Geriatric Oral Health and Pneumonia Risk

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The oral cavity is a complex microenvironment consisting of multiple bacterial and fungal species, their associated biofilms, and a cytokine milieu influenced by constant inflammatory stimulation. Multiple infectious consequences of poor oral health have been extensively described and primarily affect older adults. Probably the most common sequelae of poor oral health in aged persons is a risk of aspiration pneumonia. The risk of aspiration pneumonia is greatest when periodontal disease, dental caries, and poor oral hygiene are compounded by swallowing disease, feeding problems, and poor functional status. The effectiveness of oral hygiene interventions for preventing aspiration pneumonia and barriers to oral care of nursing home patients require additional study, but the current state of research in these areas is reviewed in this manuscript. The expense of aspiration pneumonia as a nursing home complication makes dental hygiene a potentially cost-saving intervention.

The implications of oral health for systemic health and risk of infection are often overlooked. The oral environment is a very complex ecosystem in which a mix of anaerobic bacteria, facultative aerobes, and spirochetes compete for space and nutrients [1, 2]. Bacterial biofilms and ongoing inflammatory responses further complicate the oral microenvironment. Older adults frequently experience major consequences of poor oral health, with high rates of local infection, infectious endocarditis, and aspiration pneumonia. Oral flora changes associated with aging and the relationship of periodontal disease to infections common in the elderly population have recently been reviewed in *Clinical Infectious Diseases* [3]. This review briefly highlights the differences between dentate and nondentate oral microenvironments, outlines recent data suggesting the importance of poor dental health in the pathogenesis of pneumonia in elderly persons, and examines the potential for increased oral care to reduce pneumonia risk in older adults.

THE ORAL FLORA

The oral environment is filled with microorganisms engaged in a constant struggle with host mechanisms that aim to keep these organisms in check. The oral environment in people who still have teeth is quite different from the flora that thrive in the toothless person. The dentate mouth contains periodontal pockets with a greater population of spirochetes and anaerobes, and certain key periodontal pathogens can gain an advantage [4]. However, extensive procedures to retain native teeth in older adults are likely contributors to the changing flora common in dentate persons. Implanted teeth in the older person's mouth may be more easily colonized with *Staphylococcus aureus* and other aerobic organisms (F. Scannapieco, personal communication). In contrast to the dentate microenvironment, the edentulous mouth contains relatively fewer anaerobes and more yeast and lactobacilli [4, 5].

RISKS OF PNEUMONIA AND ASPIRATION

Devastating consequences of poor oral health can include a variety of local and systemic illnesses, including local abscess formation, rapid spread of infection through fascial planes, and infective endocarditis [3, 6–10]. Older adults are disproportionately affected by these illnesses, and several excellent recent reviews have been authored on these topics (see [3], among others). Probably the most common infectious sequelae of poor oral health in seniors—particularly those who reside in nursing homes—is aspiration pneumonia. Studies from the University of Michigan (Ann Arbor), Yale University (New Haven, CT), and Japan have investigated the oral and dental causes of aspiration pneumonia. These studies have linked the outcome of aspiration pneumonia with dental decay, periodontal disease, poor hygiene, the need for help feeding, and trouble swallowing [11–14]. These studies varied with regard to methodology, measurements, and definitions and must be placed in the context of current understanding of oral microflora.

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In the 1970s and 1980s, many studies of aspiration pneumonia focused on its probable origin as an anaerobic infection of the lung [15–17]. These studies attempted to differentiate the large mix of organisms aspirated from the mouth from the organisms actually involved in lower respiratory tract infections using such techniques as transtracheal aspiration. The technique of transtracheal aspiration is now rarely used and has been widely replaced by bronchoscopy with lavage or protected brush specimens. Aspiration pneumonia is a dynamic disease, and the exact mix of anaerobes and aerobes involved probably changes over time and on the basis of functional status. The medical risk factors include swallowing and feeding problems (which have been incompletely quantified) [18]; decreased efficacy of lung defense mechanisms, including poor clearance and weak cough [19, 20]; diabetes [21]; impaired immune status [22]; poor feeding techniques [23]; positioning [24]; neurologic issues [19, 20, 24]; and the patient's functional status [12, 14]. The dental risk factors documented have included dental decay, periodontal disease, high levels of *S. aureus* in the saliva, salivary flow, infrequent visits to the dental hygienist, and generally poor oral hygiene [11, 12, 14]. In this complex situation, only a few studies have included both medical and dental risk factors [11, 12, 14].

In a study of 358 older veterans, the most prominent risk factors for aspiration pneumonia were requirement of help feeding, oral *S. aureus* colonization (as evidenced by positive saliva culture results), periodontal disease, and caries (table 1) [11]. A second study of 613 elderly nursing home residents in Connecticut examined modifiable risk factors for nursing home–acquired pneumonia, although the study did not specifically focus on aspiration pneumonia [12]. Nine modifiable risk factors were examined, including inadequate oral care, difficulty swallowing, lack of influenza vaccination, depression, feeding position of <90° from horizontal, active smoking, receipt of sedative medication, receipt of gastric acid–reducing medication, and use of angiotensin-converting enzyme inhibitors. Only 2 risk factors were demonstrated to have significant associations with pneumonia risk, and both (inadequate oral care [hazard ratio, 1.55; $P = .03$] and difficulty swallowing [hazard ratio, 1.61; $P = .043$]) remained significant after multivariate analysis.

A major limitation in aspiration pneumonia studies to date is that the methods used to quantify swallowing problems have been poor [11, 14]. These limitations have been measured in speech pathology with fiber optic endoscopic evaluation of swallowing (FEES) examinations, but most patients with aspiration pneumonia are not studied, other than noting nonspecific signs or symptoms on the medical chart, such as "trouble swallowing" or "coughs while being fed" [11, 12]. As the methods of assessing the variables swallowing, feeding, and cough advance, the quality of studies of pneumonia is likely to improve as well [25–27].

Table 1. Logistic regression of risk factors for aspiration pneumonia in subjects undergoing dental care at a Veterans Affairs nursing home.

Variable	Coefficient estimate	OR (95% CI)	*P*
Intercept	−6.62	NA	<.001
Requirement of help eating	2.63	13.9 (3.2–60.0)	<.001
COPD	1.55	4.7 (1.6–14.3)	.006
Diabetes mellitus	1.24	3.5 (1.2–9.8)	.02
Staphylococcus aureus colonization	2.0	7.4 (1.8–30.0)	.006
Porphyromonas gingivalis colonization	1.44	4.2 (1.6–11.3)	.004
No. of decayed teeth	0.19	1.2 (1.1–1.4)[a]	.007
Streptococcus sobrinus colonization	1.83	6.2 (1.4–27.5)	.016

NOTE. Data are adapted from [11]. COPD, chronic obstructive pulmonary disease; NA, not available.

[a] OR is to be multiplied by the number of carious teeth.

PREVENTION OF PNEUMONIA IN ELDERLY PERSONS: IMPORTANCE OF ORAL HYGIENE

Although interventional studies to reduce the risk of aspiration pneumonia in older adults have been numerous, most are fraught with marked limitations and susceptibility to bias. A recent extensive review of randomized, controlled trials identified 17 such trials, only 8 of which met selection criteria of inclusion and analysis of subjects aged ⩾65 years, aspiration pneumonia as a primary end point, and radiological confirmation of pneumonia [24]. In that review, the only randomized, controlled trial of oral care [28] was found to be lacking several important factors in study design, including a lack of blinding that may have introduced ascertainment bias. However, the authors suggested the large number of participants in the study ($n = 417$) and the significant reduction in the rate of aspiration pneumonia associated with aggressive, labor-intensive oral care (i.e., nurses or caregivers cleaned the teeth of residents after every meal with an applicator of povidone iodine, and dentists or dental hygienists provided plaque and calculus control as necessary on a weekly basis) indicated the need for confirming studies [24]. Specifically, the rate of pneumonia was reduced from 19% in the control group to 11% in the active treatment group over a 2-year follow-up period [28].

The study by Yoneyama et al. [28] was reported in more detail in a subsequent publication [13] that was not available to the reviewers of the previously mentioned meta-analysis [24]. In the later report [13], the investigators demonstrated that oral care had a benefit for reducing fever in both dentate and edentate subjects, as well as for reducing the rate of pneumonia

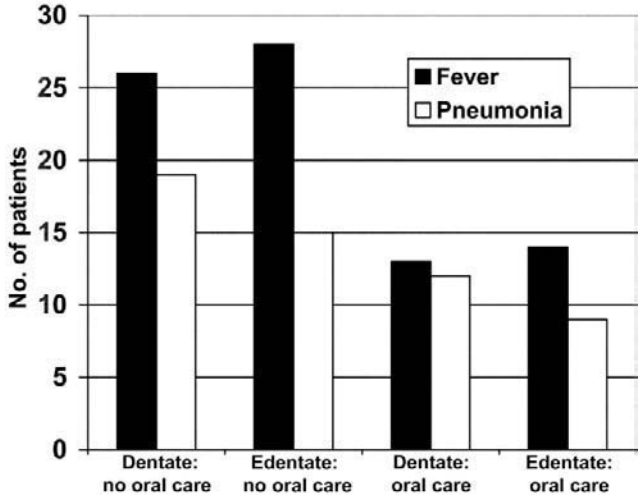

Figure 1. Cases of fever and pneumonia among dentate patients and edentate patients who did or did not receive oral care. Adapted from [13].

in dentate patients (9% vs. 21%; $P < .01$); the difference in the pneumonia rates for edentate patients, although of similar magnitude (9% vs. 20%), was not found to be statistically significant because of the lower number of subjects in the edentate group (figure 1). It was also noted in that report that the radiologists who examined the chest radiographs to confirm the diagnosis of pneumonia were blinded to the treatment protocol.

Although there is a relative paucity of high-level evidence in support of oral hygiene for the prevention of aspiration pneumonia, there is lower-level evidence to support the use of oral care for reducing aspiration pneumonia among elderly persons. The intervention in oral or dental hygiene that would be least costly and most effective has yet to be proven to reduce the rate of pneumonia: mouthwashes that reduce oral flora colonization with potential pathogens [29, 30]. Some dentists believe that toothbrushing, tongue-brushing, and even full dental hygiene care would be preferable (based on limited data [13]).

There are major barriers to oral care for older patients in nursing homes that have been reviewed in the United States and Australia [31, 32]. The barriers include the lack of specific designated personnel to perform oral care, resident noncompliance with care, and choice of oral care itself. However, overcoming these issues may prove to be a cost-effective use of resources. Aspiration pneumonia is a very costly illness for older patients in nursing homes [33]. It seems likely that cost savings, as well as improved quality of life, would be the result of an intervention to prevent cases of pneumonia in the nursing home [33]. Additional literature is available concerning the costs of aspiration pneumonia and of nosocomial pneumonia [34–37]. This literature points to the importance of understanding the true risks for aspiration pneumonia and nosocomial pneumonia.

CONCLUSIONS

It is my opinion that, in the past, aspiration pneumonia may have been almost universally caused by anaerobic and facultative aerobic bacteria, but the aerobic bacteria–colonized mouth of the present-day older nursing home patient could easily be a source of such nosocomial infections as staphylococcal pneumonia or pneumonia due to gram-negative bacteria [38–44]. Pneumonia and its connection with multiple risk factors, including oral risk factors, is a complex subject that will require significant additional study, especially in older people. Current data suggest that poor oral health is a major risk factor for aspiration pneumonia in older adults. Available evidence—although not clearly demonstrated by high-quality, randomized, controlled trials—indicates that oral hygiene measures may reduce pneumonia risk in seniors, and further studies are indicated. The cost-effectiveness of these interventions will depend on how labor-intensive the required interventions prove to be. An awareness of many factors that influence infection risk in seniors is imperative for the proper design of such studies.

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