INTRODUCTION

Esophageal cancer is a major cause of cancer death worldwide, with a 5-year survival rate of less than 50%\(^3\). Complete resection is essential for curing esophageal cancer\(^2-3\). However, the morbidity after esophageal surgery with lymph node dissection has been reported to range from 30% to 60%, and the complications are sometimes fatal\(^4-6\). Among postoperative complications, some studies have shown that the development of postoperative pneumonia particularly increased the risk of disease recurrence and reduced the overall survival in esophageal cancer patients who received esophagectomy\(^7-8\). Therefore, it is important to predict the occurrence of postoperative pneumonia before surgery and determine the most appropriate perioperative care for these patients.

The importance of multidisciplinary team efforts, such as oral and dental care programs, for preventing postoperative pneumonia after esophagectomy has been reported\(^9\). Indeed, some studies have shown that the incidence of postoperative pneumonia can be decreased by appropriate application of multidisciplinary team efforts\(^10\). However, very few tools are available for assessing the risk factors of postoperative pneumonia after esophageal cancer surgery\(^11-15\).

Recently, the Oral Health Assessment Tool (OHAT) was developed for use by non-dental professionals, such as nurses, personal care attendants and allied health or medical professionals. Originally, the OHAT was intended to be used to screen the oral health status of patients to make appropriate and timely referrals to a dentist or a dental hygienist. If the OHAT could be used to predict the risk of postoperative pneumonia after esophagectomy, we would be able to determine appropriate indications of oral care and dental care while considering the balance between the risks and benefits in patients.

The aim of this study was to determine whether or not the OHAT can be used to identify patients at risk of developing postoperative pneumonia after esophagectomy for esophageal cancer.
PATIENTS AND METHODS

Patient data

The patients were selected from among consecutive patients who underwent esophagectomy for esophageal cancer at Yokohama City University from January 2005 to September 2018. The inclusion criteria were as follows: (1) histologically proven primary esophageal squamous cell carcinoma or adenocarcinoma, (2) clinical stage IB to III (excluding T4) disease as evaluated using the 7th edition of the tumor-node-metastasis classification established by the Union for International Cancer Control (UICC), (3) complete (R0) resection of the esophageal cancer with radical lymph node dissection, and (4) screened with the OHAT. Patients who had undergone R2 or R1 resection were excluded from the study.

Surgical procedure

Our standard procedures consisted of open subtotal esophagectomy via right thoracotomy, reconstruction with a gastric tube through the posterior mediastinal route or retrosternal route, and anastomosis in the cervical incision. In principle, two-field lymph node dissection is indicated when tumors are located at the middle thoracic to lower thoracic esophagus, while three-field dissection is applied for upper thoracic tumors. A feeding tube was routinely placed at the stomach or duodenum.

Perioperative care

All of the patients received perioperative management. Antibiotics were administered 30 min before surgical incision and then again every 3 h during surgery and on postoperative day (POD) 2. The patients were allowed to eat 30% rice porridge until midnight the day before the surgery. The patients remained on ventilation overnight. Ambulation and enteral nutrition were started on POD 1. Oral intake was initiated on POD 5, beginning with water and gelatinous foods. The patients began to eat solid food on POD 10, starting with rice gruel and soft food and progressing in three steps to regular food intake.

Definition of postoperative pneumonia

All data were retrospectively retrieved from the patients’ records. The rate of postoperative pneumonia was measured by the revised Uniform Pneumonia Score. This scoring system uses the variables temperature, leucocyte count, and chest X-ray findings to determine whether or not treatment of pneumonia is indicated. Chest X-ray was performed according to unstandardized local routine care policies. On the days when chest X-ray was performed, the local researcher assessed the variables of the Uniform Pneumonia Score.

OHAT

The OHAT consists of eight categories (‘lips’, ‘tongue’, ‘gums and tissues’, ‘saliva’, ‘natural teeth’, ‘dentures’, ‘oral cleanliness’, and ‘dental pain’) with three possible scores (0: healthy, 1: some changes present and 2: unhealthy condition). Scoring of each category is based on structured observation with clear operational definitions. A score of 1 or 2 for any of the specifically marked categories (starred and underlined) mandates referral to an oral health professional (dentist, dental hygienist or denturist). The total score is the sum of the various sub scores (Table 1).

Evaluations and statistical analyses

Univariate and multivariate logistic regression analyses were performed to identify the risk factors for postoperative pneumonia. Comparisons between the two groups were analyzed by the chi-square test. In the multivariate analysis, we fitted linear regression models. To select a model, we used backward elimination. All statistical tests were two-sided, and significance was set at P < 0.05. The SPSS software package (v11.0 J Win, SPSS, Chicago, IL, USA) was used for all statistical analyses.

Ethics

This study was approved by the IRB Committee of the Yokohama City University.

RESULTS

Patients’ clinicopathological data

A total of 122 patients underwent esophagectomy for esophageal cancer between October 2008 and September 2018. Among them, 47 patients were evaluated in this study. The patients’ ages ranged from 38 to 80 years (median: 70 years); 38 patients were male, and 9 were female. Twenty patients had an OHAT score ≤2 (OHAT-low group) and 27 had an OHAT score ≥3 (OHAT-high group). The patient characteristics are summarized in Table 2. Relationships between the OHAT score and clinicopathological parameters are shown in Table 2. The patients’ background characteristics were similar between the two groups.

Surgical and pathological findings

The patients’ surgical and pathological findings are summarized in Table 3. There were no significant differences between the two groups in surgical and pathological findings.

Risk factors for surgical morbidity

Postoperative pneumonia was found in 18 of the 47 patients (38.3%) in the present study. The risk factors for postoperative pneumonia were analyzed by univariate and multivariate analyses using the preoperative and
The OHAT score was risk factor for postoperative pneumonia after esophagectomy

Perioperative factors. The results are summarized in Table 4. Among the various factor examined, the OHAT score (p < 0.001) was identified as a significant independent risk factor, and the age (p = 0.082) was identified as a marginally significant independent risk factor. In addition, the OHAT score and age were identified as significant independent risk factors in the multivariate analysis.

The incidence of postoperative pneumonia was 5% (1 of 20) in the OHAT-low group and 51.9% (14 of 27) in the OHAT-high group. In addition, the incidence of postoperative pneumonia was 41.7% (10 of 24) among patients ≥70 years old and 21.7% (5 of 23) among those <70 years old.

Table 1 Oral health assessment tool

| Category | 0 = healthy | 1 = changes | 2 = unhealthy |
|----------|-------------|-------------|---------------|
| Lips     | smooth, pink, moist | dry, chapped, or red, at corners | swelling or lump, white/red/ulcerated patch; bleeding/ulcerated at corners |
| Tongue   | normal, moist, rough, pink | patchy, fissured, red, coated | white/red patches, ulcerated, swollen |
| Gums and tissues | pink, moist, smooth, no bleeding | dry, shiny, rough, red, swollen, one ulcer sore spot under dentures | Swollen, bleeding, ulcers, white/red patches, generalized redness under dentures |
| Saliva   | moist tissues, watery and free flowing saliva | dry sticky tissues, little saliva present, resident thinks they have a dry mouth | tissues parched and red, very little/no saliva present, saliva thick, resident thinks they have a dry mouth |
| Natural teeth | Yes/No | no decayed or broken teeth/roots | 1-3 decayed or broken teeth/roots or very worn-down teeth |
| Dentures | Yes/No | no broken areas or teeth, dentures regularly worn and named | 1 broken area/tooth or dentures only worn for 1-2 h daily, or dentures not named or loose |
| Oral cleanliness | | clean and no food particles or tartar in mouth or dentures | Food particles/tartar/plaque in 1-2 areas of the mouth or on a small area of dentures or halitosis (bad breath) |
| Dental pain | | no behavioral, verbal, or physical signs of dental pain | verbal and/or behavioral signs of pain present, such as pulling at face, chewing lips, not eating, aggression |

- Arrange for resident to receive a dental examination by a dentist
- Resident and/or family/guardian refuses dental treatment
- Complete Oral Hygiene Care Plan and start oral hygiene care intervention for resident
- Review this resident’s oral health again on [date]

Table 2 Clinicopathological data of patients with oral health assessment tool scores of ≤2 and ≥3

| Characteristics | All cases | Score 0-2 (n = 20) | Score ≥3 (n = 27) | P value |
|-----------------|-----------|-------------------|------------------|--------|
| Age             | 0.900     |                   |                  |        |
| <70 years old   | 23        | 48.9              | 10               | 13     | 48.1 |
| ≥70 years old   | 24        | 51.1              | 10               | 14     | 51.9 |
| Gender          | 0.380     |                   |                  |        |
| Male            | 38        | 80.9              | 15               | 23     | 85.2 |
| Female          | 9         | 19.1              | 5                | 4      | 14.8 |
| ASA-PS          | 0.101     |                   |                  |        |
| 1               | 7         | 14.9              | 1                | 6      | 22.2 |
| 2-3             | 40        | 85.1              | 19               | 21     | 77.8 |
| Site of tumor   | 0.679     |                   |                  |        |
| Upper thoracic  | 2         | 4.3               | 1                | 1      | 3.7 |
| Middle thoracic | 30        | 63.8              | 14               | 16     | 59.3 |
| Lower thoracic  | 15        | 31.9              | 5                | 10     | 37.0 |
| Histological type | 0.170     |                   |                  |        |
| SCC             | 43        | 91.5              | 17               | 26     | 96.3 |
| Adenocarcinoma  | 4         | 8.5               | 3                | 1      | 3.7 |
| Body mass index | 21.2±2.5  | 21.4±2.3          | 21.0±2.7         | 0.515  |        |
| Smoking habit   | 0.383     |                   |                  |        |
| Yes             | 44        | 93.6              | 18               | 26     | 96.3 |
| No              | 3         | 6.4               | 2                | 1      | 3.7 |
| Alcohol habit   | 0.753     |                   |                  |        |
| Yes             | 43        | 91.5              | 18               | 25     | 92.6 |
| No              | 4         | 8.5               | 2                | 2      | 7.4 |

ASA-PS: ASA physical status, SCC: squamous cell carcinoma
Table 3  Surgical and pathological findings of patients with oral health assessment tool scores of ≤2 and ≥3

| Characteristics                  | Number | %       | Number | %       | Number | %       | P value |
|----------------------------------|--------|---------|--------|---------|--------|---------|---------|
| Neoadjuvant chemotherapy         |        |         |        |         |        |         |         |
| Yes                              | 24     | 51.1    | 9      | 45.0    | 15     | 55.6    | 0.474   |
| No                               | 23     | 48.9    | 11     | 55.0    | 12     | 44.0    |         |
| Surgery type                     |        |         |        |         |        |         |         |
| Transthoracic                    | 6      | 12.8    | 3      | 15.0    | 3      | 11.1    | 0.693   |
| Thoracoscopic                    | 41     | 87.2    | 17     | 85.0    | 24     | 81.9    |         |
| Lymph node dissection            |        |         |        |         |        |         |         |
| Two-field                        | 27     | 57.4    | 12     | 60      | 15     | 55.6    | 0.761   |
| Three-field                      | 20     | 42.6    | 8      | 40      | 12     | 44.4    |         |
| Operative duration               |        |         |        |         |        |         |         |
| <570 min                         | 15     | 31.9    | 8      | 40      | 11     | 25.9    | 0.306   |
| ≥570 min                         | 32     | 68.1    | 12     | 60      | 20     | 74.1    |         |
| Blood loss                       |        |         |        |         |        |         |         |
| <540 ml                          | 27     | 57.4    | 11     | 55.0    | 16     | 59.3    | 0.770   |
| ≥540 ml                          | 20     | 42.6    | 9      | 45.0    | 11     | 40.7    |         |
| Blood transfusion                |        |         |        |         |        |         |         |
| Yes                              | 14     | 29.8    | 6      | 30      | 8      | 29.6    | 0.978   |
| No                               | 33     | 70.2    | 14     | 70      | 19     | 70.4    |         |
| Pathological depth of invasion   |        |         |        |         |        |         |         |
| T1                               | 15     | 31.9    | 7      | 35.0    | 8      | 29.6    | 0.696   |
| T2 or more                       | 32     | 68.1    | 13     | 65.0    | 19     | 70.4    |         |
| Pathological lymph node status   |        |         |        |         |        |         |         |
| Negative                         | 25     | 53.2    | 10     | 50      | 15     | 55.6    | 0.706   |
| Positive                         | 22     | 46.8    | 10     | 50      | 12     | 44.4    |         |
| Lymph vascular invasion          |        |         |        |         |        |         |         |
| Negative                         | 14     | 29.8    | 7      | 35.0    | 7      | 25.9    | 0.501   |
| Positive                         | 33     | 70.2    | 13     | 65.0    | 20     | 74.1    |         |

Table 4  Results of univariate and multivariate analyses of risk factors for postoperative pneumonia

| Characteristics                  | Number | Univariate analysis | Multivariate analysis |
|----------------------------------|--------|---------------------|-----------------------|
|                                  |        | HR                  | 95% CI                | P value | HR          | 95% CI                | P value |
| Age                              |        | 0.082               |                       |         | 0.040       |                       |         |
| <70 years old                   | 23     | 1.000               | 0.970-1.663           | 1.000   | 1.011-1.552 | 1.000                 | 1.252   |
| ≥70 years old                   | 24     | 1.270               | 0.745-1.329           | 0.786   | 1.069       | 0.847-1.349           | 0.574   |
| Neoadjuvant chemotherapy         |        | 0.984               |                       |         |             |                       |         |
| Yes                              | 23     | 1.000               | 0.745-1.329           | 0.984   | 1.000       | 0.847-1.349           | 0.574   |
| No                               | 24     | 0.984               | 0.745-1.329           | 0.984   | 1.000       | 0.847-1.349           | 0.574   |
| Operative type                   |        | 0.526               |                       |         |             |                       |         |
| Transthoracic                    | 6      | 1.000               | 0.578-1.324           | 0.526   | 1.000       | 0.578-1.324           | 0.526   |
| Thoracoscopic                    | 41     | 0.874               | 0.578-1.324           | 0.874   | 1.000       | 0.578-1.324           | 0.526   |
| Operative duration               |        | 0.235               |                       | 0.235   | 0.847       | 0.578-1.349           | 0.574   |
| <570 min                         | 15     | 1.000               | 0.884-1.592           | 1.000   | 1.000       | 0.847-1.349           | 0.574   |
| ≥570 min                         | 32     | 1.186               | 1.069                 | 0.847   | 1.069       | 1.069                 | 0.847   |
| Blood loss                       |        | 0.688               |                       | 0.688   | 0.847       | 0.578-1.349           | 0.574   |
| <540 ml                          | 27     | 1                   | 0.713-1.250           | 0.574   | 1.000       | 0.847-1.349           | 0.574   |
| ≥540 ml                          | 20     | 0.944               | 0.713-1.250           | 0.574   | 1.000       | 0.847-1.349           | 0.574   |
| Lymph node dissection            |        | 0.413               |                       | 0.413   | 0.847       | 0.578-1.349           | 0.574   |
| Two-field                        | 27     | 1.000               | 0.850-1.486           | 1.000   | 1.000       | 0.850-1.486           | 1.000   |
| Three-field                      | 20     | 1.124               | 0.850-1.486           | 1.124   | 1.000       | 0.850-1.486           | 1.000   |
| Smoking habit                    |        | 0.614               |                       | 0.614   | 0.847       | 0.578-1.349           | 0.574   |
| Yes                              | 4      | 1.000               | 0.535-1.446           | 1.000   | 1.000       | 0.535-1.446           | 1.000   |
| No                               | 43     | 0.880               | 0.535-1.446           | 0.880   | 1.000       | 0.535-1.446           | 1.000   |
| Oral health assessment tool score|        | <0.001              |                       | <0.001  | <0.001      |                       |         |
| ≤2                               | 20     | 1.000               | 1.423-2.240           | 1.000   | 1.000       | 1.423-2.240           | 1.000   |
| ≥3                               | 27     | 1.785               | 1.761                 | 1.785   | 1.000       | 1.761                 | 1.785   |

HR: hazard ratio, CI: confidence interval
**DISCUSSION**

The present study explored whether or not the OHAT score is a risk factor of postoperative pneumonia after esophagectomy for esophageal cancer. The major finding was that the OHAT score was a significant risk factor for postoperative pneumonia after esophagectomy for esophageal cancer. To improve the oncological outcomes of patients with esophageal cancer, it is necessary to carefully plan perioperative oral/dental care using the OHAT score.

Previously, a limited study showed that there was a significant relationship between the OHAT score and pneumonia. Saensom et al. prospectively evaluated the association between the oral health score and ventilator-associated pneumonia (VAP) in 162 patients treated with a mechanical ventilator. In that study, the oral health status was assessed on Day 4 after intubation. Those authors found that the OHAT score was risk factor for postoperative pneumonia after esophagectomy for esophageal cancer. The major finding was that the OHAT score was risk factor of postoperative pneumonia after esophagectomy for esophageal cancer. To improve the oncological outcomes of patients with esophageal cancer, it is necessary to carefully plan perioperative oral/dental care using the OHAT score.

In conclusion, the OHAT score is a risk factor for postoperative pneumonia in patients who have undergone curative esophagectomy for esophageal cancer. To improve the oncological outcomes of patients with esophageal cancer, it is necessary to carefully plan perioperative oral/dental care using the OHAT score.

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CONFLICT OF INTEREST STATEMENT:
None.

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