Clinical and immunohistochemical study of eight cases with thymic carcinoma

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Abstract

Background: Thymic carcinoma is a rare neoplasm with extremely poor prognosis. To evaluate the biological characteristics of thymic carcinoma, we reviewed 8 patients.

Methods: There were 2 men and 6 women: ages ranged from 19 to 67 years old (mean 54.8 years). None of these patients had concomitant myasthenia gravis and pure red cell aplasia. No patient had stage I disease, 1 stage II, 5 stage III, and 2 stage IV. The pathologic subtypes of thymic carcinoma included 5 squamous cell carcinomas, 1 adenosquamous cell carcinomas, 1 clear cell carcinoma, and 1 small cell carcinoma. Immunohistochemical study was performed using antibodies against p53, bcl-2, Ki-67, carcinoembryonic antigen (CEA), epithelial membrane antigen (EMA), nm23-H1, vascular endothelial growth factor (VEGF), basic fibroblast growth factor (FGF-2) and factor VIII.

Results: Curative resection could be done in 4 patients (50%). Our data indicates a trend toward an association between complete resection and patient survival. Expression of p53, bcl-2, Ki-67, carcinoembryonic antigen (CEA), epithelial membrane antigen (EMA), nm23-H1, vascular endothelial growth factor (VEGF), basic fibroblast growth factor (FGF-2) and factor VIII.

When compared with our previous studies, immunohistochemical staining of these proteins in thymomas, the expression rates of these proteins in thymic carcinomas were higher than those in thymomas.

Conclusions: In this small series, it is suggested that a complete resection suggests a favorable result. Immunohistochemical results reveal that the expression of these proteins might indicate the aggressiveness of thymic carcinoma.

Background

Thymic carcinoma is a rare type of malignant tumor [1,2]. It is more invasive and with a poorer prognosis than ordinary thymoma [3–8]. At diagnosis, it is usually invasive or metastatic and complete curative resection is sometimes not possible to achieve. There are no uniform manage-
ment protocols and thymic carcinoma is treated by the same guidelines used for thymomas, despite having a more aggressive histologic appearance and clinical outcome [6–8].

In addition, in spite of numerous previous studies about expression of oncogene proteins in human cancers, very little attention has been given to the biological characteristics of thymic carcinoma [9–13].

To evaluate the outcome and biological characteristics of thymic carcinomas, we reviewed patients undergoing treatment including surgery at our hospital. In addition to clinical analysis, we also investigated expression of some cancer-related proteins to evaluate their biological characteristics. Since previous studies of ours demonstrated the expression p53, bcl-2, Ki-67, carcinoembryonic antigen (CEA), epithelial membrane antigen (EMA), nm23-H1, vascular endothelial growth factor (VEGF), basic fibroblast growth factor (FGF-2) and microvessels in thymomas [14,15], we performed immunohistochemistry using the same antibodies as in our previous studies.

Methods

Patients

Between 1988 and 2000, 8 patients with thymic carcinoma who were treated surgically at Miyazaki Medical College were included in this study. Two patients who did not receive surgical options during this period were excluded. There were 2 men and 6 women: ages ranged from 19 to 67 years old (mean 54.8 years). None of these patients had concomitant myasthenia gravis and pure red cell aplasia. Postoperative staging was made according to the Masaoka staging system [16]. No patient had stage I disease, 1 stage II, 5 stage III, and 2 stage IV. The pathologic subtypes of thymic carcinoma included 5 squamous cell carcinomas, 1 adenosquamous cell carcinomas, 1 clear cell carcinoma, and 1 small cell carcinoma. The histologic grading was based on cell differentiation, which was modified from Suster and Rosai’s classification system [4]. Carcinoid tumors, well-differentiated (keratinizing) squamous cell carcinoma, and mucoepidermoid carcinoma were delegated to low-grade tumors, and all other types were classified as high-grade tumors. In our series, only one patient with squamous cell carcinoma had low-grade tumor. Table 1 summarizes the clinical characteristics of these patients. The mean follow-up period ranged from 12 to 83 months (mean 30.8 months). The follow-up information, including cause of death, was acquired through clinic follow-up notes and direct or family contact.

Immunohistochemical studies

Surgically resected tissue samples previously fixed in formalin and embedded in paraffin were used. The specific antibodies against p53 (Dako, Glostrup, Denmark), bcl-2 (Dako), EMA (Dako), CEA (Dako), nm23-H1 (Novoceastra Laboratories, Newcastle, UK), Ki-67 (Immunotech, Marseille, France), VEGF (Santa Cruz Biotechnology, California, U.S.A.), FGF-2 (Santa Cruz Biotechnology) and factor VIII (Dako) were used in this study.

Before staining, serial 4 µm-thick sections were pre-treated with microwave heating in 10 mM citric acid buffer for 4 × 5 min. These sections were immersed in 0.6% H2O2 in methanol for 20 min. at room temperature to block endogenous peroxidase activity. After blocking non-specific protein bindings by an overnight incubation with Block Ace (Dainippon, Inc., Osaka, Japan), the sections were incubated with primary antibodies against human p53 (1:100), bcl-2 (1:100), Ki-67 (1:100), CEA (1:100), EMA (1:100), nm23-H1 (1:100), VEGF (1:50), FGF-2 (1:50) and Ki-67 (1:50), respectively, at 4°C overnight. Subsequently, sections were incubated with the secondary antiserum (1:500) for one hour, followed by an incubation with peroxidase anti-peroxidase (PAP) complex for 30 min. at room temperature. The sections were visualized using a diaminobenzidine (DAB)/Metal Concentration (10×) and Stable Peroxide Substrate Buffer (1×) system (Pierce, Rockford, Illinois, U.S.A.). The sections were then washed with water and counterstained with hematoxylin. Immunohistological results were assessed semiquantitatively by two authors. The staining for p53, bcl-2, EMA, CEA, nm23-H1, VEGF and FGF-2 proteins with the respective antibodies was considered positive if more than 10% of tumor cells were immunoreactive. The Ki-67 labeling index was determined by light microscopy with an oil-immersion objective (magnification ×1,000) randomly counting 1,000 tumor epithelial cells and expressing the results as a percentage of positive cells. Microvessel density was determined by counting in the area of the most intense vascularization (hot spot) of each tumor, and the average count (per 200× field) was recorded.

Results

Clinical Results

Preoperative biopsy using a 14-gauge Tru-cut biopsy needle was performed for 3 patients, however only one was diagnosed as thymic carcinoma and others were failed to obtain a decisive diagnosis. Preoperative diagnoses of other remaining 5 patients were invasive thymomas by radiological examinations. Therefore, only one patient underwent preoperative chemotherapy that consisted of intra-arterial infusion of cisplatin 100 mg and subsequent systemic administration of cisplatin 25 mg and etoposide 100 mg. In this case, a partial response was obtained. Surgical procedure was performed through median sternotomy. Curative resection could be done in 4 patients (50%). In other 4 of remaining patients, the resection was incomplete due to invasion into adjacent organs and/or dissem-
inated lesions. Postoperative radiotherapy was given with a total dose of 40–60 Gy for 6 patients. One patient who underwent incomplete resection and radiotherapy was also received chemotherapy that consisted of cisplatin 60 mg/m² and etoposide 120 mg/m². The median survival times for all patients was 43.8 month and the overall cumulative survival was 46.7% at 3 years. Operative mortality, defined as death within 30 days of surgery, did not occur. However, one patient, who underwent incomplete resection, died on postoperative day 39 of rapid tumor growth and respiratory failure.

Although our series included small size of patient population, we investigated a relationship between some clinical factors and survival. The median survival times for patients with completely and incompletely resected disease were 73.0 and 17.6 months, respectively. As shown in Fig. 1, there was a difference in survival between completely and incompletely resected patients. Clinical stage, squamous cell carcinoma and postoperative irradiation did not show favorable results in our series (data not shown). Prognostic value of histologic grading could not be investigated because there was only one patient with low-grade tumor in our series.

**Immunohistochemical results**

Positive immunohistochemical stainings with p53 and Ki-67 were confined to the nucleus of the tumor cells (Fig. 2). Lymphocytes and stromal cells were consistently unstained. Immunoreactivity of bcl-2, CEA, EMA, nm23-H1, VEGF and FGF-2 were predominantly observed in the cytoplasm of the tumor cells (Fig. 2). Positive immunostaining of p53, bcl-2, CEA, EMA, nm23-H1, VEGF and FGF-2 was detected in 5/8 (62.5%), 3/8 (37.5%), 4/8 (50%), 5/8 (62.5%), 6/8 (75%), 5/8 (62.5%) and 3/8 (37.5%), respectively. The Ki-67 labeling index (mean ± S.D.) was 7.01 ± 6.37 and microvessel density (mean ± S.D.) was 34.36 ± 16.7 (per 200× field). Table 2 summarizes these immunohistochemical results.

We previously investigated the expression of these proteins in thymomas [14,15]. These studies demonstrated that positive immunostaining of p53, bcl-2, CEA, EMA, nm23-H1, VEGF and FGF-2 was found in 13/38 (34.2%), 6/38 (15.8%), 6/38 (15.8%), 10/38 (26.3%), 22/38 (57.9%), 12/38 (31.6%) and 5/38 (13.2%), respectively [14,15]. They also showed that Ki-67 labeling index and microvessel density of thymomas were 2.57 ± 4.52 and 8.7 ± 6.99, respectively [14,15]. When compared these results, the expression rates of these proteins in thymic carcinoma were higher than those in thymomas, indicating the aggressiveness of thymic carcinoma.

**Discussion**

In the present study, the size of patient population is small and follow-up period is variable and relatively short. In spite of these limitations, our data showed that a complete resection suggests a favorable result. Previous

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**Table 1: Clinical characteristics**

| Case | Age | Sex | Histology                   | Grading | Stage | Resection | Preoperative therapy | Postoperative therapy |
|------|-----|-----|------------------------------|---------|-------|-----------|----------------------|-----------------------|
| 1    | 54  | F   | Clear cell carcinoma        | high    | III   | complete  | none                 | radiotherapy          |
| 2    | 64  | F   | SCC                          | low     | III   | complete  | none                 | radiotherapy          |
| 3    | 19  | F   | SCC                          | high    | II    | complete  | chemotherapy         | none                  |
| 4    | 65  | F   | Small cell carcinoma        | high    | III   | complete  | none                 | radiotherapy          |
| 5    | 67  | M   | Adenosquamous cell carcinoma| high    | III   | incomplete| none                 | none                  |
| 6    | 47  | F   | SCC                          | high    | IVa   | incomplete| none                 | radiotherapy          |
| 7    | 55  | F   | SCC                          | high    | III   | incomplete| radiotherapy         | radiotherapy          |
| 8    | 59  | M   | SCC                          | high    | Iva   | incomplete| radiotherapy         | chemotherapy radiotherapy |

SCC: squamous cell carcinoma.
studies also showed similar results [6,8]. On the other hand, Hsu et al [5] showed a lack of efficacy of complete resection, even though they showed longer median survival. We believe that surgical resection of the tumor is the best treatment for thymic carcinoma.

Our small series could not show a favorable result of clinical stage, squamous cell carcinoma and postoperative radiotherapy, while previous studies demonstrated a favorable result. Liu et al [8] found that clinical stage had statistically significant influence on patients' survival.

Table 2: Immunohistochemical results

| Case | p53 | bcl-2 | Ki-67 | CEA | EMA | nm23 | VEGF | FGF-2 | MVD |
|------|-----|-------|-------|-----|-----|------|------|-------|-----|
| 1    | -   | +     | 2.9   | -   | -   | -    | -    | -     | 15.1|
| 2    | +   | -     | 10.2  | -   | +   | +    | +    | -     | 17.2|
| 3    | -   | -     | 0.6   | -   | -   | -    | -    | -     | 19.1|
| 4    | -   | -     | 14.6  | +   | +   | +    | -    | -     | 44.3|
| 5    | +   | -     | 10.6  | +   | +   | +    | +    | +     | 34.6|
| 6    | +   | -     | 15.3  | -   | +   | +    | +    | -     | 36.2|
| 7    | +   | +     | 0.9   | +   | +   | +    | +    | +     | 45.1|
| 8    | +   | +     | 1.1   | +   | -   | +    | +    | +     | 63.3|

MVD: microvessel density (per 200× field)
Some previous studies demonstrated that squamous cell carcinoma was associated with a better outcome than other histological types [6,7,17]. Masaoka et al [17] reported that 5-year survival was 65.6% in squamous cell carcinoma and 14.3% in other type. Although we could not investigate a prognostic value of histologic grading, Liu et al [8] also reported that histologic grading had significant influence on patients' survival. With regard to the role of irradiation in the treatment of thymic carcinoma, Shimosato et al [18] reported an apparent cure from radiotherapy for an unrected squamous cell thymic carcinoma with lung invasion. There had been demonstrated a trend towards squamous cell carcinomas being radiosensitive [18,19]. Our results were not consistent with these previous studies. However the number of patients in our series was too small to permit meaningful correlation between survival and clinical stage, histologic subtype and radiotherapy. We believe that this discrepancy might be due to limited number of patients and combined treatment.

Our immunohistochemical results revealed that expression rates of p53, bcl-2, CEA, EMA and Ki-67 in thymic carcinomas were higher than those in thymomas. Since these proteins are related to tumor growth in many cancers, it is suggested that higher expression rates of these proteins might indicate the aggressiveness of thymic carcinoma.

Some previous studies also reported expression of these proteins in thymic carcinomas. With regard to p53 expression in thymic carcinoma, previous studies had also reported similar findings. Tateyama et al [9] reported 13 of 13 (100%), Hayashi et al [10] showed 5 of 6 (83.3%), Chen et al [11] reported 12 of 17 (71%) and Hino et al [12] found 14 of 19 (74%) thymic carcinomas were positive for p53 immunostaining. Tateyama et al [9] also reported that p53 gene mutation occurred early in the tumorgenesis of thymic tumors and p53 may be a useful adjunct to differentiate thymic carcinoma from thymoma. Bcl-2 is a proto-oncogene inhibiting apoptosis and Chen et al [11] showed that bcl-2 expression correlates with aggressiveness in thymic epithelial neoplasms. With regard to CEA expression, Savino et al [20] reported that CEA might act as a growth factor for proliferating thymic epithelial cells. Some previous studies also reported expression of EMA in thymic carcinoma. Truong et al [3] showed 13 of 13 and Fukai et al [13] showed 13 of 14 thymic carcinomas were positive for EMA. Fukai et al [13] concluded that immunolabeling for EMA appears to be a useful tool for determining the degree of malignant disease among thymic epithelial neoplasms. Therefore, taken together with our results, expression of p53, bcl-2, CEA, EMA and Ki-67 might be implicated in malignant potential of thymic carcinoma.

In the present result, 75% of our series showed positive for nm23-H1 expression. To our knowledge, there are no previous studies for nm23-H1 expression in thymic carcinoma. Expression of nm23-H1 is thought to play a specific biological role in suppressing tumor metastasis [21]. The role of high frequency of nm23-H1 expression in thymic carcinoma deserves further investigation.

Angiogenesis is essential for tumor growth and an enhanced vascular supply might reflect a malignant potential [22]. Our result also showed that microvessel density and expression of VEGF and FGF-2 in thymic carcinomas were higher than those in thymomas. Therefore, angiogenesis might be also related with the aggressiveness of thymic carcinoma.

The outcome of thymic carcinoma treatment must be investigated using the same histologic typing and staging. Thus, our series might be inadequate to analyze the biological characteristics of thymic carcinoma. In spite of limited number of patients and combined treatment, we found that a complete resection suggests a favorable result. Furthermore, immunohistochemical results might indicate the aggressiveness of thymic carcinoma. Further study is warranted to define the biological characteristics and precise treatment strategy for thymic carcinoma.

Competing interests
None declared.

Author’s Contributions
MT collected and compiled the data and reviewed the manuscript with YM. Immunohistological results were assessed by MT and MM. TS participated in the design of the study. ME and MM conducted the study and commented on the data analysis and manuscript. TO conceived of the study, reviewed the data collection and analytical processes, and wrote the body of the manuscript. All authors read and approved the final manuscript.

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