SBRT: Terminology and general overview
Society for American Baseball Research - Wikipedia, the ...
https://en.wikipedia.org/.../Society_for_American_Baseball_Re...
Wikipedia
The Society for American Baseball Research (SABR) is a membership organization dedicated to fostering the research and dissemination of the history and ...

What is Roger Federer's new SABR move? | For The Win
ftw.usatoday.com/.../what-is-roger-federers-new-sabr-move
USA Today
Sep 9, 2015 - This summer, tennis fans were treated to a new maneuver by the 34-year-old tennis legend Roger Federer. It's called the SABR and features ...

SABR stock quote - Sabre Corporation stock price ...
www.nasdaq.com › Quotes
NASDAQ
Stock quote for Sabre Corporation (SABR) - Get real-time last sale and extended hours stock prices, company news, charts, and company-specific research tools ...

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

Preparation

Advance

Precision

Efficient
What is our strategy?

- Multimodality images (CT/PET/MRI)
- IMRT and VMAT
- Radiosurgery and SBRT
- IGRT and adaptive RT

Precision
Accuracy
Efficiency

Prof. Scorsetti, 2009
Index

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

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

<table>
<thead>
<tr>
<th>Tumor Site</th>
<th>2010</th>
<th>2020</th>
<th>% Increase in Demand for Radiation Therapy From 2010 to 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>470,000</td>
<td>575,000</td>
<td>22</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Total cancers (n) a</th>
<th>OUP (%) b</th>
<th>Optimal radiotherapy courses (n)</th>
<th>% Var. 2012-25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
<td>2025</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Iceland</td>
<td>1449</td>
<td>1997</td>
<td>50.7</td>
<td>51.8</td>
</tr>
<tr>
<td>Ireland</td>
<td>20,808</td>
<td>28,432</td>
<td>51.5</td>
<td>52.9</td>
</tr>
<tr>
<td>Italy</td>
<td>354,456</td>
<td>411,151</td>
<td>48.2</td>
<td>49.3</td>
</tr>
<tr>
<td>Latvia</td>
<td>10,347</td>
<td>9,567</td>
<td>49.9</td>
<td>51.4</td>
</tr>
<tr>
<td>Lithuania</td>
<td>14,520</td>
<td>13,514</td>
<td>49.9</td>
<td>51.5</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>93,448</td>
<td>117,999</td>
<td>52.3</td>
<td>53.9</td>
</tr>
<tr>
<td>Ukraine</td>
<td>140,999</td>
<td>140,928</td>
<td>50.2</td>
<td>52.1</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>327,812</td>
<td>398,471</td>
<td>53</td>
<td>54.4</td>
</tr>
<tr>
<td>Global</td>
<td>3,439,598</td>
<td>3,988,288</td>
<td>50.2</td>
<td>51.7</td>
</tr>
</tbody>
</table>

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

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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Breast Increase</th>
<th>Head and neck Increase</th>
<th>Lung Increase</th>
<th>Prostate Increase</th>
<th>Rectum Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iceland</td>
<td>53</td>
<td>8</td>
<td>54</td>
<td>74</td>
<td>15</td>
</tr>
<tr>
<td>Ireland</td>
<td>744</td>
<td>146</td>
<td>714</td>
<td>905</td>
<td>155</td>
</tr>
<tr>
<td>Italy</td>
<td>4323</td>
<td>1303</td>
<td>5757</td>
<td>5596</td>
<td>1763</td>
</tr>
<tr>
<td>Latvia</td>
<td>-92</td>
<td>-18</td>
<td>-55</td>
<td>-47</td>
<td>-12</td>
</tr>
<tr>
<td>Lithuania</td>
<td>-75</td>
<td>-14</td>
<td>-68</td>
<td>-80</td>
<td>-23</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>1552</td>
<td>491</td>
<td>2641</td>
<td>2825</td>
<td>862</td>
</tr>
<tr>
<td>Ukraine</td>
<td>-124</td>
<td>-5</td>
<td>209</td>
<td>38</td>
<td>82</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6401</td>
<td>1349</td>
<td>7656</td>
<td>7419</td>
<td>2049</td>
</tr>
<tr>
<td>Global</td>
<td>40,524</td>
<td>13,337</td>
<td>56,558</td>
<td>59,493</td>
<td>18,314</td>
</tr>
<tr>
<td>Range</td>
<td>-9.4 to 30.0</td>
<td>-6.2 to 39.6</td>
<td>-6.7 to 48.1</td>
<td>-7.0 to 53.5</td>
<td>-6.4 to 42.1</td>
</tr>
</tbody>
</table>

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

Source: SG2 Consulting, Skokle, Illinois, USA
SBRT: inoperable Lung stage I

N = 843 stage I patients 75 years old

SBRT was introduced in 2005

Palma D, JCO 2010
SBRT for Lung Stage I

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

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

Surgery versus SABR for NSCLC

In Paul Van Schil and Jan Van Meerbeeck’s recent Correspondence, the authors debate the merits of a Review 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.

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. By contrast, results of hospital-volume studies suggest that surgical mortality data do not generalise well to smaller centres.
SBRT: not a machine, but type of delivery
Introduction: definitions SBRT

- steep dose gradients
- high targeting accuracy
- high dose of radiation
- single or a few fractions
- delivery precision
- non invasive
- Small target
- compensate for target movements
- team of skilled health care professionals

SBRT
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

Arc-based stereotactic frame

Lars Leksell

Cross-fired Radiation + Stereotactic Frame = “Radiosurgery”
**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.
Stereotactic radiosurgery: «the single session, precise delivery of therapeutically effective radiation dose to an imaging-defined target»
SRS: clinical applications

- **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

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.
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.
From intracranial to extracranial SBRT

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.”
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.
- ‘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)?
Stereotactic body radiation therapy: a novel treatment modality


<table>
<thead>
<tr>
<th>Table 1</th>
<th>Results of SBRT trials in early stage non-small cell lung cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study</td>
<td>Trial type</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>McGarry et al. (2005)</td>
<td>Prospective (phase I)</td>
</tr>
<tr>
<td>Fakiris et al. (2009)</td>
<td>Prospective (phase II)</td>
</tr>
<tr>
<td>Nagata et al. (2005)</td>
<td>Prospective (phase I-II)</td>
</tr>
<tr>
<td>Baumann et al. (2009)</td>
<td>Prospective (phase I-II)</td>
</tr>
</tbody>
</table>

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

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

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

Marta Scorsetti¹, Mario Bignardi¹, Filippo Alongi¹, Antonella Fogliata², Pietro Mancosu¹, Piera Navarria¹, Simona Castiglioni¹, Sara Pentimalli¹, Angelo Tozzi¹ & Luca Cozzi²
# SBRT Liver

## 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 Navarra, MD, Pietro Mancosu, MSc, Giacomo Reggiori, MSc, Antonella Fogliata, Guido Torzilli, MD, Stefano Tomatis, MSc, and Luca Cozzi, PhD

<table>
<thead>
<tr>
<th>Dose/fraction</th>
<th>Total Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard dose</td>
<td>25Gy</td>
</tr>
<tr>
<td>-10%</td>
<td>22.5 Gy</td>
</tr>
<tr>
<td>-20%</td>
<td>20.63 Gy</td>
</tr>
<tr>
<td>- 30%</td>
<td>18.75 Gy</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ORGAN</th>
<th>Dose-Volume Limits</th>
<th>Other Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy liver</td>
<td>At least 700 cc less than 15 Gy</td>
<td>Vol &gt; 1000 cc</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>Dmax &lt; 18 Gy</td>
<td></td>
</tr>
<tr>
<td>Kidneys (R+L)</td>
<td>V15 Gy &lt; 35%</td>
<td></td>
</tr>
<tr>
<td>Stomach, duodenum, small intestine, esophagus, cistifex</td>
<td>Dmax &lt; 21 Gy</td>
<td>GTV &gt; 8 mm from parallel OARs</td>
</tr>
<tr>
<td>Heart</td>
<td>&lt; 30 Gy in 3 F</td>
<td></td>
</tr>
<tr>
<td>Rib</td>
<td>D30cc &lt; 30 Gy</td>
<td></td>
</tr>
</tbody>
</table>

## Dose prescription

<table>
<thead>
<tr>
<th>Dose prescription</th>
<th>Lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 Gy</td>
<td>62 (82 %)</td>
</tr>
<tr>
<td>-10%</td>
<td>6 (8 %)</td>
</tr>
<tr>
<td>-20%</td>
<td>4 (5 %)</td>
</tr>
<tr>
<td>- 30%</td>
<td>4 (5 %)</td>
</tr>
</tbody>
</table>
SBRT Liver

PET pre

1 isocentre
1 arc
Jaw tracking

PET post

MU:5103
BOT:130s
SBRT Liver

PET before

1 isocentre
2 arcs
Jaw tracking

PET after 6 months

MU:3174+3004
BOT:170s
SBRT Liver - IGRT
SBRT Liver
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

From palliation...

...to cure.
SBRT efficiency

Past
IMAGING  \hspace{0.5cm} BEAM-ON TIME

Now
IMAGING  \hspace{0.5cm} BEAM-ON TIME

Future
IMAGING  \hspace{0.5cm} BEAM-ON TIME

Slotman, ESTRO 2011
General overview: 15 yrs of activity

Tomatis, ESTRO 2014/2018
General overview: 15yrs of activity

Tomatis, ESTRO 2014/2018
General overview: 15 yrs of activity

![Graph showing the fraction of patients over the years 2009 to 2015 for Gy/fr <= 3 and Gy/fr > 3. The graph indicates a decrease in the fraction of patients with Gy/fr > 3 over the years, while the fraction for Gy/fr <= 3 remains relatively stable.](attachment:image.png)
Take home messages

- 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

Stereotactic Ablative Radiotherapy for stage I histologically ...
by U Ricardi - 2014 - Cited by 22 - Related articles

Clinical Outcome of Stereotactic Ablative Body ...
www.ncbi.nlm.nih.gov/.../2... National Center for Biotechnology Information ▼
by F De Rose - 2015
Sep 15, 2015 - Clinical Outcome of Stereotactic Ablative Body Radiotherapy for Lung ...
... Cancer Center and Research Hospital, Rozzano, Milan, Italy.

Stereotactic ablative radiation therapy as first local therapy ...
by AR Filippi - 2015 - Cited by 6 - Related articles
Dec 24, 2014 - Stereotactic ablative radiation therapy as first local therapy for lung ...
... of Oncology, Radiation Oncology, University of Torino, Torino, Italy.

Available evidence on re-irradiation with stereotactic ...
www.ncbi.nlm.nih.gov/.../2... National Center for Biotechnology Information ▼
by B De Bari - 2015 - Cited by 1 - Related articles
Apr 16, 2015 - ... with stereotactic ablative radiotherapy following high-dose previous ...
... of Oncology, Radiation Oncology, University of Turin, Turin, Italy.
Questions?