Original Contribution

The Influence on Cardiopulmonary System in Hyperthermia for Intrathoracic Tumor

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Abstract : Patients with an intrathoracic malignant tumor are often in a bad respiratory condition. Therefore, it is important to prove the safety of hyperthermia. We investigated body temperature, respiratory rate, blood pressure, pulse rate, percutaneous oxygen saturation and arterial blood gas analysis before, immediately after and 5 minutes after hyperthermia in 13 patients. Besides an increase in the pulse rate, which has already been reported, we observed an elevation of body temperature, increase of the respiratory rate and a depression of the partial pressure of oxygen in arterial blood. None was considered serious, but we need to remember these influences during hyperthermia.

Key Words : side effect, hyperthermia, hypoxia, intrathoracic malignant tumor

Introduction

Thermotherapy has recently been applied to various diseases, and its usefulness for treatment of intrathoracic malignant tumors has been reported¹⁾. However, it is necessary to prove the safety of this method because respiratory conditions are relatively poor in many patients with an intrathoracic malignant tumor. It has been reported that an increase in the heart rate and a slight elevation of blood pressure are side effects of thermotherapy, but data of respiration conditions have not been sufficiently evaluated. In this study, we performed electromagnetic thermotherapy in patients with intrathoracic malignant tumors and evaluated the safety for respiration.

Subjects and methods

The subjects were 13 patients with intrathoracic malignant tumors who were admitted to our hospital and underwent thermotherapy and a measurement of intrathoracic temperature. The patients consisted of 11 males and 2 females with the mean age of 58.2 ± 15.2 years. The intrathoracic malignant tumors were lung cancer including recurrence after surgery in 9 patients, a mediastinal tumor in 3 and a pleural mesothelioma in 1 (Table I). All patients showed a performance status (P.S.) below 2. We explained to them that it was necessary to make sure the safety of thermotherapy for each person, and obtained their consents to these examinations by word of mouth in advance. A venula needle was inserted into the lesion

Table I. CHARACTERISTICS of PATIENTS.

Male	11
Female	2
Age	58.2±15.2
Lung cancer	9
Adeno cell ca.	5
Squamous cell ca.	3
Large cell ca.	1
Mediastinal tumor	3
Mesothelioma	1

under ultrasonographic or CT guidance to take its temperature, and thoracic thermotherapy was performed from the front and back at about 1,400 W for 60 min using a thermotron RF-8 (Yamamoto VINITA Co., Osaka, Japan). They kept the same position with overlay bolus placed for five more minutes after thermotherapy. In patients with severe pain of the skin, thermotherapy was performed at the highest possible output. We performed blood and biochemical examinations immediately before and after thermotherapy. We also examined the blood pressure, pulse rate, intraoral temperature, percutaneous oxygen saturation, temperature in the lesion and performed arterial blood gas analysis immediately before and immediately after and 5 min after thermotherapy. No patients were administered oxygen. All these measurements were performed once, in their second therapy. Statistical analysis was performed by paired Wilcoxon's test. A value of $p < 0.05$ was regarded as significant.

Results

In 7 of the 13 patients, the temperature in the lesion was higher than 41.5°C , which is considered effective against malignant tumors. The mean temperature in the lesion was elevated to $42.5 \pm 3.0^{\circ}\text{C}$ from $37.2 \pm 0.3^{\circ}\text{C}$ (mean $\pm$ SD) immediately after thermotherapy, and it fell to $40.0 \pm 3.3^{\circ}\text{C}$ 5 minutes after thermotherapy. There were no significant differences in the systolic and diastolic pressures and the mean blood pressure between before and after thermotherapy (128 ± 17 vs. 126 ± 15 mmHg, 81.0 ± 9.5 vs. 77.8 ± 9.1 mmHg, 104 ± 12 vs. 102 ± 11 mmHg). The body temperature was significantly elevated to $37.9 \pm 0.7^{\circ}\text{C}$ from $36.8 \pm 0.5^{\circ}\text{C}$ ($p < 0.005$), and it fell to $37.6 \pm 0.5^{\circ}\text{C}$ 5 minutes after thermotherapy. The pulse rate significantly increased to $101.5 \pm 19.1/\text{min}$ from $78.8 \pm 11.2/\text{min}$ ($p < 0.001$), and decreased to $90.8 \pm 12.5/\text{min}$. The respiratory rate significantly increased to $25.2 \pm 8.2/\text{min}$ from $17.5 \pm 5.2/\text{min}$ ($p < 0.01$), and decreased to $20.2 \pm 6.9/\text{min}$. Blood gas analysis revealed that the arterial oxygen pressure significantly decreased to 77.3 ± 10.9 Torr from 88.4 ± 11.0 Torr ($p < 0.005$), and increased to 83.0 ± 11.0 Torr. There were no significant differences in the arterial carbon dioxide and HCO_3^- pressures between before and after thermotherapy. The arterial oxygen saturation significantly decreased to $96.3 \pm 3.4\%$ from $97.7 \pm 2.0\%$ ($p < 0.005$), and increased to $97.3 \pm 2.7\%$, while AaDO_2 significantly increased to 22.9 ± 12.8 Torr from 10.5 ± 12.7 Torr ($p < 0.005$), and decreased to 17.8 ± 12.0 Torr (Fig. 1). There were no significant differences in the blood and biochemical examinations between before and after thermotherapy.

Discussion

Pain, changes in blood pressure and increases in the heart rate are considered as side effects of

Fig. 1. Influence of hyperthermia for intrathoracic tumor. Each graph shows significant change during hyperthermia.

thermotherapy²⁾. In the present study, the arterial oxygen pressure was found to decrease during thermotherapy. The causes were considered to be as follows:

- a) the increase in oxygen consumption with the increase in the heart rate caused by elevation of body temperature,
- b) the irregular distribution of ventilation blood flow and reduction of the diffusing capacity with changes in pulmonary blood flow, and
- c) failure in ventilation caused by external pressure on the thorax using an overlay bolus.

With regard to a), the heart rate increases during thermotherapy as reported, and the increase in oxygen consumption is clear. However, it is doubtful whether hypoxemia is caused only by the increase in oxygen consumption with the increase in the heart rate. About b), retention of secretion from the airway in the back occurs if the restricted position is maintained for 60 min, resulting in local atelectasis. Subsequently, changes in the ventilation/perfusion ratio would occur. However, the arterial oxygen pressure was higher 5 min after thermotherapy than immediately after thermotherapy. Therefore, hypoxemia cannot be explained by this reason alone. Because AaDO₂ was dilated in this study, there were at least changes in the ventilation/perfusion ratio and diffusing capacity/perfusion ratio. Hagiya et al. reported that the carbon monoxide diffusing capacity (DLco) increased at rest and while exercising during hyperventilation³⁾, suggesting that hypoxemia is related to hyperventilation during thermotherapy. The DLco level is also considered to be affected by body temperature⁴⁾.

With regard to c), *i.e.* external pressure on the thorax, ventilation will be restricted by a heavy overlay bolus placed on the body surface, but the arterial oxygen pressure was elevated 5 min after thermotherapy in spite of the same patient position with overlay bolus placed. This result suggested either that external pressure on the thorax was not the main cause of hypoxemia or that there was another main cause. The arterial oxygen pressure was considered to be reduced by a complicated combination of the above factors. In this study, there were no serious problems caused by hypoxemia during thermotherapy, but in one case, there was a severe decrease of the arterial oxygen pressure (from 65.7 Torr to 52.6 Torr) and it seemed that administering oxygen was needed. We considered that thermotherapy can be performed in patients in a bad respiratory condition by administering oxygen.

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胸腔内腫瘍に対する温熱療法が呼吸循環器系に及ぼす影響

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要 旨：胸腔内悪性腫瘍症例では呼吸状態の比較的不良な患者が多く，温熱療法を施行するにあたり安全性の証明が不可欠である．今回我々は胸腔内悪性腫瘍に対して電磁波温熱療法を施行した13症例について，治療前，直後，終了5分後に体温，呼吸数，血圧，脈拍，経皮的酸素飽和度，動脈血液ガス分析を行い副作用の検討をした．従来報告されている脈拍数の増加に加え，体温の上昇，呼吸数の増加，動脈血酸素分圧の低下を認めた．今後の同領域の治療において留意する必要があると思われた．