3D visualization of Brainstem Anatomy in relation to Lateral Medullary (Wallenberg) Syndrome

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Introduction

One of the most emergent patient presentations in medicine is a new onset neurologic dysfunction. Patients presenting with neurologic deficits often undergo immediate CT or MRI scanning to localize points of injury and determine the extent of the damage and prognosis. While the scans are necessary and useful with respect to the individual patient, new technologic innovations have opened another avenue for use of the imaging data. The slices collected from healthy and pathologic brainstems allow us to render models using 3D techniques valuable for teaching the anatomical layout and pathologic conditions of the brainstem. One devastating pathology is an infarct of the posterior inferior cerebellar artery. This infarct causes Lateral Medullary (Wallenberg) syndrome and it affects about 60,000 people a year in the US. The area of distribution of this vessel causes a range of symptoms affecting body sensation, movement, and cranial nerve reflexes. This project attempts to map the human brainstem and better visualize the pathology of Wallenberg syndrome.

Methods

The project we created to study lateral medullary syndrome includes 3D models of a randomized CT scan to demonstrate the brainstem with major tracts, cranial nerves and nuclei, and additional structures. The figures in this poster are screenshots from the final video presentation created using the Amira analytical software package. Amira is a computer program that renders data analyzed by the investigator into investigator defined animations, models, and slice images. The process of extrapolating data includes highlighting structures and interpolating based on matching density values corresponding to anatomical interpretations within a region of interest (figure 1). After isolating structures and refining the rendering, we added them to the final master brainstem model. The brainstem we created was sliced to isolate and demonstrate the structures impacted in Wallenberg syndrome (figure 5). The final product was published as a YouTube video accessible for public use (see link below).

Links:

Brainstem learning module on DufeauLab Youtube channel:
https://www.youtube.com/watch?v=itQP7qNS_7A&feature=em-share_video_user
NIH Imaging database:
http://www.cancerimagingarchive.net/

Results

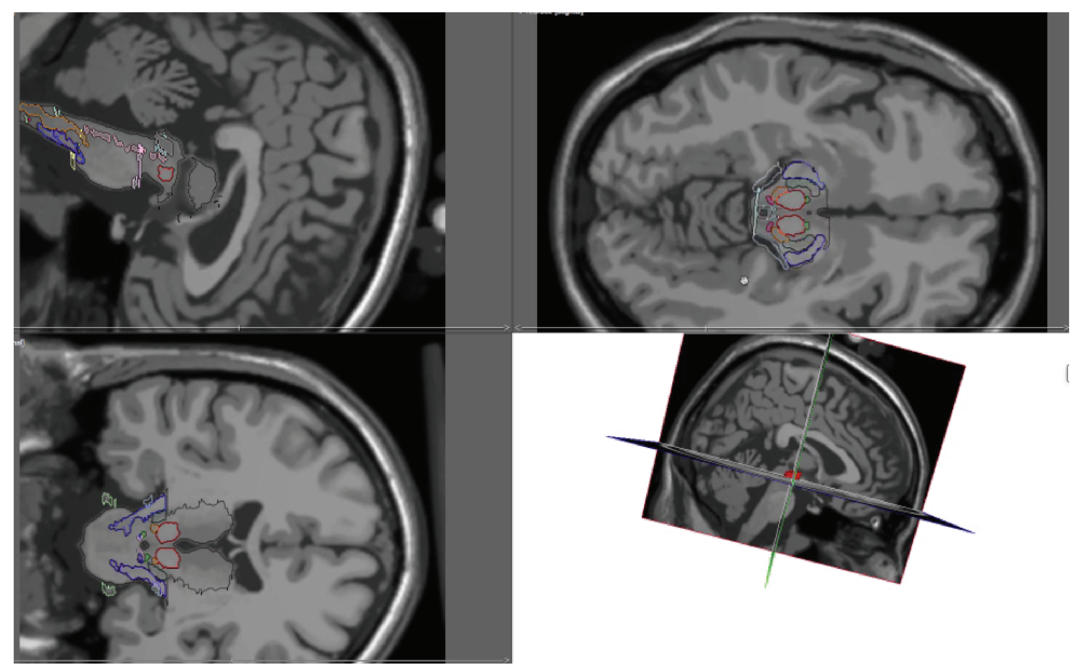


Figure 1: Amira data analysis tool showing anatomical interpretations

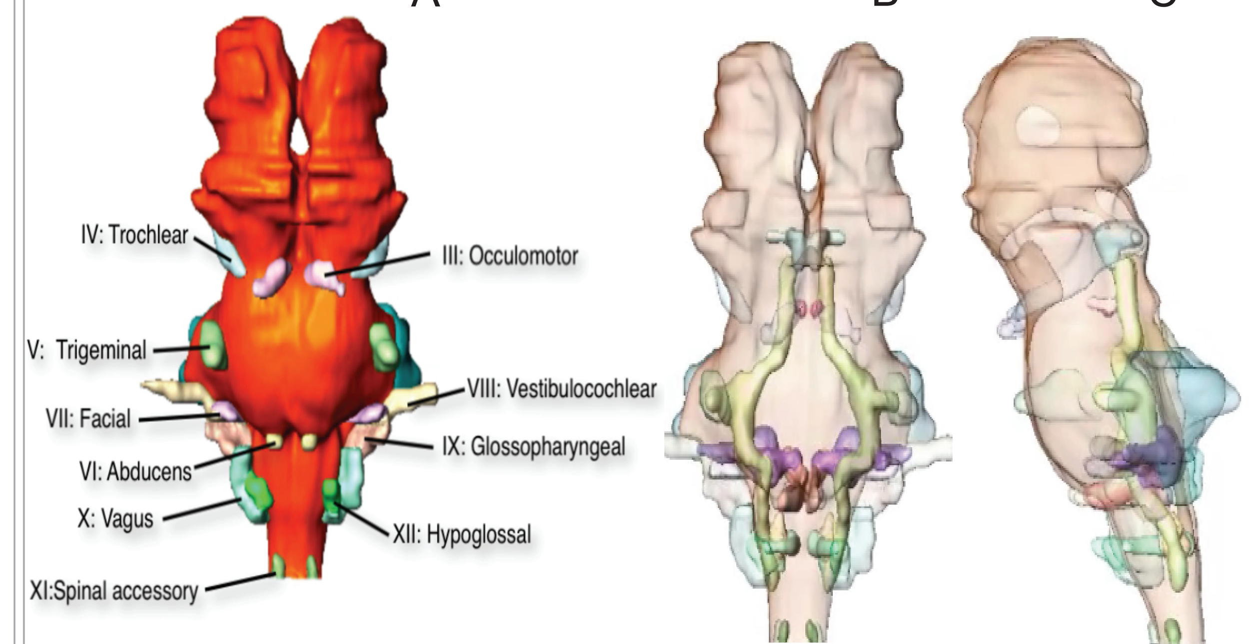
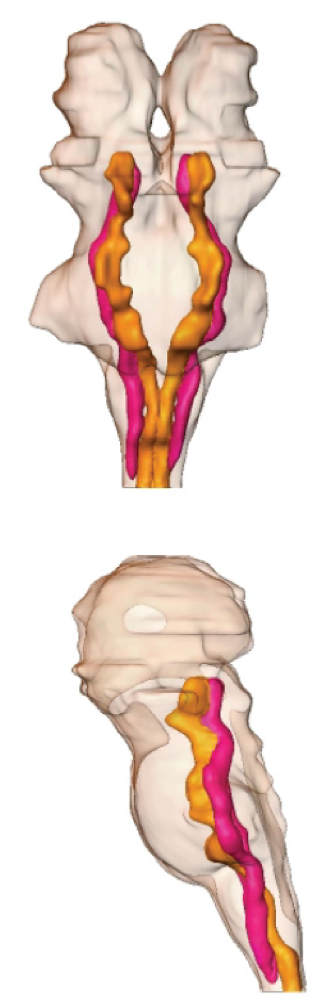


Figure 2: Cranial nerves and nuclei in A) anterior view, B) anterior view transparent, and C) left lateral view transparent

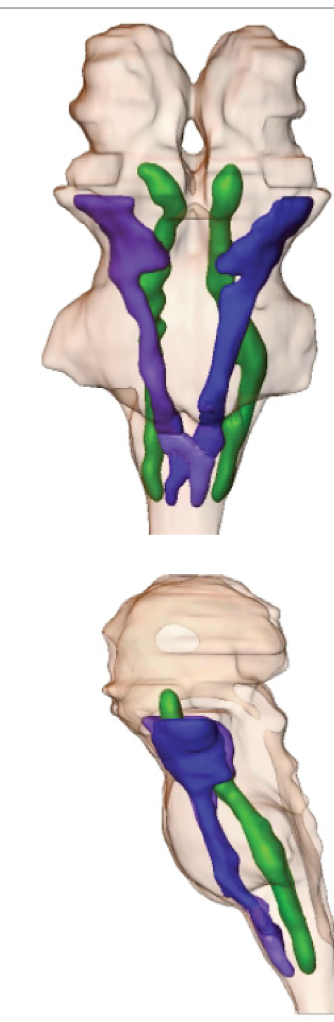
A



B

Figure 3: Ascending brainstem tracts in A) anterior and B) left lateral views

A



B

Figure 4 : Descending brainstem tracts in A) anterior and B) left lateral views

A B C D

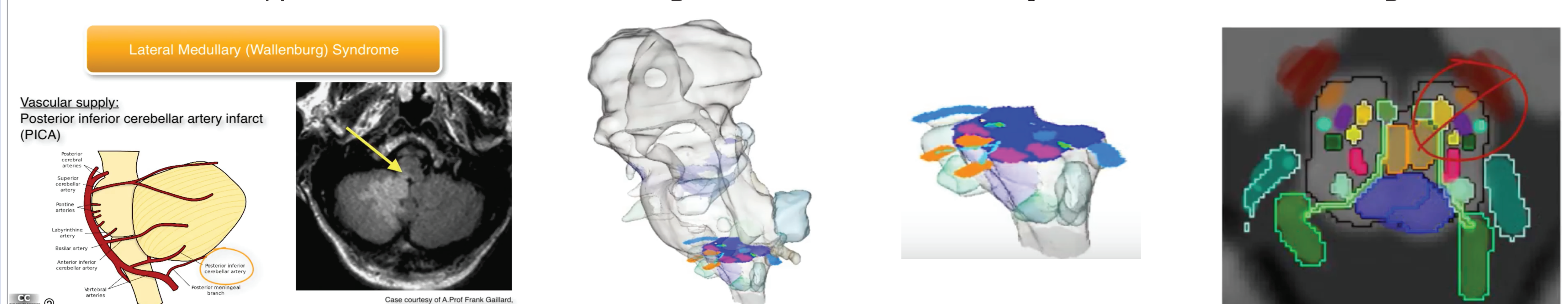


Figure 5: Demonstration of Lateral Medullary Syndrome in a simulated patient in A) Schematic and radiographic, B) Left oblique transparent, C) Left oblique transect, and D) Transverse transect views.

Discussion

The outcome of this project has provided us with a learning tool that can be useful to students and other medical professionals wanting to make reference to the brainstems functional anatomy and organization. The analytical software utilized in this study is beneficial to both students and researchers for evaluating pathologic abnormalities and anatomic variants in three dimensional form. Due to the time constraints of this project and the selected data set, much room is left for expansion studies. Our hope for this study moving forward would be to create multiple brainstem models of pathologic and conventional neural anatomy. We chose lateral Wallenberg syndrome as a classic example of a brainstem infarct but it would be beneficial to demonstrate other pathologies as well.

Conclusion

We would like to encourage students studying medicine to explore other modalities for learning neuroanatomy and to use their creativity to pass that knowledge on to others. This project provides a model to those who learn best by understanding spatial relationships of structures in the brainstem and relating structure to function.

Acknowledgements:

This project was made possible by the 3DVis Lab at MU-COM overseen by Dr. David Dufeau. The data set used to construct our model was provided by the NIH Cancer Image Database (see link).