J Neurooncol
DOI 10.1007/s11060-008-9710-6

CLINICAL STUDY - PATIENT STUDY

# Modeling the effects of resection, radiation and chemotherapy in glioblastoma

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Received: 28 June 2008 / Accepted: 22 September 2008


**Abstract** The standard treatment for newly diagnosed glioblastoma multiforme is surgical resection followed by radiotherapy and chemotherapy. Most studies on these treatments are retrospective clinical data analysis. To integrate these studies, a mathematical model is developed. The model predicts the survival time of patients who undergo resection, radiation, and chemotherapy with different protocols.

**Keywords** Glioblastoma · Resection · Radiation · Chemotherapy · Mathematical modeling

## Introduction

Glioblastoma multiforme, a type of glioma, is the most aggressive of brain tumors; life expectancy from the time when it is diagnosed is typically 1 year. The current treatment is surgical resection followed by radiotherapy and chemotherapy. There are only a few consistent clinical studies which compare life expectancy of patients who underwent different resections (residual or complete) and different protocols of radiotherapy and chemotherapy. Among the most consistent studies are those of Albert et al. [1], Lacroix et al. [2], and Stupp et al. [3].

A detailed study of 135 patient data by Albert et al. [1] showed that patients who underwent subtotal surgery postoperatively had 6.6 times higher risk of death in comparison to patients who underwent complete resection, and patients treated by radiotherapy had 0.26 times lower risk of death in comparison to patients who were not treated with radiation. Lacroix et al. [2] analyzed 416 patients data and showed that a significant survival advantage was associated with resection of 98% or more of the tumor volume, and generally, gross total tumor resection led to longer life expectancy.

The efficacy of chemotherapy has been steadily improving with the development of new cancer drugs. Stupp et al. [3] analyzed the data of 573 patients and showed that the median survival time (MST) was 14.6 months for patients who underwent radiotherapy plus chemotherapy with temozolomide, but only 12.1 months for those with radiotherapy alone.

All these clinical data analysis are retrospective. They have value for reference, but they are likely quite biased in nature, and cannot give any perspective prediction. In the present paper we develop a mathematical model which integrates the treatment of patients by surgery, radiotherapy and chemotherapy. The model parameters are chosen so that the simulation results fit with the patient data analysis reported in [1–3]. The purpose of the model is to suggest a combination of treatment protocols that can give patients maximal survival time.

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