Is Thermography a Valuable Tool in Diagnosis of Solitary Thyroid Nodules ?

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ABSTRACT. One hundred and one cases of thyroid nodules were examined telethermographically in an attempt to differentiate malignant nodule from benign ones. Hyperthermic areas were delineated in 95.6% of malignant nodules, but not at all in nodules of adenoma. In the latter case, 66.7% of the nodules were hypothermic and 33.3% were normothermic. In adenomatous nodules, hyper-, normo-, and hypothermic areas were observed in 22.5%, 15% and 62.5%, respectively. Regarding the correlation between thermograghic patterns and ^{201}TlCl, among nodule showing hyperthermic areas, ^{201}TlCl accumulation was seen in 85.4% of cancerous nodules and 88.9% of adenomatous nodules. An analysis of the thermal gradient and determination of the recovery time undertaken in an attempt to improve the accuracy of differentiation of malignant and benign nodules revealed no significant difference in the thermal gradient, but the recovery time in adenomatous nodules was shorter.

Based on the adove results, we believe that thermography is likely to become a valuable tool in the diagnosis of thyroid nodules.

Key words : thyroid nodule — thermography — imaging diagnosis

The effectiveness of thermography in differential diagnosis of the breast has been widely studied and its value has been highly evaluated, because it is a rapid, safe, and noninvasive procedure. The thyroid gland is located close to the body surface and it contains rich vascularization which is anatomically the same as that of the breast. Therefore, it represents an ideal organ for thermographic examination. However, to date, there have been a few report on use of the thermography in the diagnosis of thyroid disorders. The purpose of this study was to evaluate the diagnostic reliability of thermography in the diagnosis of solitary thyroid nodules.

MATERIALS AND METHODS

The subjects of this study were 101 patients (10 males and 91 females) with a solitary thyroid nodule. All of their thyroid functions were within normal limits. No autonomous functioning nodules were encountered. Ultrasonography and scintigraphy were employed before or after the performance of thermography in all the patients. All cases had been histologically confirmed

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by surgical specimens. Telethermography, JTG-3300 (Nihon Denshi Co., Ltd.) was used for this study. The neck and upper thorax were extended and exposed in a room with a temperature of 24°C and a relative humidity of 50% or less. The patients were in a quiet state for at least 15 min until the temperature of the body surface achieved equilibrium with the ambient temperature. Alcohol was applied after the initial examination to selectively cool the entire scanning area, thus allowing any abnormal hot or cold spot seen on the previous thermogram to return to its former temperature at either an accelerated or delayed rate. This also enhanced the temperature differential between adjacent tissue. These results were computerized and estimated as the recovery time of the temperature from after cooling to normal status at the time of initial examination.

^{201}Tl-chloride was purchased from the Daiichi Radioisotope Laboratory. The Nuclear Chicago scintilation camera with pin-hole collimator equipped with Elscint computer display processing device was used throughout the study. The imaging was performed for about 10 minutes immediately following an intravenous administration of 2 mCi of ^{201}TlCl.

RESULTS

1. Thermographic patterns of solitary thyroid nodules

Three types of thermographic pattern were obtained in the nodular regions based on the degree of the local temperature: namely, hyperthermic, normothermic, and hypothermic areas were observed. The smallest nodule which could be represented was 1 cm in diameter. Typical cases in which hyperthermic and

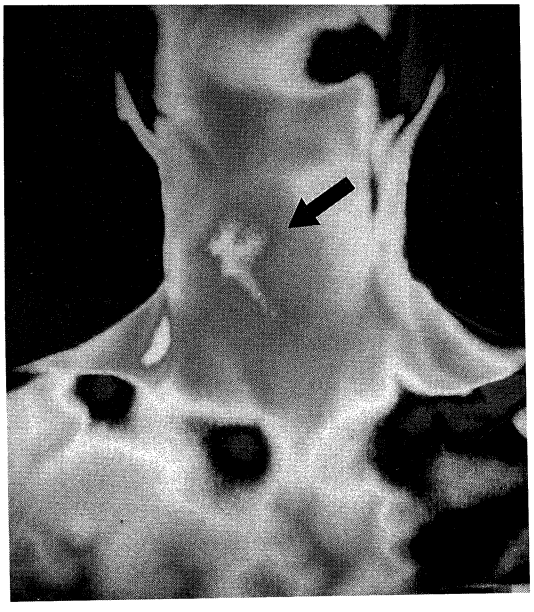

Fig. 1. A 43-year-old female with a right solitary malignant thyroid nodule. Thermography revealed a hyperthermic area (arrow).

hypothermic areas were demonstrated can be seen in Fig. 1 and 2. The correlation between thermal patterns and histological classification is shown in Table 1. Of 45 nodules classified as carcinoma, hyperthermic areas were delineated in all but two. In the remaining two, hypothermic and normothermic areas were respectively noted. In contrast, of 12 nodules classified as adenoma, none had hyperthermic areas while 8 had hypothermic areas, 4 had normothermic. Of 40 nodules classified as adenomatous nodules, hyperthermic, normothermic and hypothermic areas were demonstrated in 9, 6 and 25, respectively. As for cysts, hypothermic areas were delineated in all cases.

When a hyperthermic area was found to be malignant, the overall diagnostic accuracy for the thermography was 95.6%. However, hyperthermic areas were also seen in 16.1% of benign nodules.

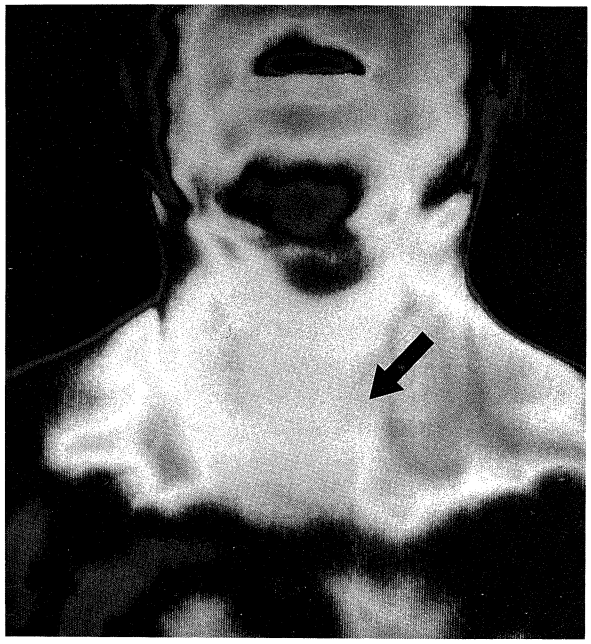

Fig. 2. A 52-year-old female with a right solitary thyroid cyst. Thermography revealed a hypothermic area (arrow).

TABLE 1. Correlation between thermal patterns and histological classification.

	Hyperthermic area	Hypothermic area	Normothermic area
carcinoma	95.6% (43/45)	2.2% (1/45)	2.2% (1/45)
adenoma	0% (0/12)	66.7% (8/12)	33.3% (4/12)
adenomatous nodule	22.5% (9/40)	62.5% (25/40)	15.0% (6/40)
cyst	0% (0/4)	100% (4/4)	0% (0/4)

2. The correlation between thermographic patterns and ^{201}TlCl scintigrams

Correlation between the thermographic patterns and accumulation on ^{201}TlCl scintigrams is shown in Fig. 3. Of 41 malignant nodules showing hyperthermic areas, accumulation of ^{201}TlCl was seen in 35, and of 9

adenomatous nodules, accumulation was seen in 8. None of adenoma showed accumulation.

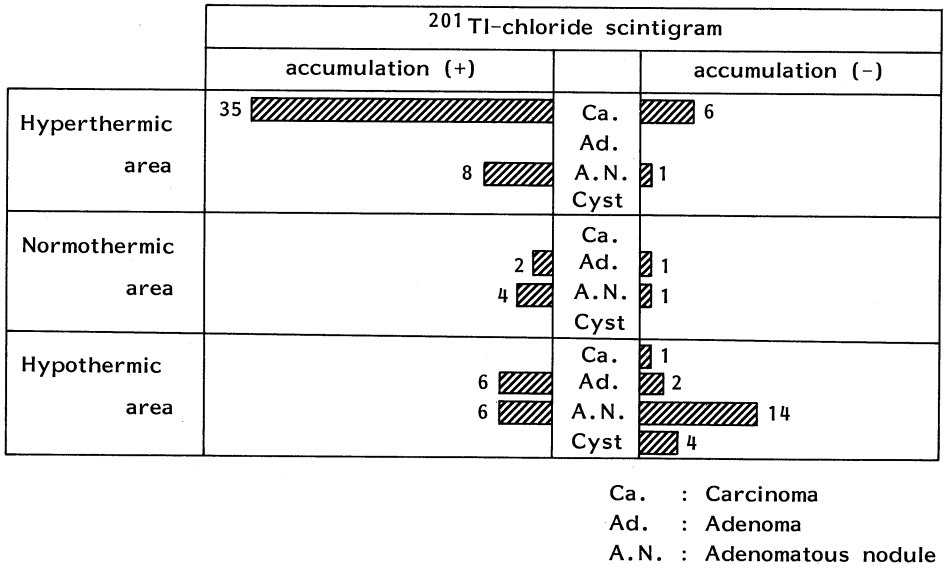

Fig. 3. Correlation between thermal patterns and ^{201}Tl scintigrams.

3. Comparison of the thermal gradient and recovery time after cooling between malignant nodules and adenomatous nodules showing hyperthermic areas

In an attempt to differentiate malignant nodules from benign nodules, an analysis of the thermal gradient and recovery time after cooling was carried out. Regarding the thermal gradient, no statistically significant differences were found as shown in Table 2. A statistical difference in recovery time after cooling, however, was noted as shown in Table 3.

TABLE 2. Comparison of the thermal gradients of a malignant nodules and adenomatous nodules showing hyperthermic area.

carcinoma (n=45)	0.84±0.40	N.S.
adenomatous nodule (n=9)	0.91±0.46 (°C)	

TABLE 3. Comparison of the recovery time after cooling between malignant and adenomatous nodules showing hyperthermic areas.

carcinoma (n=43)	286.7±75.3	P<0.01
adenomatous nodule (n=9)	455.6±54.3 (sec)	

DISCUSSION

The thyroid gland's anatomical location and rich vascularization appear to make it an ideal organ for thermographical studies. In an earlier thermographic study, patients with hyperthyroidism were the subjects of investigation because they may have both increased vascularity and an elevated cutaneous temperature. Williams[1] reported a case of thyrotoxicosis showing an increased temperature in the bilateral lobes and Gros[2] described a case of toxic adenoma delineated as a local hyperthermic area.

Attempts have also been made to thermographically differentiate benign nodules from malignant ones. The data in the literature on the diagnostic value of thermography are still controversial. In general, however, many studies have reported the presence of hyperthermic areas in malignant nodules and hypothermic or normothermic areas in benign nodules. Johnes,[3] De Reniz,[4] and GaLLi[5] reported that hyperthermic areas were noted in 100% of malignant nodules, but they were observed in only 75% by Rocchi,[6] in 61% by Planiol,[7] and 59% by Diego.[8] In our study as mentioned earlier, hyperthermic areas were demonstrated in 95.6% of malignant nodules.

In contrast, most benign nodules with the exception of functioning tumors have been reported to be depicted as either normothermic or hypothermic; Robert[9] reported the presence of normothermia or hypothermia in 80% of the benign nodules, and De Reniz[4] found these conditions in 96.3%, Planiol in 90%, Diego in 85%. Those figures were similar to our finding of 83.9%.

^{201}TlCl accumulates not only in normal thyroid tissue but also more intensively in malignant tumors and some hyperplastic benign tumors. The mechanism of ^{201}TlCl uptake by tumors is still unclear. Our previous study,[10] however, revealed that uptake of ^{201}Tl significantly correlated with that of ^{42}K. Therefore, the mechanism of ^{201}Tl-tumor affinity appears to be triggered by acceleration of the potassium metabolism of a tumor. It is of interest that all nine benign nodules showing a hyperthermic pattern histologically were adenomatous nodules rather than adenomas. Furthermore, all but one of those nodules accumulated ^{201}TlCl. The reason why no hypothermic areas were noted in adenomas, but they were observed in some adenomatous nodules remains unclear. It is also unclear why ^{201}TlCl accumulated in the majority of nodules with hyperthermic areas. Further study in therefore necessary.

Analysis of the thermal gradient and determination of recovery time after cooling undertaken in an attempt to improve the accuracy of differentiation between benign and malignant nodules revealed no significant difference in the thermal gradient, but the recovery time after cooling was shorter in all adenomatous nodules. Thus, the cooling method is useful for excluding benign nodule, and it should be employed after taking thermograms in usual method, whenever the nodule shows a hyperthermic pattern.

When compared with ultrasonography, the diagnostic accuracy of thermography is limited but, almost the same as that ultrasonography. In addition, interpretation of thermographic imaging is easier and more objective. De Reniz[4] pointed out some of the limitations of the thermographic method: a) difficulty in showing formations under 2 cm; b) difficulty in showing formations extending under the jugular; c) difficulty in showing alterations next

to the large vessels of the neck and marginal zones covered by the sternoclaidmastoids. In our study, no nodule smaller than 1 cm showed any appreciable changes on thermograms and there were no nodule which were enlarged beyond the anterior edge of the sternoclaidmastoid muscles or the internal jugular veins.

In conclusion, despite the above-mentioned limitations, we believe that thermographic examination with determination of the recovery time after cooling is useful in the differential diagnosis of thyroid nodules. Thermography, therefore, is likely to become an important tool in the diagnosis of thyroid nodules.

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