Online adaptive MR-guided SABR for pancreatic cancer: Multiple dose level planning techniques and experience

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Introduction

The relative radio-resistance of pancreatic cancer and the ubiquitous presence of highly radio-sensitive organs at risk (OARs) makes treatment planning for these cases challenging. A BED_{10} (α/β = 10) of up to 100 Gy may be required to increase the chances of tumour control, which must be delivered whilst minimising doses to nearby critical OARs[1]. Online adaptive MR-guided SABR provides technological advantages to enable ablative doses to be delivered in these complex cases:

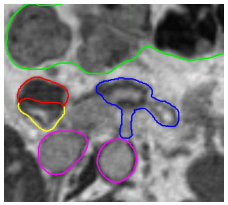
- Excellent soft tissue visualization for fast and accurate contouring
- Daily plan re-optimisation
- Real-time cine imaging and target tracking
- Automatic beam gating

Case study

A 75-year-old male with locally advanced pancreatic cancer. Stable disease after six cycles of FOLFIRINOX. Imaging revels compression of SMV and broad-based contact with SMA ad SA. Deemed inoperable by local multidisciplinary team. GenesisCare SABR MDT recommendation of online adaptive MR-guided SABR to primary disease, 50 Gy in 5# with 33 Gy to elective CTV.

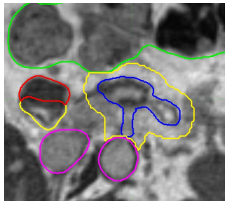
Contouring, margins and doses

Contouring guidance recommends the inclusion gross tumour, involved vessels, and a CTV expansion to incorporate areas of microscopic spread. Dose prescription is 50 Gy In 5#, with 33 Gy to the elective CTV.



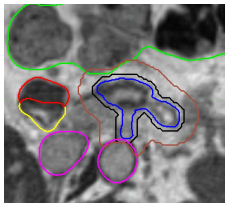
GTV

Primary tumour, extended to include CT and SMA to origin, involved vessels at that level



CTV33

CTV33 = GTV + 9 mm
Trimmed to liver, vessels, duodenum, stomach, small bowel



PTV50 PTV33

PTV50 = CTV50 + 3 mm
PTV33 = CTV33 + 3 mm

Duodenum Stomach

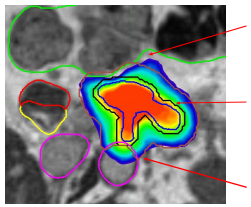
Small bowel Vessels

PTV50 is subdivided into PTVhigh, a section of the PTV which avoids OARs, and PTVlow, an intersection PTV50 and OARs with an expansion to account for dose drop off. Planning aims are set such that PTVhigh V(95%) > 98%, to ensure that as much of the PTV as possible is covered by the prescription dose. A core within PTVhigh is created where doses ≥ 130% of the prescription dose can be deposited is also created.

To enable fast recontouring during the adaption process, luminal GI structures (oesophagus, stomach, duodenum, small bowel, large bowel) are combined into a single visceral OAR structure.

Organ at risk	Volume	Dose
Visceral OARs	D(0.1 cc)	≤ 36 Gy
	D(0.5 cc)	≤ 33 Gy
Aorta, IVC	D(0.5 cc)	≤ 53 Gy

33 Gy GI OAR tolerance
50 Gy Prescription dose
60 Gy



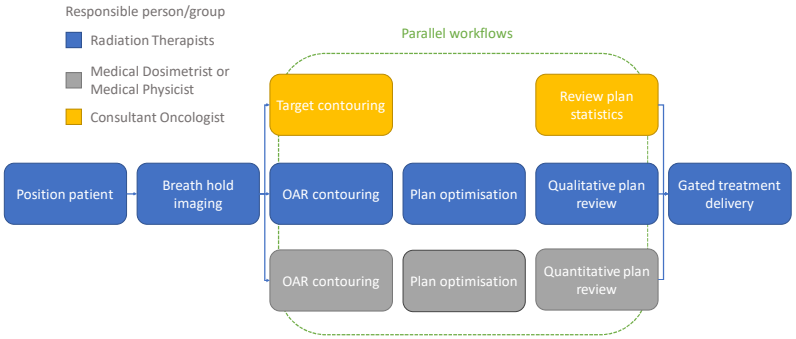
Steep dose gradients to drop to 33 Gy to spare critical GI oars

Maximum doses centred on GTV

Avoiding hot spots within the vessels, whilst maintaining 50 Gy coverage of the PTV

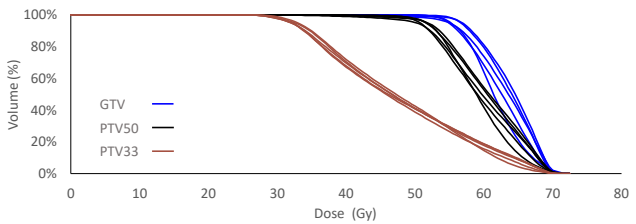
Online adaptive workflow

An online adaptive workflow is carried out at each fraction. This involves adjusting the GTV and nearby OARs to match the anatomy of the day, recreating CTVs, PTVs and optimisation structures, and making any corrections to the electron density to account for the presence or absence of air bubble each day. A parallel workflow is utilised, allowing all member of the multidisciplinary treatment team to work simultaneously. All contouring is expected to be completed in 10 minutes, with the total in-room time for the patient under 1 hour.



Plan optimisation based on the daily anatomy is carried out in parallel. When a suitable potential plan has been identified, a Medical Dosimetrist or Medical Physicist reviews the plan to confirm that quantitate plan metrics are consistent with the baseline plan and inside acceptable ranges. This includes percentage change in GTV volume, PTV coverage, location of hot spots, and prescription dose spillage.

The online adaptive workflow results in consistent GTV and PTV coverage, whilst ensuring that the daily variation in the position of dose sensitive organs at risk are considered. Dose volume histogram for all adaptive fractions is shown below.



	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Fraction 5
GTV D(mean)	63.0 Gy	63.6 Gy	63.9 Gy	62.3 Gy	61.6 Gy
PTV5000 V(50 Gy)	94.5%	97.8%	97.4%	96.7%	97.3%
PTV3300 V(33 Gy)	91.6%	92.8%	94.2%	92.6%	94.8%
Total in-room time	57 minutes	53 minutes	48 minutes	81 minutes	64 minutes

Summary

Online adaptive MR-guided SABR can be utilised to deliver high doses to difficult to reach targets. Complex, multiple dose level planning is feasible and allows for coverage of an elective CTV, which aims to reduce the risk of local recurrence.

References

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