Relationships between activity of daily living, and oral cavity care and the number of oral cavity microorganisms in patients with cerebrovascular diseases

Fumiko Michishige*, Sumiko Yoshinaga*, Eriko Harada*, Katsuhiko Hirota†, Yoichiro Miyake†, Takashi Matsuo‡, and Susumu Yasuoka*

*Department of Nursing, School of Medical Sciences, The University of Tokushima, Tokushima, Japan, and †Department of Microbiology, and ‡Department of Conservative Dentistry, The University of Tokushima School of Dentistry, Tokushima, Japan

Abstract : We examined the relationships among the activity of daily living (ADL), oral cavity care, and the number of oral cavity microorganisms in 40 patients with cerebrovascular diseases (CVD). The CVD patients were classified into 4 groups, I, II, III and IV based on their ADL and the method used for oral cavity care. The ADL was highest in group I and lowest in group III. Only the patients of only group III could not eat by themselves and were receiving naso-esophageal feeding. Oral cavity care was performed by the patients themselves in groups I and IV, but was performed by caregivers in groups II and III. The group IV patients had no teeth, but could eat by themselves using full dentures. The numbers of microorganisms in the pharyngeal swabs from the 4 groups were measured and expressed as colony-forming units (cfu). The numbers of both *Staphylococci* spp. and *Candida* spp. were significantly higher in group III than in the other groups. Moreover, *Pseudomonas aeruginosa* was isolated only from patients of group III (in about 66%). The oral cavity care by caregivers was almost the same in groups II and III, but the numbers of oral cavity microorganisms were significantly higher in group III than in group II. These results indicated that microorganisms grow more easily in the oral cavities of CVD patients with low ADL compared with CVD patients with higher ADL, and that eating is thought to be important for the prevention of an increase of microorganisms in the oral cavity. J. Med. Invest. 46 : 79-85, 1999

Key words **:** *oral cavity care, aspiration pneumonia, cerebrovascular disease, pharyngeal swab, bacteria*

INTRODUCTION

The function of host neurological defense systems, such as the cough reflex and swallowing reflex is often lowered in aged persons or patients with cerebrovascular diseases (CVD). Such individuals are subject to aspiration pneumonia, because bacteria in the oral cavity and pharynx move easily into the lungs during sleep (1, 2).

Received for publication December 17, 1998 ; accepted January 28, 1999.

Address correspondence and reprint requests to Fumiko Michishige, Department of Nursing, School of Medical Sciences, The University of Tokushima, Kuramoto-cho, Tokushima 770-8509, Japan and Fax : +81-88-633-9015.

Aspiration pneumonia is thought to be caused by pathogens of bacterial flora in the upper airway and oral cavity (3, 4). For instance, it has been reported that the *Streptococci anginosus* group of pathogens are common in aspiration pneumonia (5). Oral cavity care including tooth brushing and gargling is thus thought to be effective not only for the prevention of tooth diseases but also for the prevention of aspiration pneumonia.

Oral cavity care can be classified into that by carried out by oneself and that carrried out by a caregiver. The latter is carried out not only by professional oral cavity care managers, but also by nurses, caregivers and family members. It is postulated that in Japan, in the near future, the number of

persons who cannot take care of their oral cavities by themselves because of disorders such as CVD and dementia may increase because the number of aged persons is now rapidly increasing. Therefore, the need for oral cavity care of these patients by caregivers is also expected to increase.

We are attempting to develop effective new methods for oral cavity care by caregivers from standpoint of the caregivers, for the prevention of both aspiration pneumonia and oral cavity infections in CVD patients who cannot care for their oral cavities by themselves. We speculated that the methods of oral cavity care suitable for individual CVD patients differ depending on the degree of their ADL and on the underlying CVD. Therefore, in this study, we investigated the relationships among the ADL scores, method of oral cavity care, and the numbers of microorganisms in the oral cavity of CVD patients who were hospitalized .

MATERIALS AND METHODS

Study Population

The subjects consisted of 40 CVD patients who were hospitalized in a recuperation hospital. There were 24 males and 16 females, and their ages ranged from 42 to 88 years old. The underlying CVD are listed in Table 1. Informed consent was obtained from each patient or the patient's family. The patients were classified into four groups depending on their ADL and on the content of their oral cavity care as follows. Group I consisted of the 11 patients who could eat and brush their teeth by themselves. Group II was the 12 patients who could eat by themselves but were receiving oral cavity care from caregivers. Group III consisted of 8 patients who were given nutrients via naso-esophageal tube feeding and received oral cavity care from caregivers. Group IV was the remaining 9 patients who had no teeth but could eat with full dentures, and performed their oral cavity care by themselves. Table 1

Table 1. Background of the study population of 40 patients with cerebrovascular disease classified according to their activity of daily living and oral cavity care method

Group*			I N=11	II N=12	III N=9	IV N=8
Sex	Male		8	10	2	4
	Female		3	2	6	5
Age (year)	Mean		62	63	80	79
	(range)		(42～67)	(52～84)	(54～88)	(64～87)
Underlying Disease	Alzheimer's disease		0	0	1	0
	Subarachnoid hemorrhage		2	0	0	0
	Spinal cord injury		1	0	0	0
	Multiple cerebral infarction		2	4	3	3
	Cerebral infarction		2	3	3	3
	Cerebral contusion		0	1	0	0
	Brain tumor		0	0	1	0
	Cerebral hemorrhage		4	4	1	2
Bedridden status	Independence	J1**	0	0	0	0
		J2	5	0	0	3
	Partially	A1	1	0	0	0
		A2	2	0	0	1
	Completely	B1	1	0	1	1
		B2	2	10	0	3
		C1	0	1	0	0
		C2	0	0	8	0
No. of teeth	Mean		22	15	0	0
	(range)		(12～24)	(4～24)	(0～24)	

*The patients were classified based on their activity of daily living (ADL) and methods of oral cavity care, as follows ;

Group I : They could brush their teeth and eat by themselves.
Group II : They could eat themselves, but were receiving oral cavity care from caregivers
Group III : They were receiving naso- esophageal feeding and oral cavity care from caregivers
Group IV : They had no teeth, but could eat by themselves using full dentures

**Classification of the bedridden status was carried out based on the criteria reported by the Ministry of Public Welfare of Japan (4).

summarizes the backgrounds, ages, underlying diseases, bedridden status and numbers of remaining teeth of the patients in each group.

The mean age (62 years) of group I was almost the same as that (63 years) of group II. The mean ages of group III (80 years) and group IV (79 years) were almost the same, and higher than that of group I. The number of patient aged over 80 years was 0 (0%) in group I, 1 (8.3%) in group II, 4 (50.0%) in group III and 4 (44.4%) in group IV.

The grading of the bedridden status was performed according to the criteria reported by the Ministry of Health and Welfare of Japan (6). The ADL was the lowest in group III ; these patients could not eat or take care of their oral hygiene by themselves because of the existence of disorders such as dysphagia and dementia.

Table 2 shows the history of hospitalization, type of diet, and content of oral cavity care for each group. For the patients of groups II and III, the caregivers wiped the surfaces of the oral cavity and pharynx once a day in the morning with gauze soaked with popidone iodine (Isodine gargle, Meiji Seika Co., Tokyo, Japan).

The mean frequency of intravenous administration of antibiotics for respiratory infection or urinary infection during the previous 12 months was 2.5 times in group III, and the intravenous administration of antibiotics was not carried out in any of the patients in groups I, II and IV. Patients with decubitus were not found in groups I and IV, but decubitus was found in 3 patients (25.0%) in group II and in 5 patients (55.5%) in group III.

Materials

Mannitol salt agar and NAC agar were obtained from Eiken Co. (Tokyo). *Candida* GE agar was obtained from Nissui Co. (Tokyo). A spiral system (Pleter model D) was obtained from Spiral Co. (Ohio City, OH).

Collection of pharyngeal swabs

To obtain microorganisms from the oral cavity, the mucosa of the pharynx of each patient was

Table 2. Hospitalization, diet and the oral cavity condition of the patient groups

	Mean hospitalization (month) (range)	Diet	Condition of oral cavity
Group I N=11	45.90±36.50*	normal diet ; 10 patients soft diet ; 1 patient	All patients were brushing their teeth at least everyday, and five patients were brushing their teeth after every meal. dental caries ; 6 patients gingival swelling ; 6 patients oral cavity redness ; 3 patients
Group II N=12	57.75±38.01	normal diet ; 2 patients soft diet ; 8 patients mixed diet ; 2 patients	They undewent cleaning of the oral cavity with gauze by a caregiver once a day, in the morning. dental caries ; 6 patients gingival swelling ; 6 patients oral cavity redness ; 6 patients
Group III N=9	19.77±16.87	They ware receiving 330-400ml of a commarcial liquid diet, MA-8 via a naso-esophageal tube 3 times a day	They underwent cleaning of the oral cavity with gauze by a caregiver once a day, in the morning. no teeth ; 4 patients dental caries ; 1 patient gingival swelling ; 4 patients oral cavity redness ; 4 patients
Group IV N=8	72.75±66.87	normal diet ; 5 patients soft diet ; 3 patients	Seven patients were always wearing their full dentures, and one patient was taking out his full dentures each night. Their dentures were washed with dentistfrice, and not washed with washing agent for dentures.

* Values are means±SD

wiped once with sterilized cotton in the early morning, and the microorganisms on the cotton were immersed in a sterile transport fluid (0.05% sodium thioglycolate in phosphatebuffered saline) for 30 sec.

Measurement of numbers of microorganisms in the pharyngeal swabs

The numbers of *Staphylococci, Pseudomonas* spp. and *Candida* spp. were measured by the method reported previously (7). Fifty μl of the original sterilized fluid containing bacteria without dilution was inoculated onto a Mannitol salt agar plate for the measurement of the number of *Staphylococci* spp., and on a Candida GE agar plate for the measurement of the number of *Candida* spp. An NAC agar plate was used for counting *Pseudomonas aeruginosa*. The inoculation of the fluid onto agar was performed using the spiral system. The mannitol salt agar plates, NAC agar plates and Candida agar plates were incubated aerobically for 2 days at 37°C, and the number of colonies was counted. The data are expressed as the colony number of each microorganism per ml (cfu/ml).

Statistical analysis :

The results are expressed as the mean±SD. The significance of differences between groups was analyzed by the Fisher's PLSD using Stat View J-45 software. A p value <0.05 was considered significant.

RESULTS

The number of Staphylococci spp. in the pharyngeal swabs

The number of patients in whom a *Staphylococci* spp. was detectable was 6 (54.5%) in group I, 8 (66.6%) in group II, 8 (88.8%) in group III and 6 (75%) in group IV. Thus, the rate of *Staphylococci* spp. was the highest in group III. The mean number of *Staphylococci* spp. (cfu×10^3) of group III was 1.77, significantly higher than those of the other 3 groups ($p<0.01$), as shown in Fig.1.

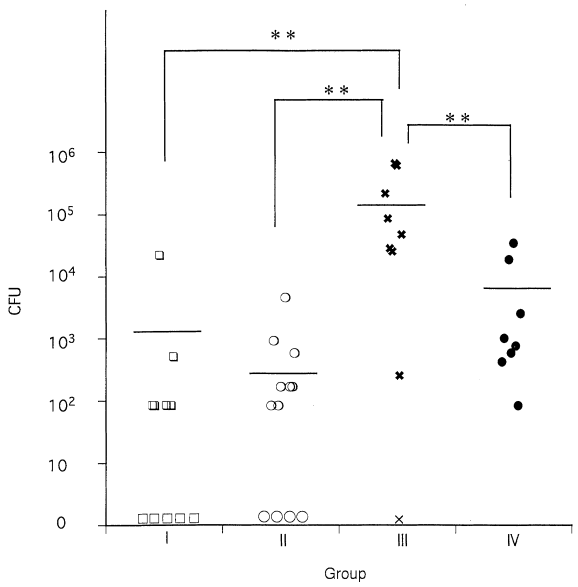

Fig.1. The numbers of *Staphylococci* spp. in pharyngeal swabs
Each symbol represents one patient. Group I, n=11 ; group II, n=12 ; group III, n=9 ; group IV, n=8
Horizontal lines show the means.
**$p<0.01$

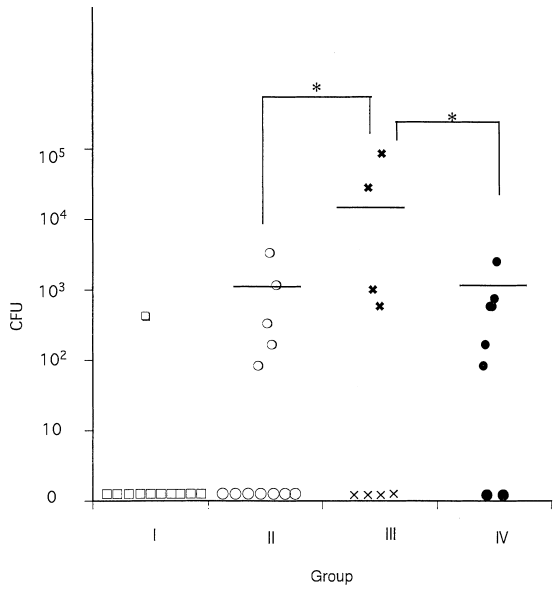

Fig. 2. The numbers of *Candida* spp. in pharyngeal swabs
Each symbol represents one patient.
Horizontal lines show the mean.
*$p<0.05$

The numbers of Candida spp in the pharyngeal swabs

The number of patients in whom *Candida* spp. was detectable was 1 (9.0%) in group I, 5 (41.6%) in group II, 4 (44.4%) in group III, and 6 (75.0%) in group IV. The mean number of *Candida* spp. (cfu× 10^4) of group III was 1.24, significantly higher than those of groups I and II ($p<0.05$), but not significantly different from that of group IV (Fig. 2).

The numbers of Pseudomonas aeruginosa in the pharyngeal swabs

Pseudomonas aeruginosa was not detectable in any samples from the patients of groups I , II and IV. However, it was detectable in 6 patients (66.6%) of Group III. The mean number (cfu× 10^4) of *Pseudomonas aeruginosa* of group III was 2.56 (Fig. 3)

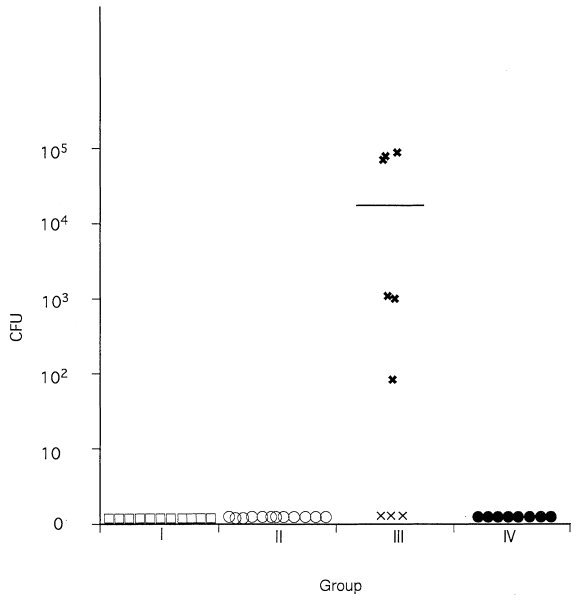

Fig. 3. The numbers of *Pseudomonas aeruginosa* in pharyngeal swabs
Each symbol represents one patient.
Horinzontal lines show the means.

DISCUSSION

As described in the Introduction, oral cavity care is important to prevent the occurrence of aspiration pneumonia in aged people, especially CVD patients with low ADL. To investigate the relationships among patient ŝ ADL, including eating and care of their oral cavities, the method of oral cavity care and the number of oral cavity microorganisms in CVD patients, we classified the present patients into 4 groups based on their ADL and oral care method.

The group III patients had the lowest ADL of the 4 groups. All the patients of this group were completely bedridden, and were given nutrients through a naso-esophageal tube because they had a disturbance in swallowing due to CVD such as multiple cerebral infarction. Kikuchi *et al*. reported a higher incidence of aspiration pneumonia in patients with bilateral cerebral infarction (1). Therefore, judging from the standpoint of neurological dysfunction, the patients in group III are suspected to be very susceptible to aspiration pneumonia, compared with the other patient groups.

The numbers of *Staphylococci* spp. in the pharyngeal swabs were significantly higher in group III than in the other 3 groups. For instance, the mean number of *Staphylococci* spp. in group III was 88-fold, 300-fold and 25-fold higher those of group I, group II and group IV, respectively. The numbers of *Candida* spp. in the pharyngeal swabs also were significantly higher in group III than in group I or II, and tended to be higher in group III than in group IV. Moreover, *Pseudomonas aeruginosa* was detectable only in the patients of group III. Matsuura *et al*. reported that β-*Streptococci* (groups B and G) and *Pseudomonas aeruginosa* were detectable in the oral cavities of aged subjects who were completely bedridden and given nutrients through a naso-esophageal tube, but not detectable in those of other aged subjects (8). Our present findings are in good accordance with their results. The results of the analysis of microorganisms in pharyngeal swabs suggested that microorganisms grow very well in the oral cavities of patients of group III, and that group III patients may have a high risk of contracting aspiration pneumonia, judging from the standpoint of microorganism flora.

The exact reasons why bacteria and fungi increased in the pharyngeal swabs of group III are unknown. Probably several factors are related to the increase of microorganisms in group III. We postulated that the following 3 factors are at least related to the increase of microorganisms ; (1) a decline in function of local host defense systems in the oral cavity, (2) poor oral hygiene state due to unsatisfactory or no oral cavity care, (3) a decline in the function of the systemic host defense system.

Of these factors, dysfunction or decline in function of the biological defense system is thought to be important. The functions of both local and systemic defense systems have been shown to decline with aging from adult stage to old stage (9-13). Therefore, in the present study, we must consider the effect of age on the numbers of microorganisms in the oral cavities of the 4 patient groups.

There have been no reports which examine the effect of age on numbers of oral cavity microorganisms in the healthy population. Therefore, it is unknown whether or not the numbers of oral cavity microorganisms increase, in response to a decline in the function of local and systemic defence systems with aging. As described in Subjects and Methods, the age distribution of group III was very similar to that of group IV, and the age distribution of group I was very similar to that of group II, the patients of group III and IV being older than those of group I and II. The numbers of both *Staphylococci* spp. and *Pseudomonas aeruginosa* in the pharyngeal swabs of group III were larger than those of not only groups I and II, but also group IV. These results indicate that some factors other than age

are related to the increase of bacteria in the pharyngeal swabs of group III.

It is well known that various types of bioactive substances such as secretory immunoglobulin A (IgA) and lysozyme, which are related to local host defense in the oral cavity, are present in saliva (9, 10, 14, 15). The present group III patients were given nutrients via a naso-esophageal tube, while the patients of the other groups ate by themselves. Only the patients of group III did not eat or masticate food by themselves. Moreover, the secretion of saliva depends in part on the amount of water intake. The intake of water might be restricted in group III patients compared with subjects who are taking food and water by themselves per os. We therefore suspect that in group III patients, the secretion of saliva is markedly lowered or does not occur, that the local defense system function is lowered or disturbed in the oral cavity, and that factor (1) described above is related to the increase of pharyngeal microorganisms in group III.

The patients of Group III could not care for their oral cavities by themselves due to motor disturbance and or dementia. Moreover, the caregivers often could not perform sufficient oral cavity care for some of the group III patients because the patients did not cooperate with them. Therefore, factor (2) described above also is thought to be related to the increase of pharyngeal microorganisms in group III.

The patients of group III could not eat by themselves, while the patients of group II could eat by themselves. But the patients in both groups II and III received the same oral cavity care by caregivers, namely cleaning of the oral cavity with gauze soaked in popidone iodine. Nevertheless, the number of bacteria and fungi in the pharyngeal swabs was clearly higher in group III than in group II. This result indicates that eating is effective for inhibition of the growth of microorganisms in the oral cavity. Moreover, the fact that the patients of group III were older than those of group II, indicates that some age-related factor may also be related to the difference of numbers of microorganisms between group II and III.

In this study, we did not investigate the functioning of the systemic defense system in the patients. It is thus unknown whether the systemic defense system function was lowered in the patients, especially in the patients of group III. The group III patients received naso-esophageal feeding over a long term. In general, long-term nutrition through a naso-esophageal tube is thought to be inadequate for these patients. Moreover, the patients of group III were frequently suffering from infection. We therefore suspect that the nutritional states of the group III patients were poorer than those of the other patient groups, and that the function of the host systemic defense system may also be markedly lower in the patients of group III compared to the other groups. It may be that a decline in the function of the systemic defense system with age was more marked in group III than in group I and II, because the patients of group III were older than those of group I and II.

It is very rare for *Pseudomonas aeruginosa* to be detectable in the pharyngeal swabs of healthy subjects. In the present study, *Pseudomonas aeruginosa* was not detectable in any patients of groups I, II and IV, but was detectable in 66% of the patients of group III. It is well known that *Pseudomonas aeruginosa* appears or increases and displays pathogenicity as a consequence of microbial substitution (change of bacterial flora) due to the administration of antibiotics for the pathogenic bacteria. Moreover, it has been reported that when patients are given nutrients through a naso-esophageal tube, *Pseudomonas aeruginosa* adhere on the tube, form a biofilm, and become resistant to antibiotics (16). Since the present patients of group III had been repeatedly treated by antibiotics for pulmonary, urinary and dermal infections, the *Pseudomonas aeruginosa* detected may have occurred as a consequence of the microbial substitution .

Anaerobic bacteria have been reported to be common pathogens in aspiration pneumonia (17). In this study, we did not analyze the anaerobic bacteria in pharyngeal swabs. We thus do not know whether anaerobic bacteria were increased in the oral cavities of the patients of group III.

The results of the present study indicated that it is necessary to develop effective new methods for oral cavity care administered by caregivers to CVD patients with low ADL, especially for patients who cannot eat by themselves and receive nutrients through a naso-esophageal tube. An enhancement of the functioning of local and systemic host defense systems is also necessary for the prevention of aspiration pneumonia in CVD patients with low ADL.

ACKNOWLEDGMENTS

This study was supported by a Grant-in-AID for Scientific Research (C) No.09672401 and Grant-in-AID for Encouragement of Young Scientists No.09772100, from the Ministry of Education, Science, Sports and Culture of Japan.

REFERENCES

1. Kikuichi R, Watabe N, Konno T, Mishima N, Sekizawa K, Sasaki H : High incidence of silent aspiration in elderly patients with community acquined pneumonia. Amer J Respir Crit Care Med 150 : 251-253, 1994
2. Teasell RW, Mcrae M, Marchuk Y, Finestone HM : Pneumonia associated with aspiration following stroke. Arch Phys Med Rehabil 77 : 707-709, 1996
3. Bartlett JG, Gorbach SL, Finegold SM : The bacteriology of aspiration pneumonia. Am J Med 56 : 202-207, 1974
4. Finegold SM : Aspiration pneumonia. Rev infect Dis 13 : 737-742, 1991
5. Shinzato T, Uema H, Inadome J, Shimoji K, Kusano N, Fukuhara H, Saito A : Bacteriological and clinical studies in 23 cases of thoracic empyema -The role of oral Streptococci and anaerobes-. Jap J Thoracic Diseases (in Japanese) 31 : 486-491, 1993
6. The Ministry of Public Welfare of Japan : Manual for Guidance of Oral Cavity Hygeine for the Bedridden Subjects (in Japanese). Shin-kikaku Syuppansya, Tokyo, 1994, pp. 58
7. Hirota K, Yoneyama T, Ota M, Hashimoto K, Miyake Y : Pharyngeal bacteria andprofessional oral health care in elderly people. Jap J Geriat (in Japanese) 34 : 125-129, 1997
8. Matsuura T, Suzuki K, Yamakoshi M, Yamamoto T, Yamamoto T, Yoshitomo K, Tonegawa K, Ariga K, Odawara F : Study of bacterial flora in the oral cavity and stomach in elderly patients receiving nasogastric tube feeding. Kansenshogaku-zasshi (in Japanese) 71 : 397-404, 1997
9. Smith DJ, Joshipura K, Kent R, Taubman MA : Effect of age on Immunoglobulin content and volume of human labial gland saliva. J Dent Res 71 : 1891-1894, 1992
10. Percival RS, Marsh PD, challacombe SJ : Age-related changes in salivary antibodies to commensal oral and gut biota. Oral Microbiol Immunol 12 : 57-63, 1997
11. Berson PB : Alleged susceptibility of the elderly to infection. Yale J Biol Med 58 : 71-77, 1985
12. Ben-Yehuda A, Weksler ME : Host resitence and the immune system. Clin Geriatr Med 8 : 701-711, 1992
13. Fietta A, Merlini C, Dos-Santos C, Rovida S, Grassi C : Influence of aging on some specific and nonspecific mechanisms of the host defense system in 146 healthy subjects. Gerontology 40 : 237-245, 1994
14. Bergmann KC, Waldman RH : Stimulation of secretory antibody following oraladministoration of antigen. Rev Infect Dis 10 : 939-950, 1988
15. Smith DJ, Taubman MA, Alisalaam P : Immunoglobulin isotypes in human minor gland saliva. J Dent Res 70 : 167-170, 1991
16. Pederson SS, Hoiby N, Espersen F, Koch C : Role of alginate in infection with mucoid Pseudomonas aeruginosa in cystic fibrosis.Thorax 47 : 9-13, 1992
17. Bartlett JG, Gorbach SL, Thadepalli H, Finegold SM : Bacteriology of empyema. Lancet 1 : 338-340, 1974