Measurement of Surface Temperature in Lung Cancer*

Tatsuo Ohgimi, M.D.; Saburo Akiyama, M.D.; and Kaoru Shimokata, M.D.

We measured the surface temperature of the tumors in 27 patients with primary lung cancer, using a flexible bronchofiberscope and a thermometer made from chromel-constantan. The thermometer was inserted into the aspiration channel of the bronchofiberscope, and temperature was studied under bronchofiberscopic observation. The surface temperatures of the tumors located in the central portion of the lung were higher than those of the carina of the trachea (P<0.01), truncus superior (P<0.01), or truncus inferior (P<0.05), and almost equal to those of the peripheral lung. Thus, lung cancer showed a significantly higher surface temperature. When 67Ga scintigraphy was performed in 22 patients with lung cancer, the temperature of the high-uptake group was higher than that of the low-uptake group.

Many studies have reported the temperature of various organs. Although the temperature in the upper respiratory system has been investigated, few reports have dealt with the lower respiratory system, especially in man. This might be due to the limitations of the actual instrumentation for temperature measurement. However, the development of a flexible bronchofiberscope, the progress of anesthetia, and the invention of new thermometers have made it possible to measure the temperature of the bronchopulmonary mucous membrane.

It is well known that the temperature of a malignant breast tumor is higher than that of the surrounding tissues. However, little is known about the temperature of other tumors. If the temperature on the surface of lung cancer tissue is significantly high, it would have great implications for thermometric or other means of diagnosis.

We describe the temperature of the bronchopulmonary mucous membrane and the surface of primary lung cancer using a flexible bronchofiberscope and a thermometer made from chromel-constantan.

MATERIALS AND METHODS

Twenty-four male and three female patients with primary lung cancer were studied. Fifteen patients with pulmonary tuberculosis, ten with bronchitis, and five with bronchiectasis also were studied in the convalescent stage. The age of the patients with lung cancer was between 38 and 73 years. According to the histopathologic classification, the lung cancers encountered consisted of 17 cases of squamous cell carcinoma, 7 cases of undifferentiated small cell carcinoma, and 3 cases of adenocarcinoma. The reason for the greater incidence of squamous cell carcinoma was that the study was restricted to patients whose tumors were located in the central portion of lungs to permit observation using a bronchofiberscope.

The surface temperature on the bronchopulmonary mucous membrane and on the lung cancer was measured by a chromel-constantan thermometer (Anritsu Keiki & Yayoi) as shown in Figure 1. Deep-body temperature was measured from 10 AM to 12 noon, and the room temperature was kept at about 20°C. After local anesthesia was administered, the bronchofiberscope was introduced into the trachea, and the thermometer was inserted into the aspiration channel of the bronchofiberscope and placed on the bronchopulmonary mucous membrane or lung cancer surface under bronchofiberscopic observation. Figure 2 shows the tip of the thermometer placed on the mucous membrane of the carina in the trachea. Temperature measurement...
sites were the carina of the trachea, the superior and inferior bronchi, the peripheral lung of the lower lobe, the tumor itself, and the bronchial mucous membrane around the tumor that was considered to be normal by bronchofiberscopic observation. Temperature at the axilla was also measured. Scintigraphy with $^{67}$Ga was performed in 22 cases and bronchial arteriography in six cases of primary lung cancer, and the relationship between these findings and the temperature on the surface of the lung cancer tumor was discussed. Moreover, the temperature on the surface of the tumor was compared in five cases before and after chemotherapy and irradiation.

**RESULTS**

**Surface Temperature of the Bronchopulmonary Mucous Membrane in Respiratory Disease and of Lung Cancer Tumor**

We examined the temperature on the bronchopulmonary mucous membrane in 30 cases of respiratory diseases in the convalescent stage—15 cases of pulmonary tuberculosis, 5 cases of bronchitis, and 10 cases of bronchiectasis. The temperature of healthy sites was measured. The temperature on the carina was 0.24 to 0.56°C lower than that on the axilla. However, the superior or inferior truncus and peripheral lung tended to show a gradually increasing temperature, as shown in Table 1.

In 27 cases of lung cancer, the mean ± SD of the temperature on the mucous membrane of the carina in trachea was $36.63 ± 0.54°C$, $36.92 ± 0.51°C$ in the superior truncus, $37.00 ± 0.49°C$ on the inferior truncus, and $37.26 ± 0.46°C$ on the lung cancer. Findings suggested that the deeper the measured site, the higher the temperature. Although tumors whose temperatures were measured were located in the central portion of the lung, the surface temperature on the tumor was almost equal to that on the peripheral lung (Table 1).

**Surface Temperature of Lung Cancer Tumors According to Histopathologic Classifications**

The temperature on the mucous membrane around a squamous cell or an undifferentiated small cell tumor was almost equal to that on the truncus inferior, and tended to be lower than that of tumor itself (Table 2).

Table 3 summarizes the difference in surface temperature between the bronchopulmonary mucous membrane and the lung cancer. In 27 cases of lung cancer, $t$-test findings revealed a significant difference in the surface temperatures of the tumor and the carina ($P<0.01$), truncus superior ($P<0.01$), and inferior ($P<0.05$), respectively. However, the tumor, peripheral lung, and mucous membrane around the tumor showed no significant temperature difference.

**Surface Temperature of the Bronchopulmonary Mucous Membrane and the Lung Cancer Before and After Treatment**

In five cases not completely cured by chemo-

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### Table 1—Deep-Body Temperature in Various Lung Diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Axilla</th>
<th>Carina</th>
<th>Truncus Superior</th>
<th>Truncus Inferior</th>
<th>Peripheral Lung</th>
<th>Tumor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulmonary tuberculosis</td>
<td>$36.71 ± 0.40^*$</td>
<td>$36.37 ± 0.44$</td>
<td>$36.64 ± 0.51$</td>
<td>$36.72 ± 0.48$</td>
<td>$36.97 ± 0.37$</td>
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<tr>
<td>Bronchitis (n=10)</td>
<td>$36.42 ± 0.59$</td>
<td>$36.18 ± 0.57$</td>
<td>$36.56 ± 0.44$</td>
<td>$36.73 ± 0.37$</td>
<td>$37.11 ± 0.35$</td>
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<tr>
<td>Bronchiectasis (n=5)</td>
<td>$37.06 ± 0.51$</td>
<td>$36.50 ± 0.46$</td>
<td>$36.84 ± 0.40$</td>
<td>$36.98 ± 0.40$</td>
<td>$37.22 ± 0.27$</td>
<td></td>
</tr>
<tr>
<td>Lung cancer (n=27)</td>
<td>$36.70 ± 0.43$</td>
<td>$36.63 ± 0.54$</td>
<td>$36.92 ± 0.51$</td>
<td>$37.00 ± 0.49$</td>
<td>$37.22 ± 0.45$</td>
<td>$37.26 ± 0.46$</td>
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</table>

*Mean ± SD (°C).*

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therapy or irradiation, we compared the temperature before and after treatment, and there was no significant difference in the temperature of an incurable tumor before and after treatment (Table 5).

**Relationship Between the Surface Temperature of Lung Cancer and ⁶⁷Ga Scintigram**

We next studied the surface temperature of the lung cancer tumor in 22 cases examined by ⁶⁷Ga scintigram; findings were divided into four groups: O = negative; I = opacity of the lesion weaker than II; II = opacity of the lesion the same as that of vertebra; III = opacity of the lesion the same or stronger than that of the liver. The mean surface temperature of the lung cancer was 37.15 ± 0.07°C in groups 0 and I (n = 2), 38.99 ± 0.39°C in group II (n = 8), and 37.05 ± 0.45°C in group III (n = 12). There was a significant difference (Fig 3) between groups II and III (P < 0.05).

**DISCUSSION**

Deep-body temperature is an interesting problem that has been studied for a long time, but the various methods used were not physiologic. For example, a thermometer needle has been used to pierce the chest wall to measure percutaneously the temperature in the respiratory system. Needless to
Score of $^{67}$Ga-scintigram

Figure 3. Relationship between temperature on surface of lung cancer and stage of $^{67}$Ga scintigraphic findings. O = negative; I = opacity of lesion weaker than II; II = opacity of lesion same as that of vertebra; and III = opacity of lesion same or stronger than that of liver (II-III P<0.05).

say, there is a need for noninvasive procedures. Mukaiyashi et al. reported that the temperature of the deep bronchopulmonary mucous membrane, as obtained through exacting bronchoscopy, was higher than that of the shallow ones. It is difficult to reach the peripheral portion of the lung with the conventional bronchoscope. The application of glass fiber in the bronchoscope removed these drawbacks, and the development of a flexible bronchofiberscope made it possible to observe easily the entire segmental or subsegmental bronchi. Using a flexible bronchofiberscope, we measured the temperature of the bronchopulmonary mucous membrane. We concluded that the deeper the measured sites, the higher the temperature; a temperature gradient was observable in the bronchopulmonary system.

We also used the flexible bronchofiberscope for measurement of the surface temperature of lung cancer, because it was expected that it would be higher than that of the neighboring bronchopulmonary mucous membrane as already reported in the case of breast cancer. A fine prototype thermometer made from chromel-constantan (Anritsu Keiki & Yayoi) was inserted into the aspiration channel of the flexible bronchofiberscope and placed on the tumor. Thus, the surface temperature of the lung cancer could be measured under direct observation. As expected, it was significantly higher than that of the truncus superior or inferior and almost equal to that of the peripheral lung, although the tumor was located at the main, segmental, or subsegmental bronchi. The reason for the high temperature of the tumor was probably the active metabolism and vascularization, as has been demonstrated in the case of breast cancer. However, we did not observe any relationship between the surface temperature of the lung cancer and the bronchial arteriogram, although many more cases must be investigated.

Among the imaging diagnostic modalities, thermography is sensitive to functional parameters such as metabolic rate and blood circulation. For these reasons, considerable attention was directed to its potential in cancer diagnosis. However, the application of thermography has been limited to superficial tumors such as breast cancer. Tomographic thermography is now in the developmental stage. We believe the present study will offer the basic data for the application of tomographic thermography for the evaluation of tumors located in the deeper portions of the body.

ACKNOWLEDGMENT: We wish to thank Professor Ituuro Sobue, the First Department of Internal Medicine, Nagoya University School of Medicine, for his support and encouragement throughout the course of this study.

REFERENCES

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<th>Table 6—Relationship Between Deep-Body Temperature of Lung Cancer Patients and Bronchial Arteriogram</th>
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<td>Squamous</td>
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*Tumor stain, dilation, or meandering of bronchial artery were considered positive findings.

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