Case study series for CK
LOOK FORWARD TO LIFE BEYOND CANCER
In 1989, a dedicated group of oncologists, lead by Dr. Ajaikumar, launched the Bangalore Institute of Oncology - the first comprehensive cancer centre in the country offering a full suite of oncology services. In 2004, Health Care Global Enterprises was founded as a holding company with two flagship hospitals: Bangalore Institute of Oncology and Curie Centre of Oncology. Today, HCG Enterprises is the largest network of oncology hospitals and functions as a hub and spoke model. It is a successful doctor-led initiative with over 350 doctors on board.
<table>
<thead>
<tr>
<th></th>
<th>CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hepatocellular carcinoma, early stage</td>
</tr>
<tr>
<td>2.</td>
<td>Recurrent Nasopharyngeal Carcinoma</td>
</tr>
<tr>
<td>3.</td>
<td>CyberKnife Treatment Rationale in Carcinoma Prostate</td>
</tr>
<tr>
<td>4.</td>
<td>Locally advanced carcinoma prostate</td>
</tr>
<tr>
<td>5.</td>
<td>Locally advanced carcinoma prostate post-TURP</td>
</tr>
<tr>
<td>6.</td>
<td>Organ confined carcinoma prostate</td>
</tr>
<tr>
<td>7.</td>
<td>Organ Confined Carcinoma prostate post-TURP</td>
</tr>
<tr>
<td>8.</td>
<td>Carcinoma head of pancreas, cT2N1M0/stage IIb, post-operative and post-chemotherapy</td>
</tr>
<tr>
<td>9.</td>
<td>Carcinoma body of pancreas with oligo metastases liver</td>
</tr>
<tr>
<td>10.</td>
<td>Carcinoma urinary bladder</td>
</tr>
<tr>
<td>11.</td>
<td>Hypothalamic glioma</td>
</tr>
<tr>
<td>12.</td>
<td>Carcinoma endometrium, post operative, post chemoradiation with paraaortic lymphnodal recurrence</td>
</tr>
<tr>
<td>13.</td>
<td>Low grade left frontal astrocytoma</td>
</tr>
<tr>
<td>14.</td>
<td>Recurrent salivary gland carcinoma, post operative post radiotherapy</td>
</tr>
<tr>
<td>15.</td>
<td>Hepatocellular carcinoma T4N0M0 post TACE with residual disease</td>
</tr>
</tbody>
</table>
Hepatocellular carcinoma, early stage

Fig 1: MRI and CT picture of the patient showing the HCC lesion in segment 8/7 before treatment.

TREATING CONSULTANT
Dr. Kumara Swamy

DEMOGRAPHICS
Sex: Male
Age: 80 Years
Histology: Hepatocellular carcinoma – right lobe of liver
Past Medical History: Nil

CASE HISTORY
Patient presented with complaints of decreased appetite since 6 months. Routine evaluation with USG of Abdomen & Pelvis on 08.09.09 revealed hypo echoic mass in the right lobe of liver. Upper GI Endoscopy was normal. CT Scan of Abdomen and Pelvis on 01.09.09 revealed solitary lesion in segment 8/7 measuring 5.3 x 5.3 cm with no portal vein thrombosis or pelvic lymphadenopathy. Ectopic left kidney in the lower abdomen. PET CT showed no uptake. MRI showed localized disease, but with mass very close to the right hepatic vein with mild mass effect. AFP level was within normal limits < 7.5 ng/ml. FNAC from the Hepatic lesion on 03.09.09 revealed hepatocellular carcinoma. LFT on 27.09.09 - normal. Chronic smoker (2-3 packs / day) for 40 years and by occasional alcoholic consumption.

TREATMENT OPTION
The treatment options available were surgery or RFA or CyberKnife radiosurgery or combinations.

WHY CYBERKNIFE RADIOSURGERY?
This patient of age 80 years, although in good general condition, did not opt for surgery. The next treatment option that is traditionally available was RFA (radiofrequency ablation). In this patient RFA was contraindicated in view of presence of blood vessel close to the lesion. Therefore, CyberKnife was the treatment offered supported by the following literature.

CYBERKNIFE TREATMENT RATIONALE:
- Although liver cancer surgery (surgical resection) is preferred among the treatments for liver cancer, only 20% of patients are candidates.
- Stereotactic radiotherapy (SRT) offers a treatment option for hepatocellular carcinoma (HCC) patients that are not eligible for surgery, embolization, chemotherapy, or radiofrequency ablation.
- In a recent publication, October 2010, Louis C et al have evaluated the feasibility, tolerance and toxicity of SRT for 25 HCC patients who were not eligible for these other modalities. The patients (6 women and 19 men) were treated with CyberKnife stereotactic radiotherapy using respiratory motion tracking. All patients had liver cirrhosis with an Eastern Cooperative Oncology Group (ECOG) performance score of less than 2 and pre-treatment...
Child scores ranging from A5 to B9. Overall the treatment was well tolerated with two Grade 3 acute toxicities and no acute Grade 4 toxicities. The actuarial 1- and 2-year local control rate was 95% (95% CI: 69-95%). At a median overall follow-up of 12.7 months (range, 1-24 months), six of the twenty-five (24%) patients have died. Overall actuarial survival at 1- and 2-years was 79% (95% CI: 52-92%) and 52% (95% CI: 19-78%), respectively. According to the authors, their results suggest promising therapeutic efficacy and good clinical tolerance to CyberKnife SRT treatment for HCC patients not eligible for other treatment modalities.

- Thus far in the treatment of liver tumors, centers have treated with the CyberKnife® System alone or in combination with transhepatic arterial chemoembolization. Single-fraction approaches have achieved local liver tumor control with a dose of 25 Gy.
- Other centers have treated with three fractions to a total dose of 30-39 Gy, with just a few mild side effects.

**TREATMENT DETAILS:**

- Tumor volume: 17.2cc
- Fractions/Treatment time: 5/90min / fraction
- Imaging Technique(s): PETCT, MRI
- Path Template: 2path
- Rx Dose & Isodose: 30Gy to 73%
- Tracking method: Fiducial tracking
- Conformality Index: 1.43
- Collimator(s): 25mm
- Tumor Coverage: 91.52%
- Number of beams: 130

**TREATMENT PLANNING PROCESS:**

Tumor target volume and surrounding critical structures (Right Lung, remaining liver) were contoured to fully reconstruct a three-dimensional tumor target to include critical structure volumes. The tumor target volume measured 17.2cc. The treatment plan was prescribed to deliver 30Gy in five fractions of 6Gy each. The tumor target volume was covered by 91.52% using this plan. It provided a 1.37 homogeneity index score and a 1.43 conformality index score while minimizing dose to the critical structures.

**TREATMENT DELIVERY**

The patient was treated on outpatient basis with a dose of 30 Gy to the 73 % isodose line in 5 daily fractions (equivalent of minimal dose of 54 Gy/27fractions, of conventional radiation). The patient tolerated his treatment and was sent home after each session.

**OUTCOME AND FOLLOW UP**

- Follow up PET-CT on 04.01.10 (3 months post CK) mass in segment 8/7 - unchanged in size without FDG concentration in the mass. Appetite improved, no fresh complaints.
- MRI Abdomen - 11/11/10 -> Stable disease, no change in size
- MRI Abdomen-11/11/10 -> Stable disease, no change in size
- Ultrasound Evaluation in September 2011 lesion size < 3.5
- Patient has remained asymptomatic 24 months post CyberKnife, in September 2011. AFP levels continued to remain within normal limits
CONCLUSION AND CYBERKNIFE ADVANTAGES:

Cyberknife robotic radiosurgery system is the only one of its kind which tracks the tumour with breathing as the treatment is going on. This leads several advantages. Unlike with linear accelerator based radiosurgery, no margins of normal tissue need to be given. Hence least amount of normal tissue gets included. Tolerance for the treatment increases tremendously. Higher dose per treatment can be given with total dose being the same biological equivalent. Since cancer cells do not recover between the treatment sessions, cancer cell resistance is overcome. At the same time side effects decreases drastically.

Increasing the total dose of biological equivalent can be done safely, to a level which is hither to not dreamed of. For the first time, this is expected to give significant number of long term control and cure, in patients who have early disease but not suitable for surgery. In patients with more advanced disease, with other forms of therapy like chemo and targeted drugs, one can attempt for medium and long term control, especially in slow progressing liver cancers.

Liver is one of the critical organs and conventional radiation techniques leads to significant number of patients ending up with radiation induced liver disease. However, now for the first time, using CyberKnife robotic radiosurgery system, it is possible to exclude the normal liver tissue to maximum extent and deliver the required dose to control the tumour. The lesion may respond in 3 months or may take longer duration to decrease in size especially in lower grade tumours.

Post Script:

1. CyberKnife is also indicated in patients who are waiting for liver transplant, the indication considered as "bridge to liver transplant". This will help in prevention of progression of disease as the patient is waiting for liver transplant, which may take months of preparation.

2. In patients with thrombus in the portal vein it is possible to recanalize the portal vein with cyberknife radiosurgery and make the patient feasible for either chemoembolization or radiochemoembolization.

REFERENCES


Recurrent Nasopharyngeal Carcinoma

**TREATING CONSULTANT**
Dr. Kumar swamy, MD

**DEMOGRAPHICS**
Sex: Male
Age: 23 Years
Histology: Undifferentiated carcinoma
Past Medical History: Nil

**CASE HISTORY**
A young gentleman of 23 years presented with complaints of continuous nasal discharge for 4 weeks. CT scan of Neck on 09.12.2005 revealed fairly large lobulated diffusely enhancing mass lesion in the posterior nasopharynx, extending superiorly causing erosion of the inferior wall of the sphenoid sinus on the right side and posterior portion of the right nasal cavity. Biopsy from Nasopharyngeal mass on 14.12.2005 revealed undifferentiated nasopharyngeal carcinoma.

Patient was treated with radiotherapy to a dose of 70Gy to nasopharynx from 26.12.2006 to 18.02.2006, along with 6 cycles of concurrent chemotherapy with CDDP + 5FU. Patient developed decreased salivation with difficulty in taking food and decreased hearing (both ear) as a sequelae of therapy.

Follow up CT Scan on 14.03.07 revealed fullness of the nasopharyngeal wall which has remained more or less unchanged since the previous CT, without contrast enhancement. Whole Body PET CT scan on 11.09.07 showed no evidence of disease in the nasopharyngeal region, the neck nodes and elsewhere in the body.

About 3 years later MRI Brain on 06.04.10 revealed mild enhancing soft tissue along the posterior nasopharynx more towards the right side abutting the adjacent clivus which showed altered marrow signal changes. Although lesion appeared to be inflammatory, biopsy was suggested in view of nasopharyngeal soft tissue fullness. Also, there was fluid and mild enhancing soft tissue seen in both mastoid air cells and in the region of right middle ear. Biopsy from nasopharynx on 14.04.10 revealed recurrent undifferentiated nasopharyngeal carcinoma.

The patient was referred to HCG for CyberKnife Radiosurgery and was taken up for the same after evaluation.

**CYBERKNIFE TREATMENT RATIONALE:**
This is a classical young patient of Carcinoma Nasopharynx recurring after conventional radiation, locally, almost 4 years from the diagnosis. Presently there are several studies indicating improvement in the local control with Radiosurgery boost. In these group of patients who have less probability of metastasis the local control becomes a critical factor. Additionally there are also a number of
studies indicating the role of radiosurgery in recurrent nasopharyngeal carcinoma. There are two limitations in treating post radiotherapy recurrent lesions. One is that the probability of these lesions being resistant to conventional dose per fraction is higher. Second is that there is an issue of normal tissue tolerance and delivery of effective total dose. Both these issues are addressed by the hypofractionation and extremely conformal technique of Cyberknife radiosurgery. Therefore, this patient considered is ideal for such a approach and is taken up for Cyberknife radiosurgery.

**TREATMENT DETAILS:**
- Tumor volume: 28.24cc
- Fractions/ Treatment time: 5/60min / fraction
- Imaging Technique(s): PETCT
- Path Template: 2paths
- Rx Dose & Isodose: 30Gy to 70%
- Tracking method: 6-D skull
- Conformality Index: 1.43
- Collimator(s): 10mm
- Tumor Coverage: 99.72%
- Number of beams: 274

**TREATMENT PLANNING PROCESS:**
Tumor target volume and surrounding critical structures (Brain stem, optic chiasm, and optic nerve) were contoured to fully reconstruct a three – dimensional tumor target to include critical structure volumes. The tumor target volume measured 28.24cc. The treatment plan was prescribed to deliver 30Gy in five fractions of 6Gy each. The tumor target volume was covered by 99.72% using this plan. It provided a 1.43 homogeneity index score and a 1.43 conformality index score while minimizing dose to the critical structures.

**TREATMENT DELIVERY**
The patient was treated on outpatient basis with a dose of 30 Gy to the 70 % isodose line in 5 daily fractions from 28.04.10 to 02.05.10 (equivalent of minimal dose of 54 Gy/27fractions, of conventional radiation). The patient tolerated his treatment and was sent home after each session.

**OUTCOME AND FOLLOW UP**
- Follow up PET-CT on 02.08.10 (3 months post CK) → Interval resolution of thickening in the right lateral and posterior wall of Nasopharynx. No cervical or distant metastasis. Good response to therapy.
- Follow up MRI of Head and Neck on 06.12.10 (8 months post CK) → No evidence of disease except post treatment changes in Nasopharynx and few bilateral reactive nodes.
- Follow up PET-CT on 06.12.10 (8 months post CK) → No recurrent mass in the Nasopharynx, SUV Nil, no cervical lymphadenopathy or distant metastasis. Good response to treatment, Right nasopharynx SUV Nil previously Nil, 3.4 Rest of the nasopharynx: SUV: Nil previously 2.7
Patient is doing fine and doing regular work as on September 2011. Has complaints of general nature regarding skin allergy and dental problems.

![Image](https://via.placeholder.com/150)

*Fig 2: Beams and the isodose distribution showing excellent sparing of brain stem, spinal cord normal brain tissue and targeting precisely the tumour in coronal and sagital section.*
CONCLUSION AND CYBERKNIFE ADVANTAGES

The Radiosurgery is an effective modality for local control as a boost after conventional treatment and is expected to give a local control of over 95%. In carcinoma nasopharynx, it is also an excellent modality for recurrences after conventional treatment. The possibility of prolonged remission or cure is feasible in such patients especially when the tumor is of biologically less aggressive and is of slow proliferating type.

Fig 3: PET-CT images, Pre Cyberknife (26-04-10), 3 months post CK (02-08-10), 8 months post CK (06-12-10) revealing good local control with no local, regional or distant recurrence.
• Published results in carcinoma prostate with Gleason Score of 6/7 with PSA of less than 15ng/ml i.e., low and intermediate risk has indicated comparable results with IMRT/IGRT (Table 1). There are several articles indicating possibility of improved long term control with hypofractionated schedules in view of low $\alpha/\beta$ value of prostate carcinoma.

• On the other hand the patients with higher risk or with intermediate risk with adverse factors, taking into possibility of spread to the pelvic lymph node and periprostatic areas, initial IM-IGRT is required.

• Katz et al (1) had published results of cyberknife monotherapy for high risk (PSA >20ng/ml and/ or Gleason Score of 8-10) patients undergoing IGRT, with comparable outcome endpoints.

• Considering all the above, usually patients with GS of 7 or more with initial PSA value of >15ng/ml, (with or without periprostatic or seminal vesicle involvement) either 40 to 42 sitting of IGRT lasting 8 to 9 weeks or IGRT of 25 to 28 sittings followed by Cyberknife boost of 3 fractions lasting 6 weeks is offered as options at our center.

• In patients with Gleason score of 7 or less with initial PSA value of less than 15 ng/ml and without periprostatic or seminal vesicle involvement (organ confined disease) either 40 to 42 sitting of IGRT alone lasting 8 to 9 weeks or Cyberknife radiosurgery alone (monotherapy with Cyberknife SBRT) of 5 fractions lasting 1 to 2 weeks is offered as options at our center.

Clinical results from various treatment modalities support the hypothesis of a low $\alpha/\beta$ ratio. Shown are the biologically equivalent doses at 1.8 Gy per fraction at for $\alpha/\beta$ ratios of 10, 3 and 1.5 Gy.

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment</th>
<th>BED $\alpha/\beta = 10$ Gy</th>
<th>BED $\alpha/\beta = 3$ Gy</th>
<th>BED $\alpha/\beta = 1.5$ Gy</th>
<th>Biochemical control rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kupelian et al (14)</td>
<td>IMRT, 70 Gy in 28 fractions</td>
<td>72 Gy</td>
<td>81 Gy</td>
<td>84 Gy</td>
<td>95% for low risk, 85% for intermediate risk patients at 7 yrs</td>
</tr>
<tr>
<td>Cahlon et al (21)</td>
<td>IMRT, 86 Gy in 48 fractions</td>
<td>86.4 Gy</td>
<td>86.4 Gy</td>
<td>86.4 Gy</td>
<td>98%, 85% and 70% for low, intermediate and high risk patients at 5 yrs</td>
</tr>
<tr>
<td>Martinez et al (22)</td>
<td>HDR, 38 Gy in fractions or 42 Gy in 6 fractions</td>
<td>63 Gy</td>
<td>95 Gy</td>
<td>125 Gy</td>
<td>91% at 5 yrs</td>
</tr>
<tr>
<td>Demanes et al (23)</td>
<td>HDR + EBRT, range of doses</td>
<td>58-85 Gy</td>
<td>90-95 Gy</td>
<td>87-120 Gy</td>
<td>87% and 69% for intermediate and high risk patients at 10 yrs</td>
</tr>
<tr>
<td>King et al (8)</td>
<td>SBRT, 36.25 Gy in 5 fractions</td>
<td>52 Gy</td>
<td>78 Gy</td>
<td>96 Gy</td>
<td>100% at 33 months</td>
</tr>
<tr>
<td>Katz et al (10)</td>
<td>SBRT , 35 Gy in 5 fractions</td>
<td>50 Gy</td>
<td>72 Gy</td>
<td>92 Gy</td>
<td>100% at 30 months</td>
</tr>
<tr>
<td>Katz et al (38)</td>
<td>EBRT, 45 Gy in 5 fractions, plus SBRT, 18-21 Gy in 3 fractions</td>
<td>69-76 Gy</td>
<td>77- 89 Gy</td>
<td>88-98 Gy</td>
<td>92% for intermediate risk, 79% for high risk</td>
</tr>
</tbody>
</table>

REFERENCES
Locally advanced carcinoma prostate

TREATING CONSULTANT
Dr KUMAR SWAMY

DEMOGRAPHICS
Sex: Male
Age: 59 Years
Histology: Adeno carcinoma
Clinical History: Lower Urinary Tract Symptoms
Past Medical History: DM since 20 yrs, CAD and GOUT

CASE HISTORY
Patient presented with urinary retention and dysuria since Oct 2007. When evaluated at Guwahati, PSA was found to be elevated (22ng/dl) and USG pelvis showed enlarged Gr III prostate having volume of 60cc. In July 2008 TRUS guided biopsy done at Hyderabad was suggestive of Adeno carcinoma with GLEASON Score of 7. Patient preferred to be on Ayurvedic treatment since july 2008.

During June 2009 he presented at hospital in Delhi with increased symptoms. At that time MRI showed 5x4.8x3.8cm prostatic lesion extending to seminal vesicles. His PSA also increased to 36.06 ng/ml. He was provided with the options of Radical Prostatectomy or Radical Radiotherapy. He received neoadjuvant hormone therapy Inj Lucrin Depot 11.25 mg on 10/6/09 and started on Caluran 50mg. He reported to our centre for Cyberknife opinion by end of June 2009. As he fell under the locally advanced high risk category CT3bN0M0, he was advised for conventional fractionated radiation to pelvis (prostate and the pelvic nodes) with IGRT to a dose of 45Gy/25# followed by Cyberknife boost. He received IGRT from 03.07.09 to 03.08.09. This was followed by Cyberknife radiosurgery boost to the prostate and involved seminal Vesicle to a dose of 19.50 Gy in 3 sessions from 04.08.09 to 06.08.09. Also, intrarectal amiphostine instillation during the radiosurgery boost was done as a radiation protector. Mean time he was continued on hormone therapy.

TREATMENT DETAILS:
Tumor volume : 110.62cc
Fractions/ Treatment time : 3/90min / fraction
Imaging Technique(s) : PETCT, MRI
Path Template : 1path
Rx Dose & Isodose : 19.55Gy to 70%
Tracking method : Fiducial tracking
Conformality Index : 1.07
collimator(s) : 30mm
Tumor Coverage : 96.4%
Number of beams : 137

TREATMENT PLANNING PROCESS:
Tumor target volume and surrounding critical structures (Rectum, Bladder and Penile Bulb) were contoured to fully reconstruct a three – dimensional tumor target to include critical structure volumes. The tumor target volume measured 110.62cc. The treatment plan was prescribed to deliver 19.50Gy in three fractions.

Figure showing coverage of prostate with 70% isodose and 50% (pink color) over the anterior rectal wall.
of 6.5Gy each. The tumor target volume was covered by 70% using this plan. It provided a 1.43 homogeneity index score and a 1.42 conformality index score while minimizing dose to the critical structures.

**TREATMENT DELIVERY**

This patient received IM-IGRT to a dose of 45Gy/25# from 03.07.09 to 03.08.09 to whole pelvis, with alternate day imaging. Later he received cyberknife SBRT boost to prostate region with hypofractionated dose of 6.5Gy per fraction for 3 days to a total dose of 19.5Gy completely on an outpatient basis.

**OUTCOME AND FOLLOW UP**

- On 3rd month follow up, PSA was nil. And the periprostatic and seminal vesicles lesion resolved according to MRI. Size 4.28x3.3x3.9 cm
- During 5th month follow up in January 2010, MRI showed resolution of left periprostatic component.
- On 9th month follow up MRI was repeated in which the prostate was of similar size with 4x 3.3 x 3.7. There were no lesion in the prostate or seminal vesicle. Except for thin urinary flow only during early morning, he is asymptomatic.

- One and half year post therapy MRI showed transitional zone patchy enhancement with slightly asymmetrical peripheral zone. With loss of hyperintense signal intensity likely representing post RT fibrosis.

Response to treatment in terms of size of prostate is slow in case of carcinoma prostate. This is in view of its slow proliferating cells, although patient becomes asymptomatic by 3rd month. MRI changes including spectroscopic findings indicative of residual lesion may persist even after an year, which requires no further treatment. Only increase in size might warrant further local therapy.

This patient had slow decrease in the size of prostate, excellent biochemical control and quality of life.
Locally advanced carcinoma prostate post-TURP

TREATING CONSULTANT
Dr. SOMRAT BHATTACHARJEE

DEMOGRAPHICS
Sex: Male
Age: 54 Years
Histology: Adeno carcinoma

Clinical History: Presented at HCG with severe pain in abdomen and increased frequency, poor urinary stream and pain during voiding urine July 2009

Past Medical History: Hypertensive

CASE HISTORY
Patient presented in September 2008 with increased frequency, poor urinary stream and pain during voiding urine on and off since 6 months. He was evaluated with USG abdomen & Pelvis in July 2009 which revealed prostatomegaly, volume 46.1 gm, with significant post void residual thickening of bladder wall. And cystoscopy revealed bilateral large lateral lobes of prostate and median lobe causing the obstruction. About 20gm of prostate resected completely. Post TURP, his residual urine was 159 ml. on USG. Histopathologically it was adenocarcinoma with perineural invasion and Gleason Score of 5+4 = 9. Bone Scan revealed no evidence of skeletal metastases. Whole body PET CT Scan did around the same time revealed 4.4 x 3.3 x 4.3 cm prostatic mass with contiguous infiltration of the bladder base and bilateral seminal vesicles and no significant pelvic lymphadenopathy. Bilateral lung nodules 5-6 mm seen were interpreted as may be of inflammatory/ infectious etiology. Also, extensive right paratracheal, pretracheal, precardinal, aorta-pulmonary window and subcarinal lymphadenopathy seen were considered inflammatory/ infectious etiology. Additionally, 1.4 x 1.2 cm metabolically inactive hypodense left adrenal nodule was seen, likely representing an adenoma

As he was diagnosed to have locally advanced ca prostate he was started on hormonal therapy and planned for IGRT to pelvis with dose of 50 Gy / 25 # which was started from 04.09.09 upto 08.10.09 over 5 weeks. He was planned for CyberKnife boost, hence MRI of pelvis was done for planning purpose on 14/10/09- and it revealed post TURP changes. Mild irregular heterogeneous enhancement of the prostate was present and size was 3.8 x 3.4 cms. Contiguous infiltration of the bladder base & bilateral seminal vesicle with the growth abutting the anterior wall of anal canal without obvious wall infiltration were the other findings. He received Cyberknife boost dose of 18 Gy / 3 # for 3 days with fiducial tracking on 22nd, 23rd, & 24th of October 2009. He also continued hormone therapy while on RT and as adjuvant therapy afterwards.

TREATMENT DETAILS:
IGRT DETAILS:
Whole pelvis radiotherapy was given with IMRT plan and alternate image guided localization
was performed with the help of the gold fiducials and a dose of 50Gy/25# with 1.8Gy/ # with 5# per week over 5 weeks. from 04.09.09 to 08.10.09.

**CYBERKNIFE DETAILS:**
- Tumor volume: 119.1cc
- Fractions/ Treatment time: 390min / fraction
- Imaging Technique(s): PETCT, MRI
- Path Template: 2path
- Rx Dose & Isodose: 18Gy to 73%
- Tracking method: Fiducial tracking
- Conformality Index: 1.22
- collimator(s): 20mm
- Tumor Coverage: 85.85%
- homogeneity index: 1.43
- Number of beams: 207

**OUTCOME AND FOLLOW UP**
Patient continued to have GU and GI symptoms at 4 months. PET CT scan on 17.02.10 (4 months later) was repeated to assess his disease status which revealed urinary bladder with mild circumferential wall thickening, unchanged since prior study along with post TURP changes. Mild irregular heterogeneous enhancement of the prostate, size relatively unchanged. Contiguous infiltration of bladder base & B/L SV, prostate abutting ant wall of anal canal without obvious wall infiltration was seen. Lung nodule, (granulomas) - unchanged. Mediastinal lymphadenopathy, L adrenal adenoma stable.

He subsequently developed grade 2 GU symptoms for a period of 2 months during May and June 2010 as difficulty in passing urine. He required dilatation of urethra. Subsequently, when came for follow-up in December 2010 (1 year 2 months later) he was free of GU and GI symptoms and prostate was relatively stable in PETCT.

In mean time PSA had dropped to 0.112ng/ml 2 months after CK and 0.005ng/ml 4 months later, 0.0 ng/ml 8 months later, and continued to remain 0.0 ng/ml during march 2011. (1 yr 5 months post CK)

**CONCLUSION AND CYBERKNIFE ADVANTAGES**
In locally advanced lesion of carcinoma prostate combination of IGRT to take care of the gross and microscopic pelvic disease followed by CK boost which is biologically expected to have better control, seems to be an option in terms of maximal possible tumor control and minimal side effects. This fits in very well the radiobiological model of the carcinoma prostate, which is a slow proliferating type requiring higher dose per fraction. Cyber knife radiosurgery boost with its ability to track the prostate during the treatment resulting in lesser volume of normal tissue to be included and higher dose per fraction which is possible due to exclusion of normal tissues appears to be optimization of all the advantages of different techniques of radiotherapy / radiosurgery.

**REFERENCES**
Organ confined carcinoma prostate

TREATING CONSULTANT
Dr. M.S. BELLIAPPA

DEMOGRAPHICS
Sex: Male
Age: 70 Years
Histology: Adeno carcinoma
Clinical History: On routine health check up, found to have elevated PSA.
Past Medical History: Nil

CASE HISTORY
A 70 yr foreigner working in Bangalore had h/o renal calculi and was on regular health check up. His PSA was found to be elevated to 22.04ng/ml on June 2009. He then underwent USG Abdomen and pelvis which revealed enlarged prostate measuring 5.6 x 4.5 x 4.5 cm, with ill defined hypo echoic area in the external zone on the left side. Capsule was intact and prostate weighed 41gm. He underwent biopsy of prostate which revealed Adenocarcinoma, GS= 3+2= 5. MRI on July 2009 showed prostate moderately enlarged and measuring 5.8x5.1x4.8cm vol=70ml. Peripheral zones on either sides showed altered signal intensities. Focal T2 hypo intense lesion on each in the either side of peripheral zone was noted. The lesion in the left peripheral zone measured17x10mm and is seen extending from 4'O' clock to 5'O'clock position. The other lesion in the right peripheral zone measured 17x12mm and extended from 7'O'clock to 8'O' clock position, right peripheral zone. Metastatic work up was negative. As he was elevated PSA beyond 20ng/ml, he was started on neo-adjuvant hormone therapy Inj. Zoladex 10.8mg S/C x 2 cycles on 18.07.09 and 12.10.09.

He was subsequently taken up for CyberKnife monotherapy (without IGRT) in view of organ confined disease without involvement of seminal vesicles. In preparation for tracking of tumor gold fiducials were inserted into the prostate using TRUS guided approach. Immobilization device and PET-CT simulation was done. He received CyberKnife radiosurgery to prostate with dose of 37.5Gy/5# from 23.10.09 to 30.10.09 on alternate days.

TREATMENT DETAILS:
- Tumor volume: 74.36cc
- Fractions/Treatment time: 5/90min/fraction
- Imaging Technique(s): PETCT, MRI

Rx Dose & Isodose: 37.5Gy to 70%
Tracking method: Fiducial tracking
Conformality Index: 1.43
Collimator(s): 30mm
Tumor Coverage: 92.99%
Number of beams: 170

OUTCOME AND FOLLOW UP
During follow up after 6 months in May 2010, he complained of increased frequency of urination off and on. MRI revealed enlarged prostate measuring 4.8 x 4.5 x 4 cm showing moderate response, with residual hyperplasia lesion in the Right & Left peripheral zone. His PSA declined to 0.05 ng/ml.

MRI repeated on December 2010, after 1yr 3mth follow up revealed heterogeneous post contrast enhancement of whole of the prostate with few areas of slightly restricted diffusion and elevated choline with reduced citrate peaks on DWI and 3D CSI respectively. Heterogeneous T2 hypointensity in bilateral peripheral zones is extending to the base of seminal vesicles bilaterally. PSA was nearer to zero.

CONCLUSION AND CYBERKNIFE ADVANTAGES
Patient is an active person in full service and his routine work even during radiosurgery procedure was not interrupted. Except for minimal symptoms (transient grade I toxicity) off and on his quality of life has been excellent. Now a more than a year and 4 months later his PSA is nearer to zero continuing with hectic work.

Radiosurgery has made a significant impact in the management of ca prostate with minimal toxicity and excellent biochemical and disease control. With increase in incidence of carcinoma prostate due to aging population in India, Cyberknife is going to play a significant role in management of these patients.

REFERENCES
Organ Confined Carcinoma prostate post-TURP

Fig: PETCT scan showing organ confined carcinoma prostate

TREATING CONSULTANT
Dr. RAMESH S BILIMAGGA

DEMOGRAPHICS
Sex: Male
Age: 60 Years
Histology: Adeno carcinoma
Clinical History: urinary retention on and off
Past Medical History: Hypertension for since 7 years on regular treatment

CASE HISTORY
This patient aged 60 years presented with history of urinary retention on and off, in the month of August 2009. PSA level was 11.8 ng/ml. He was evaluated by an Urologist and underwent Transurethral Resection of Prostate (TURP) in September 2009. Histopathology showed adenocarcinoma of prostate, Gleason Score estimated to be 4+3=7. MRI of pelvis revealed organ confined prostate cancer and metastatic workup including F-18 bone scan were negative. Options of surgery and radiosurgery were discussed with the patient and the patient decided on CyberKnife radiosurgery.

TREATMENT PLANNING PROCESS & TREATMENT DELIVERY:
Four gold seeds were inserted into the prostatic tissue under transrectal USG guidance as internal fiducials to help tracking the tumor during treatment. Vacloc immobilization was prepared and planning CT scan was done according to Cyberknife protocol. MRI of pelvis was fused with the planning CT scan to delineate the extension of the tumor and prostate. The tumor and organs at risk were delineated on the CT scan and good conformal plan was created to deliver a dose of 37.5 Gy / 5 sittings to the prostate. He received the planned treatment from 29.09.09 to 09.10.09. Radio protector Amifostine was used intra rectally during the Cyberknife treatment. Patient tolerated the therapy well.

As he is considered as intermediate risk he was started on hormone therapy also.

CYBERKNIFE TREATMENT RATIONALE:
NCCN Guideline indicates that for intermediate risk patients irradiation of pelvic nodes is a choice. Therefore, in these patients when volume of the disease is small, Cyberknife radiosurgery alone is an option. Advantages are the tracking of the prostate during treatment (resulting in need for minimal treatment margin around the prostate), more conformality, radiobiological advantage of hypofractionation in slow proliferating carcinoma prostate and maximum of 2 weeks of treatment (compared to 8 weeks of conventional radiotherapy treatment schedule).

Recent analyses and reviews of clinical tumor control data support a low a/b ratio for prostate cancer, which suggests that prostate cancer...
should be treated with fewer and larger doses of radiation - ie hypofractionated approach (Fowler, J. et al, 2001; Ritter, M et al 2008). There is increasingly convincing evidence that biochemical control, indicated by blood prostate-specific antigen (PSA) concentrations, improves with higher doses of radiation delivered per fraction, an observation noted by recent articles of publication (Zelefsky et al 2002, King, C. R. et al 2003, Kupelian et al 2007).

Giampaolo Bolzicco et al from Italy, published results of 45 patients treated with Cyberknife alone (having 23 patients of intermediate risk) found no patient had biochemical failure with median follow-up was 20-months (range 6-42-months).

Friedland J L et al (2009) treated 112 patients of localized carcinoma prostate T1/2, N0M0 between, aged 55 to 87 years between February 2005 and December 2006, with CyberKnife SBRT (with or without hormone therapy) as primary therapy (without external beam radiotherapy covering the lymph nodes) in Naples, Florida. In this group, 23 patients were with Gleason Score 3+4 and 6 patients were with Gleason Score 4+3. All had PSA less than 20 ng/ml. In their series, at a median follow-up of 24 months, the mean PSA value was 0.78 ng/ml. Two patients have developed biopsy-confirmed local relapse; one developed distant metastases. Acute side effects were generally mild and resolved shortly after treatment. A single Grade 3 rectal complication was reported (bleeding). Eighty-two percent of patients who were sexually potent before treatment maintained erectile function post-treatment.

**TREATMENT DETAILS:**

<table>
<thead>
<tr>
<th>Tumor volume</th>
<th>153.8cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions/ Treatment time</td>
<td>5/60min / fraction</td>
</tr>
<tr>
<td>Imaging Technique(s)</td>
<td>MRI</td>
</tr>
<tr>
<td>Path Template</td>
<td>1path</td>
</tr>
<tr>
<td>Rx Dose &amp; Isodose</td>
<td>37.5Gy to 70%</td>
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<tr>
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<td>Fiducial tracking</td>
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<td>Conformality Index</td>
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</tr>
<tr>
<td>collimator(s)</td>
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<tr>
<td>Tumor Coverage</td>
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</tr>
<tr>
<td>Homogeneity Index</td>
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</tr>
<tr>
<td>Number of beams</td>
<td>226</td>
</tr>
</tbody>
</table>

**OUTCOME AND FOLLOW UP**

On 20.01.10- 3months post CK- PSA- 0.001ng/dl. During April 2010, 7 months later, PSA remained 0.001ng/dl without any urinary or rectal complaints.

**CONCLUSION AND CYBERKNIFE ADVANTAGES**

Carcinoma prostate is going to be an important public health issue in India, in view of growing percentage of aged population. Number of patients diagnosed in the early stage is going to increase incrementally in view of awareness and increasing number of people seeking PSA estimation with minimal urinary symptoms. Under these circumstances, it becomes very relevant to have a treatment method which is noninvasive without significant early and late side effects and at the same time be effective in the range of 95 to 100% of patients. Since the life expectancy of these patients is going to be long, it is important that the treatment should attain long term control without affecting the normal quality of life. CyberKnife radiosurgery fits into this situation like a glove in early stage carcinoma prostate, with the patient moving “from the treatment table to the office” without any break in the normal activity.

**REFERENCES**


TREATING CONSULTANT
DR. SRIDHAR. P. S

DEMOGRAPHICS
Sex: Female
Age: 61 Years
Histology: Ductal Adenocarcinoma
Clinical History: h /o itching, lassitude nausea, anorexia, loss of weight, high color urine, dull aching upper abdominal pain on & off. Patient
Past Medical History: Diabetes and hypertension, on medication

CASE HISTORY
She presented on 03.08.09 with history of itching, lassitude and nausea, vomiting, anorexia, loss of weight, high color urine, and dull aching upper abdominal pain on & off. She was evaluated with upper GI Endoscopy which revealed ulcero-proliferative growth in the periampullary region. CT scan of abdomen revealed mass arising near distal CBD / ampulla probably pancreatic neoplasm.

During September 2009, on Laparotomy she was detected to have hard tumour 4 x 5cm in head and uncinate process of pancreas with few large peripancreatic, paraaortic lymphnodes without liver or peritoneal deposits. She underwent palliative cholecystojejunostomy and jejunojejunostomy. Transduodenal trucut biopsy of tumour and lymph node was taken. HPR revealed adenocarcinoma.

She was put on chemotherapy with Gemcitabine 1.4 gm once in 2 weeks along with Erlotinib 150mg OD which she tolerated well and disease was under control. She has been referred here for radiosurgery opinion and was taken up for the same.

CYBERKNIFE TREATMENT PROCEDURE
Four fiducials were inserted into the pancreas under CT guidance to facilitate the tracking of the tumor during radiosurgery. PET-CT was done along with the planning CT. The target area delineated using the fused PET and CT images. A dose of 24 Gy / 3 # in 3 days was prescribed to 77% isodose curve to the lesion in the pancreas from 07.10.09 to 09.10.09 along with intravenous amifostine as radioprotector.

Follow up Repeat PET CT on 04.03.10, five months later showed near total resolution of pancreatic head mass, interval development of three portocaval and solitary metabolically active mesenteric root lymphnodes, of concern for metastatic disease. No hepatic or pulmonary metastases were present.

Repeat PET CT on 03.05.10 revealed mild interval increase in the size of portocaval nodes and stable solitary mesenteric root lymphnodes, no hepatic or pulmonary metastases. In view of progressive nodes patient was considered for repeat radiosurgery for the positive nodal region. She was treated with PET CT based Cyberknife Robotic Radiosurgery with a dose of 24 Gy / 3 # in 3 days to the 77% isodose curve on 07.10.09 to 09.10.09 along with intravenous amifostine as radioprotector.

Figure: PET CT on 05.10.09 and 04.03.10 showing near total resolution of pancreatic head mass
24 Gy/3# to 69% isodose value, from 6.05.10 to 8.05.10. For tracking, fiducials inserted during the earlier CyberKnife radiosurgery procedure were used.

**TREATMENT DETAILS:**

| Tumor volume | 153.8cc |
| Tumor volume | 31.436cc |
| Fractions/Treatment time | 5/60min / fraction |
| Imaging Technique(s) | MRI |
| Path Template | 1path |
| Rx Dose & Isodose | 37.5Gy to 70% |
| Tracking method | Fiducial tracking |
| Conformality Index | 1.46 |
| collimator(s) | 30mm |
| Tumor Coverage | 95.74% |
| Homogeneity Index | 1.43 |
| Number of beams | 226 |

**TREATMENT DETAILS: 07.10.09 to 09.10.09**

| Tumor volume | 153.8cc |
| Tumor volume | 31.436cc |
| Fractions/Treatment time | 3/90-110min / fraction |
| Imaging Technique(s) | PETCT |
| Path Template | 2path |
| Rx Dose & Isodose | 24Gy to 77% |
| Tracking method | Fiducial tracking |
| Conformality Index | 1.34 |
| collimator(s) | 10mm |
| Tumor Coverage | 97.30% |
| Number of beams | 201 |

**TREATMENT DETAILS: 06.05.10 to 08.05.10**

| Tumor volume GTV1 | 5.017cc |
| Fractions/ Treatment time | 3/250min / fraction |
| GTV2 | 19.312 |
| Imaging Technique(s) | PETCT, |
| Path Template | 2path |
| Rx Dose & Isodose | 24Gy to 69% |
| Tracking method | Fiducial tracking |
| Conformality Index | GTV1-6.83; GTV2-1.84 |
| collimator(s) | 10mm |
| Tumor Coverage | 97.91% |
| Number of beams | 224 |

**FOLLOW UP**

Patient was continued on tablet erlotinib for 1 year. Presently, more than 1 year 6 months she has no complaints and is on regular follow up.

**CONCLUSION AND CYBERKNIFE ADVANTAGES**

In inoperable carcinoma pancreas, non metastatic, Sterotactic Body Radiosurgery with CyberKnife has the potential to cure or at least have long term control of the disease in patients who have disease localized and who respond to chemotherapy and small molecule targeted drugs. In other patients it has the potential to control the disease locally and useful in preventing the distressing situation of intractable pain. Since, the prognosis is poor and significant number being inoperable, CyberKnife plays a major role in quality of life and local disease control and is potentially curable role in patients having excellent response to chemotherapy and targeted drugs.
Carcinoma body of pancreas with oligo metastases liver

Carcinoma body of pancreas with oligo metastases liver

TREATING CONSULTANT
Dr. SRI DHAR, P. S

DEMOGRAPHICS
Sex: Female
Age: 52 Years
Histology: Adenocarcinoma – pancreas
Clinical History: dyspepsia in November 2009
Past Medical History: NIL

CASE HISTORY
A 52 year old lady from Punjab presented with complaints of dyspepsia since Nov 2009, for which she was evaluated with MDCT dual phase scan abdomen on 16.11.09. This revealed SOL measuring 2.9 x 2.4 x 2.8cm involving the proximal body of the pancreas and abutting the retropancreatic distal splenic vein superiorly. The arterial phase showed encasement of the proximal course of the splenic artery coursing through the mass lesion. Dilatation of the pancreatic duct in the distal body and tail of the pancreas was noted. Atrophy of the distal body and tail of pancreas was present. FNAC revealed features consistent with adenocarcinoma of pancreas. She received 4 cycles of chemotherapy with Inj. Gemcitabine + Carboplatin till Dec 2009. CT scan of whole abdomen on 18.12.09 revealed persistent mass in proximal body of the pancreas encasing the proximal part of splenic artery and left gastric artery. Patient opted for Alternative therapy subsequently.

She was again evaluated on 26.02.10, which showed elevated LDH of 217U/L and elevated CA 19.9 of 438.23U/ml. CT scan of chest and abdomen around that time revealed mass lesion of 4.4 x 3.5 x 2.5 cms in relation to the body and the head of the pancreas causing encasement of the pancreaticodudenal and splenic artery with added parapancreatic lymphadenopathy. She presented at HCG during July 2010 Whole Body PET CT scan revealed 4.1 x 3.9 cm pancreatic body and neck mass(SUV= 11.1 max.), with infiltration of gastrohepatic ligament, celiac artery branches and distal superior mesenteric vein, thrombus of splenic vein with collateral in the mesentery and splenic hilium, at least three hepatic metastases(SUV- 6.3) were present.

CYBERKNIFE TREATMENT RATIONALE:
Carcinoma pancreas is a disease with poor prognosis. Cyberknife radiosurgery which has the ability to deliver focused radiation with higher dose per fraction has been tried extensively in local regional control of the disease. This patient presented with the locally advanced disease with limited number of liver metastases after the conventional therapies. Radiosurgery is also indicated in oligo metastases of the liver.

This patient was offered CyberKnife radiosurgery both to primary and metastatic
lesion with objective of improving the progression free survival without adversely affecting the quality of life. CyberKnife, the only radiosurgery equipment which tracks the tumor and automatically corrects the patient position during the treatment, is ideal to treat the gross disease and avoid the normal tissue. This treatment therefore gives maximum possibility of control and improvement in quality of life.

**TREATMENT GIVEN:**
The patient was planned and treated with PET CT based CyberKnife radiosurgery to a dose of 24Gy/3# to Gross Tumor Volume identified by PET in the pancreas, (30Gy/3# to SUV-6 pancreas) and 24Gy/3# to liver lesions from 19.07.10 to 22.07.10. Fiducials were used for tracking the target volume. Patient tolerated the treatment well.

**TREATMENT DETAILS:**

<table>
<thead>
<tr>
<th>Tumor volume</th>
<th>SUV6 - GTV PET-35.65cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIVER1 - 6.46cc</td>
<td></td>
</tr>
<tr>
<td>LIVER 2 - 2.85cc</td>
<td></td>
</tr>
<tr>
<td>LIVER3 - 2.836cc</td>
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<table>
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<tr>
<th>Imaging Technique(s)</th>
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</thead>
<tbody>
<tr>
<td>Path Template</td>
<td>2path</td>
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<tr>
<td>Rx Dose &amp; Isodose</td>
<td>24Gy to 70%</td>
</tr>
<tr>
<td>Tracking method</td>
<td>Fiducial tracking</td>
</tr>
</tbody>
</table>

| Conformality Index   | 1.43                   |
| Homogeneity index    |                        |

| Number of beams      | 303                    |
| Tumor Coverage       | 100%                   |
|                      | 97.86%                 |
|                      | 84.89%                 |
|                      | 90.91%                 |
|                      | 88.63%                 |

**LIVER1 - 10.59**

**LIVER2 - 22.41**

**LIVER3 - 23.12**

collimator(s) : 10-20mm

OUTCOME AND FOLLOW UP

She tolerated the treatment well and follow up PET SCAN- ON 15.01.11 (post 6 month CyberKnife) revealed a mildly FDG avid non-enhancing 2.0 x 1.7cm. in size soft tissue mass lesion in the region of the body of the pancreas- suggestive of minimal residual disease (SUV max: 1.86) with. Non FDG avid mildly heterogeneously enhancing soft tissue lesion in segment V/VI of the liver - metabolically inactive residual lesion measuring 2.0 x 1.9cm. On comparison to PET-CT ON 12.07.10 the pancreatic and hepatic lesions have significantly decreased in metabolic activity suggesting a good treatment response.

**CONCLUSION AND CYBERKNIFE ADVANTAGES**

This patient of carcinoma body of pancreas, locally advanced, had good response to cyberknife radiosurgery and had progression free survival for more than 6 months despite presenting with metastatic lesion in the liver as on last date of follow up recently.

Cyberknife radiosurgery would be an excellent technique in this type of patients who have no other option of established modality of effective treatment.
Carcinoma urinary bladder

TREATING CONSULTANT
DR. SOMRAT BHATTACHARJEE

DEMOGRAPHICS
Sex: Male
Age: 53 Years
Histology: Transitional Cell Ca

CASE HISTORY
Patient with history of DM on medications presented with complaints of haematuria (on & off) since 1½ yrs and painful micturition (since 1 week) in June 2009. He was evaluated with USG abdomen and CT scan which revealed echogenic SOL measuring 6.8 x 3cm in left postero-lateral wall of bladder - ? papilloma. Scan also showed enlarged median lobe of prostate with bladder outflow obstruction.

Patient underwent TURBT procedure on 19.06.09. HPE was suggestive of Transitional cell Carcinoma Grade III with deep musculature infiltration.

PET CT scan on 21.07.09 at HCG revealed:
• 2.6 x 0.8 cm focal thickening and enhancement of the left lateral wall of urinary bladder anterior to the left vesico-ureteric junction, metabolically active. No obvious peri-vesical fat stranding or nodularity.
• 10 x 8 mm metabolically active left external iliac lymph node - metastases cannot be excluded.
• 6 mm nodule in the anterior segment of right upper lobe and 6 mm subpleural nodule in the superior segment of right lower lobe of lung. Recommend follow up to confirm stability.
• Multiple prominent prevascular, aorto-pulmonary window and subcarinal lymph nodes - may be reactive.

Impression was focal thickening described in the left lateral wall of urinary bladder is of concern for Post TURBT residual tumor.

Patient was planned & treated with IMRT simultaneous integrated boost technique to the lymph node drainage area to a dose of 50 Gy / 25 # and to the residual gross tumor 55Gy in the same 25# from 27.07.09 to 31.08.09 along with four cycles of weekly concurrent chemotherapy with Inj. Cisplatin 70 mg, on 30.07.09, 05.08.09, 12.08.09, and 19.08.09. Following this he was planned for Cyberknife boost with a dose of 1200 cGy / 2 # / 2 days on 14.09.09 & 15.09.09.

CYBERKNIFE TREATMENT RATIONALE:
Advantages of radiosurgery in treating the gross disease are obvious. In the literature innovative technology of giving cyberknife radiosurgery in a case of carcinoma bladder is available. The authors, Thariat et al, 2010 (BJR), felt that transurethral bladder resection followed by chemoradiation and a stereotactic CyberKnife radiotherapy boost seems a promising approach for the treatment of invasive bladder cancer in heavily pre-treated
patients or patients eligible for preservation strategies. In their case study of a patient with a previously irradiated pelvis, CyberKnife radiotherapy was feasible and well tolerated, with disease control and non-altered functional results two years after treatment completion. CyberKnife irradiation may also be considered for the conservative treatment of locally advanced T2-T4a N(0) M(0) bladder cancer with incomplete or uncertain transurethral resection. They described the technique of Radio-opaque gold markers that can be implanted in the bladder during transurethral resection and used for online image-tracking during radiation to compensate for bladder filling and target movements. 1

The present patient wanted organ preservation treatment, and underwent initially standard chemoradiation. He was offered radiosurgery a boost to improve the local control.

**TREATMENT DETAILS:**

<table>
<thead>
<tr>
<th>Tumor volume</th>
<th>11.1cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions/ Treatment time</td>
<td>2/70min / fraction</td>
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<tr>
<td>Imaging Technique(s)</td>
<td>PETCT</td>
</tr>
<tr>
<td>Path Template</td>
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<tr>
<td>Rx Dose &amp; Isodose</td>
<td>1200Gy to 75%</td>
</tr>
<tr>
<td>Tracking method</td>
<td>Fiducial tracking</td>
</tr>
</tbody>
</table>

**OUTCOME AND FOLLOW UP**

- Follow up PET-CT on 22.03.10 (6 months post IMRT-CK boost) showed Interval resolution of left lateral wall of urinary bladder mass (SUV NIL previously 13.7). Marked interval regression of the left external iliac lymph node was also seen, now measuring 5 x 4 mm (previously 10x 8mm) SUV nil. Previously 2.2), Lung nodule was stable. Mild interval regression of prevascular, aorto-pulmonary window and subcarinal lymph nodes was observed - likely reactive. Patient was asymptomatic.
- PET CT on 06.09.10 (1 year later) - No urinary bladder mass noted. Stable 5 x 4mm left external iliac lymph node. Stable lung nodule and the mediastinal lymph nodes.
- He had removal of DJ stent by cystoscopy. There was telangiectasia on left lateral wall with TURBT scar. No tumor in the bladder or tabeculations was present. Left RGP showed lower ureteric narrowing non distensible ureter up to lower border of sacroiliac joint. No peristalsis in lower ureter even after instilling contrast was present with hold up of contract up to mid ureter. Stricture was dilated.
- During follow-up in January 2011 (1yr 4 months later) patient was asymptomatic
CONCLUSION AND CYBERKNIFE ADVANTAGES

Cyberknife radiosurgery is an innovative technology in the boost therapy of organ preservation management of urinary bladder after initial concurrent chemoradiation. The present patient is without any evidence of disease 1 year 4 months later with excellent quality of life, following organ preservation management approach.

REFERENCES

Hypothalamic glioma

**TREATING CONSULTANT**

Dr. SRIDHAR. P. S.

**DEMOGRAPHICS**

Sex: Female  
Age: 78 Years  
Radiologically: Glioma  
Clinical history: Loss of memory since 4 months associated with slurred speech.  
Past Medical History: Diabetic mellitus since 18 months and hypertensive since 5-6 yrs, on medication.

**CASE HISTORY**

A 78 yr old lady, resident of Delhi, had history of difficulty to open her mouth, slurring of speech, loss of memory for 2-3 days in June 2009, which was transient. But by September 2009 she progressed to difficulty in speaking & walking. She also had drowsiness, headache, loss of memory and incontinence of urine for which she was investigated further and MRI Brain on 29.09.09 revealed homogenous enhancing solid mass measuring 2.1 x 2cm in right Hypothalamic region, suggestive of Hypothalamic Glioma / Metastatic deposits. On 01.10.09 with MRI revealed suppressed NAA peaks and mild increased Choline, She had memory loss and lower limbs had 4/5 power with normal deep tendon reflex.

PET CT on 05.10.09 revealed right hypothalamic mass [SUV-15] measuring 2.2 x 1.5 x 1.3cm in right hypothalamic region indenting the infundibular recess of the 3rd ventricle with perilesional edema in the right inferior thalamus, post limb of internal capsule, right ½ mid brain. No other lesion in other parts of the body.

As there was no other lesion elsewhere in body it was radiologically diagnosed to be hypothalamic glioma. After considering the options of conventional radiation with radiosurgery boost or radiosurgery alone in view of the age and rapidly progressing symptoms patient and attendants opted for CyberKnife radiosurgery. Treatment was delivered to the lesion using MRI & PET-CT based planning to a dose of 24Gy/3# for 3 days from 08.10.09 to 10.10.09.

**TREATMENT DETAILS:**

- Tumor volume: 6.87cc  
- Fractions/Treatment time: 3/90-100min/fraction  
- Imaging Technique(s): PETCT, MRI  
- Path Template: 2path  
- Rx Dose & Isodose: 24Gy to 78%  
- Tracking method: 6D Skull  
- Conformality Index: 1.49  
- collimator(s): 10mm  
- Tumor Coverage: 96.03%  
- Number of beams: 147

**Fig:** Good coverage of target with rapid dose falloff (above). Dose volume histogram showing, minimal dose to the critical structures.
OUTCOME AND FOLLOW UP
Follow up PET CT scan of brain on 04.01.10 (3 months) revealed total interval resolution of the mass in the right hypothalamic region and perilesional edema. Patient had improved significantly symptomatically.

CONCLUSION AND CYBER KNIFE ADVANTAGES
This is a patient of high grade expansile lesion in the region of thalamus and brain stem, usually the the outcome of which is considered poor. Radiosurgery has been an option of treatment either alone or as boost after conventional treatment including in recurrent types. In this elderly patient, with rapidly declining faculty, and since these lesions are known to respond poorly to conventional techniques and being expansile type of lesions cyberknife radiosurgery was offered to this patient. She has done well and therefore represents a small group of patients with expansile lesion in the thalamus brain stem region where CyberKnife radiosurgery offers a good prospect of cure or long term control with good quality of life. Short duration of treatment is an advantage when expected life span is short. Also, fractionated radiosurgery may carry the advantage of lesser side effects, as is the case with conventional radiotherapy, than single dose of GammaKnife radiosurgery.
Carcinoma endometrium, post operative, post chemoradiation with paraaortic lymphnodal recurrence

TREATING CONSULTANT
Dr. KUMAR SWAMY, MD

DEMOGRAPHICS
Sex: Female
Age: 57 Years
Past Medical History: Nil

CASE HISTORY
This is an international patient who presented with complaints of backache in Oct 2007, she was diagnosed as a case of carcinoma endometrium, on 14.10.07. Patient underwent extended Total Abdominal Hysterectomy + Bilateral salphingo-ophorectomy + Pelvic & iliac lymphnode dissection. Histopathology revealed Adenocarcinoma stage III c FIGO. PET CT scan on 11.10.07 revealed active disease in right paraaortic lymphnode. Patient was treated with chemoradiation, weekly Cisplatin x 5 + External beam radiotherapy to a dose of 45 Gy / 25 #, followed by intravaginal Brachytherapy.

Patient was on regular follow up and found to have recurrence in retroperitoneal lymph node region which was confirmed with biopsy. Patient was treated with 6 cycles of chemotherapy with Paclitaxel + carboplatin. PET CT evaluation after 3 cycles showed 50% reduction in disease and which continued bepersistent disease even after 6 cycles with development of persisting backache. Hence patient was referred to HCG for evaluation regarding Cyberknife Radiosurgery.

PET CT Scan On 11.10.09 revealed persistent disease in the retroperitoneal lymphnodal mass, 5.5 x 3.3 cm size, with marginal increase in metabolic activity. There was increased tracer uptake in nodal mass (SUV- 14.7). The mass lesion was extending into adjacent right psoas muscle and found enclosing / compressing adjacent right ureter causing moderate right hydroureteronephrosis. There was dilatation of 2nd part of duodenum due to extrinsic pressure. On 23.10.09 patient underwent cystoscopy + right RGP + Dilatation of stricture and DJ stenting (silicon). After this procedure, the patient was planned for Cyberknife radiosurgery along with Hormonal therapy.

CYBERKNIFE TREATMENT RATIONALE:
This patient presented with infiltrating paraaortic mass with ureteric obstruction and going for duodenal obstruction. One option was reirradiation with IMRT to the paraaortic region followed by Radiosurgery boost. In view of impending duodenal obstruction and established ureteric obstruction option of relieving duodenal obstruction, radiosurgery to the paraaortic mass and Hormonal therapy to take care of systemic component was offered.
TREATMENT DETAILS:
- Tumor volume: 11.1 cc
- Tumor volume: 212 cc
- Fractions/Treatment time: 5/75 min / fraction
- Imaging Technique(s): PET CT
- Path Template: 2paths
- Rx Dose & Isodose: 25 Gy to 70%
- Tracking method: Fiducial tracking
- Conformality Index: 1.33
- Collimator(s): 20 mm
- Tumor Coverage: 96.75%
- Number of beams: 181

TREATMENT PLANNING PROCESS:
Tumor target volume and surrounding critical structures (Right kidney, Intestine, duodenum) were contoured to fully reconstruct a three-dimensional tumor target and to include critical structure volumes. The tumor target volume measured was 212 cc indicating that it is a large volume disease. The treatment plan was prescribed to deliver 25 Gy in five fractions of 5 Gy each. The 70% prescription dose covered 96.75% of the tumor target volume by using this plan. It provided a 1.34 homogeneity index score and a 1.33 conformality index score while minimizing dose to the critical structures.

TREATMENT DELIVERY
The patient was kept under observation as an inpatient to keep a watch for intestinal obstruction. A minimal dose of 25 Gy to the 70% isodose line in 5 daily fractions was delivered. The patient tolerated her treatment uneventfully. Patient was put on Progesterone Hormonal therapy (Magestrol Acetate 40 mg QID) and was discharged subsequently.

OUTCOME AND FOLLOW UP
- Patient did present 3 months later with bilateral pitting edema. Follow up PET-
CT on 18.02.10 (3 months post CK)
→ Significant reduction in soft tissue mass encasing right common iliac vessels, Good response to therapy. Other findings were right renal vein thrombus, insufficiency fracture of sacrum. Patient was evaluated for deep vein thrombosis and put on long term thrombolytic therapy.

- Follow up PET-CT on 01.10.10 (11 months post CK) → Showed further interval reduction in retro peritoneal soft tissue mass encasing right common iliac vessels with a small residual lesion of 1.4x 2.6 cm. Stable bilateral sacral ala changes. Interval resolution of right renal vein thrombosis. Good response to therapy. No new metastatic lesions.

- Asymptomatic and continued on Hormonal therapy, presently patient is doing fine and due for follow up in 2011

CONCLUSIONS AND CYBERKNIFE ADVANTAGES:
In patients with indolent disease, especially when it is locally advanced, combinations of the treatment are likely to improve the disease free survival and quality of life, if not the overall survival. Combinations of CyberKnife radiosurgery which has the potential to give excellent local control (where systemic therapy may not be as effective), with a form of systemic therapy that can prevent the recurrence elsewhere would be made for each other. This is especially true in cancer following an indolent course.
Low grade left frontal astrocytoma

TREATING CONSULTANT
Dr. Sridhar P S, MD

DEMOGRAPHICS
Sex: Male
Age: 36 Years
Histology: Low Grade left frontal Astrocytoma
Past Medical History: Known case of Asthma since childhood

CASE HISTORY
Patient presented with history of single episode of seizure in 2006. He was evaluated with MRI Brain on 26.04.06 which revealed well defined lesion on T2 and flair in the left frontal region, involving the pericallosal gyrus. Anteriorly no contrast enhancement was seen with minimal oedema around the lesion. These features were suggestive of low grade glioma. Patient underwent stereotactic biopsy on 24th May 2006 which revealed low grade astrocytoma with gliosis. Patient was advised observation and close follow up, then, since the patient was not willing for radiotherapy. However he presented with complaints of seizures again on 28.12.09. MRI Brain revealed left fronto-parietal patchy enhancing mass with extension and mass effect consistent with low grade glioma. He was then referred for Cyberknife radiosurgery.

Repeat MRI Brain on 15.02.10 revealed non-enhancing ill-defined hyperintense lesions with foci of haemorrhage and suspicious focal calcification involving left frontal lobe, corona radiata, centrum semiovale and extending into corpus callosum associated with gyral broadening and mild mass effect suggestive of neoplastic lesion. All the options of treatment were discussed in detail with the patient and relatives. They opted for Cyberknife Radiosurgery and were continued to be unwilling for conventional radiation.

CYBERKNIFE TREATMENT RATIONALE:
This was a patient of low grade glioma who was under observation for long time. Patient not waiting to undergo neither gross tumor resection nor safe marginal resection nor the conventional radiotherapy when advised. Due to progressive symptoms patient opted for Cyberknife Radiosurgery. SRS has been one of the options for Juvenile pilocytic astrocytoma.

TREATMENT DETAILS:
Tumor volume: 116 cc
Fractions/ Treatment time: 5/45 min / fraction
Imaging Technique(s): PET-CT/ MRI
Path Template: 1path
Rx Dose & Isodose: 25Gy to 78%

Fig 1: Beams, DVH (Dose Volume Histogram) and the isodose distribution showing excellent sparing of normal brain tissue and targeting precisely the tumour
Tracking method : 6 D-skull tracking
Conformality Index : 1.11
Collimator(s) : 30 mm
Tumor Coverage : 95.65%
Number of beams : 242

TREATMENT PLANNING PROCESS
Tumor target volume and surrounding critical structures (Brain stem, optic chiasm, optic nerves, Eyes) were contoured to fully reconstruct a three-dimensional tumor target to include critical structure volumes. The tumor target volume measured 116 cc. The treatment plan was prescribed to deliver 25 Gy in five fractions of 5 Gy each. The tumor target volume was covered by 95.65 % using this plan. It provided a 1.17 homogeneity index score and a 1.28 conformality index score while minimizing dose to the critical structures.

TREATMENT DELIVERY
The patient was treated on outpatient basis with a dose of 25 Gy to the 78 % isodose line in 5 daily fractions (equivalent of minimal dose of 42 Gy/21fractions, of conventional radiation), from 24.02.10 to 2602.10. The patient tolerated the treatment and was sent home after each session.

OUTCOME AND FOLLOW UP
Patient did develop recurrent of seizures in May 2010. When evaluated with MRI (3 months post CK) which showed moderate reduction in size of the left frontal lesion measuring 7.1x3.4x4.8 cm (previously 8.1x5.2x5.8 cm) indicating reasonable response at 3 months for a low grade glioma.

CONCLUSION
This young patient of 36 years with low grade glioma was unwilling for conventional therapies preferred to be under observation. With the progression of symptoms opted for Radiosurgery, had moderate response as early as 3 months.

Patients with juvenile pilocytic astrocytoma can be good candidates for Cyberknife fractionated stereotactic radiosurgery, which is expected to give lesser side effects and better control.
Recurrent salivary gland carcinoma, post operative post radiotherapy

TREATING CONSULTANT
Dr. KUMAR SWAMY, MD

DEMOGRAPHICS
Sex: Female
Age: 45 Years
Histology: Acinic cell carcinoma
Past Medical History: None

CASE HISTORY
Patient was diagnosed with Carcinoma Right Parotid Gland (Acinic Cell Carcinoma) in end of 2005. She underwent right total parotidectomy on 06.02.06, followed by adjuvant External beam radiation therapy. Immediately afterwards patient had recurrence of the lesion at the primary site for which she underwent surgery again. She was disease free for some time and had recurrence for the second time in 2007 for which she underwent neck nodal clearance. Locally, third recurrence happened in 2008 for which sleeve resection was done. One year later (3 years from the initial presentation ) PET CT evaluation, on 24.07.09, revealed local recurrence in the base of skull on the right side (tragus, external Auditory canal & middle ear),with destruction of mastoids & adjacent bones and infiltration towards jugular foramen. Along with this recurrence, patient developed complaints of mild headache, giddiness, vomiting & difficulty in walking, loss of hearing in the right ear. In view of localized recurrence in the region of base of skull, patient was referred to HCG for further management and feasibility of CyberKnife. She was assessed and found to be a candidate for Cyberknife Radiosurgery.

CYBERKNIFE TREATMENT RATIONALE:
The patient was not considered to be a resection candidate or treatment with reirradiation since patient had already undergone resection thrice and EBRT once. Patient had indolent type of disease often recurring around the primary site without metastatic manifestation. Now the patient presented with severe disabling symptoms with impending erosin intracranially. There are several published articles regarding Radiosurgery as a good treatment option in recurrences around the base of the skull and head and neck region. CyberKnife radiosurgery has the ability to track during the treatment and hence has a very precise technique in targeting the tumor and excluding the surrounding normal critical structures without the limitation of size of the tumor unlike in Gammaknife . Hence this patient was offered Cyberknife Radiosurgery to improve the local control and disease free survival along with control of distressing symptoms.

Fig 1: PET-CT axial section showing recurrent lesion in the skull base. There was no breach in the bone to posterior cranial fossa yet.

Fig 2: PET-CT axial section showing recurrent lesion in the skull base with GTV, CTV contours
TREATMENT DETAILS:

<table>
<thead>
<tr>
<th>Imaging Technique(s)</th>
<th>PET CT, MRI</th>
</tr>
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<tbody>
<tr>
<td>No of Paths</td>
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</tr>
<tr>
<td>Rx Dose &amp; Isodose</td>
<td>24 Gy to 70%</td>
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<tr>
<td>Tracking Method</td>
<td>6 D-SKULL</td>
</tr>
<tr>
<td>Number of Beams</td>
<td>635</td>
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<tr>
<td>collimator(s)</td>
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<tr>
<td>Fractions/Treatment Time</td>
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</tbody>
</table>

TREATMENT PLANNING AND DELIVERY

PET CT images were acquired. The tumour and critical structures (spinal cord, brain stem, cochlea, eyes etc) were contoured for dose calculation purpose. The patient was positioned supine in a customized thermoplastic mask device. Inverse planning was used to generate a plan of 179 beams. A dose of 24 Gy was prescribed to the 70% isodose and delivered in 3 daily fractions using a 10 mm Collimator. 6 D-SKULL tracking was used and each outpatient session lasted 60 minutes including setup.

OUTCOME AND FOLLOW UP:

Follow up PET CT was performed at 3 months Post treatment, revealed residual disease but with no metabolic activity. There were minimal residual mass in right mastoid, no obvious intracranial extension, mild interval regression of neck nodes. Symptomatically patient was ambulatory with complete relief from headache. However, there were subcentimeter pulmonary nodules to be kept under observation.

Fig 3: Beams, DVH (Dose Volume Histogram) and the isodose distribution showing excellent sparing of Brain stem and targeting precisely the tumour

Fig 4: Beams and the isodose distribution showing excellent sparing of Brain stem, spinal cord and targeting precisely the tumour in coronal and sagittal section as well

Fig 5: showing near total resolution of the recurrent lesion 3 months post CK
Hepatocellular carcinoma T4N0M0 post TACE with residual disease

TREATING CONSULTANT
Dr. Kumara Swamy

DEMOGRAPHICS
Sex: Male
Age: 75 Years
Histology: Poorly differentiated Hepatocellular carcinoma
Past Medical History: Known case of Diabetic and Hypertensive since 10 years on treatment

CASE HISTORY
Patient presented with history of low back pain, breathlessness in Nov 2008. Patient was investigated and diagnosed with a cystic lesion in the liver. FNAC from liver lesion revealed poorly differentiated Hepatocellular carcinoma. PET CT Scan on 28.11.08 revealed dense calcifications replacing the two hepatic lesions, consistent with HCC; diffuse heterogeneous density of the spine with relative lucency of L1 vertebral body, stable since prior study, of unclear significance. There was also interval development of a small irregular pleural based opacity in the upper lobe of right lung - inflammatory/ infectious etiology.

Patient underwent 3 sessions of treatment with TACE using lipiodol and Adriamycin, 3rd session on 15.06.09. Whole body PET CT on 23.09.09 revealed metabolically active lesion in segment 7 of right lobe measuring 3.9 x 3.8 cms. and the other lesion was metabolically inactive. AFP level on 27.05.09 was 2760 ng/ml and AFP level on 10.09.09 is 37,600 ng/ml.

In view of rising AFP and PET CT findings, patient was evaluated for cyberknife treatment. Both the active and inactive (to have long term control) lesions were planned for Cyberknife Radiosurgery.

PreCyberknife CT Scan of thorax, abdomen and pelvis on 23.10.09 revealed two ill defined subcapsular space occupying lesions in the liver with central necrosis, no portal/ retroperitoneal adenopathy, no pulmonary parenchymal pathology, no pleural effusion / ascities, diffuse osteopenia with lumbar spine degenerative changes.

WHY CYBERKNIFE RADIOSURGERY?
This patient of age 75 years, in good general condition, had recurred after conventional therapies. AFP had peaked to nearer to 40,000 ng/ml, indicating progression of liver lesions. The literature indicates better outcome when Radiationtherapy is combined with TACE or RFA. In this patient RFA was not feasible. Therefore, CyberKnife treatment was offered, to be followed by systemic therapy.

Fig 1: Beams, DVH (Dose Volume Histogram) and the isodose distribution showing excellent sparing of normal liver tissue, spinal cord and targeting precisely the tumour
CYBERKNIFE TREATMENT RATIONALE:

- Although liver cancer surgery (surgical resection) is preferred among the treatments for liver cancer, only 20% of patients are suitable candidates.
- Stereotactic radiotherapy (SRT) offers a treatment option for hepatocellular carcinoma (HCC) patients that are not eligible for surgery, embolization, chemotherapy, or radiofrequency ablation.
- In a recent publication, October 2010, Louis C et al have evaluated the feasibility, tolerance and toxicity of SRT for 25 HCC patients who were not eligible for these other modalities. The patients (6 women and 19 men) were treated with CyberKnife stereotactic radiotherapy using respiratory motion tracking. All patients had liver cirrhosis with an Eastern Cooperative Oncology Group (ECOG) performance score of less than 2 and pre-treatment Child scores ranging from A5 to B9. Overall the treatment was well tolerated with two Grade 3 acute toxicities and no acute Grade 4 toxicities. The actuarial 1- and 2-year local control rate was 95% (95% CI: 69-95%). At a median overall follow-up of 12, 7 months (range, 1-24 months), six of the twenty-five (24%) patients have died. Overall actuarial survival at 1- and 2-years was 79% (95% CI: 52-92%) and 52% (95% CI: 19-78%), respectively. According to the authors, their results suggest promising therapeutic efficacy and good clinical tolerance to CyberKnife SRT treatment for HCC patients not eligible for other treatment modalities 1.

- Thus far in the treatment of liver tumors, centers have treated with the CyberKnife® System alone or in combination with transhepatic arterial chemoembolization. Single-fraction approaches have achieved local liver tumor control with a dose of 25 Gy 2.
- Other centers have treated with three fractions to a total dose of 30-39 Gy, with just a few mild side effects noted 3.

TREATMENT DETAILS:

- Tumor volume: 60.6 cc
- Fractions/ Treatment time: 5/ 90 min / fraction
- Imaging Technique(s): PETCT, MRI
- Path Template: 2path
- Rx Dose & Isodose: 30Gy to 70%
- Tracking method: Fiducial tracking
- Conformality Index: 2.57
- collimator(s): 10 mmTumor
- Coverage: 99.41%
- Number of beams: 156

TREATMENT PLANNING PROCESS:

Tumor target volume and surrounding critical structures (Right Lung, remaining liver, kidney etc) were contoured to fully reconstruct a three-dimensional tumor target to include critical structure volumes. The tumor target volume measured 60.6 cc. The treatment plan was prescribed to deliver 30Gy in five fractions of 6Gy each. The tumor target volume was covered by 99.41 % using this plan. It provided a 1.43 homogeneity index score and a 2.57 conformality index score while minimizing dose to the critical structures.

Fig 2: Beams and the isodose distribution showing excellent sparing of normal liver tissue, lung, intestines and targeting precisely the tumour in coronal and sagital section as well
TREATMENT DELIVERY
The patient was treated on outpatient basis with a dose of 30 Gy to the 70 % isodose line in 5 daily fractions (equivalent of minimal dose of 54 Gy/27fractions, of conventional radiation) from 28.10.09 to 02.11.09. The patient tolerated his treatment and was sent home after each session.

OUTCOME AND FOLLOW UP
- PET-CT, 3 months post CK (10.02.10) showed interval reduction in size and enhancement of the previously noted residual mass with an exophytic component in the segment VI of liver, status post TACE and CK. Was started on Tab Sorafenib (Nexavar) from Feb 2010
- AFP dropped to 1880 ng/ml (Feb 2010 , 3 months post CK) and 1380ng/ml (Jul 2010, 8 months post CK)
- PET-CT, 11 months post CK (30.10.10) No significant interval change in the size and morphology of the exophytic component in the segment VI of liver was seen. No new lesions appeared.
- Jan 2011 -Continued on Tab Nexavar (since 14 months post CK) AFP – 3290 ng/ml , referred for consideration of TACE
- Patient underwent Radiochemoembolization with Transarterial I-131 Lipiodol therapy on 29-1-2011. Post therapy study showed good uptake of Radioiodine in the lesion.
- Patient has remained asymptomatic 16 months post CK, with excellent quality of life

CONCLUSION AND CYBERKNIFE ADVANTAGES
Cyberknife robotic radiosurgery system is the only one of its kind which tracks the tumour, with breathing, as the treatment is going on. This leads to several advantages. Unlike with linear accelerator based radiosurgery less or no margins of normal tissue need to be given. Hence least amount of normal tissue gets included. Tolerance for the treatment increases disproportionately. Higher dose per treatment can be given with total dose being the same or higher biological equivalent. It is established that, higher the dose per session, lesser the chances of cancer cell recovery between treatment sessions, including that of cancer stem cells. This way cancer cell resistance is overcome. At the same time possibility of severe side effects decrease drastically.

Increasing the total dose of biological equivalent can be done safely, to a level which is hither to not dreamed of. This is expected to give significant number of long term control if not cure, in patients who have early disease but not suitable for surgery. In patients with more advanced disease, with other forms of therapy like chemo and targeted drugs, one can attempt for improvement in disease free survival, especially in slow progressing liver cancers.

Fig 3 : PET-CT images, Pre Cyberknife (23.09.09), 3 months post CK (10-02-10), 11 months post CK (30-10-10) revealing good local control.
Liver is one of the critical organs and conventional radiation techniques leads to significant number of patients ending up with radiation induced liver disease. However, now for the first time, using CyberKnife robotic radiosurgery system, it is possible to exclude the normal liver tissue to maximum extent and deliver the required dose to control the tumour.

This patient of HCC, with 2 lesions in the liver, is progression free 16 months post diagnosis with combinations of therapies. His quality of life has been excellent. In this group of patients with indolent course, offering combination of targeted therapies including Cyberknife Radiosurgery is rewarding. The combination of these advanced targeted therapies ensures good control of disease with excellent quality of life.

Post Script:
1. CyberKnife is also indicated in patients who are waiting for liver transplant, the indication considered as "bridge to liver transplant". This will help in prevention of progression of disease as the patient is waiting for liver transplant, which may take months of preparation.

2. In patients with thrombus in the portal vein it is possible to recanalize the portal vein with cyberknife radiosurgery and make the patient feasible for either chemoembolization or radiochemoembolization.

REFERENCES