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Journal

JOURNAL OF INVESTIGATIVE MEDICINE, 71(1)

ISSN

1081-5589

Authors

Salehi, S

Chang, P

Shao, W

et al.

Publication Date

2023

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DEEP LEARNING FOR PAROTID TUMOR SEGMENTATION AND SCREENING

Salehi S, Chang P, Shao W, Chu E. University of California, Irvine, School of Medicine, Irvine, CA

Purpose of Study: Parotid tumors represent over 70% of all salivary gland masses. Automated accurate segmentation of parotid tumors is a critical step in computational image analysis, including radiomics and other machine learning workflows. Additionally, incidental parotid tumor screening may be a valuable diagnostic aid, particularly in busy clinical practices. This study proposes a deep learning solution for parotid tumor segmentation and screening.

Methods Used: For the segmentation task, a retrospective cohort of patients with parotid masses were aggregated from two separate academic centers. For the screening task, a cohort of consecutive patients were aggregated from a single academic center. All exams were visually inspected for the presence of a parotid mass > 10 mm; when available, histopathology was used to verify diagnosis. 3D tumor masks were generated for each patient. All annotations were performed by a CAQ-certified neuroradiologist. Both dedicated CT neck protocols and routine exams (including head CT) were included to maximize algorithm generalizability. Two serial 3D deep learning algorithms were developed. The first algorithm localizes the right/left parotid glands individually and is optimized through random sampling of known tumor and non-tumor regions. The second algorithm uses cropped volumes generated by the first algorithm as inputs into a 3D contracting-expanding (U-Net) segmentation model. Both models are implemented using an identical 3D network comprised of 15 convolutional layers and 578,089 parameters.

Summary of Results: A total of 201 patients with parotid masses were identified from two academic medical centers (N=100 for first site, N=101 from second site). The median tumor volume was 4.62 cm3 (IQR 2.40-12.50 cm3). Parotid mass segmentation yielded a Dice score of 0.743 (IQR 0.567-0.819; cross-validation on N=161 patients) and 0.725 (IQR 0.500-0.788; test on N=40 hold-out patients). No significant differences in performance were noted between different academic centers or imaging protocols ($p > 0.05$). For the screening task, a total of 200 consecutive unique asymptomatic patients were identified. The deep learning model yielded a total 8 positive predictions, 3 of which were confirmed by a neuroradiologist to be true positive parotid masses; none of the masses were identified in the original radiology report.

Conclusions: The proposed automated algorithm can accurately: (1) detect incidental parotid masses on routine CT exam; (2) segment parotid tumors for calculation of tumor volume as well as facilitating radiomics and other machine learning workflows.

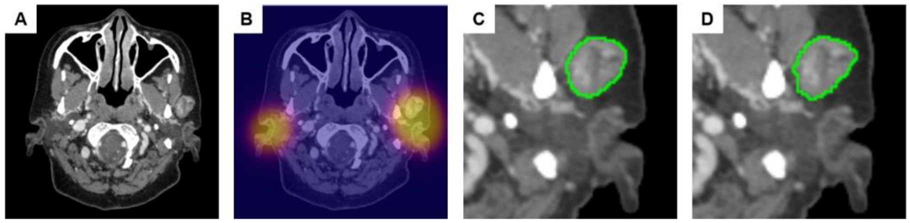

Figure 1. Overview of two-step deep learning algorithm for parotid mass detection and segmentation. (A) Original full resolution CT exam is used by initial deep learning localization algorithm to generate prediction heatmaps (B) isolating the right and left parotid glands. The initial localization algorithm outputs are used to generate cropped volumes of each individual parotid gland, after which a second segmentation algorithm is used to identify parotid masses. (C) Final algorithm output, and (D) corresponding ground-truth annotation show high consensus.