Acute Myocardial Infarction During Hospitalization for Community-Acquired Pneumonia in Geriatric Patients: A Cross-Sectional Study

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Research article

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Abstract

**Background:** Community-acquired pneumonia (CAP) and acute myocardial infarction cardiovascular (AMI) are two important health issues in elderly. Little is known regarding characteristics of AMI in elderly hospitalized for CAP. Therefore, we investigated the prevalence, characteristics compared with younger patients, impact on clinical outcomes and risk factors of AMI during hospitalization for CAP in geriatric patients.

**Methods:** 11009 adult inpatients consisted of 5111 elderly patients ≥ 65 years and 5898 patients < 65 years in respiratory ward and 1095 inpatients ≥65 years in geriatrics ward diagnosed with CAP were retrospectively analyzed by electronic medical records.

**Results:** 159 (3.1%) elderly patients in respiratory ward and 77 (7.0%) patients in geriatrics ward experienced AMI during hospitalization for CAP. AMI were more frequently seen in elderly patients (3.1% vs. 1.0 %). Patients ≥65 years who experienced AMI during hospitalization for CAP had higher percentage of respiratory failure (P = 0.001), hypertension (P = 0.008), dyspnea (P=0.046), blood urea nitrogen (BUN) ≥7mmol/L (P < 0.001), serum sodium <130 mmol/L(P = 0.005) and had higher in-hospital mortality compared to patients <65 years (10.1% vs. 6.6%). AMI was associated with increased in-hospital mortality (odds ratio, OR, with 95% confidence interval: 1.49 [1.24-1.82]; P<0.01). Respiratory failure (OR, 1.34 [1.15–1.54]; P<0.01), preexisting coronary artery disease (OR, 1.31[1.07–1.59]; P = 0.02), diabetes (OR, 1.26 [1.11–1.42]; P = 0.02), BUN (OR, 1.23 [1.01–1.49]; P = 0.04), and impaired consciousness (OR, 1.19 [1.07–1.32]; P = 0.03) were correlated with the occurrence of AMI in the elderly.

**Conclusions:** The incidence of AMI during CAP hospitalization in geriatric patients is notable and have an impact on in-hospital mortality. Characteristics of the elderly differ from the general population. Particular attention should be paid to elderly patients with risk factors for AMI. Our study may represent useful information for clinical strategies aimed at preventing AMI and decreasing mortality in geriatric patients hospitalization for CAP.

**Background**

The growing proportion of older adults provides a compelling reason for an increased focus on public health problems of older people. Community-acquired pneumonia (CAP) and acute myocardial infarction cardiovascular (AMI) are two major public health issues in elderly. It is estimated that incidence of CAP patients ≥ 65 years old was 140 cases per 10,000 persons per year and 105 cases per 10,000 for hospitalized\[^1\]. The mortality rate for CAP has been decreasing after the introduction of antibiotics, even so, high mortality still in the elderly. Mortality in geriatric patients with CAP may be 25% higher than in the general population (10%) \[^2,3\]. The incidence and mortality risk in CAP are linked to increasing age and the presence of age-related comorbidities and complications. Thus, there is a clear need to recognize the life-threatening complications among geriatric patients with CAP.
A link between acute infections and the development of cardiovascular complications has been proposed [4–9]. Pneumonia contributes to the acute worsening of pre-existing cardiac conditions and can trigger new cardiac events. Moreover, a higher likelihood of a poorer outcome in a patient with CAP complicated by an acute cardiovascular event [10]. Cardiovascular complications represent a heavy burden on the course and outcomes of patients admitted to hospital with CAP. Recent clinical observations suggest that acute cardiovascular complications are more frequent in high-risk CAP patients. The elderly people are at high risk of CAP. An increase in pneumonia hospital admissions and potentially deaths mainly due to the ageing population [11], a population that is also at the highest risk for cardiovascular diseases. Cardiovascular complications after pneumonia including new or worsening heart failure, new or worsening arrhythmias and AMI. Hitherto, reports of cardiovascular complications after CAP were mostly focus on heart failure, few about AMI, which is a life-threatening complication. In particularly, systematically studied of geriatric patients are unavailable to date.

Despite AMI after CAP in geriatric patients is a worthy concern, little is known regarding the clinical characteristics of the elderly. Therefore, our study aimed to determine the prevalence, characteristics compared with younger patients, impact on clinical outcomes and risk factors of AMI during hospitalization for CAP in geriatric patients.

**Methods**

**Study population and data collection**

We identified a total of the 11009 patients who were diagnosed with CAP and age ≥ 18 years was hospitalized in the respiratory ward of Beijing Chao-yang Hospital between June 2012 and June 2020, Of these, there were 5111 patients ≥ 65 years. While, 1095 patients were admitted to the geriatrics ward were retrospectively and consecutively analyzed. Beijing Chao-Yang Hospital has 1,900 beds including 196 beds in the respiratory department and 62 beds in the geriatrics department. Beijing Chao-Yang Hospital not only has the Beijing Institute of respiratory diseases, well-recognized at the national level, but also houses one of the key construction geriatrics wards in Beijing.

The 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 (body temperature, respiratory rate, blood pressure, heart rate, mental status and percutaneous oxygen saturation) and laboratory findings on hospital admission. In our center, clinical information collection and laboratory examinations were performed during the first 24 hours after admission and according to standards of practice.

**Diagnosis and Definitions**

**Diagnosis of CAP**
CAP was diagnosed in our center according with the IDSA/ATS guidelines: 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.

**Diagnosis of AMI**

AMI that occurred at any time during hospitalization for pneumonia was included. In our center, AMI were diagnosed according to the following criteria: detection of troponin with at least one value above the 99th percentile of the upper reference limit together with evidence of myocardial ischaemia with at least one of the following: (1) symptoms of ischaemia: including chest pain, chest tightness and other symptoms; (2) acute electrocardiographic changes of new ischaemia (ST segment and T wave changes or new left bundle branch block); (3) new pathological Q-waves in the electrocardiographic; or (4) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality. Diagnosis of AMI was done by cardioligist consultation in the respiratory ward. Meanwhile, in geriatrics ward, most of the decision was made by the geriatrician and partly by cardiologist consultation.

**Other Clinical Characteristics**

The main outcome was the in-hospital mortality. In-hospital mortality was depended on vital status at discharge including death by any cause occurred during hospital stay. In addition, we also investigated the length of hospital stay, length of hospital stay was considered as the number of days from the date of admission to the date of discharge. The proportion of patients who developed respiratory failure or required ventilator use in patients with and without AMI during hospitalization were compared. Diagnostic criteria for respiratory failure were as follows: PO2 < 60 mmHg, with or without PCO2 ≥ 45 mmHg, under room air according to blood gas analysis on admission. Ventilator use including invasive mechanical ventilation (IMV) or non-invasive ventilation (NIV).

**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 occurrence of AMI during hospitalization for pneumonia in the elderly and investigated the relationship between AMI and the in-hospital mortality, logistic regression analysis was performed. The odds ratios (OR) with 95% confidence intervals (CI) were presented.

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. Clinical characteristics of geriatric patients who experiencing AMI and those who without AMI during CAP hospitalization

There were 5111 patients in the respiratory ward and 1095 patients in geriatrics ward hospitalized for CAP and aged ≥ 65 years. 159(3.1%) experienced AMI during hospitalization in respiratory ward and 77(7.0%) in geriatrics ward. A total of 236 patients developed AMI among the 6206 geriatric patients, the overall incidence of AMI in geriatric patients during CAP hospitalization in our study was 3.8%. Among patients who experienced AMI in geriatrics ward, 58 (75.3%) had a non-ST segment elevation myocardial (NSTEMI), on the other hand, this was unclear due to incomplete data in the respiratory ward.

The clinical characteristics of geriatric patients who experiencing AMI and those who without AMI during CAP hospitalization are shown in Table 1. Comparison to patients without AMI, whether in respiratory ward or geriatrics ward, those geriatric patients with AMI during CAP hospitalization were older (P < 0.001, P < 0.001, respectively) and showed a higher prevalence of respiratory failure (P = 0.001, P = 0.021, respectively) and required ventilator use (P < 0.001, P = 0.001, respectively), had longer hospital stays (P = 0.023, P = 0.030, respectively) Additionally, a high proportion of patients presenting chief complaint of chest pain (P = 0.030, P = 0.004, respectively), heart rate ≥ 125 bpm (P < 0.001, P = 0.015, respectively), BUN ≥ 7 mmol/L (P < 0.001, P < 0.001, respectively), PLT < 10.0 × 10⁹/L (P < 0.001, P = 0.002, respectively), serum sodium < 130 mmol/L (P < 0.001, P = 0.011, respectively), blood glucose ≥ 14 mmol/L (P < 0.001, P = 0.034, respectively) on hospital admission and longer length of hospital stay was observed in elderly patients with AMI both in respiratory ward and geriatrics ward. Moreover, we noted that there were a higher percentage of males (P = 0.001), preexisting coronary artery disease (P < 0.001), hypertension (P = 0.001), hypercholesterolemia (P < 0.001), chronic heart failure (P = 0.003), cerebrovascular disease (P = 0.001), chief complaint of dyspnea (P < 0.001), abnormal blood pressure (P < 0.001) or body temperature (P = 0.003) on admission in elderly patients with AMI during CAP hospitalization in the respiratory ward. While, the proportions of patients who had impaired consciousness (P < 0.001), respiratory rate ≥ 30/min (P = 0.028), abnormal white blood cell count (P < 0.001) and PH < 7.35 (P = 0.001) was higher in patients who experiencing AMI compared with those who without AMI during hospitalized for CAP in the geriatrics ward.
Table 1
Clinical characteristics of geriatric patients who experiencing AMI and those who without AMI during CAP hospitalization

| Characteristic | Patients in respiratory ward, n = 5111 | Patients in geriatrics ward, n = 1095 |
|----------------|----------------------------------------|---------------------------------------|
|                | AMI, n = 159                           | Without AMI, n = 4952                  | AMI, n = 77                           | Without AMI, n = 1018 | P value* |
| Age, years     | 76.7 ± 6.9                             | 73.9 ± 6.6                            | 85.8 ± 5.6                            | 83.1 ± 7.3            | 0.001    |
| Male, n (%)    | 112 (62.1)                             | 2847 (57.5)                           | 56 (72.7)                             | 649 (63.8)            | 0.138    |
| Comorbid conditions, n (%) | | | | |
| Smoking        | 67 (42.1)                              | 2618 (52.9)                           | 25 (32.5)                             | 372 (36.5)            | 0.617    |
| Preexisting coronary artery disease | 67 (42.1)                              | 877 (17.7)                           | 23 (29.9)                             | 258 (25.3)            | 0.417    |
| COPD           | 26 (16.4)                              | 667 (13.5)                            | 15 (19.5)                             | 228 (22.4)            | 0.866    |
| Lung cancer    | 16 (10.1)                              | 463 (9.3)                             | 7 (9.1)                               | 102 (10.0)            | 0.812    |
| Diabetes       | 65 (40.9)                              | 1031 (20.8)                           | 35 (45.5)                             | 334 (32.8)            | 0.033    |
| Hypertension   | 99 (62.3)                              | 2409 (48.6)                           | 23 (29.9)                             | 347 (34.1)            | 0.523    |
| Hypercholesterolemia | 29 (18.2)                              | 432 (8.7)                             | 62 (80.5)                             | 873 (85.8)            | 0.239    |
| Chronic heart failure | 6 (3.8)                                | 40 (0.8)                              | 27 (35.1)                             | 355 (34.8)            | 0.936    |
| Cerebrovascular disease | 22 (13.8)                              | 327 (6.6)                             | 16 (20.8)                             | 187 (18.4)            | 0.648    |
| Chronic renal failure | 6 (3.8)                                | 85 (1.7)                              | 10 (12.9)                             | 69 (6.8)              | 0.062    |
| Chronic liver disease | 6 (3.8)                                | 145 (2.9)                             | 5 (6.5)                               | 37 (3.6)              | 0.211    |

*For comparisons between AMI group and Without AMI group. Data are presented as mean (standard deviation) or %. AMI: acute myocardial infarction. CAP: community-acquired pneumonia. COPD: chronic obstructive pulmonary disease. IMV: invasive mechanical ventilation. NIV: non-invasive ventilation. 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. HCT: hematocrit.
| Characteristic                          | Patients in respiratory ward, n = 5111 | Patients in geriatrics ward, n = 1095 |
|----------------------------------------|---------------------------------------|---------------------------------------|
|                                       | Patients | (%)          | Patients | (%)          | p-value | Patients | (%)          | Patients | (%)          | p-value |
| Fever                                  | 95 (59.7)| 3170 (64.0) | 11(14.3) | 321(31.5)   | 0.276   | 3170 (64.0) | 11(14.3) | 321(31.5)   | 0.276   |
| Cough and expectoration                | 79 (49.7)| 2362 (47.7) | 24(31.2) | 395(38.8)   | 0.629   | 2362 (47.7) | 24(31.2) | 395(38.8)   | 0.629   |
| Chest pain                             | 13 (8.2) | 222 (4.5)   | 9(11.7)  | 38(3.8)     | 0.030   | 222 (4.5)   | 9(11.7)  | 38(3.8)     | 0.030   |
| Dyspnea                                | 42(26.4) | 693 (13.9)  | 64(83.1) | 884(86.8)   | <0.001  | 693 (13.9)  | 64(83.1) | 884(86.8)   | <0.001  |
| Duration of symptoms                   | 6.9 ± 6.7| 7.17 ± 7.0  | 5.6 ± 4.9| 5.1 ± 7.0   | 0.927   | 7.17 ± 7.0  | 5.6 ± 4.9| 5.1 ± 7.0   | 0.716   |

**Clinical data, n (%)**

|                          | Patients | (%)          | Patients | (%)          | p-value | Patients | (%)          | Patients | (%)          | p-value |
|--------------------------|----------|--------------|----------|--------------|---------|----------|--------------|----------|--------------|---------|
| NIV/IMV                  | 17 (10.7)| 155 (3.1)   | 7(9.1)   | 16(1.6)     | 0.001   | 155 (3.1) | 7(9.1)     | 16(1.6) | 0.001        |
| Respiratory failure      | 41(25.8) | 776(15.7)   | 28(36.3) | 253(24.9)   | 0.001   | 776(15.7) | 28(36.3)  | 253(24.9) | 0.001   |
| Impaired consciousness   | 3 (1.9)  | 40 (0.8)    | 13(16.9) | 46(4.5)     | <0.001  | 40 (0.8)  | 13(16.9)  | 46(4.5)  | <0.001  |
| Respiratory rate ≥ 30/min| 4(2.5)   | 55(1.1)     | 2(2.6)   | 13(1.3)     | 0.110   | 55(1.1)   | 2(2.6)     | 13(1.3)  | 0.028   |
| SBP < 90 mmHg or DBP ≤ 60 mmHg | 19(11.9) | 12(0.2)     | 10(12.9) | 133(13.1)   | 0.576   | 12(0.2)   | 10(12.9)  | 133(13.1) | 0.576   |
| T < 36°C or ≥ 40°C       | 2(1.3)   | 4(0.1)      | 2(2.6)   | 4(0.4)      | 0.061   | 4(0.1)    | 2(2.6)     | 4(0.4)   | 0.061   |
| Heart rate ≥ 125 bpm.    | 2(1.3)   | 45(0.9)     | 5(6.5)   | 17(1.7)     | 0.015   | 45(0.9)   | 5(6.5)     | 17(1.7)  | 0.015   |
| BUN ≥ 7 mmol/L           | 95(59.7) | 1412(28.5)  | 67(87.0) | 610(59.9)   | <0.001  | 1412(28.5)| 67(87.0)  | 610(59.9) | <0.001  |
| WBC < 4.0 × 10^9/L or ≥ 10.0 × 10^9/L | 71(44.7) | 2319(46.8)  | 26(33.8) | 72(7.1)     | <0.001  | 2319(46.8)| 26(33.8)  | 72(7.1)  | <0.001  |
| PLT < 10.0 × 10^9/L      | 14(8.8)  | 7(0.1)      | 4(5.2)   | 5(0.5)      | 0.002   | 7(0.1)    | 4(5.2)     | 5(0.5)   | 0.002   |
| PH < 7.35                | 15(9.4)  | 447(9.0)    | 17(22.1) | 2(0.2)      | 0.001   | 447(9.0)  | 17(22.1)  | 2(0.2)   | 0.001   |
| Serum sodium < 130 mmol/L| 50(31.4) | 903(18.2)   | 29(37.7) | 274(26.9)   | 0.011   | 903(18.2) | 29(37.7)  | 274(26.9) | 0.011   |
| HCT < 30%                | 21(13.2) | 491(9.9)    | 8(10.4)  | 68(6.7)     | 0.157   | 491(9.9)  | 8(10.4)   | 68(6.7)  | 0.157   |
| Blood glucose ≥ 14 mmol/L | 11(6.9)  | 74(1.5)     | 36(46.8) | 362(35.6)   | 0.034   | 74(1.5)   | 36(46.8)  | 362(35.6) | 0.034   |

*For comparisons between AMI group and Without AMI group. Data are presented as mean (standard deviation) or %. AMI: acute myocardial infarction. CAP: community-acquired pneumonia. COPD: chronic obstructive pulmonary disease. IMV: invasive mechanical ventilation. NIV: non-invasive ventilation. 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. HCT: hematocrit.*
2. Comparison of the characteristics between elderly patients and non-elderly patients who experiencing AMI during CAP hospitalization

In a further analysis, patients ≥ 65 years were compared with those patients <65 years experiencing AMI during CAP hospitalization(Table 2). We identified a total of the 11009 patients who were diagnosed with CAP and age ≥ 18 years was hospitalized in the respiratory ward, consisted of 5111 elderly patients ≥ 65 years and 5898 patients <65 years. 159 patients ≥ 65 years and 61 patients <65 years experienced AMI during hospitalization for CAP in respiratory ward. As shown in Fig. 1, AMI after CAP were more frequently seen in elderly patients (3.1% vs. 1.0%).
Table 2
Comparison of clinical characteristics between ≥ 65 years and < 65 years inpatients with CAP experiencing AMI

| Characteristic                                      | ≥ 65 years, n = 159 | <65 years, n = 61 | P value* |
|-----------------------------------------------------|---------------------|-------------------|----------|
| **Age, years**                                      | 76.7 ± 6.9          | 57.8 ± 5.2        | <0.001   |
| **Male, n (%)**                                     | 112 (62.1)          | 56(91.8)          | 0.012    |
| **Comorbid conditions, n (%)**                      |                     |                   |          |
| Smoking                                             | 67 (42.1)           | 54(88.5)          | <0.001   |
| Preexisting coronary artery disease                 | 67 (42.1)           | 39(63.9)          | 0.768    |
| COPD                                                | 26 (16.4)           | 9(14.8)           | 0.968    |
| Lung cancer                                         | 16 (10.1)           | 3(4.9)            | 0.203    |
| Diabetes                                            | 65(40.9)            | 43(70.5)          | <0.001   |
| Hypertension                                        | 99 (62.3)           | 29(47.5)          | 0.008    |
| Hypercholesterolemia                                | 29 (18.2)           | 24(39.3)          | 0.002    |
| Chronic heart failure                               | 6 (3.8)             | 1(1.6)            | 0.376    |
| Cerebrovascular disease                             | 22 (13.8)           | 4(6.6)            | 0.115    |
| Chronic renal failure                               | 6 (3.8)             | 1(1.6)            | 0.376    |
| Chronic liver disease                               | 6 (3.8)             | 5(8.2)            | 0.300    |
| **Clinical symptoms of chief complaint on admission, n (%)** | | | |
| Fever                                               | 95 (59.7)           | 46(75.4)          | 0.224    |
| Cough and expectoration                             | 79 (49.7)           | 40(65.6)          | 0.143    |
| Chest pain                                          | 13 (8.2)            | 12(42.1)          | 0.018    |
| Dyspnea                                             | 42(26.4)            | 9(14.8)           | 0.046    |
| Duration of symptoms                                | 6.9 ± 6.7           | 5.2 ± 3.8         | 0.589    |
| **Clinical data, n (%)**                            |                     |                   |          |
| NIV/IMV                                             | 17 (10.7)           | 4(6.6)            | 0.255    |

*For comparisons between ≥ 65 years group and < 65 years group. Data are presented as mean (standard deviation) or %

AMI: acute myocardial infarction. CAP: community-acquired pneumonia. 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.
| Characteristic                                | ≥ 65 years, n = 159 | <65 years, n = 61 | P value* |
|----------------------------------------------|---------------------|-------------------|----------|
| Respiratory failure                         | 41(25.8)            | 6(9.8)            | 0.001    |
| Impaired consciousness                       | 3 (1.9)             | 0(0.0)            | 0.376    |
| Respiratory rate ≥ 30/min                   | 4(2.5)              | 1(1.6)            | 0.575    |
| SBP < 90 mmHg or DBP ≤ 60 mmHg              | 19(11.9)            | 7(11.5)           | 0.596    |
| T < 36°C or ≥ 40°C                          | 2(1.3)              | 2(3.3)            | 0.308    |
| Heart rate ≥ 125 bpm.                       | 2(1.3)              | 1(1.6)            | 0.108    |
| BUN ≥ 7 mmol/L                              | 95(59.7)            | 14(22.9)          | 0.000    |
| WBC < 4.0 × 109/L or ≥ 10.0 × 109/L         | 71(44.7)            | 41(67.2)          | 0.002    |
| PLT < 10.0 × 109/L                          | 14(8.8)             | 5(8.2)            | 0.562    |
| PH < 7.35                                   | 15(9.4)             | 2(3.3)            | 0.106    |
| Serum sodium < 130 mmol/L                   | 50(31.4)            | 8(13.1)           | 0.005    |
| HCT < 30%                                   | 21(13.2)            | 6(9.8)            | 0.333    |
| Blood glucose ≥ 14 mmol/L                   | 11(6.9)             | 6(9.8)            | 0.319    |
| Pleural effusion                            | 122 (76.7)          | 53(86.9)          | 0.482    |
| **Pathogens**                               |                     |                   |          |
| Bacterial pneumonia                         | 126 (79.2)          | 49 (80.3)         | 0.892    |
| Viral pneumonia                             | 3 (1.9)             | 2(3.3)            | 0.425    |
| Fungal pneumonia                            | 8 (5.0)             | 3(4.9)            | 0.638    |
| **Died during hospital stay, n (%)**        | 16 (10.1)           | 4(6.6)            | 0.301    |
| **Length of stay, days**                    | 13.8 ± 8.9          | 12.3 ± 7.4        | 0.328    |

*For comparisons between ≥ 65 years group and < 65 years group. Data are presented as mean (standard deviation) or %.

AMI: acute myocardial infarction. CAP: community-acquired pneumonia. 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.

We noted that higher proportion patients suffer from respiratory failure in elderly patients (P = 0.001). More patients ≥ 65 years had hypertension (P = 0.008) and dyspnea (P = 0.046). Moreover, BUN ≥ 7 mmol/L (P < 0.001), serum sodium < 130 mmol/L (P = 0.005) were more frequently present in patients ≥
On the other hand, those patients 65 years had higher percentage of male (P = 0.012), smoking history (P < 0.001), diabetes (P < 0.001), hypercholesterolemia (P = 0.002), chest pain (P = 0.019) and abnormal white blood cell count (P = 0.002). As shown in Fig. 1, patients ≥ 65 years had a higher in-hospital mortality compared to patients <65 years (10.1% vs. 6.6%).

3. Association between incidence of AMI during CAP hospitalization and in-hospital mortality

As shown in Fig. 1, in-hospital mortality was higher among elderly patients hospitalized with CAP in the respiratory ward who developed AMI compared to those who did not (10.1% vs. 2.4%). We also investigated the association between incidence of AMI during CAP hospitalization and in-hospital mortality using logistic regression, the occurrence of AMI and Age as the independent variable and patient's vital status at discharge as the dependent variable.

In logistic regression model (Fig. 2), the development of AMI was associated with an increase in the risk of death during CAP hospitalization, AMI during hospitalization showed an OR for in-hospital mortality of 1.49 (95% CI: 1.24–1.82; P < 0.01). This association remained significant after adjustment for Age (OR, 1.47; 95% CI, 1.32–1.64; P < 0.01) and for respiratory failure (OR, 1.31; 95% CI, 1.25–1.36; P < 0.01). Conversely, we did not identify evidence of an association between in-hospital mortality and MI in people aged < 65 years. Similar meaningful statistical results could not be obtained.

4. Risk factors correlated with the occurrence of AMI during hospitalization for pneumonia in the elderly patients

The logistic regression analysis of risk factors for AMI during hospitalization in the elderly patients is shown in Table 3. Input variables for logistic regression analysis were selected from significant variables obtained from the univariate analysis. In 5111 elderly patients ≥ 65 years in the respiratory ward, respiratory failure (OR, 1.34; 95% CI, 1.15–1.54; p < 0.01), preexisting coronary artery disease (OR, 1.31; 95% CI, 1.07–1.59; p = 0.02), diabetes (OR, 1.26; 95% CI, 1.11–1.42; p = 0.02), BUN (OR, 1.23; 95% CI, 1.01–1.49; p = 0.04) were significantly correlated with the occurrence of AMI, as shown in Table 3. In 1095 geriatric patients in geriatrics ward, logistic regression analysis showed that impaired consciousness (OR, 1.19; 95% CI, 1.07–1.32; P = 0.03) and respiratory failure (OR, 1.29; 95% CI, 1.19–1.41; P = 0.01) were independent risk factors for the occurrence of AMI.
Table 3
Logistic regression analyses of risk factors for AMI during hospitalization in geriatric patients with CAP*

| Characteristics                        | OR (95% CI)       | P value |
|----------------------------------------|-------------------|---------|
| Patients in respiratory ward           |                   |         |
| Respiratory failure                    | 1.34(1.15–1.54)   | 0.01    |
| Preexisting coronary artery disease    | 1.31(1.07–1.59)   | 0.02    |
| Diabetes                               | 1.26(1.11–1.42)   | 0.02    |
| BUN                                    | 1.23(1.01–1.49)   | 0.04    |
| Patients in geriatrics ward            |                   |         |
| Respiratory failure                    | 1.29(1.19–1.41)   | 0.01    |
| Impaired consciousness                 | 1.19(1.07–1.32)   | 0.03    |

*Variables in the logistic regression that did not have a significant independent association with AMI in both model were: Age, Male, Hypertension, Hypercholesterolemia, SBP, WBC, Serum sodium.

OR: odds ratio. CI: confidence interval. AMI: acute myocardial infarction. CAP: community-acquired pneumonia. BUN: blood urea nitrogen. SBP: Systolic blood pressure. WBC: white blood cell. HCT: hematocrit.

Discussion

In this study, we found that 159 (3.1%) elderly patients in respiratory ward and 77 (7.0%) patients in geriatrics ward experienced AMI during hospitalization for CAP. A total of 236 patients developed AMI among the 6206 geriatric patients, namely, the overall incidence of AMI during CAP hospitalization in elderly patients was 3.8% in our study. Compared with earlier published data, we demonstrate that AMI occurred during CAP hospitalization in a limited but significant proportion of geriatric patients. Hitherto, systematically studied of geriatric patients are unavailable to date. The incidence of acute coronary syndromes (ACS) in previous studies of adult CAP inpatients has varied widely, the frequency in the range between 0.7% and 11% \[8,9,14−16\]. One meta-analysis suggested the pooled ACS event rates after CAP was 4.5% \[17\]. A few studies reported only on myocardial infarction. Vicente et al.\[^{18}\] reported cardiac complications of CAP inpatients mentioned the frequency of Myocardial infarction was 3.1%. Perry et al.\[^{5}\] reported a 1.5% 90-day incidence of myocardial infarction following hospital admission for pneumonia, which has the largest number of cases in previous studies about cardiovascular events after pneumonia with 50119 patients. In our study, the incidence of AMI in geriatrics ward was higher than in respiratory ward. Patients in geriatrics ward were older than patients in respiratory ward. Moreover, a higher incidence of AMI in our geriatrics ward may be due to the meticulous attention paid to detecting myocardial ischaemia. In our geriatrics ward, the troponin and electrocardiograph were routinely examined when the patients were initially admitted or when chest pain, dyspnea, and other symptoms appeared, whether have previous history of coronary heart disease or not. And medicine administration of
myocardial infarction were more timely and comprehensive in the geriatric ward. Higher right diagnostic but similar mortality rates may reflect the fact that compared with specialists, comprehensive geriatric management are superior to usual care in dealing with complications. We suggested that routinely troponin and electrocardiograph examination on admission and when symptoms appeared may improve the detection of AMI.

This study is the first to investigated the characteristics of elderly patients who experiencing AMI during CAP hospitalization. We faces the day-to-day challenges of aging. Hence, in a further analysis, patients ≥ 65 years were compared with those patients <65 years experiencing AMI during CAP hospitalization in our study. AMI is more prevalent in geriatric patients with CAP than in the general population, the incidence of AMI during hospitalization in elderly patients (3.1%) was nearly almost triple versus non-elderly patients (1.0%) in our respiratory ward. We noted that higher proportion patients suffer from respiratory failure in elderly patients. Symptoms in the elderly were more of a dyspnea, unlike chest pain in the younger patients. Usually, chest pain is considered as a typical symptom of AMI, however, symptoms in the elderly were not always typical. Since the clinical presentation of AMI in the elderly may be atypical, clinicians should suspect AMI in older patients presenting symptoms such as dyspnea. The elderly patients experiencing AMI had more history of hypertension, and younger patients had more diabetes and hyperlipidemia. In laboratory findings, BUN ≥ 7 mmol/L and serum sodium < 130 mmol/L were more frequently present in the elderly. High levels of BUN may be related to the poor renal reserve function in the elderly. The presence of hyponatremia in the elderly may be due to poor feeding, increased consumption and decreased basal status. Identify the characteristics of the elderly is benecial to clinical diagnosis, evaluation and individual-based treatment.

In-hospital mortality was significantly higher among those who experienced AMI in comparison patients who did not during hospitalization in elderly patients (10.1% vs. 2.4%). Moreover, in patients who experiencing AMI during CAP hospitalization, patients ≥ 65 years had a higher in-hospital mortality compared to patients <65 years (10.1% vs. 6.6%). AMI associated with increased in-hospital mortality of geriatric patients with CAP. The development of AMI was associated with a nearly 50% increase in the risk of death during hospitalization (OR = 1.49; 95% CI: 1.24–1.82; P < 0.001). This association remained significant even after adjustment for age and for respiratory failure. Conversely, we did not identify evidence of an association between in-hospital mortality and MI in people aged < 65 years, Could be due to the incidence of AMI and the number of deaths in the non-elderly patients were low. Recognize the life-threatening complications among geriatric patients with CAP conducive to clinical decision-making process.

Another important aspect of our study was related to identification of risk factors associated with the occurrence of AMI during CAP hospitalization in geriatric patients. Risk Factors of ACS after CAP only three previous studies, possible risk factors included older age, congestive heart failure or previous myocardial infarction, female sex, severe sepsis, chronic obstructive pulmonary disease, chronic kidney or liver disease. Through logistic regression analysis in our study, we demonstrated that preexisting coronary artery disease, diabetes, respiratory failure and BUN were significantly correlated with the
occurrence of AMI in the respiratory ward. While, impaired consciousness and respiratory failure were independent risk factors for the occurrence of AMI in geriatrics ward. It is interesting to note that the both traditional and non-traditional cardiovascular risk factors were probably associated with the occurrence of AMI. An increased serum BUN levels suggested acute kidney injury, which is common during pneumonia. Renal insufficiency and diabetes are acknowledged risk factors for myocardial infarction\[^{21-22}\]. Impaired consciousness and BUN are both indicators of the severity of pneumonia. More important however, is our finding that respiratory failure was an important factor associated with the occurrence of AMI. Respiratory failure indicates more severe disease status, hypoxia, and more severe inflammation, that suggests a role for the body’s inflammatory and hypoxia in the mechanisms accounting for cardiovascular complications in patients with CAP.

According to new clinical classification of myocardial infarction\[^{23}\], most AMI during CAP hospitalization in geriatric patients may be classified as type 2. This type MI secondary to ischaemia due to either increased oxygen demand or decreased supply. The actual mechanisms by which pneumonia triggers myocardial ischaemia have not yet been fully evaluated. Acute pneumonia can induce inflammatory changes in atherosclerotic plaques, demand ischemia, endothelial dysfunction, and procoagulant changes in blood\[^{24-25}\]. Accumulating evidence on the mechanisms of ACS after acute infections suggests that inflammatory activity is thought to play a key role in the pathogenesis of coronary events. Acute infections induce substantial inflammatory reactions, they can potentially contribute to the development of ACS\[^{26-28}\]. Pneumonia contributes to the acute worsening of pre-existing cardiac conditions and can trigger new cardiac events. In pneumonia, a generalized inflammatory response is usually fully activated by the time patients present to hospital\[^{29}\]. Previous studies suggests that systemic inflammatory response may cause inflammation in coronary arteries and their pre-existing atherosclerotic lesions\[^{30}\]. Infections can induce pro inflammatory changes in the cellular composition of the atherosclerotic lesions and make them more vulnerable to cause coronary\[^{31-32}\]. Acute infections can also cause acute dysfunction and/or physical disruption of the endothelium\[^{33-34}\].

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. Data of peripheral arteriosclerosis evaluation were incomplete in respiratory ward and some patients in respiratory wards did not have BNP results at the time of admission, that were not available for our analyses. Since the D-Dimer detection was done in the respiratory ward by a analyzer used only in the respiratory department, the data was not recorded in the electronic medical records management system of our hospital. Meanwhile, only a partly of patients in the geriatrics ward had a CURB- 65 or PSI score, which are most commonly scales for assessment the severity of CAP, nevertheless, the variables in both scales were included in the study. Secondly, in our real-world study, treatment regimens were relatively individual, and few patients underwent coronary angiography which is why it was not easy to analyze the relationship between Specific treatment regimens and clinical outcomes. Future research will be required to determine if specific measures such as Aspirin or drugs lowering systemic inflammation could prevented cardiovascular complications in CAP inpatients. Thirdly, 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.

**Conclusions**

The incidence of AMI during CAP hospitalization in geriatric patients is notable and have an impact on in-hospital mortality. Characteristics of the elderly differ from the general population. Particular attention should be paid to elderly patients with respiratory failure, preexisting coronary artery disease, diabetes, with high BUN level and impaired consciousness. Our study may represent useful information for planning of clinical strategies aimed at preventing AMI and decreasing mortality rate in geriatric patients hospitalization for CAP.

**Abbreviations**

CAP: community-acquired pneumonia; AMI: myocardial infarction cardiovascular; BUN: blood urea nitrogen; OR: The odds ratios; CI: confidence intervals; ACS: acute coronary syndromes; IDSA/ATS: Infectious Diseases Society of America and the American Thoracic Society; IMV: invasive mechanical ventilation; NIV: non-invasive ventilation; PLT: blood platelet; PH: potential of hydrogen.

**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. (2019-315) 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.

**Availability of data and materials**

The datasets of the current study are available from the corresponding author on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

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Authors' contributions

YK conceptualized and designed the study, collected data, drafted the initial manuscript, and reviewed and revised the manuscript. XYF carried out the initial analyses, and DW coordinated data collection. XJW coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Figures
Figure 1

Comparison of the characteristics between elderly patients and non-elderly patients (a) The incidence of AMI during hospitalization for CAP and (b) The in-hospital mortality. AMI: myocardial infarction cardiovascular; CAP: community-acquired pneumonia.
Figure 2

The in-hospital mortality risk in geriatric patients with CAP who developed AMI versus those who did not.

CAP: community-acquired pneumonia; AMI: myocardial infarction cardiovascular