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Enhancing SABR Workflow Efficiency with Automated VMAT Planning: Operational Impact of TPAS for Liver and Spine SABR Treatments

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ABSTRACT

Purpose: Stereotactic Ablative Radiotherapy (SABR) requires highly complex treatment planning, often consuming many hours of manual effort. The Treatment Planning Automation System (TPAS) was developed to improve efficiency and reduce planner workload while maintaining or improving plan quality. This study demonstrates the impact of TPAS on SABR planning efficiency and quality across two distinct disease sites.

Materials and Methods: Fourteen liver SABR and twenty spine SABR cases were replanned using TPAS. Estimated manual planning times were compared with actual TPAS planning times, including preparation, optimization, and dose calculation. Plan quality was independently reviewed by Radiation Oncologists (ROs) in blinded comparisons, focusing on organ-at-risk sparing, PTV coverage, and overall preference.

Results: In all 34 cases, TPAS plans were unanimously preferred by reviewing ROs over manual plans, confirming that efficiency gains did not compromise quality. TPAS improved average PTV coverage (V100%) from 84.7 ± 15.0% to 90.9 ± 7.2% for spine plans and from 81.98 ± 16.29% to 90.1 ± 9.2% for liver SABR, with all individual TPAS plans showing increased coverage. TPAS reduced estimated planning times from ~3 hours to ~40 minutes for liver SABR, and from on average 8 to 14 hours to ~1 hour for spine SABR. Manual times were based on typical clinical experience.

Conclusions: TPAS substantially reduces SABR planning time while generating clinically superior treatment plans. This efficiency gain can reduce dosimetry workload, shorten patient wait times, and support broader clinical adoption of automated planning. These results demonstrate that TPAS has been successfully integrated into routine SABR workflows, contributing to improved resource utilization and enhanced patient care.

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BACKGROUND

- **TPAS** (Treatment Planning Automation System) was developed to enable fully automated VMAT plan generation using Eclipse scripting and institutional planning protocols. TPAS integrates automatic arc selection, collision avoidance, optimization, and dose calculation into a one-click workflow without supervision.
- TPAS supports our SABR workflows as a planning tool within the dosimetry department. In contrast to our rapid palliative TPAS workflows where physicians launch TPAS directly, more complex techniques have TPAS initiated and the automatic plans reviewed by dosimetrists before physician approval.
- TPAS was initially introduced for standard fractionation but has recently been extended to include SABR applications, including liver and spine treatments.
- This study aimed to demonstrate the impact of TPAS on SABR planning efficiency and plan quality across two distinct disease sites.

MATERIALS AND METHODS

- **Fourteen liver SABR** and **twenty spine SABR** cases were replanned using TPAS.
- Plan quality was independently reviewed in blinded comparisons by four liver radiation oncologists (ROs) and three spine ROs.
- Assessment criteria included OAR sparing, PTV coverage, dose conformity, and overall plan preference.
- Per local clinical practice, the highest priority is meeting safe OAR constraints, followed by PTV coverage, then dose conformity.
- Critical constraints included dose to the spinal cord/thecal sac, normal liver, bowel, stomach, esophagus, duodenum, great vessels and heart, depending on PTV location.
- Typical optimization times were calculated by consensus among experienced dosimetrists in the department

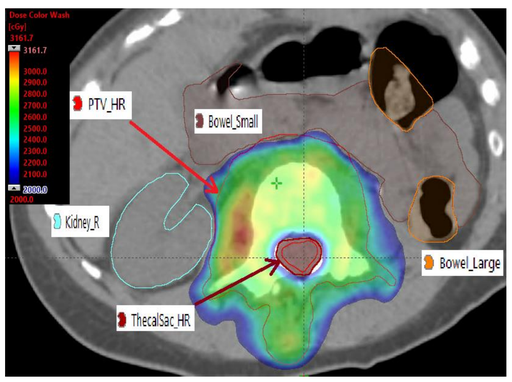

Figure 1: Example contours showing PTV, thecal sac, kidney, small bowel, and large bowel with dose coverage and planning goals planed by TPAS.

RESULTS

- **Radiation oncologists unanimously selected every TPAS plan over the original clinical one.**
- TPAS plans consistently achieved superior tumor coverage while meeting all OAR dose constraints.

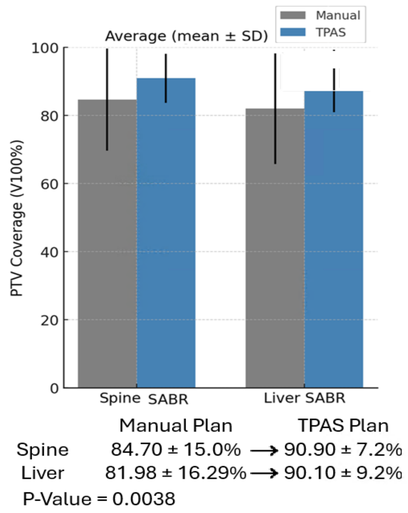

Figure 1: PTV coverage comparisons for both cohorts

Structure	Manual	TPAS	p-value
Heart	1576.5 ± 1093.1	1666.5 ± 1030.0	0.11
Duodenum	895.4 ± 722.7	865.6 ± 689.8	0.68
Esophagus	**930.2 ± 322.0**	**1104.1 ± 349.9**	**0.02**
GreatVessels	**2549.0 ± 1224.0**	**2912.8 ± 1348.0**	**0.03**
Bowel_Large	1475.0 ± 1173.4	1499.0 ± 1244.8	0.85
SpinalCanal	926.1 ± 229.6	995.9 ± 178.8	0.29
Stomach	1111.3 ± 892.2	1023.4 ± 511.9	0.67
Stomach_PRV	42.9% ± 30.4%	35.9% ± 21.1%	0.48
Liver-ITV	231.0 ± 108.7	252.6 ± 111.7	0.10
Kidneys	10.9 ± 21.6	10.7 ± 18.2	0.88
ProxBronchTree	432.9 ± 465.0	454.7 ± 510.1	0.55
ProxTrachea	27.0 ± 17.4	31.3 ± 18.0	0.07

Table 1: OAR doses for the Liver SABR cohort (mean ± 1 SD [cGy]). Significant differences in bold.

Structure	Manual	TPAS	p-value
SpinalCordPRV_HR	1906.1 ± 462.4	1879.4 ± 525.7	0.62
ThecalSac_HR	2319.7 ± 663.3	2332.2 ± 644.3	0.71
SpinalNerves_HR	**92.2% ± 27.1%**	**96.5% ± 28.6%**	**0.003**
BrachialPlexs	1244.6 ± 1608.5	1198.1 ± 1509.3	0.53
Heart	1081.9 ± 898.4	1150.8 ± 976.7	0.16
GreatVessels	2634.8 ± 1160.6	2685.4 ± 1197.6	0.06
PulmonaryArtery	322.1 ± 549.3	433.1 ± 645.6	0.17
Larynx	1171.8 ± 1299.4	1216.9 ± 1260.0	0.58
ProxBronchialTree	692.0 ± 803.7	732.8 ± 881.0	0.40
Pharynx	1947.1 ± 473.9	1928.0 ± 485.4	0.63
Esophagus	1662.6 ± 1105.7	1655.3 ± 1112.9	0.83
Esophagus_PRV	1991.3 ± 119.5	1996.8 ± 71.8	0.96
Stomach	944.6 ± 852.0	644.9 ± 596.2	0.09
Duodenum_PRV	1720.4 ± 0.0	1790.4 ± 20.9	0.13
Bowel_Small	1748.5 ± 763.5	1815.1 ± 835.3	0.20
Bowel_Large	**1615.9 ± 969.0**	**1745.8 ± 1017.5**	**0.02**

Table 2: OAR doses for the Spine SABR cohort (mean ± 1 SD [cGy]). Significant differences in bold.

Liver SABR:
~3 hr → ~40 min (~77% reduction)

Spine SABR:
>8 hr → <2 hr (>80% reduction)

Consistent time savings observed for all TPAS cases

DISCUSSION

- TPAS consistently produced clinically preferable plans across two anatomically distinct SABR disease sites, finding variations that significantly improved target coverage without exceeding OAR tolerances.
- This demonstrates a dual benefit: significant improvements in plan quality alongside dramatic reductions in planning time.
- The system was designed to reduce repetitive manual planning steps while maintaining dosimetry, radiation oncology, and physics oversight within the existing clinical quality assurance framework.
- All TPAS planning occurs in the background, allowing planners to perform other clinical tasks during automated plan generation. This feature is operationally important because the elapsed computation time is not equivalent to continuous active planner time.
- Based on internal evaluations across multiple treatment sites, approximately 80% of TPAS plans met all planning goals directly or with simple normalization, without requiring manual plan modification. This performance was observed in brain, CNS, and pelvis cases.
- The time savings associated with TPAS implementation have the potential to reduce operational costs and improve resource utilization.
- Limitations of this study include its retrospective nature and lack of quantitative assessment of per-case engaged planner time. Conclusions regarding workflow efficiency will require prospective validation during implementation.

CONCLUSIONS

- TPAS substantially reduces SABR planning time while generating clinically superior treatment plans.
- This efficiency gain can reduce dosimetry workload, shorten patient wait times, and support broader clinical adoption of automated planning.
- These results strongly support the integration of TPAS for automated liver and spine SABR planning in routine clinical practice, enabling utilization of highly skilled clinical resources.
- TPAS promotes planning standardization and consistent plan quality across disease sites.

REFERENCES

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