Stony Brook School of Health Professions

Utilizing RapidPlan for knowledge-based planning of malignant pleural mesothelioma: Can RapidPlan help reach a higher prescription dose compared to the clinical plan?

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Background

Malignant pleural mesothelioma (MPM) presents unique challenges for radiation therapy due to its large target volume and proximity to critical organs. Traditional planning methods often limit the prescription dose to avoid excessive exposure to organs-at-risk such as the lungs, heart, and esophagus. RapidPlan (RP), a knowledge-based planning tool, offers a data-driven approach to optimize treatment plans and potentially allow for higher prescription doses. Our institution developed and validated an RP model using patient data to explore its effectiveness in improving dose escalation while maintaining organ sparing. This study investigates whether RP can outperform traditional planning in MPM cases and how lung volume impacts the ability to reach higher prescription doses.

Purpose

Treatment planning for MPM can be a challenge due to the large size of the target and the need to spare critical organs that overlap with the target volume. Our institution developed a knowledge-based model using RP for patients with two intact lungs. The aim of this project was to see if using RP can help reach a higher prescription dose for the target volume compared to clinical counterparts. Our institution also studied the influence of lung volume on prescription dose.

Materials and Methods

A RP model was constructed using data from 57 patients treated with Volumetric Modulated Arc Therapy (VMAT) to train a dose estimation model at a single dose level; previously validated and tested on 23 patients. A new set of validation cases comprising of 30 patients were replanned with the RP model. The prescription dose was increased for each plan until the mean lung dose reached 20 Gy maximum. Correlations were performed between the ipsilateral lung volume and the achieved prescription dose.

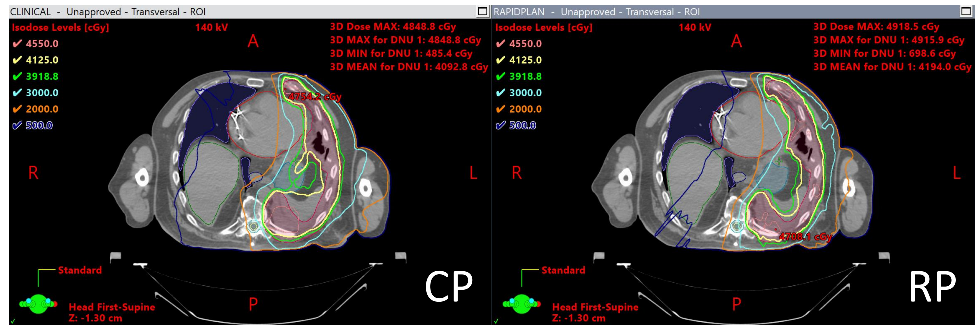

Figure 1. Comparison of isodose distributions for an MPM patient in the clinical plan (CP) and RP. The prescription dose in both plans is 41.25 Gy . RP was able to provide better organ sparing for critical structures, such as the heart, lungs, stomach, and esophagus.

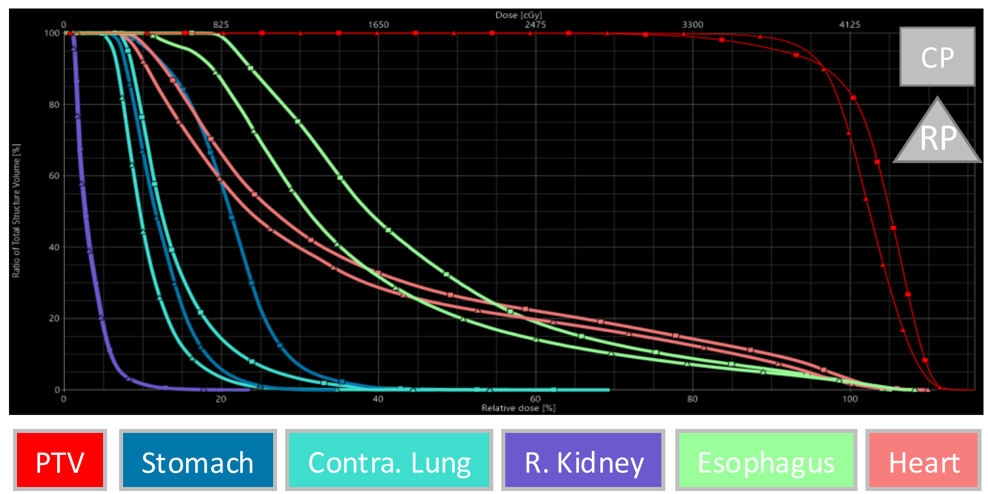

Figure 2. Dose volume histogram comparison of normal organ doses for a MPM patient in the CP and RP at the same treatment dose of 41.25 Gy. The CP is represented by the squares while RP is represented by the triangles. Plan doses to the organs at-risk (stomach, contralateral lung [left lung], right kidney, esophagus, and heart) all show that RP creates a plan that has at least equal, if not better, normal organ sparing as shown by the DVH doses.

Results

For similar target coverage and plan inhomogeneity, RP significantly improved the sparing of the contralateral lung, heart, stomach, esophagus, and ipsilateral kidney. On average, the contralateral lung V5Gy and V10Gy were reduced by 7% and 6% respectively ($p < 0.01$). The mean heart dose was reduced by 3 Gy ($p < 0.001$). Mean dose to the stomach and esophagus were also reduced by 3 Gy and 5 Gy respectively ($p < 0.001$). The median prescription reached with the clinical plan was 46.8 Gy and that with the RP was 50.4 Gy. The ipsilateral lung volume for plans that could achieve a highest prescription dose of 50.4 Gy was on average 1170 cc less than those that could not, while the total lung volume was 1708 cc less.

Conclusion

The study demonstrated that RP significantly improved organ sparing while enabling higher prescription doses compared to traditional clinical plans for MPM. The RP model consistently reduced radiation exposure to critical structures, including the heart, lungs, stomach, and esophagus. Additionally, smaller ipsilateral lung volumes were associated with a greater ability to safely escalate the prescription dose. These findings highlight the potential of knowledge-based planning to enhance treatment quality in complex thoracic cases.

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