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博士論文

Relationship between the Functional Independence Measure and Mann Assessment of Swallowing Ability in hospitalized patients with pneumonia

(入院肺炎患者における機能的自立度評価[FIM]と Mann Assessment of Swallowing
Ability[MASA]の関連性について)

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**Relationship between the Functional Independence Measure
and Mann Assessment of Swallowing Ability in hospitalized
patients with pneumonia**

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Abstract:

Aim: Pneumonia ranks high among the causes of death worldwide. However, the predictive values of activities of daily living, the nutrition index and the aspiration index measured objectively remain unclear. The present study aimed to examine the associations of activity, nutrition and dysphagia with pneumonia.

Methods: We assessed 992 hospitalized patients. Logistic regression analysis was used to examine the predictors of pneumonia. Receiver operating characteristic curve analysis was used to determine the cut-off values of variables. Kaplan-Meier and Cox hazards regression analyses were used to examine the incidence of pneumonia and the factors associated with pneumonia.

Results: We finally enrolled 393 inpatients. Of the 393 patients, 102 (26.0%) had pneumonia. On logistic regression analysis, age, Functional Independence Measure (FIM)-motor score and Mann Assessment of Swallowing Ability (MASA) score were independent predictors of pneumonia. The FIM-motor and MASA cut-off values were 19.5 (area under the curve 0.83, $P<0.01$) and 170.5 (area under the curve 0.82, $P<0.01$), respectively. Kaplan-Meier analysis showed that the no pneumonia rate was significantly lower among patients with FIM-motor scores <20 than among those with FIM-motor scores ≥ 20 (log-rank test, $P<0.01$), and was significantly lower among patients with MASA scores <171 than among those with MASA scores ≥ 171 (log-rank test, $P<0.01$). Cox regression analysis showed that FIM-motor (hazard ratio 0.97, $P=0.009$) and MASA scores (hazard ratio 0.99, $P<0.01$) were significantly associated with pneumonia.

Conclusions: In addition to the infectious risk, the FIM-motor and MASA scales are useful tools to predict the development of pneumonia in older adults.

Introduction

Lower respiratory infections, including pneumonia, rank high among the causes of death (3.2 million deaths worldwide in 2015).¹ The incidence of hospital-acquired pneumonia has been estimated to be 5-10 per 1000 hospital admissions.² It is considered that the incidence of pneumonia will increase in the future because of an increase in the mean life expectancy. It has been reported that antibiotic administration, pneumococcal vaccination and oral cavity care are effective for the prevention or treatment of pneumonia.²⁻⁷ A previous study showed that aspiration pneumonia can occur in up to 50% of cases of aspiration among older people.⁸ In 2002, Langmore *et al.* reported that a bedridden state, weight loss, bed mobility, locomotion and swallowing problems were predictors of aspiration pneumonia among nursing home residents.⁹ In contrast, a poor nutritional status can lead to the development of infectious disease, affecting activities of daily living (ADL) in older people. We previously reported that low activity and malnutrition could lead to the development of pneumonia.¹⁰ However, few reports have investigated the relationship among ADL, malnutrition and aspiration. The predictive values of ADL, the nutrition index and the aspiration index measured objectively remain unclear. Most evaluations of physical activity in cases of chronic respiratory disease use an accelerometer. Additionally, video fluorography and video endoscopy are used for the evaluation of swallowing. However, these approaches are not always readily available in hospitals and institutions. Therefore, a useful tool for predicting the development of pneumonia is required.

The Functional Independence Measure (FIM) scale has been used to measure a patient's progress and to assess rehabilitation outcomes, making it useful in clinical settings. The Controlling Nutritional Status (CONUT) score, which was reported to correlate with subjective global assessment, was developed to evaluate the nutritional status more easily and objectively.¹¹ Additionally, the Mann Assessment of Swallowing Ability (MASA) scale has been used to evaluate the degree of aspiration.

The present study aimed to determine whether the FIM scale (ADL), CONUT score (nutrition index) or MASA scale (aspiration index) can be used to predict the development of pneumonia during a follow-up period of 365 days from hospitalization in a geriatric hospital.

Methods

Participants and data collection

The present retrospective observational study included 992 inpatients who were hospitalized for long-term medical treatment in Sapporo Nishimaruyama Hospital (Sapporo, Hokkaido, Japan) between April 2015 and December 2016. Patients who developed pneumonia on admission and those without complete data were excluded. The follow-up period was 365 days from hospitalization. We collected clinical and rehabilitation records, and extracted data, including age, sex, etiology, serum albumin level, total cholesterol level, total lymphocyte count, and MASA and FIM scores (at admission, 1 month later, 3 month later, 6 month later, and 1 year later). The ethics committees of Kobe University Graduate School of Health Sciences (No. 606) and Sapporo Nishimaruyama Hospital approved the present study. Written informed consent was obtained from the participants at admission for the use of data.

FIM scale

The FIM scale was developed by *Granger et al.* as a scale to measure a patient's disability level.¹² It indicates how much assistance is required for individuals to maintain their ADL. The FIM scale consists of 18 tasks (13 motor tasks and 5 cognitive tasks). The tasks are rated on a 7-point ordinal scale that ranges from 1 (total assistance or complete dependence) to 7 (complete independence). The total score ranges from 18 to 126, and a higher score indicates a higher function level.^{10, 12}

CONUT score

The CONUT score was developed to assess nutritional status more easily and objectively.¹¹ The CONUT score considers the serum albumin level, total peripheral lymphocyte count and total cholesterol level. The total score ranges from 0 to 12, and the score indicates the level of issues with regard to nutritional status (0-1, none; 2-4, light; 5-8, moderate; 9-12, severe).

MASA scale

The MASA scale was developed by Mann.¹³ The MASA scale consists of 24 items, and the

measured scores are converted into weighted scores of 5 or 10 points, which are summed to obtain a final score (200 points maximum).^{13,14} The score indicates the level of aspiration risk according to the extent of abnormality (170-200, no abnormality; 149-169, mild; 141-148, moderate; ≤ 140 , severe).

Statistical analysis

Values are shown as mean $\pm$ standard deviation. A χ^2 -test and Mann-Whitney test were used to compare the pneumonia and no pneumonia groups. A logistic regression analysis was carried out to assess the relationship between the pneumonia and no pneumonia groups (stepwise method likelihood ratio and forced entry method). A receiver operating characteristic curve (ROC) analysis was used to determine the cut-off values of predictors (shown by the logistic regression analysis) for the development of pneumonia.

The cut-off value was calculated as follows:

sensitivity (true-positive rates) — specificity (false-positive rates).

Youden Index= (sensitivity + specificity — 1).

The greatest calculated Youden Index values were identified as the cut-off values. The area under the curve (AUC) and 95% confidence interval (CI) were also calculated.

AUC values of >0.9 were considered to show high accuracy, values of 0.7-0.9 were considered to show moderate accuracy and values of 0.5-0.7 were considered to show low accuracy.

Kaplan-Meier analysis was carried out to examine the rate of development of pneumonia according to the cut-off value (shown by the ROC analysis), with significance based on the log-rank test. The relative risk of developing pneumonia was assessed with Cox hazards regression analysis (stepwise method likelihood ratio). Statistical analyses were carried out using IBM SPSS Statistics 22 (IBM Corporation, Armonk, NY, USA). A P -value <0.05 was considered statistically significant.

Results

The study finally enrolled 393 inpatients aged 52-103 years (mean age 79.2 ± 11.4 years), and 61.6% of the patients were women. The etiologies of the participants were as follows:

Parkinson's disease ($n=111$), multiple cerebral infarctions ($n=73$), cerebral infarction ($n=57$), orthopedic diseases ($n=23$), disuse ($n=10$), cerebral hemorrhage ($n=9$), subarachnoid hemorrhage ($n=6$), chronic obstructive lung disease ($n=3$), neuromuscular disease (excluding Parkinson's disease; $n=66$) and others ($n=35$). Of the 393 patients, 102 (26.0%) developed pneumonia. The clinical characteristics of the pneumonia and no pneumonia groups are shown in Table 1. FIM scores (total, motor items and cognition items) and MASA score were significantly lower in the pneumonia group than in the no pneumonia group, whereas age and the CONUT score were higher in the pneumonia group than in the no pneumonia group.

In logistic regression analysis, age, the FIM-motor score and the MASA score were independent and significant predictors for the development of pneumonia (age OR= 0.96, 95% CI 0.93-0.99, $P=0.03$; FIM-motor OR= 1.04, 95% CI 1.02-1.06, $P<0.01$; and MASA OR= 1.01, 95% CI 1.00-1.01, $P=0.01$; Table 2, model 1). Therefore, MASA score was a significant predictor for the development of pneumonia (OR= 1.01, 95% CI 1.01-1.02, $P=0.005$; Table 2, model 2) after adjustment for age.

In ROC analysis, for predicting the development of pneumonia, the FIM-motor cut-off value was 19.5 (sensitivity 0.74, specificity 0.81; AUC 0.83, 95% CI 0.79-0.87, $P<0.01$) and the MASA cut-off value was 170.5 (sensitivity 0.70, specificity 0.83; AUC 0.82, 95% CI 0.78-0.87, $P<0.01$; Fig. 1).

During the 365-day follow-up period, 102 patients developed pneumonia. Patients were divided into two groups according to the FIM-motor and MASA cut-off values on ROC analysis. Kaplan-Meier analysis showed that the no pneumonia rate was significantly lower in the

FIM-motor score < 20 group ($n=156$) than in the FIM-motor score ≥ 20 group (log-rank test,

$P<0.01$), and was significantly lower in the MASA < 171 group ($n=170$) than in the MASA $\geq$

171 group (log-rank test, $P<0.01$; Fig. 2). Cox hazards regression analysis showed that the FIM-motor score, MASA score and age were significantly associated with the development of pneumonia (FIM-motor HR= 0.97, 95% CI 0.95-0.99, $P=0.009$; MASA HR= 0.99, 95% CI 0.99-0.99, $P<0.01$; and age HR= 1.03, 95% CI 1.00-1.05, $P=0.015$; Table 3).

Relationship between the FIM and MASA in hospitalized patients with pneumonia

Table 1 Clinical characteristics of subjects

	Pneumonia group	No pneumonia group	P - value
n (%)	102(26.0)	291(74.0)	
Age	84.5±8.4(86)	77.4±11.8(79)	<.01 *
Man/Woman (n)	43/59	108/183	0.368 **
FIM • total (median)	31.6±18.5(23.5)【19.3-33】	72.9±36.5(74)【39-105】	<.01 *
FIM • motor (median)	19.0±12.6(13)【13-17.8】	49.4±28.2(48)【19.5-77】	<.01 *
FIM • cognition (median)	12.6±7.5(10)【6-18】	23.4±9.7(26)【15.5-32】	<.01 *
CONUT	4.9±2.8(5)【3-7】	3.1±2.5(3)【1-5】	<.01 *
MASA	109.5±60.9(129.5)【38-164.8】	171.5±43.2(188)【165.5-200】	<.01 *

Data presented as mean ±standerd deviation (median) 【Interquartile Range】. *Mann-Whitney U test. ** χ^2 -test. Shapiro-Wilk test ; $P < 0.05$.
CONUT, Controlling Nutritional Status; FIM, Functional Independence Measure; MASA, The Mann Assessment of Swallowing Ability

Table 2 Results of logistic regression analysis of the factors associated with the onset of pneumonia

Model 1	partial regression coefficient	P-value	OR	95%CI (lower—upper)
Age	-0.03	0.03	0.96	0.93-0.99
FIM-motor	0.04	<.01	1.04	1.02-1.06
MASA	0.01	0.001	1.01	1.00-1.01
FIM-total		0.936		
FIM-cognition		0.936		
CONUT		0.963		
Sex		0.299		
Model 2				
Age	-0.036	0.037	0.965	0.933-0.998
FIM-motor	0.039	0.254	1.040	0.972-1.113
MASA	0.009	0.005	1.009	1.003-1.015
FIM-total	0.005	0.842	1.005	0.956-1.057
CONUT	0.004	0.948	1.004	0.897-1.123
Sex	0.31	0.291	1.363	0.767-2.423

The χ^2 -model test, $P < 0.01$; Hosmer-Lemeshow test, $P = 0.507$. Percentage of correct classifications, 80.4%.

Independent variables: age, sex and FIM (total,motor,cognition), CONUT, MASA

Model 1: stepwise method likelihood ratio Model 2: forced entry method

Confounding factor; age

FIM; Functional Independence Measure CONUT; Controlling Nutritional Status MASA; The Mann Assessment of Swallowing Ability

95%CI ;95% confidence interval OR ;odds ratio

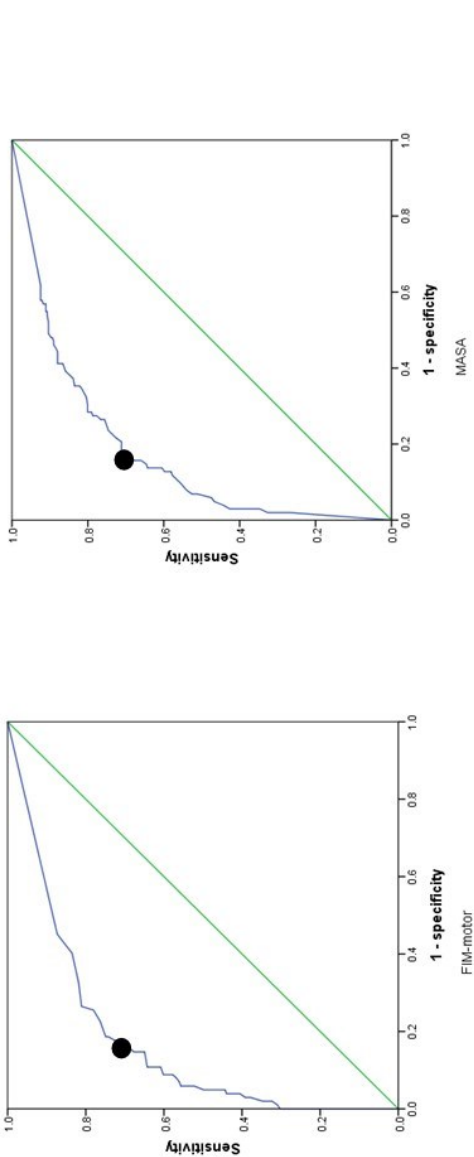


Figure1 Cut off values for the onset pneumonia in the Japanese long term facilities inpatients. (i) The cut off value of Functional independence measure-motor(FIM-motor) calculated by ROC analysis was 19.5 (sensitivity 0.74, specificity 0.81, AUC:0.83, 95%CI0.79-0.87, P< 0.01). (ii) The cut off value of The Mann assessment of swallowing ability calculated by ROC analysis was 170.5 (sensitivity 0.70, specificity 0.82, 95%CI0.78-0.87, P< 0.01).

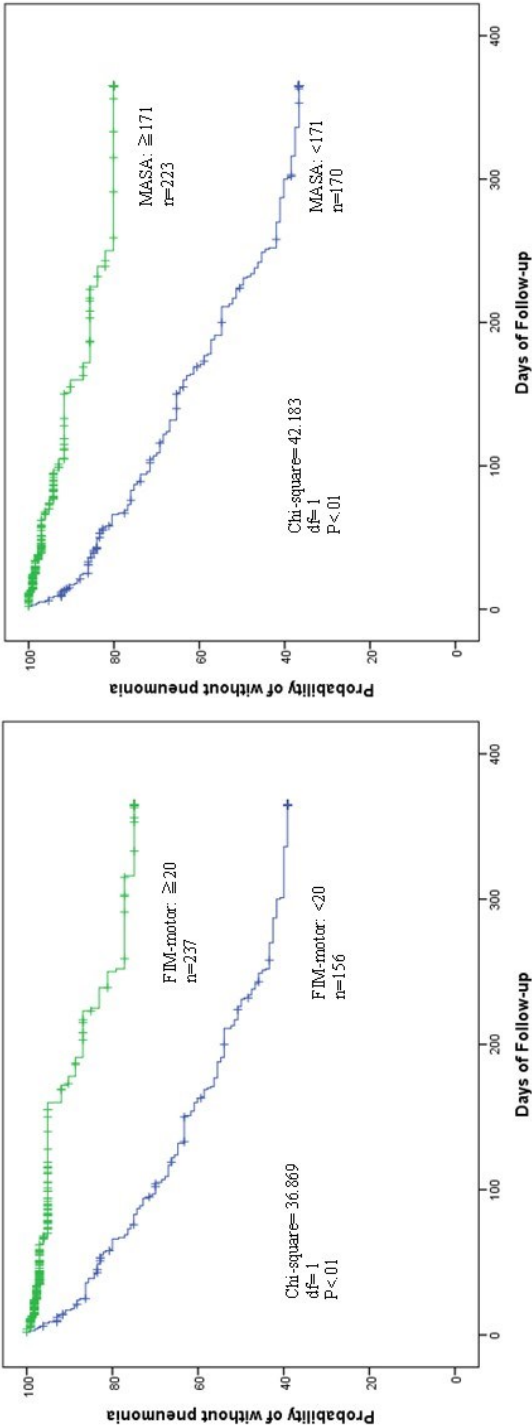


Figure2. Without pneumonia rate of inpatients(left figure, FIM-motor, right figure, MASA) Kaplan-Meier curves according to cut off values of FIM-motor by receiver operating characteristic analysis(ROC). Individuals in the FIM-motor<20 group(underline) had a significantly lower without pneumonia rate than FIM-motor ≥ 20 group(overline)
Kaplan-Meier curves according to cut off values of MASA by receiver operating characteristic analysis(ROC). Individuals in the FIM-motor<171 group(underline) had a significantly lower without pneumonia rate than MASA ≥ 171 group(overline)

Table 3 The results of Cox hazard regression analysis of the factors associated with onset of pneumonia

	partial regression coefficient	P-value	HR	95%CI (lower—upper)
Age	0.03	0.015	1.03	1.00-1.05
FIM-motor	-0.03	0.009	0.97	0.95-0.99
MASA	-0.007	<.01	0.99	0.99-0.99
FIM-total		0.819		
FIM-cognition		0.819		
CONUT		0.216		

The χ^2 -model test; $P < 0.0001$. Independent variables: age, Functional Independence Measure(FIM; total,motor,cognition), Controlling Nutritional Status (CONUT) and The Mann Assessment of Swallowing Ability (MASA).
95%CI ;95% confidence interval HR ;hazard ratio

Discussion

The main finding of the present retrospective observational study was that ADL, the nutrition index and the aspiration index measured objectively might predict the development of pneumonia during a follow-up survey 365 days from hospitalization in a geriatric hospital.

In the present study, the FIM-motor and MASA scores were significant predictors for the development of pneumonia. The no pneumonia rate was significantly lower in the FIM-motor < 20 and MASA < 171 groups than in the FIM-motor ≥ 20 and MASA ≥ 171 groups, respectively.

The FIM-motor scale assessed self-care, sphincter control, transfers and locomotion. The reliability of the FIM scale for other diseases (including stroke) has been shown in quantitative reviews and among people from a multilevel continuing-care retirement community.^{15, 16}

The present results support the findings of the study by *Langmore et al.*⁹ Thus, the previous study reported that aspiration was suspected in 77.1% of the performance status 3 (capable of only limited self-care) to 4 (completely disabled) patients.¹⁷⁻²⁰

Maeda *et al.* reported that low muscle mass is a potential predictor of mortality in individuals with aspiration pneumonia, indicating that individuals with low muscle mass might be unable to expectorate an aspirate because of low respiratory muscle strength.²¹

The mean total FIM score in the pneumonia group was 31.6 (median 23.5), and these patients depended heavily on support for their ADL. It has been reported that patients with an FIM score ≤ 36 were completely dependent.¹² We previously reported that the FIM-total score was an independent predictor of the development of pneumonia.¹⁰ A previous study reported that a

decrease in ADL might be a risk factor for aspiration pneumonia.²² In contrast, few reports have carried out detailed examinations of ADL;²³ thus, further studies are required for clarification.

The MASA scale has been used in patients with various underlying diseases.^{13, 24} In the present study, the mean MASA score in the pneumonia group was 109.5 (median 129.5), and these patients had a very high risk of aspiration. The present study showed that the MASA scale might be a useful tool for predicting the development of pneumonia, which is consistent with the finding in the study by Chojin *et al.*¹⁴ The relationship between dysphagia and pneumonia has been reported in various previous studies.^{5, 22} A previous study found that dysphagia was an independent risk factor for malnutrition,²⁵ and another study showed that sarcopenia might be a risk factor for dysphagia.²⁶ The present study also found that the CONUT score was higher in the pneumonia group than in the no pneumonia group.

Sarcopenia involves decreases in reserve capacity, muscle mass and strength, which contribute to dysphagia.²⁷ Therefore, not only activity and swallowing function, but also nutrition should be considered with regard to the prevention of pneumonia.

A previous study showed that early rehabilitation (intervention) might help reduce the incidence of pneumonia (hospital-acquired pneumonia) and in-hospital mortality.^{28, 29} However, there is no specific strategy (pulmonary rehabilitation) for use in all older patients with dysphagia.³⁰ Thus, it is necessary to establish a detailed strategy.

The present study had some limitations. First, this was a single-center study with a small sample size. Second, the study evaluated inpatients with a diagnosis of pneumonia; however, not all had aspiration pneumonia. As all patients did not undergo detailed assessments (e.g. video fluorography), it was difficult to make an accurate diagnosis of aspiration pneumonia in all patients. Third, additional factors, such as pneumococcal vaccination and oral cavity care, are difficult to investigate in such a retrospective observational study.

In conclusion, the assessment of FIM-motor function and MASA might be potential predictors for the development of hospitalized pneumonia in older people in addition to the infectious risk. It is necessary to examine these factors for each disease. Further multicenter and prospective studies are required to investigate these in future.

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Author contributions

Yuji Mitani involved in the conception and design of the study, acquisition of data, analysis and interpretation of data, and drafting the article. Yutaro Oki, Yukari Fujimoto, Takumi Yamaguchi and Akira Ishikawa involved in the conception and design of the study, acquisition of data, analysis and interpretation of data, and revising the article. Yoji Yamada, Kanji Yamada, Takashi Ito and Hideyuki Shiotani involved in the acquisition of data and revising the article. All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the work.

Conflict of interest

The authors declare no conflict of interest.

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