Comparison of Intratumor and Intraluminal Temperatures During Locoregional Deep Hyperthermia of Pelvic Tumors

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Purpose: To investigate whether intraluminal thermometry provides sufficient information to apply high quality deep hyperthermia in pelvic tumors.

Patients and Methods: The intratumor and intraluminal temperatures of 48 patients were analyzed per cancer type: rectum (21 male, 14 female), cervix (n = 8), and bladder (n = 5). Temperature-dose parameters were calculated, temperature curves within each treatment session were compared, and correlation between intratumor and intraluminal temperatures was analyzed.

Results: Intratumor and intraluminal temperatures at the same time points during individual treatments were highly correlated (mean correlation coefficient: 0.93). However, the quantitative level differed from 0.1 to 1.1 °C and the differences of the time-temperature graphs varied per tumor group. Average intratumor and intraluminal temperatures were not different in the four groups. Intratumor thermometry was found not superior over intraluminal thermometry to improve tumor temperature level and homogeneity by SAR steering.

Conclusion: Intraluminal thermometry provides sufficient information to apply deep hyperthermia to individual patients with centrally located rectum, cervix or bladder cancer.

Key Words: Hyperthermia · Pelvic tumor · Intratumor/intraluminal thermometry

Vergleich von intratumoralen und intraluminalen Temperaturen während lokoregionaler tiefer Hyperthermie von Beckentumoren

Ziel: Es wurde untersucht, ob die intraluminale Thermometrie genug Informationen für die Anwendung einer qualitativ hochwertigen regionalen Hyperthermie bei Beckentumoren liefert.

Patienten und Methodik: Die intratumoralen und intraluminalen Temperaturen von 48 Patienten wurden nach Krebsart analysiert: Rektum (21 Männer, 16 Frauen), Gebärmutterhals (n = 8) und Blase (n = 5). Temperatur-Dosis-Parameter wurden berechnet, die Temperaturkurven im Rahmen jeder Behandlung wurden verglichen, und die Korrelation zwischen intratumoralen und intraluminalen Temperaturen wurde analysiert.

Ergebnisse: Intratumorale und intraluminalen Temperaturen zu denselben Zeitpunkten während individueller Behandlungen zeigten eine hohe Korrelation (mittlerer Korrelationskoeffizient 0.93). Die absoluten Temperaturen differierten jedoch von 0,1 bis 1,1 °C, und die Unterschiede in den Zeit-Temperatur-Diagrammen waren tumorgruppenspezifisch. Die mittleren intratumoralen und intraluminalen Temperaturen waren in den vier Gruppen nicht unterschiedlich. Bezüglich einer Verbesserung der Tumortemperatur und der Homogenität fand sich keine Überlegenheit der intratumoralen Thermometrie gegenüber der intraluminalen Thermometrie.

Schlussfolgerung: Die intraluminale Thermometrie liefert genug Informationen zur Anwendung der regionalen Hyperthermie bei individuellen Patienten mit zentral lokализierten Rektum-, Gebärmutterhals- oder Blasenkarzinomen.

Schlüsselwörter: Hyperthermie · Rektum · Gebärmutterhals · Blase · Intratumor/intraluminale Thermometrie

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Introduction

In the recent decades, multimodality treatment approaches for deep-seated pelvic malignancies including surgery, radiotherapy, chemotherapy, and hyperthermia have become increasingly sophisticated [2, 6, 9, 14]. When patients with deep seated tumors are under treatment, hyperthermia groups apply intratumor and/or intraluminal thermometry for temperature data acquisition. Strong variation exists in the opinions whether intratumor thermometry provides superior information over intraluminal thermometry. Sneed et al. [7] state that intratumor thermometry is critically important, while van der Zee et al. [11] and Wust et al. [16] suggest, if intraluminal thermometry is available, intratumor thermometry is neither an important requirement for prevention of toxicity, nor necessary for SAR (specific absorption rate) steering.

Van der Zee et al. [11] focused on the complications and clinical limitations of intratumor thermometry during deep hyperthermia of pelvic tumors and present a very limited thermal analysis. Wust et al. [16] demonstrated that intraluminal measurements, specifically for cervical and rectal cancers, are suitable for estimating feasibility and effectiveness, and that there is no need for intratumor thermometry.

The present study is an extension of that by van der Zee et al. [11]. It provides a rigorous analysis of temperature data, acquired both intratumorally and intraluminally, of patients with pelvic tumors, making it an independent replicate of the study by Wust et al. [16]. Questions were: (1) Is there a positive correlation between intratumor and intraluminal temperatures? (2) What are the quantitative/qualitative differences between intratumor and intraluminal temperatures? (3) Can intratumor temperature distribution be improved by SAR steering?

Patients and Methods

Patients

Data used in this retrospective study were selected from our patients’ database. Selection criteria were: (1) intratumor and intraluminal temperature measurements, (2) tumor location: pelvis, (3) tumor type: rectum, cervix, or bladder. Based on these criteria, 58 patients (143 treatments) were selected.

Accessibility of temperature data, as registered by the BSD-2000 system, requires specific tools and it is subjected to failures as explained by Fatehi et al. [3]. For the present study, it was not possible to transfer the PDOS-formatted data of nine patients (16 treatments) to MSDOS. Additionally, during the data processing by means of RHyThM (Rotterdam Hyperthermia Thermal Modulator), it was not possible to access temperature data of one patient (2 treatments) and 25 single treatments.

With these limitations, 48 patients (100 treatments) were available for analysis. Patients were grouped in four categories: male rectal cancer (n = 21 patients, 39 treatments), female rectal cancer (n = 14 patients, 27 treatments), cervical cancer (n = 8 patients, 21 treatments), and bladder cancer (n = 5 patients, 13 treatments). For a detailed description of patient characteristics and tumor stage see van der Zee et al. [11].

Hyperthermia

Hyperthermia was performed using the BSD-2000 with the Sigma-60 applicator (BSD Corporation, Salt Lake City, UT, USA) [10]. One to five (mean: four) locoregional hyperthermia treatments were delivered to the pelvis once weekly during the period of radiotherapy or chemotherapy. Hyperthermia was started at 400 W RF power. The treatment settings for frequency, amplitude distribution, and phase shifting at the start of the first treatment were selected according to the local protocol. Patients were carefully instructed to mention any unpleasant sensation that might be the result of a hot spot [11]. Power output was increased to the patient’s tolerance without pain. To improve the temperature distribution or to relieve pain complaints, treatment settings were adapted, i.e., phase, power per channel, frequency, or by placing additional water boluses. Treatment duration was 60 min after any of the intratumor-measured temperatures had reached 42 °C, or to a maximum of 90 min. Water bolus temperature was maintained at 20 °C. Systemic temperature was controlled by cooling measures: undressing, air-conditioning, wet towels, and ice packs. The bladder was kept empty with a Foley catheter [4].

Thermometry

Intratumor catheter placement was planned at least 1 day prior to the first hyperthermia treatment. 5 F polyethylene closed-tip thermometry catheter(s) (William Cook Europe ApS, Bjaeverskov, Denmark) were introduced in the tumor transgluteally under CT control. For details see van der Zee et al. [11]. Intraluminal catheters were inserted in bladder, rectum, and vagina lumen (as relevant) before each treatment. After catheter placement, the intratumor and intraluminal depths were documented. Insertion length of the intraluminal catheters was measured manually using a standard caliper. Bowman probes [1] were used to assess real-time temperature reading (accuracy: ± 0.1 °C). Temperature mapping was performed in 1 cm increments to a maximum length of 14 cm. Thermal mapping started just before the treatment and was repeated at 5-min intervals.

Data Processing and Definitions

The method of data processing has been extensively described by Fatehi et al. [3, 4]. In this study, the intratumor temperature is defined as temperature data acquired from within the tumor. The intraluminal temperatures are reported as normal tissue, tumor contact, tumor-indicative, or overall measurements. Tumor contact means that the catheter at the site of measurement lies in contact with tumor. When the site of