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The Warburg effect in patients with brain tumors: a comprehensive analysis of clinical significance

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Abstract

Purpose: The Warburg Effect, referring to an elevation in serum lactate level attributable to increased tumor metabolism, is present in patients with brain tumors. This study comprehensively analyzes the Warburg effect in patients undergoing brain tumor resection.

Methods: We retrospectively analyzed the baseline intraoperative serum lactate levels of 2,053 patients who underwent craniotomies, including 415 with cerebral aneurysms and 1,638 with brain tumors. The brain tumor group was divided into subgroups based on the tumor pathology (extra-axial and intra-axial tumor) and the WHO tumor grade (high-grade and low-grade).

Results: Serum lactate level was significantly higher in the tumor group than in the aneurysm group (1.98 ± 0.97 vs. 1.09 ± 0.57 mmol/L, $p < 0.001$). The hyperlactatemia incidence (serum lactate level > 2.2 mmol/L) was higher in the tumor group (33.5 vs. 3.1%, $p < 0.001$). Severe hyperlactatemia (serum lactate level > 4.4 mmol/L) was found in 34 patients (2.1%) of only the tumor group. In patients with intra-axial tumors, serum lactate level was greater in high- than low-grade tumors (2.10 ± 1.05 vs. 1.88 ± 0.92 mmol/L, $p = 0.006$). Factors predictive of hyperlactatemia included supratentorial tumor location (odds ratio[95%CI] 2.926[2.127-4.025], $p < 0.001$) and a long tumor diameter ($1.071[1.007-1.139]$, $p = 0.028$). In high-grade intra-axial brain tumor patients, there was a significant difference in overall survival between patients with hyperlactatemia than those without ($p = 0.048$).

Conclusion: Our results show that brain tumor patients exhibit the Warburg effect and serum lactate may be a useful diagnostic and prognostic biomarker in patients with high-grade intra-axial brain tumors.

Keywords: Brain Tumor; Serum lactate; Warburg effect.

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