The CyberKnife

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Purpose

• To familiarize Rad Onc PG students on the availability of newer conformal Radiotherapy equipments-Cyber Knife

• To know about Cyber Knife-Definition, Components, principles, advantages, limitations, clinical applications, future directions.
CyberKnife

- Image guided Robotic Radio surgery system that uses a compact Linear accelerator mounted on robotic arm to deliver concentrated beam of radiation to the targeted tumor from multiple positions and angles.

All in one
The Synchrony® camera, Linear accelerator, Manipulator, X-ray sources, Image detectors, ROBOTIC DELIVERY SYSTEM, and Treatment Couch are part of the imaging and treatment delivery system.
Radiobiology - Hypoxic model

- Oxygen
- Migration
- Oxic
- Anoxic
- Density of cells → Vascularization
Radiobiology-MTMT model of cancer therapy
(Maximal Therapy Minimal Time)

Higher dose/boost

Critical Status for metastases

Boost with CT

Late intensification
Days worst drug

Window of Curability

Clinical Cure

Critical size for metastatic phenotypes

Development of resistant phenotype

Critical stage for metastasis
<table>
<thead>
<tr>
<th>Dose/fraction</th>
<th>TDF equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.8 Gy/5f (24.00 Gy)</td>
<td>40 Gy</td>
</tr>
<tr>
<td>5.1 Gy/5f (25.50 Gy)</td>
<td>45 Gy</td>
</tr>
<tr>
<td>6.1 Gy/5f (30.5 GY)</td>
<td>60 Gy</td>
</tr>
<tr>
<td>7.5 Gy/5f (37.5 Gy)</td>
<td>76 Gy</td>
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</table>
CyberKnife® Accuracy

• Sub-millimeter accuracy
• Treats all parts of the body
• Treats lesions that were previously untreatable
• So accurate, head and body frames are not required
CyberKnife® Conformality

Non-Coplanar Beam Delivery, Non-Isocentric Beam Delivery

- Highly collimated beams, Non-convergent beams
- Automatically minimizes entrance/exit beam interactions
- No patient or linac re-positioning required
- Superior conformality while maximizing homogeneity
CyberKnife® Treatment Overview
CyberKnife® Treatment Procedure

1. Patient Consult
2. Patient Setup
3. Image Acquisition
4. Treatment Planning
5. Treatment Delivery
CyRIS™ MultiPlan™ Treatment Planning

Benefits
• Fast, multi-modality image fusion
• Simplified contouring
• Supports forward and inverse planning methods
• Achieves desired plan results quickly and efficiently
• Streamlines overall planning process
• Maximize the capabilities of CyberKnife System
CASES
Intra Cranial

Metastasis
Glioma

Meningioma
Pituitary adenoma
Pineal region tumor
Craniopharyngioma

AVM
Trigeminal neuralgia
Functional disorders
28 yrs/M/AVM
Acoustic Neuroma

An acoustic neuroma, also known as a vestibular schwannoma, is a benign growth that occurs along the 8th cranial nerve.
22yr/m/B/L Ac schwannoma
Radiosurgical Rhizotomy for Trigeminal Neuralgia

- Linac-based & GammaKnife (GK) SRS are well established treatment options

  Primarily a replacement for other “destructive” lesions (Glycerol, RF, etc.)

  Not a substitute for Micro Vascular Decompression!!
CyberKnife radiosurgical rhizotomy was offered to medically-refractory TN patients that failed or refused surgery or were not suitable candidates for MVD due to age or medical contraindications.
SRS for Trigeminal Neuralgia

Measure length!!
High Grade Glioma – Supratentorial: 3 months Post CK – **No Uptake**

Pre-CK

Post-CK
72yrs/M/Recurrent GBM
72yrs/M/Recurrent GBM
45 yrs/f, recurrent pituitary adenoma
Pituitary adenoma
69Yrs/F/Ca Lung with Brain mets
Head and Neck

- Nasopharyngeal tumor
- Primary and metastatic cancer
- Glomus jugular tumor
- Chondrosarcoma
- Ocular melanoma
Nasopharynx
Nasopharynx
85yrs/M/Ca tongue T2N0
40yr/m Chondrosarcoma recurrent
Cyberknife Stereotactic Radiosurgery for Disease of the Spine
- Metastatic
- Benign lesions
- Post irradiated
- Sacral sarcoma
- Pediatric tumors
Indications for Spinal Radiosurgery

- **Spinal Lesions**
  - Metastases which recurred after conventional radiation (renal, colon, lung) or surgery
  - Patients with isolated lesions, potentially long life expectancy and the likelihood of re-treatment in the same area (solitary plasmacytoma, renal, breast)
Indications for Spinal Radiosurgery

- **Spinal Lesions**
  - Cancers which are not sensitive to radiation in doses tolerated by the spinal cord (renal, sarcoma, melanoma)
  - Patients in whom shortening the duration of treatment would be advantageous
  - Patient with a short life expectancy or significant co-morbidity
Indications for Spinal Radiosurgery

- **Spinal Lesions**
  - Definitive treatment of primary spinal tumors in patients in whom definitive surgery would not be tolerated
  - Any tumor but especially benign tumors which would require extensive surgery or a difficult approach for treatment (hemangioma, schwannoma, meningioma, desmoplastic fibroma)
**Xsight™ Spine Tracking System**

- An alternative that eliminates risk for patients
- Sub-millimeter accuracy with non-rigid registration
- Utilizes the bony anatomy of the spine:
  - Cervical
  - Thoracic
  - Lumbar
  - Sacrum
65yr/M/Rec spinal ependymoma
65yr/M/Rec spinal ependymoma
Stereotactic Radiation Surgery: Lung

- Patient of carcinoma lung T1 (or T2) N0 MO, <5 cm in size, peripherally located, medically inoperable/ surgery not feasible
WARNING: Incorrect Offset may lead to Mis-treatment.

Prior to applying offset, visually verify that the registration accurately aligns visible anatomy or landmarks.

Press "ACCEPT" after your have verified the registration.

Isocenter Name: Isocenter 1
Beams: G150C5T355, G190, G280, G320, G150C10T270

Patient is loaded to Adaptive Targeting
Synchrony™ Respiratory Tracking System

- Synchrony camera
- Synchrony tracking markers
- Fiber optic sensing technology
- Tracks patient’s respiratory motion
CyberKnife® Treatment with Synchrony

Synchrony’s Benefits:
• Patient breathes normally
• Lesion tracked throughout treatment
• Sub-millimeter tracking accuracy*
• Minimal irradiation of healthy tissue

Respiratory Tracking System

- Delivers radiation throughout the respiratory cycle without gating or breath-holding
- Instantly adapts to variations in breathing patterns
Stereotactic Radiation Surgery: Lung

- Hoopes DJ et al, 2007 24 to 72Gy/3 f Stage I NSCL
  - LC – 74.8%. Nodal rec. 10%. 3 YOSR – 48.9% PET activity may persist for 2 Y

- Aoki M et al, 2007, early lung cancer 54 Gy/9 f (11 to 22 days)
  - LC - 95%, Survival 9.4-39.5 (median 17.7) mo. 2YSR- 89.5%

- Ongoing RTOG trial 20 Gy x 3 f

- Present option: Radiation surgery 16 Gy x 3 fr
  [ >5 cm lesions cyberknife 7 Gy X 5 f/ Artiste IGRT]
GI Cancers
Hepato-Cellular Carcinoma

- Not Suitable for surgery
- Not Suitable for RFA (close to vessel)
CARCINOMA BREAST, 4 METASTASES LIVER
→ complete response after CK at 6 months

Before
Amazing precision

6 months later
CK Inoperable Carcinoma Pancreas
Stereotactic Radiation Surgery: Pancreas

- Patient of Carcinoma Pancreas with local infiltration-Inoperable/surgery not feasible

- Conventional option:
  - Radio-Chemotherapy
  - Clinical trial
  - Poor GC – Best supportive care
Internal fiducial gold seeds or Coils (Viscicoil©)

Fiducial gold seed markers with applicators
Before, 3 mo., 6 mo.
AFTER CK
Stereotactic Radiation Surgery: Pancreas

- Chang ST et al, 2007
  Treated with cyberKnife radiosurgery, 25 Gy in single fraction
    - local control of 90%

Present option (even with poor GC) :
  Cyberknife +/- Chemotherapy
  [larger lesions cyberKnife therapy with 35 Gy/5 fractions]
GU Cancers
Prostate – Low & intermediate risk

- Surgery not feasible
- Is also an option instead of surgery
Locally advanced Ca Prostate – High risk
IGRT + CyberKNife + HT

PSA 30, SV +

3 months – PSA 0
Renal Cell Carcinoma
– inoperable
- Bilateral

PRE

3 months Later
Clinical Benefits

• Staged/Fractionated Radiosurgery
  – 1-5 fractions/stages
  – Larger lesions
  – Lesions next to critical structures/organs at risk

• Improved Patient Quality of Life
  – Short treatment course: 1-5 days CyberKnife vs. 6-8 wks Radiotherapy
    • Optimal for patients
    • Optimal for patients with limited life expectancy
    • Increased convenience
  – No infection risk
  – No general anesthesia
  – Minimal to no recovery time, as compared to open surgery
Limitations

• Availability/Cost
• Treatment time

Future

• Movable Collimation
• Increased dose rate
• Robotic couch movement
CYBERKNIFE-1YR

- 30/05/09-13/08/10
- Total – 395
- Extracranial-224
- Intracranial-171
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<th>Tumor Type</th>
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<tr>
<td>METS</td>
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<td>GLIOMA</td>
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<td>AVM</td>
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<td>CHORDOMA</td>
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## EXTRACRANIAL

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