RT plan evaluation in primary liver tumors-
Sparing the organs

Dr Anand Narayan
Consultant Radiation Oncologist
GKNM Hospital, Coimbatore.
Liver Radiotherapy

- Traditionally considered too toxic. Experience with conventional liver RT (RILD).
- Unique anatomy knowledge.
- Many competing local therapies.
- Modern radiotherapy can spare the dose limiting tissues - revival of RT for liver tumors both primary and secondaries.
Must know....

• Liver anatomy

• Radiology in HCC

• Child Pugh score

• Barcelona Clinic Liver cancer staging (BCLC)

• TNM staging- pitfalls
Child Pugh score

- Used to predict the severity of chronic liver disease - cirrhosis.
- Five point scoring 1-3
  - Albumin
  - Bilirubin
  - Clotting factor - PT/INR
  - Distention - Ascites
  - Encephalopathy
- Class A - 5-6 points
- Class B - 7-9 points
- Class C - >=10 points
Marrero et al, HEPATOLOGY, 2018
HCC- Management overview

• TNM staging – inadequate for non surgical therapies.
• Does not take into account the associated liver disease and co-morbidities.
• Surgical resection +/- transplant is the standard for operable tumors.
• Other local therapies for inoperable tumors.
  • RFA/ MWA
  • TACE
  • TARE
  • SBRT
• BCLC- staging most commonly used -accounts for both tumor and associated liver disease.

RT is notably absent in its recommendation!
Indications

Klein J, Dawson L, IJROBP 2013
SBRT scores vs RFA/ TACE...

• Tumor size > 2-3 cm- better local control.
• Tumor near vasculature/ central biliary system.
• Difficult visualization or percutaneous approach.
• Portal vein thrombosis.
• Non invasive (except fiducials)
• No anaesthesia
• PT/ INR not a constraint.
• Seems safe in pretreated patients as well.
Evidence till now

• Comparison with other local therapies-
  • Multiple retrospective studies, single institution prospective, Phase I/ II studies.

• RT with other local therapies like TACE / resection/ LT is being explored.

• 2 yr local control 65- 90%

• Predictors - BCLC stage- PS, CP score, size.
Ideal patient

- Child Pugh class A
- Ineligible for resection/other local therapies.
- >1 cm from critical OAR like bowel, diaphragm, central liver, chestwall
- 1-3 lesions
- No extrahepatic disease
- Tumor clearly defined in TPCECT/ MRI
- Vascular thrombus
Unique Challenges in Liver Radiotherapy

• No fixed anatomy

• OARs differ with location of tumor in liver

• Reduced baseline functional reserve
  • Cirrhosis, previous resection, chemotherapy

• Dynamic changes due to breathing, bowel movement/ distention

Cannot be accounted for by a “snapshot image” of simulation scan.

Sparing organs require more than RT planning.
Unique Challenges in Liver Radiotherapy

• Optimizing therapeutic ratio
  • Achieving ablative dose
  • Sparing normal tissues
  • Underlying liver disease

• Target localisation

• Motion management
  • Intra fraction
  • Inter fraction
Unique Challenges in Liver Radiotherapy

• Optimizing therapeutic ratio through planning.
  • Achieving ablative dose
  • Sparing normal tissues

• Managing underlying liver disease

• Target localisation

• Motion management
  • Intra fraction
  • Inter fraction
Organ motion management

- ITV based volume
- Motion mitigation
- Gating
- Tracking
RT planning

• Simulation
• Target delineation
• Target dose requirements
• OAR and toxicities
• Plan evaluation criterias
Simulation

- Immobilisation- Supine, arms over head, knee rest in a Vacuum bag.
- CT scan-
  - 2-3 hours fasting
  - Non contrast, Triple phase contrast CT
    - Gating depends on motion management used
  - MRI in same position
  - 2 mm slice thickness
  - 15-20 cm above and below liver.
Target delineation

• GTV-
  • Arterial phase enhancement with delayed washout.
  • Guidance from all phases of CT + MRI.
  • Exclude RFA cavity
  • Include enhancing thrombus- not bland ones.

• CTV- 3-5 mm

• PTV- depending on motion management used.
Plan evaluation

• Clear written instructions-
  • Ref ICRU 91 minimum standards of reporting.

• Aims-
  • Ablative, non uniform dose for PTV, hot within GTV.
  • Tightly conforming dose
  • Rapid dose fall off outside PTV
  • High dose gradient
  • Maximum sparing of OAR
Dose prescription

• No standard dose prescription

• Dose depends on achievement of OAR constraints and CP score.

• Aims at $\text{BED}_{10} \sim 100 \text{ Gy}$. 

• Common SBRT doses
  • 15-18 Gy x 3#
  • 8-10 Gy x 5#

• Prescribed to 70-80% isodose.

• Prescribed isodose covers at least 95% PTV.
<table>
<thead>
<tr>
<th>OAR</th>
<th>3# constraints</th>
<th>5# constraints</th>
<th>Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver-GTV</td>
<td>700cc &lt;15Gy Mean&lt;13 Gy</td>
<td>700cc&lt;21Gy Mean&lt;18Gy (CP-A) Mean&lt;6Gy (CP-B)</td>
<td>RILD</td>
</tr>
<tr>
<td>Stomach</td>
<td>V16.5 &lt;10 cc Dmax &lt;22 Gy</td>
<td>V18 &lt;10 cc Dmax &lt;32 Gy</td>
<td>Ulcer/ fistula/ perforation</td>
</tr>
<tr>
<td>Duodenum</td>
<td>V16.5 &lt;5 cc V11.5&lt;10cc Dmax &lt;22 Gy</td>
<td>V18 &lt;5 cc V12.5&lt;10cc Dmax &lt;32 Gy</td>
<td>Ulcer/ fistula/ perforation</td>
</tr>
<tr>
<td>Esophagus</td>
<td>V18 &lt;5cc Dmax&lt;25 Gy</td>
<td>V20 &lt;5cc Dmax&lt;35 Gy</td>
<td>Stenosis/ fistula/ perforation</td>
</tr>
<tr>
<td>Colon</td>
<td>V24&lt;20cc Dmax&lt;28Gy</td>
<td>V25&lt;20cc Dmax&lt;38Gy</td>
<td>Colitis/ fistula</td>
</tr>
<tr>
<td>Heart/ pericardium</td>
<td>V24&lt;15cc Dmax&lt; 30Gy</td>
<td>V32 &lt;15cc D max&lt; 38Gy</td>
<td>Pericarditis</td>
</tr>
<tr>
<td>Skin</td>
<td>V30 &lt;10cc D max&lt; 33 Gy</td>
<td>V37 &lt;10cc D max&lt; 40Gy</td>
<td>ulceration</td>
</tr>
<tr>
<td>Rib</td>
<td>V29&lt; 1cc D max&lt; 37Gy</td>
<td>V35&lt;1 cc D max&lt; 43</td>
<td>Pain/ fracture</td>
</tr>
<tr>
<td>Spinal cord</td>
<td>V18&lt; 0.35 cc</td>
<td>V23 &lt; 0.35 cc</td>
<td>Myelopathy</td>
</tr>
<tr>
<td>Central biliary tree</td>
<td>V18&lt; 0.35 cc</td>
<td>V23 &lt; 0.35 cc</td>
<td>Stenosis/ leak</td>
</tr>
</tbody>
</table>

Based on TG 101 and QUANTEC. D max= V0.035cc
ICRU reporting standards

- Prescription dose
- Prescription ICRU reference point or dose/volume e.g. % isodose covering PTV
- Number of treatment fractions
- Total treatment delivery period
- Target coverage
- Plan conformity
- Dose gradient
- Heterogeneity index
- Dose to organs at risk.
Take home..

• Promising treatment with good local control rates.

• Proper case selection is important- multidisciplinary team management.

• Preventing complications through achieving dose constraints is the key.

• Meticulous attention at every step of treatment is necessary for achieving ablative dose with sparing of normal structures.
Further reading

• ICRU 91
• AAPM TG 101- SBRT
• AAPM TG 76- motion management in RT.