

Oropharyngeal dysphagia is a risk factor for community-acquired pneumonia in the elderly

Jordi Almirall^{1,2,3*}, Laia Rofes^{4*}, Mateu Serra-Prat^{4,5}, Roser Icart¹, Elisabet Palomera⁵, Viridiana Arreola⁶, Pere Clavé^{3,4,6}

¹Intensive Care Unit, Hospital de Mataró, Consorci Sanitari del Maresme, Spain.

²Centro de Investigación Biomédica en Red de enfermedades respiratorias (CIBERES), Instituto de Salud Carlos III, Spain.

³Department of Medicine and Surgery, Universitat Autònoma de Barcelona, Spain.

⁴Centro de Investigación Biomédica en Red de enfermedades hepáticas y digestivas (CIBEREHD), Instituto de Salud Carlos III, Spain.

⁵Research Unit, Hospital de Mataró, Consorci Sanitari del Maresme, Spain.

⁶Gastrointestinal Motility Unit, Hospital de Mataró, Consorci Sanitari del Maresme, Spain.

Corresponding author: Jordi Almirall, MD, PhD.

Intensive Care Unit, Hospital de Mataró.

Carretera de Cirera s/n, 08304 Mataró (Barcelona), Spain.

e-mail: jalmirall@csgm.cat

*These authors contributed equally to this manuscript and can be considered as co-1st authors.

ABSTRACT

Objectives: To explore whether oropharyngeal dysphagia is a risk factor for community-acquired pneumonia in the elderly and to assess the physiology of deglutition of patients with pneumonia.

Methods: *Case-control study:* 36 elderly patients (>70 years) hospitalized with pneumonia were matched by age and sex with two independently-living controls. All subjects were given the volume-viscosity swallow test to identify signs of oropharyngeal dysphagia. *Pathophysiological study:* All cases and 10 healthy elderly were examined with videofluoroscopy.

Results: *Case-control study:* Prevalence of oropharyngeal dysphagia was 91.7% in cases and 40.3% in controls ($p<0.001$). Adjusting for functionality and co-morbidities, dysphagia showed an independent effect on pneumonia (OR=11.9, 95%CI:3.03-46.9). *Pathophysiological study:* Among cases, 16.7% showed safe swallow, 30.6% high penetrations, 36.1% severe penetrations and 16.7% silent aspirations during videofluoroscopy, while in the healthy elderly these percentages were 80.0%, 20.0%, 0% and 0%, respectively ($p<0.001$). A delay in the laryngeal vestibule closure ($0.414\pm0.029s$ vs $0.200\pm0.059s$, $p<0.01$) was the main mechanism of impaired airway protection.

Conclusions: In elderly subjects, oropharyngeal dysphagia is strongly associated with community-acquired pneumonia independently of functionality and co-morbidities. Elderly patients with pneumonia presented a severe impairment of swallow and airway protection mechanisms. We recommend universal screening of dysphagia in older persons with pneumonia.

Keywords: ageing; aspiration pneumonia; pneumonia; swallowing.

INTRODUCTION

Community-acquired pneumonia (CAP) is a common disease and a frequent cause of hospitalization and death among the elderly[1]. According to population-based studies, the annual incidence rate of CAP in adults varies between 2.6 and 13.4 per 1,000 inhabitants, somewhat higher in elderly people[2;3]. Studies found old age as a relevant risk factor for the acquisition of pneumonia[4]. Other associated factors that predispose to CAP in the elderly include: lifestyle and patient characteristics such as smoking, alcohol use, poor functional and nutritional status, weight loss and use of immunosuppressants; co-morbidities such as heart diseases, renal diseases and chronic obstructive pulmonary disease; and environmental exposure such as secondhand smoke, gases, fumes and chemicals[5-7].

We recently found oropharyngeal dysphagia was also a highly prevalent clinical finding in up to 23% of independently living older (>70 y) persons, 0.74% of them presenting signs of aspiration during swallow[8]. In these patients with oropharyngeal dysphagia, a decrease in the efficacy of deglutition was associated with development of malnutrition and a decrease in the safety was associated with high prevalence of respiratory infections during follow up[9]. Oropharyngeal dysphagia has been identified as a serious risk factor for developing aspiration pneumonia in frail older people[10]. The pathogenesis of aspiration pneumonia in immunocompetent adults has been attributed to pharyngeal colonization of respiratory pathogens and subsequent inhalation of infectious particles[11]. Oropharyngeal dysphagia has also been proposed as an independent risk factor associated with CAP in the elderly[6;12;13] but this has not yet been proved. Moreover, the pathogenic mechanism that leads to oropharyngeal dysphagia in the frail elderly and in neurological patients has been identified in recent years[14;15]. In

contrast, the pathophysiology of impaired swallow response of elderly people with pneumonia has not yet been studied.

The present study has two main objectives: i) to provide further evidence of the association between oropharyngeal dysphagia and CAP in the elderly and ii) to assess the pathophysiology of oropharyngeal dysphagia in elderly subjects with CAP.

METHODS

Case-control study

An observational case-control study was designed. The study protocol was approved by the Ethics Committee of Consorci Sanitari del Maresme (Mataró, Spain). Cases were defined as subjects ≥ 70 years with confirmed CAP that required hospitalization in the Hospital of Mataró from February 2008 to February 2010 and were consecutively included in the study as long as videofluoroscopic examination was available. We have described the criteria for the diagnosis of CAP previously[2]. Patients from nursing homes or those that had been discharged from hospital 7 or fewer days before the onset of symptoms were excluded. For each case, two matched (by sex and age) controls without CAP were randomly selected from the list of independently-living older subjects assigned to the Cirera-Molins Primary Care Centre in Mataró (Spain). All cases and controls were explored by the volume-viscosity swallow test (see the on-line supplementary material) to assess the clinical signs for oropharyngeal dysphagia and impaired efficacy and safety of swallow. Co-morbidities and pre-admission functional capacity were also registered for all participants.

Pathophysiological study

a) Clinical characteristics of pneumonia and concomitant medications were collected in all cases. Vaccination history, number of previous pneumonias, fever, days of clinical symptoms, lobes affected, severity of CAP[16], Intensive Care Unit admissions and hospital death were recorded. To determine the etiology of pneumonia, blood cultures (n=30) and urine antigen tests for *S. pneumoniae* (n=30) and *L. pneumophila* (n=33) were performed. Whenever possible, respiratory samples were also obtained: sputum (n=9), tracheal aspirate (n=1) and pleural fluid (n=2). A sublingual smear (n=29) was also obtained to assess the oral flora. b) 10 healthy elderly persons (≥ 70 years) and all patients with CAP were studied by videofluoroscopy during the admission. Details on the videofluoroscopic procedures are provided in the online supplementary material. Digitization and analysis of videofluoroscopic images were made using the software Swallowing Observer (Image and Physiology SL, Barcelona, Spain). Laryngeal vestibule penetrations and tracheobronchial aspirations were classified according to a validated scale[17] (Figure E1) and oropharyngeal residue was also identified. Timing of the oropharyngeal swallow response, hyoid bone movement and bolus velocity (m s^{-1}) were also measured[14]. c) CAP patients were followed through the electronic clinical records of the hospital of Mataró for one year or contacted by telephone one year after discharge in order to register death or readmissions caused by lower respiratory tract infections. If telephone contact could not be made, patients' family doctors were contacted.

Statistical analysis

Categorical variables were described as percentages and compared by the Chi-square test or the Fisher exact test when appropriate. Quantitative variables were

described as mean \pm SEM and compared by the Mann–Whitney U-test. As a measure of association between oropharyngeal dysphagia, impaired efficacy and safety of swallow and pneumonia, estimations of the relative risk through odds ratios (OR) and 95% confidence intervals (CI) were calculated. The effect of oropharyngeal dysphagia and impaired safety and efficacy of swallow on the risk of the development of CAP was adjusted by co-morbidities and pre-admission functional capacity in a multivariate model using logistic regression. Survival curves according to safety of swallow were compared using a Log rank test. Statistical significance was accepted if P values were less than 0.05. Statistical analysis was performed using SPSS 15.0 (SPSS Inc., Chicago, USA).

RESULTS

Case-control study

45 cases with CAP were screened during the study period and 9 cases were excluded because patients were discharged before the videofluoroscopic examination was available. 36 cases with CAP (81.22 \pm 0.77 years, 24 men) were finally included in the study and matched with 72 controls (81.21 \pm 0.53 years, 48 men). The univariate analysis showed that the prevalence of oropharyngeal dysphagia and clinical signs of impaired efficacy and safety of swallow were higher in cases than in controls (Table 1). Cases also presented lower functional capacity than controls according to the Barthel Index (67.1 vs 97.4, $p<0.001$) and higher prevalence of chronic bronchitis/chronic obstructive pulmonary disease (COPD) and chronic heart failure. A multivariate logistic regression analysis showed an independent effect of oropharyngeal dysphagia related to the development of CAP

when adjusting for suboptimal Barthel Index scores (<100), chronic bronchitis/COPD and chronic heart failure (Table 2).

Pathophysiological study

a) General characteristics and etiology of pneumonia. General features of patients with pneumonia are described in Table 3. Most of them were treated with corticosteroids (55.6%) and beta(2)-agonists (55.6%); 15 (41.7%) received proton-pump inhibitors; 13, diuretics (36.1%) and 12, ACE inhibitors (33.3%). Patients that received SNC-acting drugs were: 10, (27.8%) benzodiazepines; 6, (16.7%) antidepressants; 3, (8.3%) neuroleptics and 3, (8.3%) antiparkinsonians. The etiologic diagnosis of pneumonia was achieved in 20 patients (55.6%). *Streptococcus pneumoniae* was found in 17 (47.2%), of whom 9 (52.9%) presented impaired safety of swallow and 8 (47.1%) presented safe swallow. *Pseudomonas aeruginosa* (2.8%), *Klebsiella pneumoniae* (2.8%) and a co-infection of *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (2.8%) were also found as etiologic agents in patients with impaired safety of swallow. On the other hand, normal oral flora was found in 69.0% of oral smears. *Candida albicans* (8.3%), *Pseudomonas aeruginosa* (8.3%), *Klebsiella pneumoniae* (2.8%) and *Streptococcus agalactiae* (2.8%) were the pathogens isolated from patients' oral cavity.

b) *Videofluoroscopic study*. Efficacious swallows without any residue during all series of the videofluoroscopic study were observed in 60% of healthy elderly persons (75.80 ± 0.97 years, 70% men) and in 41.67% of elderly patients with CAP ($p=0.066$) (Figure 1). Safe swallows (score 1 on the penetration-aspiration scale) were observed in 80% of healthy elderly persons, and high penetrations into the laryngeal vestibule (score 2) in 20%. In contrast, 16.7% of elderly patients with CAP showed safe swallow ($p<0.001$), 30.6% presented high penetrations, 36.1% severe

penetrations into the laryngeal vestibule (not ejected from the airways and/or contacting the vocal folds, scores 3-5) and 16.7% silent aspirations (score 8) (Figure 1). General prevalence of oropharyngeal dysphagia among CAP patients according to the videofluoroscopic study was 75.0%. In healthy elderly, total duration of swallow response (time from glossopalatal junction opening to laryngeal vestibule opening) for 5 mL nectar boluses was 0.888 ± 0.042 s, the interval for oropharyngeal reconfiguration from a respiratory to a digestive pathway (time to laryngeal vestibule closure) was 0.240 ± 0.039 , and timing of upper esophageal sphincter opening was 0.276 ± 0.039 s. Elderly patients with CAP showed similar duration of swallow response (1.00 ± 0.042 s, $p=0.241$) and time to upper esophageal sphincter opening (0.333 ± 0.025 s, $p=0.178$) as healthy elderly persons, but a significant delay in laryngeal vestibule closure (0.414 ± 0.029 s, $p=0.002$). When comparing elderly patients with CAP according to the safety of swallow, patients with safe swallow (scores 1-2 on the penetration-aspiration scale) showed a significantly shorter laryngeal vestibule closure time than patients with impaired safety of swallow (scores 3-8) (Figure 2). In contrast, no differences were found in the timing of upper esophageal sphincter opening (0.287 ± 0.024 s and 0.375 ± 0.040 s respectively, $p=0.144$) or the total duration of swallow response (0.948 ± 0.039 s and 1.05 ± 0.071 s respectively, $p=0.437$). Regarding hyoid bone movement, healthy elderly persons achieved maximal vertical extension in 0.314 ± 0.041 s and maximal anterior extension in 0.349 ± 0.058 s. Elderly patients with CAP reached maximal vertical and anterior extension significantly later (0.437 ± 0.039 s and 0.549 ± 0.040 s, $p<0.05$). CAP patients with impaired safety of swallow also achieved maximal vertical extension later than CAP patients with safe swallow (Figure 3). Maximal vertical and anterior hyoid displacement was similar among groups (data not shown). Finally, the maximal

velocity acquired by the bolus at the upper esophageal sphincter was very similar between healthy elderly ($0.481 \pm 0.073 \text{ m s}^{-1}$) and elderly patients with CAP ($0.482 \pm 0.035 \text{ m s}^{-1}$, $p=0.946$) and was not affected by impairment in the safety of swallow.

c) *1-year follow up.* CAP patients with impaired safety of swallow showed decreased survival rates compared to patients with safe swallow 1 year after admission (Figure 4). Up to 50.00% of CAP patients with safe swallow and 71.43% with impaired safety of swallow ($p=0.201$) were readmitted during the follow up with lower respiratory tract infections.

DISCUSSION

The most remarkable finding of our study was that oropharyngeal dysphagia is strongly associated with CAP and should be considered as an independent risk factor for CAP in the elderly. The clinical assessment of oropharyngeal dysphagia showed that prevalence of dysphagia and impaired efficacy and safety of swallow among elderly patients with CAP was very high compared to matched controls. These clinical results were confirmed by the gold standard for swallowing evaluation, videofluoroscopy. The videofluoroscopic study showed that 52.8% of elderly patients with CAP presented severe penetrations or aspirations during swallow. We also observed a high prevalence of oropharyngeal residue in these patients. Oropharyngeal residue is also an important finding, as it can predispose to oral colonization and post-swallow aspirations[18]. Finally, the oropharyngeal swallow response was severely impaired in our elderly patients with CAP. A severe delay in the oropharyngeal reconfiguration from a respiratory phase to a digestive phase,

caused by slow laryngeal vestibule closure and vertical hyoid motion, was the key parameter associated with impaired safety of swallow. Diagnostic etiology of pneumonia was achieved in half the cases. All patients with CAP and safe swallow presented *Streptococcus pneumoniae* as the etiologic agent of pneumonia. Most patients with impaired safety of swallow also presented *Streptococcus pneumoniae* as the etiologic agent, followed by Gram-negative bacilli. Taken together, our data strongly suggests that aspiration among patients with CAP is much more common than was believed and is a relevant pathogenic mechanism for older patients with pneumococcal CAP as well as for those with Gram-negative pneumonia.

Some studies have discussed the importance of aspiration and swallowing impairment in developing CAP[6;12] in elderly patients but, as far as we know, the present study is the first that evaluates the specific role of dysphagia as a predisposing and prognostic factor for CAP in the elderly and that assesses the mechanisms of the impaired swallow response of elderly patients with CAP. Moreover, the assessment of dysphagia was made prospectively, both in cases and controls. The prospective evaluation of dysphagia is a relevant point because dysphagia is often underdiagnosed and several cases may be missed in clinical records. We used an accurate and validated clinical method for the clinical assessment of dysphagia, the volume-viscosity swallow test, and found that not only impaired safety of swallow is associated with CAP, but impaired efficacy of swallow is also a risk factor for CAP in the elderly. In healthy people, the effective clearance of most of pathogens from the oropharynx is due to effective salivary flow and efficient swallowing. Therefore, when the efficacy of swallow is impaired, a reduction in mechanical clearance occurs leading to oropharyngeal residue, and potential pulmonary or oropharyngeal pathogens may colonize the oropharynx and be a

potential source of pulmonary infections[19]. Teramoto *et al*[20] reported that the prevalence of aspiration pneumonia in patients with CAP aged 70 and older was 60.1% using a wide variety of clinical assessment methods. We found a prevalence of oropharyngeal dysphagia among patients with CAP of 91.7% by means of the volume-viscosity swallow test and of 75.00% in the videofluoroscopic study, with 52.8% the patients having severe penetrations or aspirations during swallow. This is the first time, to the authors' knowledge, that a gold standard, videofluoroscopy, has been used to assess the prevalence of aspiration during swallow in elderly patients admitted with CAP. Prevalence of silent aspirations in our study was 16.7%. A previous study, using a radioactive tracer, found that the occurrence of silent aspiration during sleep was 71% in CAP patients whereas only 10% of aged matched controls aspirated[21]. The aspiration of small amounts of oropharyngeal secretions during sleep is a common finding in older adults[22;23] and usually happen without consequences due to preserved cough reflex, ciliary transport and immune system and to the low virulence of normal pharyngeal flora. However silent aspiration of large amounts during swallowing is an abnormal and serious finding that, together with several factors common in the elderly such as progressive decrease in pulmonary function, decline in host defenses, impaired cough reflex and increased oropharyngeal colonization with respiratory pathogens[19], can lead to aspiration pneumonia. A key point of our study is that we elucidated the pathogenic mechanism of the aspiration process and impaired airway protection of patients with CAP through videofluoroscopy. Delayed airway protection caused by delayed laryngeal vestibule closure and vertical hyoid movement caused the aspirations and penetrations in elderly CAP patients. This impairment in swallow response is similar to that found in

frail elderly patients[14] and patients with neurological diseases[15] and must be treated.

Our results show that impaired safety of swallow is a prognostic factor of mortality in elderly patients with CAP. These results agree with that found by Riquelme *et al*[12] and with one of our previous studies in patients with pneumonia admitted to an acute geriatric unit[24]. Again, use of the videofluoroscopy to determine patients with a predisposition to aspiration improves the diagnosis of aspiration pneumonia and confirms the results found by these previous studies using clinical records or clinical methods of screening.

A limitation of our study is that swallowing ability was not re-evaluated after discharge to assess whether these patients had improved after the acute condition and also those who had deteriorated over time. Therefore our design cannot exclude CAP as the cause of the swallowing problem. Another limitation was the small sample size. It was large enough to determine dysphagia as a risk factor for CAP, to characterize the swallow response of CAP patients and to evaluate the impairment of swallow response as a prognostic factor. However, the small size limits the microbiological and clinical comparisons between CAP patients with and without oropharyngeal dysphagia. Further studies are needed in this area including the assessment of the oral health status and the use of molecular strategies to improve the assessment of the oral microbiota in these patients. On the other hand, although cases and controls were matched by age and sex, they could not be strictly comparable in terms of co-morbidities, functional capacity or frailty. However, the multivariate analysis adjusted for the mentioned factors showed an independent effect of oropharyngeal dysphagia.

In summary, we have confirmed that oropharyngeal dysphagia is a major risk and prognostic factor for CAP in the elderly. We have established its high prevalence by means of a gold standard and determined that the pathogenic mechanism of impairment of swallow response in this cohort of patients with CAP was delayed airway protection. Therefore, we propose universal screening for oropharyngeal dysphagia in elderly patients admitted with CAP and the adoption of strategies to assess and treat oropharyngeal dysphagia when aspiration is suspected.

ACKNOWLEDGMENTS

We would like to thank Dra Goretti Sauca for the microbiologic assessments, Ms Thaïs Zaro and Ms Ivana Anglada for their help in the samples collection, Mr Alberto Martin for his help in the videofluoroscopic studies and Ms Jane Lewis for writing assistance. This work was supported by grants from the Spanish Ministerio de Ciencia e Innovación (PI080448, PS09/01012, INT 10/228), and the Agencia de Gestió d'Ajuts Universitaris i de Recerca (2009 SGR 708).

REFERENCES

1. Jackson ML, Neuzil KM, Thompson WW, Shay DK, Yu O, Hanson CA, Jackson LA. The burden of community-acquired pneumonia in seniors: results of a population-based study. *Clin Infect Dis* 2004; 39:1642-1650.
2. Almirall J, Bolibar I, Vidal J, Sauca G, Coll P, Niklasson B, Bartolome M, Balanzo X. Epidemiology of community-acquired pneumonia in adults: a population-based study. *Eur Respir J* 2000; 15:757-763.
3. Jokinen C, Heiskanen L, Juvonen H, Kallinen S, Karkola K, Korppi M, Kurki S, Ronnberg PR, Seppa A, Soimakallio S, . Incidence of community-acquired pneumonia in the population of four municipalities in eastern Finland. *Am J Epidemiol* 1993; 137:977-988.
4. Loeb M, McGeer A, McArthur M, Walter S, Simor AE. Risk factors for pneumonia and other lower respiratory tract infections in elderly residents of long-term care facilities. *Arch Intern Med* 1999; 159:2058-2064.
5. Jackson ML, Nelson JC, Jackson LA. Risk factors for community-acquired pneumonia in immunocompetent seniors. *J Am Geriatr Soc* 2009; 57:882-888.
6. Loeb M, Neupane B, Walter SD, Hanning R, Carusone SC, Lewis D, Krueger P, Simor AE, Nicolle L, Marrie TJ. Environmental risk factors for community-acquired pneumonia hospitalization in older adults. *J Am Geriatr Soc* 2009; 57:1036-1040.
7. Koivula I, Sten M, Makela PH. Risk factors for pneumonia in the elderly. *Am J Med* 1994; 96:313-320.

8. Serra-Prat M, Hinojosa G, Lopez D, Juan M, Fabre E, Voss DS, Calvo M, Marta V, Ribo L, Palomera E, Arreola V, Clave P. Prevalence of oropharyngeal dysphagia and impaired safety and efficacy of swallow in independently living older persons. *J Am Geriatr Soc* 2011; 59:186-187.
9. Serra-Prat M, Palomera M, Gomez C, Sar-Shalom D, Saiz A, Montoya JG, Navajas M, Palomera E, Clavé P. Oropharyngeal dysphagia as a risk factor for malnutrition and lower respiratory tract infection in independently-living older persons: a population-based prospective study. *Age Ageing* 2012.
10. van der Maarel-Wierink CD, Vanobbergen JN, Bronkhorst EM, Schols JM, de BC. Meta-analysis of dysphagia and aspiration pneumonia in frail elders. *J Dent Res* 2011; 90:1398-1404.
11. Marik PE. Aspiration pneumonitis and aspiration pneumonia. *N Engl J Med* 2001; 344:665-671.
12. Riquelme R, Torres A, El-Ebiary M, de la Bellacasa JP, Estruch R, Mensa J, Fernandez-Sola J, Hernandez C, Rodriguez-Roisin R. Community-acquired pneumonia in the elderly: A multivariate analysis of risk and prognostic factors. *Am J Respir Crit Care Med* 1996; 154:1450-1455.
13. Marik PE , Kaplan D. Aspiration pneumonia and dysphagia in the elderly. *Chest* 2003; 124:328-336.
14. Rofes L, Arreola V, Romea M, Palomera E, Almirall J, Cabre M, Serra-Prat M, Clave P. Pathophysiology of oropharyngeal dysphagia in the frail elderly. *Neurogastroenterol Motil* 2010; 22:851-8, e230.

15. Clave P, de Kraa M, Arreola V, Girvent M, Farre R, Palomera E, Serra-Prat M. The effect of bolus viscosity on swallowing function in neurogenic dysphagia. *Aliment Pharmacol Ther* 2006; 24:1385-1394.
16. Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC, Dowell SF, File TM, Jr., Musher DM, Niederman MS, Torres A, Whitney CG. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clin Infect Dis* 2007; 44 Suppl 2:S27-S72.
17. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. *Dysphagia* 1996; 11:93-98.
18. Gosney M, Puneekar S, Playfer JR, Bilsborrow PK, Martin MV. The incidence of oral Gram-negative bacteria in patients with Parkinson's disease. *Eur J Intern Med* 2003; 14:484-487.
19. Palmer LB, Albulak K, Fields S, Filkin AM, Simon S, Smaldone GC. Oral clearance and pathogenic oropharyngeal colonization in the elderly. *Am J Respir Crit Care Med* 2001; 164:464-468.
20. Teramoto S, Fukuchi Y, Sasaki H, Sato K, Sekizawa K, Matsuse T. High incidence of aspiration pneumonia in community- and hospital-acquired pneumonia in hospitalized patients: a multicenter, prospective study in Japan. *J Am Geriatr Soc* 2008; 56:577-579.
21. Kikuchi R, Watabe N, Konno T, Mishina N, Sekizawa K, Sasaki H. High incidence of silent aspiration in elderly patients with community-acquired pneumonia. *Am J Respir Crit Care Med* 1994; 150:251-253.

22. Huxley EJ, Viroslav J, Gray WR, Pierce AK. Pharyngeal aspiration in normal adults and patients with depressed consciousness. *Am J Med* 1978; 64:564-568.
23. Gleeson K, Eggli DF, Maxwell SL. Quantitative aspiration during sleep in normal subjects. *Chest* 1997; 111:1266-1272.
24. Cabre M, Serra-Prat M, Palomera E, Almirall J, Pallares R, Clave P. Prevalence and prognostic implications of dysphagia in elderly patients with pneumonia. *Age Ageing* 2010; 39:39-45.

Figure 1. Prevalence of main videofluoroscopic signs of efficacy (A) and safety (B) of swallow. Prevalence is expressed as number of subjects with sign presence versus total number of subjects. * $p < 0.05$, *** $p < 0.001$.

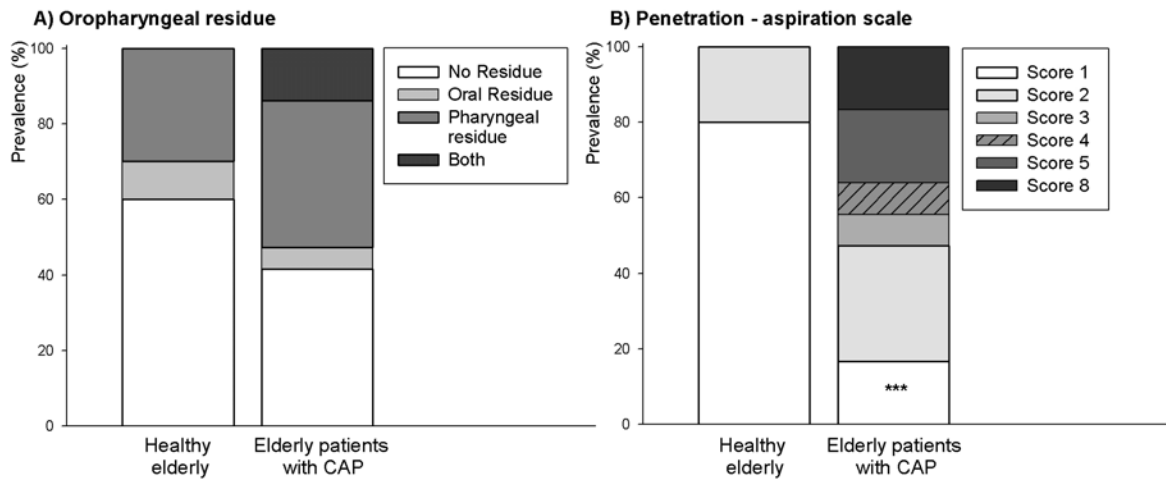


Figure 2. Laryngeal vestibule closure time. Patients with CAP were divided into patients with safe swallow (scores 1-2) and patients with impaired safety of swallow (scores 3-8). Each box plot graphs the median, 10th, 25th, 75th and 90th percentiles. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

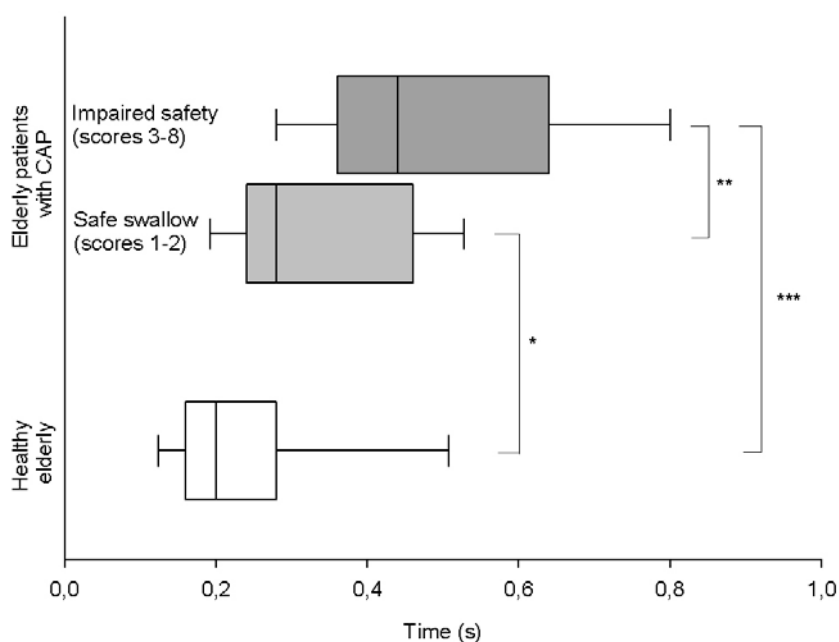


Figure 3. Hyoid movement. Time of maximal hyoid vertical (A) and anterior (B) extension of healthy elderly and patients with CAP divided into patients with safe swallow (scores 1-2) and patients with impaired safety of swallow (scores 3-8). Each box plot graphs the median, 10th, 25th, 75th and 90th percentiles. *p<0.05, **p<0.01.

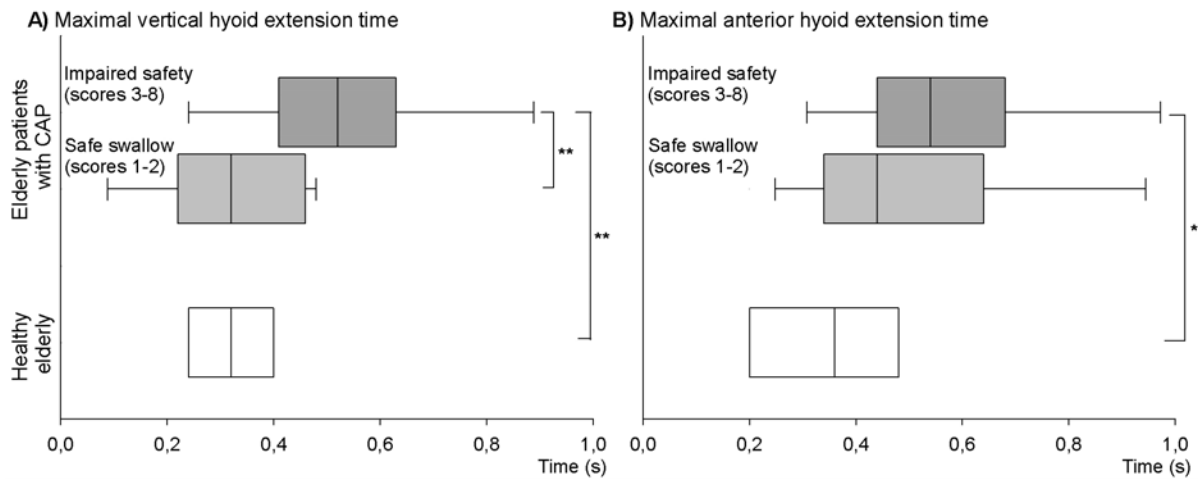
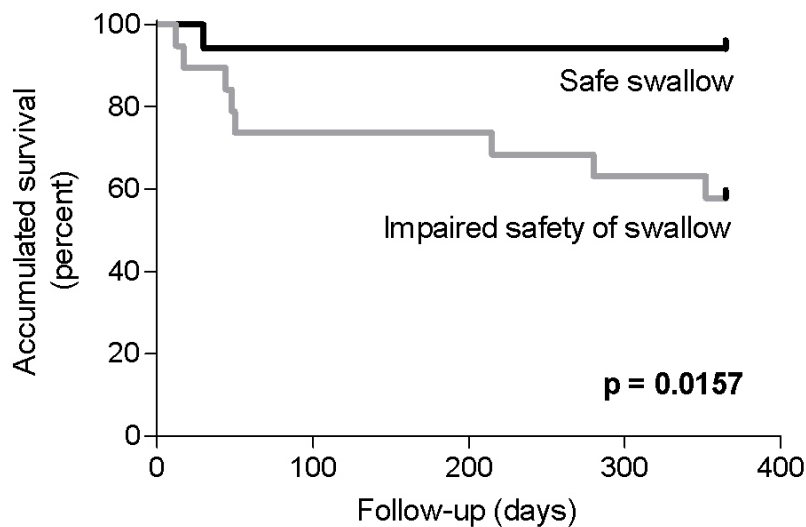


Figure 4. Survival curves. Accumulated survivals of patients with CAP at 1 year according to the impairment of swallow (safe swallow, scores 1-2 and impaired safety of swallow, scores 3-8).



TABLES

Table 1. Univariate analysis of risk factors associated with pneumonia in the elderly.

	<i>Cases (N=36)</i>	<i>Controls (N=72)</i>	<i>P value</i>	<i>OR</i>	<i>95% CI</i>
Barthel Index (<100)	25 (69.4%)	18 (25.0%)	<0.001	6.82	2.81-16.6
COPD/Chronic bronchitis	18 (50%)	20 (27.8%)	0.023	2.60	1.13-5.98
Chronic heart failure	16 (44.4%)	15 (21.1%)	0.012	2.99	1.25-7.13
Benzodiazepine use	10 (27.8%)	16 (22.2 %)	0.254	1.34	0.54-3.37
Oropharyngeal dysphagia	33 (91.7%)	29 (40.3%)	<0.001	16.3	4.57-58.2
Safety impairment	22 (61.1%)	18 (25.0%)	<0.001	4.71	2.00-11.1
Efficacy impairment	30 (83.3%)	24 (33.3%)	<0.001	10.0	3.66-27.3

Data presented as number of cases (percentage). COPD indicates chronic obstructive pulmonary disease; OR, Odds Ratio; CI, confidence interval.

Table 2. Multivariate logistic regression analysis of risk factors associated with pneumonia in the elderly.

	<i>P value</i>	<i>OR</i>	<i>95% CI</i>
Barthel Index (<100)	0.001	6.93	2.13 -22.5
COPD/Chronic bronchitis	0.032	3.80	1.12 -12.9
Chronic heart failure	0.184	2.19	0.69 -6.95
Oropharyngeal dysphagia	<0.001	11.9	3.03 -46.9

COPD indicates chronic obstructive pulmonary disease; OR, Odds Ratio; CI, confidence interval.

Table 3. Clinical characteristics of patients with pneumonia.

<i>N=36</i>		
Influenza vaccination		20 (55.6%)
Pneumococcal vaccination		5 (13.9%)
Number of previous		
pneumonias:	0	25 (69.4%)
	1	8 (22.2%)
	≥2	3 (8.3%)
Body temperature <37°		11 (30.6%)
Days of clinical symptoms*		3.9 (3.6)
Lung location:	RUL	14 (38.9%)
	RLL	11 (30.6%)
	ML	3 (8.3%)
	LUL	3 (8.3%)
	LLL	11 (30.6%)
Number of affected lobes ≥2		6 (16.7%)
PSI:	I	0
	II	0
	III	8 (22.2%)
	IV	21 (58.3%)
	V	7 (19.4%)
CRB-65*		2.0 (0.9)
ICU admission		7 (19.4%)
Hospital death		3 (9.7%)

Data presented as number of cases (percentage), except *mean (SD). RUL indicates right upper lobe; RLL, right lower lobe; ML, middle lobe; LUL, left upper lobe; LLL, left lower lobe; PSI, pneumonia severity index; ICU, intensive care unit.