Cranial Stereotactic Radiotherapy
The role of RTT

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Disclosure Statement of Financial Interest

Authors **DO NOT** have a financial interest/arrangement or affiliation with one or more organizations that could be perceived as a real or apparent conflict of interest in the context of the subject of this presentation.
Radiotherapy of brain metastases: WBRT +/- SRS (SRT) boost

Oligometastatic brain disease: WBRT + SRS (SRT) boost:

- Survival benefit for the combined WBRT+SRS boost approach for patients with single brain metastasis (RTOG study 9508)
- Significant improvement in intracranial disease control
- Improvement in performance status
- Improvement in steroid use for patients with multiple brain metastases

Whole brain radiation therapy with or without stereotactic radiosurgery boost for patients with one to three brain metastases: phase III results of the RTOG 9508 randomized trial.

Radiotherapy of brain oligometastases: Standard approach

WBRT (20-30 Gy / 5-10 fr) → 1-2 weeks interval → SRS/SRT
STEREOTACTIC RADIOTHERAPY / RADIOSURGERY (SRS/SRT):
GAMMA KNIFE / TOMOTHERAPY/ CYBER KNIFE / LINAC BASED

- Precise (conformal) application of high dose per fraction
- Steep peripheral dose gradient
Highly conformal Intensity Modulated 3D dose distribution delivered with 1-2 arcs. Planning algorithm uses optimisation with simultaneous:

- Dynamic changing of the shape of treatment aperture (MLC)
- Changing rotation speed of the gantry
- Changing dose rate
Treatment in five fractions (SRT)  
WBRT + SRT/SIB
Positioning and immobilization

- Supine
- Macromedics „Double shell“ mask system DSPS
• RT-CT imaging: Slice 1.25 mm
• RT-MRI imaging

• Patient: 1976. g; ECOG 0
• DG: Meta. cerebri (VIII/2015.)
• Ca ovarii l. dex cum meta. lymphonodorum paraaortalis, St. post hysterectomiam cum adnexectomiam bil.(2012.), St. Post CT
• Meta pulmo bil (VII/2013). St. Post CT

Head MRI (07.07.2015): Two metastases in the brain with perifocal edema (38 mm in the right frontal lobe, 6 mm in the left parietal lobe).
RT IMAGING: CT/MRI registration
RT VOLUMES: Brain contouring

**WBRT volume:**

- $\text{CTV}_{20\text{ Gy}} = \text{Brain (autosegmentation)}$
- $\text{PTV}_{20\text{ Gy}} = \text{CTV}_{20\text{ Gy}} + 2\text{mm margin}$
RT VOLUMES: Metastases contouring

SIB-SRT mets.volume:

- $\text{GTV}_{40\text{ Gy}} = \text{metastase}$
- $\text{PTV}_{40\text{ Gy}} = \text{GTV}_{40\text{ Gy}} + 2$ mm margin
Contouring organs at risk

- Lens
- N. Opticus
- Chyasma
- Brain stem
- Brain
- Cohlea
Treatment plan

- 6-MV photons
- 5 mm MLC
- Collimator rotation: +/- 30%
- TPS: Varian- Eclipse 10.0
- (2 arcs)
- Max dose rate: 600 MU/min
- Average: 1970 MU/40 Gy

40 Gy (5 fr) to the PTV$_{meta}$ volume corresponds to a biologically effective dose (BED) $66.7 \text{ Gy}_{10}$ and 21 Gy (1 fr) = $65 \text{ Gy}_{10}$
**CONFORMAL DOSE DISTRIBUTION:**

Whole brain (20 Gy) with simultaneous integrated boost (SIB) of brain metastases (40 Gy) in 5 fr

<table>
<thead>
<tr>
<th>pat</th>
<th>vol cc</th>
<th>R cm</th>
<th>meta 1</th>
<th>meta 2</th>
<th>SUM cc</th>
<th>d cm</th>
<th>R cm cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>25% (40 Gy)</td>
<td>3614.04</td>
<td>9.52</td>
<td>PTV2 cc</td>
<td>32.82</td>
<td>1.62</td>
<td>34.44</td>
</tr>
<tr>
<td>12</td>
<td>30% (40 Gy)</td>
<td>3101.58</td>
<td>9.05</td>
<td>PTV3 cc</td>
<td>34.44</td>
<td>4.04</td>
<td>2.02</td>
</tr>
<tr>
<td>14</td>
<td>35% (40 Gy)</td>
<td>2732.35</td>
<td>8.67</td>
<td>SUM cc</td>
<td>34.44</td>
<td>4.04</td>
<td>2.02</td>
</tr>
<tr>
<td>19</td>
<td>47.5% (40 Gy)</td>
<td>1988.18</td>
<td>7.80</td>
<td>SUM cc</td>
<td>34.44</td>
<td>4.04</td>
<td>2.02</td>
</tr>
<tr>
<td>20</td>
<td>50% (40 Gy)</td>
<td>1379.18</td>
<td>6.91</td>
<td>SUM cc</td>
<td>34.44</td>
<td>4.04</td>
<td>2.02</td>
</tr>
<tr>
<td>28</td>
<td>70% (40 Gy)</td>
<td>66.00</td>
<td>2.51</td>
<td>R(d+0.5)</td>
<td>36.14</td>
<td>0.40</td>
<td>9.52</td>
</tr>
<tr>
<td>32</td>
<td>80% (40 Gy)</td>
<td>50.95</td>
<td>2.02</td>
<td>R(d+0.5)</td>
<td>34.74</td>
<td>0.40</td>
<td>2.02</td>
</tr>
<tr>
<td>36</td>
<td>90% (40 Gy)</td>
<td>39.37</td>
<td>2.11</td>
<td>R(d+0.5)</td>
<td>34.74</td>
<td>0.40</td>
<td>2.02</td>
</tr>
<tr>
<td>38</td>
<td>95% (40 Gy)</td>
<td>34.74</td>
<td>2.02</td>
<td>R(d+0.5)</td>
<td>34.74</td>
<td>0.40</td>
<td>2.02</td>
</tr>
</tbody>
</table>
CONFORMAL DOSE DISTRIBUTION:

Whole brain (20 Gy)+ with simultaneous integrated boost (SIB) of brain metastases (40 Gy) in 5 fr Min 98% (100%) volume of all PTV must be covered with 95% isodose (ICRU 83).
QA of RA plans (patient specific quality assurance):

- Portal Dosimetry, EPID Portal Vision aSi1000, pixel size 0.39 mm
- Delta4 (ScandiDos), 1069 p-type Si detectors
OBI-CBCT is done before each treatment fraction – on line correction
SetUp error correction in three planes: x, y, z (translational setup errors=0)
Rotational setup errors≠0 (Roll, Pitch, Rtn)
RT Treatment

-physician
-physicist
-RTT
Follow Up

25.3.2015

03.06.2015

18.08.2015

Meta cerebelli pp Npl.pulmo dex (2.1.73y)
Single fraction (SRS)

- Same RT procedure (chain)
- Dose delivered in one fraction (18-25 Gy)
- Dose delivered only to metastasis (OAR: Brain-Meta)

Patient: 68 years, ECOG 0
DG: Meta. cerebri reg. parietalis l. dex.
St. post reectio TU auriculae l. sin et parotidectomiam tot. l. sin.
Recidivus localis cum lymphadenopathia colli l. Sin.

Brain MRI: Solitary metastatic tumor in subcortical region of right parietal lobe (19 mm in diameter).
STEREOTACTIC RADIOSURGERY (SRS)/ 5 semi-arcs: 20 Gy/1 fr
STEREOTACTIC RADIOSURGERY (SRS)
- dose distribution: 20 Gy/1 fr (isodose 100% and 50%)
DVH

Brain-PTV
V12<8cc

PTVmeta
Aim: To analyze precision of whole brain radiation therapy (WBRT) with simultaneous integrated stereotactic boost (SIB) of brain metastases treatment using RapidArc (RA) (Varian Medical Systems, Palo Alto, CA) volumetric modulated arc technique (VMAT).

- 23 patients with stable performance status (PS≥2) and up to three brain metastases were treated with stereotactic procedure in the period from March 2014 to September 2015:
  - 15 patients (65.2%) had whole brain radiotherapy (WBRT) with simultaneous stereotactic integrated boost (SIB) to macroscopic metastases
  - 6 patients (26.1%) had only stereotactic radiotherapy (SRT) to metastases since the WBRT was performed previously
  - 2 patients (8.7%) with solitary brain metastases were treated with SRS only
Off line review software VMS

![Graph showing Offline Adjusted OBI Match Results](image-url)
### Margin calculation

|                        | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| **Patient**            |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| **Set-up**             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

**N:**

- **Snmp/29**
  - Snmp = 0.12

**mp/29**

- Snmp = 0.12
  - mp = 0.08, 0.10, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00

**Set-up**

- Snmp = 0.12
  - mp/29 = (mp/29)^2 + (mp / mp)^2
  - mp = (mp)^2 + (mp)^2

**mp/29**

- Snmp = 0.12
  - mp = 0.08, 0.10, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00

**mp/29**

- Snmp = 0.12
  - mp = 0.08, 0.10, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00
Translational / rotational error results

<table>
<thead>
<tr>
<th>PAT 17</th>
<th>SIB+2met</th>
<th>Pitch</th>
<th>Roll</th>
<th>Rtn</th>
<th>d (isoc-meta) (mm)</th>
<th>Δ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 fr</td>
<td>0,1</td>
<td>0,1</td>
<td>-0,2</td>
<td>0,1</td>
<td>54</td>
<td>0,2107</td>
</tr>
<tr>
<td>2 fr</td>
<td>0,2</td>
<td>0,1</td>
<td>-0,1</td>
<td>0,1</td>
<td>54</td>
<td>0,2309</td>
</tr>
<tr>
<td>3 fr</td>
<td>-0,1</td>
<td>0,1</td>
<td>0,1</td>
<td>0,1</td>
<td>54</td>
<td>0,1632</td>
</tr>
<tr>
<td>4 fr</td>
<td>0,1</td>
<td>0</td>
<td>0,2</td>
<td>0,1</td>
<td>54</td>
<td>0,2107</td>
</tr>
<tr>
<td>5 fr</td>
<td>-0,5</td>
<td>-0,1</td>
<td>0,1</td>
<td>0,1</td>
<td>54</td>
<td>0,4897</td>
</tr>
</tbody>
</table>

Translational errors (mm)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VRT (mm)</td>
<td>0,032</td>
</tr>
<tr>
<td>Lng (mm)</td>
<td>0,032</td>
</tr>
<tr>
<td>Lat (mm)</td>
<td>0,065</td>
</tr>
</tbody>
</table>
Let`s make small summary

1. Patient positioning and immobilization
2. Simulation
3. OARs delineation
4. Target delineation
5. Treatment planning
6. PSQA
7. Treatment delivery and image guidance
Let`s make small summary

1. Patient positioning and immobilization ✓
2. Simulation ✓ ✓
3. OARs delineation ✓ ✓
4. Target delineation
5. Treatment planning
6. PSQA ✓
7. Treatment delivery and image guidance ✓
CONCLUSIONS

• Radiation Therapists plays significant role in the process of delivering highly sophisticated SRT treatments, proper training and continuous development of acquired knowledge's is crucial for success.
• RapidArc treatment planning and delivery of integrated plans of WBRT and IGRT stereotactic boosts to multiple brain metastases is a rapid and accurate technique which provides highly conformal three dimensional (3D) dose distributions.
• RapidArc provides an efficient alternative to single-fraction SRS irradiation, combining advantages of short treatment time and good conformity in addition to accuracy of selected cases with complication-free clinical realization.
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