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M. Gautherie (Ed.)

Methods of External Hyperthermic Heating

With Contributions by
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Preface

The development of equipment capable of producing and monitoring safe, effective and predictable hyperthermia treatments represents a major challenge. The main problem associated with any heating technique is the need to adjust and control the distribution of absorbed power in the tissue during treatment. Power distribution is considered adequate only when tumor tissue can be maintained at the required hyperthermic levels while, at the same time, healthy tissue is not overheated. This problem is particularly crucial when external heating devices are used to produce hyperthermia. External hyperthermia refers to those methods which supply heat to tumor tissue in an external, noninvasive manner, as opposed to internal hyperthermia by which heat is supplied to tumor tissue in situ.

Until recently, most of the technical developments and clinical trials of thermotherapy for superficial and deep tumors have been based on electromagnetic systems. Presently, there is increasing interest in the use of ultrasound to accomplish these goals. Electromagnetic techniques of external thermotherapy include radiative, capacitive, and, to a lesser extent, inductive procedures. Recent designs for radiative applicators have incorporated microstrip structures. These have the advantage of being compact and lightweight compared with dielectrically loaded waveguide applicators. When using radiative applicators, proper control of power distribution can be achieved by scanning the applicator over the tissues or using arrays of simple applicators, such as annular phased arrays in which relative powers and phases are adjusted electronically. Capacitive electrodes have also been utilized extensively, based upon their capacity to deliver heat at depth. Control over power deposition, however, is difficult, and problems arise when thick layers of subcutaneous fat are present and when tissue heterogeneity leads to regions of high-current density and related hot spots.

A variety of ultrasound heating systems are being investigated. For the treatment of superficial tumors, single-plane transducers are useful, but multielement applicators offer greater control over the power deposition pattern. Recent designs for deep heating apply advanced ultrasound technologies such as multiple focussed transducers moved mechanically in such a way that the heating foci are scanned through the tumor volume, or phased arrays with electronic scanning allowing complex spot-focus scan paths for precise synthesis of heating patterns. In spite of significant limitations related to intervening bone and gas, ultrasound systems are suitable for external heating of superficial and deep tumors in a variety of anatomical sites.

Regardless of the method selected, quality control is of paramount importance for two reasons. The first is to evaluate the heating capabilities of the equipment; the second is to objectively compare the results of multicenter trials performed using different heating systems. Procedures, guidelines, and study criteria are presently being discussed by the European Society for Hyperthermic Oncology (ESHO), the North American Hyperthermia

Group (NAHG), and the Japanese Society of Hyperthermic Oncology (JSHO). The use of standard, tissue-equivalent phantoms has been recommended to investigate power deposition patterns as measured by the distribution of the so-called specific absorption rate (SAR).
The techniques for providing external hyperthermia have improved considerably during the past decade. Further progress is required, however, particularly to develop a precise concentration of hyperthermia within the target tumor volume. In this regard, the potentials of microwave and ultrasound heating devices appear to be greater than those of other modalities. The design and development of any thermotherapy equipment should always consider in parallel the heat-producing and the temperature-measuring systems in order to allow feed-back control of tumor hyperthermia.

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