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Original Article

An analysis of the factors affecting the number of bacteria in the saliva of elderly adults in need of care

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SUMMARY

Background: Aspiration pneumonia frequently occurs in elderly people requiring care. The importance of oral care for preventing aspiration pneumonia has been widely recognized, but the appropriate method for ideal oral care method has not been determined. The aim of this study was to investigate the relationship between various clinical factors and the number of bacteria in the saliva.
Methods: This is a retrospective observational study. The subjects consist of 120 people receiving care at 4 facilities for the elderly. The correlation among various demographic, general, and oral-related factors and the number of bacteria in the saliva were analyzed by a one-way analysis of variance and multiple regression analysis.
Results: The univariate analysis showed that older age, tube feeding, inability to gargle, and increased number of bacteria on the tongue were correlated with the number of bacteria in the saliva, but dental plaque was not. Among these variables, the multivariate analysis revealed that tube feeding, inability to gargle, and higher number of bacteria on the tongue were independent risk factors for growth of bacteria in the saliva.
Conclusions: To prevent pneumonia in the elderly requiring care, oral feeding, gargling, and tongue cleansing may be important.

1. Introduction

The percentage of those aged 65 years or older in the Japanese population has increased rapidly; it was 14.5% in 1995, 21.5% in 2007, and 25.0% in 2013, which is the highest in the world.[1] The most frequent cause of death in Japanese people is malignant neoplasm, followed by heart disease and pneumonia. Approximately 97% of those who die of pneumonia are elderly people over 65 years of age. Most cases of pneumonia in the elderly are aspiration pneumonia, which develops in individuals with reduced immunity who aspirate saliva containing pathogenic microorganisms. These facts suggest that preventing aspiration pneumonia is important in order for elderly people to achieve healthy longevity.

Several reports have indicated that oral care that is focused on removing dental plaque and calculus by dentists or dental hygienists can reduce aspiration pneumonia in elderly people.[2–5] However, a detailed examination of these reports reveals some problems in their research designs, and it is not clear whether the incidence of pneumonia actually decreased due to oral care. We believe that it is important to determine an appropriate method for oral care in order to reduce oral bacteria and thereby prevent aspiration pneumonia. Kikutani et al. reported that oral bacteria in the saliva was a risk factor for pneumonia onset in elderly nursing home residents.[6] The aim of the current study was to investigate the relationship between various oral conditions and the number of bacteria in the saliva in elderly people requiring care.

2. Materials and methods

The study is a retrospective observational study and involved 112 elderly people who were receiving care at facilities for the elderly. They received professional oral care consisting of tooth brushing, scaling, and professional mechanical tooth cleaning (PMTC) by dentists and dental hygienists once per week. Age, sex, performance status (PS), form of nutrition, oral wetness, ability to gargle, presence of residual teeth, amount of dental plaque, amount of denture plaque, tongue coatings, number of bacteria on the dorsum of the tongue, and the number of bacteria in the saliva were examined (Table 1). PS was defined as PS 0 to PS 4 according to the classification of Eastern Cooperative Oncology Group (ECOG).[7] Form of nutrition was divided into perioral normal food, mixer diet, and tube feeding. Oral wetness was measured three times at the surface of the buccal

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mucosa using an oral hydrometer (Moisture Checker Mucus®, Life Co., Ltd., Saitama, Japan) and defined as normal when the median was ≥30, and as dry mouth when the median was <30. The amount of dental plaque was defined as the percentage of all tooth surfaces to which dental plaque adhered (%) multiplied by the number of residual teeth, and classified as "few" if the value was less than 500 and as "many" if the value was 500 or more. The amount of denture plaque was classified as "few" and "many" based on a macroscopic observation by a dentist. The degree of tongue coating was evaluated according to the method reported by Winkel.[8] The dorsum of the tongue was divided into six areas, and in each area a score of 0–2 was given, as follows: 0, no tongue coating; 1, thin tongue coating; and 2, thick tongue coating. Each number was summed together, and the overall tongue coating was evaluated as "few" if it was less than 5 and as "many" if it was 5 or more. The number of bacteria on the tongue and in the saliva was measured before oral care according to the method reported previously[9] with a rapid oral bacteria quantification system (Panasonic Healthcare Co. Ltd., Osaka Japan) using the dielectrophoresis and impedance measurement methods.[10,11]

Statistical analyses were performed using SPSS software (version 24.0; Japan IBM Co., Tokyo, Japan). A univariate analysis of the correlation between the number of bacteria in the saliva and other predictive variables was performed by a one-way analysis of variance, and the multivariate analysis was performed by a multiple regression analysis.

Participants or substitute person provided informed consent to participate. Ethics approval for the study was obtained from the Institutional Review Board of Nagasaki University Hospital (No. 16052315).

3. Results

The subjects consisted of 38 men and 74 women, and the age ranged from 50 years to 103 years (average, 82.0 years). A poor general condition (PS 2–4) was observed in 65% of subjects, and 23 (21%) received a mixer diet or tube feeding. Dry mouth was found in 46 (41%). Dental and denture plaques were relatively uncommon, probably due to oral care by dentists, dental hygienists, and facility staff. Twenty-eight people (25%) were unable to gargle. Seventy-four (66%) had residual teeth, while 38 (34%) were edentulous. The degree of tongue coating was few in 50 people and many in 62.

The results of the univariate analysis of the relationship between each variable and the number of bacteria in the saliva is shown in Table 2. Age ($p = 0.036$), form of nutrition ($p = 0.000$), ability to gargle ($p = 0.000$), and the number of bacteria on the tongue ($p = 0.031$) were significantly correlated with the number of bacteria in the saliva. However, there was no relationship between dental plaque or denture plaque and the number of bacteria in the saliva. The multivariate analysis showed that tube feeding ($p = 0.049$), inability to gargle ($p = 0.025$), and the higher number of bacteria on the tongue ($p = 0.001$) were independent risk factors for growth of bacteria in the saliva ($R^2 = 0.318$) (Table 3).

Table 1
Background factors of the participants.

Variable	Category	Number of cases
Gender	male	38
	female	74
Age	<80 years	37
	≥80 years	75
PS	0–1	39
	2–4	73
Meal form	oral food	89
	tube feeding	23
Oral wetness	normal	66
	dry mouth	46
Dental plaque	few	83
	many	29
Denture plaque	few	63
	many	49
Gargle	possible	84
	impossible	28
Tongue coat	few	50
	many	62
Number of bacteria on the tongue	$<10^7$ cfu/mL	40
	$\geq 10^7$ cfu/mL	72
Total		112

4. Discussion

Pneumonia is the most frequent cause of death among elderly people in Japan. It is thought that aspiration of saliva containing pathogenic microorganisms into the lower respiratory tract is involved in the onset of pneumonia, in addition to the reduction of immunity of the host. In particular, in elderly people who need long-term care, it is not easy to keep the oral cavity clean, since not only do the activities of daily living and muscular strength of the whole body decrease, but the motivation to maintain oral hygiene also decreases as cognitive function decreases.

There have been many reports that focus on the relationship between oral hygiene and aspiration pneumonia in the elderly. It has been reported that oral bacteria are frequently detected in sputum examinations and are one of the main causative microorganisms related to aspiration pneumonia.[4] However, these are also indigenous bacteria in the oral cavity, and it is impossible to determine whether they actually cause pneumonia. Terpenning et al. reported that some gram-negative anaerobic bacteria that are periodontal pathogens are important pathogenic bacteria related to aspiration pneumonia, so the incidence of pneumonia is lower for edentulous elderly than for those with teeth.[5] On the other hand, Yoneyama et al. reported that the incidence of pneumonia for dentulous and edentulous elderly was equal, 21% and 20%, respectively.[2] Their study provides no evidence for a hypothesis that periodontal pathogens are the major cause of pneumonia.

Yoneyama et al. reported the results of a large randomized controlled trial covering 11 nursing homes on the relationship between oral health and the development of pneumonia.[2] They divided elderly people in need of care into two groups: the control group (182 persons) who performed oral health care by themselves, and the oral care group (184 persons) who received oral care by

Table 2
Univariate analysis between each variable and number of bacteria in the saliva.

Variable	Category	Number of bacteria in the saliva[a] (cfu/mL)	*p* value
Gender	male	6.43 ± 0.797	0.781
	female	6.63 ± 0.727	
Age	<80	6.50 ± 0.820	0.036
	≥80	6.59 ± 0.723	
PS	0–1	6.31 ± 0.651	0.135
	2–4	6.70 ± 0.774	
Meal form	oral food	6.38 ± 0.68	<0.001
	tube feeding	7.22 ± 0.659	
Oral wetness	normal	6.56 ± 0.723	0.504
	dry mouth	6.56 ± 0.804	
Dental plaque	few	6.53 ± 0.750	0.687
	many	6.65 ± 0.773	
Denture plaque	few	6.71 ± 0.751	0.129
	many	6.36 ± 0.718	
Gargle	possible	6.36 ± 0.652	<0.001
	impossible	7.17 ± 0.719	
Tongue coat	few	6.57 ± 0.784	0.975
	many	6.56 ± 0.735	
Number of bacteria on the tongue	$<10^7$ cfu/mL	6.23 ± 0.859	0.031
	$\geq 10^7$ cfu/mL	6.74 ± 0.622	

[a] Expressed as logarithm (mean ± SD).

Table 3
Multivariate analysis between significant variables in the univariate analysis and number of bacteria in the saliva.

Variables	Non-standardized		Standardized	95% confidence interval [C.I] of non-standardized B	*p* value
	B	SE	β		
Meal form (oral food vs. tube feeding)	0.429	0.215	0.231	0.003 to 0.856	0.049
Gargle (possible vs. impossible)	0.458	0.201	0.265	0.059 to 0.858	0.025
Number of bacteria on the tongue ($<10^7$ cfu/mL vs. $\geq 10^7$ cfu/mL)	0.426	0.126	0.272	0.178 to 0.675	<0.001

staff or a nurse consisting of tooth brushing and rinsing using 1% povidone iodine after each meal, and professional oral care consisting of tooth brushing, scaling, and PMTC by a dentist and a dental hygienist once per week, and they were followed up for 2 years. The incidence of pneumonia was significantly reduced to 11% in the oral care group, compared to 19% in the control group. Their study was the first prospective study to clarify that oral health care can prevent pneumonia in elderly people who require long-term care. However, some weakness are present in their study. First, those receiving tube feeding were excluded from the study, although their risk of pneumonia was much higher than it was in those who ate food orally. Second, it was not clear in their study whether the reduction in pneumonia was due to professional oral care once per week, toothbrushing after each meal, or washing the mouth with povidone iodine after each meal. We aimed to establish the appropriate oral care method that could prevent pneumonia in the elderly in need of care, and the number of bacteria in the saliva rather than the development of pneumonia was regarded as the end point in the current study.

The univariate analysis revealed that older age, tube feeding, inability to gargle, and an increased number of bacteria on the tongue were correlated with the number of bacteria in the saliva, but dental plaque was not. Although no valid conclusions could be drawn because of the small number of subjects, these findings seem to indicate that dental plaque is not a primary cause of pneumonia for the elderly in need of care. This may support the results of Yoneyama's study mentioned above,[2] in which the incidence of pneumonia did not differ between dentulous and edentulous persons.

The multivariate analysis showed that the ability to gargle and the number of bacteria on the tongue were independent risk factors for an increased number of bacteria in the saliva. These findings may suggest that gargling and removing coatings on the tongue are more important for preventing pneumonia than are tooth brushing and scaling. However, it is often difficult for those undergoing tube feeding to gargle. Hayashida et al. reported that in patients under mechanical ventilation, bacteria in the oropharyngeal fluid rapidly grew to 100-fold higher or more than that before intubation, and that tooth brushing with wiping and suction could not reduce the number of bacteria in the oropharyngeal fluid, although irrigation of the oral cavity and oropharynx with 200 mL of water reduced it to the pre-intubation level.[12] Irrigation should be considered instead of gargling for the elderly unable to gargle in order to reduce the number of bacteria in the saliva. Further, removal of tongue coatings is also difficult for elderly persons. We previously examined the effect of mechanical brushing, wiping with 0.05% chlorhexidine, and wiping with 3% oxydor on reducing the number of bacteria on the tongue in healthy people among, and concluded that 3% oxydor was the most effective.[13] The most effective method for irrigation and removing tongue coatings in elderly people requiring care should be established.

The current study was a pilot study with some weakness. It was an observational study with a small number of subjects, and the endpoint was not the development of pneumonia but the number of bacteria in the saliva. Additionally, all bacteria, not just pathogenic bacteria, were counted. However, we believe that our study was valuable since it suggests that in order to decrease the number of oral bacteria, improvement in the method of feeding as well as gargling and cleaning the tongue may be more effective than tooth cleaning, scaling, and PMTC are. Of course, tooth brushing, scaling, and PMTC are necessary for oral care of the elderly in order to prevent dental caries and periodontal disease, but it should be noted that these procedures are performed to prevent dental disease, not pneumonia. We attempted to establish an appropriate oral care method for elderly patients in need of care, especially those who are incapable of eating orally and gargling.

5. Conclusion

The multivariate analysis revealed that the tube feeding, inability to gargle, and higher number of bacteria on the tongue were independent risk factors for growth of bacteria in the saliva. To prevent pneumonia in the elderly requiring care, oral feeding, gargling, and tongue cleansing may be important.

Conflicts of interest

All authors declare to disclose any potential conflicts of interest.

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References

1. *Cabinet Office. Annual Report on the Aging Society*; 2014 (Summary). Available at http://www8.cao.go.jp/kourei/whitepaper/w-2014/gaiyou/index.html. Accessed on: June 12, 2017. Accessed September 27, 2017.
2. Yoneyama T, Yoshida Y, Ohrui T, et al. Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc*. 2002;50:430–433.
3. Ishikawa A, Yoneyama T, Hirota K, et al. Professional oral health care reduces the number of oropharyngeal bacteria. *J Dent Res*. 2008;87:594–598.
4. Pierce AK, Sanford JP. Aerobic gram negative bacillary pneumonia. *Am Rev Respir Dis*. 1974;110:647–658.
5. Terpenning M, Bretz W, Lopatin D, et al. Bacterial colonization of saliva and plaque in the elderly. *Clin Infect Dis*. 1993;16(suppl 4):S314–S316.
6. Kikutani T, Tamura F, Tashiro H, et al. Relationship between oral bacteria count and pnewmonia onset in elderly nursing home residents. *Geriatr Gerontol Int*. 2015;15:417–421.
7. *Common Toxicity Criteria, Version2.0*; 1999. Available at http://ctep.cancer.gov/protocolDevelopment/electronic_applications/docs/ctcv20_4-30-992.pdf. Accessed September 27, 2017.
8. Winkel EG, Roldán S, Van Winkelhoff AJ, et al. Clinical effects of a new mouthrinse containing chlorhexidine, cetylpyridinium chloride and zinc-lactate on oral halitosis: a dual-center, double-blind placebo-controlled study. *J Clin Periodontol*. 2003;30:300–306.
9. Funahara M, Hayashida S, Sakamoto Y, et al. Efficacy of topical antibiotic administration on the inhibition of perioperative oral bacteria growth in oral cancer patients: a preliminary study. *Int J Oral Maxillofac Surg*. 2015;44:1225–1230.
10. Hamada R, Suehiro J, Nakano M, et al. Development of rapid oral bacteria detection apparatus based on dielectrophoretic impedance measurement method. *IET Nanobiotechnol*. 2011;5:25–31.
11. Hirota K, Inagaki S, Hamada R, et al. Evaluation of a rapid oral bacteria quantification system using dielectrophoresis and the impedance measurement. *Biocontrol Sci*. 2014;19:45–49.
12. Hayashida S, Funahara M, Sekino M, et al. The effect of tooth brushing, irrigation, and topical tetracycline administration on the reduction of oral bacteria in mechanically ventilated patients: a preliminary study. *BMC Oral Health*. 2016;16:67.
13. Funahara M, Soutome S, Hayashida S, et al. Oral care method for removal of tongue coating: comparison of decontamination effects among brushing, Concool F, and oxydol. *JSOC*. 2016;11:65–69 [in Japanese].