ENDOTRACT ANTENNA FOR APPLICATION OF HYPERTHERMIA TO MALIGNANT LESIONS

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As hyperthermia treatment for deeply located malignant lesions is most difficult, two types of endotract antenna were devised, one constructed for radio frequency and the other for administration of microwave to tumors of the esophagus and colorectum. Well-controlled temperatures can be applied to the narrowed pyloric canal of dogs with these two instruments, which appear to have great promise for clinical application.

Key words: Hyperthermia — Endotract antenna — Radio frequency — Microwave

Hyperthermia is particularly effective for the treatment of clinical carcinoma when applied concomitantly with radiation and chemotherapy.4,7) There are certain difficulties when hyperthermia is to be applied to a deeply located lesion and the approach to heating only a deep portion of the body and measurement of the exact temperature in these deep areas has remained a problem in therapeutics.

We devised two types of antenna, one for microwave (MW) and the other for radio frequency (RF). When one of these antennae is inserted into the gastro-intestinal tract, a deep portion can be properly warmed and the exact temperature monitored.

The main structure of the antenna consists of the following three parts (Fig. 1).

1. Transmitter for MW (915 MHz, 24 W) or RF radiation (13.56 MHz, 100 W).
2. A balloon and a cooling system which eliminates the agp between the malignant tissue and the transmitter: 60 ml/min of water at room temperature was circulated to prevent overheating of the transmitter.
3. Thermosensor: Copper/constantan thermo - couples (IT-18, Bailey Company, U.S.A.) were fixed on the outside of the balloon.

The narrowly plasticized pyloric canal of mongrel dogs was used as an experimental model for temperature assessment (Fig. 2). Three thermo-sensors were inserted into each layer of the gastric wall, and the time course of temperature during RF or MW

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irradiation was measured. When measuring the temperature, the generator output was interrupted. In both MW and RF experiments, the desired temperature range for hyperthermic treatment was readily obtained, even at 6 mm from the mucosal surface (Fig. 3). The exact temperature of the lesion can be obtained from the thermometer attached to the balloon surface.

Fig. 4 is schematic diagram of how a carcinoma of the esophagus is warmed by the RF antenna. A thin, long electrode in the esophagus and a broad and wide counter-electrode at the body surface makes possible localization of the electro-magnetic field at the esophagus, and provides effective heat to portions of the esophagus, which it would otherwise not be feasible to reach. The temperature of the endotract antenna is controlled by the cooling water system within the balloon. Thermosensors attached to the balloon surface indicate the temperature of the tumor surface. By suitably rotating the counter-electrode, circumferential heating of the esophagus is feasible.

The MW endotract antenna, which requires no counter-electrode, can be used for carcinoma of the esophagus or colorectum.

Fig. 2. Scheme of warming

The temperature of the narrowly plasticized gastric wall of a mongrel dog was monitored at three points by the use of thermosensors. The antenna was inserted through the gastric wall to administer hyperthermia.

Fig. 3. Temperature at each depth of the gastric wall

A: MW heating. a: outer surface of the balloon; b: 4.0 mm depth; c: 6.5 mm depth; d: subserosa (7.0 mm depth). B: RF heating. a: outer surface of the balloon; b: 2.2 mm depth; c: 2.8 mm depth; d: subserosa (5.6 mm depth). An ideal temperature for hyperthermia was easily obtained with either antenna.

Fig. 4. Temperature of esophageal carcinoma heated with RF

A suitable temperature for hyperthermic treatment was obtained with a heating time of 5 min.
Various methods of producing local and regional hyperthermia, such as regional perfusion of the extremities, water bath immersion, ultrasound, and nonionizing electromagnetic radiation, including radio frequency and microwave radiation, have been used to investigate the efficacy of heat as a clinical modality for treating superficial cancers.\textsuperscript{1-3,5,6} However, selective heating of deeply located malignant tissue has heretofore not been possible.

In 1978, we initiated a clinical study on esophageal carcinoma by infusing water at 55–60° into the esophageal balloon of a Sengstaken-Blakemore tube, usually applied as a hemostasis for bleeding esophageal varices.\textsuperscript{7} In 6 of 8 patients treated with heat combined with radiation and chemotherapy the response was positive (75%). However, it was difficult to apply this system to patients with a severe stenosis due to esophageal carcinoma. After several years of continued research on designs, we devised hyperthermia antennae which can heat the deep portion of the body. These small antennae used to produce local hyperthermia include one for radio-frequency and one for microwave administration. Both are 4 mm in diameter, and can be inserted into the esophagus or colon.

The results of clinical applications of these antennae will be reported in detail elsewhere.

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\textbf{REFERENCES}


