Activities of Daily Living (ADL) Predicts in-hospital Mortality in Geriatric Patients with Community-acquired Pneumonia (CAP)

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Research article

Abstract

Background: Community-acquired pneumonia (CAP) is an important problem with significant mortality. Activity of daily living (ADL) function decline is associated with increased mortality in elderly patients. We aimed to investigate the prognostic value of ADL at admission on the in-hospital mortality in geriatric patients with pneumonia.

Methods: Patients over 65 years old admitted to Beijing Chao-yang hospital due to CAP from June 2012 through June 2020 were retrospectively reviewed by electronic medical records. Risk factors for mortality in pneumonia patients described in literature were included in our study. ADL evaluation at admission was performed by Barthel index (BI).

Results: 4880 patients were included, 131 patients (2.7%) died during their admission. 69.5% patients in Dead group had a BI scores < 60. Mean BI score in the Dead group and Alive group were 49.89±30.20 and 81.57±22.14, respectively. Dead group had lower BI scores than Alive group (p⊠0.001). A low BI was associated with increased in-hospital mortality. Logistic regression analyses demonstrated that ADL function at admission was significantly and independently associated with the in-hospital mortality, either in younger (age 65-74years) or very elderly (age≥75years) patients. Receiver operating characteristic (ROC) curve analysis revealed that BI at admission is an predictor related to in-hospital mortality in elderly patients, The area under the receiver operating characteristic (ROC) curves of BI in predicting in-hospital mortality was 0.81 (with 95% confidence interval: 0.78−0.85).

Conclusion: ADL decline is associated with increased risk of in-hospital mortality among elderly patients hospitalized with CAP. ADL function at admission can predict in-hospital mortality in geriatric patients with CAP. Barthel Index (BI) can be used as a simple and convenient method for the assessment of the ADL functional status at admission in geriatric patients with CAP to identify patients at high risk and conducive to clinical decision making.

Introduction

Pneumonia is a major public health problem, particularly among older adults. Community-acquired pneumonia (CAP) causes has a high morbidity and mortality, is the commonest cause of infectious death[1]. A high morbidity and mortality probably due to the ageing population[2]. Aging is associated with deterioration of function dictates clinical outcomes[3].

It is essential to perform detailed evaluation functional status of the elderly and predicting the outcome in geriatric patients with pneumonia. Various host and environmental factors influence the prognosis of CAP among older adults[4−5].PSI, CURB-65, increasing age and comorbidities can be used to predict clinical outcomes [6]. However, there are other intrinsic factors had adverse effect on outcomes are not included in the scales. Due to frequent variations in 'biological age', functional status in these elderly

patients are frequently individualized, we also wanted to seek other factors for in the high mortality risk elderly patients which conducive to clinical decision-making process.

ADL functional status decline can lead to adverse clinical outcomes in pulmonary infections, dementia[7], heart failure[8], hip fractures[9−10], and acute medical patients[11]. The baseline ADL functional status may be one of the determinants for the evolution of pneumonia. However, there are few data on relationship between ADL and in-hospital mortality in elderly patients diagnosed with CAP.

Thus, here we aimed to determine whether activity of daily living (ADL) are associated with in-hospital mortality in geriatric patients with CAP, and investigate the prognostic value of ADL function at admission on the in-hospital mortality.

Patients And Methods

Study Subjects

Between June 2012 and June 2020, 4880 patients diagnosed with CAP and age ≥ 65 years were admitted to Beijing Chao-yang Hospital, Capital Medical University were included in this study. Beijing Chao-Yang Hospital has the Beijing Institute of respiratory diseases, well-recognized at the national level and the hospital has 1,900 beds. All patients underwent ADL evaluation by charge nurse within 2 hours of admission to ward.

The demographic and clinical information data from all patients were extracted from the electronic medical records. The study protocol was approved by the Institutional Review Board for Human Studies of Beijing Chaoyang Hospital, Beijing, China. The following variables were collected: age, sex, smoking, co-morbidity, clinical symptoms, clinical condition and laboratory findings on hospital admission.

The main outcome was the in-hospital mortality. The patients were divided into Alive (n = 4749) and Dead (n = 131) groups depending on Vital status at discharge.

Diagnosis and Definitions

Diagnosis of Pneumonia

CAP was diagnosed in accordance with the IDSA/ATS guidelines[12]: At least one of the clinical symptoms: cough, sputum, fever, dyspnea, and pleuritic chest pain; at least more than one finding of coarse crackles by auscultation or inflammatory biomarkers elevated; a new infiltrate be found on chest radiograph.

ADL Evaluation

The BI was used to assess the level of dependency in ADL at the time of hospital admission. The BI measures ten functions that are important for independent living [13]: feeding, dressing, transferring,

grooming, bathing, toileting, walking, stair climbing, bowel control, and bladder care. BI score ranging from 0 to100 points, higher BI score indicates lower dependency. BI score < 60 indicates functional depend.

Statistical Analysis

Categorical variables were described using counts and percentages, and groups were compared using a chi-square test or Fisher's exact probability test. Continuous variables were presented as means and standard deviations, and significant differences between two groups were determined with a Student's *t*-test. For non-normally distributed data, median and interquartile ranges were used to describe the features, while comparisons of the two sets were performed using a Mann-Whitney U test. To determine the factors associated with the in-hospital mortality logistic regression analysis was performed. The odds ratios (OR) with 95% confidence intervals (CI) were presented. The receiver operating characteristics (ROC) curves and the areas under the curves (AUCs) were applied in the model to assess the prognostic value.

The statistical analyses of data were performed by using SPSS 20.0 (SPSS Inc., Chicago, IL, USA) and R software (version 3.3.2) with the corresponding R packages. All tests were two-sided, and a value of $P < 0.05$ was considered statistically significant.

Results

1. Characteristics of the study population

A total of 4880 patients diagnosed with CAP and aged ≥65 years were included in the study with a median age 72 years (range, 68-80 years) and over half (59.3%) were male. The mean length of stay were 12.26±9.93 days. 131 patients (2.7%) died during their admission. The characteristics of the 4880 patients in the study are shown in Table 1.

69.5% patients in Dead group had a Barthel index (BI) scores < 60. Mean BI score in the Dead group and Alive group were 49.89±30.20 and 81.57±22.14, respectively. Dead group had lower BI scores than Alive group (p < 0.001). Patients in the Dead group were older than patients in the Alive group (p < 0.001). While, the prevalence of lung cancer (p = 0.004) and diabetes history (p = 0.037) were different between the two groups. The Dead group patients had a higher percentage of dyspnea (p = 0.002) and impaired consciousness (p ⬚ 0.001). The ratio of respiratory rate ≥30/min, body temperature < 36℃ or ≥ 40℃, heart rate ≥ 125bpm, BUN ≥7mmol/L, PLT < 10.0×109/L, PaO2 < 60mmHg or SPO2 < 90%, PH < 7.35, albumin < 30g/L, serum sodium < 130 mmol/L, blood glucose ≥14mmol/L or HCT < 30% were significantly different between the two groups(p ⬚ 0.001 or p = 0.001). The proportions of patients who had pleural effusion was higher in the Dead group than in the Alive group (p = 0.001). As for the distribution of causative pathogens, there was a difference between the two groups (p < 0.001),viral pneumonia and fungal pneumonia were more frequent in the Dead group. Invasive mechanical

ventilation or Non-invasive ventilation were required in 52 (39.7%) patients of the Dead group and 115 (2.4%) of the Alive group, which were significantly different between the two groups (p < 0.001).

Table 1
Demographic data and baseline characteristics at time of admission

Characteristic	Total patientsn=4880	Vital status at discharge Alive n=4749 Dead n=131		*P* value*
Age, years	72 (68-80)	71 (67-79)	75 (70-84)	⟨ 0.001
Male, No. (%)	2895(59.3)	2809 (59.1)	86 (65.6)	0.149
Barthel index (BI) BI<60 BI≥60	80.69±23.00720 (14.8)4160 (85.2)	81.57±22.14629 (13.2)4120 (86.8)	49.89±30.2091 (69.5)40 (59.3)	⟨ 0.001 ⟨ 0.001
Comorbid conditions n (%)				
Smoking	2336 (47.9)	2268 (47.8)	68 (51.9)	0.425
COPD	676 (13.9)	656 (13.8)	20 (15.3)	0.609
Lung cancer	478 (9.8)	455 (9.6)	23 (17.6)	0.004
Diabetes	1214 (24.9)	1172 (24.7)	42 (32.1)	0.037
Chronic heart failure	922 (18.9)	893 (18.8)	29 (22.1)	0.365
Hypertension	2392 (49.0)	2321 (48.9)	71 (54.2)	0.250
Cerebrovascular disease	330 (6.8)	316 (6.7)	14 (10.7)	0.077
Chronic renal failure	86 (1.8)	83 (1.7)	3 (2.3)	0.520
Chronic liver disease	146 (2.9)	145 (3.1)	1 (0.8)	0.188
Clinical symptoms				
Fever	1773 (36.3)	1715 (36.1)	58 (44.3)	0.065
Cough and expectoration	1014 (20.8)	980 (20.6)	34 (25.9)	0.155
Chest pain	433 (8.9)	427 (8.9)	6 (4.6)	0.086
Dyspnea	853 (17.5)	816 (17.2)	37 (28.2)	0.002
Duration of symptoms	6.90±8.78	6.86±9.03	6.93±8.21	0.964
Clinical data				
Length of stay	12.26±9.93	12.16±9.77	15.63±13.92	0.005
NIV/IMV	167 (3.4)	115 (2.4)	52 (39.7)	⟨ 0.001
Impaired consciousness	40 (0.8)	28 (0.6)	12 (57.9)	⟨ 0.001
Respiratory rate≥30/min	66 (1.4)	57 (1.2)	9 (6.9)	⟨

				0.001
Blood pressure SBP <90mmHg	26 (0.8)	23 (0.5)	3 (2.3)	0.050
DBP≤60mmHg	594 (12.2)	570 (12.0)	24 (18.3)	0.265
T <36℃ or ≥40℃	133 (2.7)	121 (2.5)	12 (59.3)	0.001
Heart rate ≥125bpm.	24 (0.5)	18 (0.4)	6 (9.2)	0.001
BUN≥7mmol/L	1531 (31.4)	1405 (29.6)	126 (96.2)	〈 0.001
WBC <4.0×10^9/LPLT <10.0×10^9/L PaO2<60mmHg or SPO2<90% PH <7.35	544 (11.1)255 (5.2)680 (13.9)240 (4.9)	524 (11.0)210 (4.4)593 (12.5)168 (3.4)	20 (15.3)45 (34.4)87 (66.4)72 (54.9)	0.522 〈 0.001 〈 0.001 〈 0.001
Albumin< 30g/LSerum sodium <130 mmol/LBlood glucose ≥14mmol/LHCT<30%	1066 (21.8)303 (6.2)82 (1.7)931 (19.1)	963 (20.3)259 (5.5)68 (1.4)845 (17.8)	103 (78.6)44 (33.6)14 (10.7)86 (65.6)	〈 0.001 〈 0.001 〈 0.001 〈 0.001
Pleural effusion	910 (18.6)	864 (18.2)	46 (35.1)	0.001
Pathogens				〈 0.001
Bacterial pneumonia	4144 (94.9)	4050 (85.3)	94 (71.8)	
Viral pneumonia	62 (1.3)	56 (1.2)	6 (4.6)	
Fungal pneumonia	146 (3.0)	129 (2.7)	17 (12.9)	
Mycoplasma pneumonia/Chlamydial pneumonia	528 (10.8)	514 (10.8)	14 (10.7)	

Data are presented as median (interquartile range), mean (standard deviation) or %

COPD: chronic obstructive pulmonary disease. SBP: Systolic blood pressure. DBP: Diastolic blood pressure. T: Body temperature. bpm: beats per minute. BUN: blood urea nitrogen. WBC: white blood cell. PLT: blood platelet. PaO2: arterial oxygen tension. SPO2: pulse oxygen saturation. PH:potential of hydrogen. IMV: invasive mechanical ventilation. NIV: non-invasive ventilation.

*For comparisons between Alive group and Dead group

2. Factors associated with in-hospital mortality

Based on risk factors for mortality in pneumonia patients described in literature, the logistic regression analysis was performed to investigate the

association between in-hospital mortality. Two logistic regression models were constructed: model 1 independently included the BI and the comorbidities, model 2 included BI and the clinical data were selected from significant variables obtained from the univariate analysis. In addition, we also investigated the risk factors in younger (age 65-74years) and very elderly (age≥75years) patients, respectively. The logistic regression analyses of risk factors for in-hospital mortality are shown in Table 2. ADL function at admission was independently and significantly associated with the in-hospital mortality in both models.

Table 2
Logistic regression analyses of factors associated with the in-hospital mortality

	OR (95% CI)	P value*
Model 1 (ADL + Comorbidities)		
Model 1a (Total)		
ADL	0.31(0.29−0.33)	⬚0.001
Lung cancer	2.91(2.18−3.64)	⬚0.001
Model 1b (Age 65-74 years)		
ADL	0.22(0.19−0.25)	⬚0.001
Lung cancer	3.51(2.80−4.22)	⬚0.001
Model 1c (Age ≥ 75 years)		
ADL	0.32(0.30−0.34)	⬚0.001
Model 2 (ADL + Clinical data)		
Model 2a (Total)		
ADL	0.32(0.30−0.34)	⬚0.001
Body temperature	2.91(1.9−3.92)	0.04
WBC	0.92(0.88−0.95)	⬚0.001
Model 2b (Age 65-74 years)		
ADL	0.23(0.21−0.25)	⬚0.001
Systolic blood pressure	1.02 (1.01−1.03)	0.01
Model 2c (Age ≥ 75 years)		
ADL	0.32(0.30−0.34)	⬚0.001
WBC	0.72(0.52−0.91)	⬚0.001
OR: odds ratio. CI: confidence interval. ADL: Activities of Daily Living. WBC: white blood cell.		

In the Model 1, in all 4880 patients and 65-74 years patients, ADL and Lung cancer were significantly correlated with the in-hospital mortality. In patients≥75years, only ADL was found to be an independent prognostic factor. ADL: (Model 1a: OR = 0.31, 95% CI: 0.29−0.33, p⬚0.001; Model 1b: OR = 0.22, 95% CI: 0.19−0.25, p⬚0.001; Model 1c: OR = 0.32, 95% CI: 0.30−0.34, p⬚0.001)

In the Model 2, ADL remained significant as factors related to in-hospital mortality in three groups. In addition, Body temperature and WBC in total patients, Systolic blood pressure in the younger group and WBC in the very elderly group were significant risk factors, respectively. ADL: (Model 2a: OR = 0.32, 95%

CI: 0.30−0.34, p◻0.001; Model 2b: OR = 0.23, 95% CI: 0.21−0.25, p◻0.001; Model 2c: OR = 0.32, 95% CI: 0.30−0.34, p◻0.001)

3. Relationship between BI levels and in-hospital mortality

As shown in Fig. 1, a low BI was associated with increased in-hospital mortality. In all 4880 patients, the in-hospital mortality in patient with BI◻40,BI 40-59 and BI≥60 were 12.9%, 6.0%, 1.2%, respectively. The same trend were showed in age≥75 years group and age 65-74 years group.

4. Prognostic value for in-hospital mortality

The relationship between the in-hospital mortality and the predictive factor is shown in Fig. 2.

We examined the role of Barthel index as a predictor of in-hospital mortality in geriatric patients admitted to medical wards because of CAP. The area under the receiver operating characteristic (ROC) curves of Barthel index in predicting in-hospital mortality was 0.81 (95% CI, 0.78−0.85). Using Youden index, the best cut-off point for Barthel index was 67.5 for in-hospital mortality (sensitivity: 0.79 and specificity: 0.68). While, According to ROC curve analysis, age and respiratory rate, and WBC, and BUN revealed significantly wide AUC. No significant predictive value for in-hospital mortality was found in impaired consciousness and systolic blood pressure at admission in this study.

Discussion

The main finding in this study was the independent association between ADL function at admission and in-hospital mortality in geriatric patients with pneumonia. We examined the role of ADL function at admission as a predictor of in-hospital mortality in geriatric patients with pneumonia. Hitherto, association between ADL function at admission and in-hospital mortality in geriatric patients with pneumonia has not been studied, and our study had relatively adequacy sample size. We noted that a low BI was associated with increased in-hospital mortality. In our study logistic regression analyses demonstrated that ADL function at admission was significantly and independently associated with the in-hospital mortality, we also adjusted for age group to evaluate differences in patients of different ages, the ADL function was found to be independently associated with the in-hospital mortality either in younger (age 65−74 years) or very elderly (age ≥ 75 years) patients. ROC curve analysis revealed that BI at admission is an important predictor related to in-hospital mortality in elderly patients, rather than consciousness impairments and systolic blood pressure. The prognostic value of ADL function at admission was good, as shown by the ROC curves.

CAP continues to be an important problem with a 30-day mortality rate as reported of 6.7−25% [6, 14−15]. In-hospital mortality rate for severe community-acquired pneumonia (SCAP) remains unacceptably high, range from 17 to 49% in large multicentre cohort studies [16−17]. The in-hospital mortality observed in this

study was 2.7%, again in line with a multicenter study on adult admissions reporting rates 2.2% [18], while other study reporting in-hospital mortality 1–5% [19−20]. A range of risk assessment and preventive interventions are recommended to identify patients at high risk and implementing strategies for preventing functional which considered preventable risk factors.

Predicting the outcome and identifying potentially modifiable risk factors for pneumonia in elderly patients is crucial in clinical decision making. Jason Phua[21] found that early and aggressive management measures, implemented and valuation of prognosis within 24 hours decrease mortality in severe CAP. Different prognostic scales have been documented to assess in CAP, the most commonly be used are the PSI and CURB- 65. Carmen Gonzalez [22]found that the PSI prediction sensitivity in 28-day mortality is 82% and specificity is 34%, while, sensitivity of CURB-65 is 45% and specificity is 81%. PSI includes demographic parameters, comorbidities, physical examination and laboratory/imaging findings [23]. In contrast is the CURB-65 (Confusion, Urea nitrogen, Respiratory Rate, Blood pressure, Age > 65 years) [24]. These variables above in PSI and CURB-65 were included in this study. Variables in IDSA/ATS severe pneumonia criteria[12] were also included in the study, as the following: mechanical ventilator, tachypnoea, hypoxaemia, multilobar infiltrates, hypothermia, hypotension and WBC, PLT. These are known risk factors for mortality were included in our study, and in-hospital mortality are also likely to be associated with activities of daily living functional. However, both the PSI and the CURB-65, in contrast to our study data on ADL functional status was lacking. The relationship between comorbidities and survival was found in previously study [25]. However, comorbidities was not found to be a significant risk factor for in-hospital mortality by logistic analysis in our study, except for lung cancer in our study.

ADL function declines is associated with increased mortality [26−28]. Function declines is part of the process of healthy state change from risk factors, loss of function and diseases. The death of frail elderly with pneumonia is not frequently only due to pneumonia itself [29]. Even little changes in the ADL function could lead to poor clinical outcomes [30−31]. ADL functional status has been shown to be an independent predictor of mortality in heterogeneous populations [7−11]. In CAP, a worse ADL is directly related to increased immediate and long-term mortality [32]. It was reported that a BI level◻80 was associated with 30-day mortality in pneumonia patients [33] and a low BI with increased mortality in institutionalized patients[34]. On the other hand, a high BI level has been reported was related to reduced 30-day and 18 months mortalities in elderly CAP patients[35]. It was found that BI was one of the risk factors for 6 month mortality in COPD patients[36].While, a worse baseline BI was reported associated with greater mortality in elderly patients admitted to the emergency because of fever [37].

Our study show the same trend as all these previous studies, ADL decline is associated with increased risk of in-hospital mortality among elderly patients hospitalized with CAP. Assessment of ADL at admission in combination with the pneumonia severity scale could potentially be used in further management of CAP in geriatric patients. Barthel index (BI) can effectively performed to evaluate ADL. Barthel index is a widely used functional assessment of ADL. BI is the official ADL tool of geriatric

patients. All patients admitted to ward were evaluated in our hospital. The Barthel Index (BI) is reliable, simple, and it can be used as a conventional method for the assessment of the ADL functional status at admission in geriatric patients with CAP to identify patients at high risk and conducive to clinical decision making.

The cause of behind ADL function and in-hospital mortality have not been clarified. The association of nutritional status and psychological with patient's activities of daily living has been attention recently. Decreased activities of daily living functional was shown to be associated with the reduced muscle mass [38]. Elderly people with impaired ADL function may lose the ability to brush teeth, which may increase aspiration pneumonia [39]. In addition, studies have reported association between increased inflammatory markers and functional disability [40].

The study has some limitations. The first is the retrospective design of the study which resulted in some variables cannot be extracted from the electronic medical records. This study was conducted in a single hospital serving an urban area. It would be interesting to extend these observations in a larger sample and multicenter. Secondly, BI has some limitations, that may be influenced by the environment. Thirdly, it is unknown if specific measures such as exercise or nutrition supplementation, could improve activities of daily living function outcomes to improve prognosis in this high-risk subgroup of geriatric patients with pneumonia patients.

Conclusions

ADL decline is associated with increased risk of in-hospital mortality among elderly patients hospitalized with CAP. ADL function at admission can predict in-hospital mortality in geriatric patients with CAP. Barthel Index (BI) can be used as a simple and convenient method for the assessment of the ADL functional status at admission in geriatric patients with CAP to identify patients at high risk and conducive to clinical decision making.

Abbreviations

CAP: Community-acquired pneumonia; ADL: Activity of daily living; BI: Barthel index; ROC: Receiver operating characteristic; PSI: pneumonia severity index; IDSA/ATS: Infectious Diseases Society of America and the American Thoracic Society; OR: The odds ratios; CI: confidence intervals; ROC: The receiver operating characteristic curve; AUC: the areas under the curves; COPD: chronic obstructive pulmonary disease; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; T: Body temperature; BUN: blood urea nitrogen; WBC: white blood cell; PLT: blood platelet; PaO2: arterial oxygen tension; SPO2: pulse oxygen saturation; PH: potential of hydrogen; IMV: invasive mechanical ventilation; NIV: non-invasive ventilation.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board for Human Studies of Beijing Chaoyang Hospital, Beijing, China. The review board exempted the acquisition of informed consent from patients included in the study.

Consent for publication

Not applicable – this study does not contain any patient personal details.

Competing interests

The authors declare they have no competing interests.

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Authors' contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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Availability of data and materials

Data can be provided by contacting the first author if required.

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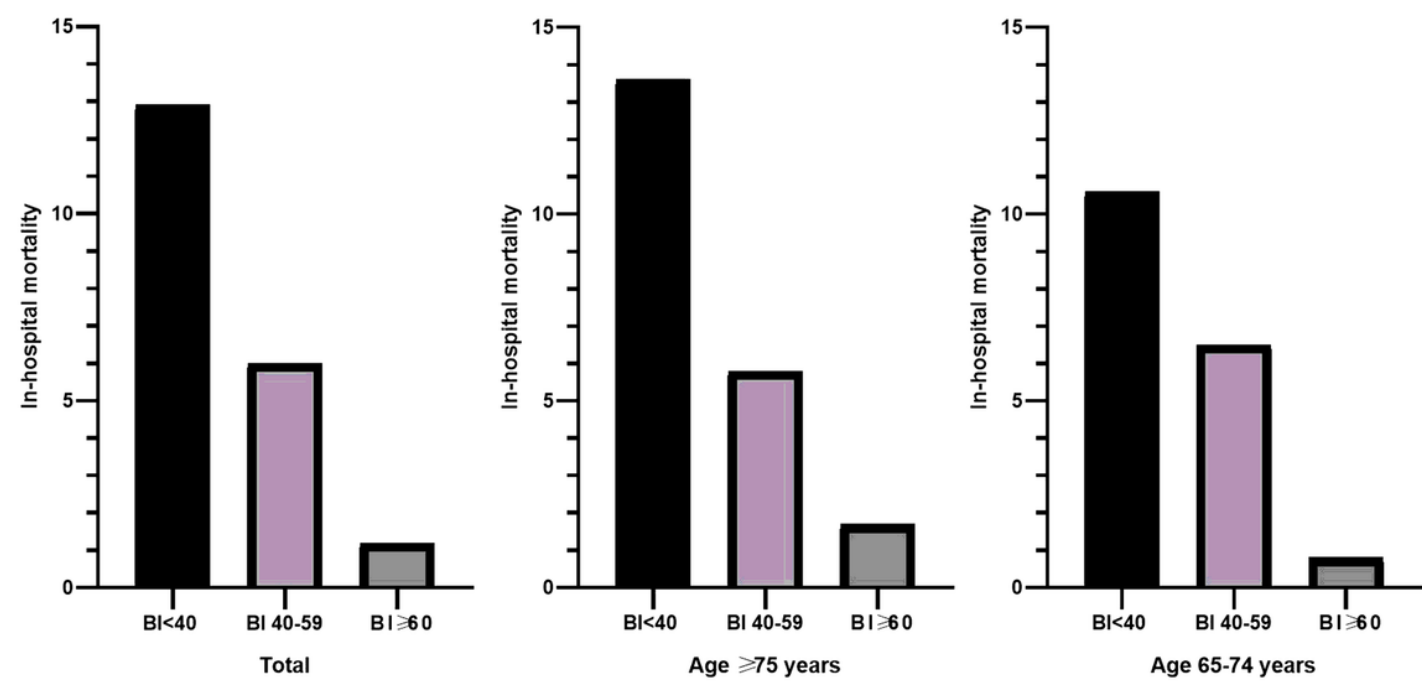
Figures

Fig. 1 In-hospital mortality according to BI levels

Figure 1
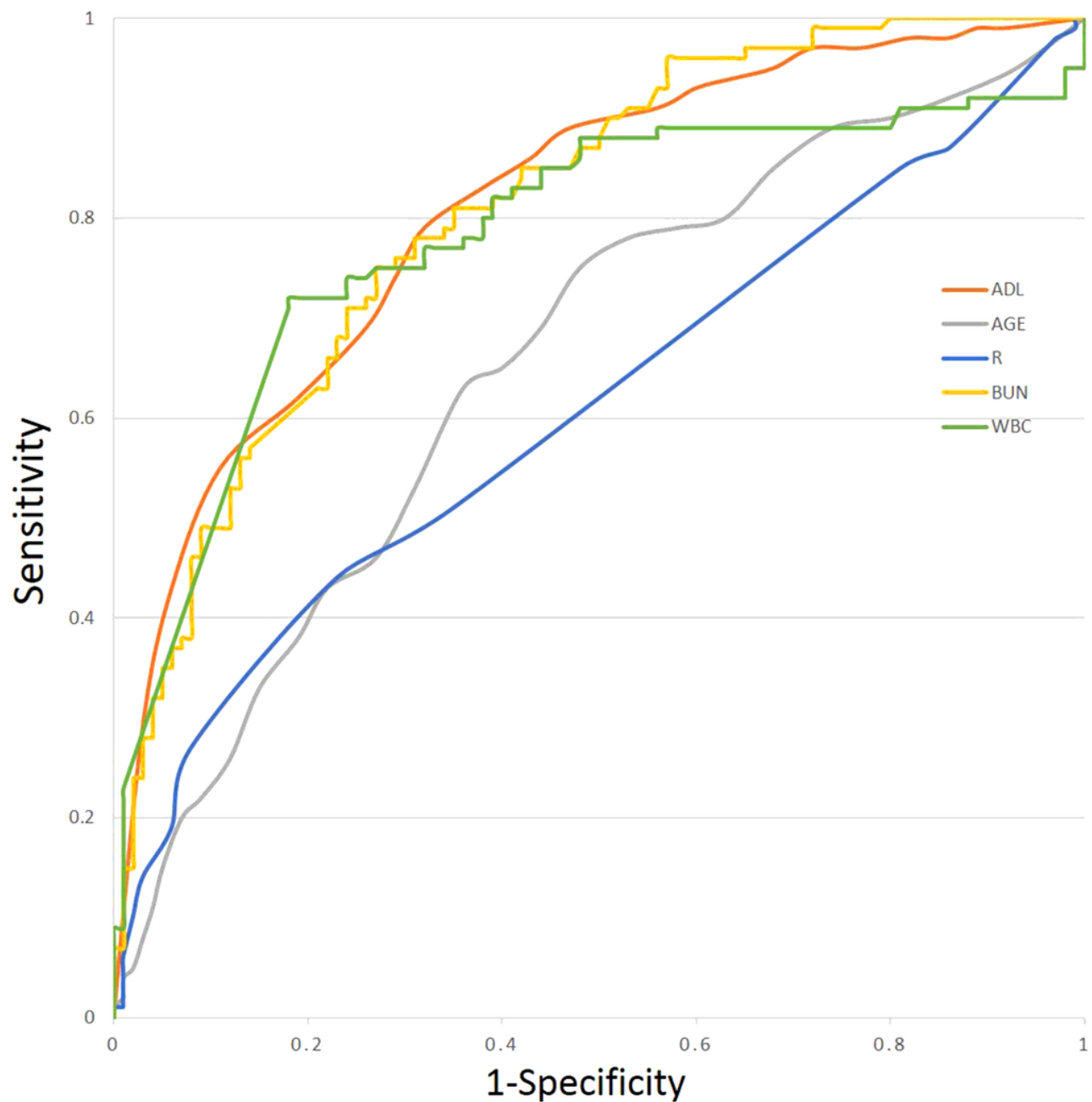
In-Hospital mortality according to BI levels

Fig.2   Receiver operating characteristic (ROC) curves of ADL, Age, Respiratory rate, BUN and WBC
for prediction of in-hospital mortality
AUC: area under curves. CI: confidence interval. ADL: activities of daily living. R: respiratory rate.
BUN: blood urea nitrogen. WBC: white blood cell.

Figure 2

Receiver operating characteristic (ROC) curve of ADL, Age, Respiratory rate, BUN and WBC for prediction of in-hospital mortility AUC:area under curve. CI:confidence interval. ADL:activities of daily living. R:respiratory rate. BUN:blood urea introgen, WBC:white blood cell