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Rapid Intraoperative Differentiation of Pseudoprogression and Glioma Recurrence using Stimulated Raman Histology

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Introduction

Accurate intraoperative differentiation of tumor progression and pseudoprogression is essential in the surgical management of recurrent gliomas. Reliably differentiating recurrent tumor versus pseudoprogression can be challenging and time-intensive with conventional intraoperative histology. Stimulated Raman histology uses the intrinsic biochemical properties of fresh, unprocessed surgical specimens to provide rapid label-free virtual histologic images. Here, we report a deep convolutional neural network (CNN), which differentiates pseudoprogression and recurrent glioma in fresh surgical specimens imaged with SRH in a fraction of the time required for conventional histologic techniques.

Methods

For CNN training, 1.1 million 400x400µm SRH fields of view (FOV) from 405 patients was used to build a robust multiclass CNN. Our deep neural network was developed from the GoogleNet InceptionV3 CNN architecture, which includes 24 million trainable parameters. For model testing, 36 previously treated glioma patients were used to determine classification accuracy. The model was evaluated on its ability to diagnose 1) normal brain 2) pseudoprogression/gliosis/treatment effect, 3) low-grade glioma (LGG) recurrence, 4) malignant glioma recurrence, and 5) overall diagnostic accuracy.

Results

Time to acquire a SRH image was less than 1 minute. The trained CNN achieved an overall diagnostic accuracy of 97.2%. When evaluating each imaged specimen, the model was able to diagnose normal brain (10 patients), pseudoprogression (6 patients), LGG (8 patients), and malignant glioma (12 patients) with 94.1%, 96.3%, 95.0%, 88.6% accuracy, respectively. The only classification error made by the CNN was an instance of dense gliotic brain tissue due to treatment effect being incorrectly classified as recurrent LGG.

Conclusions

Our study demonstrates the feasibility of applying deep learning for intraoperative diagnosis of pseudoprogression and recurrent glioma in SRH imaged tissues. In the future, convolutional neural networks may ultimately be used to guide decision-making in the surgical care of recurrent gliomas, independent of conventional neuropathology resources.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Describe the importance of differentiating tumor progression versus pseudoprogression using SRH images analyzed using deep convolutional neural networks

2) Discuss, in small groups, how modern artificial intelligence techniques can improve intraoperative diagnosis and detection of tumor infiltration.

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