

Pneumonia in nonambulatory patients

The role of oral bacteria and oral hygiene

Frank A. Scannapieco, DMD, PhD

Considerable evidence is available to support the belief that a relationship exists between poor oral health, the oral microflora and bacterial pneumonia. Together, pneumonia and influenza constitute the sixth most common cause of death in the United States and in most developed countries.^{1,2} These conditions are the most common cause of infection-related mortality.

Pneumonia can be divided into two general categories: community acquired and nosocomial. Community-acquired pneumonia develops in noninstitutionalized people, while nosocomial pneumonia is observed in patients 48 hours after admission to an institution, such as a hospital or nursing home. While both forms of the disease often are polymicrobial, a distinction exists between the two forms regarding their microbial etiology.

Community-acquired pneumonia often is caused by organisms considered to be common residents of the upper airway, including the following: *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Legionella pneu-*

ABSTRACT



Background. Considerable evidence exists to support a relationship between poor oral health, the oral microflora and bacterial pneumonia, especially ventilator-associated pneumonia in institutionalized patients. Teeth or dentures have nonshedding surfaces on which oral biofilms (that is, dental plaque) form that are susceptible to colonization by respiratory pathogens. Subsequent aspiration of respiratory pathogens shed from oral biofilms into the lower airway increases the risk of developing a lung infection. In addition, patients may aspirate inflammatory products from inflamed periodontal tissues into the lower airway, contributing to lung insult.

Types of Studies Reviewed. The author reviewed laboratory studies, clinical trials and review articles.

Conclusions. A number of studies have shown that the mouth can be colonized by respiratory pathogens and serve as a reservoir for these organisms. Other studies have demonstrated that oral interventions aimed at controlling or reducing oral biofilms can reduce the risk of pneumonia in high-risk populations. Taken together, the evidence is substantial that improved oral hygiene may prevent pneumonia in vulnerable patients.

Clinical Implications. Institution of rigorous oral hygiene regimens for hospitalized patients and long-term-care residents may reduce the risk of developing pneumonia.

Key Words. Nosocomial pneumonia; ventilator-associated pneumonia; chlorhexidine rinse.

JADA 2006;137(10 supplement):21S-25S.

Dr. Scannapieco is a professor and chair, Department of Oral Biology, School of Dental Medicine, University at Buffalo, State University of New York, 109 Foster Hall, Buffalo, N.Y. 14214, e-mail "fas1@buffalo.edu". Address reprint requests to Dr. Scannapieco.

mophila, *Candida albicans* and anaerobic bacteria (often those associated with periodontal disease). Nosocomial pneumonia often is caused by gram-negative enteric bacteria such as *Escherichia coli*, *Klebsiella pneumoniae* and other enteric species; *Pseudomonas aeruginosa*; and *Staphylococcus aureus*.

A related disease is aspiration pneumonia, which typically is caused by anaerobic organisms, in turn typically derived from the gingival crevice.³ Aspiration pneumonia often develops in patients at risk of aspirating oral contents into the lung, such as those with dysphagia or depressed consciousness. Aspiration pneumonia occurs both in the community and in institutional settings.

ORAL HEALTH AND VENTILATOR-ASSOCIATED PNEUMONIA

Ventilator-associated pneumonia (VAP) is the leading cause of death from nosocomial infections, and it is the second most common nosocomial infection in the United States. Mechanically ventilated patients have a sixfold to 21-fold increased risk of developing pneumonia, with 10 to 25 percent of ventilated patients developing the disease. With each day spent on a ventilator, the risk of developing pneumonia increases by 1 percent. Mechanical ventilation involves the placement of an endotracheal tube into the lower airway. The bacteria that cause disease colonize the tube surface, which facilitates the transit of bacteria to the lung.⁴ This is an important problem, not only because of increased mortality, but also because of the resulting extended length of hospital stay and the significant expansion of costs. Indeed, the onset of pneumonia easily can double the length of the patient's hospital stay, and the cost of VAP treatment has been estimated to average as high as \$40,000 per case.⁵

The connection between oral health and VAP is rather straightforward. For pneumonia to develop, the pathogen must be aspirated from a proximal site (for example, the oropharyngeal cavity) into the lower airway. A person with teeth or dentures has nonshedding surfaces on which oral biofilms form. These biofilms are susceptible to colonization by respiratory pathogens.⁶ Poor oral hygiene may predispose high-risk patients to oral colonization by respiratory pathogens. Subsequent aspiration would deposit these bacteria into the lower airway, thereby increasing the risk of infection.

In addition, the host response to oral biofilms results in inflammation of the periodontal tissues. Thus, inflammatory products from the gingival tissues, as well as pathogenic bacteria shed from oral biofilms into the secretions, can be aspirated into the lower airway to promote lung infection.⁷

Respiratory pathogens. Scannapieco and colleagues⁶ compared the colonization of dental plaque by respiratory pathogens in patients receiving treatment in medical intensive care units (ICUs) with that in matched, untreated control subjects. They examined the association between oral hygiene status together with other variables (for example, antibiotic exposure) and the prevalence of oral colonization by potential respiratory pathogens. The results showed that patients treated in the ICU harbored greater levels of dental plaque than did the control subjects. Importantly, the authors found that bacterial pathogens known to cause pneumonia were prevalent only in the dental plaque of patients treated in the ICU. In some cases, up to 100 percent of the aerobic flora was *S. aureus*, *P. aeruginosa* or one of several enteric species. In contrast, the dental plaque of control subjects rarely was colonized by respiratory pathogens. This finding suggests that the oral surfaces, especially dental plaque, could be a major reservoir of infection by respiratory pathogens in patients treated in the ICU.

Exposure to antibiotics. The authors⁶ also found a correlation between pathogen colonization and exposure to antibiotics. Many patients in the hospital environment receive antibiotic treatment, either prophylactically to prevent infection or to treat an existing infection. The study results showed that the dental plaque of patients with recent exposure to antibiotics had a much greater chance of being colonized by respiratory pathogens than did the plaque of those who were not receiving antibiotic treatment. Antibiotic exposure undoubtedly contributes to the propensity of these patients' dental plaque to become colonized by potential respiratory pathogens by inhibiting the commensal flora that typically competes with and excludes pathogens.

These findings have been corroborated by several subsequent studies. Fourrier and colleagues⁸ studied dental plaque colonization by respiratory pathogens in 57 patients admitted to an ICU. Twenty-three percent of the dental plaque samples tested positive for respiratory pathogens on

the day of admission, 39 percent on day 5 and 46 percent on day 10. Twenty-one (37 percent) of the patients in the medical ICU developed an infection, and having plaque colonized by respiratory pathogens was highly predictive of the development of pneumonia.

ORAL HYGIENE

Poor oral hygiene itself appears to be related to subsequent lung infection. Abe and colleagues⁹ conducted a study of 145 Japanese patients living in nursing homes. They evaluated dental and tongue plaque indexes, the number of viable microorganisms in the saliva of each subject and the relationship of these microorganisms to episodes of pneumonia during a one-year period. The authors found a significantly higher number of febrile days ($P = .0012$) and a greater number of patients who developed pneumonia ($P < .01$) among dentate patients with poor hygiene scores compared with those with good hygiene scores.

Limeback^{10,11} suggested that poor oral hygiene also has a negative impact on the overall health of patients receiving long-term care (for example, in a nursing home). He suggested that poor oral hygiene among residents of long-term-care facilities increases exposure to pathogenic microorganisms found in the mouth, which together with reduced host defense mechanisms leads to an increased incidence of systemic disease.

Russell and colleagues¹² reported that 14 percent of institutionalized elderly people had dental plaque that became colonized by a respiratory pathogen, while no one in a cohort of dental outpatients did. In patients whose plaque was colonized, a significant proportion of the plaque flora was composed of one or more species of respiratory pathogens.

These studies support the notion that institutionalized subjects, especially those in hospital ICUs and nursing home settings, are at greater risk of developing dental plaque colonization by respiratory pathogens than are community-dwelling subjects. The former subjects also tend to have poorer oral hygiene than do community-dwelling subjects. Thus, oral biofilms likely serve as reservoirs of respiratory pathogens that sub-

sequently can infect the lungs. This suggests that oral intervention to reduce or control the amount of dental plaque may be a simple, cost-effective method of reducing pathogen colonization in high-risk populations.

ORAL INTERVENTIONS

A number of studies have been conducted to test the hypothesis that oral interventions reduce the risk of pneumonia in high-risk populations.¹³⁻²⁴ A recent systematic review of the literature²⁵ examined the association between poor oral hygiene and the risk of nosocomial pneumonia and chronic lung disease. The authors found that interventions aimed at improving oral hygiene can significantly reduce the incidence of pulmonary disease.

Chlorhexidine rinse. DeRiso and colleagues¹⁶ conducted a prospective study that is an example of a well-designed intervention that demonstrates the potential for improved oral hygiene to prevent pneumonia. The authors examined two groups of subjects who were admitted to a surgical ICU: a test group of 173 people who received a 0.12 percent chlorhexidine oral rinse twice a day and a control group of 180 subjects who received a placebo rinse.¹⁶ The incidence of pneumonia in the chlorhexidine group was 60 percent lower than that in the control group.

Chlorhexidine gel. A subsequent study by Fourrier and colleagues¹⁷ found that use of a 0.2 percent chlorhexidine gel twice a day in 30 subjects in the ICU resulted in a 60 percent reduction in the incidence of pneumonia compared with that in a placebo control group of 30 matched subjects. Yoneyama and colleagues²⁰ compared 184 test patients living in a nursing home with 182 control patients. The intervention consisted of supervised toothbrushing three times a day plus use of povidine iodine mouthrinse once a day. Subjects in the control group followed their routine oral care regimen. The authors found that the incidence of pneumonia in the test group was 39 percent lower during a two-year period than it was in the control group.

Meta-analysis. Scannapieco and colleagues²⁵ conducted a meta-analysis of all studies published from 1966 until 2002 (summarizing data from almost 500 subjects) that used various

Studies support the notion that institutionalized subjects are at greater risk of developing dental plaque colonization by respiratory pathogens than are community-dwelling subjects.

methods to reduce dental plaque in the mouth (including mechanical toothbrushing, use of topical disinfectants or use of topical antibiotics). The results showed that treatment reduced the risk of pneumonia compared with that in placebo or control groups. Several recently published studies also support the efficacy of improved oral hygiene in the prevention of VAP.^{23,24}

I must point out, however, that not all studies have demonstrated a reduced incidence of pneumonia after intervention to improve the oral hygiene of subjects treated in ICUs. A recently published multicenter trial tested the efficacy of gingival and dental plaque antiseptic decontamination to reduce VAP in the ICU.²² This double-blind, placebo-controlled trial conducted in six ICUs enrolled a total of 228 dentate patients who required mechanical ventilation and who had an anticipated stay of five or more days in the ICU.

The intervention was a 0.2 percent chlorhexidine gel versus a placebo used three times a day during the entire stay in the ICU. Only 66 subjects were in the unit long enough to undergo plaque sampling at baseline, as well as up to 10 days after admission to the ICU. Although the authors noted no significant differences in baseline characteristics between the groups, suggesting adequate randomization, the colonization of dental plaque by respiratory pathogens was lower in subjects in the treated group than in subjects in the control group.²² However, the study found no difference in the incidence of pneumonia between the treated and control groups. It is possible that the number of enrolled subjects was not large enough to enable the authors to detect an effect of the intervention on the primary end point (that is, pneumonia).

Because most studies showed that improved oral hygiene can reduce the risk of pneumonia in vulnerable patients, we should consider the status of oral hygiene practices in hospitals and nursing homes. Traditional nursing care textbooks recommend that toothbrushing be performed twice a day together with swabbing of the mouth with glycerine and lemon swabs.²⁶ In light of some of the studies described above, routine nursing practice needs to include more rigorous oral care procedures.

A recent survey assessed the type and frequency of oral care provided in ICUs in the United States, as well as the attitudes, beliefs and knowledge of health care personnel.²⁷ The

findings showed that while 512 (92 percent) of 556 respondents perceived oral care to be a high priority, the primary oral care procedures involved the use of foam swabs, moisturizers and mouthwash. Interventions thought to reduce oral colonization by respiratory pathogens, such as toothbrushing and the use of antiseptic rinses such as chlorhexidine gluconate, appear to be used infrequently in critical care settings.²⁸

QUESTIONS TO BE RESOLVED

Many questions need to be answered to improve our understanding of the role of oral health in respiratory infections. With respect to inpatients, the optimal oral hygiene regimen for reducing oral respiratory pathogen colonization remains to be elucidated. It is not clear if topical oral disinfection with chemotherapeutic agents alone is adequate, or if mechanical oral hygiene methods also are required. The role of the dental hygienist in preventing nosocomial respiratory infection also deserves attention.

Would routine professional tooth scaling reduce or eliminate infection in these high-risk patients? Because many medications used to treat these patients are xerostomic, the role of saliva in this process and the effect of reduced salivary flow need further study. Finally, large-scale multicenter trials are needed to confirm the efficacy of improved oral hygiene and identify the most effective regimens to prevent pneumonia in vulnerable populations.

CONCLUSION

Considerable evidence exists to support the relationship between poor oral hygiene and bacterial pneumonia in special-care populations, including people in hospital and nursing home settings. However, it is important to point out that these associations have been documented only for nosocomial pneumonia. Little evidence exists that poor oral hygiene and periodontal disease may increase the risk of developing community-acquired pneumonia.

It is important for practicing dentists to be aware of the particular risks to patients in institutional settings such as ICUs and nursing homes that can result from poor oral hygiene. The dental profession needs to become more involved in the care of hospitalized and nursing home populations, because preventive dental care can be crucial in the prevention of serious lung infections in these settings. ■

1. Murray CJ, Lopez AD. Mortality by cause for eight regions of the world: Global Burden of Disease Study. *Lancet* 1997;349(9061):1269-76.
2. Guyer B, Martin JA, MacDorman MF, Anderson RN, Strobino DM. Annual summary of vital statistics: 1996. *Pediatrics* 1997;100(6):905-18.
3. Marik PE. Aspiration pneumonitis and aspiration pneumonia. *N Engl J Med* 2001;344(9):665-71.
4. Safdar N, Crnich CJ, Maki DG. The pathogenesis of ventilator-associated pneumonia: its relevance to developing effective strategies for prevention. *Respir Care* 2005;50(6):725-41.
5. Rello J, Ollendorf DA, Oster G, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. *Chest* 2002;122(6):2115-21.
6. Scannapieco FA, Stewart EM, Mylotte JM. Colonization of dental plaque by respiratory pathogens in medical intensive care patients. *Crit Care Med* 1992;20(6):740-5.
7. Scannapieco FA. Role of oral bacteria in respiratory infection. *J Periodontol* 1999;70(7):793-802.
8. Fourrier F, Duvivier B, Boutigny H, Roussel-Delvallez M, Chopin C. Colonization of dental plaque: a source of nosocomial infections in intensive care unit patients. *Crit Care Med* 1998;26(2):301-8.
9. Abe S, Ishihara K, Adachi M, Okuda K. Oral hygiene evaluation for effective oral care in preventing pneumonia in dentate elderly. *Arch Gerontol Geriatr* (published online ahead of print Nov. 2, 2005).
10. Limeback H. The relationship between oral health and systemic infections among elderly residents of chronic care facilities: a review. *Gerodontology* 1988;7(4):131-7.
11. Limeback H. Implications of oral infections on systemic diseases in the institutionalized elderly with a special focus on pneumonia. *Ann Periodontol* 1998;3(1):262-75.
12. Russell SL, Boylan RJ, Kaslick R, Scannapieco FA, Katz RV. Respiratory pathogen colonization of the dental plaque of institutionalized elders. *Spec Care Dentist* 1999;19(3):128-34.
13. Kuriakona NV. Effect of oral cavity sanitation on the activity of the course of chronic pneumonia in children [in Russian]. *Stomatologia (Mosk)* 1977;56(1):94-5.
14. Pugin J, Auckenthaler R, Lew DP, Suter PM. Oropharyngeal decontamination decreases incidence of ventilator-associated pneumonia: a randomized, placebo-controlled, double-blind clinical trial. *JAMA* 1991;265(20):2704-10.
15. Yoneyama T, Hashimoto K, Fukuda H, et al. Oral hygiene reduces respiratory infections in elderly bed-bound nursing home patients. *Arch Gerontol Geriatr* 1996;22(1):11-9.
16. DeRiso AJ 2nd, Ladowski JS, Dillon TA, Justice JW, Peterson AC. Chlorhexidine gluconate 0.12% oral rinse reduces the incidence of total nosocomial respiratory infection and nonprophylactic systemic antibiotic use in patients undergoing heart surgery. *Chest* 1996;109(6):1556-61.
17. Fourrier F, Cau-Pottier E, Boutigny H, Roussel-Delvallez M, Jourdain M, Chopin C. Effects of dental plaque antiseptic decontamination on bacterial colonization and nosocomial infections in critically ill patients. *Intensive Care Med* 2000;26(9):1239-47.
18. Genuit T, Bochicchio G, Napolitano LM, McCarter RJ, Roghman MC. Prophylactic chlorhexidine oral rinse decreases ventilator-associated pneumonia in surgical ICU patients. *Surg Infect* 2001;2(1):5-18.
19. Bergmans DC, Bonten MJ, Gaillard CA, et al. Prevention of ventilator-associated pneumonia by oral decontamination: a prospective, randomized, double-blind, placebo-controlled study. *Am J Respir Crit Care Med* 2001;164(3):382-8.
20. Yoneyama T, Yoshida M, Ohru T, et al. Oral care reduces pneumonia in older patients in nursing homes. *J Am Geriatr Soc* 2002;50(3):430-3.
21. Houston S, Hougland P, Anderson JJ, LaRocco M, Kennedy V, Gentry LO. Effectiveness of 0.12% chlorhexidine gluconate oral rinse in reducing prevalence of nosocomial pneumonia in patients undergoing heart surgery. *Am J Crit Care* 2002;11(6):567-70.
22. Fourrier F, Dubois D, Pronnier P, et al. Effect of gingival and dental plaque antiseptic decontamination on nosocomial infections acquired in the intensive care unit: a double-blind placebo-controlled multicenter study. *Crit Care Med* 2005;33(8):1728-35.
23. Mori H, Hirasawa H, Oda S, Shiga H, Matsuda K, Nakamura M. Oral care reduces incidence of ventilator-associated pneumonia in ICU populations. *Intensive Care Med* 2006;32(2):230-6.
24. Koeman M, van der Ven AJ, Hak E, et al. Oral decontamination with chlorhexidine reduces incidence of ventilator-associated pneumonia. *Am J Respir Crit Care Med* (published online ahead of print April 7, 2006).
25. Scannapieco FA, Bush RB, Paju S. Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease: a systematic review. *Ann Periodontol* 2003;8(1):54-69.
26. Luckman J, Sorensen K. *Medical-surgical nursing: a psychophysiological approach*. Philadelphia: Saunders; 1987.
27. Binkley C, Furr LA, Carrico R, McCurren C. Survey of oral care practices in US intensive care units. *Am J Infect Control* 2004;32(3):161-9.
28. Grap MJ, Munro CL, Ashtiani B, Bryant S. Oral care interventions in critical care: frequency and documentation. *Am J Crit Care* 2003;12(2):113-9.