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Tongue-coating as risk indicator for aspiration pneumonia in edentate elderly

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Abstract

Silent aspiration of oral microorganisms is a major cause of aspiration pneumonia. To establish oral hygiene criteria for the prevention of aspiration pneumonia in edentulous elderly persons, we investigated the relationship between presence of tongue-coating and number of oral bacteria in saliva and episodes of pneumonia. A total of 71 edentulous Japanese people aged 65 years or older living in nursing homes were enrolled in the study. A tongue plaque index (TPI) was used to evaluate quantity of tongue-coating, with TPI 0 signifying no tongue-coating and TPI 1 signifying presence of tongue-coating. Edentate elderly with TPI 1 demonstrated significantly higher salivary bacterial counts than those with TPI 0 (p<0.05). The number of elderly patients developing aspiration pneumonia was larger (p<0.005) in patients with TPI-based poor scores (average TPI>0.5) than in those with TPI-based good scores. The relative risk of developing pneumonia in the good tongue hygiene group compared with in the poor tongue hygiene group was 0.12 (95% CI: 0.02-0.9). The results demonstrate that tongue-coating is associated with number of viable salivary bacterial cells and development of aspiration pneumonia, suggesting that tongue-coating is a risk indicator of aspiration pneumonia in edentate subjects.

Keywords: Oral care · Tongue-coating · Respiratory infection · Oral bacteria · Edentate elderly
1. INTRODUCTION

Aspiration pneumonia-associated mortality is one of the most serious problems in elderly patients (Marrie and Blanchard, 1997, Mylotte, et al., 2003). A number of oral bacteria have been reported to be etiologic agents of pneumonia (Bentley, 1984, Pierce and Sanford, 1974, Scannapieco, et al., 1992). Aspiration of oral bacteria due to impairment of the swallowing and cough reflexes associated with cerebrovascular disorders has been reported to be a cause of aspiration pneumonia (Bartlett, et al., 1974, Levison, 1994). Previous studies have revealed that silent aspiration occurred during sleep in 70% of elderly persons with a past history of pneumonia (Kikuchi, et al., 1994). Taking these findings into account, it has been shown that oral health care is effective in preventing aspiration pneumonia in elderly persons requiring care (Adachi, et al., 2002, Yoneyama, et al., 1999, Yoneyama, et al., 2002). Furthermore, DNA samples of intrapulmonary bacteria and dental plaque bacteria were found to be consistent in pneumonia patients (El-Solh, et al., 2004). These findings suggest that transfer of oral bacteria to the lower airway induces aspiration pneumonia.

Many bacterial species inhabiting the oral cavity are believed to cause aspiration pneumonia, and it is difficult to selectively decrease these specific bacteria. Inglis et al. (Inglis, et al., 1993) reported that the major factor in the development of pneumonia was not the type of oral bacteria, but the amount of bacteria aspirated. An increase in the number of oral pathogenic species has been demonstrated in the oral cavity of elderly persons requiring nursing care, while professional oral care has been shown to bring about a reduction in this number (Abe, et al., 2001). Oral care reduced frequency of idiopathic fever (Adachi, et al.,
2002, Yoneyama, et al., 1996) and mortality rate from pneumonia in the elderly (Adachi, et al., 2002, Meguro, et al., 1992, Yoneyama, et al., 1999). However, which criteria reflect risk of aspiration pneumonia and indicate the need for oral care in terms of oral hygiene have yet to be established; as has the kind of oral care that should be provided for high risk patients for aspiration pneumonia. Although several methods for evaluation of oral hygiene have been reported (Beck, 1979, Eliers, et al., 1988, Passos and Brand, 1966), problems in reliability and validity have also been noted (Susan and Elizabeth, 1993). To perform effective oral care and prevent aspiration pneumonia, the condition of the oral cavity should be evaluated before specific care is given, so that that care may be tailored to the specific oral hygiene conditions encountered.

We have recently reported the visual evaluation of plaque adherence on remaining teeth, and found that the prevalence of pneumonia was high in the group with poor oral hygiene (Abe, et al., 2006). Although a method of evaluating oral hygiene aimed at preventing aspiration pneumonia in the care-requiring dentulous elderly is available, there is currently no such method for the care-requiring edentulous elderly. The tongue has been reported to be a reserve of oral bacteria (Gibbons, et al., 1964, Gordon and Gibbons, 1966, Sumi, et al., 2006). Cleaning of the tongue has been shown to decrease the number of oral bacteria (Gilmore and Bhaskar, 1971, 1972, Yonezawa, et al., 2003).

In this study, the oral hygiene of edentulous subjects was visually evaluated based on status of tongue-coating to clarify its relationship to number of oral bacteria and prevalence of pneumonia. Our goal was to use these findings to establish a standard oral care procedure for the prevention of pneumonia in care-requiring edentulous elderly persons.
2. METHODS

2.1 Subjects and examination methods

Participants consisted of 71 edentulous elderly patients aged 65 years or older (mean age: 89.5 ± 7.5) living in a nursing home in Tokyo. The study was approved by the Tokyo Dental College Ethics Committee. Informed consent was obtained from all participants or their families. Evaluation of the oral cavity and bacteriological analysis: as there are no other methods of determining salivary bacterial level by visual evaluation of the tongue surface, the tongue plaque index (TPI, Abe, et al., 2006) was used to assess tongue-coating, with TPI 0 indicating no tongue-coating (Fig. 1A) and TPI 1 indicating presence of tongue-coating (Fig. 1B). To determine bias among TPI evaluators, the Kappa test was performed. Using the TPI, two dental hygienists evaluated the status of tongue hygiene in 20 elderly patients. Kappa value was 0.95, indicating that the evaluation criteria in this study were reliable. Physical and oral examinations were performed in all subjects before the study (Table 1). Activity of daily living (ADL) was evaluated based on the Barthel index (Mahonery and Barthel, 1965).

2.2 Saliva sampling and bacteriological analysis

Saliva samples were used to evaluate number of bacteria in saliva as described previously (Abe, et al., 2006). Bacterial testing was performed in the 40 patients (mean age: 89.9 ± 6.6) in whom saliva sampling was possible. To minimize bias, saliva was collected at immediately after the patients woke up, at which time tongue-coating was also evaluated. To avoid variation resulting from different sampling sites and samplers, the patients were
required to spit saliva into a sterile cup. Immediately after sampling, 10 µl saliva was
diluted with phosphate-buffered saline (PBS, pH 7.4) in a gradient of 1:10 steps down to
1:10^{-8}, and 100 µl of each dilution was inoculated onto Tryptic soy agar plates (Becton
Dickinson, Cockeysville, MD, USA) supplemented with hemin (5 µg·ml^{-1}), menadione (0.5
µg·ml^{-1}) and 10% defibrinated horse blood in duplicate. These inoculated plates were
incubated at 37°C under anaerobic conditions (10% CO_{2}, 10% H_{2}, and 80% N_{2}) for a week.
The viable anaerobic bacterial cells in the saliva were calculated and expressed as colony
forming units (CFUs/ml). Evaluation of oral hygiene and bacterial analysis were performed
by the double-blind method.

2.3 Follow-up survey

A monthly evaluation of oral hygiene was performed over a period of one year by the
same dentists and dental hygienists in all 71 patients. In addition, the number of febrile days
(febrie defined as a temperature of more than 37.8°C) and number of patients who newly
developed pneumonia during the intervention period were investigated, and the relationship
between TPI and occurrence of pneumonia determined. At the one-year tongue hygiene
evaluation, patients with median scores (TPI =0.5) and below were categorized into the good
hygiene group, and those with higher scores were categorized into the poor hygiene group
(Abe, et al., 2006). Pneumonia was diagnosed when chest X-ray radiography revealed
pulmonary infiltration and either cough, dyspnea, or a fever of 37.8°C or higher were noted.
2.4 Statistical analysis

Differences between the 2 groups based on TPI were evaluated with the Student’s t-test. Differences in number of febrile days between the good and bad oral hygiene groups were analyzed with the Mann Whitney U-test, and for pneumonia with the $\chi^2$ test. The statistical analysis software used was SAS (ver. 8.02), and significance was established as p<0.05.

3. RESULTS

3.1 Relationship between TPI and bacterial cell number

To clarify the relationship between TPI and number of salivary bacterial cells, the patients were divided into two groups according to their score on the TPI (Table 2). No significant differences were found in the baseline physical characteristics of each group. The total number of salivary bacteria significantly increased in the TPI 1 group (p<0.05, Fig.2). To evaluate the relationship between salivary viable bacteria and TPI, subjects were divided into two groups by the median of bacterial cell number ($6.4 \times 10^7$ CFU/ml) at the start of the study. The average and standard error of viable bacterial cells in the low and high groups were $2.7 \times 10^7 \pm 3.5 \times 10^6$/ml and $4.7 \times 10^8 \pm 2.1 \times 10^9$/ml, respectively. The TPIs (mean $\pm$ SE) of the low group and high group were $0.35 \pm 0.11$ and $0.7 \pm 0.11$, respectively. Number of febrile days (mean $\pm$ SE) was significantly higher in patients with a high salivary bacterial count ($3.00 \pm 0.51$) than in those with a low salivary bacterial count ($1.30 \pm 0.39$, p<0.01). The number of patients who developed pneumonia was higher in those with a high salivary bacterial cell count (3/20) than in those with a low one (0/20, p<0.05).
3.2 Relationship between number of febrile days and TPI.

To confirm the reliability of the TPI, the number of the febrile days was evaluated in the good and poor oral hygiene groups. The average age in the good and poor groups was almost the same (89.5 ± 7.2 and 89.4 ± 12.2, respectively). Values were significantly higher for number of febrile days (p<0.001) and number of patients developing pneumonia (p<0.005, Table 2) for those in the poor hygiene group. The relative risk of developing pneumonia in the good tongue hygiene group compared with in the poor tongue hygiene group was 0.12 (95% confidence interval = 0.02-0.9).

4. DISCUSSION

Our results showed a correlation between number of salivary microorganisms and occurrence of pneumonia. Terpenning et al. (2001) reported dental decay, presence of cariogenic bacteria and periodontal pathogens as potentially important risk factors for aspiration pneumonia. Yoneyama et al. (2002) and the authors of this study (Adachi, et al., 2002) have suggested that reduction of oral microorganisms by oral care reduced the development of pneumonia. However, as yet, no criteria for predicting risk of aspiration pneumonia have been available. As saliva is the medium that transports oral bacteria to the lower respiratory tract; we selected saliva as our target for bacteriological investigation of aspiration pneumonia in this study. The number of salivary viable bacteria in subjects with tongue-coating was higher than that in those without. Several reports indicated that tongue-cleaning reduced the number of oral bacteria (Gilmore and Bhaskar, 1971, 1972, Yonezawa, et al., 2003) and odor (Yaegaki and Sanada, 1992). Tongue-cleaning using a
tongue-brush reduced salivary mutans streptococci (White and Armaleh, 2004). In this study, 40 of the patients were classified according to number of salivary viable microorganisms, with the group yielding a high viable bacterial cell number showing a higher average score for TPI. This suggests that tongue-coating reflects salivary bacterial number in edentulous subjects. On the other hand, Mantilla et al. (2001) found no association between evaluation of tongue-coating and number of salivary bacteria. However, they compared the relationship between color and thickness of tongue-coating in periodontitis patients and healthy subjects who were dentate. Our previous data (Abe, et al., 2006) indicated that viable bacterial count was influenced by accumulation of plaque on the teeth in dentate subjects. Therefore, it is possible that the viable cell number of salivary microorganisms was influenced by the quantity of accumulated dental plaque, rather than tongue-coating.

Evaluation of salivary bacteria varies markedly depending on how saliva sampling is achieved. In the report of Mantilla et al (Mantilla Gomez, et al., 2001), no details were given on how sampling was carried out. Difficulty in saliva sampling is widely recognized, and the standardization of salivary sampling methods is necessary for evaluation of bacterial levels (Dawes, et al., 2001). Nolte (1982) reported that the number of bacteria in saliva samples changes within a day, and sampling method, position and sampler also have to be taken into account. To investigate saliva under the same conditions as those that might prevail at the time of a person silently aspirating during sleep, saliva was collected at immediately after patients woke up, with tongue evaluation being performed at the same time.

In this study, the results showed a correlation between TPI and bacterial cell number in saliva. Although the effectiveness of oral care as a preventative measure against pneumonia
has been demonstrated, no appropriate oral care criteria based on oral hygiene evaluation have been reported for determining risk of aspiration pneumonia. We recently reported an oral care index for dentulous elderly persons based on oral evaluation aimed at the prevention of aspiration pneumonia (Abe, et al., 2006). In that study, we clarified the relationship between amount of dental plaque adhering to teeth and salivary bacteria, and found that the prevalence of pneumonia was higher in the poor oral hygiene group. We also investigated the relationship between tongue evaluation and number of salivary bacteria in edentulous subjects, but found no significant correlation. We believe that it is possible that the small number of cases investigated may have been the reason for this absence of significance. Therefore, in this study, we used a larger number of subjects, and found a significant difference.

A significant correlation was noted between TPI and total viable salivary bacterial cells in edentulous elderly patients, showing the potential of visual tongue evaluation in predicting salivary bacteria and risk of aspiration pneumonia. Evaluation of patients in this study was carried out over a period of one year, and the results showed significantly high numbers of febrile days, as well as more cases of pneumonia, in the poor hygiene group, as evaluated with the TPI. These findings suggest that evaluation of certain tongue hygiene criteria such as the state of the tongue-coating provides a significant indicator for prevention of aspiration pneumonia. Our results showed a direct relationship between number of salivary microorganisms and pneumonia (p<0.05), suggesting that this index indicates risk of pneumonia. This suggests that this index offers a simple method of intraorally evaluating edentulous elderly persons that may be used by nurses and care-givers, even if they are not specialists in dentistry.
The results of this study suggest that evaluation of oral hygiene in the edentulous elderly using the TPI offers criteria for establishing risk predictors for aspiration pneumonia. Our findings also suggest that it is necessary to further develop effective tools and methods for removal of tongue-coating. We believe that these results offer a potential platform for the further development of practical and efficient oral care for elderly persons.

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<table>
<thead>
<tr>
<th>TPI 0 (n=19)</th>
<th>Mean age ± SD</th>
<th>Sex (F/M)</th>
<th>ADL</th>
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<tr>
<td>TPI 1 (n=21)</td>
<td>90.3</td>
<td>16/3</td>
<td>54.1</td>
</tr>
<tr>
<td></td>
<td>89.2</td>
<td>13/8</td>
<td>58.7</td>
</tr>
<tr>
<td>TPI</td>
<td>Febrile days (Mean ± SD)</td>
<td>Pneumonia</td>
<td>Infected</td>
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<td>--------------------</td>
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<tr>
<td>Good hygiene (n=39)</td>
<td>0.92 ± 1.06</td>
<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Poor hygiene (n=32)</td>
<td>5.05 ± 3.86**</td>
<td>7*</td>
<td>25</td>
</tr>
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Good hygiene means yearly average score of 0.5 or less; poor hygiene indicates score of more than 0.5.  *p<0.005, **p<0.001
FIGURE LEGENDS

Figure 1.  A: Tongue with no tongue-coat (TPI 0)
             B: Tongue with tongue-coat (TPI 1)

Figure 2.  Relationship between TPI and total CFUs in edentate elderly.
            Mean bacterial count from saliva in dentate subjects compared between TPI 0 and 1.  TPI 0: Tongue with no tongue-coat, TPI 1: Tongue with tongue-coat  Values represent means ± standard error.  *p < 0.05.
Fig. 2