Stereotactic Radiosurgery (SRS) & Body Radiotherapy (SBRT)

Acknowledgements

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DEFINITION

- Method to deliver a **high dose** of radiation to the target, utilizing either a **single dose** or a **small number of fractions** with a high degree of precision within the body.

RADIOBIOLOGY
Vascular damage

• Indirect cell death

High Doses

Repair of sublethal radiation damage

Cells interphase death

Repopulation negligible

The 4 Rs

Vascular damage

Reoxygenation

>10 Gy

Repair

Long treatment

Repopulation

Treatment in 1 or 2 weeks

Redistribution

The linear quadratic model

Is still Valid?

Dose per fraction?

<10 Gy

NO

YES

>10 Gy

Non classical effects

• Vascular damage

• Immune stimulation

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<table>
<thead>
<tr>
<th>When?</th>
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<tbody>
<tr>
<td><strong>Before Treatment</strong></td>
<td>• To define Target and OARs</td>
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<tr>
<td><strong>During Treatment</strong></td>
<td>• To locate the Target and OARs</td>
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<tr>
<td><strong>After Treatment</strong></td>
<td>• To evaluate local control and toxicities</td>
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**Image:**

- **Before:** A sunset over the ocean, with the sun just below the horizon.
CT
• Exact geometry
• Physics model of the patient

MRI
• High soft tissue contrast
• Spectroscopy

PET
• Functional image
• Radioisotope
  • FDG
  • ¹⁸F-choline

ANGIOGRAPHY
• Functional imaging

ULTRASOUND
• Soft tissue differentiation

Special Care with Fusion

PET/CT, PET/RM

Brain
• CT + MRI

Liver
• CT + PET + MRI

Lung
• CT + PET

Breast
• CT + Ultrasound

Prostate
• CT + MRI
Outside the treatment room

- CT
- PET
- RM

Inside the treatment room

- MV X-Rays
- KV X-Rays
- Ultrasound
- Visible light

3D image
- CT
- CBCT (kV, MV)
- Tomotherapy (MVCT)
- Ultrasound
- Visible light

2.5D image
- Exactrac (kV)
- Cyberknife

2D image
- Portal image (kV, MV)

Dose
- No dose, ultrasound, visible light
- High dose, MV X-Rays

Clearance
- High clearance: Exactrac, Tomotherapy, Cyberknife and Visible light

Time
- Fast: Exactrac, Cyberknife
- Higher for systems with kV
- Highest for CT

Image quality (only for X-Rays)
- CT, kVCT, MVCT, Tomotherapy

Replanning
- Exactrac, Cyberknife, Visible light, kV portal image

Control During irradiation
- Exactrac, Cyberknife, Visible light, kV portal image

Soft tissue differentiation (except VL)
- kVCT, MVCT, ultrasound, Cyberknife (Xsight)
- Rest of systems need implanted markers
**Algorithms**

**In Dose calculation**
- Clarkson: NO
- Pencil Beam: Fast but not for all situations
- Convolution/superposition: Fast and Accurate
- Monte Carlo: Most Accurate and slowest

**In Inverse planning**
- Resources
- Time
- Integral Dose

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**Small Field Dosimetry**

Lack of lateral charged particle equilibrium

Standard formalism?

\[ D_{\text{eq}} = N_0 \cdot \frac{D_{\text{eq}}}{N_0} \]
An EGSnrc Monte Carlo study of the microionization chamber for reference dosimetry of narrow irregular IMRT beamlets
Capote et al. Medical Physics (31) 2010-22

Ionization chamber dosimetry of small photon fields: a Monte Carlo study on stopping-power ratios for radiosurgery and IMRT beams

No significant effect influence of $s_{w,irr}$ on $k_O$

New Formalism

IAEA + AAPM
Question: Which do you prefer?

- C-arm
- Cyberknife
- Tomotherapy
- Gammaknife
- Vero
Question: Which do you prefer?

- C-arm 20%
- Cyberknife 20%
- Tomotherapy 20%
- Gammaknife 20%
- Vero 20%

They are all very good.

It’s moving!

GATING
C-ARM

TRACKING
CYBERKNIFE
VERO
Correlation between internal and external movement

Irradiate the patient

CHECKING?

Correlation can change

EXTERNAL REFERENCE

Tendency in conventional Radiotherapy: to irradiate smaller volumes with high doses in less fractions

Radiobiology studies are justifying the success of SRS and SBRT process

There will be an increased demand on SBRT techniques

INTERNAL REFERENCE

Ultrasound perineal probe

CONCLUSIONS

Marc Posner, Futures Conference March 2012
CONCLUSIONS

• These techniques are highly demanding in all aspects: imaging, treatment planning and irradiation.
• High technology is required but ...

CONCLUSIONS

You have to buy

CONCLUSIONS

To commission