

## **Augmenting CNS Tumor Surgery: The Era of Artificial Intelligence**

Artificial intelligence (AI) and machine learning (ML) algorithms are on the tremendous rise for being incorporated into the field of neurosurgery. AI and ML algorithms are different from other technological advances as giving the capability for the computer to learn, reason, and problem-solving skills that a human inherits. The reliability of the AI algorithms developed is directly proportional to the size of the dataset utilized to develop it. The safety and efficacy of surgery is our number one priority. Using novel, cutting edge artificial intelligence and machine learning techniques, our goal is to mine through millions of patient records to

predict outcomes following all types of surgery. This is the very foundation of precision medicine.

The prognosis of CNS tumors depends on the type of tumor, malignant or benign, and the patient's age. According to the data published by the American Cancer Society, the 5-year relative survival rate can be as low as <10% in middle-aged patients with glioblastoma, a malignant type of CNS tumor. However, a favorable prognosis is seen in younger patients (20–44 years of age) and those with benign tumors such as meningiomas (84%), oligodendrogliomas (90%), and ependymomas (92%). In the hope of improving survival, neurosurgeons are constantly incorporating updated scientific data and technological advances into their practice). Therefore, AI is introduced due to the difficulty of treating CNS tumors. The shortcomings of MRI include the difficulty in detecting small metastases

and differentiating between tumors, between tumor and infectious foci, as well as between tumor recurrence and treatment effects. Researchers have been trying to address these challenges, and the incorporation of AI might help in that direction. While preoperative planning, using a 3D printed model of the skull to understand better the anatomy of the skull base in preparation for endoscopic endonasal transsphenoidal pituitary surgery. Carlson and Link note that the lifetime prevalence of vestibular schwannoma is one in 500 persons. They are best evaluated by a volumetric measurement and managed based on tumor size. Semi-automated segmentation of tumors, especially schwannomas, saves time and improves segmentation accuracy and effort.

Regarding virtual training and simulation, Birkmeyer et al. noted in their study that for most surgeries, the patient outcome is better if a surgeon with greater cumulative experience operates on them. Dewan et al. highlight that the neurosurgeon to neurosurgical cases ratio is low, especially in low, middle-income countries. Given this shortage they re-emphasize the importance of ensuring that residents receive sufficient, organized skill-oriented training that will enable them to perform surgery confidently even early in their career

A study conducted by Khalsa et al. reported the use of a microscopic technique called Raman scattering, coupled with an imaging technique called Stimulated Raman Histology to create virtual Hematoxylin and Eosin slides. This AI application helped determine the grade of the tumor without processing the tissue in real-time. The same study reported the intraoperative use of AI algorithms

to diagnose, classify and grade pediatric brain tumors with 100% accuracy. Emblem et al. used a SVM and a whole-tumor cerebral blood volume for this purpose, while Nematollahi et al. proposed the C5.0 decision tree model, with tumor width and Karnofsky performance status scores being the most critical parameters for prediction of survival. Mattei et al. explain how neurosurgeons from a remote workstation used an MRI-compatible robotic arm to successfully perform neurosurgical procedures, such as tumor biopsies and microsurgical dissection.

It is essential to validate AI algorithms before implementing them clinically thoroughly. The importance of incorporating the practical and ethical aspects while developing these algorithms to “bridge the gap between research and clinical care” has paramount importance.

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