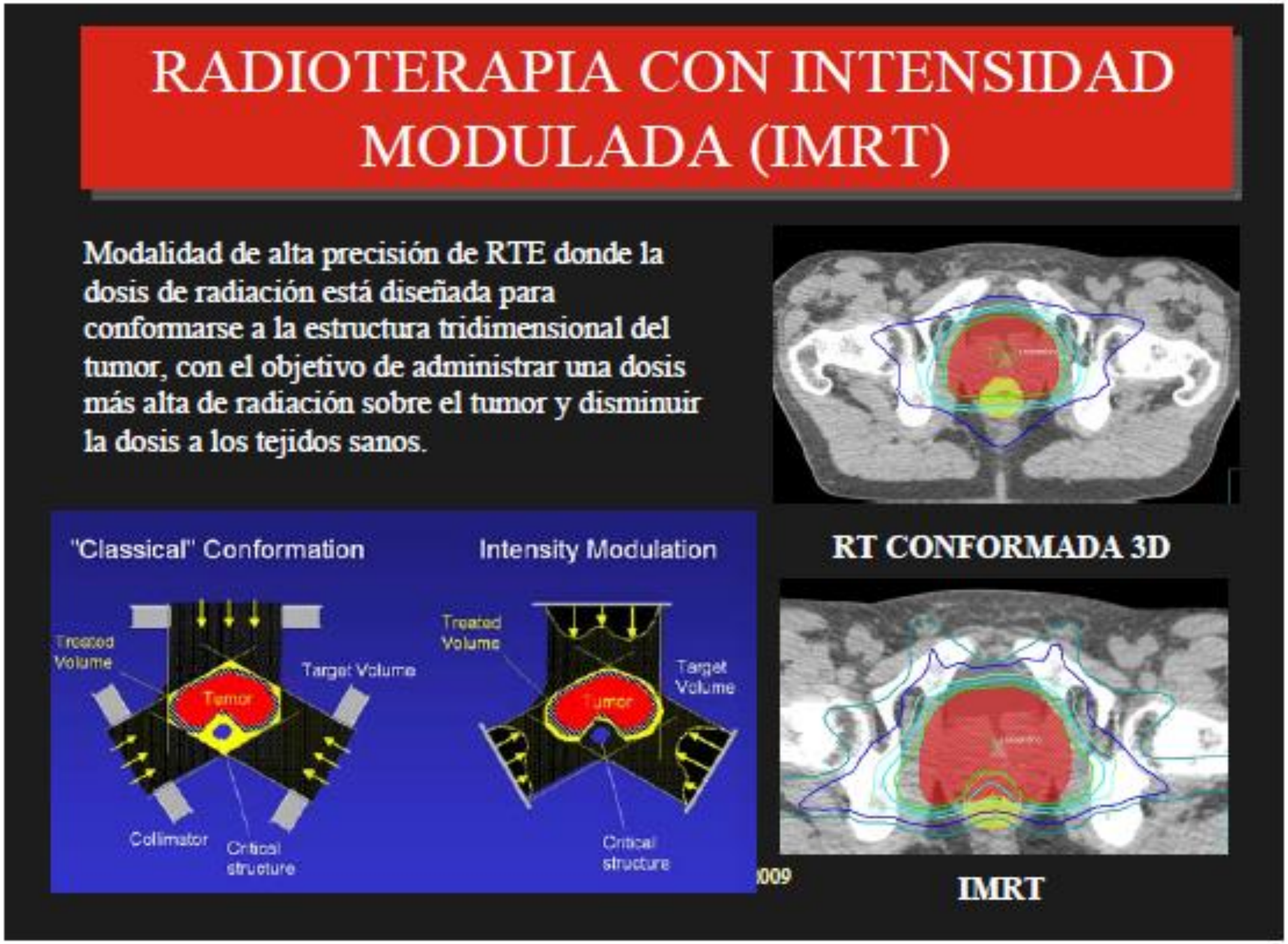
Radioterapia conformada en 3D


D
Seminal Vesicle
Bladder
Rectum
Tumor
Prostate

Integration of CT Imaging and 3-D Visualization Techniques

Estudio randomizado en el MD Anderson

conventional	53%
conformal	**72%**



RADIOTERAPIA CON INTENSIDAD MODULADA (IMRT)

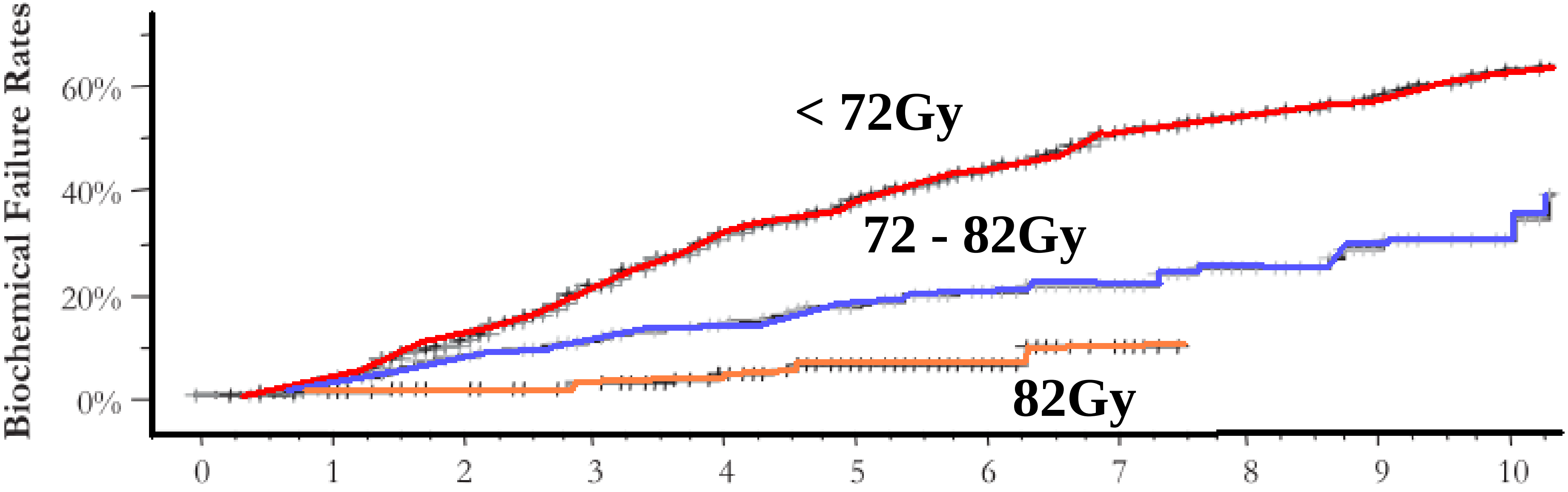
Modalidad de alta precisión de RTE donde la dosis de radiación está diseñada para conformarse a la estructura tridimensional del tumor, con el objetivo de administrar una dosis más alta de radiación sobre el tumor y disminuir la dosis a los tejidos sanos.

"Classical" Conformation
Treated Volume
Target Volume
Tumor
Collimator
Critical structure
Intensity Modulation
Treated Volume
Target Volume
Tumor
Critical structure
009

RT CONFORMADA 3D

IMRT

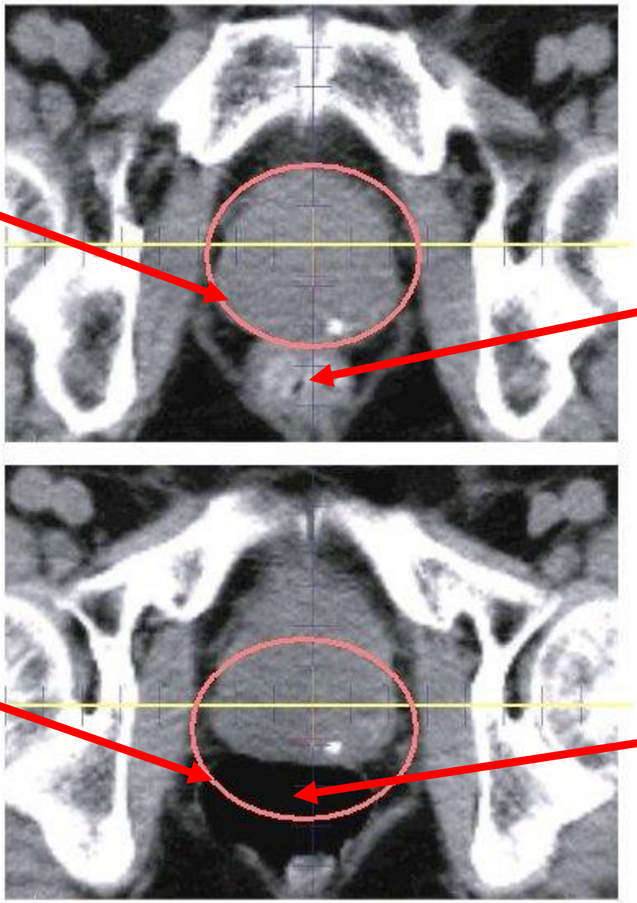
Recurrencia en Cáncer de Próstata y dosis de radiación



años

Kupelian. IJROBP 2008:71:16

Existe movimiento significativo de la próstata por el gas rectal



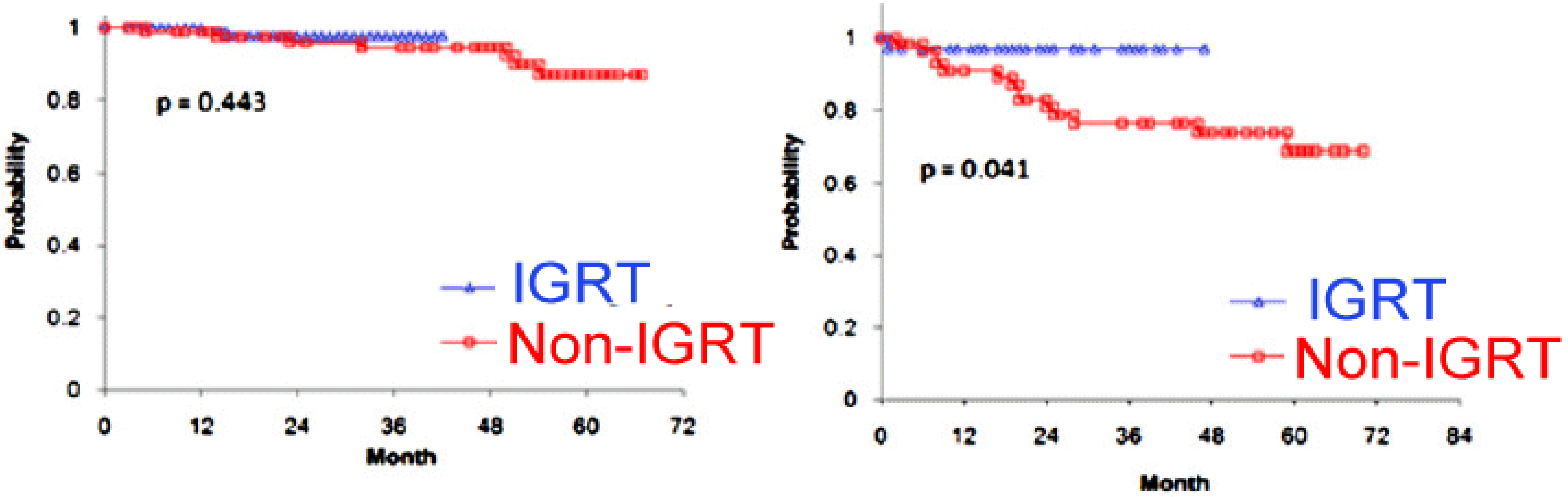
Planned target

No Rectal gas

Planned target, missed badly if rectal gas pushes the prostate forward

Rectal gas

IGRT comparado a IMRT en cáncer de próstata



riesgo intermedio

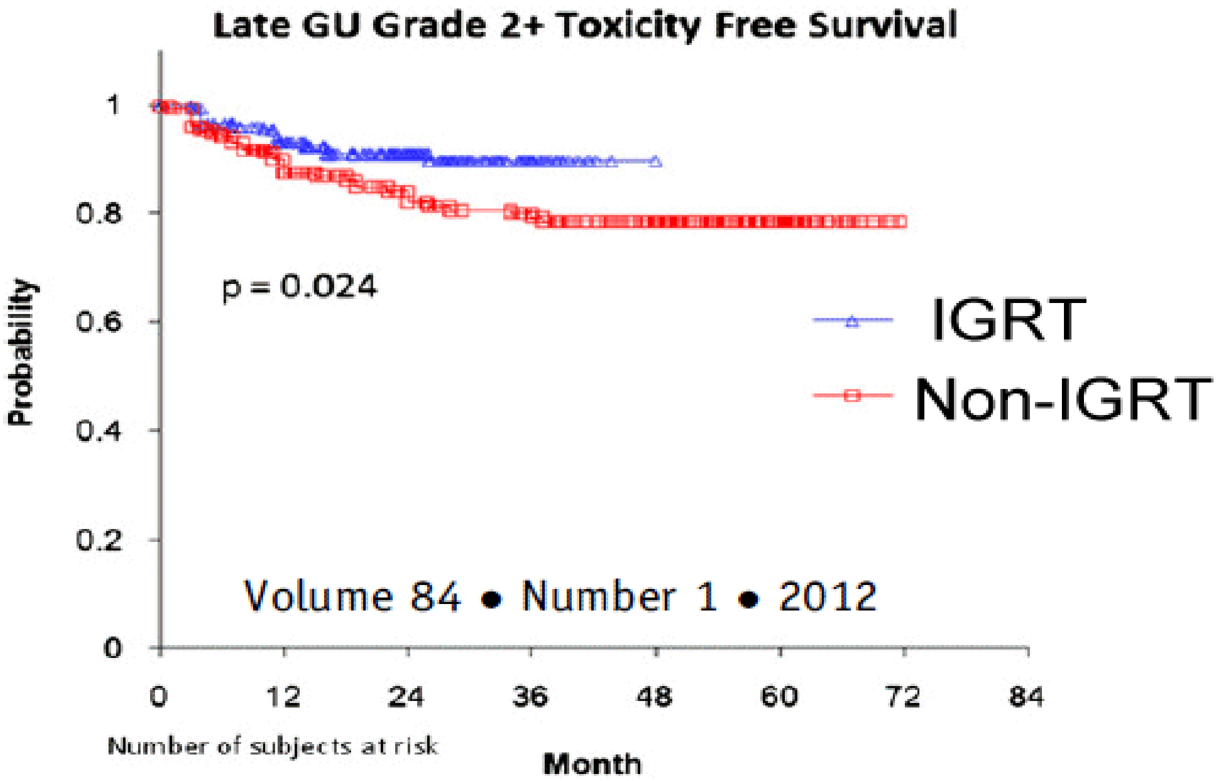
alto riesgo

Comparison of prostate specific antigen relapse-free survival outcomes between patients treated with image-guided radiotherapy (IGRT) to 86.4 Gy and those treated with intensity-modulated radiotherapy to the same dose level.

Zelefsky et al. International Journal of Radiation Oncology • Biology • Physics

Bajo riesgo de efectos secundarios con IGRT comparado a IMRT

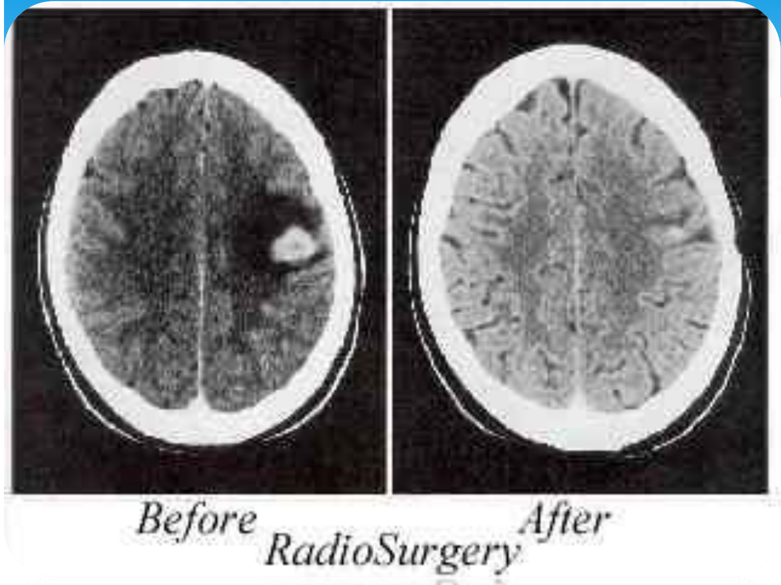
High-dose IGRT vs non-IGRT for prostate cancer 127



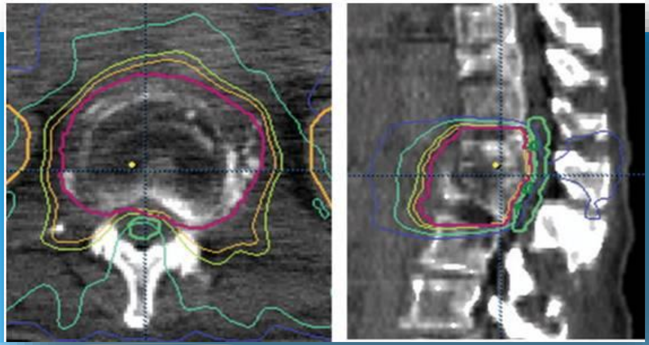
Volume 84 • Number 1 • 2012

Fig. 1. Comparison of actuarial likelihood of grade 2 or higher late urinary toxicity for patients treated with image-guided radiotherapy (IGRT) to 86.4 Gy vs. intensity-modulated radiotherapy.

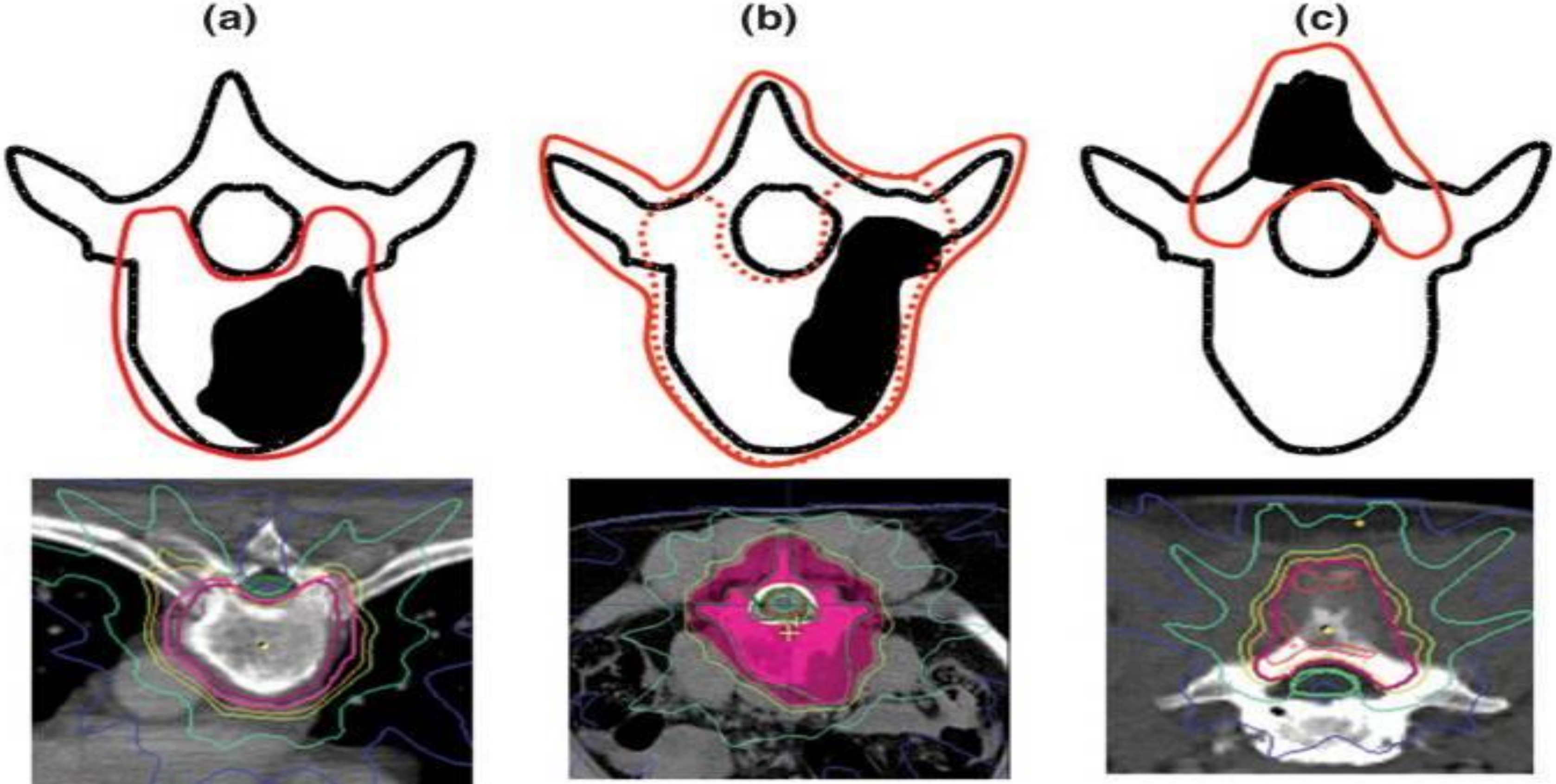
METASTASIS CEREBRAL


Before
RadioSurgery
After

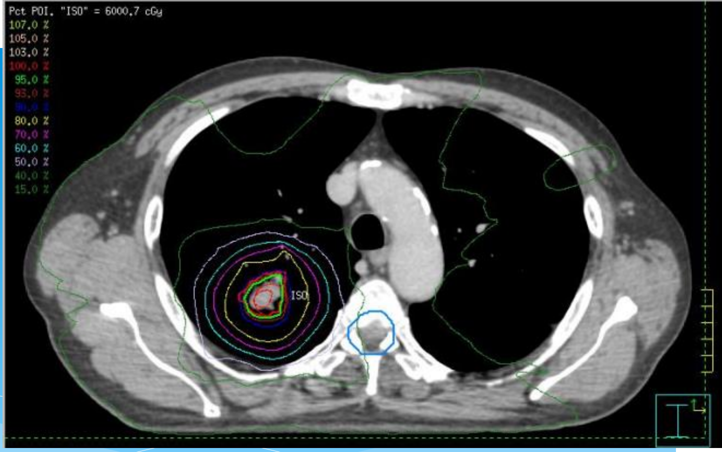
Whole brain external	8 – 15 w	52%
surgical resection	33 – 38 w	20%
rasdiosurgery	44 w	14%



RADIOCIRUGIA DE CUERPO VERTEBRAL



Irradiación localizada de SBRT


Pct POI. "ISO" = 6000,7 cGy
107,0 %
105,0 %
103,0 %
100,0 %
95,0 %
93,0 %
80,0 %
70,0 %
60,0 %
50,0 %
40,0 %
15,0 %
ISO

Multiple non-coplanar fixed fields

Arcing IMRT (VMAT/RapidArc/Tomotherapy)

Robotic Mounted Linac (cyberknife)

High precision localised radiotherapy for NSCLC

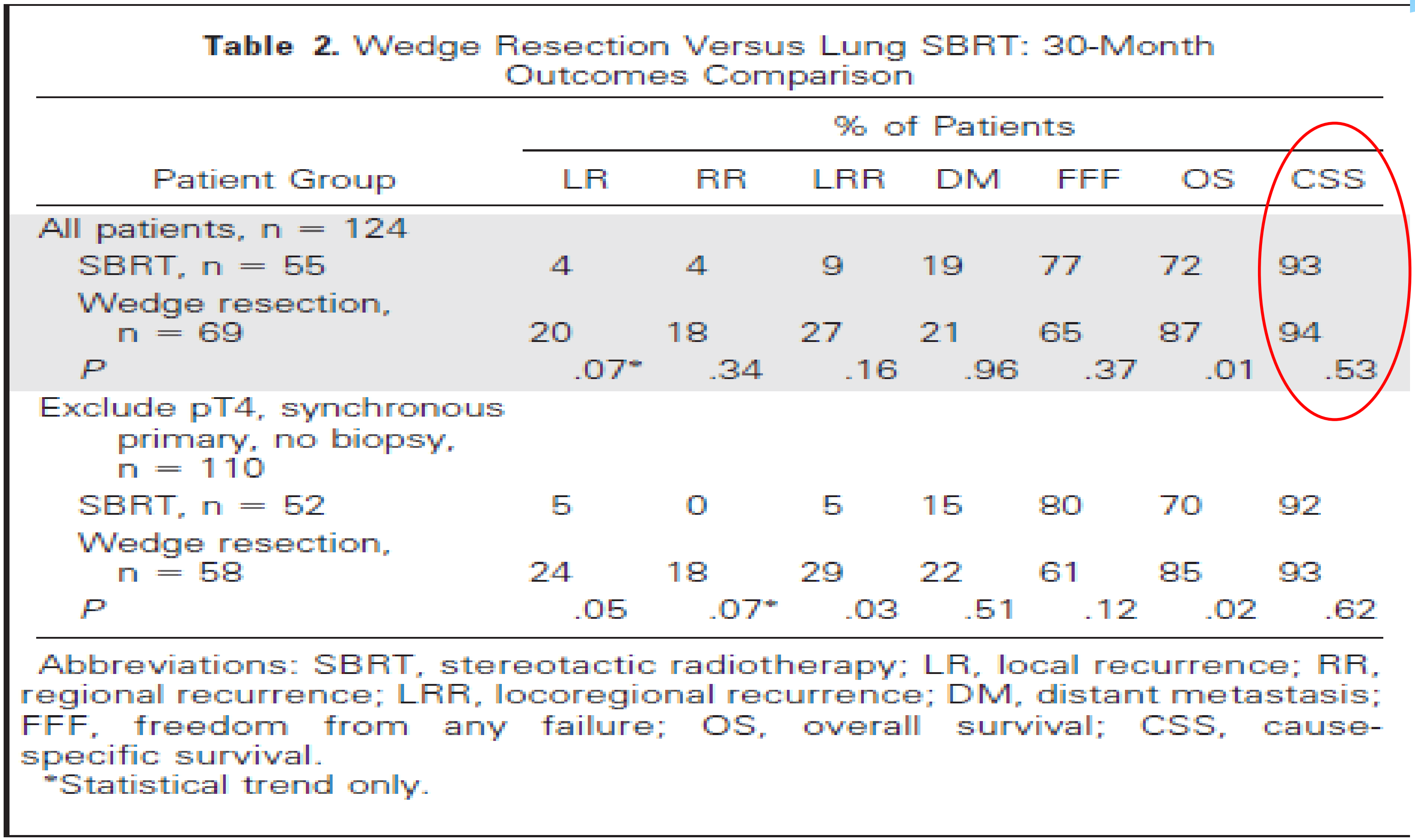


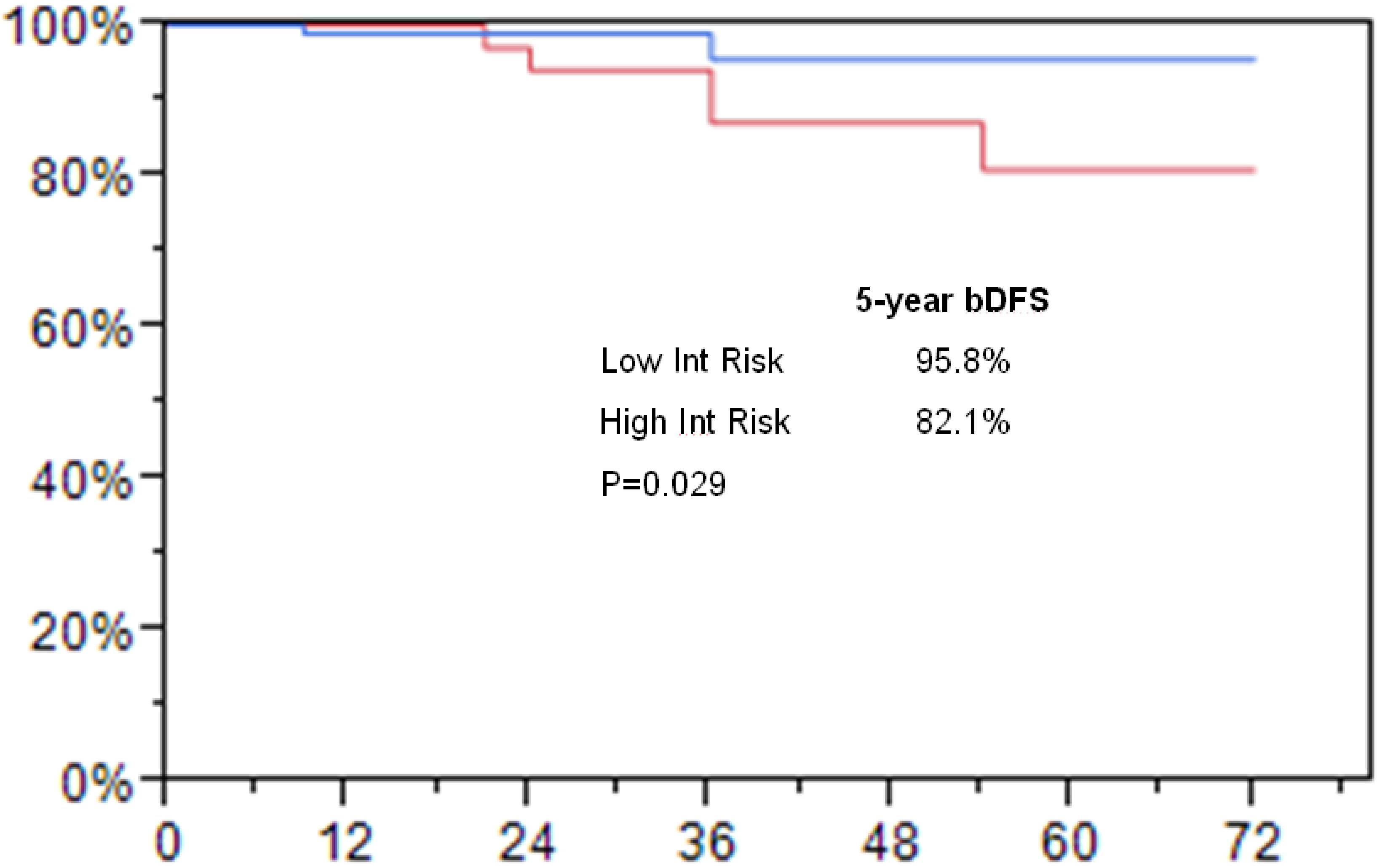
Table 2. Wedge Resection Versus Lung SBRT: 30-Month Outcomes Comparison

Patient Group	% of Patients						
	LR	RR	LRR	DM	FFF	OS	CSS
All patients, n = 124							
SBRT, n = 55	4	4	9	19	77	72	93
Wedge resection, n = 69	20	18	27	21	65	87	94
P	.07*	.34	.16	.96	.37	.01	.53
Exclude pT4, synchronous primary, no biopsy, n = 110							
SBRT, n = 52	5	0	5	15	80	70	92
Wedge resection, n = 58	24	18	29	22	61	85	93
P	.05	.07*	.03	.51	.12	.02	.62

Abbreviations: SBRT, stereotactic radiotherapy; LR, local recurrence; RR, regional recurrence; LRR, locoregional recurrence; DM, distant metastasis; FFF, freedom from any failure; OS, overall survival; CSS, cause-specific survival.

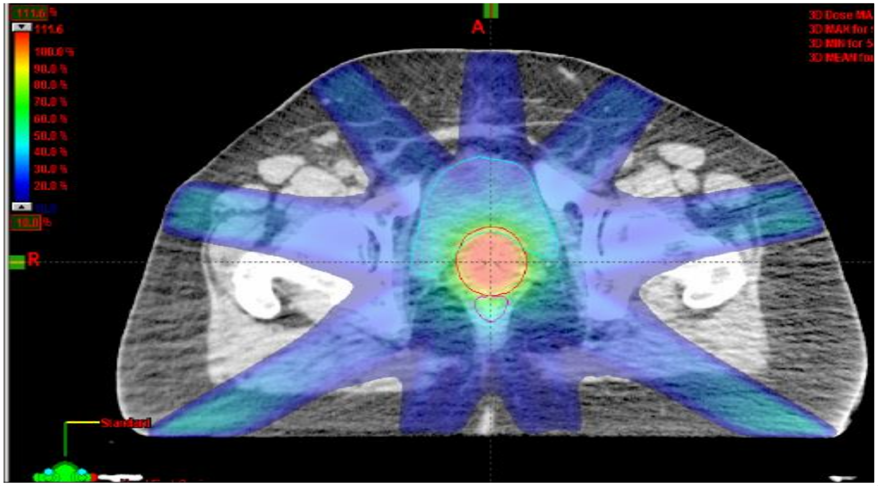
*Statistical trend only.

TASAS DE CURACION EN CANCER DE PROSTATA CON CYBERKNIFE



N = 515, Alan Katz in New York

IMRT Vs BRAQUITERAPIA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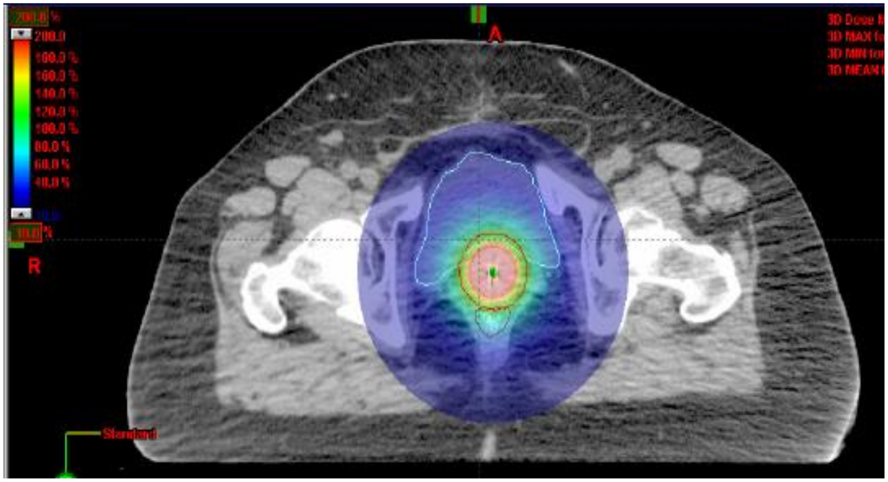
200.0 %
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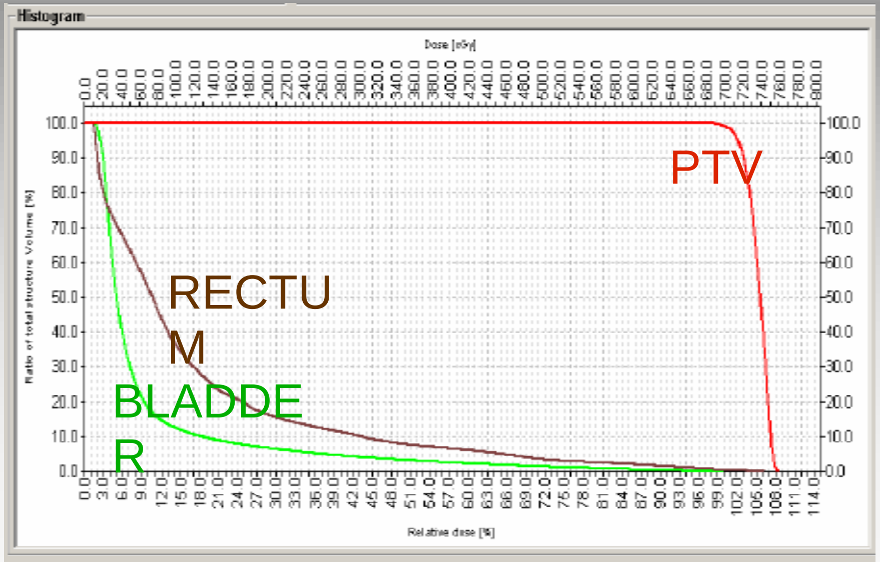
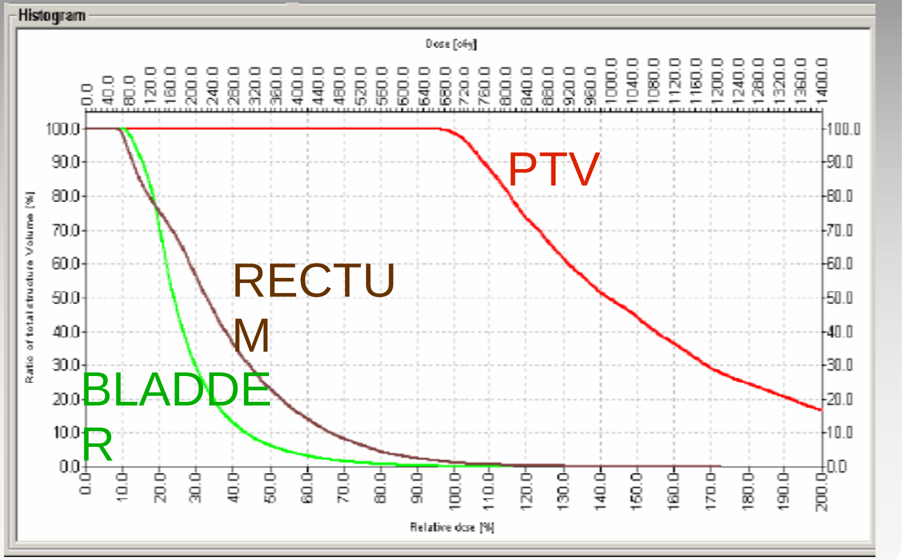
IMRT

BRACHYTHERAPY





DESVENTAJAS POTENCIALES DEL IMRT

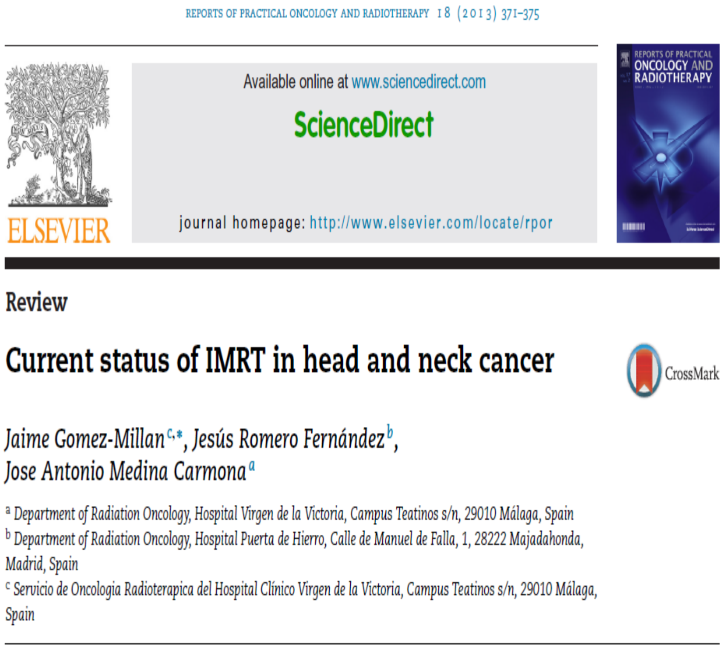
RADIACIÓN DISPERSA, aumento de la dosis absorbida fuera del campo del tratamiento.

NEOPLASIAS SECUNDARIAS (Aumenta 1 a 1.75%) – Hall et al., 2003.

MEJOR DELINEAMIENTO (MÁS PRECISO Y MÁS ORGANOS QUE EL CONVENCIONAL)

NECESITA MÁS TIEMPO Y MÁS RECURSOS QUE EN RT CONVENCIONAL.

PRECISIÓN DE ALTA TECNOLOGÍA.



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Review

Current status of IMRT in head and neck cancer

CrossMark

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