

Predictors of in-hospital mortality of older patients admitted for community-acquired pneumonia

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Abstract

Background: there were a few studies on the case mortality of pneumonia in older people, of which results were conflicting.

Objectives: this study aimed to identify risk factors associated with in-hospital mortality in older patients admitted for community-acquired pneumonia (CAP).

Design: a prospective cohort study.

Setting: hospital sample.

Subjects: during the 1-year study period (from October 2009 to September 2010), 488 older patients aged 65 or above were recruited.

Methods: demographic characteristics, medical illnesses (Charlson's comorbidity index (CCI)), premorbid functional status (Katz's index) and baseline blood tests were recorded. The outcome was in-hospital mortality.

Results: in this cohort of patients, the mean age was 81.0 years (± 7.9) and 282 (57.8%) were male. Nursing home residents accounted for 23.8% (116/488) of study subjects. The median CCI was 2 (inter-quartile range (IQR): 1–3); 60 (12.3%) patients succumbed during hospital stay. Logistic regression showed that comorbidities, mid-arm circumference, serum albumin level and severity of pneumonia (Confusion, blood Urea nitrogen, Respiratory rate and low Blood pressure (CURB) score) were independent predictors of in-hospital mortality of pneumonia.

Conclusion: in keeping with previous studies, CURB score and comorbidities were the most significant independent predictors of mortality of CAP in older patients. Our study concluded that nutritional status was also an important factor affecting their survival. This study failed to demonstrate functional status as a predictor of mortality due to limitation of Katz's index.

Keywords: pneumonia, old people, mortality, elderly

Introduction

Community-acquired pneumonia (CAP) is a common cause of medical admission. There were many studies on the association between pneumonia and short-term mortality in older patients. Some may use in-hospital mortality as the primary outcome, whereas some may use 30-day mortality. Those in Europe showed a wide range of in-hospital mortality from 6 to 26% due to different inclusion and exclusion criteria [1–6]. Meanwhile, studies in Asia revealed more consistent results with the 30-day mortality rate of 7.3–8.6% [7, 8].

There are several international guidelines on the prognostic indicators and management of CAP [9–11]. Poor prognostic factors included advancing age, multiple comorbid illnesses and severity of pneumonia. It was observed that premorbid functional status had strong bearing on the clinical outcomes of pneumonia. Previous studies agreed that those with better premorbid functional status had a shorter length of stay in hospital [12] and lower short-term and long-term case-fatality rates [1]. Poor functional status was also a risk factor for CAP in immunocompetent old persons [13].

Old people with lower body weight and recent weight loss had a greater risk of acquiring CAP [13]. It was logical to postulate that poor nutritional status was associated with worse clinical outcomes. Riquelme *et al.* compared a group of older patients suffering from CAP with the control. After matching age and gender, it was found that those with pneumonia weighed less and had lower serum protein, albumin and prealbumin levels. However, no relationship was found between nutritional parameters (triceps skinfold thickness, mid-arm perimeter and serum albumin level) and clinical outcomes (length of stay in-hospital and mortality rate) [6].

We have good knowledge on the risk factors of mortality in pneumonia. However, many previous studies did not focus on older patients, although they represented a significant portion of patients admitted for CAP, i.e. 11.0–25.3% [8, 14–16]. In particular, the effects of nutritional and functional status on mortality were not well established.

The aim of this study was to identify risk factors of in-hospital mortality for older patients admitted for CAP.

Patients and methods

Study design

This study was a prospective cohort study on older patients admitted for clinico-radiological CAP. The study was conducted in the Department of Medicine and Therapeutics of Prince of Wales Hospital. It is a 1200-bed teaching hospital of the Chinese University of Hong Kong. This hospital served 1.5 million people and had 350 medical beds. The study was conducted from October 2009 to September 2010. After the acute medical illness was settled, some patients may be transferred to another hospital, Shatin Hospital, for convalescence care. The target population was older patients with CAP requiring hospital admission.

Inclusion criteria included patients aged 65 or above with new onset of abnormal infiltrates on chest radiographs (interstitial shadowing, consolidative changes or pleural effusion) and two of three clinical features: fever (tympanic temperature $\geq 37.8^{\circ}\text{C}$), chest symptoms (shortness of breath, cough and increase in sputum production or purulence) and abnormal chest signs on physical examination (crepitations, bronchial breathing or pleural effusion).

Exclusion criteria included patients on non-oral feeding (nasogastric tube or percutaneous gastrostomy), discharged from hospital in the 14-day period prior to the index admission or with predominantly congestive heart failure on chest radiographs. Patients were represented only once in the first admission during the study period and excluded in the subsequent admissions.

Data collection

Investigators screened the newly admitted patients in medical wards every day. Eligible patients were enrolled in the study. They monitored the clinical course of every

patient until discharge from hospital or death. The decisions of investigation and treatment were at the discretion of the attending physicians. Investigators did not provide any medical intervention.

On admission, demographic characteristics, medical comorbidities, premorbid functional status, smoking and drinking history, physical examination findings and mid-arm circumference (MAC) were collected. Baseline blood tests were retrieved.

MAC was defined as the diameter of the mid-point between acromial process of the scapula and olecranal process of the elbow. Right upper arm, presumed to be the dominant side, was chosen to be the reference in this study. Instead, left upper arm would be taken for those with right upper limb amputation or right hemiplegia.

Confusion was defined as new onset of depressed consciousness level or disorientation to time, place or person. Charlson's comorbidity index (CCI) was calculated to evaluate the burden of medical illnesses [17].

CURB score (Confusion, blood Urea nitrogen, Respiratory rate and low Blood pressure) was used for assessing the severity of pneumonia. CURB score ranged from zero to four. One point was given for each if: confusion, serum urea level >7.0 mmol/l, respiratory rate (RR) $\geq 30/\text{min}$ and shock (systolic blood pressure <90 mmHg or diastolic blood pressure ≤ 60 mmHg) [9].

Katz's index is a simple, semi-quantitative two-point measurement of six basic activities of daily living (ADL): bathing, dressing, toileting, transferring, continence and feeding. For each ADL, one point was given for independence and zero point for partial or total dependence. The index ranged from zero to six. A score of six indicates total independence; four implies moderate impairment and two or less suggests severe impairment [18].

To ensure the accuracy of data collection, investigators may obtain supplementary and collateral information from patients' carers, relatives or staff members of nursing homes if patients were confused or non-communicable. This was also important in the assessment of new onset of confusion.

Clinical outcomes

Several clinical outcomes were recorded upon discharge from hospital, including in-hospital mortality, length of stay in hospital, use of mechanical ventilation, admission to intensive care unit and change in residential status upon discharge. The in-hospital mortality was chosen as the dependent variable for statistical analysis.

Data analysis

Categorical variables were presented as counts (frequency). Continuous variables with normal distribution were expressed as mean (\pm standard deviation) while those with skewed distribution as median (inter-quartile range). The associations between in-hospital mortality and other variables were analysed by Chi-square test or Fisher exact test

for categorical variables, and by Student's *t*-test or Mann–Whitney *U* test for continuous variables. Stepwise backward logistic regression was performed with variables of *P*-value <0.05. Two-tailed tests with a significance level of 5% ($\alpha = 0.05$) were used for all analyses. The Statistical Package for Social Sciences 13.0 (SPSS, Inc., Chicago, IL, USA) was used for the statistical analyses.

Consent

All data were captured from clinical notes of routine care and consent was deemed unnecessary. This study was approved by the Research Ethics Committee of the hospital.

Results

During the 1-year study period, we have screened 612 patients and 124 patients were excluded for the following reasons: on nasogastric tube feeding (16), discharged from hospital in the 14-day period prior to index admission (91) and predominant congestive heart failure on chest radiographs (17). A total of 488 patients were recruited. Their demographic characteristics, clinical parameters, routine blood test results, pneumonia severity and clinical outcomes are shown in Table 1.

The comorbid illnesses were distributed as follows: congestive heart failure (65, 13.3%), ischaemic heart disease (78, 16.0%), chronic lung diseases (186, 38.1%), diabetes (140, 28.7%), cerebrovascular accident (93, 19.1%), chronic kidney disease (75, 15.4%), chronic liver disease (12, 2.5%) and active malignancy (36, 7.4%).

Only 15.4% (75/488) of patients had renal impairment with serum creatinine level ≥ 150 $\mu\text{mol/l}$. However, estimated glomerular filtration rate (GFR), i.e. modification of diet in renal disease (MDRD), showed that over half of patients (51.2%) had renal impairment with GFR <60 ml/min. A similar percentage of patients (50.2%) had leucocytosis with WBC $\geq 10.9 \times 10^9/\text{l}$. (Results are not shown in Table 1.)

The results of univariate analysis are shown in Table 2. The significant predictors included advancing age, nursing home residence, CCI, Katz's index, RR, tachypnoea, MAC, confusion, blood urea nitrogen (BUN), urea >7 mmol/l, serum albumin level and CURB score.

Confusion, tachypnoea (and RR) and urea >7 mmol/l (and BUN) were the components of CURB score so they were not selected for multivariate analysis. All other variables were entered into multivariate analysis. There was no co-linearity between the continuous variables. Stepwise backward regression analysis showed that CCI, MAC, serum albumin level and CURB score were independent predictors of in-hospital mortality. The results are summarised in Table 3.

To summarise, severity of pneumonia was the most significant independent predictor of mortality in older patients

Table 1. Demographic characteristics, clinical parameters, investigation results, antibiotic treatment and clinical outcomes of hospitalised older patients with clinico-radiological community-acquired pneumonia ($n = 488$)

Variables ^a	Mean/median or count (%)
Demographic characteristics	
Age (year)	81.0 (± 7.9)
Gender (male:female)	282:206
Nursing home residence	116 (23.8%)
Charlson's comorbidity index (CCI)	2 (1–3)
Katz's index (range: 0–6)	6 (2–6)
On immunosuppressant	10 (2.0%)
Smoking history	
Smoker (%)	48 (9.8)
Ex-smoker (<5 years)	45 (9.2)
Ex-smoker (≥ 5 years)	145 (29.7)
Non-smoker	250 (51.2)
Drinking history (%)	
Drinker	25 (5.1)
Ex-drinker (<5 years)	16 (3.3)
Ex-drinker (≥ 5 years)	66 (13.5)
Non-drinker	381 (78.1)
Clinical parameters	
Pulse rate (b.p.m.)	99 (85–113)
Tachycardia (pulse rate ≥ 100)	243 (49.8%)
Hypotension	19 (3.9%)
Respiratory rate (breaths per minute)	20 (18–24)
Tachypnoea (RR ≥ 30 per minutes)	68 (13.9%)
Fever (temperature $\geq 37.8^\circ\text{C}$)	251 (51.4%)
MAC (cm)	23.1 (± 3.6)
Confusion	99 (20.3%)
Routine blood tests	
Sodium (mmol/l)	138 (134–141)
Urea (mmol/l)	8.8 (5.3–9.8)
Urea >7 mmol/l	257 (52.7%)
Creatinine ($\mu\text{mol/l}$)	94 (74–124)
MDRD ^b (ml/min)	60 (43–77)
Albumin (g/l)	35 (31–38)
White cell counts ($\times 10^9/\text{l}$)	10.9 (8.2–14.7)
Alanine dehydrogenase, ALT (U/l)	18 (13–29)
Pneumonia severity	
CURB score (range: 0–4) (%)	1 (0–1)
0	181 (37.1)
1	195 (40.0)
2	88 (18.0)
3	21 (4.3)
4	3 (0.6)
Clinical outcomes (%)	
In-hospital mortality	60 (12.3)
ICU admission	7 (1.4)
Non-invasive mechanical ventilation	84 (17.2)
Length of stay (days)	10 (6–20)
Change in residential status	10 (2.0)

^aContinuous variables were expressed as mean (\pm SD) or median (IQR) and categorical variables as counts (frequency).

^bMDRD, modification of diet in renal disease—an estimation of glomerular filtration rate (GFR) based on the age, gender and serum creatinine level.

with pneumonia. Comorbidity was also an important predictive factor. Poor nutritional parameters (smaller MAC and lower serum albumin level) were less significant factors.

Table 2. Univariate analysis of risk factors associated with in-hospital mortality

Variables ^a	Survivors (<i>n</i> = 428)	Death cases (<i>n</i> = 60)	<i>P</i> -value
Demographic characteristics			
Age (year)	80.6 (±7.8)	84.0 (±7.8)	0.002
Gender (male:female)	249:179	33:27	0.641
Nursing home residence	89 (20.8%)	27 (45%)	<0.001
CCI	2 (1–3)	3 (2–5)	<0.001
Katz's index	6 (4–6)	1 (0–4)	<0.001
On immunosuppressant	9 (2.1%)	1 (1.7%)	1.00
Smoking history			
Smoker	47 (11.0%)	1 (1.7%)	0.102
Ex-smoker (<5 years)	40 (9.3%)	5 (8.3%)	
Ex-smoker (≥5 years)	128 (29.9%)	17 (28.3%)	
Non-smoker	213 (49.8%)	37 (61.7%)	
Drinking history			
Drinker	22 (5.1%)	3 (5.0%)	0.842
Ex-drinker (<5 years)	15 (3.5%)	1 (1.7%)	
Ex-drinker (≥5 years)	59 (13.8%)	7 (11.7%)	
Non-drinker	332 (77.6%)	49 (81.7%)	
Clinical parameters			
Pulse rate	100 (85–113)	98 (87–115)	0.820
Tachycardia	214 (50.0%)	29 (48.3%)	0.809
Shock	15 (3.5%)	4 (6.7%)	0.274
Respiratory rate	20 (18–24)	26 (22–30)	<0.001
Tachypnoea	49 (11.4%)	19 (31.7%)	<0.001
Fever (temp ≥37.8°C)	226 (52.8%)	25 (41.7%)	0.106
MAC (cm)	23.6 (±3.4)	19.9 (±3.4)	<0.001
Confusion	61 (14.3%)	38 (63.3%)	<0.001
Laboratory results			
Sodium (mmol/l)	138 (134–140)	138 (133–142)	0.567
Urea (mmol/l)	6.9 (5.1–9.1)	10.6 (6.9–17.3)	<0.001
Urea >7 mmol/l	212 (49.5%)	45 (75.0%)	<0.001
Creatinine (μmol/l)	93 (75–118)	112 (66–182)	0.087
MDRD ^b (ml/min)	61 (45–77)	51 (27–86)	0.058
Albumin (g/l)	35 (32–38)	30 (25–33)	<0.001
WCC (×10 ⁹ /l)	11.0 (8.1–14.9)	10.8 (8.5–13.9)	0.666
ALT (U/l)	18 (13–29)	17 (10–25)	0.339
Pneumonia severity			
CURB score	1 (0–1)	2 (1–2)	<0.001
Length of stay (days)	10 (6–20)	9 (4–18)	0.165

^aContinuous variables were expressed as mean (±SD) or median (IQR) and categorical variables as counts (frequency).

^bMDRD, modification of diet in renal disease—an estimation of glomerular filtration rate (GFR) based on the age, gender and serum creatinine level.

Table 3. Logistic regression analysis of risk factors associated with the in-hospital mortality

Variables	Relative risk (95% CI)	<i>P</i> -value
Nursing home residence	1.178 (0.486–2.856)	0.717
Age	1.011 (0.962–1.063)	0.654
Katz's index	0.923 (0.792–1.076)	0.923
CCI	1.596 (1.338–1.904)	<0.001
MAC	0.729 (0.645–0.823)	<0.001
Albumin	0.875 (0.817–0.936)	<0.001
CURB score	2.583 (1.733–3.851)	<0.001

Discussion

Our study revealed that the in-hospital mortality rate was 12.3%. CURB score and comorbidities were the most powerful predictive factors of mortality of pneumonia. Nutritional parameters (serum albumin level and MAC) were less significant predictors.

CURB score is originally designed to predict the 30-day mortality. However, our hospital has a high turnover rate of patients and a short length of stay. The median LOS was 10 days in our study. They may be discharged from hospital after recovery and readmitted for another illness on the Day 30 of index admission. Thus, we have used the in-hospital mortality as the outcome. In our study, the 30-day mortality rate was 11.3% (55/488) which was comparable with the in-hospital mortality rate.

The in-hospital mortality rate of our study was in keeping with the findings of European studies [1–6]. A similar cohort study in Hong Kong had a younger mean age of 72 years and a lower 30-day mortality rate of 8.6% [8]. This figure was slightly lower than our finding. The difference was due to the lower case-fatality rate in patients younger than 65 years old. This notion was supported by the higher 30-day mortality rate of CAP in those aged 65 or above than those younger than 65 (10.3 versus 2.2%) in the study conducted by Kothe *et al.* [14].

Compared with their community-dwelling counterparts, nursing home residents usually have more medical illnesses, a higher degree of disability and poorer nutritional status. In our study, they had a higher CCI (2.5 versus 2.0, *P* = 0.003), lower Katz's score (1 versus 6, *P* < 0.001), lower serum albumin level (33 versus 35, *P* < 0.001) and smaller MAC (21.0 versus 23.5, *P* < 0.001). Previous studies demonstrated that nursing home residence was a risk factor of case-fatality of pneumonia [4, 14]. However, Lim and Macfarlane showed that, after adjusting for confounding factors, residence in nursing home was not a risk factor. The difference in mortality was attributed to poorer functional status in nursing home residents [19].

This study failed to prove that poor functional status was a risk factor for case fatality. This was likely due to the severe ceiling effect of Katz's index. In this cohort of patients, Katz's score had a right-sided skewed distribution that the mean and median Katz's score were 4.4 and 6, respectively. Furthermore, Katz's index can only assess basic ADL. In contrast, a study, which used Barthel index (BI) to assess functional status, concluded that good functional status was a protective factor against the 30-day mortality [1]. BI is the most commonly used scale to assess basic and instrumental functional status of older people by allied health professionals. It is sensitive enough to detect small differences in functional status.

Our study demonstrated that good nutritional status was a protective factor against case-fatality of pneumonia in older patients. Both MAC and serum albumin level were shown to be predictors of mortality. However, serum albumin is not a good marker for nutrition and is in fact an

acute phase reactant (negative) whose production by the liver reduces acutely during inflammatory conditions. In contrast, MAC depends on the muscle bulk and subcutaneous fat thickness that it remains static in the initial phase of acute illnesses. Physiologically, MAC is a better surrogate marker of nutritional status than serum albumin level. Practically, measurement of MAC with a tape does not incur any extra cost in clinical practice or research. Therefore we would recommend the use of MAC as a surrogate marker of nutritional status. One may argue that body mass index (BMI) is even a better marker than MAC. However, BMI calculation involves measurement of body weight and height, which may not be feasible in clinical practice, especially in frail old persons. Osteoporosis may further complicate the calculation of BMI due to loss of vertebral height. A randomised controlled trial demonstrated that nutritional supplementation in older patients admitted for pneumonia achieved a faster and greater physical and functional recovery [20]. Therefore, nutritional assessment is not only important for prognostication, but also for treatment of elderly people with pneumonia.

CURB score is the most commonly used scoring system to assess pneumonia severity. Pneumonia severity index (PSI) is also commonly used to predict pneumonia severity and mortality [21]. However, it may not be applicable to every patient because arterial blood gas would not be taken in those with less severe pneumonia. Recently, Myint *et al.* proposed that another scoring system, SOAR (Systolic blood pressure, Oxygenation, Age and Respiratory rate) be used in older patients with CAP [22]. Further studies are needed to validate this new scoring system in other groups of patients.

The non-invasive ventilation rate was higher (17.2%) than those reported in previous studies, i.e. 3.1–7.6% [3, 4, 7]. This was due to the hospital policy on mechanical ventilation and intensive care. Invasive mechanical ventilation is only provided in intensive care unit. To avoid invasive ventilation, clinicians usually offer a trial of non-invasive ventilation in the general medical wards for the majority of older patients with severe pneumonia. Human swine flu pandemic further increased the number of medical admission for severe pneumonia requiring ventilatory support.

This study had several limitations. First, it was a single-centre study with non-probability sampling. Second, the use of antibiotics before admission was not asked. Third, the association between aspiration and pneumonia was not assessed in this study. Fourth, the amounts of smoking and drinking were not considered, which may be related to case mortality of pneumonia. Lastly, our study has a slightly higher portion of patients with less severe pneumonia (CURB score ≤ 1) compared with previous studies [16, 23]. This was probably due to a lower threshold of medical admission of patients with pneumonia as a result of change in infectious disease policy after the human swine flu pandemic. Social reasons also play a significant role in medical admission. The in-hospital mortality rate may be low compared with other studies which had fewer patients with less severe pneumonia.

To conclude, this study confirmed that CURB score was the most important independent predictor of mortality in pneumonia. In addition, nutritional parameters (serum albumin and MAC) were also significant predictors.

Key points

- A great majority of patients hospitalised for CAP are older patients. Advancing age and nursing home residence are not risk factors of mortality.
- In addition to pneumonia severity, comorbidities and nutritional status are also significant prognostic factors.
- We recommend that a clinical prediction rule be designed for prognostication of in-hospital mortality of older patients hospitalised for CAP, incorporating CURB score, CCI and MAC in future studies. Functional status may also be included provided that it is represented by a robust ADL index.

Conflicts of interest

None declared.

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