MRI textural features can differentiate pediatric posterior fossa tumors

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INTRODUCTION

Objective: Identify a set of radiomics (computer extracted) features on routine MRI sequences that can distinguish the most common posterior fossa tumors - Medulloblastoma, Ependymomas, & Gliomas in children.

Background:
- Medulloblastoma (MB), Ependymomas (EP), and Gliomas are common posterior fossa (PF) tumors, which account for ~47% of all pediatric brain tumors. [1]
- PF tumor types have different treatment regimens. MB are the most aggressive and require gross total resection (GTR), radiation and chemotherapy whereas Gliomas are just monitored after GTR. [2]
- Currently, histological findings are used to confirm the type of PF tumor via stereotactic biopsy. [3]
- There is a clinical need to identify novel structural, and functional imaging based markers that can predict PF tumor type in a non invasive preoperative setting – that can help with prognosis and treatment planning.

Previous Work:
- Radiomics: The conversion of quantitative medical images into high-dimensional data that can be mined to uncover the underlying pathophysiology. [4]
- Radiomic features like Haralick capture 1st and 2nd order statistical patterns, while steerable filters like Gabor capture dominant orientations that solicit a textural response.
- Previous studies have used 2D and 3D based radiomic features to distinguish the PF types. But did not have an independent validation set. [5,6]
- Recently, we developed a new computerized descriptor, CoLlAGe, that distinguishes subtly different pathologies in adult brain tumors. [7]
- CoLlAGe captures co-occurrence of localized dominant orientations at pixel level, and brings together classical Haralick and steerable filters by capturing statistics and features of local gradient orientations.

Hypothesis: We hypothesize that radiomic descriptor – CoLlAGe, can identify subtle microarchitectural differences between MB, EP and Gliomas on routine pediatric MRI scans.

MATERIALS and METHODS

Data acquisition and Feature extraction
- T2w, and FLAIR were co-registered to Gd-T1w MRI using BSpline registration and normalized using pediatric atlases by age [8,9]
- Lesion annotated by an expert into four regions:
  - Tumor necrosis
  - Enhancing tumor
  - Non enhancing tumor
  - Edema (not shown)
- 52 radiomic features capturing lesion heterogeneity (CoLlAGe) were extracted from the entire region of interest

Feature selection and classification
- Wilcoxon rank sum test implemented to determine the top 10 discriminable features within training set (p < 0.05)
- Random forest (RF) classifier model with a randomized 3-fold cross-validation was developed on this dataset.
- Using this model, an independent test set was validated via area under receiver operating characteristic (AUC).

REFERENCES

RESULTS

Dataset Description:
- A retrospective cohort consisting of 59 MRI studies (Male = 30, Female = 29 ) was acquired from The University Hospitals between 2003 – 2016.
- The tumors were pathologically classified (MB = 22, EP = 12, Gliomas = 25) based on 2016 WHO Classification of Tumors of CNS. [10]
- The training set consisted of 30 patients (MB = 11, EP = 6, Gliomas = 13) and the independent validation set comprised of 29 patients (MB = 11, EP = 6, Gliomas = 12)

Result and Take-aways:
- On the independent set, we found that sum variance and entropy of CoLlAGe (p < 0.002) on T2w protocol could reliably distinguish MB from (EP + Gliomas) with an AUC of 0.88 (Accuracy = 0.82, Sensitivity = 0.63 and Specificity = 0.94)
- Sum variance of CoLlAGe possibly accounts for greater variation of scattered atypia and local accumulation of mitotic processes as observed on histopathology. [7]
- Higher entropy of CoLlAGe is indicative of more chaotic arrangement in areas of high viable cell population. [7]
- Our results suggest that entropy of CoLlAGe from the entire tumor potentially captures high cellularity of MB which enables its discrimination from (EP + Gliomas).

CONCLUSIONS

- We presented a novel radiomics descriptor – CoLlAGe, based approach to identify non-invasive surrogate markers of Posterior Fossa tumor types on routine T2w - MRI protocol.
- CoLlAGe captures disorder in local arrangement of pixel-wise gradient orientations on radiologic imaging.
- Medulloblastoma (aggressive brain tumor) reported higher CoLlAGe entropy values than Ependymomas and Gliomas on MRI for pediatric brain tumor cases.
- Our presented radiomic approach may allow for a noninvasive understanding of the various posterior fossa tumor types as manifested on T2w images.

Future directions:
- To validate our analysis on a multiinstitutional independent dataset.