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Lower Barthel Index Is Associated with Higher Risk of Hospitalization-Requiring Pneumonia in Long-Term Care Facilities

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Pneumonia is an important infectious entity that affects residents in long-term care facilities (LTCFs), whereas hospitalization-requiring pneumonia (HRP) represents a more critical patient condition with worse outcomes. The evidence addressing the association between Barthel index and risk of HRP among LTCF residents is lacking. A multicenter, retrospective cohort study was conducted in three LTCFs enrolling adult patients who resided for 3 months or more and ever underwent Barthel index evaluation within a study period of January 1 to December 31, 2010. The endpoint was HRP after enrollment. A total of 299 patients (169 women; age, 79.0 ± 12.2 years) were enrolled and categorized into HRP Group (n = 68; 36 women; age, 79.1 ± 11.3 years) and Non-HRP Group (n = 231; 133 women; age, 79.0 ± 12.4 years) by the endpoint. The patients in HRP Group had significantly lower Barthel index (8.6 versus 25.8 points, $p < 0.001$) but higher proportion of chronic obstructive pulmonary disease (13.2% versus 3.9%, $p = 0.004$). By the multivariate analysis of logistic regression, we found that lower Barthel index (odds ratio (OR), 0.967; $p < 0.001$), existence of chronic obstructive pulmonary disease (OR, 4.192; $p = 0.015$), and feeding route (percutaneous endoscopic gastrostomy comparing with oral feeding; OR, 0.177; $p = 0.012$) were independently associated with HRP. In conclusion, a lower Barthel index is significantly associated with the occurrence of pneumonia that requires hospitalization in long-term care residents. Barthel index is a useful and reliable tool for risk evaluation in this population.

Keywords: Barthel index; hospitalization; long-term care facilities; nursing home-acquired pneumonia; percutaneous endoscopic gastrostomy
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Introduction

Owing to the increase of aging populations and the change of social patterns, more people would turn to be cared in long-term care facilities (LTCFs) which offer assists for living, or nursing homes which provide skilled nursing care or advanced service for those with lower functional capacity (Sligl and Majumdar 2011; Briggs et al. 2013). The residents in these facilities are susceptible to infection because they are elderly and have more underlying diseases and functional deficits. Thus infection is a crucial issue in LTCFs and one of the major reasons for transferring residents to acute care hospitals (Irvine et al. 1984; Mehr et al. 2001). Whereas nursing home-acquired pneumonia (NHAP), which is defined as pneumonia occurring in the residents of LTCFs or nursing homes, is a major cause of hospitalization and a leading cause of morbidity and mortality in the elderly population (Muder 1998; Hutt et al. 2010).

Although NHAP has similar pathophysiology and microbiology as community-acquired pneumonia (CAP), the two entities should be distinguished for the different

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patient characters and outcomes (Martinez-Moragon et al. 2004; Raghavendran et al. 2007). The incidences of NHAP varied from 0.3 to 2.3 episodes per 1,000 person-days in the elderly LTCF individuals, which are significantly higher than that of CAP in the community-based population (Muder 1998; Mylotte 2002). And NHAP also accounts on 20% of critically ill patients admitted to intensive care units with severe pneumonia (Valles et al. 2014). Among the elderly patients who are admitted due to pneumonia, those live in LTCFs tend to be older and frailer with lower BI, and have more medical burden such as multiple comorbidities and dementia. They also have tendency towards "atypical presentations" of pneumonia and worse vital signs and survival rates comparing with those live in the communities (Janssens and Krause 2004; Martinez-Moragon et al. 2004; Raghavendran et al. 2007). The mortality rates of patients with NHAP are reported as 32%-57% (Janssens and Krause 2004), which is significantly higher in the NHAP patients who needs hospitalization for treatment than those treatment in the LTCFs (Raghavendran et al. 2007).

The risk factors contributing to the development of NHAP include advanced age, male gender, functional dependency, chronic lung diseases, comorbid disease, presence of nasogastric tube (NGT) or tracheostomy, dysphagia, occurrence of an unusual event or conditions caused by aspiration (Muder 1998; Raghavendran et al. 2007; Wojkowska-Mach et al. 2013). In the aspect of evaluating functional status, Barthel index (BI) which is firstly introduced by Mahoney and Barthel in 1965 (Mahoney and Barthel 1965), is the most common tool applied in many field including LTCFs to evaluate the individuals' ability of carrying out their daily activity. Lower BI is found to be associated with higher risk of developing NHAP by Wojkowska-Mach et al. (2013).

However, it is difficult to make a proper diagnosis of NHAP without sending the individual to the hospitals because of the "atypical" presentation of the pneumonia in LTCF residents, along with the "caregiver-dependent" awareness of pneumonia and the insufficient availability of laboratory and radiologic examinations in the LTCFs (Raghavendran et al. 2007). Besides, hospitalization-requiring NHAP is even clinically relevant because it carries worse patient outcomes than those without hospitalization (Raghavendran et al. 2007). Nonetheless, the evidence addressing BI and risk of hospitalization-requiring NHAP is lacking. Thus we conducted current study to investigate the association between BI and the occurrence of hospitalization-requiring pneumonia (HRP) in elder residents of LTCFs.

Materials and Methods

Study design and participants

This multicenter, retrospective cohort study was conducted in three LTCFs in the Northern Taiwan. In these LTCFs, the residents were routinely encouraged to receive vaccines against streptococcus pneumoniae and/or seasonal influenza. The Institutional Review Board of Saint Mary's Hospital approved the study (No. SMHIRB-100024) and the informed consent was waived since there was neither breach of privacy nor interference with clinical decisions. The data were analyzed anonymously as well.

The whole study period were from January 1 to December 31, 2010, while the enrollment period was between January 1 and September 30, 2010, in which adult patients who lived in the LTCFs for 3 months or more and ever underwent BI evaluation were eligible for this study. The exclusion criteria included less than 18 years of age, living in the institutions for less than 3 months, as well as lacking of BI questionnaire evaluation. All the enrolled participants were followed until December 31, 2010.

The baseline demographic data, comorbid diseases, and hospitalization records of the enrolled participants were reviewed from the medical record of LTCFs and were further confirmed by the doctors' records and reports of relevant laboratory and imaging examinations in the hospitals. The BI evaluation was performed by the nursing staffs in the three LTCFs. The diagnosis of pneumonia was established by clinical symptoms/signs along with chest radiological and microbiological examinations. Other recorded comorbidities were defined as followings: chronic kidney disease (CKD), baseline estimated glomerular filtration rate $\leq$ 45 ml/min/1.73 m^2, which was calculated using the Chinese Modification of Diet in Renal Disease equation (Ma et al. 2006), for more than 3 months (Hsu et al. 2009); diabetes mellitus, previous usage of insulin or oral hypoglycemic agents; heart disease, including coronary artery disease and congestive heart failure; lung disease, a composite variable containing chronic obstructive pulmonary disease (COPD), asthma, and pulmonary tuberculosis; gastrointestinal disease, mainly peptic ulcers or reflux esophagitis; malignancy, including all the cancers over whole body; bone and joint disease, including osteoarthritis, bony fracture, severe osteoporosis, and gout. Besides, the feeding routes including oral intake, NGT, and percutaneous endoscopic gastrostomy (PEG) were also recorded.

Barthel index

In current study, we used the original version of BI (Mahoney and Barthel 1965) for functional status evaluation of the residents in residents in LTCFs. It comprises 10 items with a total score ranging from 0 to 100 points. A higher score means better capacity to perform daily living activities on the scale (Table 1).

Study endpoint

The endpoint of this study was HRP that occurred after the BI evaluation during the 1-year study period. Residents with NHAP requiring hospitalization for treatment were categorized into "HRP Group", while others were categorized into "Non-HRP Group". Then we evaluated the difference in demographic data between the two groups, and determined the risk factors for HRP.

Statistical methods

The statistical analyses were performed using the Scientific Package for Social Science (PASW Statistics for Windows, Version 18.0, Chicago: SPSS Inc). The continuous data were expressed as mean ± standard deviation, unless otherwise specified, and compared using the independent-samples T-test. The categorical variables were shown as numbers (percentages) and analyzed using Pearson's Chi-square test. We then determined the risk factors and calculated their odds ratio (OR) and 95% confidence interval (CI) for HRP using

Table 1. The Barthel index (Mahoney and Barthel 1965).

Activity	Scores	Content
Feeding	10 =	Independent
	5 =	Needs help cutting, spreading butter…or requires modified diet
	0 =	Unable
Transfers (Bed to chair and back)	15 =	Independent
	10 =	Minor help (verbal or physical)
	5 =	Major help (one or two people, physical), can sit
	0 =	Unable, no sitting balance
Grooming	5 =	Independent face/hair/teeth/shaving (implenments provided)
	0 =	Needs to help with personal care
Toilet use	10 =	Independent (on and off, dressing, wiping)
	5 =	Needs some help, but can do something alone
	0 =	Dependent
Bathing	5 =	Independent (or in shower)
	0 =	Dependent
Mobility (on level surfaces)	15 =	Independent (but may use aid; ex, stick) > 50 yards
	10 =	Walks with help of one person (verbal or physical) > 50 yards
	5 =	Wheelchair independent, including corners, > 50 yards
	0 =	Immobile or < 50 yards
Stairs	10 =	Independent
	5 =	Needs help (verbal, physical, carrying aid)
	0 =	Unable
Dressing	10 =	Independent (including buttons, zips, laces…)
	5 =	Needs help but can do about half unaided
	0 =	Dependent
Bowels	10 =	Continent
	5 =	Occasional accident
	0 =	Incontinent (or need to be given enemas)
Bladder	10 =	Continent
	5 =	Occasional accident
	0 =	Incontinent, or catheterized and unable to manage alone

backward method of logistic regression analysis. All the variables were selected for multivariate analysis if they had a $p \leq 0.15$ on univariate analysis or if they are considered to be clinically important. In all statistical analyses, a two-sided $p \leq 0.05$ was considered statistically significant.

Results

Participants screening and enrollment

During the enrollment period, a total of 409 individuals admitted in the three LTCFs. After excluding 12 stayed for less than 3 months and 98 for lack of BI evaluation, 299 patients (169 women; age, 79.0 ± 12.2 years) were enrolled in this study and followed until December 31, 2010. According to the endpoint, participants were categorized into HRP Group (n = 68; 36 women; age, 79.1 ± 11.3 years) and Non-HRP Group (n = 231; 133 women; age, 79.0 ± 12.4 years). The flowchart of patient selecting and categorizing was shown in Fig. 1.

Microbial etiology

Among the 68 patients who had ever admitted due to NHAP, 66 sets of sputum cultures obtaining from 40 patients (58.8%) yielded microorganism while sputum culture from the rest 28 patients grew nothing. These bacteria included *Pseudomonas aeruginosa* (grew in 34 out of the 66 sets (51.5%) of sputum culture), *Klebsiella pneumoniae* (21.2%), *Haemophilus influenzae* (15.2%), *Proteus mirabilis* (13.6%), *Escherichia coli* (13.6%), *Corynebacterium* (12.1%), *Staphylococcus aureus* (12.1%), *Acinetobacter baumannii* (10.6%), *Alpha-hemolytic streptococcus* (10.6%), *Moraxella catarrhalis* (7.6%), *Serratia marcescens* (7.6%), *Stenotrophomonas maltophilia* (6.1%), *Neisseria* (3.0%), *Providencia stuartii* (1.5%), *Citrobacter koseri* (1.5%), *Burkholderia cepacia* (1.5%), *Enterobacter*

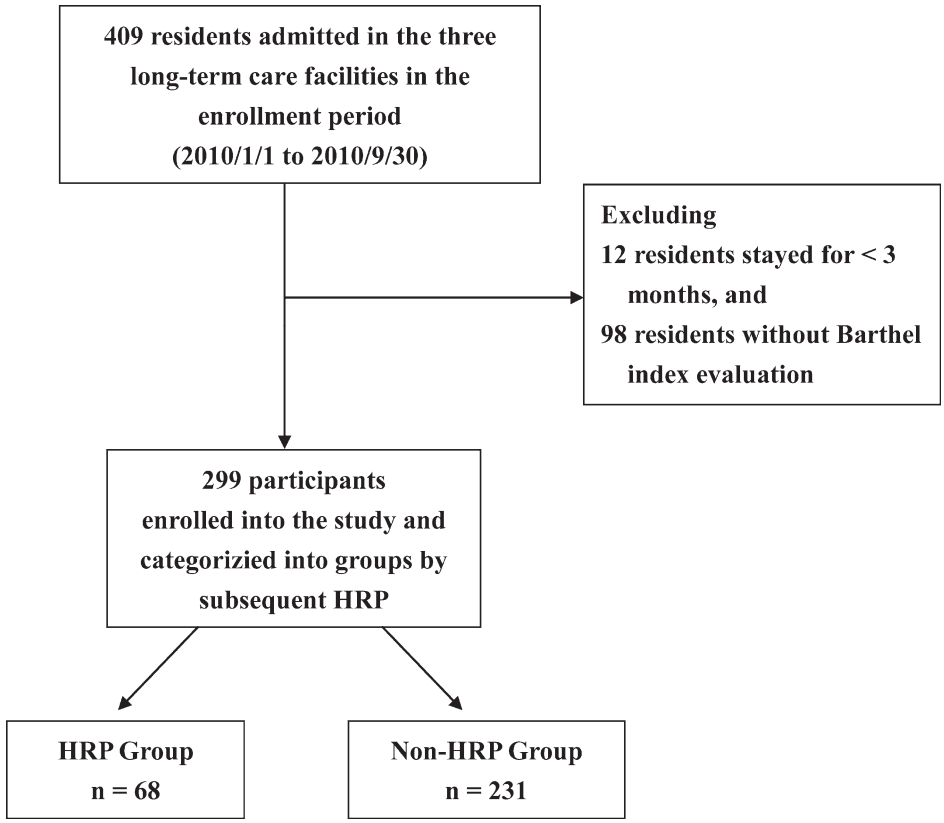

Fig. 1. Flow chart of participant screening and selecting.
HRP, hospitalization-requiring pneumonia.

cloacae (1.5%), *Group B Streptococcus* (1.5%), *Streptococcus pneumoniae* (1.5%), and *Enterococcus* (1.5%).

Parameters between the two groups

The baseline demographic data and clinical characteristics of our participants were shown in Table 2. Comparing with the Non-HRP Group, the patients in HRP Group had significantly higher proportion of lung disease ($p = 0.010$) in which COPD ($p = 0.004$) was responsive for the significance. While other clinical parameters, such as age, gender, feeding route, and comorbidities including diabetes mellitus, heart disease, stroke, asthma, pulmonary tuberculosis, CKD, benign prostatic hyperplasia, gastrointestinal disease, malignancy, bone and joint diseases, dementia and Parkinson's disease were not significantly different between the two groups.

Besides, the patients in HRP Group had significantly lower BI than those in Non-HRP Group (8.6 versus 25.8, $p < 0.001$). When the BI scores were stratified into 5 groups (namely, 0-20, 21-61, 61-90, 91-99, and 100), the HRP Group was known to have higher proportion of Barthel 0-20 points (83.8% versus 60.6%) but lower proportion of other categories than Non-HRP Group ($p < 0.005$) (Table 3).

Independent risk factors for hospitalization-requiring pneumonia

Multivariate analysis by logistic regression model was performed to determine the independent risk factors for HRP. The variables put into the multivariate analysis included age, gender, feeding routes (NGT and PEG comparing with oral intake), BI, diabetes mellitus, heart disease, stroke, COPD, asthma, pulmonary tuberculosis, CKD, benign prostatic hyperplasia, gastrointestinal disease, malignancy, dementia, and Parkinson's disease.

By the multivariate adjustment, we found that lower BI (OR, 0.967; 95% CI, 0.951-0.984; $p < 0.001$), existence of COPD (OR, 4.192; 95% CI, 1.327-13.245; $p = 0.015$), and feeding route (PEG comparing with oral intake) (OR, 0.177; 95% CI, 0.046-0.683; $p = 0.012$) were independently associated with HRP (Table 4). The BI kept the independent association with HRP (OR, 0.970; 95% CI, 0.952-0.987; $p = 0.001$) even when applying in the subgroup without stroke ($n = 207$, whole set of analysis results was not shown).

Discussion

NHAP is the most important infectious entity affecting LTCF residents owing to the high morbidity and mortality (Mylotte 2002), while NHAP requiring hospitalization maybe represent a more critical patient condition resulting in worse outcomes (Raghavendran et al. 2007). Among the

Table 2. Baseline demographic and clinical data of the two groups.

	Total (n = 299)	HRP Group (n = 68)	Non-HRP Group (n = 231)	P-value
Age	79.0 ± 12.2	79.1 ± 11.3	79.0 ± 12.4	0.936
Age ≥ 65yrs	272 (91.0%)	63 (92.6%)	209 (90.5%)	0.583
Gender, Female	169 (56.5%)	36 (52.9%)	133 (57.6%)	0.498
Feeding route†				0.173
Oral	179 (64.2%)	36 (62.1%)	143 (64.7%)	
NGT	71 (25.4%)	19 (32.8%)	52 (23.5%)	
PEG	29 (10.4%)	3 (5.2%)	26 (11.8%)	
Cormobidity				
Diabetes mellitus	75 (25.1%)	18 (26.5%)	57 (24.3%)	0.722
Heart disease	74 (24.7%)	17 (25%)	57 (24.7%)	0.957
Stroke	92 (30.8%)	17 (25%)	75 (32.5%)	0.241
Lung disease (composite variable)	35 (11.7%)	14 (20.6%)	21 (9.1%)	0.010
COPD	18 (6.0%)	9 (13.2%)	9 (3.9%)	0.004
Asthma	16 (5.4%)	6 (8.8%)	10 (4.3%)	0.148
Pulmonary tuberculosis	6 (2.0%)	2 (2.9%)	4 (1.7%)	0.532
Chronic kidney disease	37 (12.4%)	11 (16.2%)	26 (11.3%)	0.279
Benign prostatic hyperplasia	25 (8.4%)	2 (2.9%)	23 (10%)	0.066
Gastrointestinal disease	41 (13.7%)	5 (7.4%)	36 (15.6%)	0.083
Malignancy	27 (9.0%)	6 (8.8%)	21 (8.7%)	0.974
Bone and joint disease	51 (17.1%)	8 (11.8%)	43 (18.6%)	0.187
Dementia	41 (13.7%)	6 (8.8%)	35 (15.2%)	0.182
Parkinson's disease	22 (7.4%)	4 (5.9%)	18 (7.8%)	0.596

Values were presented as mean ± standard deviation or number (percentage) unless otherwise stated. P-value was calculated using independent-samples T-test for continuous data and Pearson's Chi-square test for count data. †n = 279.
COPD, chronic obstructive pulmonary disease; HRP, hospitalization- requiring pneumonia; NGT, nasogastric tube; PEG, percutaneous endoscopic gastrostomy.

Table 3. Comparisons for Barthel index of the two groups.

	Total (n = 299)	HRP Group (n = 68)	Non-HRP Group (n = 231)	P-value
Barthel index	21.9 ± 29.7	8.6 ± 16.7	25.8 ± 31.6	< 0.001
				0.005
Barthel 0-20	197 (65.9%)	57 (83.8%)	140 (60.6%)	
Barthel 21-60	54 (18.1%)	9 (13.2%)	45 (19.5%)	
Barthel 61-90	43 (14.4%)	2 (2.9%)	41 (17.7%)	
Barthel 91-99	1 (0.3%)	0 (0%)	1 (0.4%)	
Barthel 100	4 (1.3%)	0 (0%)	4 (1.7%)	

HRP, hospitalization-requiring pneumonia.

residents in LTCFs, the nonspecific general symptoms, rather than the specific respiratory symptoms and signs, are more commonly presented than community-based or younger populations (Mylotte 2002). Thus the diagnosis of NHAP is needed to be facilitated by careful evaluation of the residents for signs and symptoms related to the respiratory tract, including respiratory rate, hear rates, change in cognitive or functional status, sign of hypoxemia, and auscultatory findings on chest examination (Iregui at al. 2002). Among the risk factors for NHAP, many of them such as poor functional status, presence of NGT or tracheostomy, dysphagia, or occurrence of unusual event, are different from that for CAP (Raghavendran et al. 2007).

In current study, we found that lower BI and existence of COPD were risk factors, while PEG feeding, comparing with oral intake, played a protective role for hospitalization-

Table 4. Independent risk factors for HRP using backward model of logistic regression analysis.

	OR	95% CI	P-value
Barthel index (every increment of 1 point)	0.967	0.951-0.984	< 0.001
Feeding route (PEG versus oral)	0.177	0.046-0.683	0.012
COPD (with versus without)	4.192	1.327-13.245	0.015
constant	0.515		0.007

CI, confidence interval; COPD, chronic obstructive pulmonary disease; HRP, hospitalization-requiring pneumonia; OR, odds ratio; PEG, percutaneous endoscopic gastrostomy.

requiring NHAP.

Barthel index

An increasing body of evidence has showed that functional status is more important than other factors such as age and comorbidities, for prognosis-predicting in elderly patients (Murcia et al. 2010). Although it only takes about 5 minutes to answer by the patient himself/herself or the main caregiver (Murcia et al. 2010), the BI scale is regarded as reliable and extensively applied on the field of in-patient rehabilitation, home care, nursing care, skilled nursing, and community (Wojkowska-Mach et al. 2013; Meyer et al. 2015). Even a small change of BI scores is clinical relevant and beyond measurement error (Hsieh et al. 2007). And the reliability, predictive validity, and responsiveness of BI are adequate even after several months following stroke (Hsueh et al. 2001; Quinn et al. 2011).

BI has been used to predict length of hospital stay, prognosis and mortality in many acute and chronic health problems (Torres et al. 2004; Murcia et al. 2010). By using it to evaluate functional status of CAP patients, Uematsu et al. (2015) found that lower BI scores were associated with higher hospitalization costs and longer duration of hospital stay, Calle et al. (2014) demonstrated that functional deficit defined as BI < 40 points at admission was a predictor of mortality, whereas Murcia et al. (2010) disclosed that even mild functional dependence (BI ≤ 80 points) was associated with 4-times higher risk of short-term (30-day) mortality among patients with CAP. Besides, Torres et al. (2004) also revealed baseline poor functional status as a risk factor associated with longer length of hospital stay, and a higher mortality after both short-term (30-day) and long-term (18-month) follow-up in CAP patients.

Similar results were seen in the patients with NHAP, poorer functional status defined by lower BI is associated with higher risk of NHAP (Wojkowska-Mach et al. 2013) and poorer patient outcomes including mortality (Muder 1998; Mehr et al. 2001). In current study, we found that functional status measuring by BI is an important factor associated with the occurrence of hospitalization-requiring NHAP among residents of LTCFs.

Chronic obstructive pulmonary disease

COPD has similar physiological presentations with the important ageing- associated physiological changes, which include an enlargement of alveoli, along with decreases in the ventilatory response, elastic recoil of the lung, compliance of the chest wall, strength of respiratory muscles, forced expiratory volumes and peak expiratory flow (Janssens and Krause 2004). Such changes result in an increased functional residual capacity and decreased mucus clearance, and probably more susceptible to pneumonia. In concordance with the findings in current study, COPD was found as a risk factor of pneumonia in both community population (Raghavendran et al. 2007) and critically ill patients (Valles et al. 2014).

Percutaneous endoscopic gastrostomy

The nutritional management and strategy for patients with impaired swallowing function is a complex and challenging area in the field of health care (Vesey 2013). Alternative enteral feeding routes such as NGT, nasoduodenal/nasojejunal tube (NJT), and PEG should be considered for patients with functionally normal gastrointestinal tract who have inadequate oral intake or risk of aspiration (Ferraro et al. 2013).

Several studies were performed to compare the safety and beneficial effects of these enteral feeding routes. In earlier years, some studies (Baeten and Hoefnagels 1992; Park et al. 1992) exhibited equal risk for aspiration pneumonia in patients with NGT and PEG. More recently, Onur et al. (2013) prospectively enrolled 94 in-patients who had at least once aspiration pneumonia history to compare the long-term outcomes of patients receiving different enteral feeding routes (PEG, NJT, and oral feeding). After follow-up for 6 months, they found that the development of the nutritional status and the intake in the 3 groups were similar. However, the patients with PEG had significantly lower overall re-aspiration rate (58% comparing with 78% in NJT group, and 91% in oral group, $p < 0.05$) and higher satisfaction scores ($p < 0.001$). In current study, comparing with oral intake, PEG plays a protective role in preventing pneumonia. This finding is consistent with the result of the previous study, (Onur et al. 2013; Schneider et al. 2014) and could also explain the phenomenon that PEG is an increasingly common treatment option for patients who are more and more being cared in the community (Vesey 2013).

Furthermore, in a retrospective cohort analysis including 110 elderly patients with PEG feeding, patients' functional status was found to be an independent risk factor for

patient mortality (OR, 9.76; 95% CI, 3.26-29.3) (Cortes-Flores et al. 2015). Taken together, these findings underlined the importance of functional capacity and optimal feeding route on long-term patient outcomes.

Limitations

Several limitations of this study should be addressed. First, as a retrospective study, it is potentially prone to bias and insufficiency of some clinical parameters. Second, we could only found the "association" rather than the "causal relationship" between BI and HRP in current study design. Third, the study was performed with a limited number of LTCF residents in northern Taiwan. Thus the results may not be extensively applied to all the LTCFs residents with different characteristics throughout the world. Further multicenter randomized controlled studies enrolling more participants with wider patient characteristics are warranted to confirm our findings.

In conclusion, a lower BI is significantly associated with the occurrence of hospitalization-requiring NHAP in long-term care residents. BI is a useful and reliable tool to for risk evaluation in this population.

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Conflict of Interest

The authors declare no conflict of interest.

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