

Introduction

Sequential SABR delivery is common in oligometastatic disease, but liver reirradiation using conventional techniques is often challenging due to cumulative normal liver dose. The use of on table MRI-informed target volume delineation, daily plan adaptation and cine-MR gated beam delivery can significantly reduce the volume of normal liver receiving both the prescription dose and low dose bath, increasing the scope for reirradiation. We present a case of liver reirradiation illustrating the benefits of MR-guided radiotherapy (MRgRT).

Treatment course 1

Case summary

A 50-year-old lady with a diagnosis of metastatic breast cancer, who had had a previous wide local excision and subsequent breast radiotherapy. She later presented with a single solitary liver metastases. MDT review recommended SABR using MR-guidance, 45 Gy in 3 fractions on alternative days.



Diagnostic PET/CT scan showing single intense focus of uptake in the right lobe of the liver measuring greater than 1 cm in diameter.

Patient consented to MRgRT SABR and travelled to GenesisCare, Oxford for treatment in May 2020. Daily use of gadolinium-based Primovist prescribed to better visualise the target volume on setup imaging and during tracking and gating.

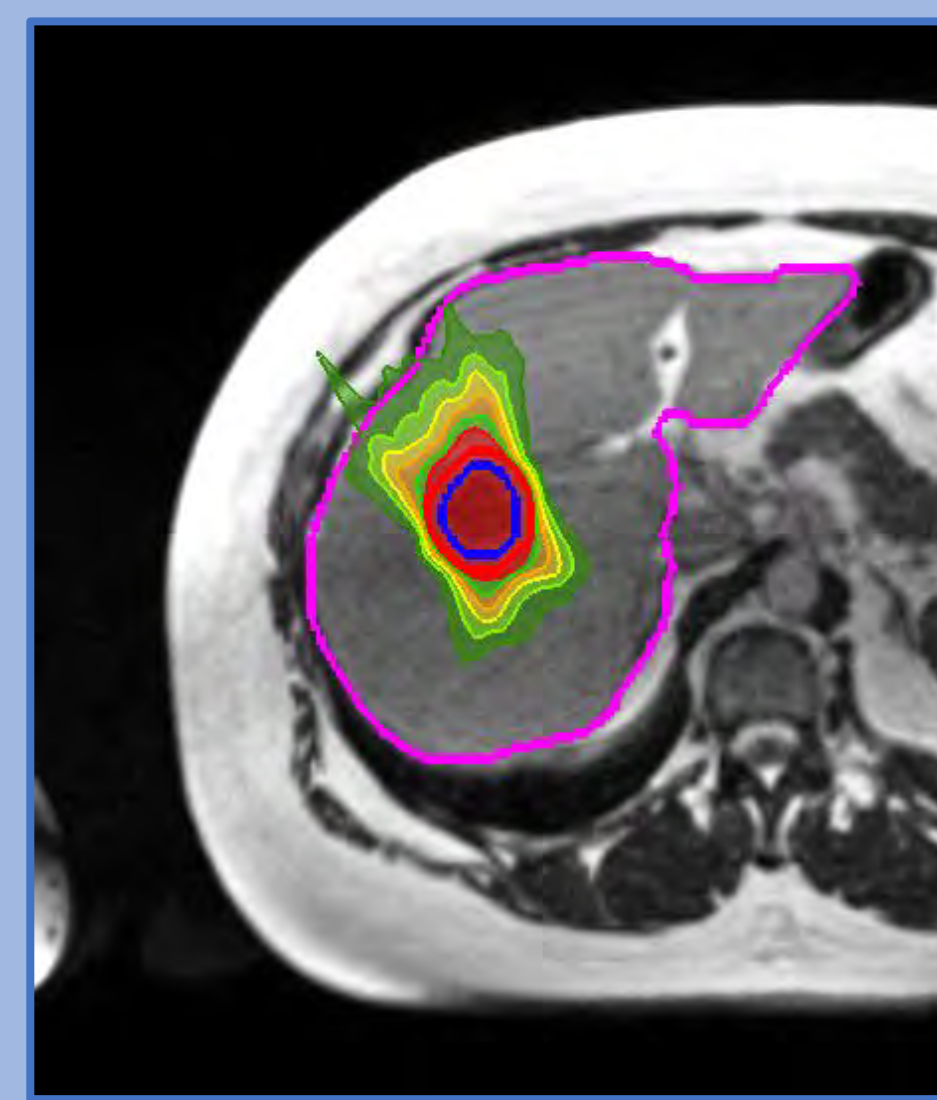
MRgRT SABR treatment

Treatment margins:

$$CTV = GTV + 0.3 \text{ cm}$$

$$PTV = CTV + 0.3 \text{ cm}$$

All treatment fractions delivered using fully adaptive workflow, including MR-guided setup imaging and positioning; target and OAR recontouring; plan-re-optimisation; and real-time cine-MR image tracking with beam gating.



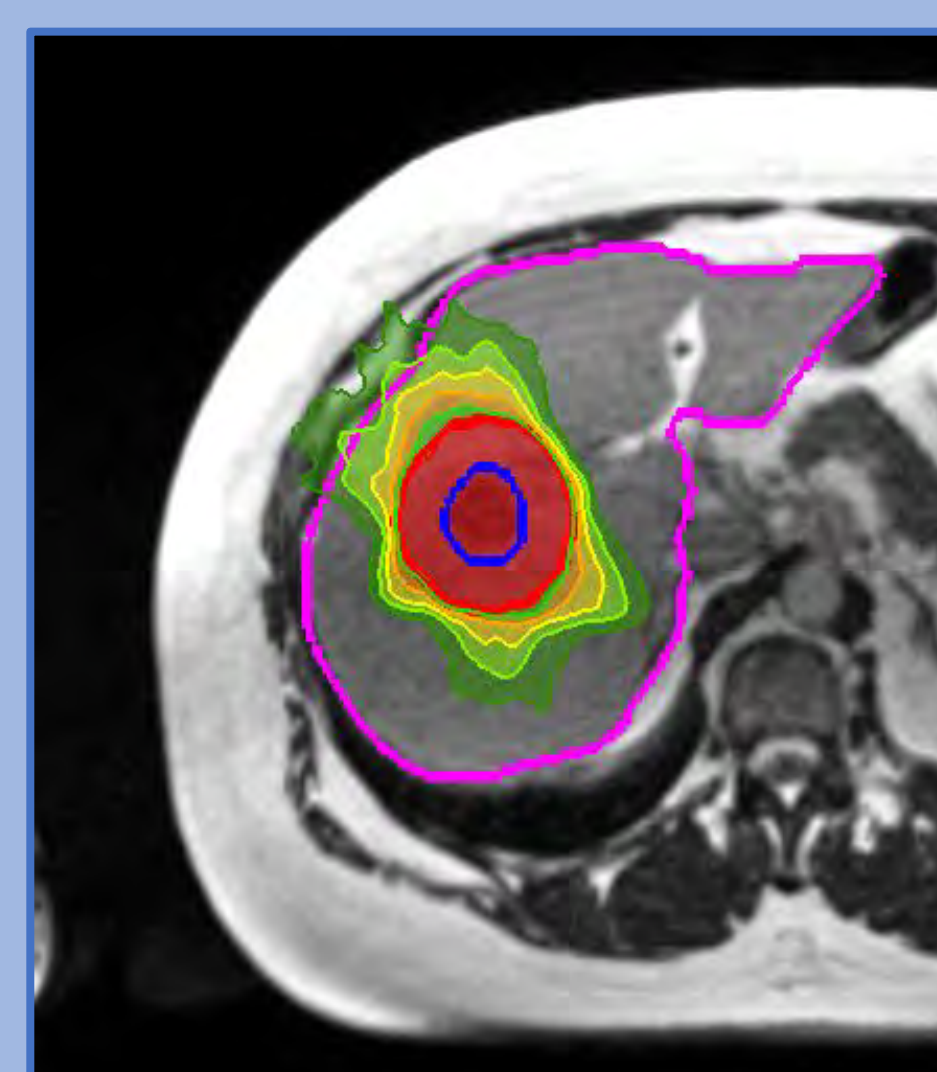
Conventional SABR

Treatment margins:

$$CTV = GTV + 0.3 \text{ cm}$$

$$PTV = CTV + 1.5 \text{ cm}$$

Simulated CBCT guided treatment without adaption or gating. Larger PTV margin required to ensure adequate coverage of the CTV when registering to skeletal landmarks.



	MRgRT SABR	Conventional SABR	Tolerance
PTV volume	18.33 cc	77.93 cc	
Normal liver D(50%)	1.67 Gy	9.23 Gy	15 Gy
Liver receiving 15 Gy	265 cc	534 cc	

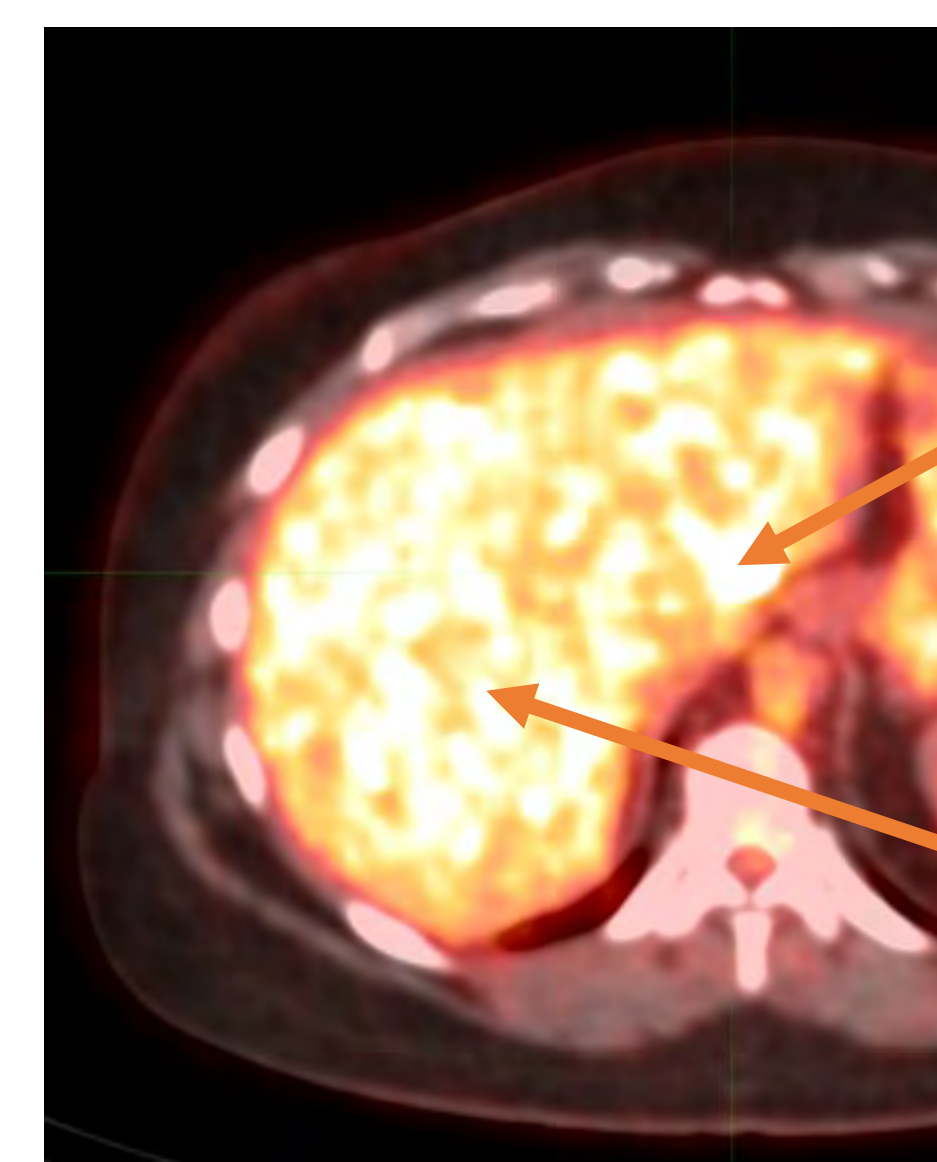
Comparison case study

Two treatment approaches are compared. The patient underwent MR-guidance for both treatments. MR guidance, particularly the acuity of tumour visualisation coupled with automated beam gating, enabled much smaller margins than would have been required using a CT-guided approach with abdominal compression. Fully ablative doses were delivered on both occasions. We simulated the dosimetry that would have been delivered using conventional SABR and show that this would have limited the ability to deliver as high a dose for the second course.

Treatment course 2

Case summary

Patient re-presented 6 months later with two new lesions in the left lobe of the liver, close to the oesophagus and IVC. MDT review recommended SABR treatment to both lesions of 45 Gy / 3#.



Lesions noted in caudate lobe and segment 2 of the liver. New when compared to previous diagnostic imaging.

CT showed area of oedema as a result of the first SABR treatment course.

Following review of the previous treatment, no changes to dose constraints were required for the gastro-intestinal OARs. To account for previous liver irradiation, the 'normal liver' volume which must be spared is reviewed as:

Normal liver =
Liver minus
GTV minus
Previous irradiated volume

MRgRT SABR treatment

Treatment margins:

$$CTV = GTV + 0.3 \text{ cm}$$

$$PTV = CTV + 0.3 \text{ cm}$$

Using MRgRT greatly limits the amount of normal liver receiving significant doses. This permitted reirradiation to be successfully planned and delivered whilst maintaining OAR tolerances.



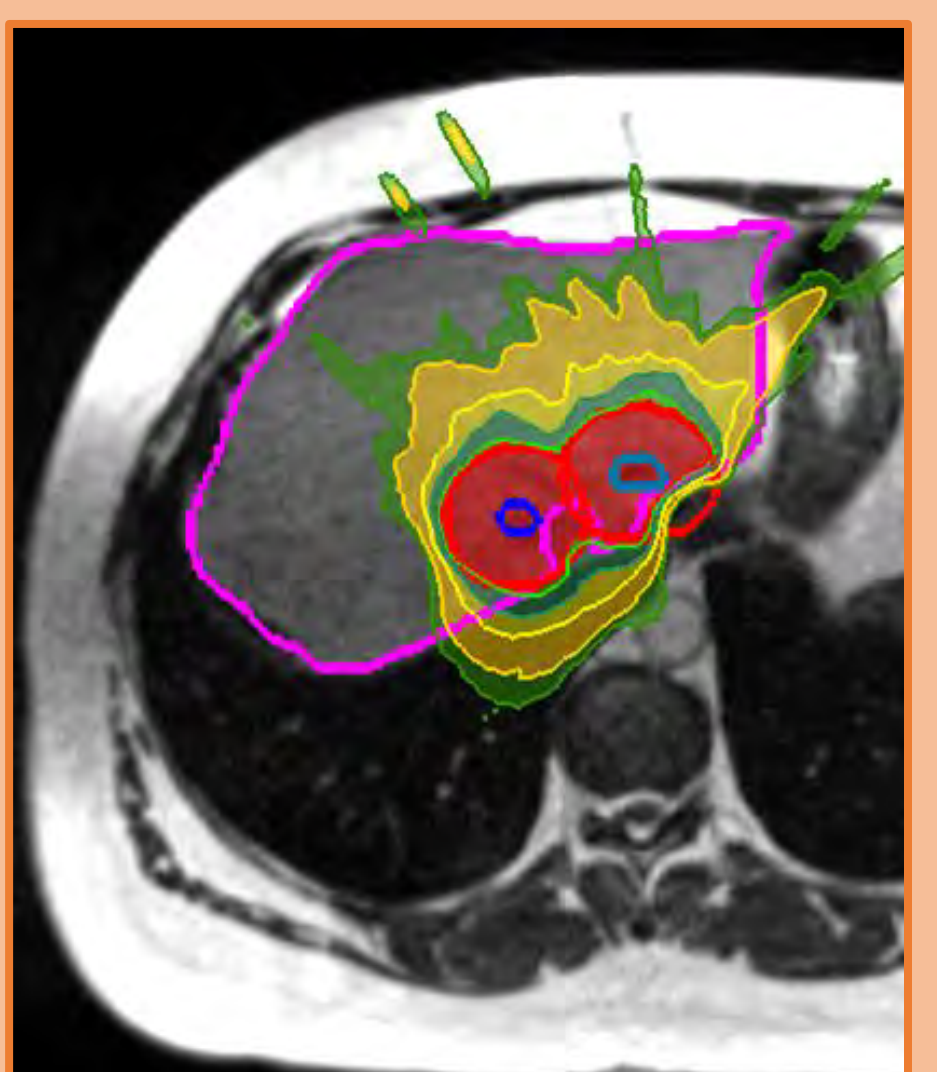
Conventional SABR

Treatment margins:

$$CTV = GTV + 0.3 \text{ cm}$$

$$PTV = CTV + 1.5 \text{ cm}$$

Due to the size of the PTV volumes required to account of intrafraction motion, a large proportion of the liver received significant doses during the first treatment course. As such, it would not be possible to safely plan the reirradiation using conventional SABR.



	MRgRT SABR	Conventional SABR	Tolerance
PTV volume	18.33 cc	77.93 cc	
Remaining normal liver	1036 cc	778 cc	
Normal liver D(50%)	2.99 Gy	15.27 Gy	15 Gy

References

Henke L, Kashani R, Robinson C, Curcuro A, DeWees T, Bradley J, Green O, Michalski J, Mucic S, Parikh P, Olsen J. Phase I trial of stereotactic MR-guided online adaptive radiation therapy (SMART) for the treatment of oligometastatic or unresectable primary malignancies of the abdomen. *Radiotherapy and Oncology*. 2018 Mar 1;126(3):519-26.

Yang W, Fraass BA, Reznik R, Nissen N, Lo S, Jamil LH, Gupta K, Sandler H, Tuli R. Adequacy of inhale/exhale breathhold CT based ITV margins and image-guided registration for free-breathing pancreas and liver SBRT. *Radiation Oncology*. 2014 Dec;9(1):1-9.

Seol SW, Yu JI, Park HC, Lim DH, Oh D, Noh JM, Cho WK, Paik SW. Treatment outcome of hepatic re-irradiation in patients with hepatocellular carcinoma. *Radiation oncology journal*. 2015 Dec;33(4):276.

Rudra S, Jiang N, Rosenberg SA, Olsen JR, Roach MC, Wan L, Portelance L, Mellon EA, Bruynzeel A, Lagerwaard F, Bassetti MF. Using adaptive magnetic resonance image-guided radiation therapy for treatment of inoperable pancreatic cancer. *Cancer medicine*. 2019 May;8(5):2123-32.

Spindeldreier CK, Klüter S, Hoegen P, Buchele C, Rippke C, Tonndorf-Martini E, Debus J, Hörner-Rieber J. MR-guided radiotherapy of moving targets. *Der Radiologe*. 2021 Jan 4:1-0.