Dosimetric Comparison Of Volumetric Modulated Arc Therapy (VMAT) And Pencil-Beam Scanning (PBS) Proton Therapy For Neoadjuvant Hypo-Fractionated Radiotherapy For Retroperitoneal Sarcoma

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Purpose

This study aims to find out whether Pencil-beam scanning (PBS) Proton Therapy has a dosimetric advantage compared to Volumetric modulated arc therapy (VMAT) for neoadjuvant short course radiation therapy (SCRT) of retroperitoneal sarcomas (RPS) in terms of reducing normal organ doses while maintaining target doses.

Methodology

6 patients were recruited with ages ranging from 43 to 82 years old. They underwent routine immobilization – lying supine in a vacuum bag, with arms above head, and CT-Sim procedure.

The Radiation Oncologists (RO) will contour the target volumes together with the surgeons. Areas with high-risk of recurrence as indicated by the surgeon will be boosted to a higher dose. For patients who have tumours too large to be safely treated with RT, the surgeon will indicate the areas where complete resection is certain, which will be excluded from the RT target volume.

For this dosimetric study, all patients are planned to a prescription of SIB 25Gy & 20Gy in 5 fractions using VMAT and PBS Proton Therapy.

For PBS Proton Therapy, all patients are planned with:
- Multifield optimization (MFO)
- 2 to 4 beams
- Optimisation on PTV
- Robust optimization of 5mm, 3% on CTV
- Beams designed to minimise passing through bowels and stomach
- Bowel contents assigned as muscle and air and optimized on as well

CTV and PTV target coverage were kept similar in VMAT and PBS Proton Therapy plans.

OAR doses were obtained, and the mean was calculated for each treatment technique. Conformity Index and Integral Dose were calculated.

Conformity Index = $\frac{Body\ V100\%}{Vol\ of\ PTV}$

Integral Dose = $\frac{Body\ Volume}{Dmean}$ (in L)

Results & Discussion

	VMAT	Proton	p=value
Stomach D0.03cc	24.0083	23.4217	0.663
Duodenum D0.03cc	15.7950	12.2867	0.115
Small Bowel D0.03cc	23.0383	22.9833	0.748
Large Bowel D0.03cc	19.3567	16.3350	0.200

No significant difference in the Dmax of the stomach and bowels as these organs are usually either overlapping with, or in close proximity with the targets (Fig 1), thus receiving doses near to the prescription dose.

	VMAT	Proton	p=value
Spinal Canal D0.03cc	11.1467	7.2600	0.072
Cauda Equina D0.03cc	10.5050	6.1783	0.048

These results might be due to avoidance and greater sparing of the bowels and kidneys in PBS proton plans at levels where spinal canal is. The absence of kidneys in the slices after about L3 allows the doses to go around the cauda equina.

	VMAT	Proton	p=value
Liver Dmean	3.0467	0.5283	0.011
Remaining Kidney(s) Dmean	3.9533	0.5033	<0.001

Although liver Dmean is significantly lower in PBS proton plans, most of these patients have targets at the inferior portions of the liver and 3 patients have left-sided tumors where proton beam entry through the liver is unnecessary (Fig 2).

For the proton plans, beam angles are designed to avoid the healthy kidney entirely when possible resulting in significantly lower kidney doses (Fig 3).

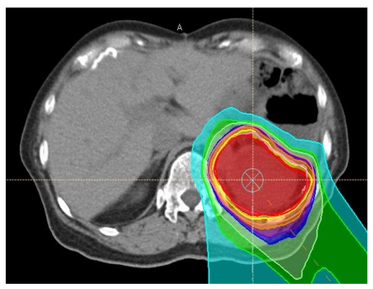

Fig 2:
Example of avoidance of liver in PBS proton plan

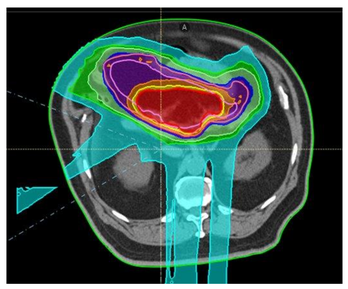

Fig 3:
Example of sparing of kidneys in PBS proton plan

	VMAT	Proton	p=value
Conformity Index	1.11150	1.11533	0.823
Integral Dose	113.49417	70.47917	<0.001

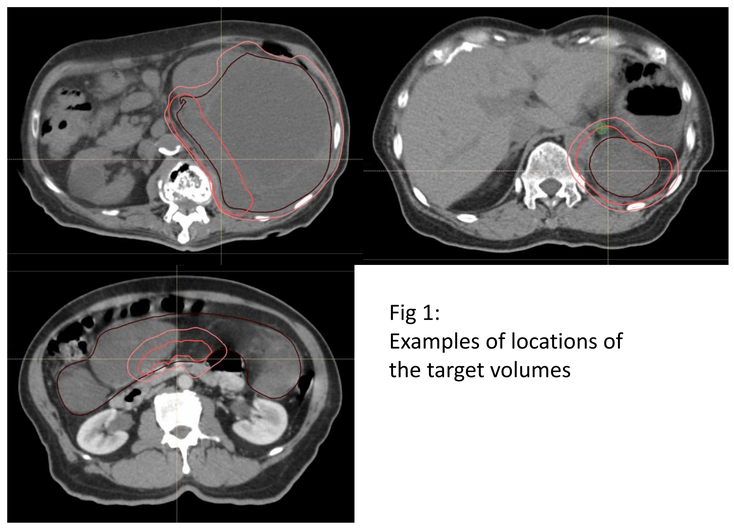

Fig 1:
Examples of locations of the target volumes

Conclusion

Proton PBS results in a significant reduction in liver and kidney doses as compared to VMAT and thus may be useful in treating patients with liver and kidney issues more safely. Although integral dose is significantly lower in PBS plans, the risk of secondary malignancies is unlikely to be a great concern for most RPS patients due to the high-mortality rates. However, Proton PBS may be a good option for younger patients with subtypes that has better prognosis.

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