

Evaluation of a Novel Independent Secondary Dose Calculation Software for Brain SRS, Lung SBRT, and MR-guided Adaptive Pancreatic SBRT

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INTRODUCTION

Modern treatment planning systems are more complicated and sophisticated by implementing rapid optimization, improving heterogeneity corrections and including on-line adaptive capabilities. Independent secondary dose calculation (ISDC) is essential in planning QA and chart check. In this study, we evaluated the feasibility and accuracy of ArcherQA®, a Monte-Carlo based independent dose calculation software, in brain SRS, lung SBRT and MR-guided adaptive pancreatic SBRT. ArcherQA® is an advanced software utilizing Monte Carlo radiation dose calculation methods, cutting-edge “near real-time” dose engine with CPU/GPU co-processor support and parallel computing technologies for calculation accuracy and speed.

METHODS AND MATERIALS

10 Brain SRS patients with totally 59 brain lesions and 10 Lung SBRT patients planned in Varian Eclipse treatment planning system (TPS), 5 Adaptive Pancreatic SBRT patients with totally 25 fractions planned in MRIdian TPS are evaluated by comparing ISDC results between Varian Mobius3D, ViewRay online adaptation QA tool and ArcherQA. Gamma passing rate (3%/3mm, 10% threshold), percentage differences (TPS vs. ISDC) of target coverage (mean dose and D90) and OAR max doses are calculated and compared.

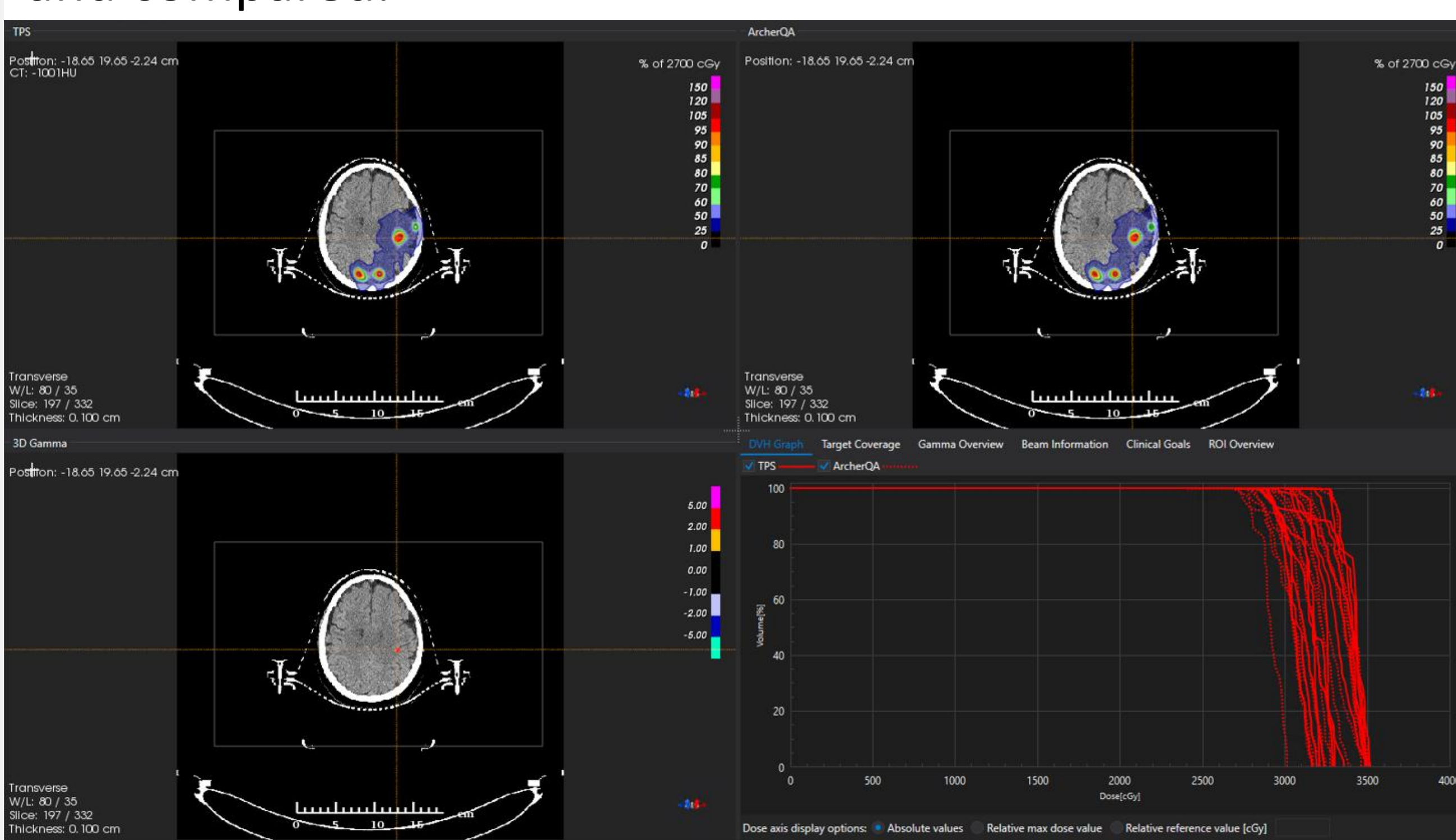


Figure1. ArcherQA dose calculation example for multi-lesion Brain SRS

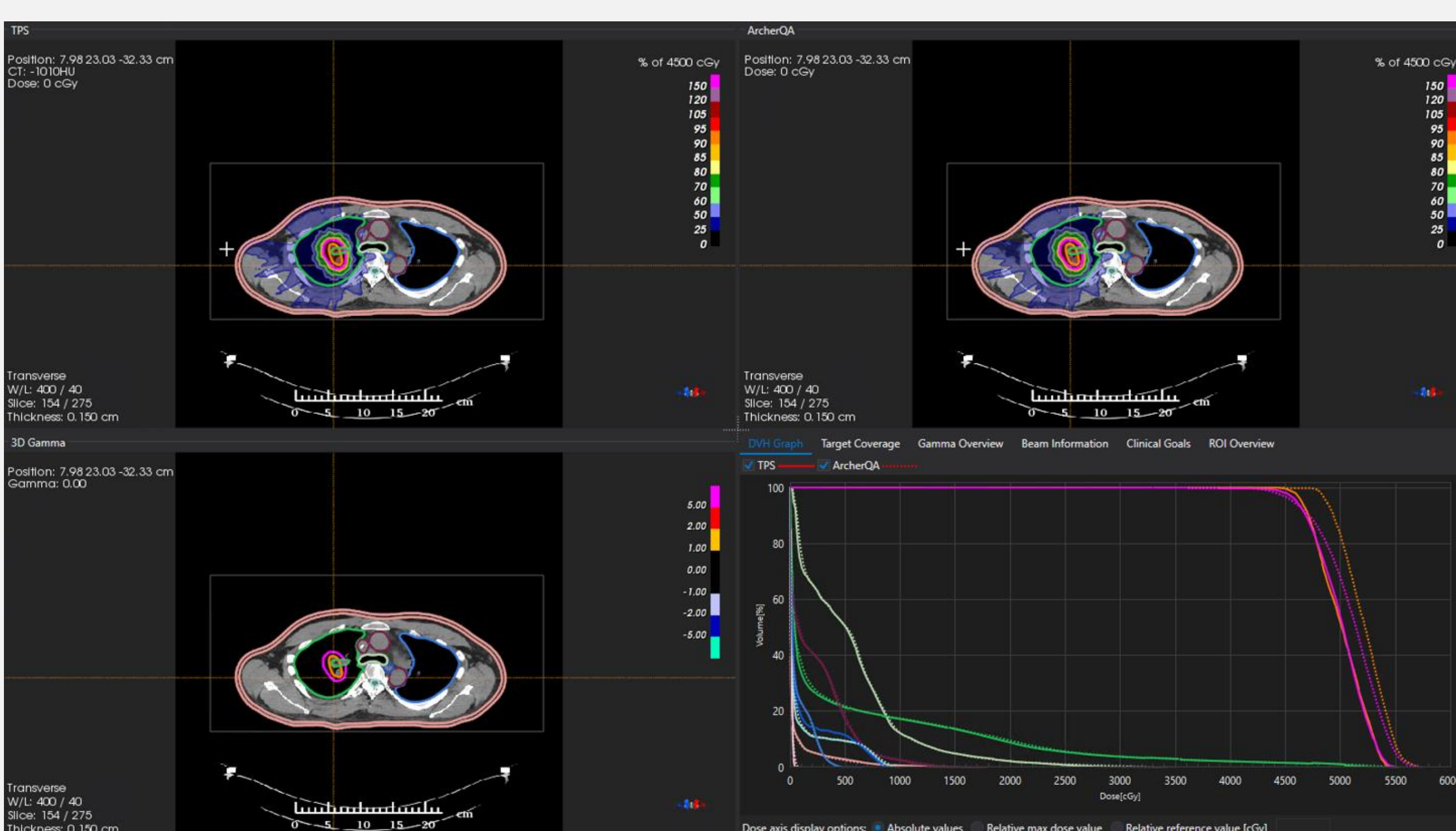


Figure2. ArcherQA dose calculation example for Lung SBRT

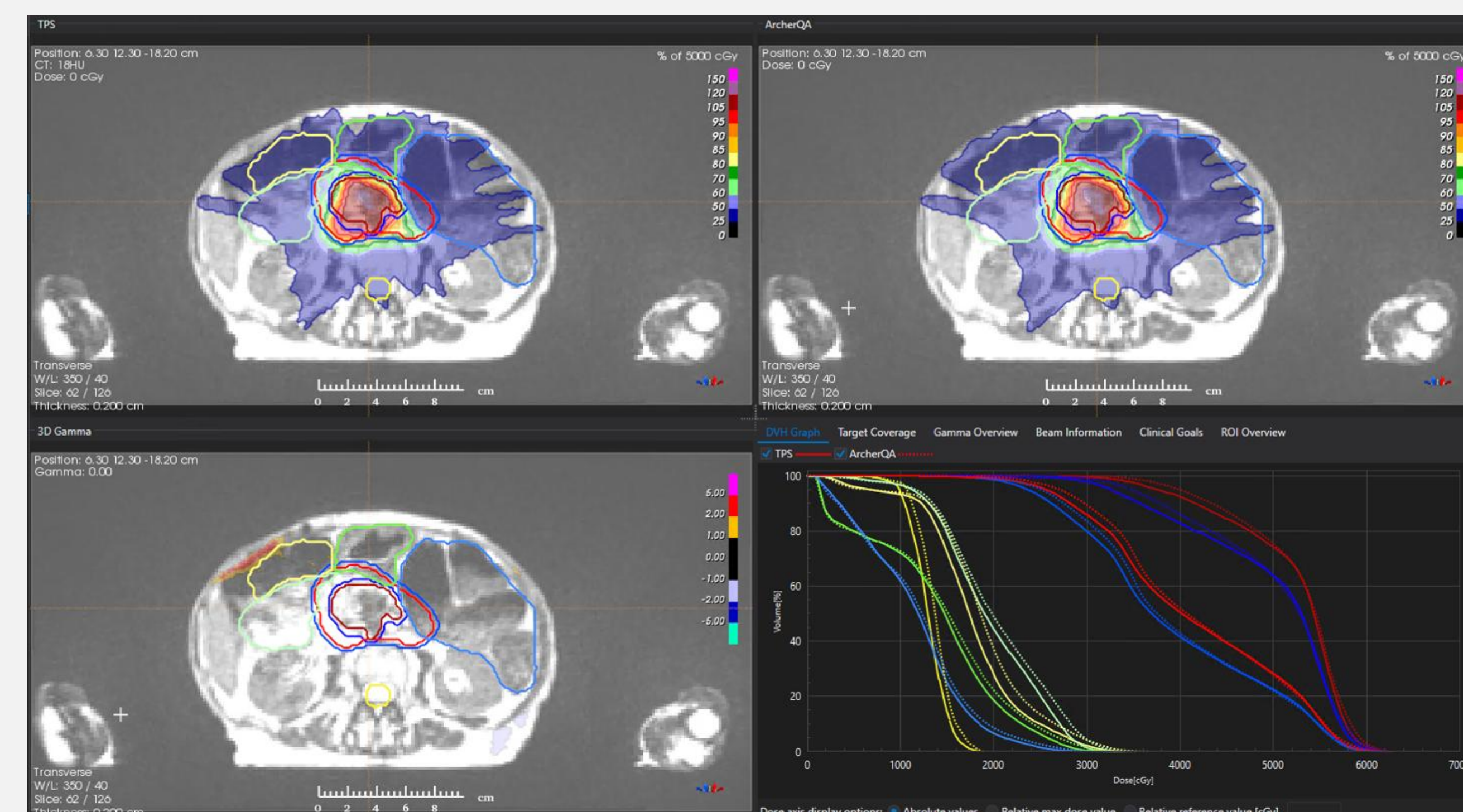


Figure3. ArcherQA dose calculation example for MR-guided adaptive Pancreatic SBRT

RESULTS

For brain SRS, ArcherQA has same gamma passing rate (100%) compared with Mobius3D (100%), but significantly improves the percentage differences in GTV Dmean ($2.06\% \pm 1.38\%$ vs. $6.26\% \pm 3.73\%$; $p < 0.001$), GTV D90 ($1.71\% \pm 1.39\%$ vs. $6.25\% \pm 3.64\%$; $p < 0.001$), PTV Dmean ($1.59\% \pm 1.20\%$ vs. $5.80\% \pm 3.37\%$; $p < 0.001$) and PTV D90 ($1.44\% \pm 1.07\%$ vs. $5.48\% \pm 3.35\%$; $p < 0.001$). For lung SBRT, ArcherQA has better results compared with Mobius3D but not significantly in gamma passing rate ($99.61\% \pm 0.47\%$ vs. $98.51\% \pm 3.19\%$), percentage differences GTV D90 ($2.09\% \pm 1.25\%$ vs. $4.42\% \pm 2.25\%$), Dmax in bronchus ($1.89\% \pm 1.66\%$ vs. $2.42\% \pm 1.74\%$), and esophagus ($0.98\% \pm 0.51\%$ vs. $1.35\% \pm 0.71\%$), heart ($1.27\% \pm 1.25\%$ vs. $2.30\% \pm 1.94\%$). However, ArcherQA significantly improves the percentage differences in PTV Dmean ($1.27\% \pm 0.68\%$ vs. $4.23\% \pm 2.14\%$; $p < 0.001$) and D90 ($3.00\% \pm 1.79\%$ vs. $6.04\% \pm 2.27\%$; $p < 0.001$). For online adaptive pancreatic SBRT, Viewray online adaptation QA tool has significantly better gamma passing rate ($98.93\% \pm 0.91\%$ vs. $96.98\% \pm 1.93\%$; $p < 0.001$), percentage differences in GTV Dmean ($0.23\% \pm 0.18\%$ vs. $1.67\% \pm 0.95\%$; $p < 0.001$), PTV Dmean ($0.21\% \pm 0.19\%$ vs. $1.71\% \pm 0.95\%$; $p < 0.001$), Dmax in duodenum ($0.48\% \pm 0.34\%$ vs. $5.79\% \pm 3.22\%$; $p < 0.001$), stomach ($0.74\% \pm 0.89\%$ vs. $6.85\% \pm 4.25\%$; $p < 0.001$) and small bowel ($0.77\% \pm 1.04\%$ vs. $4.61\% \pm 3.35\%$; $p < 0.001$) compared with ArcherQA.

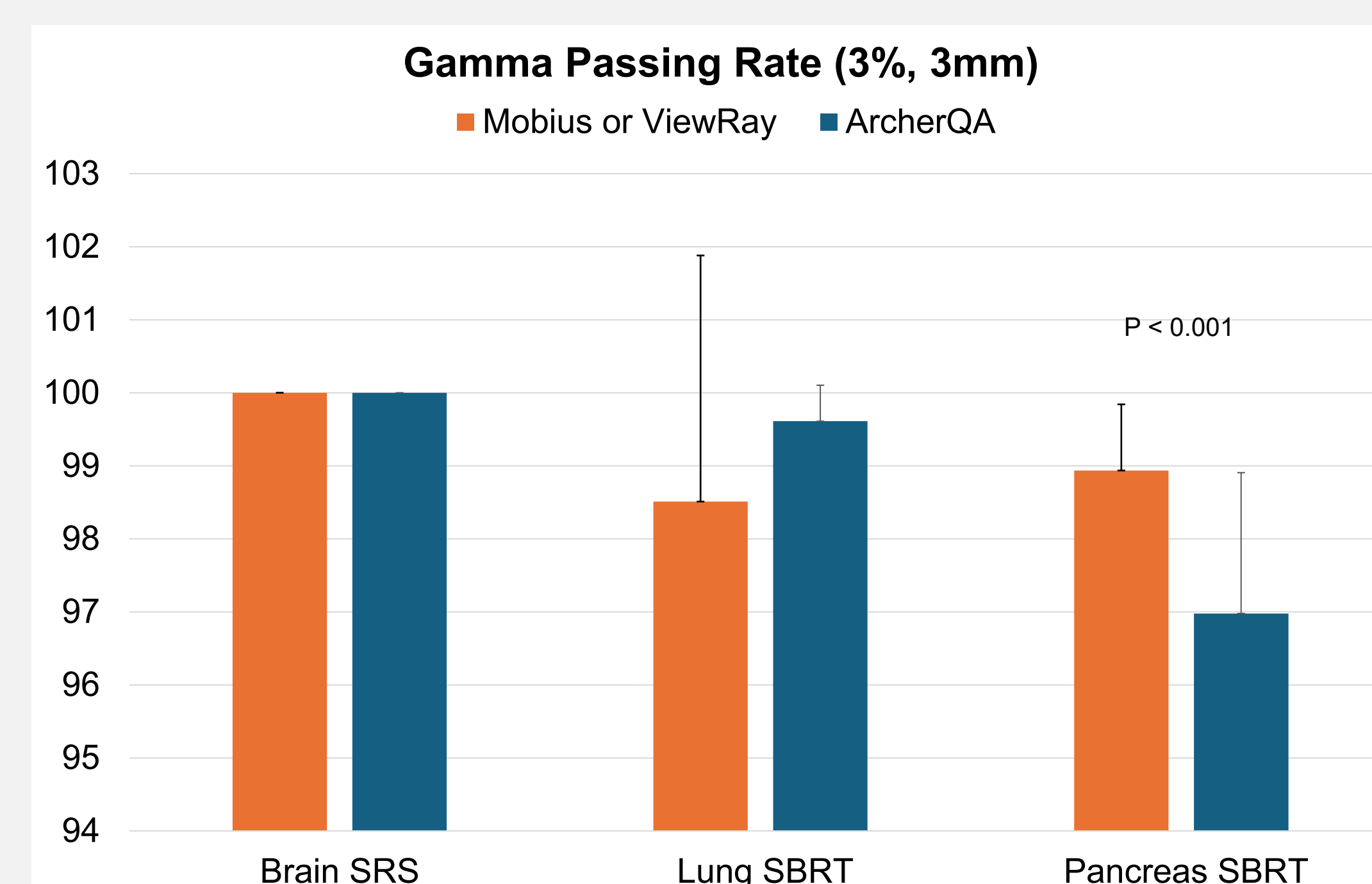


Figure4. Gamma passing rate comparisons between Mobius or ViewRay adaptive QA tool vs. ArcherQA

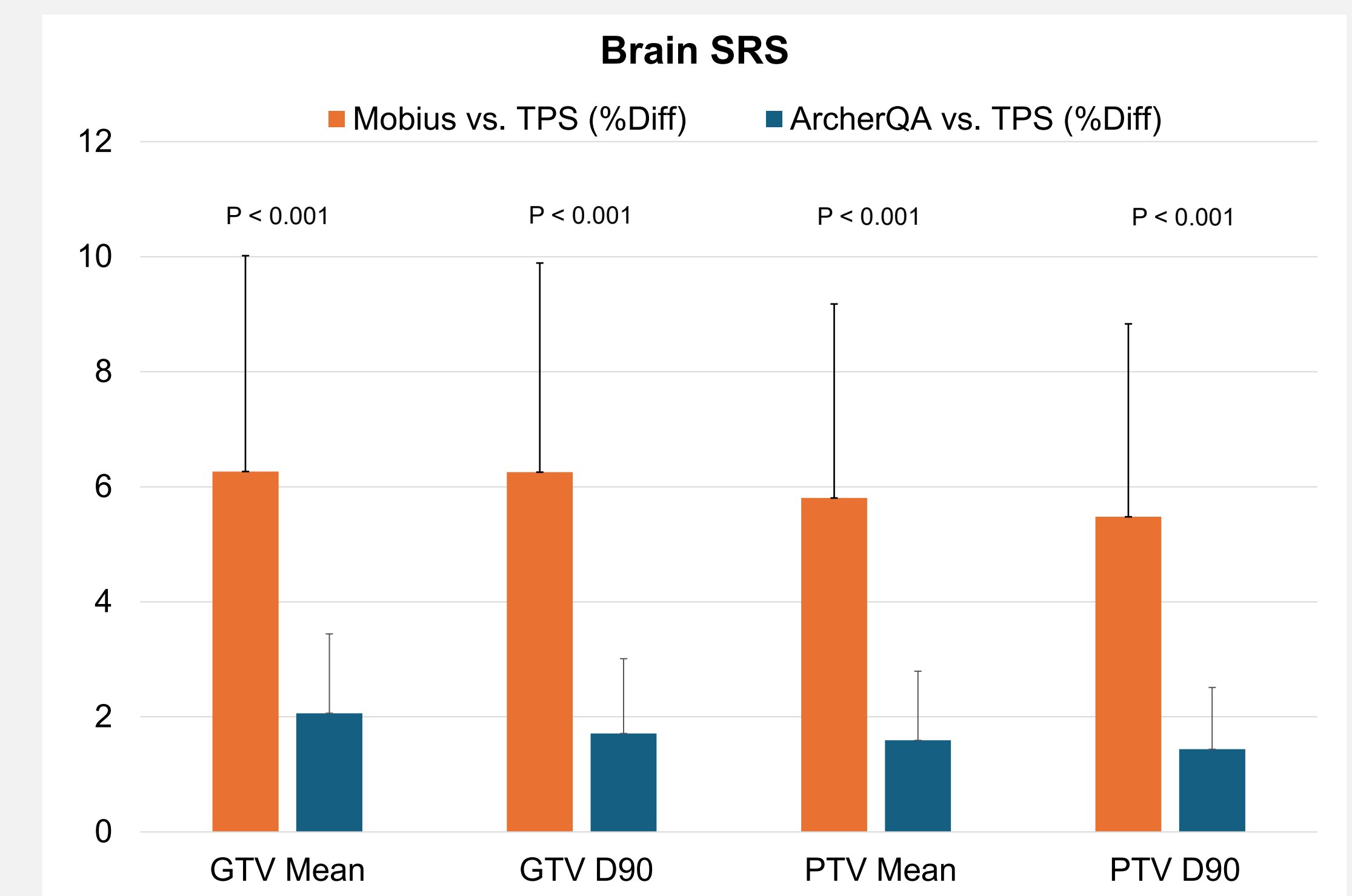


Figure5. Percentage differences of dose calculation between Mobius and Eclipse vs. ArcherQA and Eclipse in Brain SRS

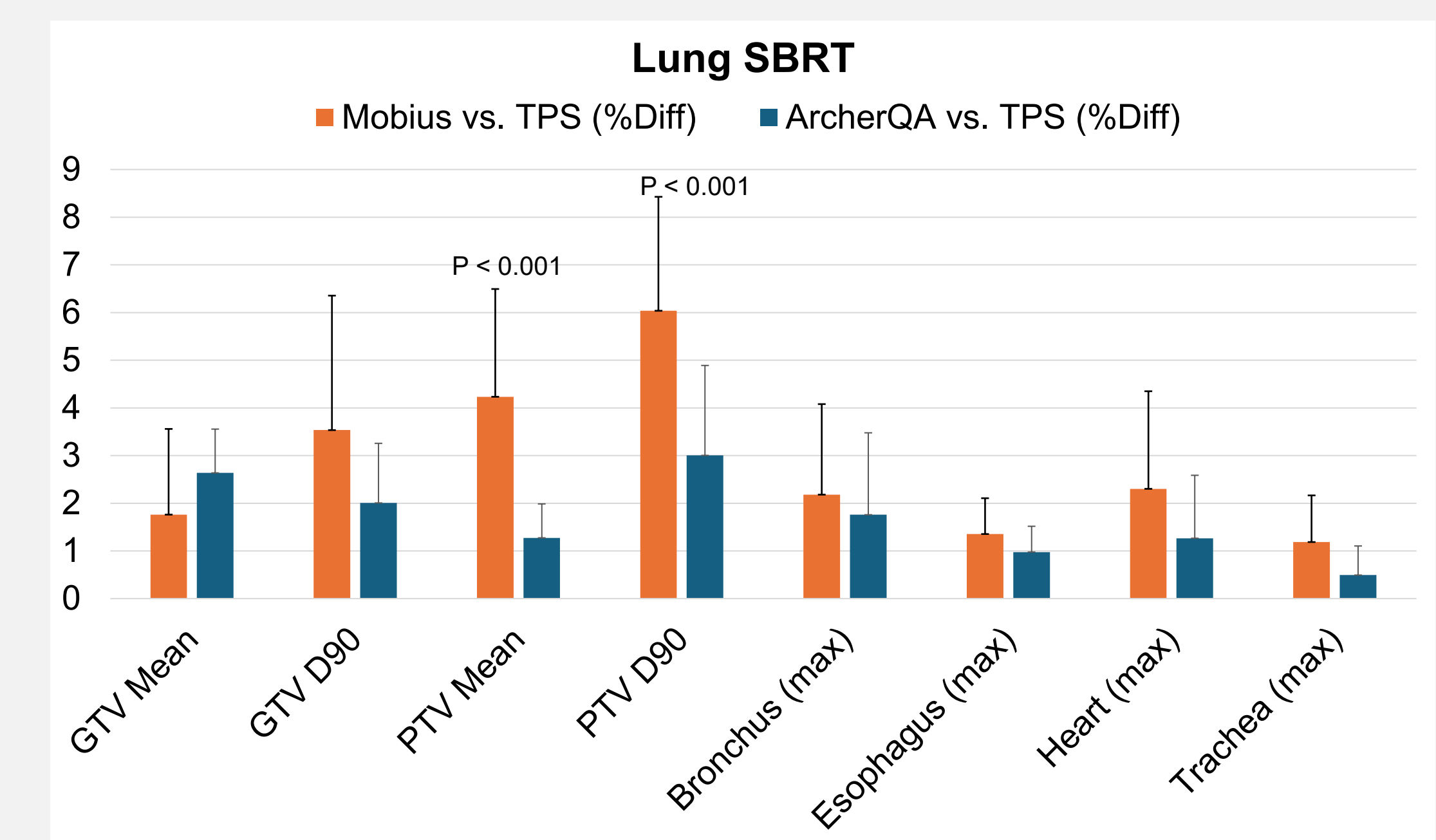


Figure6. Percentage differences of dose calculation between Mobius and Eclipse vs. ArcherQA and Eclipse in Lung SBRT

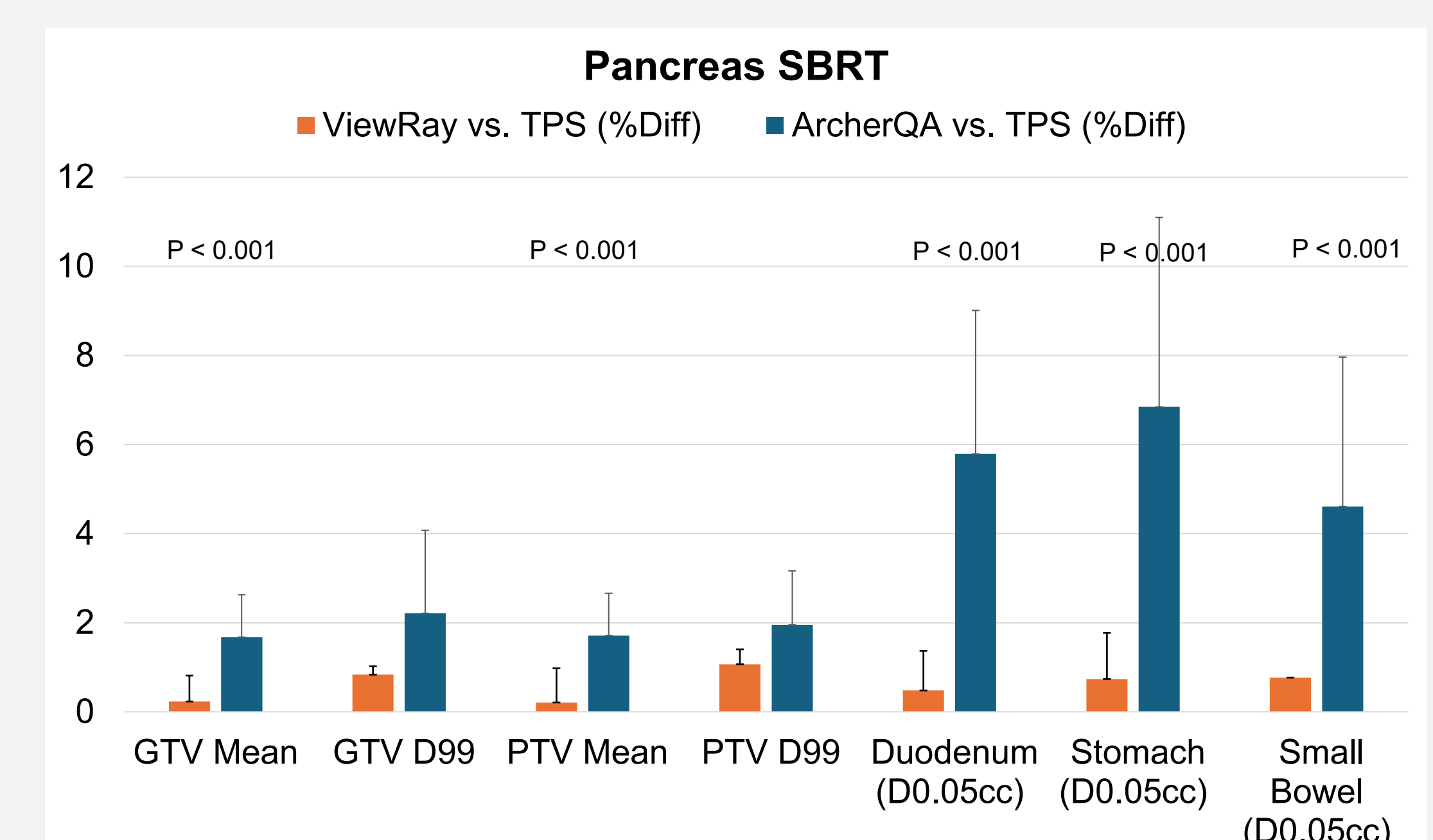


Figure7. Percentage differences of dose calculation between ViewRay adaptive QA tool and ViewRay TPS vs. ArcherQA and ViewRay TPS in Pancreatic SBRT

CONCLUSIONS

ArcherQA has similar gamma passing rate compared with Mobius3D in brain SRS and lung SBRT but significantly improves the target coverage accuracy. Even though the results are suboptimal compared with Viewray online adaptation QA tool, ArcherQA is still feasible in clinical application in online adaptive QA with good gamma passing rate as a 3rd party QA tool.