

# Limited Effect of Rehabilitation for Preventing a Decline in Functional Status after Community-Acquired Pneumonia in Elderly Patients

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## Research article

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# Abstract

**Background:** Functional status is often decreased after hospitalization in elderly community-acquired pneumonia (CAP) survivors. This study investigated factors contributing to decreased functional status.

**Methods:** This retrospective, observational study was conducted in two medical facilities from January 2016 to December 2018. Hospitalized CAP patients >64 years of age were divided into two groups: a maintained group, without decreased functional status, and a decreased group, with decreased functional status. Functional status was evaluated by the Barthel Index (BI) (range, 0–100, in 5-point increments) and graded into three categories: independent, BI 80–100; semi-dependent, BI 30–75; and dependent, BI 0–25. A decreased functional status was considered as a decline of at least one category. The primary outcome was the length of hospital stay.

**Results:** The maintained group included 400 patients, and the decreased group included 138 patients (median age: 77 vs 82 years;  $p < 0.001$ ). The decreased group had a longer hospital stay (13 vs 27;  $p < 0.001$ ), with a high rate of rehabilitation [189(47.3%) vs 104(75.4%);  $p < 0.001$ ]. Multivariable regression analysis showed that factors affecting functional status were length of hospital stay, aspiration, age, and pneumonia severity index (PSI) category V (odds ratio 1.05, 95%CI 1.04–1.07; 2.66, 95%CI 1.58–4.49; 1.05, 95%CI 1.02–1.09; and 1.92, 95%CI 1.29–3.44; respectively). Rehabilitation showed a limited effect in preventing a decreased functional status on propensity score analysis ( $p=0.327$ ).

**Conclusions:** Length of hospital stay, aspiration, age, and PSI V were independent contributors to decreased functional status. Rehabilitation showed a limited effect in preventing decreased functional status.

## Background

The aging of populations around the world has been associated with increases in morbidity and mortality attributable to lung diseases. The annual incidence of community-acquired pneumonia (CAP) in the United States has recently been estimated as 248 cases per 10,000 adults, and the incidence of hospitalization for pneumonia among adults  $\geq 80$  years old was approximately 25 times higher than that among adults 18–49 years old<sup>1</sup>. CAP hospitalizations cost \$13 billion USD annually, and this figure is expected to grow with the aging population<sup>2</sup>. Japan has been the most rapidly aging society in the world, with a life expectancy of 80.1 years for men and 86.4 years for women<sup>3</sup>. Pneumonia is the third highest cause of death, with most of these deaths among elderly patients<sup>4</sup>.

Besides the high mortality in elderly CAP patients, these patients also experience deterioration of functional status, an important component of quality of life for older adults and their caregivers, both during and after treatment<sup>5</sup>. The prevalence of functional decline was reported to be 8.6% in CAP patients<sup>6</sup>. Functional decline during or after hospitalization is associated with adverse health outcomes, prolonged hospital stays due to more frequent occurrences of hospital complications, more frequent

episodes of early hospital re-admissions, and an even higher long-term mortality rate<sup>7-9</sup>. In CAP patients, functional status has been found to be independently associated with mortality<sup>10</sup>. This study was designed to identify factors affecting the functional status of elderly CAP patients.

## Methods

This was a retrospective, cohort study of inpatients admitted to a community-based hospital and a teaching hospital in Japan from January 2015 to December 2018. This study was approved by the institutional review boards of the hospitals and conformed to the provisions of the Declaration of Helsinki (as revised in Brazil 2013).

Functional status was evaluated by the Barthel Index (BI) (range, 0–100, in 5-point increments) of activities of daily living (ADL). ADL was graded into three categories according to the BI: independent, BI 80–100; semi-dependent, BI 30–75; and dependent, BI 0–25. A decline in functional status was considered a decrease in ADL of at least one category. Functional status was assessed at admission and discharge. The need for rehabilitation was determined on the days of admission. Duration of antibiotic treatment was determined by including both parenteral and oral anti-bacterial agents.

### Patients

Elderly hospitalized CAP patients were divided into two groups: maintained group, without deterioration of functional status; and decreased group, with decreased functional status. All enrolled cases had been diagnosed with CAP according to the definitions of the American Thoracic Society/Infectious Diseases Society of America guideline<sup>11</sup>. Patients who fulfilled all of the following inclusion criteria were enrolled in the study: 1) age > 64 years; 2) symptoms compatible with pneumonia (e.g., fever, cough, sputum, pleuritic chest pain, or dyspnea); and 3) appearance of new pulmonary infiltrates consistent with pneumonia on chest X-ray or computed tomography. To ensure that all eligible cases were enrolled, the study investigators screened the hospital database for International Classification of Diseases, 10th revision (ICD-10) codes and reviewed hospital medical records.

### Exclusion criteria

Cases of healthcare-associated pneumonia (HCAP) and hospital-acquired pneumonia (HAP) were excluded<sup>12</sup>. Repeated episodes of pneumonia in the same patient within a 2-week period were regarded as a single episode. Cases with complications that occurred during admission (e.g., myocardial infarction, femoral fracture, cerebral infarction) and that would have affected functional status were also excluded.

### Outcomes

The primary outcome was the length of hospital stay. Demographic information, duration of antibacterial treatment, comorbidities, laboratory values on admission, vital signs, in-hospital mortality, and site of

acquisition for survivors were also collected. Comorbidities were identified according to the Charlson Comorbidity Index<sup>13</sup> (CCI). The Pneumonia Severity Index<sup>14</sup> (PSI) score was calculated based on data obtained at the time of admission.

## Statistical analyses

The results are presented as numbers and percentages or medians and interquartile ranges unless otherwise indicated. Groups were compared using Wilcoxon rank-sum tests. In order to check effect of rehabilitation affecting functional status, risk factors for decreased functional status were determined using stepwise regression analysis. Confounding variables of decreased functional status, age, sex, BMI, aspiration, dementia, disorder of consciousness (DOC), undergoing rehabilitation, pre-admission ADL, PSI, CCI, and length of hospital stay were chosen as candidates. Using the model of the minimum corrected Akaike's information criterion (AICc) in the backward direction, the final variables were determined. McNemar's test was performed to check the effect of rehabilitation in preventing decreased functional status for matched pairs after propensity score analysis. In all instances, two-tailed values of  $p < 0.05$  were considered significant. Data analysis was performed using JMP software (version 15.0; SAS Institute, Cary, NC).

## Results

A total of 1854 patients diagnosed with pneumonia were identified. Of these, the following were excluded: 278 due to age  $< 65$  years; 612 due to outpatient treatment; 113 due to HCAP or HAP; and 215 due to incomplete data. Of the 636 elderly patients with CAP, treatment was prolonged in 98 patients due to complications of decreased functional status. The remaining 538 cases were included in the study, comprising 400 patients in the maintained group and 138 patients in the decreased group (Fig. 1).

The participants were 370 men (68.8%) and 168 women (31.2%), with a median age of 79 years (73–84 years). Background characteristics of these patients are summarized in Table 1. Sex, bedsores, and CCI were not significantly different between the groups. Patients in the decreased group were older, with higher rates of DOC and aspiration, and higher PSI categories. Patients in the decreased group had longer antibacterial treatment (8 days vs. 11 days, respectively;  $p < 0.001$ ) and longer hospital stay (13 days vs. 27 days, respectively;  $p < 0.001$ ). Accordingly, a higher hospitalization cost was observed in the decreased group (\$4740 vs. \$8667, respectively;  $p < 0.001$ ). The decreased group had a higher frequency of rehabilitation during hospitalization than the maintained group [189 (47.3%) vs. 104 (75.4%), respectively;  $p < 0.001$ ]. The decreased group had higher frequencies of transfer to a nursing home or another facility or hospital ( $p < 0.001$ , overall), and higher in-hospital mortality [8(2.0%) vs. 37(36.8%), respectively;  $p < 0.001$ ].

Table 1  
Population demographic characteristics and outcomes of the maintained and decreased functional status groups

	Total	Maintained group	Decreased group	p-value
	n = 538	n = 400	n = 138	
Age (y)	79(73–84)	77(71.3–83)	82(76-86.3)	< 0.001
Male/Female	168/370	131/269	37/101	0.194
BMI	19.3(16.6–22.3)	19.7(16.7–22.6)	18.6(16.4–20.9)	0.002
Dementia	66(12.3%)	41(10.3%)	25(18.1%)	< 0.001
DOC	158(29.4%)	91(22.8%)	67(48.6%)	< 0.001
Bedsore	15(2.8%)	11(2.8%)	4(2.9%)	0.927
Aspiration	121(22.5%)	59(14.8%)	62(44.9%)	< 0.001
In rehabilitation	293(54.5%)	189(47.3%)	104(75.4%)	< 0.001
CCI				0.445
CCI ≤ 1	167(31.0%)	127(31.8%)	40(29.0%)	
CCI = 2	150(27.9%)	115(28.8%)	35(25.4%)	
CCI ≥ 3	221(41.1%)	158(39.5%)	63(45.7%)	
PSI score				< 0.001
II	22(4.1%)	21(5.25%)	1(0.7%)	
III	107(19.9%)	90(22.5%)	17(12.3%)	
IV	225(41.8%)	173(43.3%)	52(37.7%)	
V	184(34.2%)	116(29.0%)	68(49.3%)	
ADL before admission				< 0.001
Independent	367(68.2%)	280(70.0%)	87(63.0%)	
Semi-dependent	127(23.6%)	76(19.0%)	51(37.0%)	
Dependent	44(8.2%)	44(11.0%)	0(0.0%)	
ADL after admission				< 0.001
Independent	291(54.1%)	291(72.8%)	0(0.0%)	

BMI, body mass index; DOC, disorder of consciousness; CCI, Charlson Comorbidity Index; PSI, Pneumonia Severity Index; ADL, activities of daily living.

	Total	Maintained group	Decreased group	
Semi-dependent	121(22.5%)	65(16.3%)	56(40.6%)	
Dependent	126(23.4%)	44(11.0%)	82(59.4%)	
Antibacterial treatment	8.5(7–13)	8(7–11)	11(8-16.3)	< 0.001
Hospital Stay	15(9–26)	13(9-19.8)	27(14-46.3)	< 0.001
Survival outcome				< 0.001
Home	275(51.1%)	271(67.8%)	4(2.9%)	
Nursing home	135(25.1%)	85(21.3%)	50(36.2%)	
Facility	42(7.8%)	20(5.0%)	22(15.9%)	
Hospital	41(7.6%)	16(4.0%)	25(18.1%)	
In-hospital mortality	51(9.2%)	8(2.0%)	37(26.8%)	< 0.001
Key person				0.013
Children	239(44.5%)	163(40.9%)	76(50.1%)	
Spouse	256(47.7%)	204(51.1%)	52(37.7%)	
Others	42(7.8%)	32(8.0%)	10(7.3%)	
Cost (\$)	5231 (3822–7989)	4740 (3542–6488)	8667 (4985–12901)	< 0.001
BMI, body mass index; DOC, disorder of consciousness; CCI, Charlson Comorbidity Index; PSI, Pneumonia Severity Index; ADL, activities of daily living.				

Multivariable analyses of factors contributing to decreased functional status are shown in Table 2. Compared with the maintained group, the odds ratios for length of hospital stay, aspiration, age, and PSI category (V vs. IV + III + II) were 1.05 (95% confidence interval (CI), 1.04–1.07), 2.66 (95%CI, 1.58–4.49), 1.05 (95%CI, 1.02–1.09), and 1.92 (95%CI, 1.29–3.44), respectively. DOC, BMI, and undergoing rehabilitation were not significantly different.

Table 2  
Multivariable analyses of factors affecting decreased functional status

	OR	95% CI		p value
		Lower limit	Upper limit	
Length of hospital stay	1.05	1.04	1.07	< 0.001
Aspiration	2.66	1.58	4.49	< 0.001
Age	1.05	1.02	1.09	0.001
PSI (V vs IV + III + II)	1.92	1.29	3.44	0.010
DOC	1.59	0.95	2.64	0.078
BMI	0.95	0.90	1.02	0.165
Rehabilitation	1.52	0.90	2.56	0.114

OR, odds ratio; CI, confidence interval; DOC, disorder of consciousness; PSI, Pneumonia Severity Index; BMI, body mass index.

In order to check the effect of rehabilitation on preventing a decline of functional status, 166 cases were matched after propensity score analysis using variables identified on multivariate analysis (Table 3). Age, BMI, aspiration, DOC, length of hospital stay, and PSI category V showed no significant differences. For the matched cases, McNemar's test was conducted and showed no significant difference in preventing decreased functional status between the two groups ( $p = 0.327$ ; Table 4).

Table 3  
Detailed information of cases matched by propensity score

	Before matching		p-value	After matching		p-value
	Rehabilitation enrolled			Rehabilitation enrolled		
	Yes	No		Yes	No	
	n = 245	n = 292		n = 166	n = 166	
Age (y)	80	78	< 0.001	78	79	0.767
BMI (kg/m <sup>2</sup> )	18.8	19.7	< 0.001	19.9	18.6	0.934
Aspiration	97(33.1%)	24(9.8%)	< 0.001	27(16.3%)	23(13.9%)	0.539
DOC	100(34.1%)	58(23.7%)	0.008	46(27.1%)	45(27.7%)	0.727
LOS	19	11	< 0.001	14	14	0.835
PSI V	100(34.1%)	84(34.3%)	0.98	55(33.1%)	56(33.7%)	0.907

CAP: community-acquired pneumonia; DOC, disorder of consciousness; LOS: length of hospital stay; PSI, pneumonia severity index.

Table 4  
The effect of rehabilitation in elderly CAP patients

		With rehabilitation		
		Decreased	Maintained	Total
Without rehabilitation	Decreased	7	19	26
	Maintained	26	114	140
Total		33	133	166
p-value		p = 0.327		

CAP: community-acquired pneumonia.

## Discussion

People worldwide are living longer, and the proportion of the world's population over 60 years of age is predicted to nearly double by 2050. Aging is a major risk factor for the development of virtually every lung disease, with increased morbidity and mortality, whereas morbidities and mortalities from other prevalent diseases have declined or remained stable<sup>15</sup>. Age-associated alterations not only decrease innate and adaptive immune responses, but they also involve structural and functional deteriorations of most physiological systems, which may negatively impact the ability of the individual to carry out ADL<sup>16</sup>. In the

present study, age was independently associated with decreased functional status for elderly CAP patients.

Aspiration pneumonia is a subclass of CAP that is expected to contribute increasingly to mortality and morbidity, particularly in the elderly population over the coming decades<sup>17</sup>. Diagnosing aspiration pneumonia has been notoriously problematic because there have not been any established criteria for its diagnosis. Aspiration pneumonia is often diagnosed clinically, relying on the history and physical examination. Aspiration pneumonia accounts for 7–24% of CAP cases<sup>18</sup>. The rate of aspiration in the patients was 22.5% (overall), and up to 44.9% in the decreased group. Aspiration independently increased the risk of in-hospital mortality<sup>19</sup>, and was also an independent factor related to decreased functional status.

Various severity scores are used to predict the mortality of CAP, with the PSI considered the best predictor; a higher PSI score has been associated with higher mortality<sup>7,14</sup>. Length of hospital stay is also affected by comorbid conditions, as determined by the PSI on presentation<sup>20</sup>. Most patients who die from pneumonia are elderly, with multiple comorbidities and significant limitations in care put in place at or during admission. Surviving patients faced the additional problem of declined functional status. Furthermore, severe pneumonia was associated with a higher risk of decreased functional status.

Early rehabilitation showed an effect in preventing decreased functional status in elderly aspiration pneumonia patients, but it also increased the length of hospital stay, simultaneously resulting in higher hospitalization costs<sup>21</sup>. Unfortunately, rehabilitation showed a limited effect in preventing decline of functional status in elderly CAP patients on propensity score analysis. Further research is warranted to analyze the cost-effectiveness of rehabilitation with adjustment for patient background and hospital characteristics.

A prolonged hospital stay would result in a higher hospitalization cost. The average medical cost for the decreased group was almost double that of the maintained group. Decreased functional status and length of stay are important risk factors for unplanned re-hospitalization<sup>22</sup>. A longer hospital stay was also a risk factor for decreased functional status, since rehabilitation showed a limited effect in preventing decreased functional status. If decreased functional status cannot be avoided in elderly patients after hospitalization, early preparations for discharge are necessary. A discharge-planning intervention initiated at the beginning of hospitalization plays a key role in increasing the efficiency and economic sustainability of healthcare systems and improving quality of life for vulnerable elderly persons needing continuity of care<sup>23,24</sup>.

## Conclusions

Length of hospital stay, aspiration, age, and PSI V were independent factors contributing to decreased functional status. Rehabilitation showed a limited effect in preventing decreased functional status.

## Limitations

Some limitations to this study need to be considered when interpreting the present results. First, this study was limited to two medical facilities. Second, only CAP patients were included, and functional status in HCAP or HAP is also important for elderly patients, but it remained unclear. Third, functional status was divided into three categories, whereas continuous variables might be more informative. Fourth, there were other factors could affect functional status and the effect of rehabilitation but were not included in this study, such as exercise, social issues and economic situation.

## Abbreviations

### CAP

community-acquired pneumonia; ADL:activities of daily living; ICD-10:International Classification of Diseases, 10th revision; HCAP:healthcare-associated pneumonia; HAP:hospital-acquired pneumonia; CCI:Charlson Comorbidity Index; PSI:Pneumonia Severity index; DOC:disorder of consciousness; BMI:body mass index; CI:confidence interval; AICc:corrected Akaike's information criterion

## Declarations

### Ethics approval and consent to participate

Ethical approval for the study was obtained from the institutional review boards Yokohama City University and Kanto Rosai Hospital. The reference number was B190600008 and K2018002 respectively.

### Consent for publication

Not applicable.

### Availability of data and material

The raw data is available by email on reasonable request to the corresponding author. E-mail: [chinksmd@yahoo.co.jp](mailto:chinksmd@yahoo.co.jp)

### Competing interests

The authors declare that they have no competing interests.

### Funding

Not applicable

### Authors' contributions

HC, YH and NH conceived of the study, and participated in its design. YS did the main statistics. HC, YH, NH, YS, and TK did critical reviews for whole manuscript. HC interpreted the data and was a major contributor to writing the manuscript. All authors read and approved the final manuscript.

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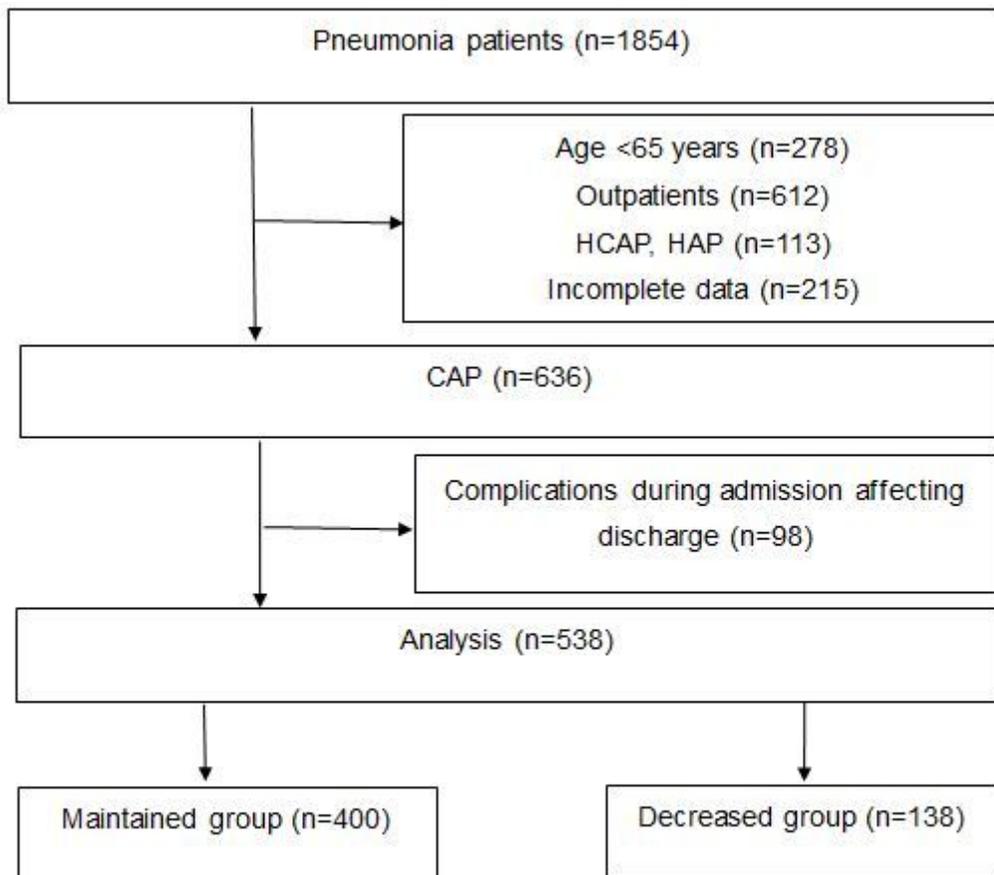
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## Figures



HCAP, healthcare-associated pneumonia; HAP, hospital-acquired pneumonia;  
CAP, community-acquired pneumonia.

**Figure 1**

Flowchart for the study