HUMANITAS
CANCER CENTER

SBRT: Terminology and general overview

pietro.mancosu@humanitas.it

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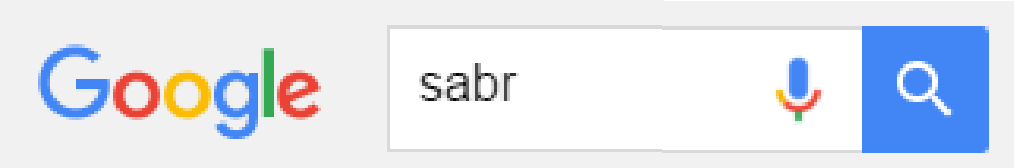

Society for American Baseball Research - Wikipedia, the ...
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What is Roger Federer's new SABR move? | For The Win
ftw.usatoday.com/.../what-is-roger-federers-new-**sabr**-move ▾ USA Today ▾
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The SABR: Federer's new bravado | News | 2015 US Open ...
www.usopen.org › News ▾ The US Open (Tennis) ▾
The **SABR**: Federer's new bravado. Print. By Neil Schlecht. Thursday, September 03, 2015. Leave it to Roger Federer to do something on a tennis court no one ...

Roger Federer Hit 3 New Shot "SABR" in One Game in US ...

https://www.youtube.com/watch?v=Nmwo1Q-gvhI
Sep 2, 2015 - Uploaded by tao dark
Federer fired up his new shot **SABR** (Sneaky Attack By Roger) 3 times in US open 2015 first round against ...

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Sneak Attack By Roger in four steps – Final US OPEN 2015

Preparation

Precision

Advance

Efficient

What is our strategy ?

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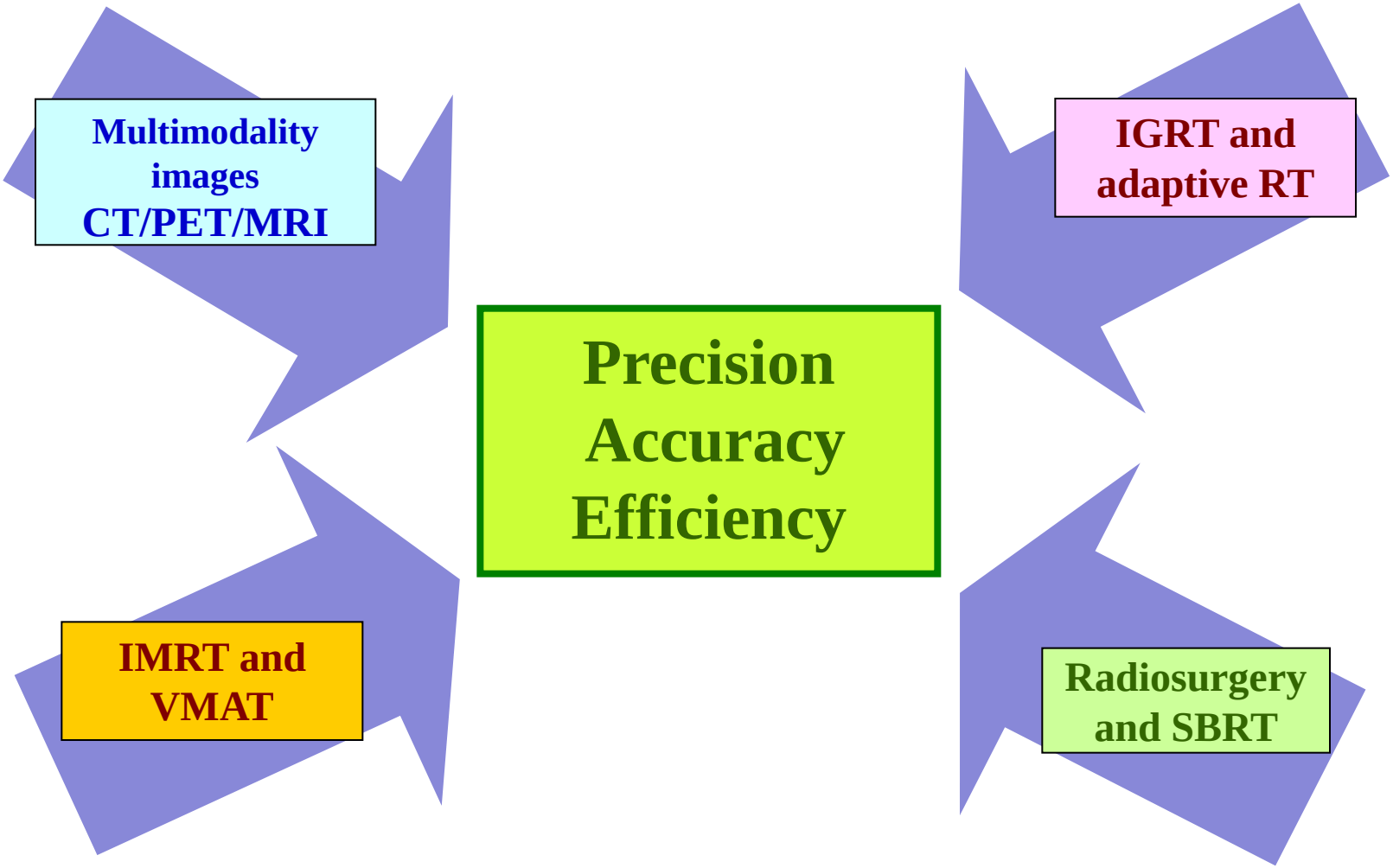

Prof. Scorsetti, 2009

Index

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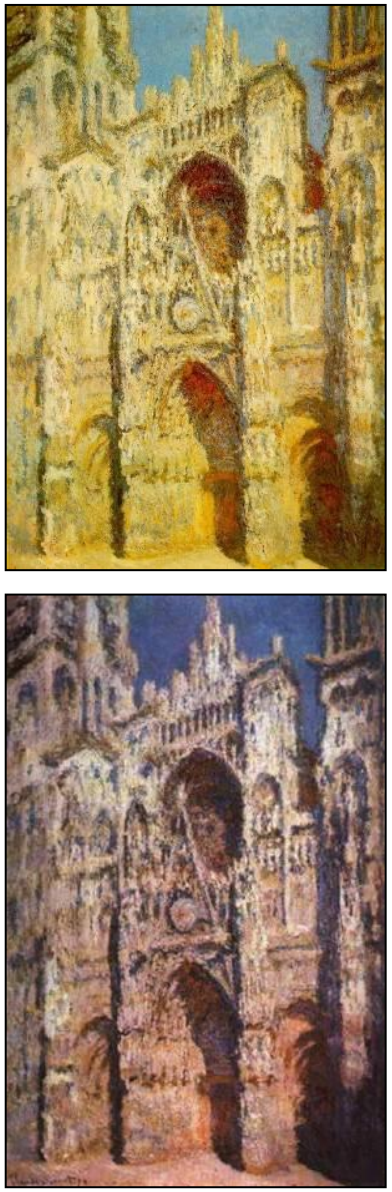
- Radiotherapy demand
- SBRT/SABR definition
- From Surgery to Radiosurgery and SBRT
- SBRT on liver
- Efficiency in SBRT
- Take home messages



Monet –Rouen cathedral, 1893/94

Radiotherapy demand

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JOURNAL OF CLINICAL ONCOLOGY

The Future of Radiation Oncology in the United States From 2010 to 2020: Will Supply Keep Pace With Demand?

Benjamin D. Smith, Bruce G. Haffty, Lynn D. Wilson, Grace L. Smith, Akshar N. Patel, and Thomas A. Buchholz

Table 1. Projected Estimates of Patients Receiving Radiation Therapy in 2010 and 2020

Tumor Site	No. of Patients Receiving Radiation Therapy		% Increase in Demand for Radiation Therapy From 2010 to 2020
	2010	2020	
Total	470,000	575,000	22

ESTRO-HERO Analysis

How many new cancer patients in Europe will require radiotherapy by 2025? An ESTRO-HERO analysis

CrossMark

Josep M. Borras [a,*], Yolande Lievens [b], Michael Barton [c], Julieta Corral [d], Jacques Ferlay [e], Freddie Bray [e], Cai Grau [f]

Table 1
Cancer cases with an evidence based indication for external radiotherapy 2012 and 2025.

Country	Total cancers (*n*)[a]		OUP (%)[b]		Optimal radiotherapy courses (*n*)				
					2012		2025		% Var. 2012–25
	2012	2025	Min.	Max.	OUP min.	OUP max.	OUP min.	OUP max.	OUP min./max.
Iceland	1449	1997	50.7	51.8	734	750	1,012	1,034	37.8
Ireland	20,808	28,432	51.5	52.9	10,714	11,017	14,640	15,053	36.6
Italy	354,456	411,515	48.2	49.3	170,821	174,764	198,320	202,897	16.1
Latvia	10,347	9567	49.9	51.4	5166	5315	4777	4914	−7.5
Lithuania	14,520	13,514	49.9	51.5	7244	7483	6742	6965	−6.9
The Netherlands	93,448	117,999	52.3	53.9	48,886	50,324	61,729	63,546	26.3
Ukraine	140,999	140,928	50.2	52.1	70,811	73,403	70,775	73,366	−0.1
United Kingdom	327,812	398,471	53	54.4	173,612	178,405	211,034	216,860	21.6
Global	3,439,598	3,988,288	50.2	51.7	1,727,538	1,778,816	2,005,480	2,064,739	16.1

Radiotherapy demand

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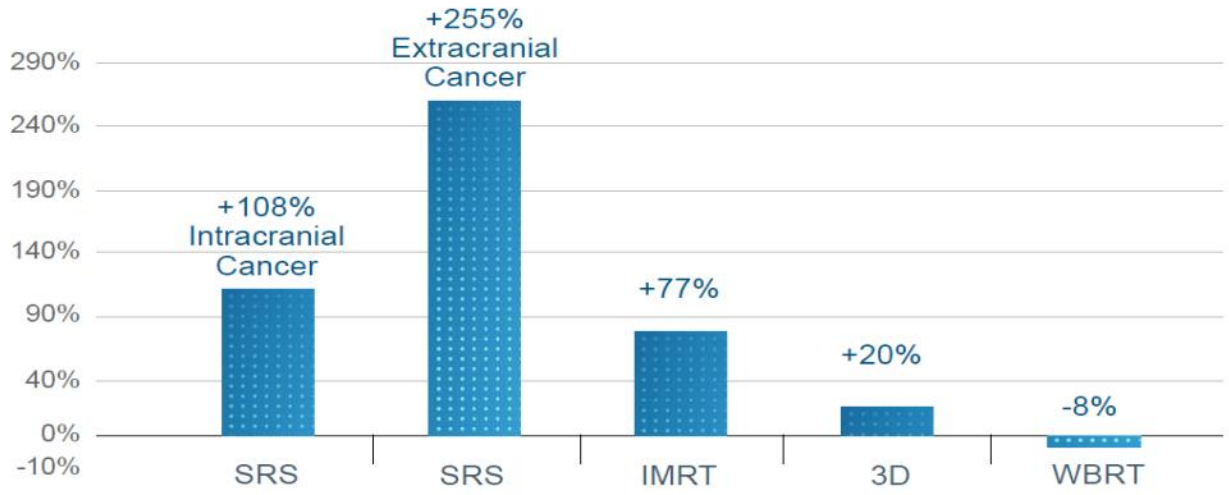
Table 3
Increase in the number of new cancer cases that would require radiotherapy by 2025 and relative percentage increase between 2012 and 2025 for the 5 most frequent indications

Country	Breast Increase		Head and neck Increase		Lung Increase		Prostate Increase		Rectum Increase	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Iceland	53	27.6	8	38.9	54	43.2	74	46.5	15	39.5
Ireland	744	30.0	146	34.0	714	40.9	905	40.9	155	40.7
Italy	4323	10.0	1303	16.3	5757	20.1	5596	21.5	1763	18.2
Latvia	−92	−9.4	−18	−6.2	−55	−6.1	−47	−5.4	−12	−6.4
Lithuania	−75	−5.9	−14	−3.2	−68	−5.7	−80	−9.0	−23	−6.4
The Netherlands	1552	13.1	491	22.5	2641	28.7	2825	36.3	862	32.4
Ukraine	−124	−0.9	−5	−0.1	209	1.6	38	1.0	82	1.6
United Kingdom	6401	14.3	1349	18.1	7656	24.7	7419	27.9	2049	24.4
Global	40,524	10.2	13,337	12.3	56,558	17.9	59,493	24.4	18,314	18.4
Range		−9.4 to 30.0		−6.2 to 39.6		−6.1 to 48.1		−9.0 to 53.5		−6.4 to 42.1

J.M. Borras et al./Radiotherapy and Oncology 119 (2016) 5–11

2014

2024



Source: SG2 Consulting, Skokie, Illinois, USA

SBRT: inoperable Lung stage I

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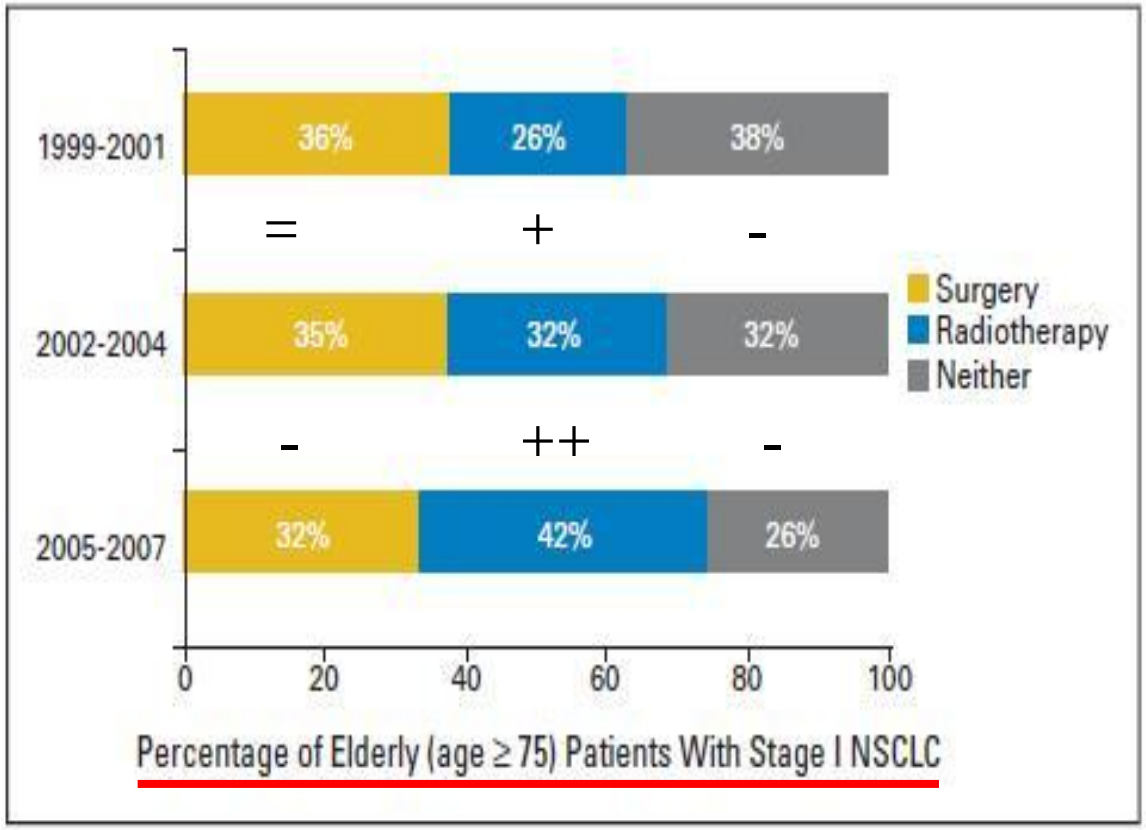

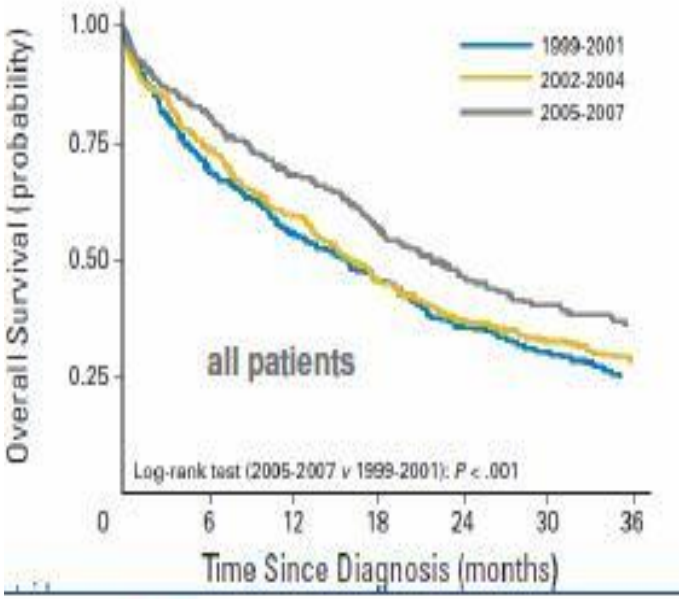

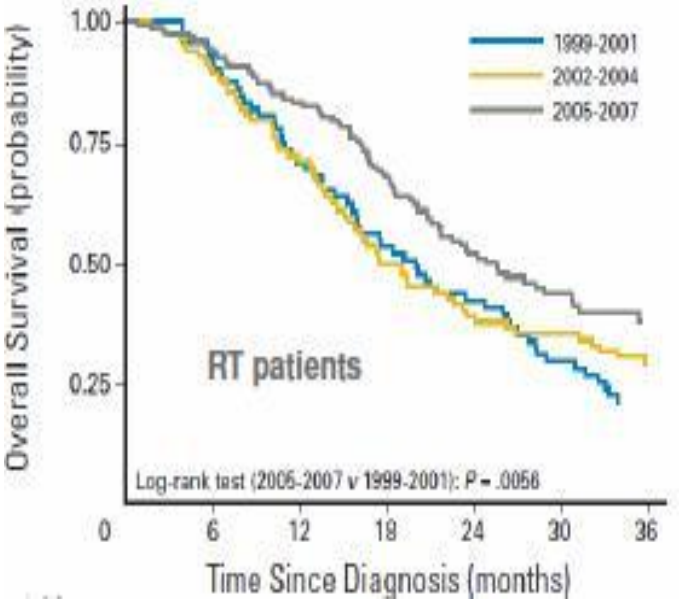

N = 843 stage I patients 75 years

SBRT was introduced in 2005

Palma D, JCO 2010

SBRT for Lung Stage I

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THE LANCET Oncology

Treatment of early-stage lung cancer detected by screening: surgery or stereotactic ablative radiotherapy?

Lancet Oncol 2013; 14: e270–74

Suresh Senan, Marinus A Paul, Frank J Lagerwaard

Panel: Key considerations in local treatment decisions

Surgery

Pros:

- Definitive pathological diagnosis
- Enables invasive nodal staging in all cases
- Appropriate delivery of adjuvant therapy in node-positive disease

Cons:

- Procedure-related morbidity and mortality
- Invasive procedure for possibly benign disease

SABR

Pros:

- 5-year local disease control rates of more than 90%
- Outpatient procedure with mild acute toxicity
- Preservation of lung function and quality of life

Cons:

- Treatment without definite pathological verification
- Post-treatment fibrosis masking local disease recurrence

Randomize trial?

Correspondence

Quality assurance is a key component of stereotactic ablative radiotherapy, as it is with surgery. Multi-institutional trials and systematic reviews suggest that outcomes with SABR are generally consistent across several centres.[3] By contrast, results of hospital-volume studies suggest that surgical mortality data do not generalise well to smaller centres.[4]

Surgery versus SABR for NSCLC

In Paul Van Schil and Jan Van Meerbeeck's recent Correspondence,[1] the authors debate the merits of a Review[2] that forms the premise for randomised trials comparing surgery with stereotactic ablative radiotherapy (SABR) for early stage lung cancers detected by CT screening. They state that such trials are only warranted in patients with a compromised pulmonary or cardiac function who have an increased operative risk. However, we believe this comment does not reflect the evidence.

SBRT: not a machine, but type of delivery

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Introduction: definitions SBRT

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Definition of SBRT

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REPORT

AMERICAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY (ASTRO) AND AMERICAN COLLEGE OF RADIOLOGY (ACR) PRACTICE GUIDELINE FOR THE PERFORMANCE OF STEREOTACTIC BODY RADIATION THERAPY

• Stereotactic body radiation therapy (SBRT) is an external beam radiation therapy method used to very precisely deliver a **high dose of radiation** to an extracranial target within the body, using either a single dose or a small number of fractions.

• Specialized treatment planning results in high target dose and **steep dose gradients** beyond the target.

• The ability to deliver a **single or a few fractions of high-dose ionizing radiation** with **high targeting accuracy** and rapid dose falloff gradients encompassing tumors within a patient provides the basis for the development of SBRT.

History: From Stereotactic Surgery to Radiosurgery

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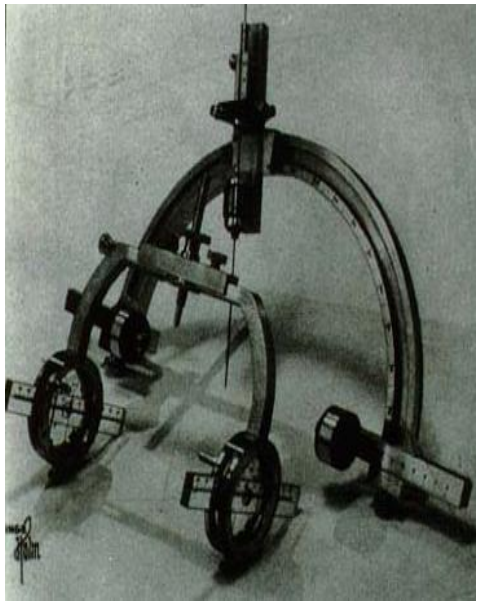
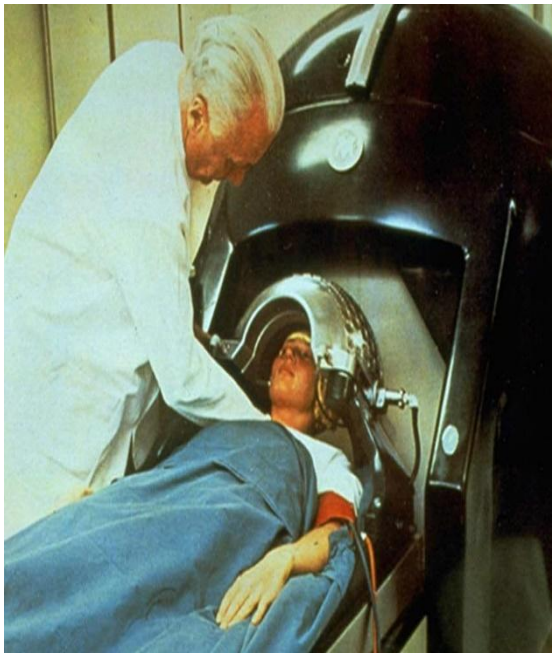
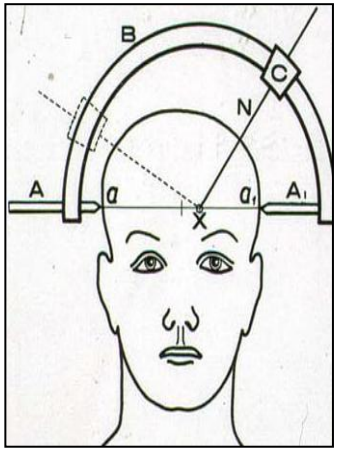


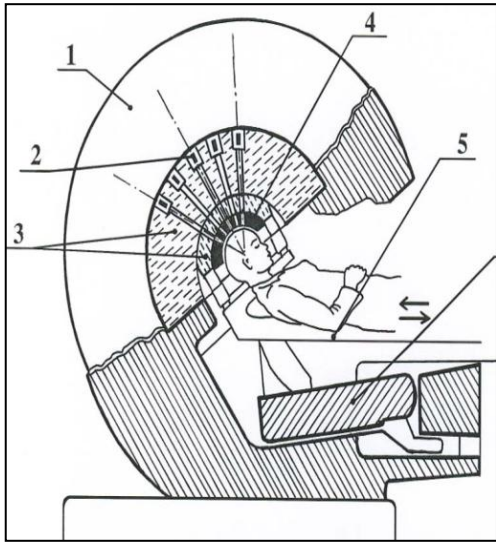
Arc-based stereotactic frame

Lars Leksell



Cross-fired Radiation + Stereotactic Frame = "Radiosurgery"





History: SRS

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Stereotaxis: stereo from the Greek root word for solid body and taxis from the Greek word for arrangement or order

SRS was first described in 1951 by Swedish neurosurgeon **Lars Leksell.** He used a stereotactic frame of his own design coupled with a 200 kV x-ray-therapy machine to treat patients for trigeminal neuralgia.

The **Leksell Gamma Knife**, first tested in 1967, was used only for treatment of functional diseases, since intracranial imaging at that time could not reveal brain tumors.

Definition of radiosurgery

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ISSUES AND POSITIONS

A Call to Define Stereotactic Radiosurgery

Bruce E. Pollock, M.D.

Department of Neurological Surgery, and Division of Radiation Oncology, Mayo Clinic College of Medicine, Rochester, Minnesota

L. Dade Lunsford, M.D.

Departments of Neurological Surgery, Radiation Oncology, and Radiology, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

Reprint requests:
Bruce E. Pollock, M.D., Department of Neurological Surgery, Mayo Clinic, Rochester, MN 55905.
Email: pollock.bruce@mayo.edu

Received, February 23, 2004.
Accepted, August 19, 2004.

STEREOTACTIC RADIOSURGERY IS the single-session, precise delivery of a therapeutically effective radiation dose to an imaging-defined target. Conceived and developed during the past 5 decades, stereotactic radiosurgery has involved significant advances, which have improved patient outcomes and made it a critical component of modern neurosurgical practice and training. In this article, a short history of stereotactic surgery and radiosurgery are presented, and radiosurgery is contrasted to radiation therapy. Adherence to accepted, descriptive terms in defining stereotactic radiosurgery and radiation therapy permits a clear distinction among the results of the different radiation delivery techniques for patients, physicians, and other interested parties.

KEY WORDS: Classification, History, Method, Radiation therapy, Stereotactic radiosurgery

Neurosurgery 55:1371-1373, 2004 DOI: 10.1227/01.NEU.0000143613.13759.D4 www.neurosurgery-online.com

The field of human stereotactic surgery has advanced for more than 5 decades since the seminal work by Spiegel et al. (13). These pioneers described the modifica-

exciting dis

accepted by

Inspired

der Wycis

Stereotactic radiosurgery: «the single session, precise delivery of therapeutically effective radiation dose to an imaging-defined target»

SRS: clinical applications

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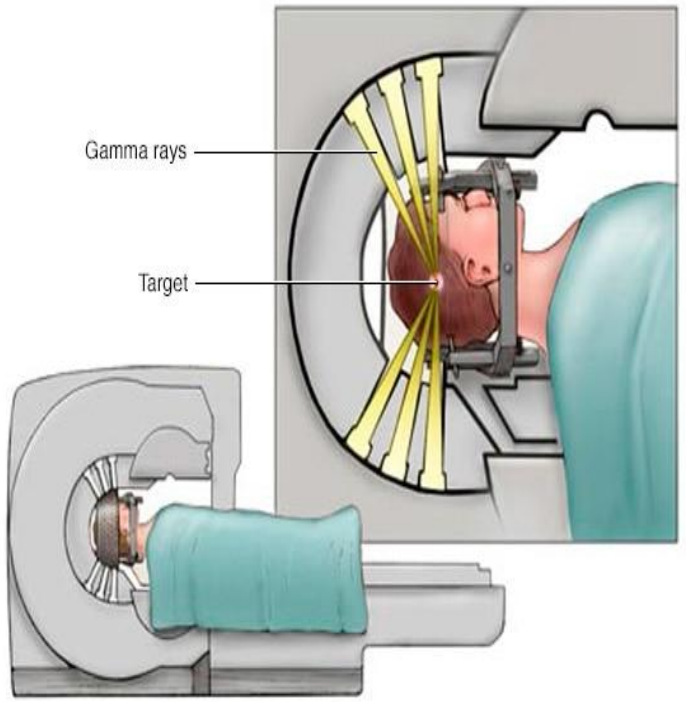
- **Trigeminal neuralgia** → dose is typically reported as a maximum point dose, which ranges from 50 Gy to 90 Gy

- **Arteriovenous malformations** → peripheral dose of 16 Gy to 25 Gy

- **Parkinson's disease, Multiple sclerosis and Essential tremor** → SRS thalamotomy with a dose of 130-150 Gy



Linac based SRS

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Whereas gamma-ray stereotactic radiosurgery devices were dedicated to a single purpose, **linear accelerators used for stereotactic radiosurgery and stereotactic radiotherapy** began as conventional radiation therapy devices that were adapted for special procedures by the addition of specialized collimators.

0148-396X/88/2203-0454$02.00/0
NEUROSURGERY
Copyright © 1988 by the Congress of Neurological Surgeons
Vol. 22, No. 3, 1988
Printed in U.S.A.

Linear Accelerator as a Neurosurgical Tool for Stereotactic Radiosurgery

Ken R. Winston, M.D., and Wendell Lutz, Ph.D.

Department of Neurosurgery of The Children's Hospital, Department of Surgery (Neurosurgery) of the Brigham and Women's Hospital, The Joint Center for Radiation Therapy, and Harvard Medical School, Boston, Massachusetts

A new system has been developed for stereotactically delivering prescribed high doses of radiation to precisely located volumes of approximately 0.6 to 10.0 ml within the brain. A Brown-Roberts-Wells stereotactic apparatus and a 6-MeV linear accelerator equipped with a special collimator (12.5 to 30 mm in diameter) have been adapted. The 20-mm collimator allows treatment of a nearly spherical volume of 2.1 ml. Outside the treatment field, the dosage declines to 80% of the dose prescribed for the periphery of the le
Localization can be accomplished via computed tom
an arcing beam of photon radiation with the turntal
extensively tested for accuracy in alignment and distr
of the apparatus and for the process of localization.
testing phase. (*Neurosurgery* 22:454–464, 1988)

Key words: Computed tomography-guided radiosurg

Stereotactic radiosurgery, the idea, a method, and even
term were published by Leksell in 1951 (16). He initially u
the stereotactic frame that he had described 2 years ear
and a special collimator attached to an x-ray tube.
collimator could be moved along a track that circumscri
an arc over the head, thereby cross firing the x-ray beam
predetermined location within the head. Later Leksell acc
plished the same with a proton beam (14, 18, 19) and,
1968, he began to use an array of cobalt-60 γ sources
produce disc-shaped lesions for functional neurosurgery
to treat certain tumors and arteriovenous malformations
humans (17). The system has been extensively modified
improved since that early report (15). Other systems of s
eotactic radiosurgery have been in use in the United Sta
and in the Soviet Union for many years, particularly
beams of protons and helium ions from synchrocyclotr
(8, 9, 13, 21).
Stereotactic radiosurgery is an attractive therapy beca

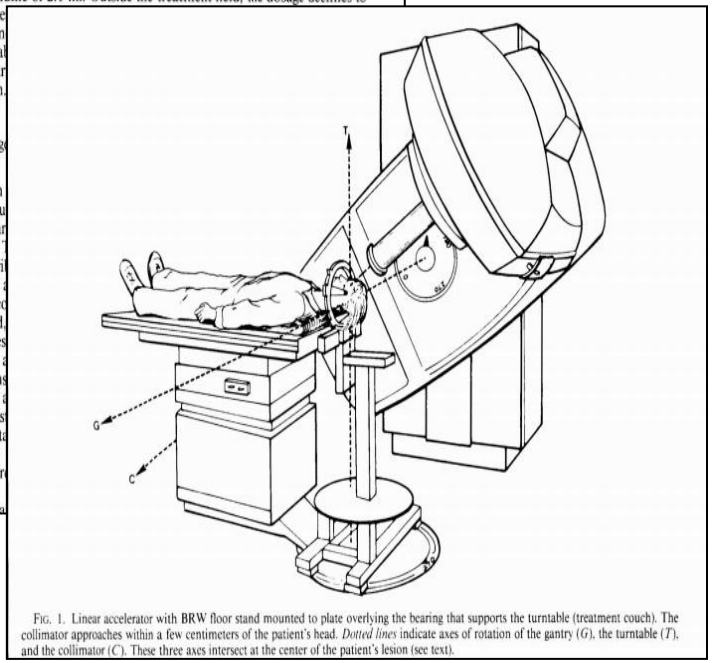

FIG. 1. Linear accelerator with BRW floor stand mounted to plate overlying the bearing that supports the turntable (treatment couch). The collimator approaches within a few centimeters of the patient's head. *Dotted lines* indicate axes of rotation of the gantry (*G*), the turntable (*T*), and the collimator (*C*). These three axes intersect at the center of the patient's lesion (see text).

SRS for brain metastases

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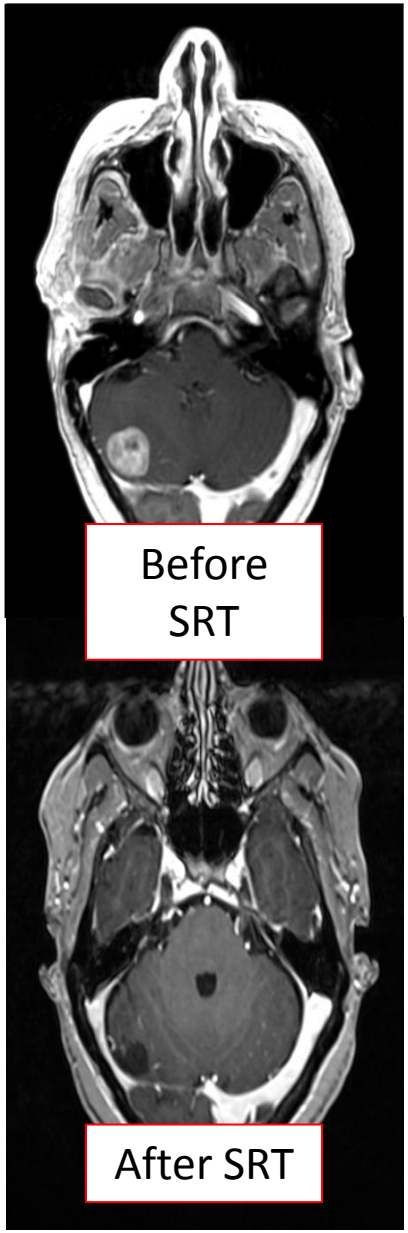
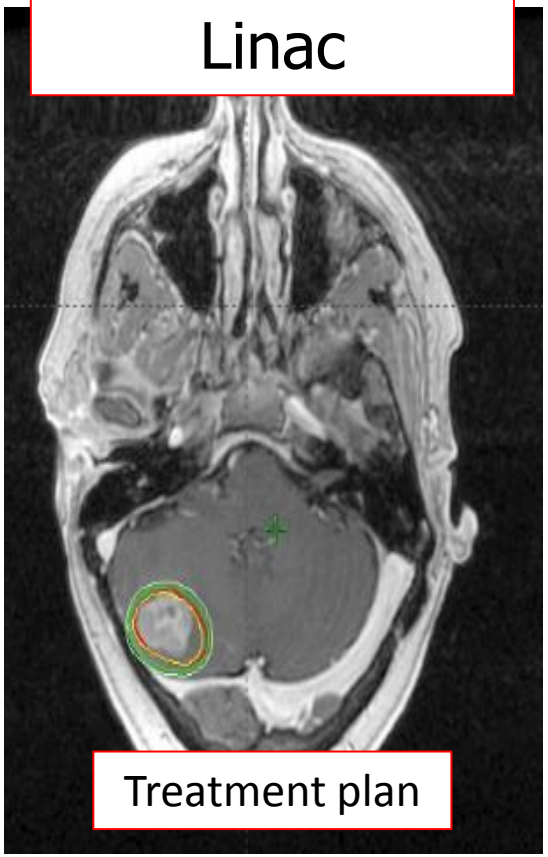
Brain metastases represent the most common intracranial target for radiosurgery.

Control of these tumors, especially if < 2 cm is good and compares **favorably to surgical removal.**

Although total **number** of lesions, tumor **location**, prior radiation, and nature of the **primary tumor** can all factor into dose selection, **target size** is typically the most important factor.



Breast cancer brain metastasis treated with Linac



From intracranial to extracranial SBRT

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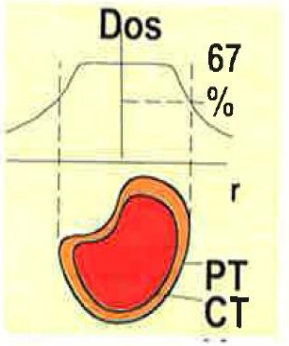
Prelude to a New Therapeutic Paradigm: The Clinical Transition from Intracranial to Extracranial Stereotactic Radiation Therapy

Acta Oncol 1994

Ingmar Lax and Henric Blomgren



"A method for stereotactic high dose-radiotherapy of malignancies in the abdomen has been developed. A stereotactic frame for the body has been developed and a method for the fixation of the patient in the frame is described".

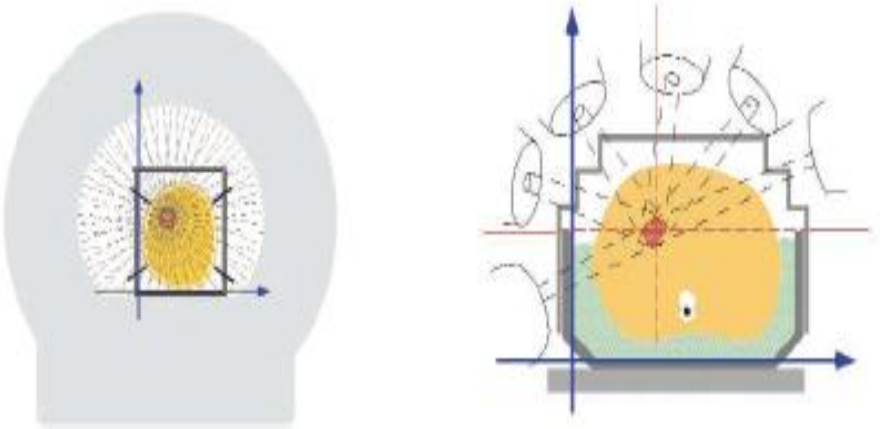


FIGURE 1. The left panel shows a schematic drawing of intracranial stereotactic radiosurgery with the Gamma Knife (Elekta, Norcross, GA). The stereotactic frame is fixed with screws into the skull. The right panel shows a schematic drawing of extracranial stereotactic radiation therapy with linear accelerator. The patient is fixed in the stereotactic body frame.

SBRT: where?

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VOLUME 25 · NUMBER 8 · MARCH 10 2007

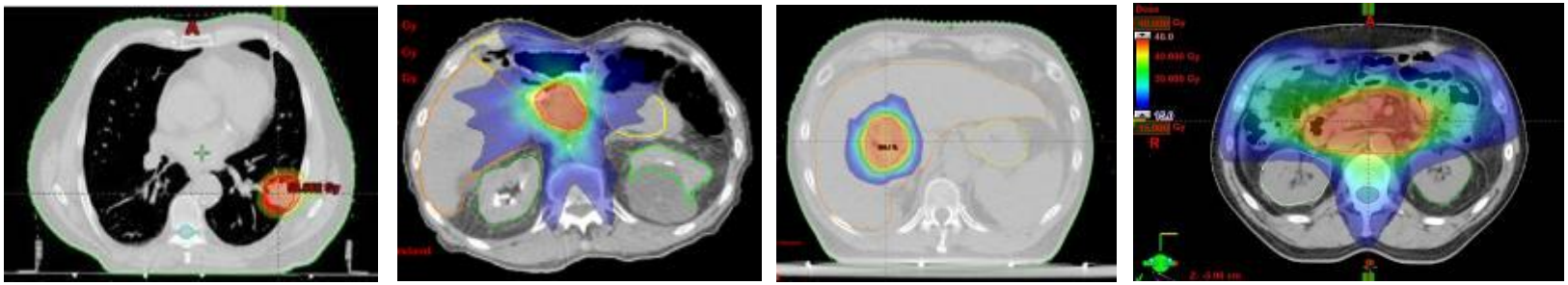
JOURNAL OF CLINICAL ONCOLOGY

REVIEW ARTICLE

Stereotactic Body Radiation Therapy in Multiple Organ Sites

Robert D. Timmerman, Brian D. Kavanagh, L. Chinsoo Cho, Lech Papiez, and Lei Xing

Stereotactic body radiation therapy (SBRT) uses advanced technology to deliver a **potent ablative dose** to deep-seated tumors in the **lung, liver, spine, pancreas, kidney, and prostate.**



SBRT concept

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-‘Parallel’ normal tissues respond according to ≈ mean dose in the tissue/organ

-The mean dose is much lower than the tumour dose.

-Furthermore the more conformal is the treatment the lower is the mean dose (relative to the tumour dose)

- What for “serial” tissues (i.e. spinal cord)?

SBRT: inoperable early stages NSCLC

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REVIEWS

Peripheral lesions

Stereotactic body radiation therapy: a novel treatment modality

Simon S. Lo, Achilles J. Fakiris, Eric L. Chang, Nina A. Mayr, Jian Z. Wang, Lech Papiez, Bin S. Teh, Ronald C. McGarry, Higinia R. Cardenes and Robert D. Timmerman

Nat. Rev. Clin. Oncol. **7**, 44–54 (2010); published online 8 December 2009; doi:10.1038/nrclinonc.2009.188

Table 1 | Results of SBRT trials in early stage non-small cell lung cancer

Study	Trial type	Disease stage	Number of patients	Radiation dose	Follow-up period (months)	Outcomes
McGarry *et al.* (2005)[27]	Prospective (phase I)	Medically inoperable stage I	47	24–72 Gy in 3 fractions at 80%	27.4 for T1 19.1 for T2	LC: 78.7%
Fakiris *et al.* (2009)[28]	Prospective (phase II)	Medically inoperable stage I	70	T1 tumors: 60 Gy in 3 fractions at 80% T2 tumors: 66 Gy in 3 fractions at 80%	50.2	LC: 88.1% at 3 years OS: 42.7% at 3 years CSS: 81.7% at 3 years
Nagata *et al.* (2005)[30]	Prospective (phase I–II)	IA and IB	45	48 Gy in 4 fractions at isocenter	30 for T1 tumors 22 for T2 tumors	LC: 98% (crude) OS: 92% and 83% at 1 and 3 years, respectively DFS: 80% and 72% at 1 and 3 years, respectively
Baumann *et al.* (2009)[31]	Prospective (phase II)	Medically inoperable stage I	57	45 Gy in 3 fractions at 67%	35	LC: 92% at 3 years OS: 86%, 65% and 60% at 1, 2 and 3 years, respectively CSS: 93%, 88% and 88% at 1, 2 and 3 years, respectively PFS: 52% at 3 years

Abbreviations: CSS, cancer-specific survival; DFS, disease-free survival; LC, local control; OS, overall survival; PFS, progression-free survival; SBRT, stereotactic body radiation therapy.

SBRT Liver

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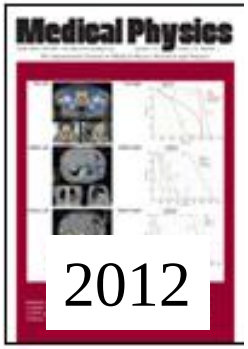
RADIATION ONCOLOGY

2012

Stereotactic body radiation therapy for liver tumours using flattening filter free beam: dosimetric and technical considerations.

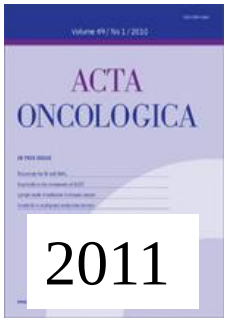
Pietro Mancosu, Simona Castiglioni, Giacomo Reggiori, Maddalena Catalano, Filippo Alongi, Chiara Pellegrini, Stefano Arcangeli, Angelo Tozzi, Francesca Lobefalo, Antonella Fogliata, Piera Navarria, Luca Cozzi and Marta Scorsetti



2012

Can volumetric modulated arc therapy with flattening filter free beams play a role in stereotactic body radiotherapy for liver lesions? A volume-based analysis

Giacomo Reggiori, Pietro Mancosu,[a] Simona Castiglioni, Filippo Alongi, Chiara Pellegrini, Francesca Lobefalo, and Maddalena Catalano
IRCCS Istituto Clinico Humanitas, 20089 Rozzano (Milano), Italy



2011

Stereotactic body radiation therapy for abdominal targets using volumetric intensity modulated arc therapy with RapidArc: Feasibility and clinical preliminary results

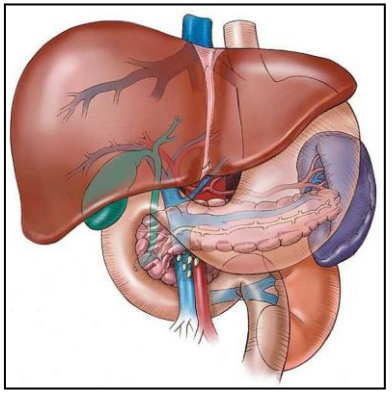
MARTA SCORSETTI[1], MARIO BIGNARDI[1], FILIPPO ALONGI[1], ANTONELLA FOGLIATA[2], PIETRO MANCOSU[1], PIERA NAVARRIA[1], SIMONA CASTIGLIONI[1], SARA PENTIMALLI[1], ANGELO TOZZI[1] & LUCA COZZI[2]

SBRT Liver

HUMANITAS CANCER CENTER

Is Stereotactic Body Radiation Therapy an Attractive Option for Unresectable Liver Metastases? A Preliminary Report From a Phase 2 Trial

Marta Scorsetti, MD,* Stefano Arcangeli, MD,* Angelo Tozzi, MD,* Tiziana Comito, MD,* Filippo Alongi, MD,* Pierina Navarria, MD,* Pietro Mancosu, MSc,* Giacomo Reggiori, MSc,* Antonella Fogliata, Guido Torzilli, MD,† Stefano Tomatis, MSc,* and Luca Cozzi, PhD‡



	Dose/fraction	Total Dose
Standard dose	25Gy	75 Gy
-10%	22.5 Gy	67.5 Gy
-20%	20.63 Gy	61.89 Gy
- 30%	18.75 Gy	56.25 Gy

Dose prescriptionc	Lesions
75 Gy	62 (82 %)
-10%	6 (8 %)
-20%	4 (5 %)
- 30%	4 (5 %)

ORGAN	Dose-Volume Limits	Other Conditions
Healthy liver	At least 700 cc less than15 Gy	Vol>1000 cc
Spinal cord	Dmax<18Gy	
Kidneys (R+L)	V15 Gy < 35%	
Stomach, duodenum, small intestine, esophagus, cistifelea	Dmax<21Gy	GTV>8mm from parallel OARs
Heart	<30 Gy in 3 F	
Rib	D30cc <30Gy	

SBRT Liver

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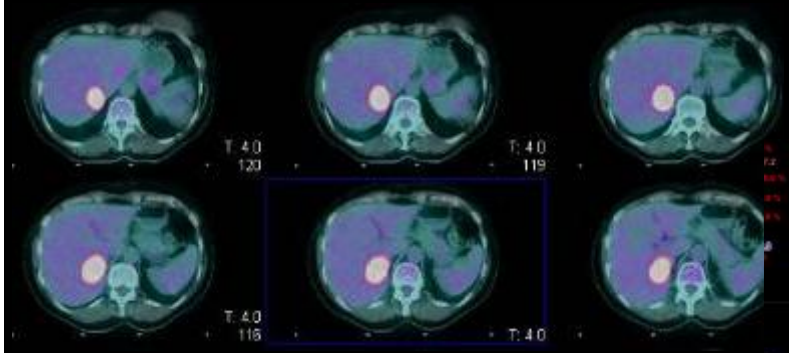
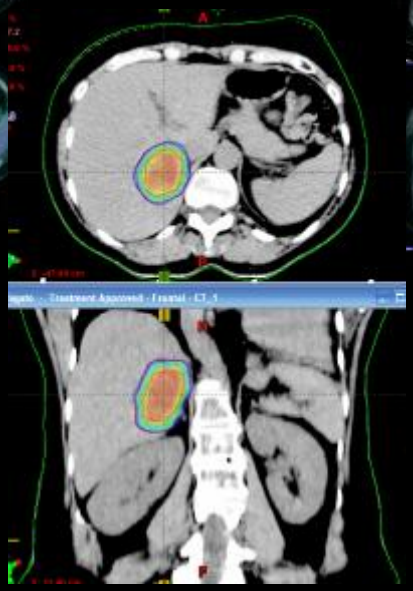
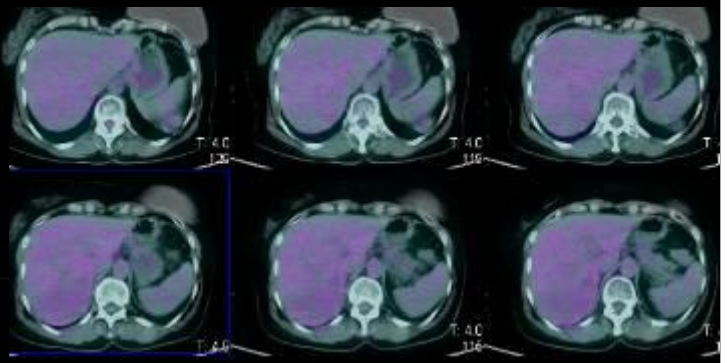
PET pre

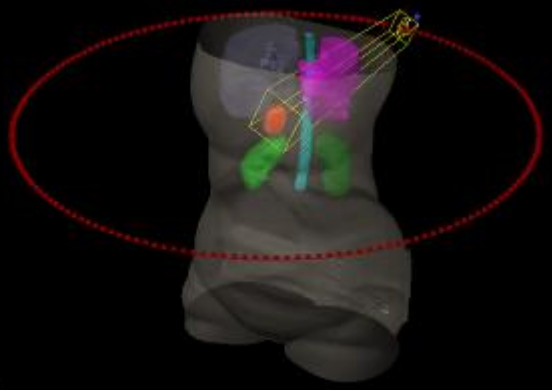


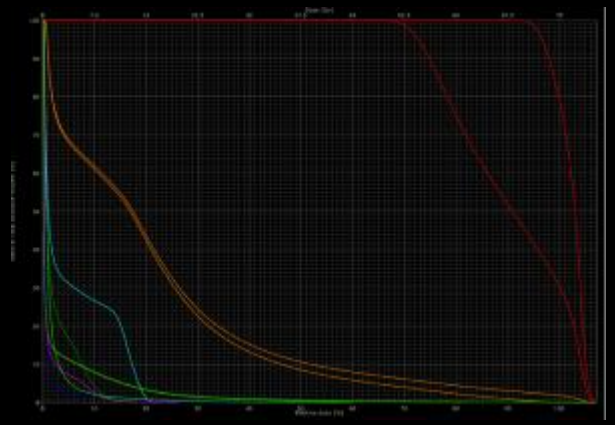
1 isocentre
1 arc
Jaw tracking



PET post







MU:5103
BOT:130s

SBRT Liver

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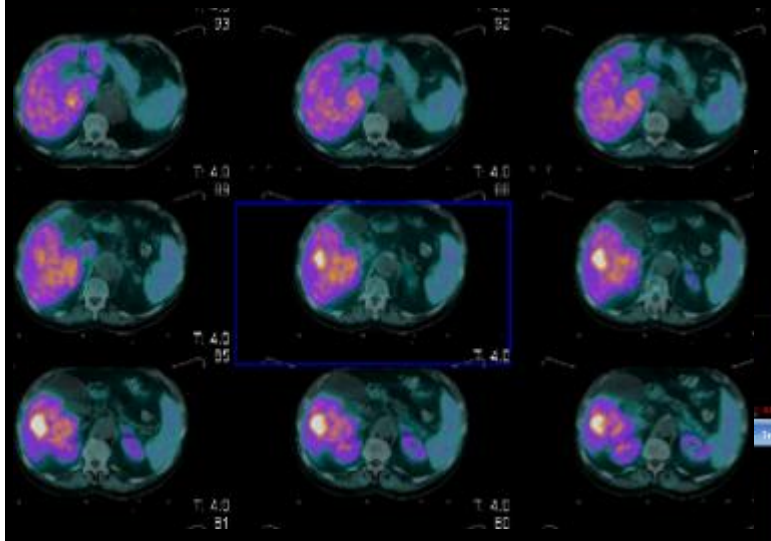
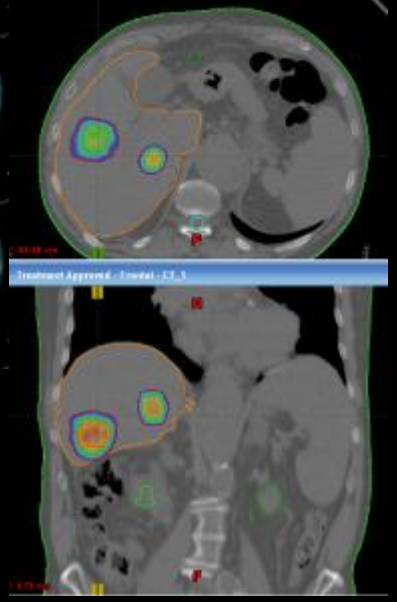
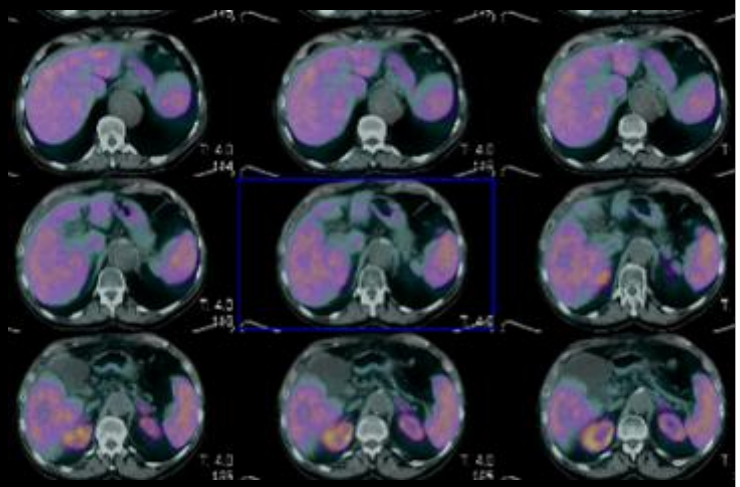
PET before

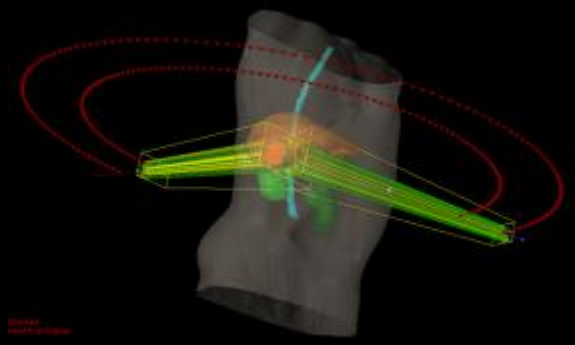


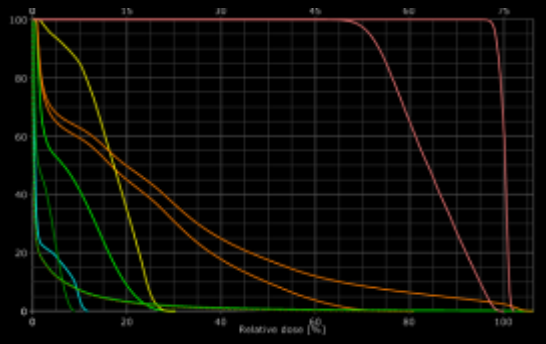
1 isocentre
2 arcs
Jaw tracking



PET after 6 months







MU:3174+3004
BOT:170s

SBRT Liver

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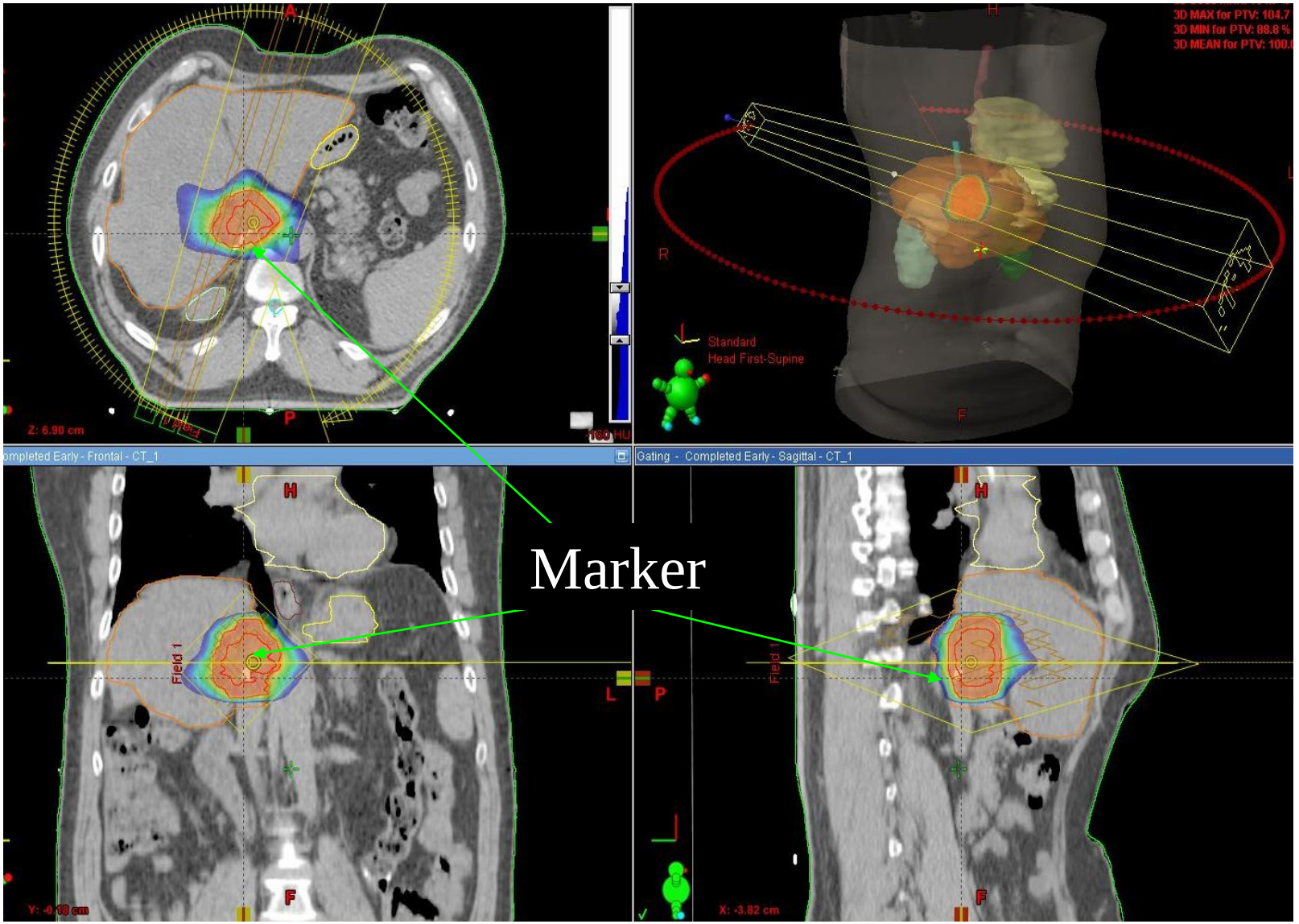
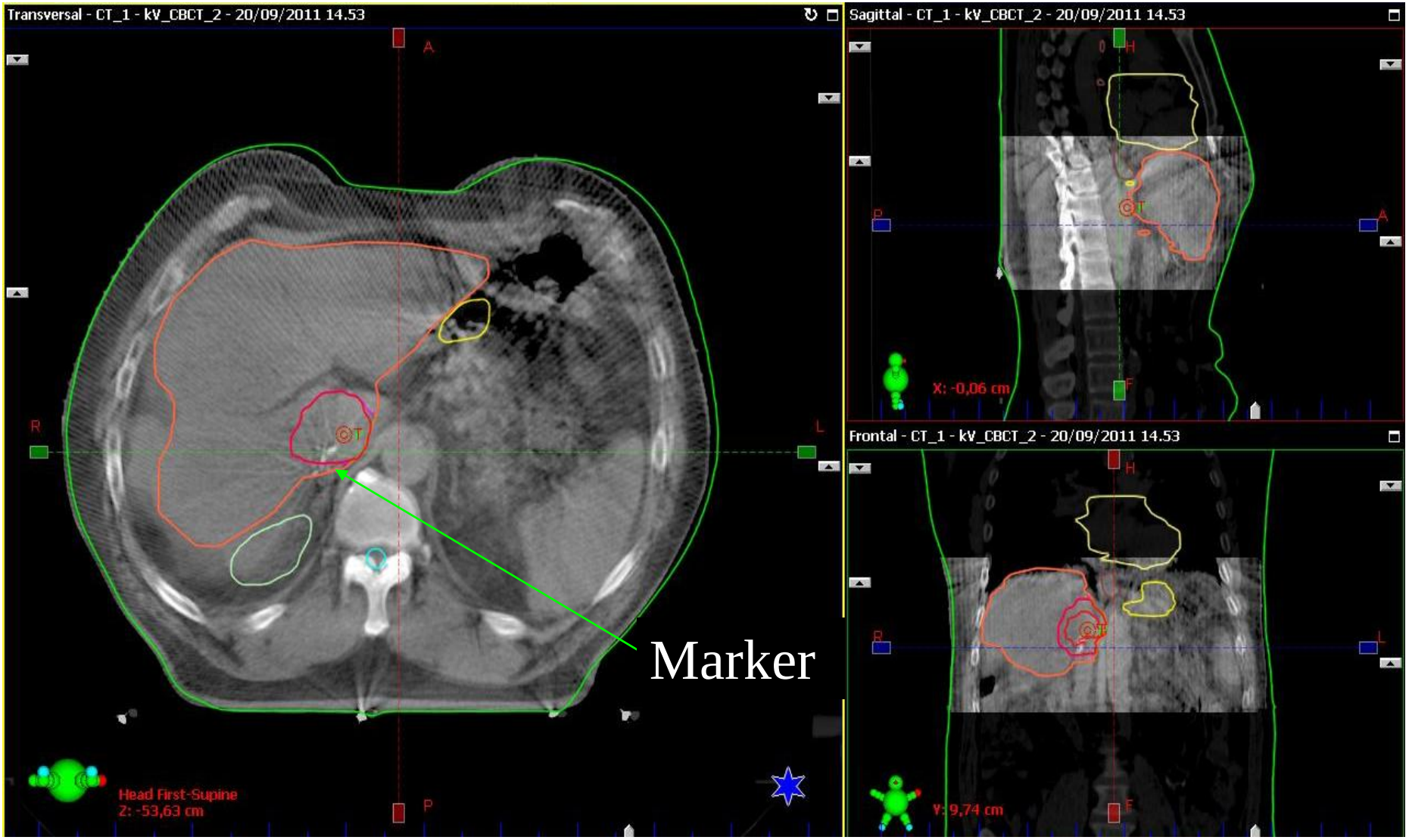


SBRT Liver - IGRT

HUMANITAS
CANCER CENTER



SBRT Liver

HUMANITAS
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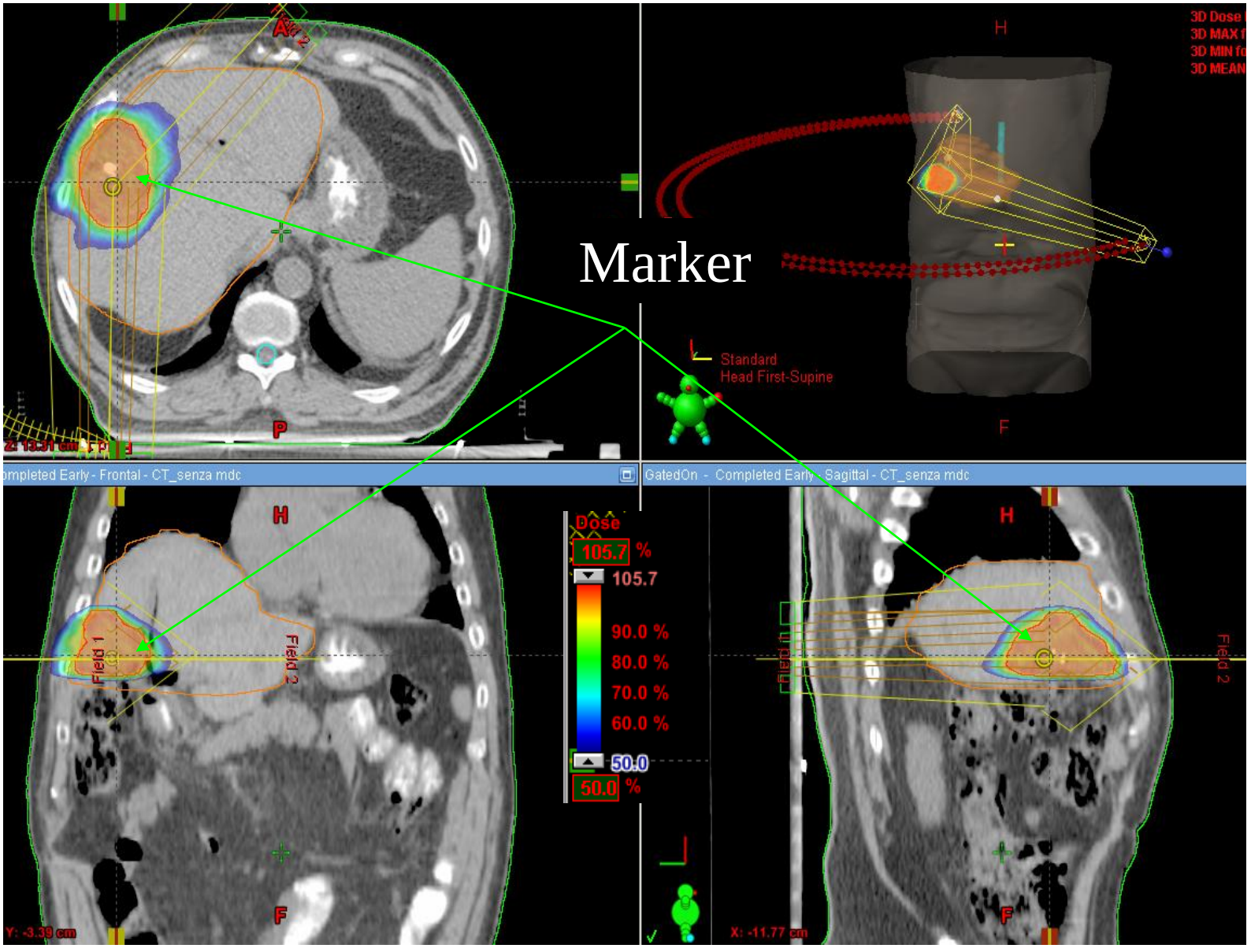

SBRT Liver

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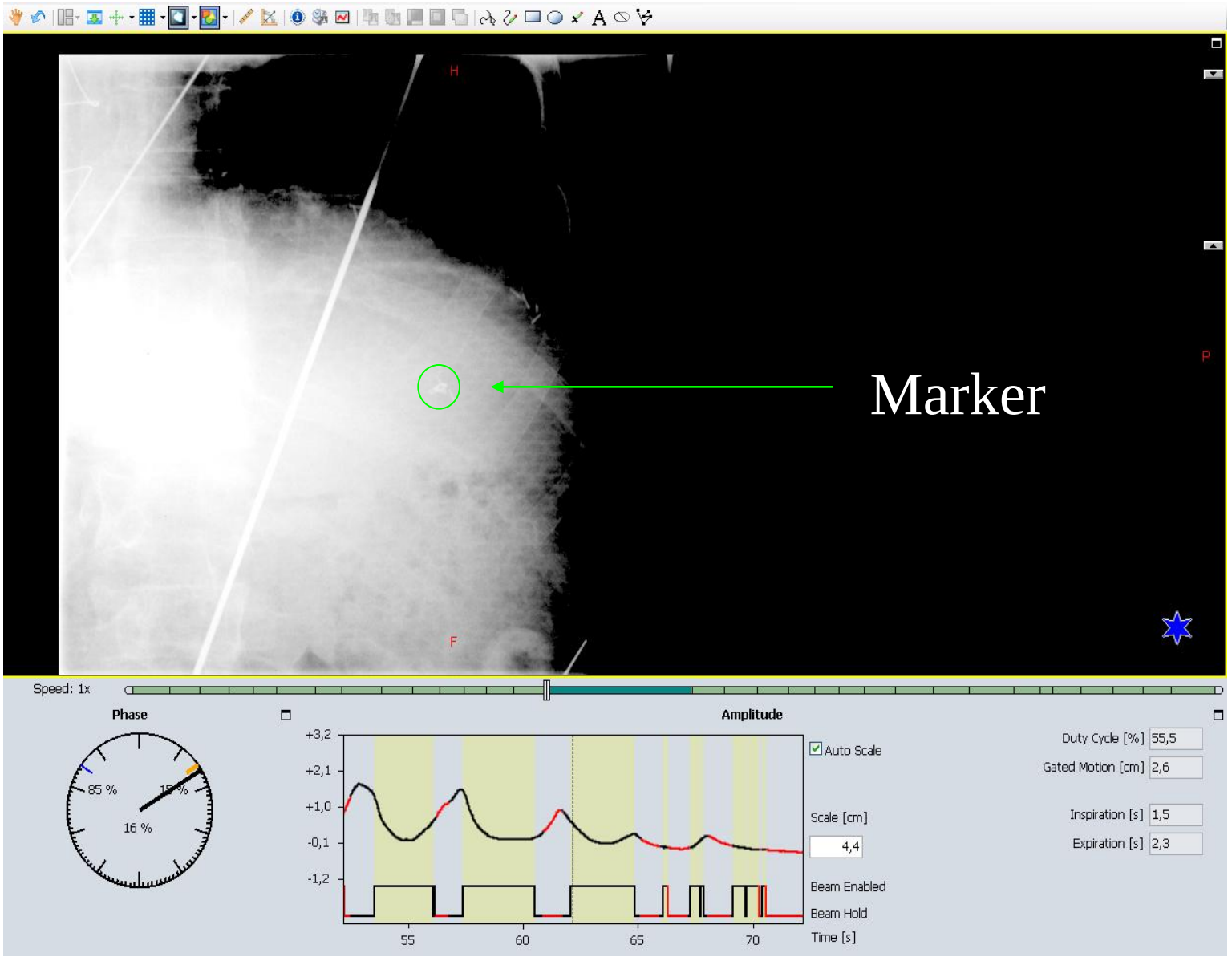

SBRT Liver

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Patient treated with SBRT for local relapse after hepatic surgery for colorectal metastasis

PET –CT pre-treatment, CEA 72

PET –CT post-treatment CEA 2.2

SBRT: bone metastases

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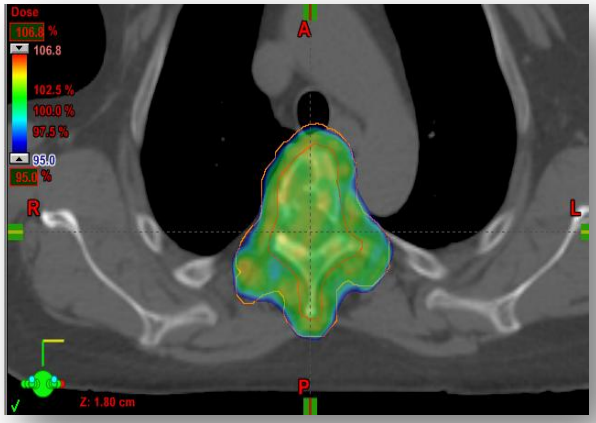
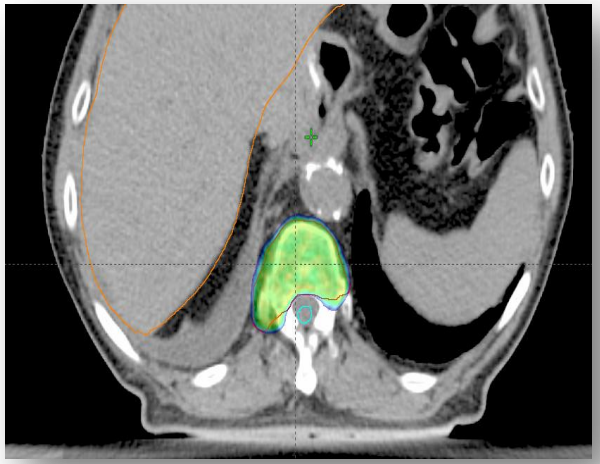
From palliation …



… to cure.



SBRT efficiency

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Past

Now

Future

Slotman, ESTRO 2011

General overview:15yrs of activity

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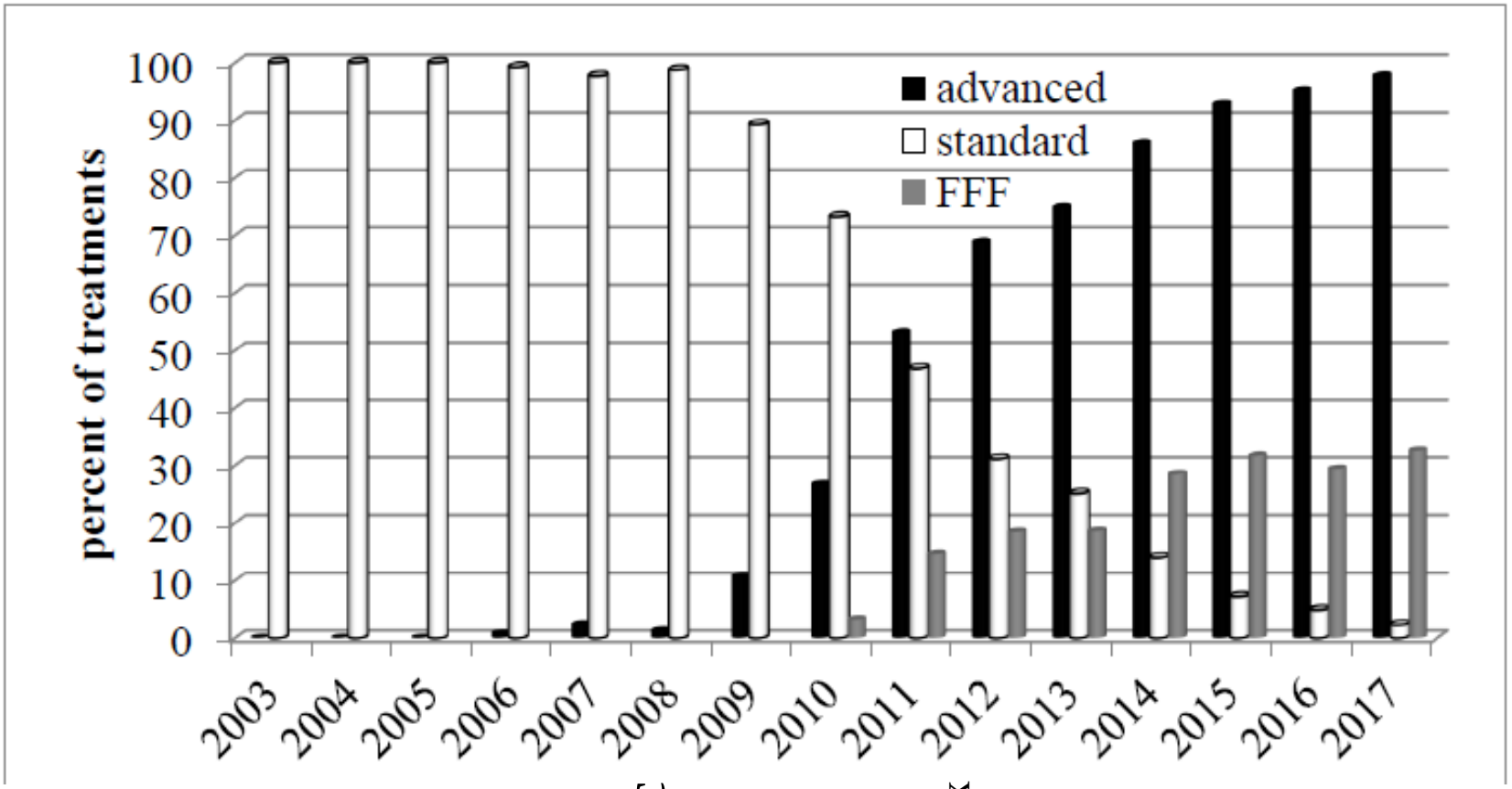

Tomatis, ESTRO 2014/2018

General overview:15yrs of activity

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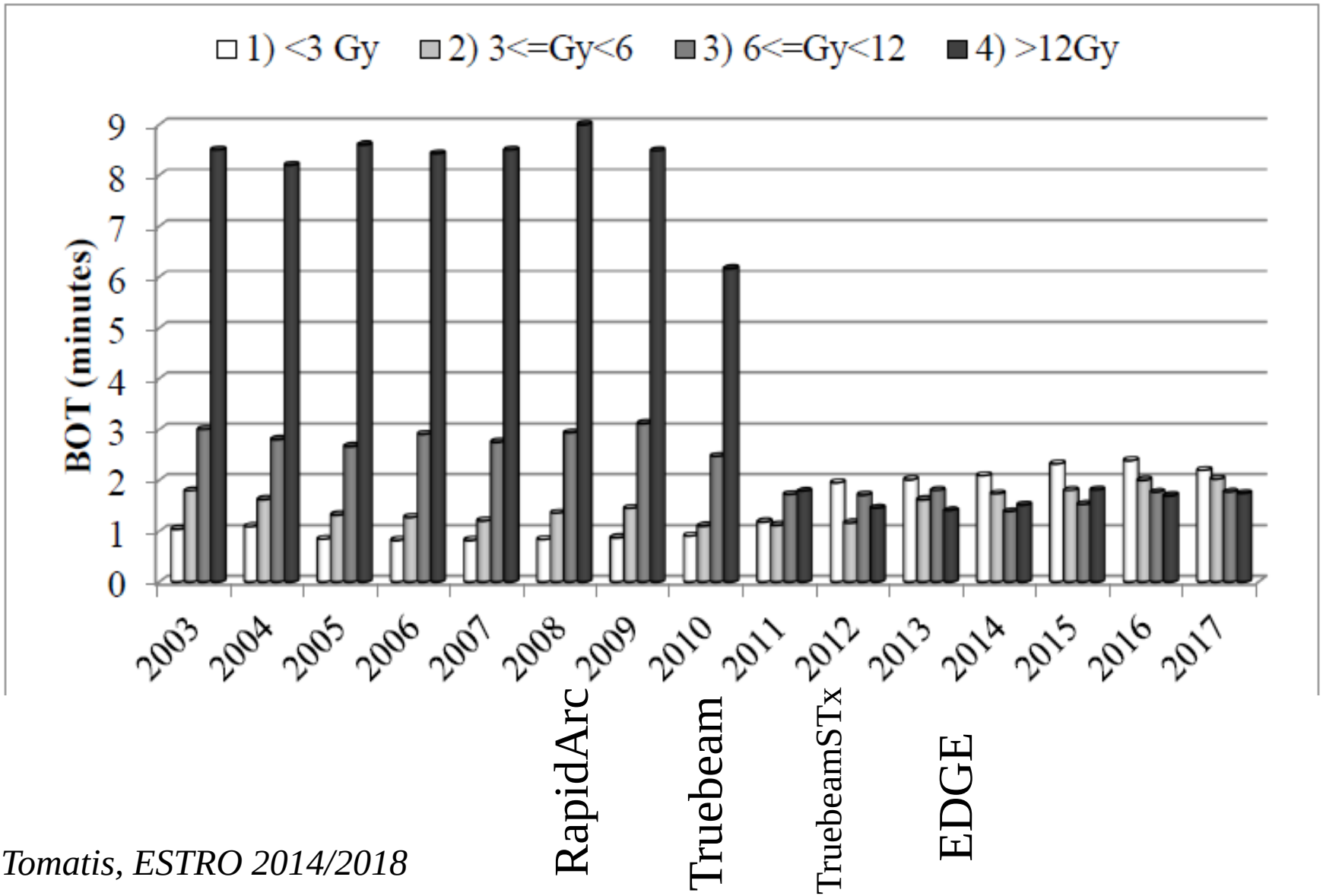

Tomatis, ESTRO 2014/2018

General overview:15yrs of activity

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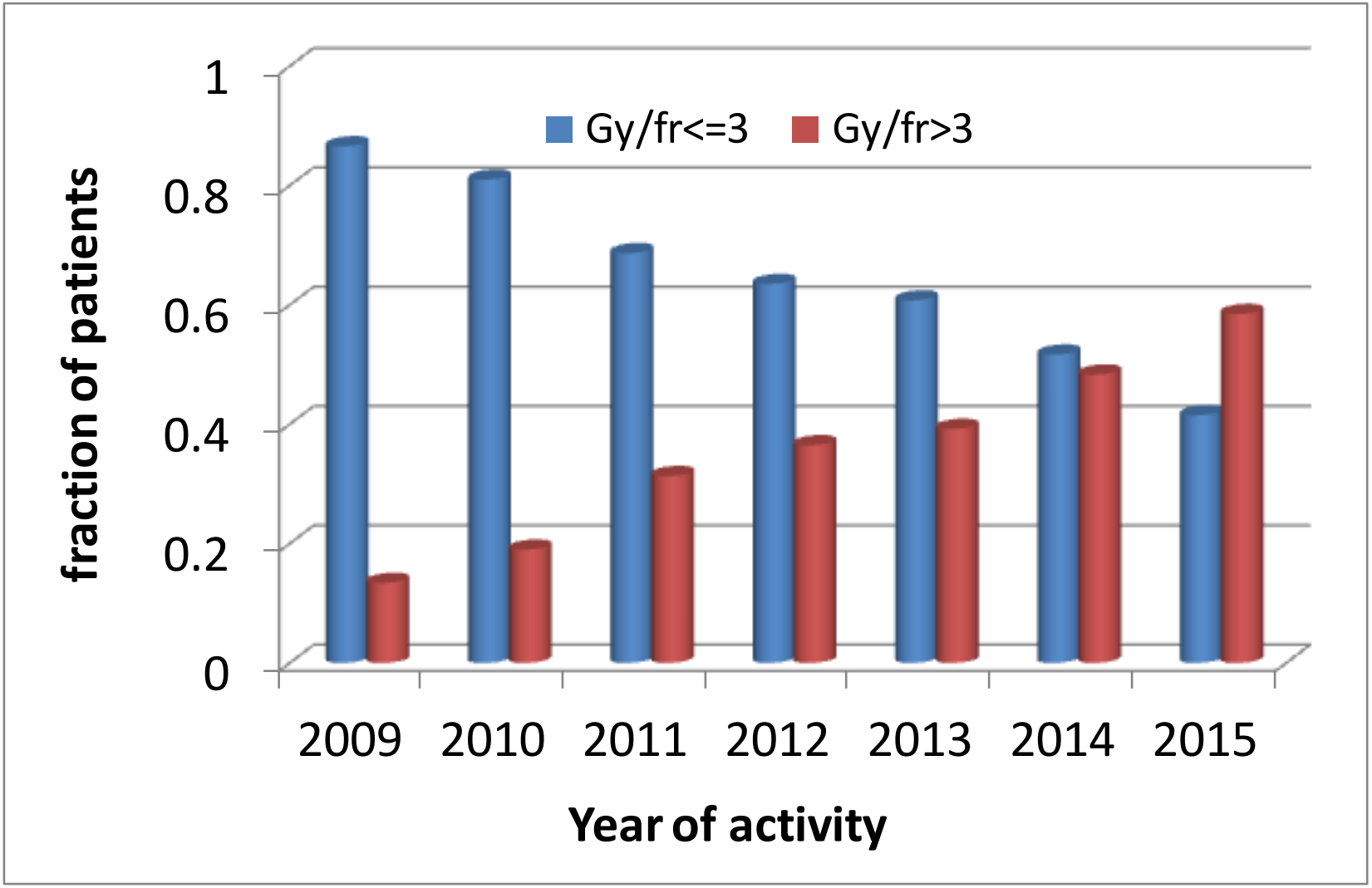

Tomatis, ESTRO 2014

Take home messages

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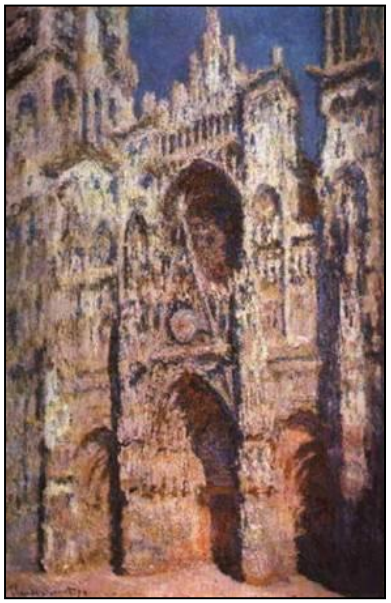
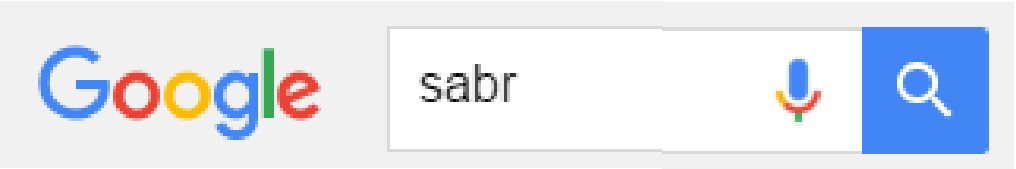
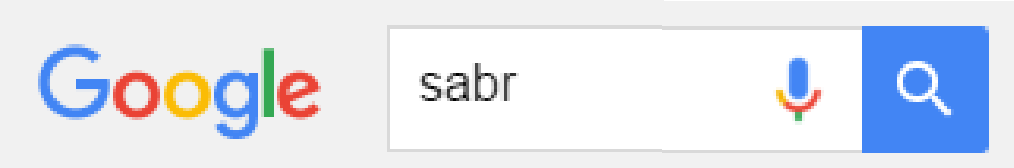
- Patients candidate to SBRT are increasing
- SBRT is NOT a machine brand but a delivery technique
- Prescription based on OARs
- We are moving from palliation to cure
- Need to be efficient, precise and accurate





Google search 2026

HUMANITAS CANCER CENTER



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Questions?

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