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Stereotactic laser ablation for pediatric central nervous system tumors: a systematic review and meta-analysis of the literature

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Abstract

Objective: Stereotactic laser ablation (SLA) or laser interstitial thermal therapy (LITT) is an emerging alternative to conventional surgery for CNS tumors. Further characterization of its effectiveness and safety in the pediatric population is needed.

Methods: A review was conducted according to PRISMA guidelines using the PubMed/MEDLINE, Scopus, Embase, Google Scholar, and Science Direct databases to investigate the effectiveness and safety in the use of LITT to treat pediatric CNS tumors in children.

Results: A total of 24 articles met the inclusion criteria. From the 4 retrospective studies comprising 97 patients (mean age 11.4 years, 55.0% males in the pooled prevalence), the most common tumor types were pilocytic astrocytoma (31.5%) and subependymal giant cell astrocytoma (SEGA; 68.5%). Tumors were primarily located in the frontal lobe (29.7%) and thalamus (24.4%). Postoperative complications included transient neurological deficits in 12.1% and permanent deficits in 6.0% of patients. At a mean follow-up of 43.9 months, mass reduction was observed in 68.8% of patients and overall disease improvement in 91.9% of patients, and the mortality rate was 2.6%. From the 20 case reports/series involving 67 patients (mean age 10.8 ± 4.7 years, 52.2% males), the mean tumor size was 15.7 ± 8.7 cm3. Predominant tumor subtypes were pilocytic astrocytoma (29.9%) and SEGA (16.4%). Tumors were located in eloquent areas in 61.3% of cases, notably the thalamus (24.2%) and ventricular system (24.2%). Prior treatments included surgery (78.8%), chemotherapy (51.5%), and immunotherapy (27.3%). Key LITT parameters were duration (7.2 ± 8.8 minutes), dose (10.2 ± 2.4 W), and extent of tumor volume decrease (68.3% ± 30.4%). The most commonly used LITT system was Visualase (95.7%). Postoperative complications were reported in 26.9% of patients, including transient neurological deficits (55.6%), perilesional edema (22.2%), and hydrocephalus (22.2%). Hospital stays were ≤ 3 days in 92.7% of patients. Tumor size reduction was achieved in 86.7% of patients, and 78.9% experienced disease improvement. Comparative analysis showed that a greater extent of ablation was associated with a reduced need for secondary surgery ($p = 0.038$, OR 0.94) and improved disease outcomes ($p = 0.023$, OR 1.05). Longer LITT duration was significantly associated with postoperative complications ($p = 0.050$).

Conclusions: LITT appears effective in reducing tumor size and improving disease outcomes in

pediatric CNS tumors. The long-term effectiveness of LITT in pediatric brain tumors requires further randomized prospective investigation.

Keywords: LITT; SLA; case series; laser interstitial thermal therapy; meta-analysis; oncology; pediatric brain tumor; stereotactic laser ablation; systematic review.