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Prevention of aspiration pneumonia (AP) with oral care

Akio Tada [a,*], Hiroko Miura [b]

[a] Department of Health Science, Hyogo University, 2301 Shinzaike Hiraoka-cyo, Kakogawa, Hyogo 675-0195, Japan
[b] Department of Oral Health, National Institute of Public Health, 2-3-6 Minami, Wako, Saitama 351-0197, Japan

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ABSTRACT

AP is a major cause of morbidity and mortality in elderly patients, especially frail elderly patients. The aim of this article is to review effect of oral care, including oral hygiene and improvement of oral function, on the prevention of AP among elderly people in hospitals and nursing homes. There is now a substantial body of work studying the effect of oral care on the prevention of respiratory diseases. Oral hygiene, consisting of oral decontamination and mechanical cleaning by dental professionals, has resulted in significant clinical effects (decreased incidence of pneumonia and decreased mortality from respiratory diseases) in clinical randomized trials. Moreover, studies examining oral colonization by pneumonia pathogens have shown the effect of oral hygiene on eliminating these pathogens. In addition, swallowing training has been shown to improve the movement and function of swallowing-related muscles, also resulting in decreased incidence of pneumonia. These findings support the contention that oral care is effective in the prevention of AP.

1. Introduction

AP is a leading cause of morbidity and mortality among elderly residents in long-term care facilities (Sarin et al., 2008). The incidence and prevalence of AP increases with age (Fernández-Sabé et al., 2003; Almirall et al., 2007), the presence of underlying diseases (Almirall et al., 2007), and the use of nasogastric tubes or percutaneous enterogastric tubes (Janssens, 2005).

There are two closely related risk factors for AP. The first concerns colonization of respiratory pathogens in oropharyngeal areas. In the oral cavity, the dynamic co-existence between commensal and pathogenic bacteria is protected from natural physical and chemical antibacterial host defense mechanisms (Marcotte and Lavoie, 1998; Socransky et al., 2002; Marsh, 2003; Handfield et al., 2008). In the elderly, three major conditions, an increase in biofilms, a decrease in immunity, and a decrease in commensal bacteria, disturb the above equilibrium, eliciting morbid microflora. Respiratory pathogens have been isolated from the oral cavities of elderly patients in hospitals and nursing homes (Marrie, 1990; Scannapieco et al., 1992; Fourrier et al., 1998; Russell et al., 1999; Tada et al., 2002a,b; Senpuku et al., 2003; El-Solh et al., 2004; Tada et al., 2004; Didilescu et al., 2005).

The second risk factor involves alterations in oropharyngeal and gastro-esophageal motility, which allows the aspiration of oropharyngeal or gastro-esophageal material into the bronchi (Marik and Kaplan, 2003; Almirall et al., 2007). Nursing home residents, who have a higher rate of cerebrovascular and degenerative neurological diseases, have a higher incidence of dysphagia and hence, an extremely high incidence of pneumonia (Marrie, 1990; Kayser-Jones and Pengilly, 1999; Marik and Kaplan, 2003). Using multivariate analysis, Loeb et al. (1999) revealed that difficulty in swallowing was significantly associated with the incidence of pneumonia in their study population (odds ratio = OR = 2.0; 95% confidence interval = 95% CI = 1.2–3.3).

These findings suggest that the incidence of AP is implicated with oral colonization by respiratory pathogens and dysphagia (Fig. 1), eliciting the hypothesis that prevention of AP requires elimination of respiratory pathogens from the oral cavity and improvement in oral functions such as swallowing. It is considered that oral care is one of the most important aspects in the prevention of AP because of its potential to control the risk factors for pneumonia (Fig. 2). Formerly, oral care focused exclusively on oral hygiene, consisting of oral cleaning. However, in recent years, due to increased awareness of some patients' lack of oral function due to various handicaps from underlying diseases, oral care has expanded to encompass both oral hygiene and training for oral function, including swallowing, mastication, and saliva secretion (Fig. 2). Oral care can be now defined as 'science and technology that is aimed at the improvement of the quality of life (QOL) by oral cavity disease prevention, oral health promotion, and oral rehabilitation' (Ueda, 2005). In this article, we review the effect of these two factors of oral care on the prevention of AP and the further direction of studies from a biological and sociological perspective.

* Corresponding author. Tel.: +81 79 427 5111; fax: +81 79 427 5112.
E-mail address: atada@hyogo-dai.ac.jp (A. Tada).

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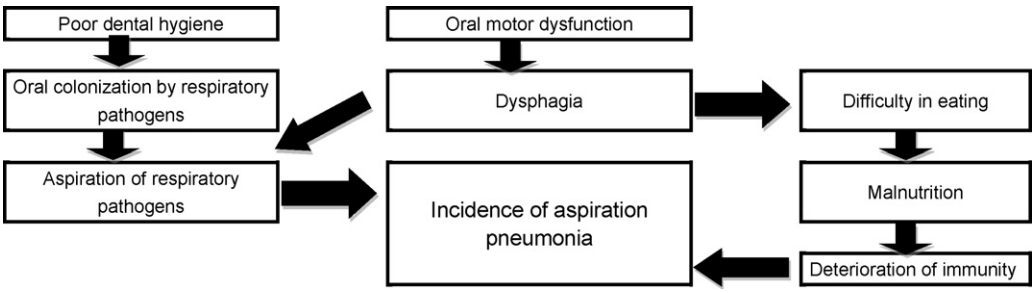

Fig. 1. Mechanism of incidence of AP.

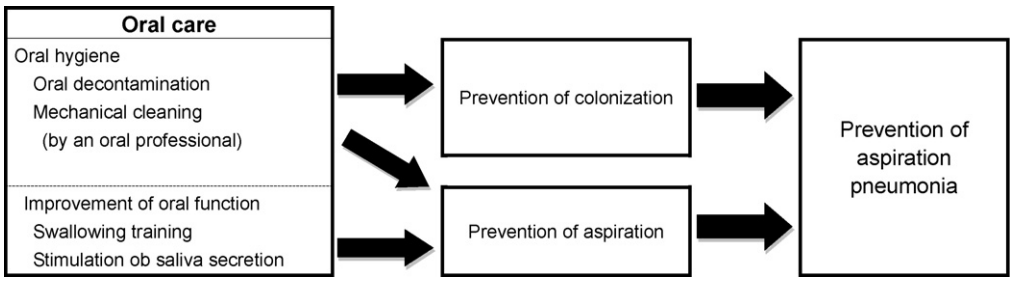

Fig. 2. Prevention of AP in relation to oral care.

2. Prevention of respiratory disease by oral hygiene

In the oral cavity, dental plaque and denture plaque serve as a reservoir of pathogens (Cvitkovitch et al., 2003; ten Cate, 2006; Senadheera and Cvitkovitch, 2008). Oral hygiene for elderly patients in hospitals and nursing homes consists of mechanical cleaning and oral decontamination. Mechanical cleaning requires assistance by caregivers because the elderly have difficulty in effectively cleaning the oral cavity (Kiyak et al., 1993; Mojon and MacEntee, 1994; Russell et al., 1999; De Visschere et al., 2006) possibly because of functional disabilities resulting from underlying diseases such as cerebrovascular or orthopedic disease, and dementia. Oral decontamination includes topical application of antimicrobial agents or treatment with broad-spectrum antibiotics. Many studies have shown the effect of oral hygiene on the incidence of respiratory disease in elderly patients in hospitals and nursing homes (Sjögren et al., 2008). We review and discuss the effects of elimination of pathogens as well as present clinical

Table 1
Preventive effects of oral hygiene interventions on AP and respiratory tract infection in elderly people.

Interventions	Subjects	Microbiological effects	Clinical effects	References
Antimicrobial 0.132% CHX oral agent	Cardiovascular ICU patients undergoing heart surgery ($n=353$)	65% reduction in nosocomial infection ($p<0.01$) 69% reduction in total respiratory tract infections ($p<0.05$)	Mortality reduction (test 1.1% vs. control 5.6%)	DeRiso et al. (1996)
0.12% CHX oral rinse twice daily	Surgical ICU patients requiring mechanical ventilation ($n=385$)	Gram-negative and -positive microorganisms with more effectiveness against Gram-negative bacteria	Risk of VAP 55% (HR = 0.454; 95% CI = 0.22–0.93; $p=0.030$)	Koeman et al. (2006)
Antibiotics: Polymyxin B, Neomycin, Vancomycin	Patients requiring mechanical ventilation ($n=52$)	Significant colonization rate by GNB ($p<0.05$) and GPC ($p<0.05$; *S. aureus*, $p=0.024$)	Incidence of VAP (test: 16% vs. control 78%)	Pugin et al. (1991)
Gentamicin COL Vancomycin	ICU patients who were intubated and needed mechanical ventilation ($n=139$)	75% reduction in oropharynx colonization by PPMO (control A: 0%, control B: 9% $p<0.00001$)*	Relative risk reduction in incidence of VAP compared control Control A: 0.67 (95 CI = 0.33–0.84) Control B: 0.55 (95% CI = 0.03–0.79)	Bergmans et al. (2001)
Mechanical cleaning by a dental hygienist	Elderly living in nursing homes ($n=141$)	Cultivable cell numbers of *Staphylococcus* species and *Candida albicans* in swab samples. (*C. albicans*: $p<0.05$)		Adachi et al. (2002)
Mechanical cleaning by a dentist or dental hygienist	Elderly institutionalized in nursing homes with physical handicaps or mental deterioration	Prevention of degradation of febrile days		Yoneyama et al. (1996)
Mechanical cleaning by a dentist or dental hygienist	Elderly institutionalized in nursing homes with physical handicaps or mental deterioration ($n=366$)	Relative risk of control Febrile day: 2.45 (1.77–3.40) Pneumonia: 1.67 (1.01–2.75) Death: 3.20 (1.34–7.14)		Yoneyama et al. (2002)

* Control group A: patients were studied in the presence of patients receiving topical prophylaxis; control group B: patients were studied in an ICU where no topical prophylaxis was used.

findings for both oral decontamination and mechanical cleaning (Table 1).

2.1. Effect of oral decontamination

A prospective, randomized, double-blind, placebo-controlled clinical trial was conducted on two study groups consisting of cardiovascular patients admitted to intensive care units (ICUs) to determine the effect of oral decontamination with a chlorhexidine (CHX) rinse. DeRiso et al. (1996) found that the CHX-treated patients showed a significantly lower rate of gram-negative infection (control: 24/180 vs. CHS-treated: 8/173; $p < 0.01$) than untreated patients. A reduction in mortality was also noted in the CHX-treated group compared with the untreated group (control: 1.16% vs. CHS-treated: 5.56%). Koeman et al. (2006) reported that the daily risk of ventilator-associated pneumonia (VAP) was reduced in both treatment groups compared with placebo groups (PLAC): 65% (hazard ratio = HR = 0.352; 95% CI = 0.160–0.791; $p = 0.012$) for CHX and 55% (HR = 0.454; 95% CI = 0.224–0.925; $p = 0.030$) for CHX/colistin (COL). With regard to oropharyngeal colonization, the preventive effects of CHX/COL and CHX were comparable for gram-positive bacteria, but CHX/COL was more effective against gram-negative bacteria. Colonization rates with gram-negative microorganisms on admission were 52% for the PLAC, 43% for CHX group, and 41% for CHX/COL patients ($p = 0.101$ for CHX vs. PLAC, and $p = 0.094$ for CHX/COL vs. PLAC).

CHX has a broad range of activity against gram-positive microorganisms, including multiresistant pathogens such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE), although activity against gram-negative microorganisms may be less optimal (WHO, 1998). This antimicrobial activity of CHX can explain both findings of these two studies. In the study of Koeman et al. (2006), CHX/COL provided a significant reduction in oropharyngeal colonization with gram-negative and gram-positive microorganisms. Some cases where gram-negative microorganisms have been detected require oral decontamination in combination with correct antibiotics.

Two studies have assessed the effect of topical application of plural antibiotics. Pugin et al. (1991) evaluated selective decontamination of the oropharynx with polymyxin B sulfate, neomycin sulfate, and vancomycin hydrochloride (PNV) in a double-blind, placebo-controlled trial in patients requiring mechanical ventilation. Tracheobronchial colonization by gram-negative bacteria and *S. aureus*, as well as pneumonia, occurred less frequently in the PNV group than in the PLAC (16% vs. 78%; $p < 0.0001$). Bergmans et al. (2001) reported that the topical prophylaxis group had a significantly lower rate of incidences of VAP ($p < 0.005$). Topical prophylaxis resulted in a higher rate of eradication of potentially pathogenic microorganisms (PPMO: *Enterobacteriaceae*, *Pseudomonadaceae* and *S. aureus*) than the placebo ($p < 0.00001$).

The profile of eliminated bacteria in these studies appears to be consistent with the spectrum of drugs. In clinical practice, the selection of antibiotics requires microbiological examination prior to oral decontamination. Reports describing oral colonization by MRSA (Tada et al., 2004, 2006) emphasize the significance of microbiological examination for oral decontamination by antibiotics. Long-term oral rinsing with antibiotics requires continuous monitoring of the oral microflora.

2.2. Effect of mechanical cleaning

The effect of the intervention of mechanical cleaning by dental professionals has been assessed in numerous studies. Adachi et al. (2002) found that the rate of fatal AP in the cleaning group during the 24-month study was significantly lower than in the non-cleaning group ($p < 0.05$). Mechanical cleaning by dental professionals resulted in a reduction of *Staphylococcus* but not to a statistically significant extent. Importantly, mechanical cleaning by a dental professional was found to eliminate *Candida* as well as bacteria. Since *Candida* species which colonize the oral cavity are potential pathogens for pneumonia (Coulthwaite and Verran, 2007), mechanical cleaning may also be effective in preventing Candida pneumonia. Yoneyama et al. (1996, 2002) had reported improved clinical outcome with a reduction in the number of febrile days and a significant decrease in the number of elderly with febrile days, newly diagnosed pneumonia, and death from pneumonia (relative risk = febrile 2.45, pneumonia 1.67, death 2.40) following an intervention in elderly patients institutionalized in nursing homes, who were physically handicapped or suffering from mental deterioration. This intervention analysis included professional oral care once a week by a dentist or dental hygienist.

In addition to the potential of eliminating wide range of microbiological species, mechanical cleaning does not bring with it the problems of resistance and susceptibility inherent in the use of antimicrobial agents or antibiotics. However, where professional care is not available, the nurse or caregiver should be educated to provide suitable oral care (Isaksson et al., 2000; Frenkel et al., 2001; Nicol et al., 2005).

Most studies mentioned in this chapter did not specify which bacterial species were reduced by oral hygiene measures. Many epidemiological studies have reported bacterial species which are specifically isolated from the oral cavities of elderly patients in hospitals and nursing homes (Scannapieco et al., 1992; Tada et al., 2002a,b, 2004; Senpuku et al., 2003; El-Solh et al., 2004; Didilescu et al., 2005). Data on more specific bacterial species that decrease in accordance with reduction in respiratory symptoms will provide indicators for oral care.

3. Prevention of respiratory disease by improvement of oral function

Elderly patients in hospitals and nursing homes frequently suffer from various disorders of oral function, such as dysphagia, decreased masticatory function, and decreased saliva secretion. Dysphagia and decreased masticatory function are caused by functional impairment of the muscles and nerves responsible for oral movement. In some cases, oral rehabilitation is required to at least partially restore diminished oral functions.

3.1. Improvement of swallowing

Approaches to dysphagia treatment include direct therapy techniques (swallowing training and pharmacological therapy) and compensatory strategies (dietary management and positioning). Because swallowing training allows patients to make an effort to recover primary functions by themselves, it could be significant in enhancing the patient's quality of life. Swallowing training consists of indirect training, which is the fundamental training of organs related to swallowing, and direct training, which is training during eating.

In recent years, various types of indirect therapies have been developed and evaluated for swallowing improvement (Table 2). Hägg and Anniko (2008) and Hägg et al. (2008) performed lip muscle training in stroke patients with dysphagia using specially devised equipment. Significant improvement was obtained in lip force and swallowing capacity by training irrespective of the presence or absence of central facial paresis.

It has been hypothesized that electrical stimulation may assist swallowing either by augmenting hyolaryngeal elevation (Freed et al., 2001; Leelamanit et al., 2002) or by increasing sensory input to the central nervous system to enhance swallowing elicitation

Table 2
Effects of swallowing training.

Content of training	Subjects	Effects	References
Lip muscle training	Stroke patient with dysphagia	Improvement for lip force and swallowing capacity	Hägg and Anniko (2008) Hägg et al. (2008)
Hyoid elevation by electric stimulation	Healthy volunteer Patients with chronic long-standing dysphagia	Increased degree of hyoid elevation Reduced aspiration and pooling ($p = 0.025$)	Park et al. (2009) Ludlow et al. (2007)
Lingual exercise	Healthy volunteer	Increased isometric and swallowing pressures Increased lingual volume of an average of 5.1%	Robbins et al. (2005)
Lingual exercise	Stroke patient with dysphagia	Increased isometric ($p < 0.001$) and swallowing pressures ($p = 0.03$)	Robbins et al. (2007)
Neck massage Stretch exercises (cheeks and lips) Vibratory stimulation (cheeks and tongue)	Elderly dysphagia patients with tube feeding	Reduced frequency of pneumonia ($p < 0.05$)	Ueda et al. (2004)

(Park et al., 1997; Power et al., 2004). Park et al. (2009) found that effortful swallowing coupled with electrical stimulation increased the degree of hyoid elevation in healthy volunteers. Ludlow et al. (2007) reported that surface electrical stimulation resulted in hyoid elevation and subsequent reduction of aspiration and penetration during swallowing in patients with chronic pharyngeal dysphagia.

Robbins et al. (2005) reported that lingual exercise significantly increased swallowing pressure and lingual volume by an average of 5.1% in healthy elderly volunteers aged 70–89, suggesting reduced dysphagia. They also found that lingual exercise enables acute and chronic dysphagic stroke patients to increase lingual strength with associated improvements in swallowing pressure, airway protection, and lingual volume (Robbins et al., 2007).

Ueda et al. (2004) evaluated the effects of swallowing training on the outbreak frequency of pneumonia in elderly tube-fed dysphagia patients. They performed indirect therapy, including neck massage, cheek and lip stretch exercises, and vibratory stimulation of the cheeks and tongue and direct therapy using gelatin jelly. They demonstrated that the frequency of pneumonia in the training group decreased year by year ($p < 0.05$), although no statistically significant differences were recognized in the non-training group.

These studies demonstrate that training for swallowing-related muscle effectively improves swallowing ability and has the potential to prevent aspiration. There have been few studies evaluating the effect of training on the prevention of aspiration and the reduction in the incidence of pneumonia. Evaluating the prevention of aspiration is difficult because of the risk of accidental aspiration occurring during training; the absence of an established effective method; and the difficulty of conducting a randomized control trial. Studies assessing the clinical effects of swallowing training need to overcome these problems. Many studies have been performed with the goal of determining appropriate swallowing training methods. During swallowing training, dental, medical, nursing, and rehabilitation professionals should collaborate to ensure patients' safety and to facilitate assessment of the effect of each method.

The association of depression of the cough reflex with pneumonia in elderly patients has been demonstrated in epidemiological studies (Sekizawa et al., 1990; Nakajoh et al., 2000). Another study reported that oral cleaning improved the cough reflex of older patients in a nursing home. The intervention of daily oral care consisting of cleaning of the teeth and gums by a caregiver after each meal in elderly nursing home patients resulted in a significant increase in cough reflex sensitivity compared with the baseline (Watando et al., 2004). The mechanism of improvement of cough reflex sensitivity by intensive oral care is unclear. The authors speculated that long-term exposure to oropharyngeal microbial pathogens introduced into the lower respiratory tract by silent aspiration might desensitize cough receptors residing within the airway epithelium, whether structurally or functionally. Long-term microaspiration may alter mucus thickness and composition or may deplete neuropeptides in nerve endings as seen in smokers (Rubin et al., 1992; Millqvist and Bende, 2001). Successful improvement of swallowing in addition to elimination of pathogens by oral cleaning will provide important findings for inclusive oral care.

3.2. Improvement of saliva secretion

Saliva facilitates mastication by moistening food particles and making a bolus, and assists swallowing (Pereira et al., 2006; van der Bilt et al., 2006). Saito et al. (2008) suggested that a dry tongue dorsum is a significant risk factor for pyrexia, independent of dysphagia. Stimulation of saliva secretion serves as an auxiliary role for other oral care in the prevention of AP. A variety of factors influence salivary flow rate, the major one being multiple drug use (Dawes, 2004, 2008; Turner and Ship, 2007). Hospitalized and bedridden elderly patients often experience multiple drug use for long periods, predictably resulting in an obvious decrease in salivary flow, particularly in those with underlying medical conditions. Mastication has also been shown to affect the salivary flow rate (Bourdiol et al., 2004; Dawes and Kubieniec, 2004; Gavião et al., 2004; Ikebe et al., 2007).

The effect of gustatory stimulation has been investigated for many years. The use of flavored gums and lozenges increases secretory output (Fox, 2004). The combination of gustatory and masticatory stimulation can transiently increase salivation and relieve symptoms of oral dryness (Fox, 2004). However, few well-designed and controlled clinical trials have formally tested these factors. Mucin-containing products have been shown to relieve oral dryness with good patient acceptance (Gravenmade and Vissink, 1993). Mouly et al. (2007) reported improvement in dryness, stickiness and dullness of oral mucosa; severity of mucositis; and thickening of the tongue in xerostomia patients using an oxygenated glycerol triester oral spray.

4. Conclusions

Research into the effect of oral care on the prevention of AP has yielded considerable amount of information. Oral hygiene and improvement of oral function, the two major components of oral care, are effective in the prevention of AP in hospitalized or institutionalized elderly patients. Nevertheless, evidence concerning the effects of oral care on preventing AP and methods for effective practice of oral care are far from complete. Further research into clinical effects and related fundamental fields will provide promising advances in oral care management.

Conflict of interest statement

None.

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