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Simulation Free Direct-to-Unit Large-Animal SBRT Workflow

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PURPOSE / OBJECTIVES

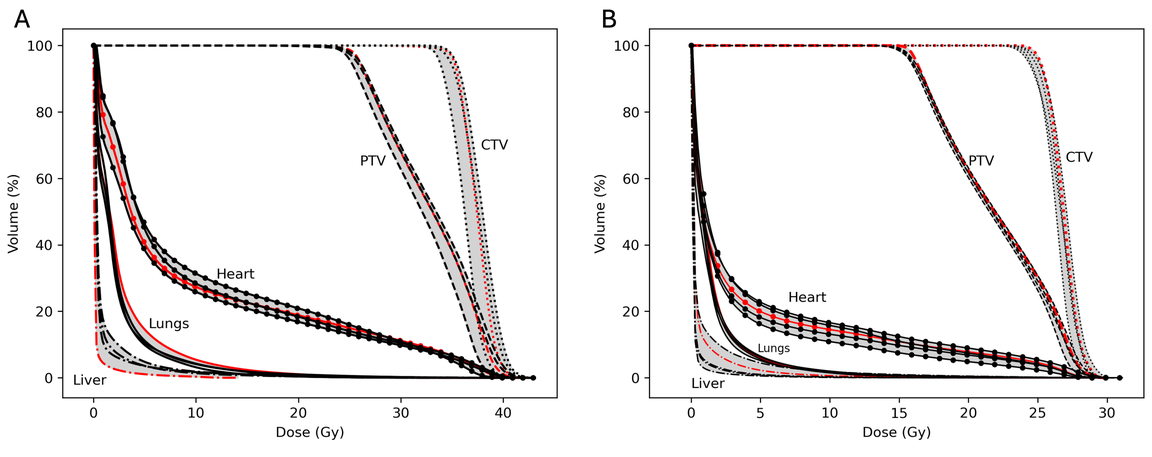
Large-animal studies of stereotactic arrhythmia radiotherapy (STAR) are faced with financial and logistical difficulties that limit widespread implementation. We developed a single-platform STAR porcine workflow on an O-ring linac utilizing manual end-exhalation gating and contrast-enhanced CBCT. We evaluated this workflow's ability to achieve adequate target coverage, OAR sparing, and QA requirements.

MATERIAL & METHODS

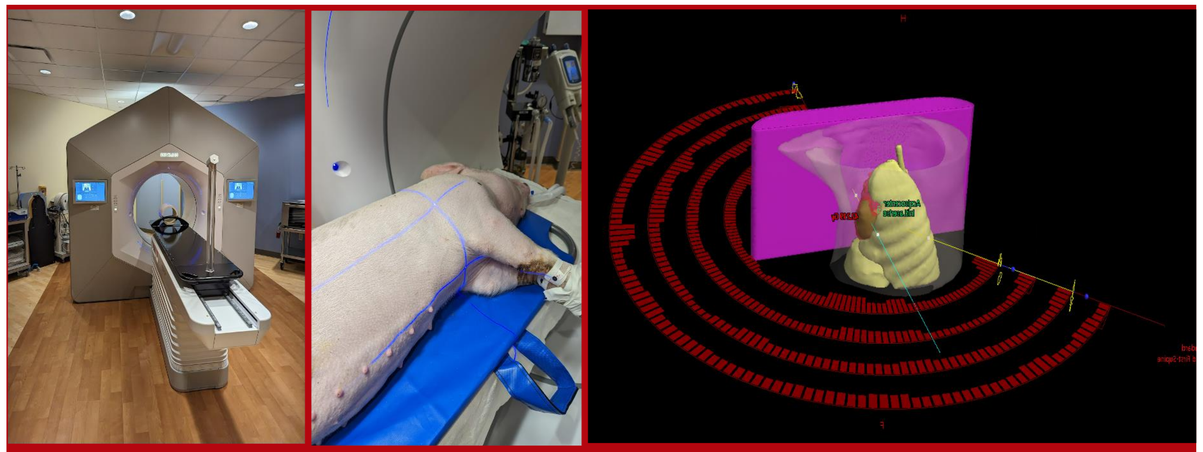
A veterinary team, certified medical physicist and radiation oncologist were present for all treatment sessions. An initial control animal underwent manually gated, contrast-enhanced CBCT imaging to create a template treatment plan. CTVs included transmural scar with 5-mm expanded PTVs. Two VMAT template workflows utilizing 6FFF were developed: one for domestic pigs with a single-fraction 25 Gy prescription to the PTV with intentional CTV hotspots >35 Gy, and one for mini pigs with 15 Gy to the PTV with intentional CTV hotspots >25 Gy. Subsequent animals were treated by aligning daily contrast-enhanced CBCT imaging to the template and treated with manual end-exhalation gating. Delivered dose-distribution for each animal was calculated by transferring the template plan to treatment-day imaging and recalculating dose. QA was performed with EPID gamma analysis and an IROC Houston phantom for end-to-testing.

RESULTS

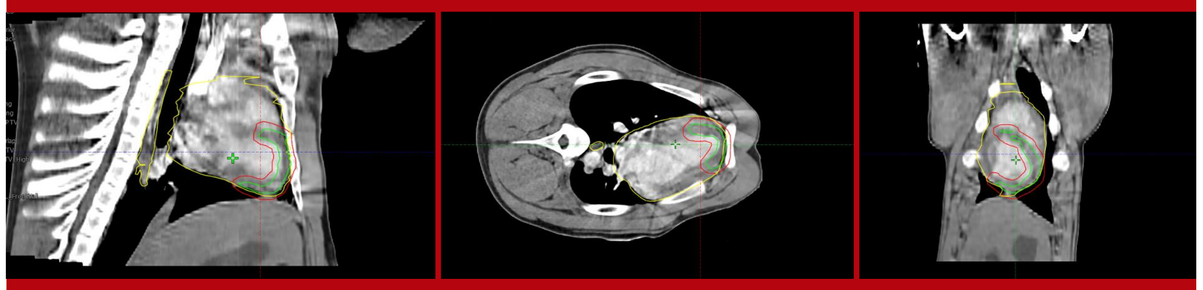
Across 3 mini pigs (template CTV/PTV=17.0/62.8 cc) and 3 domestic pigs (template CTV/PTV=35.2/98.7 cc), plans achieved adequate target coverage. For mini-pigs, CTV D95=25.22 Gy (template) vs 25.26 Gy (treated median); PTV D95=16.27 vs 16.34 Gy. For domestics, CTV D95=35.52 vs 35.13 Gy; PTV D95=26.17 vs 25.88 Gy. OAR doses remained within conservative porcine SBRT constraints. QA passed with EPID gamma of 95.7% (2%/2 mm) for domestics and 99.7% (2%/2 mm) for minis. IROC end-to-end testing passed (TLD: within 2%, film: 100% gamma at 7%/5 mm).



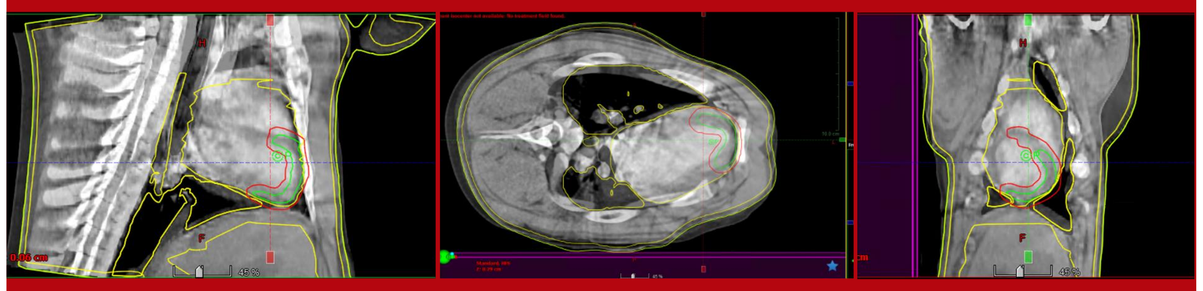
(A) DVHs for the initial 25 Gy-to-PTV cohort (domestic pigs). (B) DVHs for the subsequent 15 Gy-to-PTV cohort (mini pigs).DVHs for template plans are displayed in red. For each OAR, the gray shaded region spans the range bounded by the template plan and treated animal DVHs.



The initial animal is brought to the linear accelerator and positioned in the headfirst, left lateral decubitus position. Initial in-room alignment is performed using in-room lasers to align isocenter to the animal's heart.



Animal positioning is confirmed and contrast-enhanced CBCT imaging is acquired of the animal to generate a template treatment plan.



Subsequent animals are treated by aligning their treatment image to the template. Alignment is verified by the medical physicist and radiation oncologist. Either sham or delivery is performed with manual gating on end-exhalation. Images of the treatment day registration are displayed.

SUMMARY / CONCLUSION

This study designed and validated a large animal STAR workflow adapted for porcine studies, with acceptable coverage and OAR sparing, potentially lowering barriers that inhibit this research.

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