Risk Factors for Pneumonia and Other Lower Respiratory Tract Infections in Elderly Residents of Long-term Care Facilities

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**Background:** Little is known about the risk factors, outcome, and impact of pneumonia and other lower respiratory tract infections (LRTIs) in residents of long-term care facilities.

**Objective:** To determine the risk factors and the effect of these infections on functional status and clinical course.

**Methods:** Active surveillance for these infections was conducted for 475 residents in 5 nursing homes from July 1, 1993, through June 30, 1996. Information regarding potential risk factors for these infections, functional status, transfers to hospital, and death was also obtained.

**Results:** Two hundred seventy-two episodes of pneumonia and other LRTIs occurred in 170 residents during 228 757 days of surveillance for an incidence of 1.2 episodes per 1000 resident-days. Multivariable analysis revealed that older age (odds ratio [OR], 1.7; 95% confidence interval [CI], 1.1-2.6 per 10-year interval; \( P = .01 \)), male sex (OR, 1.9; 95% CI, 1.1-3.5; \( P = .03 \)), and the inability to take oral medications (OR, 8.3; 95% CI, 1.4-50.3; \( P = .02 \)) were significant risk factors for pneumonia; receipt of influenza vaccine (OR, 0.4; 95% CI, 0.2-0.6; \( P = .01 \)) was protective. Age (OR, 1.6 [95% CI, 1.0-2.5] per 10-year interval; \( P = .05 \)) and immobility (OR, 2.6; 95% CI, 1.8-3.8; \( P = .01 \)) were significant risk factors for other LRTIs, and influenza vaccination was protective (OR, 0.3; 95% CI, 0.2-0.4; \( P = .01 \)). Residents with pneumonia (OR, 0.7; 95% CI, 0.3-1.4; \( P = .31 \)) or with other LRTIs (OR, 0.5; 95% CI, 0.2-1.1; \( P = .43 \)) were no more likely to have a deterioration in functional status than individuals in whom infection did not develop.

**Conclusions:** Swallowing difficulty and lack of influenza vaccination are important, modifiable risks for pneumonia and other LRTIs in elderly residents of long-term care facilities. Our findings challenge the commonly held belief that pneumonia leads to long-term decline in functional status in this population.

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study were evaluated and found to be similar (Table 1), although study participants were more likely to have received influenza vaccine in the previous year (P = .008). The mean age of study residents was 85 years (range, 59-105 years); 192 (75.6%) were women.

A total of 272 episodes of pneumonia and other LRTIs occurred in 170 residents during 228,757 resident-days of surveillance. Chest radiographs were obtained in 249 (91.5%) of the episodes of infection. There were 155 episodes of pneumonia in 113 residents and 117 episodes of other LRTIs in 89 residents. Thirty-two residents had episodes of both. The overall incidence of these respiratory tract infections was 1.2 episodes per 1000 resident-days. The overall annual influenza vaccination rate in the 5 facilities during the study was 83% (range, 60%-96%). The mean pneumococcal vaccination rate was 21% (range, 0%-66%).

PNEUMONIA

Of the 113 residents who had pneumonia, 80 (70.7%) had 1 episode, 26 (23.0%) had 2 episodes, 5 (4.4%) had 3 episodes, and 2 (1.8%) had 4 episodes. There were 0.7 episodes of pneumonia per 1000 resident-days. The cumulative incidence of first episodes of pneumonia was 18% (95% confidence interval [CI], 14%-22%) at 1 year, 28% (95% CI, 22%-32%) at 2 years, and 34% (95% CI, 28%-40%) at 3 years (Figure, top). When first episodes of pneumonia were examined using univariate analysis, individuals with pneumonia were more likely to be older (odds ratio [OR], 1.7 [95% CI, 1.2-2.5]; P = .01), male (OR, 1.98 [95% CI, 1.2-3.2]; P = .01), and to have swallowing difficulty (OR, 1.6 [95% CI, 1.1-2.4]; P = .03). They were less likely to have received influenza vaccine in the year before pneumonia developed (OR, 0.4 [95% CI, 0.3-0.6]; P = .01) (Table 2). In univariate analysis, the only variable associated with recurrent episodes of pneumonia was immobility (OR, 2.1 [95% CI, 1.0-3.3]; P = .01), although this factor did not appear to be associated with the development of the first episode of infection.

The following potential risk factors were retained for the multivariable analysis: influenza vaccination, sex, history of respiratory tract infections, colonization with gram-negative bacteria, pneumococcal vaccination, swallowing difficulty, ability to take oral medications, and age.
MICROBIOLOGICAL INVESTIGATIONS

Nasopharyngeal swabs were obtained within 72 hours of the onset of symptoms for direct detection of respiratory tract viral antigens using direct immunofluorescence and for isolation of respiratory tract viruses (influenza, parainfluenza, respiratory syncytial virus, and adenovirus). Polymerase chain reaction for Chlamydia pneumoniae was also performed from nasopharyngeal swabs during the last year of the study. Acute and convalescent serum samples were obtained 2 to 4 weeks apart for serologic testing using complement fixation for respiratory tract viruses and Mycoplasma pneumoniae and using indirect immunofluorescence for Legionella species. Serologic testing for detection of C pneumoniae antibodies was performed using microimmunofluorescence.

Blood and sputum cultures were obtained whenever possible from residents with respiratory tract infection. Sputum specimens were cultured only if more than 25 polymorphonuclear leukocytes and fewer than 10 squamous epithelial cells were present per low-power field on results of Gram stain. The significance of blood or sputum culture isolates was determined using previously published guidelines.

M. pneumoniae was the most frequent isolate cultured from nosopharyngeal swabs (51.0%), and the inability to take oral medications (OR, 8.3; 95% CI, 1.4-50.3; P = .02) remained significant in the multivariable model, increasing the risk for pneumonia. Having received influenza vaccination (OR, 0.4; 95% CI, 0.3-0.5; P = .01) was protective against the development of pneumonia (Table 3).

OTHER LRTIs

Of the 89 residents who had other LRTIs, 66 (74.1%) had a single episode, 18 (20.2%) had 2 episodes, and 5 (5.6%) had 3 episodes. There were 0.5 episodes of LRTI per 1000 resident-days. The cumulative incidence of first episodes of other LRTI was 14% (95% CI, 10%-17%) at 1 year, 20% (95% CI, 16%-25%) at 2 years, and 24% (95% CI, 18%-29%) at 3 years (Figure, bottom). Univariate analysis revealed that residents in whom these infections developed were more likely to be older (OR, 1.9; 95% CI, 1.3-2.8; P = .01) and to be immobile (OR, 1.6; 95% CI, 1.2-2.1; P = .01). They were less likely to have been male (OR, 0.5; 95% CI, 0.2-1.0; P = .04) or to have received influenza (OR, 0.3; 95% CI, 0.2-0.5; P = .01) or pneumococcal (OR, 0.8; 95% CI, 0.6-0.9; P = .01) (Table 2). Residents with recurrent lower respiratory tract infections were more likely to be immobile (OR, 1.8; 95% CI, 1.0-3.2; P = .04).

The following potential risk factors were retained for multivariable analysis: influenza vaccination, immobility, age, history of respiratory tract infections, pneumococcal vaccination, sex, and swallowing difficulty. Age (OR, 1.6 [95% CI, 1.0-2.5] per 10-year interval; P = .05) and immobility (OR, 2.6 [95% CI, 1.8-3.8]; P = .01) remained in the model as significant risk factors, whereas influenza vaccination was a significant protective factor (OR, 0.3 [95% CI, 0.2-0.4]; P = .01) (Table 3).

MICROBIOLOGICAL FINDINGS

Of the 272 episodes of pneumonia and other lower respiratory tract infections, blood cultures were obtained in 100 (36.8%), sputum cultures in 24 (8.8%), nasopharyngeal swabs in 166 (61.0%), and paired acute and con-
valescent serum samples in 151 (55.5%). Table 4 summarizes the results of the microbiologic investigations. There was no difference in the distribution of microbial agents identified in residents with pneumonia or other LRTIs. The most common etiologic agents identified were respiratory tract viruses, occurring in 60 (36.1%) of 166 episodes tested. *Chlamydia pneumoniae* was not detected using polymerase chain reaction in any of the 45 residents undergoing evaluation, although 3 other residents had serologic evidence of a recent *C pneumoniae* infection. Two residents with *Escherichia coli* bacteremia had pneumonia without a urinary or other identified source of infection.

**CLINICAL COURSE AND OUTCOME**

Antimicrobial therapy was prescribed for every episode of pneumonia or other LRTI. Residents were transferred to hospital within 2 weeks of onset of symptoms in 48 (31.0%) of the 155 episodes of pneumonia. In contrast, only 11 episodes (9.4%) of other LRTIs resulted in transfer to hospital (*P* = .01). Individuals who were older were less likely to be transferred to hospital (OR, 0.9 per year [95% CI, 0.9-1.0]; *P* = .01). None of the other variables assessed, including sex, history of respiratory tract infections, swallowing difficulty, ability to take oral medications, immobility, history of smoking, receipt of influenza and pneumococcal vaccines, use of minor or major tranquilizers, chronic lung disease, congestive heart failure, stroke, cancer, oropharyngeal colonization with gram-negative bacilli, or treatment with broad-spectrum antibiotics (eg, ciprofloxacin hydrochloride, a combination of trimethoprim sulfate and sulfamethoxazole, extended-spectrum cephalosporins, and a combination of amoxicillin and clavulanate potassium), was associated with hospital transfer.

Case fatality rates for residents with pneumonia and other LRTIs did not differ; 10 residents (8.8%) in whom pneumonia developed and 7 (7.9%) with other LRTIs died within 2 weeks of the infection (*P* = .98). The case fatality rate for residents transferred to hospital was 21% compared with 7% for those treated in the nursing homes (*P* = .02). Of the 17 residents who died, death was attributed to the infection itself in 13 (76.5%).

Sixty residents in whom first episodes of pneumonia developed and 39 residents with first episodes of other LRTIs could be matched to individuals in whom infection did not develop. Other LRTIs could be matched to individuals in whom infection did not develop. Residents with pneumonia (OR, 0.7 [95% CI, 0.3-1.4]; *P* = .31) and those with other LRTIs (OR, 0.5 [95% CI, 0.2-1.1]; *P* = .43) were no more likely to have a deterioration in functional status than individuals in whom infection did not develop. The rate of decline in functional status was significantly greater before the infection than after for residents with pneumo-
We assessed risk factors for pneumonia and other LRTIs in a large cohort of nursing home residents observed up to 3 years. We also studied the effect of these infections on functional status and rates of transfer to hospital. The observed respiratory tract infection rate of 1.2 per 1000 resident-days was within the range of previous reports (0.6-2.6 per 1000 resident-days). Hospitalization and mortality rates in this study were also similar to those previously reported.

Swallowing difficulty and an inability to take oral medications were independent risk factors for the development of pneumonia. These likely represented surrogate markers for aspiration in our study. Depression of swallowing reflexes in patients with aspiration pneumonia has been previously demonstrated, and in a study assessing pulmonary aspiration in a long-term care setting, 56% of aspiration events progressed to pneumonia. In our study, the development of pneumonia but not of other LRTIs was associated with surrogate markers of aspiration, possibly because aspiration is likely to be the dominant mechanism for pneumonia in the elderly, whereas other respiratory tract infections are more likely to be caused by viruses and to be unrelated to aspiration. Our findings are in keeping with the results of a study of community-acquired pneumonia in the elderly, where aspiration was determined to be an independent risk factor for pneumonia. Difficulty with swallowing oropharyngeal secretions was also associated with pneumonia in a small case-control study in a long-term care facility. Therefore, strategies directed at preventing aspiration may be useful in preventing pneumonia in elderly nursing home residents. Some measures that deserve further study include altering the consistency of the diet, the positioning of residents (especially during feeding), and the frequency and timing of meals.
Although oropharyngeal colonization with gram-negative bacteria has been associated with increased debility and mortality in the elderly, it is uncertain whether such colonization leads to the development of pneumonia. We did not find gram-negative oropharyngeal colonization to be a risk factor for pneumonia or other LRTIs.

Receipt of influenza vaccine was found to be a significant protective factor, associated with lower rates of respiratory tract infection, although influenza immunization rates in the study facilities were suboptimal (less than 80%). Volunteer bias, with study participants being more likely to have been vaccinated but less predisposed to infection, may have led to an overestimation of vaccine efficacy. Enrolled residents were, in fact, more likely to have received the vaccine than nonparticipants, although no differences in chronic underlying illnesses or other potential risk factors were identified. Moreover, the effectiveness of influenza vaccination in our study was similar to that determined in a recent meta-analysis with pooled estimates of vaccine efficacy of 53% to 56%. These results confirm the importance of annual influenza vaccination for residents of long-term care facilities.

Pneumococcal vaccination was found to be protective in univariate analysis for other LRTIs (OR, 0.8 [95% CI, 0.6-0.9]; P = .01) and to be of borderline significance for pneumonia (OR, 0.9 [95% CI, 0.7-1.0]; P = .06). However, pneumococcal vaccination did not remain significant in the logistic regression models. Despite the uncertain efficacy of pneumococcal vaccination in preventing pneumonia, vaccination has been shown to be a cost-effective intervention for the prevention of invasive pneumococcal disease in the elderly. The low average pneumococcal vaccination rate and the wide variability in the proportion of residents vaccinated among the nursing homes in our study (0%-66%) is a concern. These results suggest that considerable improvement in use of pneumococcal vaccine needs to be made for residents of long-term care facilities.

Our findings did not indicate that pneumonia or other LRTIs lead to sustained functional decline in nursing home residents. Functional decline occurred in infected and noninfected residents. However, neither pneumonia nor other LRTIs had a significant effect on functional status when infected individuals were compared with control subjects. Furthermore, the rate of decline of functional status was greater before than after pneumonia or other LRTIs, although the difference was not statistically significant in the latter. Although an alternative explanation for this may be that there was a floor effect in functional assessment in time, such that a more rapid decline would be expected early and smaller declines later, the fact that there were no differences when infected residents were compared with noninfected residents provides strong evidence that there is not a sustained significant effect of pneumonia or LRTI on functional status in this population.

There have been relatively few studies of nursing home–acquired pneumonia that have included extensive investigations to determine the microbial cause in sporadic infections (not associated with an outbreak). It is difficult to obtain sputum or other respiratory tract specimens for culture from nursing home residents, and tests to detect viral or other atypical respiratory tract pathogens are infrequently performed. Therefore, it is often impossible to identify the specific etiologic agent. A specific microbial cause could be identified in only a few patients in this study; however, our results indicate that viral respiratory tract infections are common and frequently lead to the development of pneumonia in elderly nursing home residents. Although nursing home outbreaks of infection due to Legionella pneumophila and C pneumoniae have been described, our findings also confirm that infections due to Legionella species, C pneumoniae, or M pneumoniae occur infrequently in the institutionalized elderly.

Strengths of our study include the prospective design, the large study population size, the long observation, and the intensive infection surveillance using standardized definitions of infection. Thus, we believe all episodes of pneumonia and LRTIs among residents in the
nursing homes were identified during the 3 years of study. Residents of the long-term care facilities in our study were demographically similar to those in most nursing homes in Ontario, and we believe the results of this multicenter study are applicable to most other free-standing, community-based nursing homes in North America. Our findings, however, may not apply to Veterans Affairs facilities or other types of long-term care facilities such as chronic care hospitals or rehabilitation centers.

Our study identifies several important modifiable risk factors for the development of pneumonia and other LRTIs in elderly nursing home residents. We found that although these infections may be associated with impaired cognitive and/or functional status at onset of symptoms, they do not lead to long-term decline in functional status. Lack of influenza vaccination constituted an important risk for pneumonia and other LRTIs, confirming the importance of yearly immunization. Swallowing difficulty was also found to be a significant risk factor for pneumonia. Interventions aimed at reducing the risk for aspiration should be evaluated as a method for preventing pneumonia in residents of long-term care facilities.

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REFERENCES


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