Multi-timepoint dosiomic modeling of patient-reported dysphagia

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Impact / Innovation

- **Difficulty swallowing, or dysphagia,** is a key survivorship issue in head and neck cancer (HNC) radiation therapy. Current techniques reduce mean pharyngeal constrictor muscle (PCM) dose. **Could more be done to reduce toxicity?**
- **Dosiomics** summarizes important features of the dose distributions, which machine learning can use to **identify new correlations with toxicities[1].**
- Weekly dose variations from the original treatment plan can be measured.

Goal – use dosiomic features from multiple radiotherapy timepoints and imaging modalities to predict late patient-reported dysphagia.

Materials & Method

Patient Cohort

- 64 HNC patients were treated with curative chemo-radiotherapy. MDADI surveys were completed at >12 months after completion of treatment.
- MD Anderson Dysphagia Inventory summary score ≤60 was identified as **patient-reported dysphagia,** with a low score indicating higher symptom burden.

Dosiomic Feature Modeling

- **Deformable image registration** used to create synthetic CT images of weekly CBCT anatomy.
- Original treatment plan was re-calculated on the synthetic CT to **measure weekly delivered dose.**
- Feature extraction was performed with **original and wavelet** filters from PyRadiomics[2].
  1. Applied isotropic voxel size and discretization.
  2. Pharyngeal constrictor muscles (PCM) and 80%/95% isodose structures used as masks.
- Features are sent to **machine learning pipeline.**

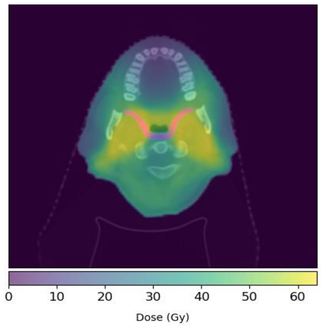

Fig. 1. Sagittal patient view of dose distribution, CT image and PCM contour.

Results

Patient Cohort

- Cohort (n=64) consisted of 14% patient-reported dysphagia patients.
- Dysphagia risk factors (i.e., age, smoking/alcohol status, etc.) were shown in equal distributions between dysphagia and asymptomatic groups.

Dosiomic Modeling Results

- **Fig. 2** shows the **random forest (RF) classification** pipeline.
  - Imbalanced learn and F-score optimization were used to balance groups.
  - SMOTE resampling was applied to up sample dysphagia group.
  - Boruta feature reduction method using with 5-fold cross validation.
- **Fig. 3.** shows the model results, presenting the balanced accuracy.
  - Testing curve does not match well with training due to low statistics.
- **Fig. 4.** presents the dosiomic feature types frequently identified.
  - Gray-level (GL) features describe relationship between nearby voxels, or textures within an image.
  - **First-order and texture features** most useful features categories**.**

Choose Timepoint → Choose Features → RF Model Tuning → Evaluate Performance

Fig. 2. Classification pipeline to predict patient-reported dysphagia.

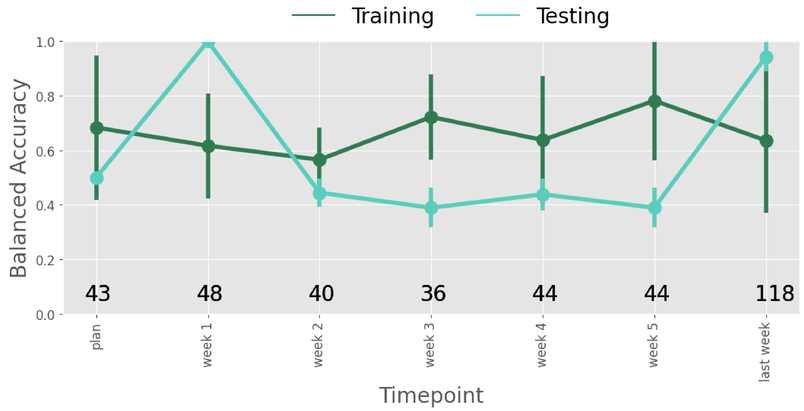

Fig. 3. Balanced accuracy for the training and testing models. The testing curve shows inconsistent performance due to low testing statistics

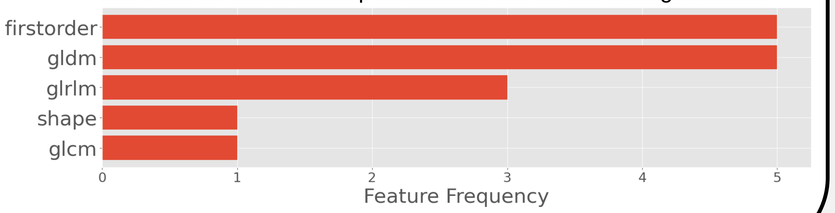

Fig. 4. Feature types most repeated in different timepoint models.

Conclusions

- **Planned dosiomic features** were able to create a successful prediction model.
- Features extracted on **weekly dose distributions have similar predictive power** to those extracted from the planned dose distribution.
- Work needs to be done to validate models, with a test set current in development.

Our machine learning model was able to identify important dosiomic features based on the planned dose distribution. Further work is required to develop a protocol aimed to reduce patient-reported dysphagia.

References

1. Wu et al. 2020. ***Oral Oncology.*** 104. DOI:10.1016/j.oraloncology.2020.104625.
2. Van Griethuysen et al. 2017. ***Cancer Research*** 77 (21): e104-e107. DOI: 10.1158/0008-5472.CAN-17-0339 .

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