Background Information (Manuscript)

Demographics, guidelines, and clinical experience in severe community-acquired pneumonia

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Abstract
Mortality in patients with community acquired pneumonia (CAP) who require intubation or support with inotropes in an intensive care unit (ICU) setting remains extremely high (up to 50%). Systematic use of objective severity-of-illness criteria, such as the Pneumonia Severity Index (PSI), BTS CURB-65 criteria, or criteria developed by the Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) to aid site-of-care decisions for pneumonia patients is emerging as a step forward in patient management.

Experience with the PIRO (Predisposition, Infection, Response, and Organ dysfunction) score, incorporating key signs and symptoms of sepsis and important CAP risk factors may represent an improvement for staging severe CAP. In addition, it is suggested that implementing a simple care bundle in the emergency department will improve management of CAP, using five evidence-based variables, with immediate pulse oxymetry and O₂ assessment as the cornerstone and initial step of treatment.
**Introduction**

Community acquired pneumonia (CAP) is an acute illness with clinical features of lower respiratory tract infection characterized by new radiological shadowing and no other explanation for the illness. CAP is a separate entity from nursing home pneumonia and other healthcare-associated pneumonia. There are many definitions of severe CAP, and the best way to define severity is controversial. Pragmatically, severe CAP can be defined as disease that necessitates admission to the intensive care unit (ICU) (1, 2), which is the definition used in many clinical trials. However, more systematic criteria are desirable in order to integrate objective measurement into assessment and avoid variation because of ICU admittance policies across different institutions (3). Even with the use of these criteria, discussed in more detail below, the decision to hospitalize or admit to an ICU relies heavily on physician judgment, particularly in illness in younger patients (4).

Severe CAP is a progressive disease, and in the event of evolution from a local to a systemic infection, the following spectrum of sepsis-related complications may develop: sepsis, severe sepsis, septic shock, and multiple organ dysfunction (MOD), as illustrated in Figure 1. Approximately 50% of CAP admissions to Spanish ICUs are associated with septic shock (5). Progression of severe CAP is associated with hypercoagulation, hypotension, alteration of the microcirculation, and ultimately MOD. Once MOD has developed, patient management is independent of the causative pathogen.

Approximately 4 million adults develop CAP annually in the US (6). Among hospitalized CAP patients in Europe and the US, rates of severe CAP (defined pragmatically as CAP requiring ICU admission) range from 6.6% -16.7% (4, 7-10). Mortality from severe CAP is high, worldwide, with pneumonia/influenza as the eighth leading cause of death in the US, accounting for 0.3% of deaths in 2004 (6). Nearly all patients who die as a consequence of severe CAP develop severe sepsis or septic shock. ICU-based studies in the UK and Spain report mortality rates of 20-50% in severe CAP patients, depending on admission criteria (11-13).

The high rates of mortality due to severe CAP are also highlighted by the Pneumonia Patient Outcomes Research Team prospective study, which compared characteristics of patient groups who did (n=170) and did not (n=1,169) require ICU admission (14). This study showed that CAP was the primary cause of hospital death in both groups, 73% versus 74%, ICU versus non ICU patients, respectively.
Mortality was almost 4 times higher in ICU patients than in non-ICU patients (18% vs 5%, p<0.0001) (14). Despite advances in antimicrobial therapy, mortality due to pneumonia has remained more or less constant since penicillin became routinely available (15, 16).

Notably, admissions to the ICU due to severe CAP are rising, which is a multifactorial phenomenon, related not only to the compromised immune systems of ageing populations, but also to a trend to recommend such patients to be treated in critical care settings. In a study of 172 ICUs which admit adults across England, Wales and Northern Ireland, there were 301,871 admissions, including 17,869 CAP admissions in the period 1996 to 2004 (17). Total annual admissions increased by 24% during this period, while annual admission due to CAP increased by a massive 128% (17). In addition, a large observational cohort study of elderly Medicare recipients showed that during the year 1997, there were 623,718 hospital admissions for CAP among Medicare recipients aged 65 or over, accounting for an incidence of 18.3 per 1000. Of these, 4 per 1000 required ICU admission. The incidence rose from 8.4 per 1000 in those aged 65 to 69 years to 48.5 per 1000 in those aged 90 or older. Overall hospitalised mortality was 10.6%, doubling from 7.8% in those aged 65 to 69 years to 15.4% per 1000 in those aged 90 or older. According to US census estimates, the annual number of hospitalised CAP cases is expected to rise to 750,000 and 1 million in the years 2010 and 2020, respectively, due to the disproportionate growth of the elderly population (18). These figures therefore highlight the growing challenge posed by severe CAP for hospital and ICU staff.

For each patient, the following decisions must be made: What is the diagnosis? Should the patient be hospitalised? Should the patient be admitted to the ICU?

Risk Factors in CAP patients
Early identification of patients at risk of severe CAP can aid patient management. While age is an important risk factor for the development of CAP, co-morbidities also play an important part in determining risk of pneumonia and disease severity. Physicians should therefore take into account any history of chronic obstructive pulmonary disease (COPD), renal insufficiency/dialysis, chronic heart failure (CHF), coronary artery disease, diabetes mellitus, malignancy, chronic neurologic disease or chronic liver disease/alcohol abuse, when determining patient management. In patients aged > 60 years of age, risk is further increased in the presence of asthma, alcoholism or immunosuppression, and in institutionalized patients (19).
Other factors which have been implicated in increasing mortality in severe CAP patients include male gender, and the development of acute respiratory failure, severe sepsis/septic shock, or bacteremia (20). Some specific pathogens also carry an increased risk of severe CAP. The most common organisms seen in patients admitted to the ICU are *Streptococcus pneumoniae*, *Legionella pneumophila*, and *Haemophilus influenzae*. The most common lethal pathogens are *S. pneumoniae*, *Pseudomonas aeruginosa*, and *L. pneumophila*, and the latter two pathogens are frequently associated with a need for mechanical ventilation (21). The most prevalent pathogen associated with severe CAP, *S. pneumoniae*, is responsible for two-thirds of CAP-related deaths. While the worst outcome is associated with infection with Gram-negative organisms, such infections are relatively infrequent.

Signs of disease progression in the first 72 hours after hospital admission are also associated with an increased risk of death. For patients without co-morbidities, the presence of multilobar consolidation, and the need for mechanical ventilation or inotropic support are associated with greater disease severity and higher mortality rates (22).

Emerging evidence suggests that critically ill patients with severe CAP and COPD are more likely to need mechanical ventilation and have an increased risk of mortality (23, 24). In a secondary analysis of a prospective study evaluating 428 immunocompetent patients admitted to the ICU for severe CAP, all patients were stratified according to the presence or absence of COPD. In total, 176 COPD patients were compared with 252 non-COPD patients and COPD proved to be an important risk factor for mortality. In COPD patients, both mechanical ventilation (OR 2.78; 95% CI 1.63-4.74) and ICU mortality (odds ratio (OR) 1.58; 95% confidence interval (CI) 1.01-1.43) rates were both higher than in non-COPD patients. The ICU mortality was 39% for COPD patients initially intubated and 50% for those who failed noninvasive ventilation (24). Patients with a history of COPD are likely to have more severe signs at presentation, such as septic shock, tachypnea, lower values of pH, pO₂, oxygen saturation and greater values of pCO₂. COPD is more common with increasing age, in male patients, and in patients with diabetes or CHF (23).

Recent reanalysis of the CAPUCI study, assessing patients with severe CAP requiring ICU admission, has suggested that radiological progression of pulmonary
infiltrates is a significant adverse prognostic feature (25). In contrast, bacteremia levels appear not to affect patient outcomes (25).

**Who should be considered for hospital admission?**

Site-of-care assessment based on severity of illness is a vital component of patient management, affecting diagnostic workup and empirical treatment with antibiotics. It is essential to identify patients with severe CAP as early as possible because of the implications for management and mortality.

There are various severity assessment tools including the Pneumonia Severity Index (PSI)(26) and the British Thoracic Society CURB-65 (Confusion, Urea, Respiratory rate, Blood pressure, age ≥ 65 years) score (27). The PSI has been developed primarily to identify those patients who can safely be treated as outpatients (Figure 2). According to this score, the main determinants of pneumonia severity are increasing age, comorbidity and vital sign abnormalities. The calculation of the PSI score also requires laboratory, blood gas and chest radiograph data, making this a more problematic set of tests to perform in the emergency room setting. The PSI has been convincingly validated in several studies and allows the confident separation of patients with a mortality risk of up to 3% (PSI classes I–III) from those with a risk of 8% (PSI class IV) and 35% (PSI class V). However, it should be noted that although the PSI takes into account renal, heart, cardiovascular or liver disease and malignancy, it does not include as risk factors COPD or diabetes. The PSI is therefore a useful tool to identify patients who can be discharged safely, and receive home treatment with antibiotics. The PSI has been also been useful in demonstrating equivalence of empiric antibiotics, and showing that delaying appropriate antibiotics worsens survival in classes IV-V pneumococcal bacteraemic pneumonia (28).

In contrast to the complexity of the PSI, the BTS CURB-65 system uses simple clinical measures and a single laboratory investigation (blood urea) readily available in most hospitals (Figure 3) (27). A simplified version omitting the blood urea nitrogen testing has also been proposed (CRB-65) (29). As with the PSI, CURB-65/CRB-65 scores are useful to determine which patients may safely be treated at home, and can flag certain hospitalized patients for careful scrutiny, and for admission to the ICU if their condition deteriorates. However, these tools have limitations in identifying all patients with severe pneumonia who require ICU admission.

**Who should be considered for ICU admission?**
The decision to admit a patient to the ICU remains one of the most important steps in the management of CAP. One of the limitations of the PSI, is that it occasionally underestimates severity, particularly in young patients without comorbidities developing severe respiratory failure (4), as hypoxia alone does not score highly enough to categorise such patients as high risk. Similarly, CURB-65 may underestimate risk in elderly patients with comorbidities. To address these issues, the Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) have recently reviewed risk factors and developed objective major and minor criteria to identify patients requiring direct admission to an ICU (1). The most up to date definitions use the need for invasive mechanical ventilation or septic shock, requiring vasopressors, as absolute indicators for direct admission to an ICU (Table 1). For patients who do not meet either of these two major criteria, minor criteria have been proposed which are based on CURB and ATS criteria with new additions. For admission to an ICU or high level unit, patients must fulfill at least 3 of these minor criteria (Table 1). Validation of the use of these objective criteria in a large patient population (n=696), of whom 116 were admitted to an ICU, indicate that CURB-65 criteria can be used as an alternative to PSI to identify low risk patients, and confirm the ability of the IDSA/ATS guidelines to predict disease severity (9). In Europe, CURB-65 or a variant of this system remains popular.

Overall, the use of established guidelines to assess whether a patient should be admitted to the ICU can yield different answers depending on which guideline is used. Clinical experience and judgement should not be underestimated in this setting. There is still room for improvement in incorporating the signs and symptoms of systemic involvement, such as sepsis, into the management of patients with severe CAP.

While factors reflecting acute respiratory failure and severe sepsis or septic shock are independent predictors of severity in CAP (20), and sepsis severity at admission significantly affects outcome (29), such factors have not yet been systematically implemented into risk classification for CAP patients. A possible advance in this area could be the development, validation and incorporation into management tools of emerging biomarkers for diseases (30, 31). Biomarkers identified as markers of sepsis may complement traditional scoring factors in predicting outcomes, but this approach has yet to be validated.
The problem has been that, although a systemic inflammatory response underlies the acute respiratory failure seen in severe CAP, and increases the risk of sepsis, attempts to incorporate the signs of the systemic inflammatory response syndrome (SIRS) into patient management have proved disappointing, as these criteria do not consistently identify severely ill patients (32).

To try to address the need to identify ICU CAP patients at high risk, using readily available clinical data, a new form of classification has been proposed, analogous to the tumour staging systems used to define aggressive and non aggressive cancers. Known as the PIRO system, sepsis patients are classified across four domains; Predisposition, Infection, Response, and Organ dysfunction (33, 34). The rationale for this approach lies in the complex nature of sepsis and overlap with pneumonia. Current opinion holds that the genetic makeup of an individual is likely to be a major determinant of the lifetime predisposition to sepsis, and progress continues to be made in identifying relevant candidate genes (20, 35). The site of infection, and the nature and spread of the pathogen within the body are also important features. While some elements of the variables that affect the host response to infection are easy to identify (age, nutritional status, sex, comorbid conditions etc) others are more complex, and arise from interactions between inflammation, coagulation, and sepsis.

We have developed an adaptation of the PIRO score applicable in the severe CAP setting, arbitrarily determining a score for the features of severe CAP (Figure 4)(36). The PIRO system takes into account risk factors, most notably the presence of COPD, in line with results showing that CAP patients admitted to ICUs with COPD have a worse prognosis, and a worse 28-day survival compared with non-COPD patients (24). Validation of the PIRO score showed an excellent correlation between increasing PIRO score and mortality rate (p<0.001), and between increasing PIRO score and healthcare resource utilization in terms of the need for mechanical ventilation, and length of stay (LOS) in the ICU (p<0.001).

While the elements of PIRO should be readily testable in clinical and basic research in sepsis, this approach has yet to be fully evaluated as a novel clinical tool for patient evaluation.

Charles and colleagues (2008) have recently developed a tool for the prediction of which CAP patients will require intensive respiratory or vasopressors support (IRVS) (37). The SMART-COP score was developed from studying 882 CAP patients in the
Australian CAP Study. The tool was then validated in 5 external databases. SMART-COP utilizes the measurement of systolic blood pressure, multilobar chest radiography, low albumin levels, respiratory rate (age adjusted), tachycardia, confusion, low oxygen (age-adjusted), and arterial pH (<7.35) (37).

Non-antimicrobial medical management of severe CAP

When a patient is admitted to the ward or ICU, other important decisions include issues of fluid resuscitation; how much fluid the patient should receive, and which fluid is chosen. High volume options include the crystalloids (saline, Ringer’s solution), while lower volume options include hydroxyethyl starch solutions (HES), gelatin, and albumin. The choice of fluid is less important than the timely initiation of fluid resuscitation.

Our clinical experience also indicates that oxygen assessment and antibiotic administration should be achieved promptly, as postponing oxygenation assessment is associated with a significant delay in initiating antibiotics (38). This is supported by secondary analysis from a prospective, observational, multicenter study including 529 patients with severe CAP admitted to the intensive care unit in 33 hospitals (the CAPUCI study). Unadjusted linear regression analysis confirmed that a delay in oxygenation assessment of >1 hr was associated with an increase in time to first antibiotic dose of 6.13 hrs (95% confidence interval, 3.42-8.83; p < 0.001). In addition, a delay in oxygenation assessment of >3 hrs was associated with an increased risk of death (relative risk, 2.24; 95% confidence interval, 1.17-4.30). Multivariable analysis, adjusting for potential confounders, revealed that delayed oxygenation assessment (>3 hrs) was an independent risk factor of death (hazard ratio, 2.06; 95% confidence interval, 1.22-3.50) (38).

Efficacy in ICU admission is an important feature of management. Patients who are admitted to the ICU after being on a medical ward for one or two days typically have worse outcomes that those who are admitted directly from the emergency department. The need for early ICU admission and prompt intervention for high risk patients is confirmed by emerging data (17, 39). In a large scale retrospective analysis, at 172 adult ICUs across England, Wales and Northern Ireland, 17,869 cases of CAP were identified (17). Fifty-nine percent of cases were admitted to the ICU <2 days after hospital admission, 21.5% between 2 and 7 days, and 19.5% < 7 days after hospital admission. Mortality was related to the time between hospital and ICU admission, with 46.3% mortality rates seen in those admitted to the ICU within 2
days of hospital admission rising to 50.4% in those admitted at 2 to 7 days and 57.6% in those admitted after 7 days following hospital admission. Despite the lower mortality associated with early ICU admission, overall mortality remains high in these patients (17).

**Antibiotic treatment**

Prompt initiation of antibiotic therapy is also key to good outcome, although this is not always achieved. Common reasons for delaying antibiotic therapy are organizational issues, incorrect diagnosis, and lack or knowledge, experience, or confidence on the part of the physician (40), which can in turn delay obtaining results of microbial cultures.

Effective combination therapy, able to cover the likely microbial pathogens, should be initiated promptly in patients with severe CAP. Combination therapy appears crucial when treating patients with shock, as shown by a secondary analysis of the CAPUCI study (5). Results showed that combination antibiotic therapy and monotherapy were equally effective in the absence of shock (n = 259), but combination antibiotic therapy improved outcome in patients with shock (n=270) (5). However, the CAPUCI study also showed that mortality in severe CAP patients receiving adequate antibiotics remains high, at 24.2% (41). This secondary analysis of the CAPUCI database confirmed that shock, acute renal failure and APACHE II score of above 24 were independently associated with mortality in immunocompetent patients with bacterial CAP who received adequate initial antibiotics and co-morbidity management.

Lujan and colleagues (2004) evaluated the effect of discordant empiric therapy on outcomes in bacteraemic pneumococcal CAP (n=100). In this study discordant therapy was defined as empiric antimicrobial given for first 2 days after pneumonia onset, which was inactive against *S. pneumoniae*. Mortality in patients receiving concordant therapy was 14%; the excess mortality for discordant therapy was 36%. Discordant therapy, multilobar involvement, underlying COPD and hospitalization during previous 12 weeks were independently associated with death. This study indicated that in patients with high severity of disease, persistance of high bacterial burden may be associated with septic shock and death in pneumococcal bacteremic pneumonia (42).
In patients with septic shock, time to starting antibiotics is very important, as indicated by a study of fourteen ICUs in Canada and the United States (43). Assessment of the medical records of 2,731 adult patients with septic shock, showed a strong relationship between any delay in effective antimicrobial initiation and in-hospital mortality. Administration of an antimicrobial effective for isolated or suspected pathogens within the first hour of documented hypotension was associated with a survival rate of 79.9%, while each hour of delay over the next 6 hrs was associated with an average decrease in survival of 7.6%.

A further retrospective study in the US assessed a random sample of 18,209 Medicare patients aged > 65 years who were hospitalized with CAP from July 1998 through March 1999. Results showed that, for patients not using outpatient antibiotics, initiation of antibiotic treatment within 4 hours of admission significantly improved in-hospital mortality from 7.4% to 6.8% (p=0.05), and improved 30-day mortality rates from 12.7% to 11.6% (p<0.01) (39).

The introduction of IDSA/ATS guidelines for antibiotic administration also represents a step forward in patient management. Adherence to these guidelines significantly improved mortality from 33% to 24% (p=0.05) in a cohort of 529 severe CAP patients treated at 33 Spanish hospitals (41). In a further study of 99 US patients, adherence to IDSA guidelines significantly improved length of stay (LOS) from 6.8 to 4.5 days (p<0.01), and resulted in lower hospital costs (p<0.05)(44). Additionally, in another Spanish study of CAP ventilated patients (n=199), patients who were not prescribed an IDSA-compliant antibiotic regimen remained on mechanical ventilation (MV) for an average of 3 days longer than patients who received an IDSA compliant regimen (45). In a multivariate hazard model, two variables were independently associated with greater durations of MV: development of acute renal failure (hazard ratio, 1.47; 95% confidence interval [CI], 1.02 to 2.12), and prescription of an IDSA-noncompliant regimen (hazard ratio, 1.40; 95% CI, 1.02 to 1.93).

**Post Discharge Mortality**
Whereas regulatory agencies suggest that 28 days is a key timepoint for patient follow up, mortality associated with CAP continues to occur even after hospital discharge, and at 90 and 180 days patients who were discharged home in good condition may present additional symptoms and associated mortality. This issue should be studied in detail for future therapeutic guidelines. The link between inflammation, modulation of inflammation in different conditions and hypercoagulation
is a potential explanation for this unexplained excess mortality, and some patients may benefit from adjuvant therapy while hospitalised.

A Care Bundle for severe CAP

Data presented here, based in part in our own research experience, suggest that a care bundle for severe CAP patients would be a valuable tool, incorporating the key elements shown in Figure 5. Risk assessment should enclose pulse oxymetry and point-of-care lactate for early identification of hypoxemia or hypoperfusion. This should be followed for a combination of measures reducing bacterial load (antibiotics), plus oxygenation and improvement of microcirculation. Identification of patients at risk of invasive respiratory and vasopressor support is crucial because delay in ICU admission is associated with reduction of survival. Newer tools for risk stratification, such as PIRO score, would facilitate understanding of patients requiring adjunctive therapy. Incorporating microbiologic information, with early detection of bacteremia, using PCR and DNAemia are the next steps to incorpore for an enhanced management of sCAP.

Summary

Although there is now considerable evidence that it is extremely important to ensure that all patients with severe CAP receive timely and appropriate antimicrobial therapy, it is clear that even with appropriate therapy, severe CAP continues to be associated with an unacceptably high mortality rate worldwide. Systematic use of objective criteria to aid site-of-care decisions for pneumonia patients is emerging as a step forward in patient management. The Pneumonia Severity Index (PSI) can predict patients who can be discharged and treated at home safely, but occasionally underestimates severity, particularly in young patients without co-morbidities who have severe respiratory failure. In addition, CURB-65 provides an easy to use tool able to identify patients at high risk of mortality, who might benefit from early ICU admission. Early admission to the ICU may be an important way to improve survival, and the decision to admit a patient to the ICU remains one of the most important steps in the management of CAP. More studies of early intervention and prompt ICU admission are needed to address this issue. Adherence to IDSA/ATS guidelines (objective major and minor criteria for direct admission to an ICU) also provides a way to improve patient outcome. It should be noted, however, that physician experience will continue to play a vital role in achieving early ICU admission and prompt intervention for high risk patients. The PIRO score, incorporating key signs and symptoms of sepsis and severe CAP risk factors to the CURB-65 score,
highlights the limitations of CURB-65 as a track and trigger tool. In addition, as postponing oxygenation assessment adversely affected outcome, it is suggested that implementing a care bundle to improve management of CAP in the emergency department, using simple evidence-based variables, with immediate pulse oxymetry and $O_2$ assessment as the cornerstone and initial step of treatment.
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Table 1. Infectious Diseases Society of America/American Thoracic Society Guidelines for ICU admission

| Major Criteria | Minor Criteria (at least three of the following): |
|----------------|--------------------------------------------------|
| Invasive mechanical ventilation | Respiratory rate ≥30 breaths/min |
| Septic shock with the need for vasopressors | PaO$_2$/FiO$_2$ ratio ≤250 |
| Multilobar infiltrates | |
| New onset confusion/disorientation | |
| Uremia (BUN level ≥20 mg/dL) | |
| Leukopenia (WBC <4000 cells/mm$^3$) | |
| Thrombocytopenia (platelets <100,000 cells/mm$^3$) | |
| Hypothermia (core temperature <36°C) | |
| Hypotension requiring aggressive fluid resuscitation | |
Figure 1. The progressive nature of severe CAP

- Severe CAP is a progressive disease which may lead to rapid decompensation, multi-organ dysfunction and significant mortality
Figure 2. PSI as a site-of-care tool

| Demographics | Co-morbidities | Physical exam / vital signs | Laboratory / imaging |
|--------------|----------------|-----------------------------|---------------------|
| • Age (1 point per year) Male Yr Female Yr -10 Nursing home residency +10 | • Neoplasia +30 • Liver disease +20 • CHF +10 • Cerebrovascular disease +10 • Renal disease +10 | • Mental confusion +20 • Respiratory rate +20 • SBP +20 • Temperature +15 • Tachycardia +15 | • Arterial pH +30 • BUN +20 • Sodium +20 • Glucose +10 • Hematocrit +10 • Pleural effusion +10 • Oxygenation +10 |

| Risk class (Points) | Mortality (%) | Recommended site of care |
|---------------------|---------------|--------------------------|
| I (<50)             | 0.1           | Outpatient               |
| II (51–70)          | 0.6           | Outpatient               |
| III (71–90)         | 2.8           | Outpatient or brief inpatient |
| IV (91–130)         | 8.2           | Inpatient                |
| V (>130)            | 29.2          | Inpatient                |
Figure 3. CURB-65 as a site-of-care tool

1 point given for each of:
- Confusion
- Urea (>7 mmol/L)
- Respiratory rate (≥30/min)
- BP (SBP <90 mmHg or DBP ≤60 mmHg)
- Age (≥65 years)

| Risk class | Mortality (%) | Recommended site of care                      |
|------------|--------------|------------------------------------------------|
| 0          | 0.7          | Outpatient                                     |
| 1          | 2.1          | Outpatient                                     |
| 2          | 9.2          | Short hospital stay / supervised outpatient     |
| 3          | 14.5         | Hospital, assess for ICU                       |
| 4          | 40           | Hospital, assess for ICU                       |
| 5          | 57           | Hospital, assess for ICU                       |
**CAP-PIRO Score**

| P | Comorbidities (COPD or Immunocompromised) | 1 point |
|---|----------------------------------------|--------|
|   | Age > 70 yrs                            | 1 point |
| I | Bacteremia                              | 1 point |
|   | Multilobar opacities                    | 1 point |
| R | Shock                                   | 1 point |
|   | Severe Hypoxemia                        | 1 point |
| O | ARDS                                    | 1 point |
|   | Acute renal failure                     | 1 point |

\[ \text{Total score} \square \text{ points} \]

**Interpretation**

| Points | Interpretation                                                                 |
|--------|-------------------------------------------------------------------------------|
| 0–2    | Low risk (1 in 30) for ICU mortality                                          |
| 3      | Mild risk (1 in 8) for ICU mortality                                          |
| 4      | High risk (2 in 5) for ICU mortality                                          |
| 5–8    | Very high risk (3 in 4) for ICU mortality                                     |

Figure 4. PIRO as a mortality risk assessment tool (modified from ref 36).
Figure 5. A care bundle for management of severe CAP patients at emergency department

Care Bundle for hospitalized CAP patients
- Risk assessment
- Early fluid resuscitation
- Prompt oxygenation
- Immediate combination antibiotic therapy
- Consider ICU admission (selected patients)