The Future of Neurosurgery
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Abstract

Careful planning is required prior to cancerous tumor resection. Even more consideration is needed when dealing with brain tumors, where surgery can result in potential functional neurological deficits. A surgical tool known as a Deformable Anatomic Template (DAT) has been developed that optimizes and expedites the analytical steps prior to surgery. A DAT is a computational interface linked to an anatomical atlas that can deform to match imported patient images, providing a unique structural map specific to the patient. This is useful in the neurological context where structures or tracts may not be as readily visible or outlined on acquired images. The DAT allows neurosurgeons to plan the procedure more accurately. Here, a software platform known as Anatom-e (Anatom-e Information Systems, Houston, TX) utilizes a DAT for this purpose. This retrospective study involves taking Magnetic Resonance (MR) presurgical images of patients (n=20) who have been diagnosed with glioblastoma multiforme (GBM) and observing the efficacy of this software against clinically gathered pre- and post-surgical symptoms. GBM is an aggressive primary brain tumor classified as a grade IV astrocytoma. Surgical resection is a common first stage treatment for this illness and symptoms are robust, allowing for both practical and evaluatory use of Anatom-e. Using a range of software tools to execute image analysis, the software has been found to be informative. Yet it also exposes complications of the DAT, such as structural variance in patients and pathological variance in illness.

Background

The first stage of treatment for aggressive primary brain tumors is often surgical removal. However, each day in between diagnosing the cancer and the resection of it allows the tumor to grow and potentially metastasize. It is therefore important to minimize this period of waiting and planning to ensure optimal safety of the patient. The planning process is complex, as is the nature of neurosurgery. As an aid, deformable anatomic templates (DATs) have been developed. Anatom-e (Anatom-e Information Systems, Houston, TX) is one such platform that utilizes a DAT to provide a unique neuroanatomical atlas for patients for the planning of surgical resection. This project aims to measure the extent of its efficacy.

Approach and Data

Twenty patients (n=20; ages 33-90 years, average age 63.5 yrs. median age 62.5 yrs.) diagnosed with glioblastoma multiforme (GBM) were included in this study and their MRI and neurologic exams were reviewed.

Figure 1. A simulated mass (in green) is overlaid on a patient image. Using the DAT interface, Anatom-e can produce a list of neuroanatomical structures and tracts that are in close proximity to the mass. This allows surgeons to plan ahead, while informing themselves and the patients on the possible outcomes and potential neurological deficits that can result from the surgery.

Figure 2. The alignment process of Anatom-e involves linear deformations. The DAT is shown in red, which matches the patient brain on the imported image. The various planes of the body are shown here: axial (L), sagittal (M), and frontal (R).

Figure 3. A T2 acquired image (L), T1 acquired image (M), and a T1 with gadolinium contrast (R). All of these imaging modalities can be uploaded to Anatom-e; however, it is the decision of the software user as to which image set to use. This study mainly used T1 with contrast, since it was easier to visualize the boundaries of the mass.

Figure 4. GBM is highly invasive and aggressively proliferates, sometimes causing abnormal mass shape. One tool (blue) is useful in accommodating these alterations, avoiding irrelevant structures while targeting relevant ones. The drill tool (green) is also capable of creating long cylindrical shapes that mimic the thin wiring of a brain tumor biopsy. Here, it is shown reaching a tumor (yellow) in the patient’s brain. Structures close in proximity can then be listed.

Conclusions

The accuracy of both tools (shown in Figure 6) was measured for every patient by comparing the symptom predictions of Anatom-e with the actual clinical conditions, both pre- and post-surgery.

Table 1. Results showing that Anatom-e correctly predicted primary tumor symptoms or post-surgical complications at least once in 80% of cases.

Overall analyses yield an 80% success rate in retrospective observation of pre-op clinical symptoms and post-surgical symptoms. The drill tool (green in Figure 6) is faster to use and reports with higher fidelity.

Take Home Messages

• The software is useful by informing doctors and patients of potential neurological deficits resulting from tumor resection
• Anatom-e is best used as a supplement to neurosurgeon decisions, as patient variability may affect surgical outcomes
• More testing is needed to gauge the efficacy of a DAT on other cancer types

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References