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Role of Intra-operative MRI (iMRI) in Improving Extent of Resection and Survival in Patients with Glioblastoma Multiforme

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Abstract

Multiple intraoperative aids have been introduced to improve the extent of resection (EOR) in Glioblastoma Multiforme (GBM) patients, avoiding any new neurological deficits. Intraoperative MRI (iMRI) has been debated for its utility and cost for nearly two decades in neurosurgical literature. Review of literature suggests improved EOR in GBM patients who underwent iMRI assisted surgical resections leading to higher overall survival (OS) and progression free survival (PFS). iMRI provides real time intraoperative imaging with reasonable quality. Higher risk for new postoperative deficits with increased EOR is not reported in any study using iMRI. The level of evidence regarding prognostic benefits of iMRI is still of low quality.

Keywords: Glioblatoma, iMRI, Extent of resection, Overall survival, Progression free survival.

Figure: Intraoperative MRI.[11]

Introduction

Maximum safe surgical resection followed by concomitant chemotherapy and radiation therapy is the standard of care for most Glioblastoma Multiforme (GBM) patients. Extent of tumour resection (EOR) has been shown by several studies, to be an independent predictor of outcome.[1,2] Several intra-operative aids have been used to maximize the EOR, including cheaper options such as ultrasound, awake craniotomy, and more expensive ones such as neuronavigation and iMRI. iMRI can provide better details of distortions caused by dural opening and brain shift in comparison to neuronavigation and is in use and under debate for nearly two decades.[3] The major argument against its use is the cost. In this article we review the present evidence of use of iMRI in GBM resection and its impact on the EOR and survival in such patients.

Review of Evidence

We conducted literature search on the use of iMRI in GBM resection and its impact on EOR, overall survival and progression free survival on PubMed database. Search result showed a total of 33 articles, out of which seven most relevant to the review objectives were selected for the study by abstract screening. The reviewed articles included three prospective cohorts, a retrospective cohort, a meta-analysis and two systematic reviews including a Cochrane review.

In one of the earliest publications on this topic, Black et al., in 1997 reported the use of iMRI in neurosurgical procedures and inferred that iMRI helps in precise localization and targeting of the lesion with immediate evaluation of the progress of the procedure. iMRI also decreases the potential errors of frame-based and frameless stereotactic surgery due to altering position with shifting brain parenchyma, helping to determine tumour margins, optimizing the surgical approaches, and achieving complete resection as well as monitoring intraoperative complications.[3] In 2009 Lenaburg et al., reviewed a series of 35 cases that underwent GBM resection using iMRI and reported an average resection of 94% with only 3 patients in less than 90% resection range, hence reporting a higher EOR with iMRI speculating higher survival time in such patients.[4]

Senft et al., in 2010 reported a prospective analysis of a

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total of 103 GBM patients undergoing iMRI-assisted resection from 2004 to 2009. iMRI identified residual tumour tissue in 49.5% patients, which led to further resection in 30.1% of the patients. Analysis of OS revealed better outcomes in patients with complete resection compared to patients with residual tumour (50% OS at 57.8 weeks vs. 33.8 weeks, p=0.003). They reported no association of extent of resection to rate of neurological deficits.[5] In a systematic review, Kubben reported level 2 evidence for iMRI assisted surgery being more effective than conventional neuronavigation-guided procedures in terms of EOR, and OS after GBM resection.[6]

In June 2013, Li Fy reported a prospective cohort study consisting of 76 GBM patients who underwent iMRI and multimodal navigation assisted resection. iMRI confirmed 31.6% cases of misestimated gross total resection (GTR) by neurosurgeons and improved rates of gross total resection (GTR) from 52.6% to 78.9% ($\chi(2) = 11.692$, P = 0.001) with total resection achieved in 26.3% of the cases. Higher PFS and OS were reported in total resection compared to subtotal resection (PFS: 12 vs 9 months; $\chi^2 = 4.756$, P = 0.029) (OS: 16 vs 12 months; $\chi^2 = 7.885$, P = 0.005). The 2-year overall survival rate was 19.7%.[7]

According to a Cochrane review the current evidence regarding intraoperative imaging is of low quality, but increased EOR in GBM is reported with iMRI. The report suggests less clear benefit of iMRI on OS and PFS, which could probably be confounded by the postoperative care.[8] Roder et al., retrospectively analyzed residual tumour volumes, clinical parameters and six months-PFS in a total of 117 GBM patients with conventional, 5-ALA and iMRI assisted resections. Mean residual tumour volume in conventional white-light surgery [4.7 (0.0-30.6) cm3] was significantly larger compared to that in 5-ALA assisted surgery [1.9 (0.0-13.2) cm3; p = 0.007], which in turn was significantly larger than that for iMRI-assisted resection [0.5 (0.0-4.7) cm3; p = 0.022]. Higher rates of total resection were seen in iMRI (74%) compared to 5-ALA assisted surgery (46%, p = 0.05) or white light surgery (13%, p = 0.03). Six-months-PFS was reported at 45% in total resection compared to 32% in subtotal resections.[9]

In December 2016, Li P et al., reported a meta-analysis comparing iMRI to conventional neuronavigation in GBM resection. Higher rates of GTR were associated with iMRI compared to neuronavigation assisted resection (3.16, 95% confidence interval [CI] 2.07-4.83, P<0.001). They also reported higher rates of PFS with iMRI (odds ratio, 1.84; 95% CI of 1.15 to 2.95; P= 0.012), although the OS was similar for the two groups.[10]

Conclusion

Review of evidence identifies the prognostic benefit of iMRI in GBM resection. Multiple studies report higher EOR in iMRI assisted GBM resections, resulting in improved OS and PFS. The level of evidence is however still of low quality. The cost and logistical requirements at the moment restrict the widespread utilization of iMRI, especially in developing countries.

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