



A treatment planning comparison of three dimensional conformal radiotherapy and proton therapy for primary liver carcinoma

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Introduction





- Primary liver carcinoma (PLC) is one of most common malignant tumor in china. While surgery is the primary treatment modality at present. Unfortunately, the most of the PLC patients are, technically unresectable or medically inoperable when they are diagnosed.



- Radiotherapy is a commonly used non-surgical treatment modality which is often the preferred choice by PLC patients.
- With the more advanced technique of three-dimensional conformal radiotherapy (3D-CRT), treatment outcomes have notably improved .



- Though 3D-CRT has been commonly used to treat PLC in recent years and better outcomes have been observed compared to the earlier conventional treatment methods , radiation-induced liver disease (RILD) is yet one of the most serious treatment-related complications for patients.



- In fact, RILD has become a major barrier for application of 3DCRT in PLC treatment.
- The liver tolerance to radiation closely correlates with the irradiated volume, the dose and hepatic functions .



The tolerance dose limits for liver

Liver volume radiated	The tolerance dose (Gy)
1/3 live	90
2/3 live	47
Entire live	31

Dawson LA, Ten-Haken RK, Lawrence TS. Partial irradiation of the liver. *Semin Radiat Oncol* 2001,11:240-246



Treatment is safe when doses not exceeding doses showed in the table

for child-Pugh A patients

Mean dose to normal liver (MDTNL)	≤ 23 Gy
V5	≤ 86 Gy
V10	≤ 68 Gy
V15	≤ 59 Gy
V20	≤ 49 Gy
V25	≤ 35 Gy
V30	≤ 28 Gy
V35	≤ 25 Gy
V40	≤ 20 Gy

Jiang GL. Three-dimensional conformal radiotherapy: a new technology for primary liver carcinoma treatment. *Oncology progress (Chinese)* 2006, 4: 279-282



The tolerance dose limits for liver

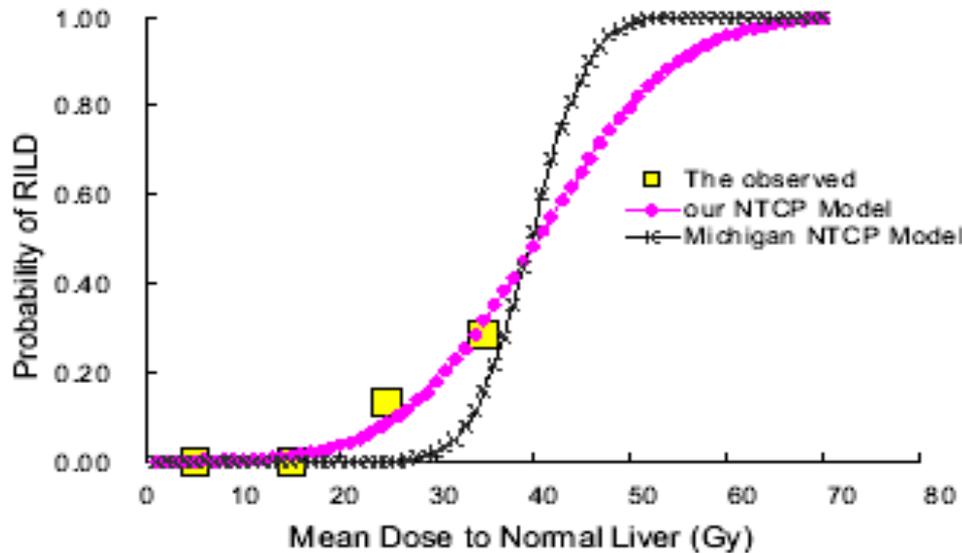


Fig. 1. Prediction of probability of radiation-induced liver disease (RILD) for Child-Pugh grade A patients by Michigan's and our Lyman NTCP models. Parameters of Lyman model were: $n = 0.97$, $m = 0.12$, $TD_{50}(1) = 39.8$ Gy and $n = 1.1$, $m = 0.28$, $TD_{50}(1) = 40.5$ Gy for Michigan's and our model, respectively. The squares on the figure were the observed incidences of RILD from 93 primary liver cancer patients with cirrhosis of Child-Pugh grade A.

The tolerable doses of **mean dose to normal liver** would be 21 Gy for Child-Pugh A patients



- Proton beam has a finite range and at the end of the range the dose falls precipitously to virtually zero . Therefore, proton radiotherapy (PRT) may be an important alternative to treat PLC cases.



- Proton beams can also be used to do three-dimensional conformal treatment. This makes it possible to deliver higher doses to the target volume while simultaneously reducing the dose to adjacent normal tissue .



- In this study, we assess the potential benefits of PRT in primary liver cancer management through the treatment plan comparisons between 3DCRT and PRT.



Methods and Materials





- Ten patients with advanced primary liver carcinoma were selected for the study.



Patient and tumor characteristics

Patient no	Sex	Age (years)	T stage	GTV (ml)	Child-Pugh classification
1	male	48	T3	802.4	A
2	male	42	T4	2151.1	B
3	male	55	T3	1318.1	A
4	male	50	T4	363	B
5	male	45	T2	16.2	A
6	male	52	T2	45.7	A
7	male	52	T ₁	132.8	A
8	male	51	T4	1733.2	A
9	male	46	T1	933.28	A
10	male	34	T4	2109.1	A



- The CTV was defined as the gross tumor volume (GTV) plus a 5-10mm margin, while the PTV encompassed the CTV with an additional 5-10mm margin.



- The organ at risk (OAR) include normal liver tissue, duodenum, stomach and spinal cord. The normal liver tissue was defined as the total liver volume minus GTV.



- The 3DCRT plans consisted of 5 coplanar photon conformal radiation fields .
- the PRT plans used two coplanar proton fields.



- All treatment plans were evaluated with dose volume histograms (DVH).
- Prescribed dose were 50 and 60 CGE to PTV for the two different treatments plans of each patient, respectively. Fractionation size was 2 CGE.



- The DVH for target volume and normal liver were calculated.



- Then the treatment plans were assessed in terms of the mean dose to normal liver (MDTNL) and other DVH parameters including V5, V10, V20, and V30 (percentage of normal liver volume receiving radiation dose at least 5 CGE, 10 CGE, 20 CGE, and 30 CGE, respectively).



- The role of PRT in primary liver carcinoma radiotherapy was evaluated based on the change of these parameters as the dose was escalated from 50 to 60 CGE.

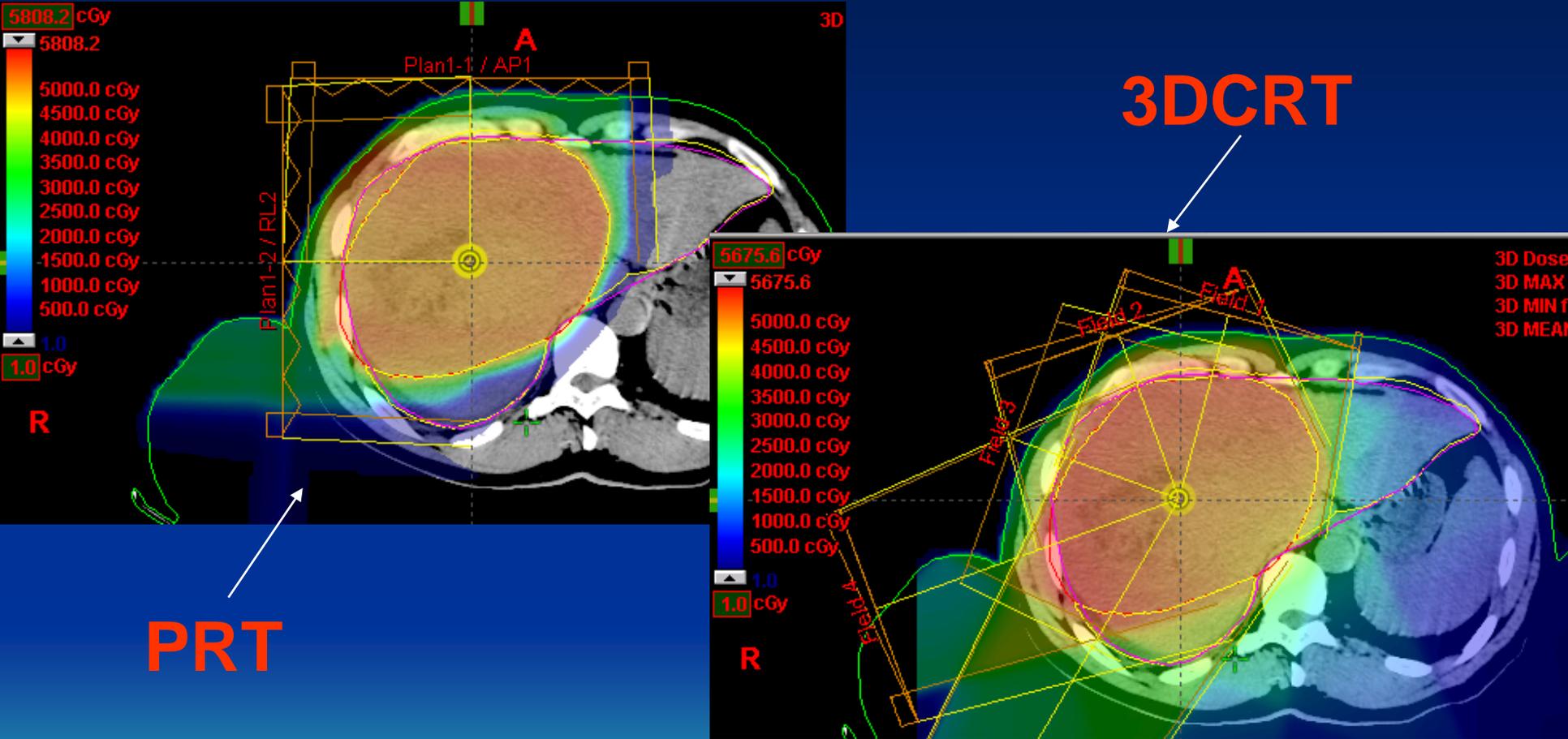


Results





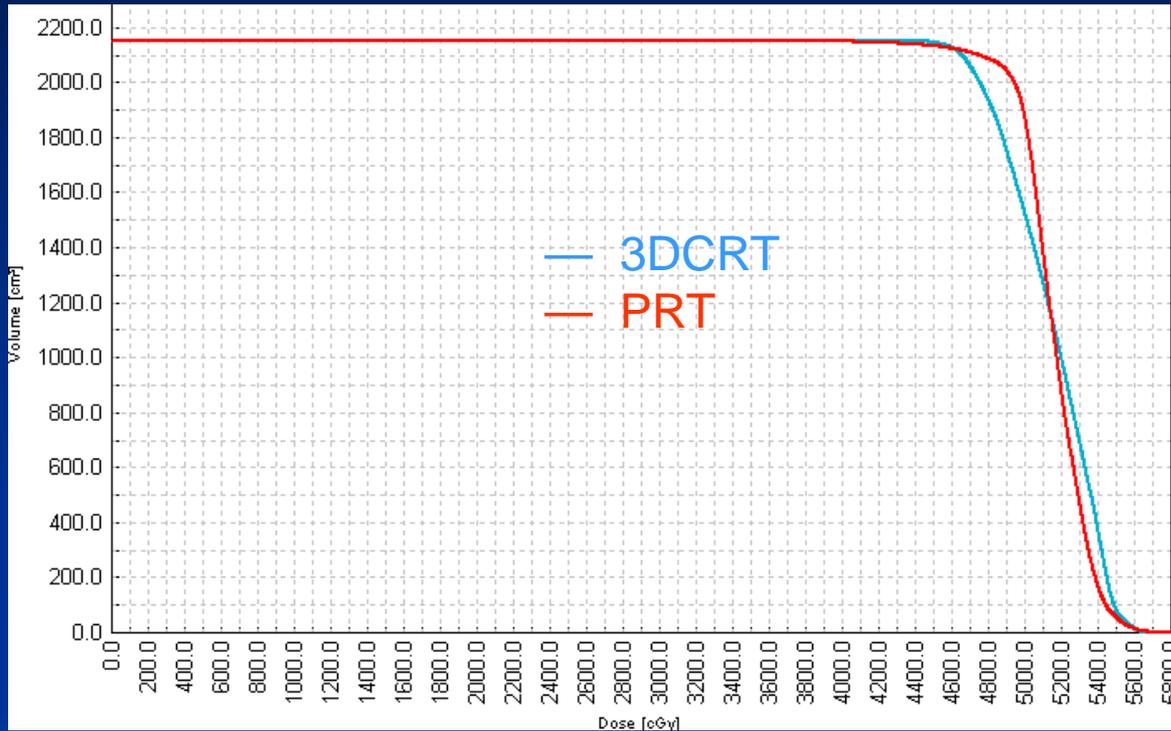
The dose distribution of two treatment plans



The figures showed that the dose distribution of PRT was obviously superior to that of 3DCRT.



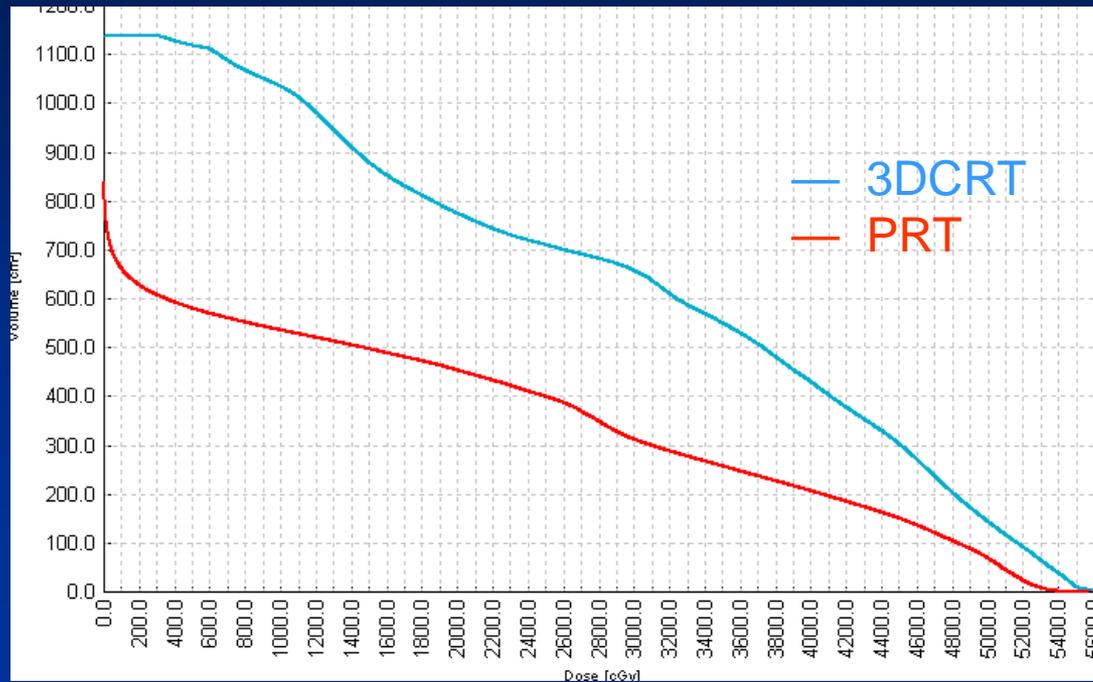
The DVH for target



- Target volume coverage were satisfactory in both plans



The DVH for normal liver



- the normal liver DVH demonstrated that the dose to normal liver for PRT was markedly lower than that for 3DCRT



Mean dose to normal liver

Patients no	Mean dose to normal liver (CGE)			
	PRT		3DCRT	
	50CGE	60CGE	50Gy	60Gy
1	16.4	19.68	41.07	49.28
2	16.65	19.98	31.52	37.83
3	14.2	17.04	30.74	36.89
4	18.39	22.07	26.26	31.52
5	15.6	17.88	20.53	24.64
6	12.62	15.43	17.2	20.64
7	12.37	14.29	21.36	25.63
8	17.96	21.78	31.06	36.92
9	13.81	16.51	27.08	32.5
10	21.05	25.04	35.68	42.82
Mean	15.91	18.97	28.25	33.87

- Regardless of 50 or 60 CGE for the prescribed dose, compared with 3DCRT all MDTNL of PRT are superior and didn't exceed the tolerance level of normal liver



• Comparison of dosimetric parameters between PRT and 3DCRT

Parameters	PRT		3DCRT	
	50CGE	60CGE	50Gy	60Gy
V_5 (%)	51.29 ± 7.29	52.07 ± 7.30	85.10 ± 10.21	86.36 ± 10.02
V_{10} (%)	46.70 ± 7.23	47.83 ± 7.23	77.34 ± 11.96	79.65 ± 11.70
V_{20} (%)	35.12 ± 8.59	38.94 ± 7.86	62.38 ± 13.05	67.13 ± 11.88
V_{30} (%)	24.88 ± 8.21	29.85 ± 9.71	45.39 ± 19.13	52.68 ± 18.27



Summary

- Due to the superior dose distribution for the proton beams, the reduction of absorbed radiation dose in surrounding normal tissues was obtained
- As a result prescribed dose may be increased further with PRT safely.

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proton therapy center**



Thanks for your attention

