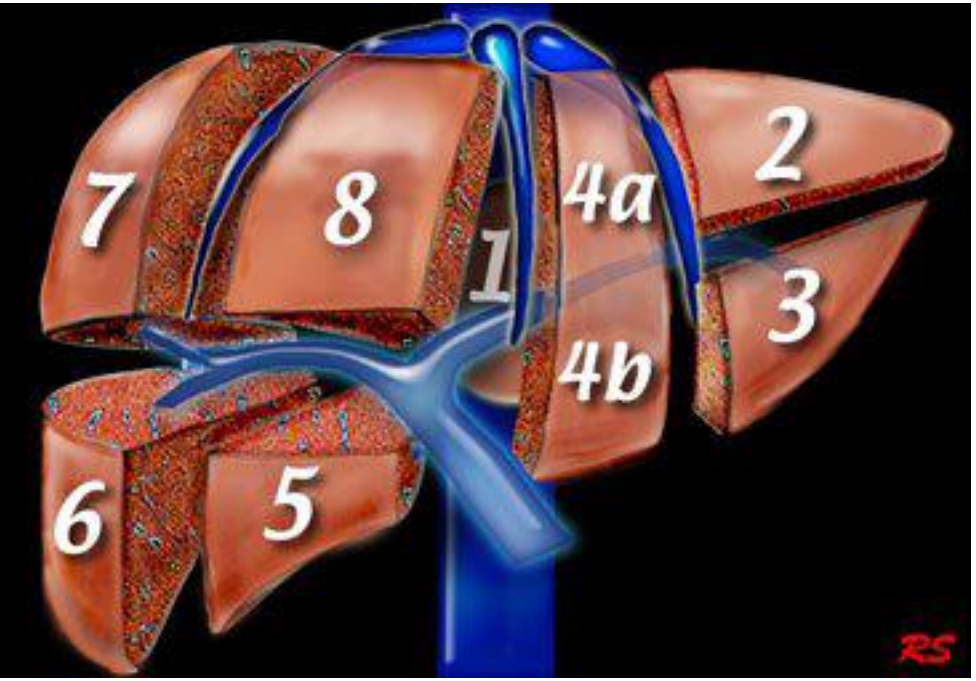

RT plan evaluation in primary liver tumors- Sparing the organs

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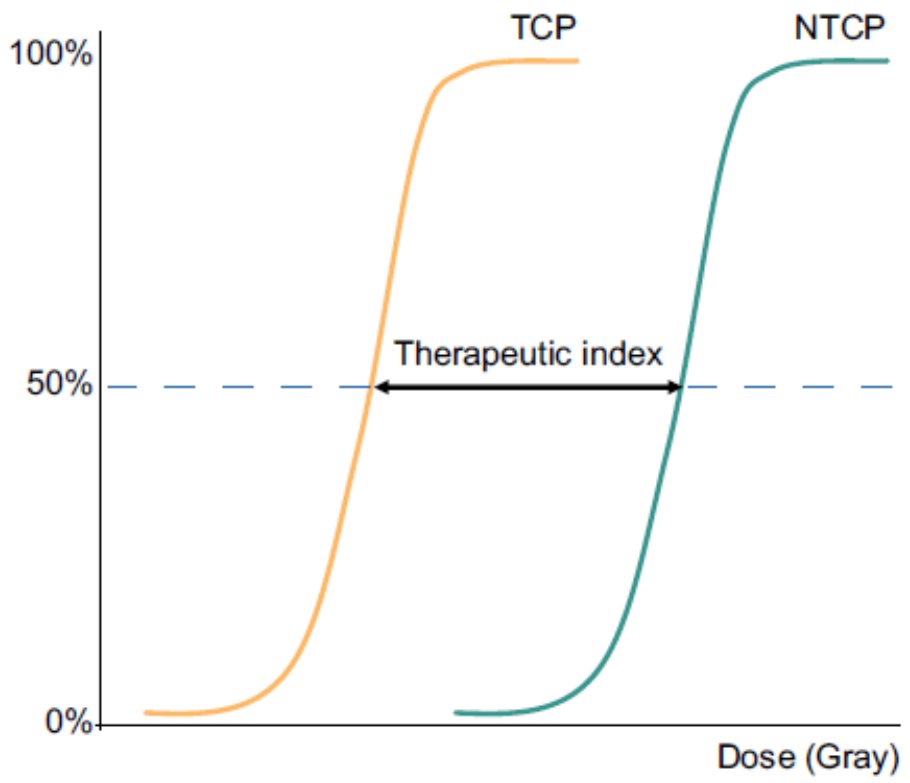
Liver Radiotherapy



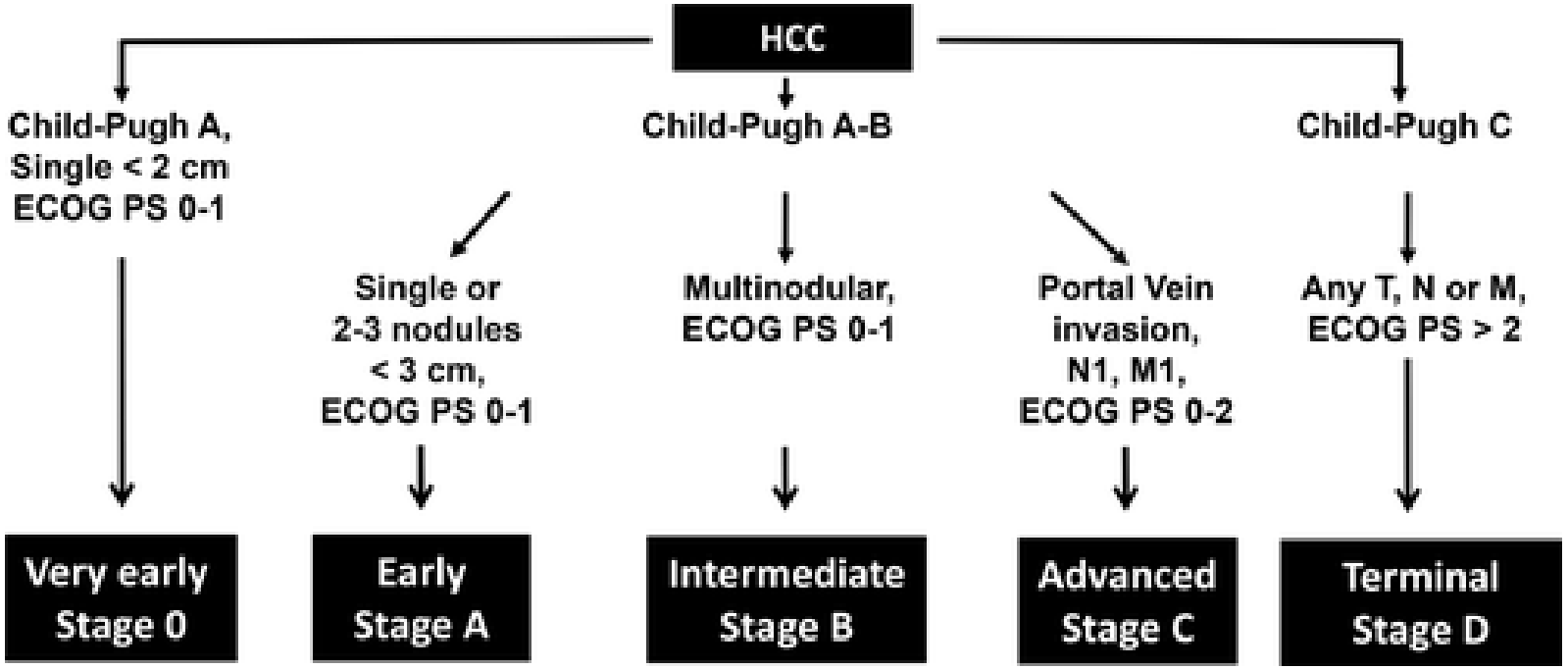
- Traditionally considered too toxic. Experience with conventional liver RT (RILD).
- Unique anatomy knowledge.
- Many competing local therapies.
- Modern radiotherapy can spare the dose limiting tissues- revival of RT for liver tumors both primary and secondaries.

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

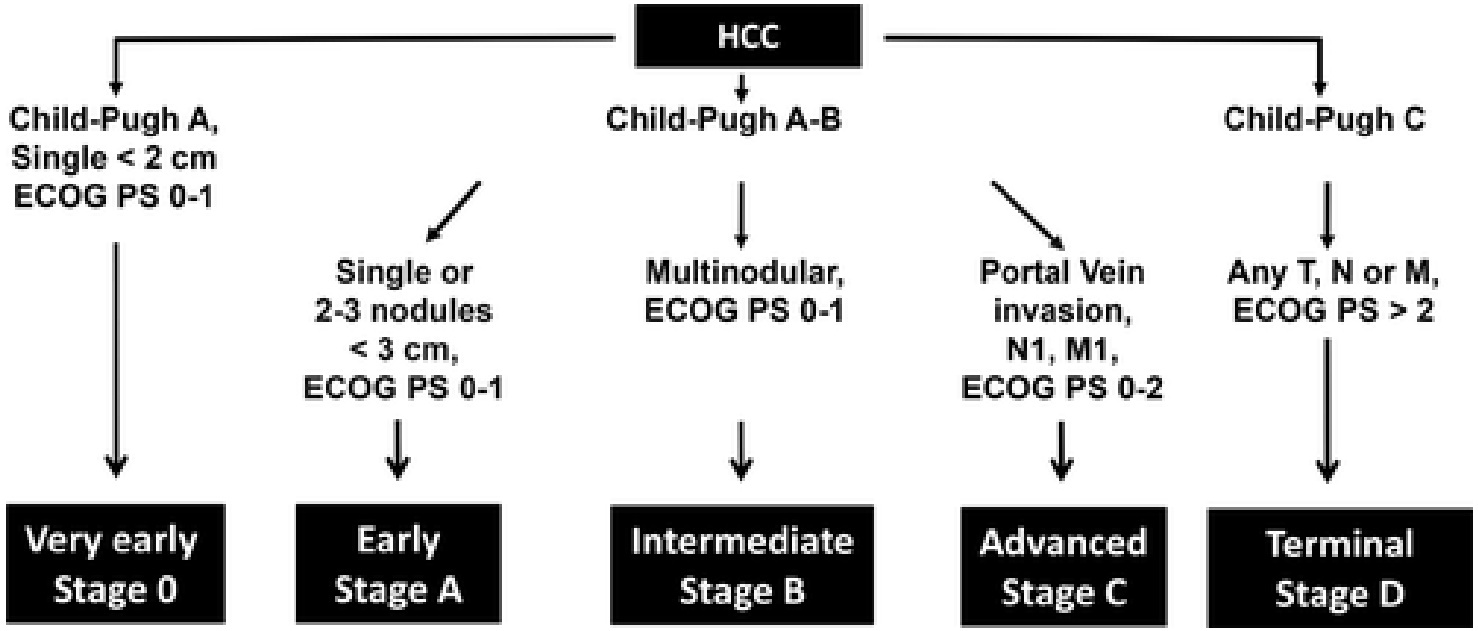


Marrero et al, HEPATOLOGY, 2018

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.

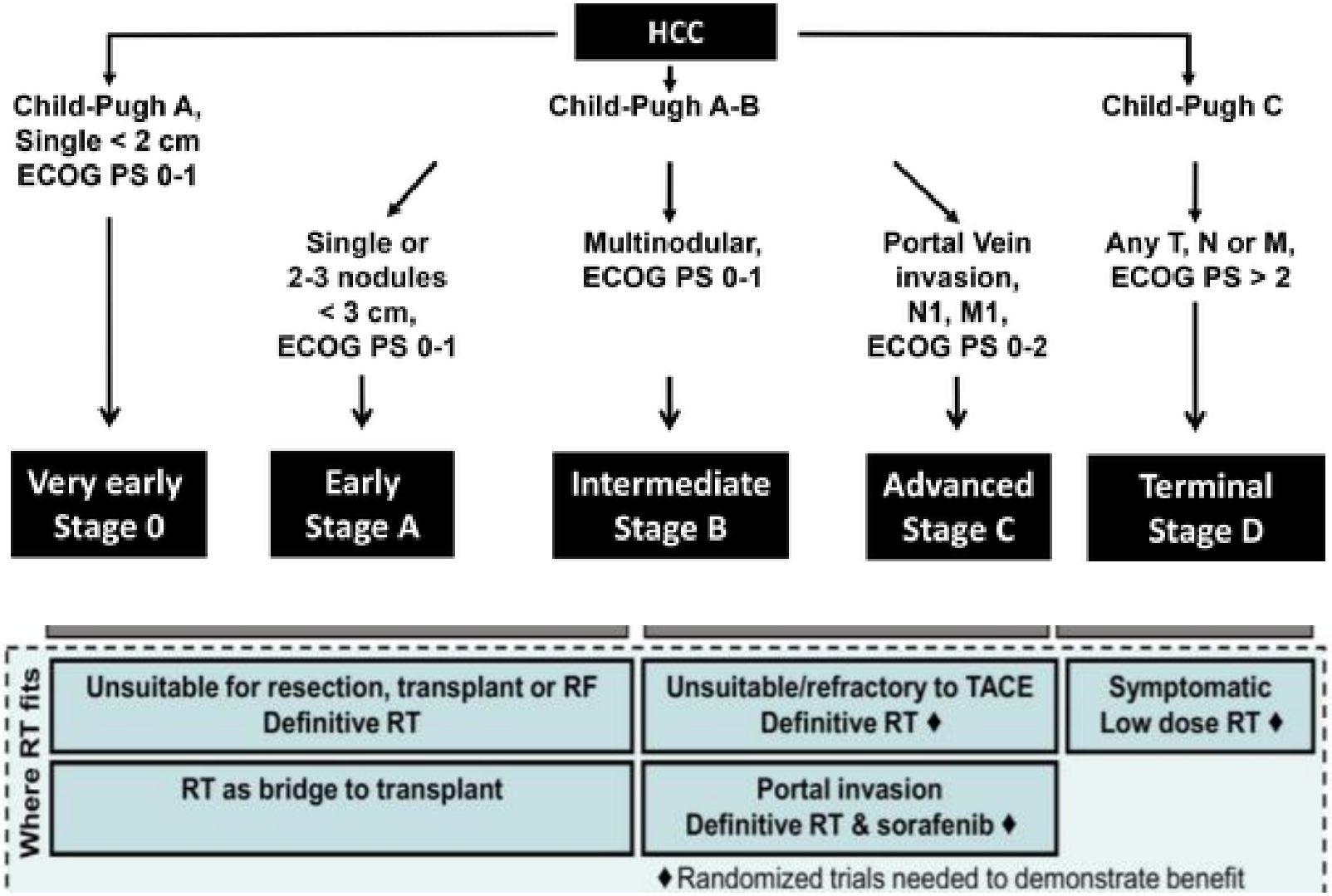
RT is notably absent in its recommendation!



Level of Evidence					
1	Resection		TACE	Sorafenib (1L) Lenvatinib (1L) Regorafenib (2L) Cabozantinib (2L)	
2	RFA MWA	Resection OLT RFA MWA TARE TACE SBRT	TARE Downsize OLT	Nivolumab (2L)	OLT BSC
3				TARE	

Marrero et al, HEPATOLOGY, 2018

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

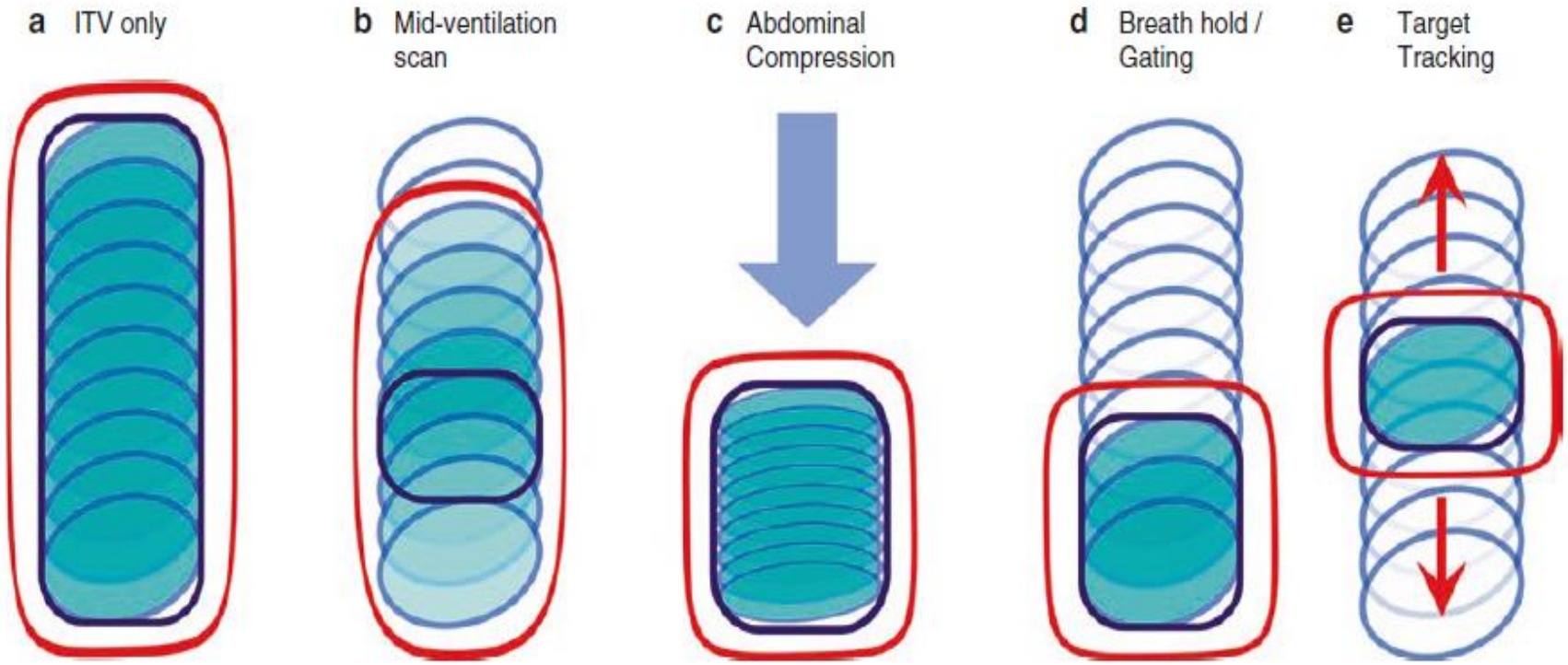
- Optimizing therapeutic ratio
  - Achieving ablative dose
  - Sparing normal tissues
  - Underlying liver disease
- Target localisation
- Motion management
  - Intra fraction
  - Inter fraction

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



https://doi.org/10.1007/978-3-030-16924-4

RT planning

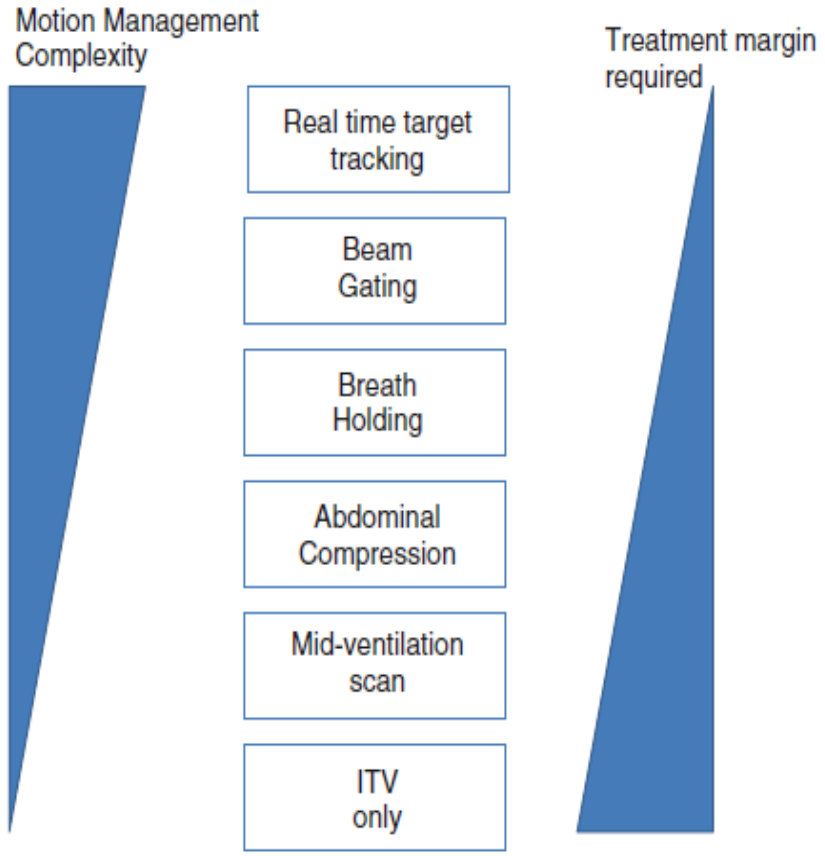
- Simulation
- Target delineation
- Target dose requirements
- OAR and toxicities
- Plan evaluation criterias

Simulation

- Immoblisation- Supine, arms over head, knee rest in a Vaccum 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 BED_{10} ~100 Gy.
- Common SBRT doses
  - 15-18 Gy x 3#
  - 8-10 Gy x 5#
- Prescribed to 70-80% isodose.
- Prescribed isodose covers atleast 95% PTV.

OAR	3# constraints	5# constraints	Endpoint
Liver-GTV	700cc <15Gy Mean< 13 Gy	700cc<21Gy Mean <18Gy (CP-A) Mean <6Gy (CP-B)	RILD
Stomach	V16.5 <10 cc Dmax <22 Gy	V18 <10 cc D max < 32 Gy	Ulcer/ fistula/ perforation
Duodenum	V16.5 <5 cc V11.5<10cc Dmax <22 Gy	V18 <5 cc V12.5<10cc Dmax <32 Gy	Ulcer/ fistula/ perforation
Esophagus	V18 <5cc Dmax-< 25 Gy	V20 <5cc Dmax < 35 Gy	Stenosis/ fistula/ perforation
Colon	V24<20cc Dmax<28Gy	V25<20cc Dmax<38Gy	Colitis/ fistula
Heart/ pericardium	V24<15cc Dmax< 30Gy	V32 <15cc D max< 38Gy	Pericarditis
Skin	V30 <10cc D max< 33 Gy	V37 <10cc D max< 40Gy	ulceration
Rib	V29< 1cc D max< 37Gy	V35<1 cc D max <43	Pain/ fracture
Spinal cord	V18< 0.35 cc	V23 < 0.35 cc	Myelopathy
Central biliary tree		V40<37cc V30<45cc	Stenosis/ leak

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.