Design of a Rotating Facility for Extracorporeal Treatment of an Explanted Liver with Disseminated Metastases by Boron Neutron Capture Therapy with an Epithermal Neutron Beam

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INTRODUCTION

The liver is the first major organ reached by the blood draining the gastrointestinal tract. Consequently, it is a common site of hematogenous metastasis from gastrointestinal malignancies. Colorectal cancer is the second leading cause of cancer-related death in developed countries. In the U.S. alone, 146,000 new cases occur annually (1), of which 50% develop liver metastases, and in a third of these, the liver will be the only site of metastases (2). Untreated hepatic colorectal metastasis has a poor prognosis, with a median survival of 6–12 months (3). In selected cases, surgery offers an effective therapeutic option leading to an improved median survival of 40 months or more and a 20% 10-year survival (3). However, in cases of multiple tumor lesions restricted to the liver that cannot be removed by partial hepatectomy, chemotherapy is the only treatment that can be offered. Even though the newest chemotherapeutic drugs have a response rate of around 40%, the overall survival benefit has been shown to be marginal. Thus attention has turned to loco-regional techniques that together with improved surgical procedures may be potentially curative. One such option could be the extracorporeal treatment of the liver by boron neutron capture therapy (BNCT).

The investigation presented here is motivated by a successful extracorporeal treatment using BNCT on one patient in Pavia (Italy) (4, 5). The 48-year-old patient developed synchronous diffuse liver metastases from an adenocarcinoma of the sigmoid colon; these liver metastases progressed after conventional chemotherapy. After intensive preclinical experiments (6, 7), the patient received 750 ml of a 0.14 M boronophenylalanine (BPA)-fructose solution (300 mg BPA per kg body weight) through the colic vein over a period of 2 h. After the infusion, tissue and tumor samples were taken to measure the boron-10 concentration just prior to hepatectomy. The explanted liver was cooled to 4°C and transported to the TRIGA reactor of the University of Pavia where it was irradiated at the thermal column for 11 min, producing a neutron fluence of $4 \times 10^{12} \pm 20\% \text{ cm}^{-2}$ (4). After BNCT, the liver was transported back to the operating theater and reimplanted. A complete

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