Pneumonia Severity Scores: Are they Accurate Predictors of Mortality?

JILL McEWEN, MD FRCPC

Clinical Professor
Department of Emergency Medicine
University of British Columbia
Vancouver, BC Canada
President, Canadian Association of Emergency Physicians
Disclosure

• I have no actual or potential conflict of interest in relation to this presentation
Objectives

• Review Pneumonia Prediction Scores
• Distinguish the usefulness of existing scores for predicting low risk vs high risk patients
• Determine if there is a Pneumonia Prediction Score that is useful in predicting mortality
Pneumonia

- Community Acquired Pneumonia (CAP)
  - Most outpatient, low mortality ~1%
  - Hospitalized, mortality ~15%

- Other
  - Hospital Acquired Pneumonia (HAP)
  - Health Care Associated Pneumonia (HCAP)
  - Ventilator Associated Pneumonia (VAP)
Community Acquired Pneumonia

Definition

Acute infection of pulmonary parenchyma associated with:

- At least some symptoms of acute infection plus
  - Acute infiltrate on radiograph OR
  - Pneumonia findings on auscultation
- Patient not hospitalized or living in a long term care facility x past 14 days

Bartlett: Clinical Infectious Diseases 2000;31:347-82
Main symptoms of infectious Pneumonia

Systemic:
- High fever
- Chills

Skin:
- Clamminess
- Blueness

Central:
- Headaches
- Loss of appetite
- Mood swings

Vascular:
- Low blood pressure

Lungs:
- Cough with sputum or phlegm
- Shortness of breath
- Pleuritic chest pain
- Hemoptysis

Heart:
- High heart rate

Gastric:
- Nausea
- Vomiting

Muscular:
- Fatigue
- Aches

Joints:
- Pain
Challenges

- Antibiotic resistance
- Changing pathogens
- Aging population
- Cost constraints
- Empirical therapy
- Identifying those at risk for increased mortality
Risk Factors

- Elderly/dementia
- COPD/Asthma
- Smoking
- Alcoholism
- Immunosuppression
- Institutionalization
Common causative pathogens

- S. pneumoniae
- H. influenza
- Legionella
- Mycoplasma
- Chlamydophila pneumoniae
- Viral
  - Influenza
  - Parainfluenza
  - RSV
- Fungal
  - Pneumocystis jirovecii

Atypicals

- 50% of hospitalized
- 18% of hospitalized
Common causative Pathogens in ICU admissions

- S. pneumonia
- Legionella
- Staphylococcus aureus (including MRSA)
- Gram negative bacilli
Decisions...

Is the patient “sick”?

Chest X-ray?
Lab tests?
Antibiotics?
Admit to hospital?
Admit to ICU?
Decisions

• Hospital admission vs outpatient?

• Ward vs ICU?
“Severe” CAP

- Challenge to identify prospectively
- Use different empiric antibiotics
- May be initially felt to be mild, then later get admitted to ICU… (higher mortality)
Severity of Illness Scores / Prognostic Models

- Pneumonia Severity Index
- CURB-65 score
- CRB-65 score

Identify low risk patients for outpatient treatment
A Prediction Rule to Identify Low-Risk Patients with Community-Acquired Pneumonia

Michael J. Fine, M.D., Thomas E. Auble, Ph.D., Donald M. Yealy, M.D., Barbara H. Hanusa, Ph.D., Lisa A. Weissfeld, Ph.D., Daniel E. Singer, M.D., Christopher M. Coley, M.D., Thomas J. Marrie, M.D., and Wishwa N. Kapoor, M.D., M.P.H.

- Pneumonia Patient Outcomes Research Team
- Immunocompetent adults
- PSI
Pneumonia Severity Index

2 step approach:

1) Algorithm to determine low risk:
   • <50
   • No comorbidities (cancer, CHF, CVD, renal or liver disease, HIV)
   • HR < 125, RR < 30, BP > 90
     T > 40 or < 35
   • Normal mentation

2) Apply Score if not “low risk”
**PSI Calculation**

**Step 1**

Patients with community-acquired pneumonia

- Is the patient more than 50 years of age?
  - Yes
  - Does the patient have a history of any of the following coexisting conditions?
    - Neoplastic disease
    - Congestive heart failure
    - Cerebrovascular disease
    - Renal disease
  - No
  - Does the patient have any of the following abnormalities on physical examination?
    - Altered mental status
    - Respiratory rate ≥30/min
    - Systolic blood pressure <90 mm Hg
    - Temperature <35°C or ≥40°C
  - No
  - Assign patient to risk class I

**Step 2**

**TABLE 2. POINT SCORING SYSTEM FOR STEP 2 OF THE PREDICTION RULE FOR ASSIGNMENT TO RISK CLASSES II, III, IV, AND V.**

**CHARACTERISTIC**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Points Assigned*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic factor</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>Age (yr)</td>
</tr>
<tr>
<td>Women</td>
<td>Age (yr) – 10</td>
</tr>
<tr>
<td>Nursing home resident</td>
<td>+10</td>
</tr>
<tr>
<td>Coexisting illnesses†</td>
<td></td>
</tr>
<tr>
<td>Neoplastic disease</td>
<td>+30</td>
</tr>
<tr>
<td>Liver disease</td>
<td>+20</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>+10</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>+10</td>
</tr>
<tr>
<td>Renal disease</td>
<td>+10</td>
</tr>
<tr>
<td>Physical-examination findings</td>
<td></td>
</tr>
<tr>
<td>Altered mental status‡</td>
<td>+20</td>
</tr>
<tr>
<td>Respiratory rate ≥30/min</td>
<td>+20</td>
</tr>
<tr>
<td>Systolic blood pressure &lt;90 mm Hg</td>
<td>+20</td>
</tr>
<tr>
<td>Temperature &lt;35°C or ≥40°C</td>
<td>+15</td>
</tr>
<tr>
<td>Pulse ≥125/min</td>
<td>+10</td>
</tr>
<tr>
<td>Laboratory and radiographic findings</td>
<td></td>
</tr>
<tr>
<td>Arterial pH &lt;7.35</td>
<td>+30</td>
</tr>
<tr>
<td>Blood urea nitrogen ≥30 mg/dl (11 mmol/liter)</td>
<td>+20</td>
</tr>
<tr>
<td>Sodium &lt;130 mmol/liter</td>
<td>+20</td>
</tr>
<tr>
<td>Glucose ≥250 mg/dl (14 mmol/liter)</td>
<td>+10</td>
</tr>
<tr>
<td>Hematocrit &lt;30%</td>
<td>+10</td>
</tr>
<tr>
<td>Partial pressure of arterial oxygen &lt;60 mm Hg§</td>
<td>+10</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>+10</td>
</tr>
</tbody>
</table>

Additional resources:
- [Free iOS app](http://www.mdcalc.com/psi-port-score-pneumonia-severity-index-adult-cap)
Pneumonia Severity Index

- Stratifies patients into 5 mortality risk categories:
  - Class I (0.1%)
  - Class II (0.6%)
  - Class III (0.9%)
  - Class IV (9.3%)
  - Class V (27.0%)

Hospitalize if > 91
doi: 10.1136/thorax.58.5.377

Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study

W Lim, M M van der Eerden, R Laing, W Boersma, N Karalus, G Town, S Lewis, and J Macfarlane

CURB-65 Score
CURB-65 Score

✓ **C**onfusion
✓ **U**remia (BUN>7)
✓ **R**espiratory rate ↑(> 30)
✓ **B**lood pressure (< 90 syst, or < 60 diast)
✓ **65** years or more

Modified from Infectious Diseases Society of America & American Thoracic Society CURB Score Criteria

CURB-65 Score

0 = 0.7%*  → outpatient
1 = 2.1%  → admit to hospital
2 = 9.2%  → ICU
3 = 14.5%
4 = 40.0%
5 = 57.0%

*30 day mortality

CRB-65 Score for office assessment
The Pneumonia Severity Index: A Decade after the Initial Derivation and Validation

Drhomir Aujesky¹ and Michael J. Fine²,³

¹Division of General Internal Medicine, University of Lausanne, Lausanne, Switzerland; and ²Veterans Affairs Center for Health Equity Research and Promotion, Veterans Affairs Pittsburgh Healthcare System, and ³Division of General Internal Medicine, Department of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania

- Rigorously derived and validated prediction rule
- Empirically shown to safely increase the percentage of patients treated in the outpatient setting
- “Reference standard” for stratification of CAP
Table 4. Studies comparing the prognostic accuracy of the pneumonia severity index (PSI) and the CURB-65 score.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sites</td>
<td>32 EDs in the US</td>
<td>1 ED in Australia</td>
<td>1 ED in Spain</td>
<td>1 ED in Hong Kong</td>
<td>1 ED in Sweden</td>
</tr>
<tr>
<td>Total no. of patients</td>
<td>3181 Immuno-competent adults</td>
<td>392 Immuno-competent adults</td>
<td>1776 Immuno-competent adults</td>
<td>1016 Immuno-competent adults</td>
<td>408 Immuno-competent adults</td>
</tr>
<tr>
<td>Patients classified as low risk, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes I–III</td>
<td>68</td>
<td>44</td>
<td>64</td>
<td>47</td>
<td>28</td>
</tr>
<tr>
<td>CURB-65 scores 0–1</td>
<td>61</td>
<td>59</td>
<td>57</td>
<td>43</td>
<td>29</td>
</tr>
<tr>
<td>30-Day mortality, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes I–III</td>
<td>1.4</td>
<td>0.6</td>
<td>0.7</td>
<td>2.9</td>
<td>3.5</td>
</tr>
<tr>
<td>CURB-65 scores 0–1</td>
<td>1.7</td>
<td>...</td>
<td>0.4</td>
<td>3.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Sensitivity for 30-day mortality, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes IV–V</td>
<td>79</td>
<td>97</td>
<td>93</td>
<td>84</td>
<td>94</td>
</tr>
<tr>
<td>CURB-65 scores 2–5</td>
<td>77</td>
<td>...</td>
<td>97</td>
<td>85</td>
<td>87</td>
</tr>
<tr>
<td>Specificity for 30-day mortality, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes IV–V</td>
<td>70</td>
<td>48</td>
<td>67</td>
<td>50</td>
<td>32</td>
</tr>
<tr>
<td>CURB-65 scores 2–5</td>
<td>63</td>
<td>...</td>
<td>60</td>
<td>46</td>
<td>33</td>
</tr>
<tr>
<td>PPV for 30-day mortality, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes IV–V</td>
<td>11</td>
<td>16</td>
<td>18</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>CURB-65 scores 2–5</td>
<td>9</td>
<td>...</td>
<td>15</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>NPV for 30-day mortality, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI risk classes IV–V</td>
<td>99</td>
<td>99</td>
<td>99</td>
<td>97</td>
<td>97</td>
</tr>
<tr>
<td>CURB-65 scores 2–5</td>
<td>98</td>
<td>100</td>
<td>97</td>
<td>97</td>
<td>93</td>
</tr>
<tr>
<td>AUC for 30-day mortality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSI</td>
<td>0.81</td>
<td>0.82</td>
<td>0.89</td>
<td>0.74</td>
<td>0.72</td>
</tr>
<tr>
<td>CURB-65</td>
<td>0.76</td>
<td>0.82</td>
<td>0.87</td>
<td>0.73</td>
<td>0.69</td>
</tr>
</tbody>
</table>

NOTE. The CURB-65 prediction rule uses 5 variables (confusion, high level of illness, lymphopenia, respiratory rate ≥30 breaths/min, low systolic or diastolic blood pressure, and age ≥65 years). AUC, area under the receiver operating characteristic curve; CAP, community-acquired pneumonia; ED, emergency department; NPV, negative predictive value; PPV, positive predictive value.
Pneumonia Severity of Illness Scores To Predict Patients at Risk for Increased Mortality

- PSI Class V / CURB-65 score
  - Proposed but not prospectively validated for ICU admission
- IDSA/ATS guidelines
  - not validated
- SMART-COP
- CURXO-80

Attempt to identify high risk patients who need ICU admission
Modified IDSA/TSA Criteria for Severe CAP

- **Minor Criteria**
  - Resp rate > 30
  - Pa O$_2$/ Fi O$_2$ ratio > 250
  - Multi-lobar infiltrates
  - Confusion
  - Uremia (BUN > 20 mg/dl)
  - Leukopenia (WBC < 4000)
  - Thrombocytopenia (plat < 100,000)
  - Hypothermia (T < 36°C)
  - Hypotension

3 minor or 1 major criteria

Modified IDSA/TSA Criteria for Severe CAP

• Major Criteria
  • Invasive mechanical ventilation
  • Septic shock with need for vasopressors

“Other criteria to consider”
  - Hypoglycemia (in non-diabetics)
  - acute alcoholism or withdrawal
  - hyponatremia
  - unexplained metabolic acidosis
  - elevated lactate level
  - cirrhosis

IDSA/ATS criteria

• Brown suggests threshold of 4 minor criteria
  • Higher positive predictive value at the expense of lower sensitivity (30% vs 54%)
• IDSA/ATS expert panel suggest 3 criteria
  • May over-admit to the ICU to ensure those at risk of decompensating are not left out on the wards

Reassessment is key until a better scoring tool is available
SMART COP

Predicts intensive respiratory or vasopressor support*

- \( \downarrow \) BP 2 points
- Multi-lobar CXR 1 point
- \( \downarrow \) Albumin 1 point
- \( \uparrow \) Resp rate 1 point
- \( \downarrow \) Heart rate 1 point
- Confusion 1 point
- Poor oxygenation 2 points
- \( \downarrow \) Arterial pH 2 points

\( > 3 = 92\% \text{ received } * \text{intensive support} \)
\( \text{incl 84\% who didn’t need ICU initially} \)

CURXO-80

- pH < 7.3
- BP < 90
- RR > 30
- Altered mental status
- BUN > 30
- PaO₂/FiO₂ < 250
- Age > 80
- Multi-lobar /bilateral lung involvement

Figure 3. The variables of score grouped in major and minor criteria. The evaluation of SCAP is based on the presence of one major criterion or two or more minor criteria. P = arterial pH; S = systolic pressure; C = confusion; U = blood urea nitrogen; R = respiratory rate; X = X-ray; O = PaO2; 80 = Age \( \geq \) 80 years.


Published in: Pedro P. España; Alberto Capelastegui; Inmaculada Gorordo; Cristobal Esteban; Mikel Oribe; Miguel Ortega; Amaia Bilbao; José M. Quintana; Am J Respir Crit Care Med 2006, 174, 1249-1256.

DOI: 10.1164/rccm.200602-177OC

© 2006 The American Thoracic Society
<table>
<thead>
<tr>
<th>Rule</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
<th>AUC (%)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCAP prediction rule</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivation</td>
<td>92.1</td>
<td>73.8</td>
<td>21.4</td>
<td>99.2</td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Internal validation</td>
<td>95.5</td>
<td>76.7</td>
<td>21.1</td>
<td>99.6</td>
<td>0.86</td>
<td></td>
</tr>
<tr>
<td>External validation</td>
<td>84.3</td>
<td>60.3</td>
<td>22.0</td>
<td>96.7</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>m-ATS*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivation</td>
<td>51.3</td>
<td>95.9</td>
<td>49.4</td>
<td>96.2</td>
<td>0.74</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Internal validation</td>
<td>61.4</td>
<td>96.7</td>
<td>55.1</td>
<td>97.5</td>
<td>0.79</td>
<td>0.07</td>
</tr>
<tr>
<td>External validation</td>
<td>50.4</td>
<td>91.9</td>
<td>47.2</td>
<td>92.8</td>
<td>0.71</td>
<td>0.37</td>
</tr>
<tr>
<td>CURB-65 (3–5)†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivation</td>
<td>68.4</td>
<td>86.8</td>
<td>28.6</td>
<td>97.3</td>
<td>0.78</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Internal validation</td>
<td>63.6</td>
<td>87.3</td>
<td>24.6</td>
<td>97.4</td>
<td>0.75</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>External validation</td>
<td>60.3</td>
<td>78.4</td>
<td>26.7</td>
<td>93.8</td>
<td>0.69</td>
<td>0.17</td>
</tr>
<tr>
<td>PSI (IV-V)‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivation</td>
<td>94.7</td>
<td>68.1</td>
<td>18.7</td>
<td>99.4</td>
<td>0.81</td>
<td>0.24</td>
</tr>
<tr>
<td>Internal validation</td>
<td>88.6</td>
<td>69.3</td>
<td>15.9</td>
<td>98.9</td>
<td>0.79</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>External validation</td>
<td>91.4</td>
<td>50.7</td>
<td>19.8</td>
<td>97.8</td>
<td>0.71</td>
<td>0.32</td>
</tr>
<tr>
<td>Adjusted PSI§</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Derivation</td>
<td>97.4</td>
<td>57.5</td>
<td>15.1</td>
<td>99.7</td>
<td>0.77</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Internal validation</td>
<td>95.5</td>
<td>61.2</td>
<td>13.8</td>
<td>99.5</td>
<td>0.78</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>External validation</td>
<td>95.7</td>
<td>36.4</td>
<td>16.7</td>
<td>98.5</td>
<td>0.66</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
Ideal Pneumonia Severity Score
to predict ICU admission criteria* /30 day mortality

*Requirement for ventilation or vasopressor support or ECMO

- Dynamic
- High NPV, high sensitivity
- Can’t use AUROC
  - It assumes equal importance of false positives and false negatives*
- Simple, few factors, easy to remember
- Needs to be better than the “astute physician” at the bedside

Conclusion

• More research is needed to determine a valid Pneumonia Severity Score to differentiate patients at risk for mortality from those who are moderately ill

• Clinical judgment and frequent reassessments in moderately ill patients is key