Recent studies suggest that oral health care can be effective in the prevention of respiratory tract infections such as pneumonia and bronchitis. Since one of the parameters most frequently emphasized is the prevention of ventilator-associated pneumonia (VAP), which is a severe respiratory infection seen in patients with poor oral hygiene undergoing mechanical ventilation, oral health care has gained recognition as a key nursing intervention in the acute stages. However, difficulties can be encountered while trying to maintain good oral health.
care in acutely ill patients ventilated mechanically, partly because of oral intubation and partly because of their inability to maintain oral hygiene by brushing teeth. Such situations can lead to bacterial contamination of the oral and pharyngeal areas. On the other hand, it is reported that oral cleaning and functional support from the early phase in the acute stages is effective in avoiding secondary infectious diseases. Based on these findings, studies have examined the activities and efforts by dentists and dental hygienists in the arena of professional oral health care in the acute or emergency stage. On the other hand, these reports indicated that how the oral health status of patients was an indicator of the difficulties faced when aiming to improve the oral health with regard to general health issues and exacerbation of diseases. Moreover, although a broad range of symptoms in the oral cavity could be improved fairly easily while others could not, few studies have been conducted on the process of improving oral health problems through intervention by dental professionals in the acute stages.

Showa University Oral Health Care Center was established in April 2008 in cooperation with a multidisciplinary team to implement oral health care and to create a standardized method of oral health care for patients in the acute stages. Feedback from facilities providing oral health care in the general wards of acute hospitals indicated that the characteristics of oral health and prevalence of intraoral problems varied among patients depending on their primary illness. Therefore, on the basis of the assumption that patients in the ICU have the same range of oral problems as those in general wards, the oral health status of the ICU patients was investigated and compared statistically among groups classified by primary diagnosis. It was hypothesized that the oral health status of patients would be worse when the oral bacterial flora levels increase. The objective of the present study was to establish an oral health care system in acute hospitals that focused on the prevention of secondary infectious diseases. Therefore, the oral health status of patients admitted to the ICU was investigated and any change was monitored following multidisciplinary oral health care management, which included dentists and dental hygienists.

**Materials and Methods**

The subjects of this study were 87 patients (49 male and 38 female) in the ICU of Showa University Hospital and who underwent mechanical ventilation and oral intubation between October 2010 and March 2011. All subjects were consulted by dentists attached to the Showa University Oral Health Care Center, and their consent for participation in this study was obtained prior to commencement of the investigation. Data regarding the subjects’ primary disease diagnoses were obtained from the medical and nursing records of the ward, and the subjects were categorized into the following four groups: cerebrovascular disease group, respiratory disease group, gastrointestinal disease group, and cardiovascular disease group. This classification was determined by reference to previous studies, and Table 1 shows typical diagnosis by group. The following categories of patients were excluded: those with undiagnosed primary disease, such as multisystem diseases; those who had developed metastasis secondary to carcinoma; and edentulous individuals.

The oral health status of participants was evaluated by dentists and dental hygienists attached to the Oral Health Care Center within 24 h of admission to the ICU as the initial assessment. Evaluation criteria were based on the Revised Oral Assessment Guide (ROAG), with the exception of the items “vocalization” and “swallowing,” and were rated on a three-point scale (Table 2). Daily oral health care in the ICU was provided every 6 h (06:00, 12:00, 18:00, 24:00), and the oral health condition was evaluated between 13:00 and 14:00. Oral health care in the ICU was performed by nurses using commercial toothbrushes and mouth swabs. Syringed water was not used, but intraoral suction by vacuum tube was included. The protocol of oral health care was standardized through the training of dental professionals prior to the onset of interventions, which were monitored by dental hygienists. When a rate of 2 or 3 was observed for any assessment...
The problems were explained and instructions on the appropriate remedial treatment, such as the usage of oral moisturizing gel, were conveyed to the attending nurses by the dental professionals. At initial evaluation, swabs of biologic specimens were obtained from the surface of the tongue in contact with the endotracheal tube (approximately 20 mm from the tip of tongue). Specimens were then cultured for 48 h at 37°C on selective agar medium (Kanto Chemical Co., Inc., Tokyo, Japan), and the number of colony-forming units (CFU) of Candida was counted. Oral health status was evaluated once per day after initial evaluation and continued until either oral intubation was no longer required or the patient was moved to another ward.

Following intervention, patient data on the classification of diagnosis and detection of Candida were collated, and the frequently noted changes in oral health status were investigated for patients undergoing three or more interventions.

Prevalence of oral health problems based on ROAG was compared among the four groups by both the chi-square and Steel-Dwass tests. Comparison of detection rates among the disease groups and comparison between the detection of Candida and prevalence of oral health problems was processed statistically by the chi-square test. All statistical analyses were performed using SPSS 16.0 (SPSS, Tokyo, Japan).

All experimental protocols of this study were approved in advance by the institutional review board of the School of Dentistry, Showa University (Approval number 2010-22).

**Results**

Mean age and standard deviation of subjects was 63.7±13.2 years (range, 42–90). Patient characteristics are shown in Fig. 1.

Figure 2 shows the oral health status of subjects at initial evaluation. Prevalence of “Lip” problems was 23.5% and 25.0% in the cerebrovascular and respiratory disease groups, respectively, with both groups including subjects evaluated with the rating 3. For problems related to the items “Teeth/dentures” and “Gingiva,” the rate was <10% in all groups, and no subject was rated as 3. In the cerebrovascular disease group, 11.8% and 5.9% of subjects were as rated 2 and 3, respectively. The rating of “Tongue” problem in the respiratory disease group yielded the highest percentage (70%), and prevalence of this problem in the other three groups was also higher than...
that for the other items. There was a statistically significant difference (p<0.05) between the prevalence in the respiratory and cardiovascular disease groups on tongue. Twenty and percent of the subjects in the respiratory and 11.8% in the cerebrovascular disease group were rated as 2 or 3 for the item “Saliva.”

Figure 3 and Table 3 show the detection rate for various Candida species. The number of subjects negative for Candida was 20 (58.8%) in the cerebrovascular, 16 (72.7%) in the cardiovascular, 11 (55.0%) in the visceral, and 2 (9.5%) in the respiratory disease groups.
respiratory, and 8 (72.7%) in the gastrointestinal disease groups. In addition, more than 100 CFU were observed in two subjects both in the cerebrovascular and respiratory disease groups (5.9% and 10.0%, respectively). However, the detection rates of the 4 disease groups did not show statistic difference (p=0.66). Among the Candida species, the prevalence of C. albicans was highest, especially in the cerebrovascular disease group (7 subjects, 20.6%), which was higher than that for the other groups. Other Candida species detected were C. glabrata, C. krusei, C. tropicalis, and C. parapsilosis, all showing rates lower than that of C. albicans.

Figure 4 shows the prevalence of oral health problems in the four groups according to positive or negative presence of Candida. In the cerebrovascular disease group, the prevalence of problems with the items “Lips” and “Tongue” was significantly higher in the Candida-positive subjects than in the Candida-negative subjects (p<0.05). Similarly, the prevalence of problems with the items “Mucous membrane” in the cardiovascular disease group and “Tongue” in the respiratory disease group was higher in the Candida-positive subjects (p=0.05). No Candida-negative subjects indicated any problems in regard to the items “Lips,” “Teeth/dentures,” “Mucous membrane,” “Gingiva,” or “Saliva” in the cardiovascular and respiratory disease groups.

In the gastrointestinal disease group, all the Candida-negative subjects indicated problems with the item “Tongue.” On the other hand, no Candida-negative subjects in this group were rated as 2 or 3, except for the
items “Lips” (1 subject, 12.5%) and “Tongue” (3 subjects, 37.5%).

Figures 5 and 6 show changes in the rates for the items “Lips” and “Tongue,” respectively, in subjects who received three or more interventions. For the item “Lips,” the number of subjects rated as 2 or 3 at initial evaluation was eight, three, five, and two in the cerebrovascular, cardiovascular, respiratory, and gastrointestinal disease groups, respectively. Among these, only two subjects in the respiratory disease group and one each in the cerebrovascular and gastrointestinal disease groups were Candida-negative. In the cerebrovascular disease group, two subjects rated as 2 changed to the rating of 1 after 1 day, and similarly three changed after 2 days, while
two subjects showed no improvement by the end of interventions. The remaining subject with a rating of 3 at the initial evaluation was downgraded to the rating of 2 after 1 day, and again downgraded to the rating of 1 six days after the onset of intervention. In the cardiovascular disease group, two subjects showed improvement in the rating after 3 and 6 days, with no change in the rate in the third subject. In the respiratory disease group, the rate in two Candida-negative subjects was downgraded from the rating of 2 to 1 after 1 or 2 days, however, 2/3 Candida- positive subjects showed no improvement by the end of interventions. Similarly, in the gastrointestinal disease group, one Candida-positive subject was downgraded from the rating of 2 to 1 after 2 days.

The number of subjects rated as 2 or 3 at initial evaluation for the item “tongue” and who received three or more interventions was 14, seven, 13, and six in the cerebrovascular, cardiovascular, respiratory, and gastrointestinal disease groups, respectively. Of these subjects, five, four, seven, and three were Candida-negative in the cerebrovascular, cardiovascular, respiratory, and gastrointestinal disease groups, respectively. In the cerebrovascular disease group, the rating of one Candida-negative subject was reduced from the rating of 3 to 1 after 3 days, though in two Candida-positive subjects, the rating of 3 was not changed to 1 until the end of interventions. To summarize, ratings were downgraded to the rating of 1 in 5/9 Candida-positive subjects and in 3/5 Candida-negative subjects. In the cardiovascular disease group, although one Candida-positive and one Candida-negative subject were downgraded to the rating of 1, no change was recorded in the other subjects of that group. Downgrading of the Candida-negative subject occurred at 2 days, which was earlier than that for the Candida-positive subjects. In the respiratory disease group, ratings were downgraded to the rating of 1 in 3/6 Candida-positive subjects and in 3/7 Candida-negative subjects. In the gastrointestinal disease group, at 2–3 days the ratings were downgraded to 1 in 2/3 Candida-positive subjects and in 1/3 Candida-negative subjects.

Discussion

There is an increasing awareness of the importance of oral care to prevent respiratory infections in acute medicine as well as home health care and nursing care facilities.\(^{18-20}\) In particular, general body and swallowing functions and immunity are often reduced in the acute phase of systemic disorders and perioperative period of surgery. Therefore, oral care is offered as a means to prevent ventilator-associated pneumonia and postoperative infections.\(^{15, 20, 21}\) In the present study, dentists and dental hygienists assessed the oral health of patients and developed and implemented appropriate oral care methods in collaboration with nurses in the ICU, and the effects on oral health problems were examined.

Regarding oral problems, although differences were noted for the item ‘Tongue’ between the disease groups, there was no marked difference for five other items. Patients with oral intubation often develop oral dryness or a coated tongue, which causes abnormalities of the dorsum of the tongue, as they are unable to close their mouth, or due to parenteral nutrition and drugs.\(^ {22}\) For this reason, xerostomia and an increase in opportunistic microorganisms were noted in patients, those with respiratory diseases in particular, whose respiratory status had worsened prior to being admitted to the ICU.\(^ {23}\) In addition, large amounts of sputum and secretions are sometimes identified in the mouths and throats of patients with cerebrovascular and respiratory disorders receiving oral care.\(^ {17}\) Since they can be risks of respiratory infections as well, it is very important to closely observe the dorsum of the tongue and throat in the assessment of oral health. The item ‘Saliva’ assessed the level of dryness on the mucous membrane of the oral cavity other than the dorsum of the tongue. In the present study, there were no marked differences between the disease groups: the highest incidence of oral dryness was 20%. The percentage of oral dryness noted in the subjects of the present study was relatively low when compared to the incidence of oral dryness in acutely-ill patients reported by previous studies: 30 to 70%\.\(^ {12, 17}\) Oral care provided four times a day in the ICU and the effective use of a
moisturizer for the oral mucosa presumably improved oral dryness, although a number of factors other than a decrease in salivary secretion are also involved in the symptom, as described earlier.

In patients with oral intubation, damage to the lips or oral mucosa, which is attributed to physical stimuli generated when securing the tube in place or by body movement, is known to cause ulcers, dryness, and angular cheilitis. To address this, the position of the tube was regularly changed following intubation in the ICU, and the lips and mouth corners were moisturized to improve dryness; these nursing care procedures reduced the incidence of the above-mentioned symptoms. In addition to care in the oral cavity, it is important to prevent dryness around the lips. However, dryness and a decrease in secretions may occur due to the adverse effects of diuretic and psychotropic drugs. Therefore, it is important to determine whether oral dryness is attributed to the underlying disease and drugs or problems related to the oral function, since it is difficult to improve dryness by solely providing oral care. As a conclusion of this study, when providing oral health care, it is necessary to assess the level of oral dryness regardless of the type of underlying disease.

Candida species, fungi that live in the mouth, pharynx, and other parts of the digestive tract, include Candida albicans and Candida glabrata, and are common pathogenic species. Although Candida species rarely cause oral candidiasis in healthy people, decreased immunity due to systemic disorders and microbial substitution attributed to the chronic administration of antibiotics may increase the likelihood of this disease. Regarding inpatients, the longer the period of hospitalization, the higher the infection risk; previous studies reported that Candida species were identified in the mouth of 35 to 54% of inpatients. Furthermore, if patients have lowered immunity due to an underlying disease or medication, Candida albicans or Candida glabrata may be identified, even when no conspicuous lesion is noted. In the present study, although there were no noticeable symptoms of candidiasis in the mouth or on the pharyngeal mucosa of subjects, Candida species were identified in 23 to 45% of them, with no underlying-disease-specific difference. Candida albicans, the most common type, and other Candida species were identified. In some cases, two or more Candida species were observed in a single person. These results, which are in line with those of previous studies, suggest that Candida species also proliferate in the mouths of patients hospitalized in the ICU.

Oral health problems were compared between patients with and without Candida species. Regarding ‘Lips’, ‘Tongue’, ‘Mucous membrane’, and ‘Saliva’, the patients with Candida species had more oral health problems, although the differences were not significant. The upper surface of a coated tongue includes not only desquamated epithelium but also a large number of Candida species and anaerobic bacteria. Furthermore, Candida species have been found on the lips and corners of the mouth, as well as the oral mucosa, of patients who have been using antibiotics for a long period of time. Therefore, the above-mentioned oral health problems suggest a possible increase in the number of Candida species. However, the proliferation of Candida species involves several factors. One of them is immune competence; a decline in immune competence is considered to be involved in oral candidiasis attributed to Candida species. The present study did not take into account the immune competence of subjects. Further research should be conducted to closely examine the relationship between oral health problems and the identification of Candida species, using a larger number of subjects.

Regarding changes in oral health problems identified in the acute phase, previous studies reported that it may take a long time to improve a coated or dry tongue and decreased oral function. The present study examined changes over time in common symptoms included in the items ‘Lips’ and ‘Tongue’. In all patients, although most of them did not have Candida species, lips-related symptoms were improved within one or two days of the intervention. On the other hand, in patients with Candida species, regardless of the disease group, the symptoms were not improved by the end of the intervention period.
or it took a long period of time to improve them. Whether or not angular cheilitis and dryness of the lips are attributed to the fungi has not yet been clarified because damage is often caused to the lips of intubated patients by physical stimuli, and Candida species were not collected from the lips and surrounding area in a previous study. Nevertheless, a candidal infection in the oral cavity may cause angular stomatitis and oral candidiasis. Since uniformed nursing procedures for intubation were implemented in the ICU to prevent damage to the soft tissue, the lips-related and angular symptoms were presumably caused by an increase in Candida species in the mouth, and it took a long period of time to improve them as ordinary oral care could not reduce the fungus. Further studies should be conducted to clarify whether the symptoms were caused by physical damage or infections, and follow-up their changes.

It took more time to improve problems included in the item ‘Tongue’ than those in the ‘Lips’, and patients often had a rating of 2 or 3 at the end of an intervention. Previous studies reported that it takes a long period of time to improve a dry or coated tongue-common symptoms often noted in the ICU and other acute care units. One reason is that, for intubated patients, the tube in the oral cavity makes it difficult to observe and clean the dorsum of the tongue. When the use of a tongue or sponge brush is allowed, sodium bicarbonate or hydrogen peroxide solution is sometimes used to remove the coating that has adhered to the tongue. However, in this study, chemical cleaning was not conducted in the ICU in order to prevent a small amount of chemicals from leaking into the trachea. As an intervention to clean the strong coating or dryness of the dorsum of the tongue, a commercially available moisturizer for the oral mucosa was used to moisten the mucosa and soften the coating. Whereas some patients responded to this treatment method, others did not, regardless of whether or not they had Candida species, which suggests a wide variety of causes of a coated or dry tongue. In fact, according to previous studies, a coated tongue is also attributed to a decrease in the oral function, changes in salivary components and secretion, and a history of antibiotic use. Taking into account this point and the results of the present study, an increase in Candida species alone does not necessarily constitute the primary cause of oral health problems.

In light of these findings, all staff of Showa University Oral Health Care Center have placed emphasis on their efforts to understand the conditions of patients by referring to the records stored in the hospital units and the opinions of physicians and nurses in charge. It was suggested that, besides problems in the oral cavity, systemic diseases and medication also affected oral health. To provide interventions and improve oral health in an effective manner, collaboration with a variety of health professionals and a better understanding of medication and underlying diseases are required.

**Conclusion**

ICU patients with oral intubation, and in particular a high percentage of patients with a significant number of Candida specie, developed a wide array of symptoms, including a coated tongue, regardless of the underlying disease. As it takes a long period of time to improve these symptoms by conducting oral cleaning, it is important to implement effective and appropriate oral health management.

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