Accuracy of Community Acquired Pneumonia (CAP) Diagnosis in the Emergency Department

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Disclosures

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  – St Vincent’s Hospital Research Endowment Fund
  – Avant Foundation
  – Medical Doctor Research Project, University of Melbourne Medical School
Is CAP overdiagnosed?
(and why do we care?)

• High Incidence, High Mortality
  – Leading cause of infection related death in developed world\(^1\)
  – 4\(^{th}\) leading cause of Emergency hospital admission in Australian\(^2\)
  – Inpatient Mortality \(\sim 12\%\) \(^3\)

• Could we cut unnecessary antibiotic use & associated adverse effects?
  – \textit{C. difficile} infection\(^4,5\)
  – Allergy and adverse drug reactions\(^6\)
  – Rise in multidrug resistant bacteria\(^4,6\)

• What might we be missing in our older, comorbid patients misdiagnosed with pneumonia?
  – ? Harm from delay to alternate diagnoses e.g. Pulmonary Embolus, Congestive cardiac failure, Sepsis\(^4,7\)

1. CDC. Leading Causes of Death. 2018
5. Stevens CID 2011
6. Campbell Emerg Radiol 2005
7. Muller BMC ID 2007

Is Pneumonia harder to diagnose than we realise?
Diagnostic Challenges

Clinical

- Clinical Signs non specific \(^1\), \(^2\)
- Not readily reproducible between clinicians \(^3\)

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Table 2. Findings in Pneumonia

<table>
<thead>
<tr>
<th>Finding</th>
<th>Positive Likelihood Ratio</th>
<th>Negative Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>History</td>
<td>1.7-2.1</td>
<td>0.6-0.7</td>
</tr>
<tr>
<td>Chills</td>
<td>1.3-1.7</td>
<td>0.7-0.9</td>
</tr>
<tr>
<td>Examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tachycardia</td>
<td>1.6-2.3</td>
<td>0.5-0.7</td>
</tr>
<tr>
<td>Tachypnoea</td>
<td>1.5-3.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Hyperthermia</td>
<td>1.4-4.6</td>
<td>0.6-0.8</td>
</tr>
<tr>
<td>Dullness to percussion</td>
<td>2.2-4.3</td>
<td>0.8-0.9</td>
</tr>
<tr>
<td>Decreased breath sounds</td>
<td>2.3-2.5</td>
<td>0.6-0.8</td>
</tr>
<tr>
<td>Crackles</td>
<td>1.6-2.7</td>
<td>0.6-0.9</td>
</tr>
<tr>
<td>Rhonchi</td>
<td>1.4-1.3</td>
<td>0.8-0.9</td>
</tr>
<tr>
<td>Egophony</td>
<td>2.0-8.6</td>
<td>0.8-1.0</td>
</tr>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevated WBC</td>
<td>1.9-3.7</td>
<td>0.3-0.6</td>
</tr>
</tbody>
</table>

WBC = white blood cell count. \(^3\) Metlay et al, Rosh et al.

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1. Metlay JAMA 1997
2. Rosh Ann Emer Med 2005
Diagnostic Challenges

Clinical

• Clinical Signs are non specific \(^1,^2\)
• Not readily reproducible between clinicians \(^1\)

Radiological

• Poor sensitivity, missing 30% of CAP compared to HRCT \(^3\)
• Significant Interobserver variability \(^4\)
• Confirmation Bias \(^5\)

Microbiological

• Low diagnostic yield w empiric antibiotic therapy \(^6,^7\)
• No pathogen detected for over 50% of patients presenting w CAP \(^8\)

Systems Based

• KPIs – unforeseen consequences
• 4 hour Abx targets (USA) led to drop in diagnostic accuracy 75 -> 59% \(^9\)
• 4 hr NEAT targets shift emphasis from diagnosis to admission

What does the literature say?

• Kanwar 2007:
  – n = 319
  – Error Rate 41.1 - 64%

• Basi 2004:
  – n= 2706
  – Error Rate 33%

• Chandra 2010:
  – n = 800
  – Error rate 27.3%

• Pink 2004:
  – n =710
  – Error rate 31.2%.

• Campbell 2005:
  – n = 671
  – Error rate ~ 50%

• Novack 2006:
  – n = 262
  – Error rate 18.3 – 29.4%
AIMs of study

- To assess the accuracy of CAP diagnosis in a large metropolitan ED.
- To examine factors which increase misdiagnosis.
- To assess the influence of misdiagnosis on mortality and length of stay.

**Hypothesis:**
Approximately 30% of patients diagnosed with CAP in the ED will be incorrectly diagnosed, when assessed against strict criteria.

**Flowchart of methods**

[Diagram showing the flowchart of methods]
Pneumonia Misdiagnosis Rate

• 208 cases analysed
  – 28 excluded due to hospital admission within 14 days
  – n=180 included in analysis

• Diagnosis at discharge?
  – CAP 128
  – Diagnosis other than CAP 52
  – Error Rate 28.89%

• According to Study Definition
  – Correctly Diagnosed 113
  – Incorrectly Diagnosed 67
  – Error Rate 37.22%

<table>
<thead>
<tr>
<th>Patient Background</th>
<th>CAP group n 113 (%)</th>
<th>Misdiagnosis gr. n 67 (%)</th>
<th>OR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (median IQR)</td>
<td>69 (48-82)</td>
<td>74 (64-82)</td>
<td>0.5 (0.3 - 0.9)</td>
<td>0.02</td>
</tr>
<tr>
<td>Male</td>
<td>72 (63.7%)</td>
<td>31 (46.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpreter Required</td>
<td>27 (23.9)</td>
<td>18 (26.9)</td>
<td>1.2 (0.6 - 2.3)</td>
<td>0.66</td>
</tr>
<tr>
<td>Nursing Home</td>
<td>12 (10.6)</td>
<td>9 (13.4)</td>
<td>1.3 (0.5 - 3.3)</td>
<td>0.57</td>
</tr>
<tr>
<td>Asthma</td>
<td>14 (12.4)</td>
<td>10 (14.9)</td>
<td>1.2 (0.5 - 3)</td>
<td>0.629</td>
</tr>
<tr>
<td>COPD</td>
<td>26 (23)</td>
<td>16 (23.9)</td>
<td>1.1 (0.5 - 21)</td>
<td>0.894</td>
</tr>
<tr>
<td>Dementia</td>
<td>10 (8.9)</td>
<td>9 (13.4)</td>
<td>1.6 (0.6 - 4.2)</td>
<td>0.337</td>
</tr>
<tr>
<td>HTN</td>
<td>46 (40.7)</td>
<td>35 (52.2)</td>
<td>1.6 (0.9 - 2.9)</td>
<td>0.134</td>
</tr>
<tr>
<td>IHD</td>
<td>19 (17)</td>
<td>15 (22.4)</td>
<td>1.4 (0.7 - 3)</td>
<td>0.372</td>
</tr>
<tr>
<td>CCF</td>
<td>12 (10.6)</td>
<td>11 (16.4)</td>
<td>1.7 (0.7 - 4)</td>
<td>0.263</td>
</tr>
<tr>
<td>Diabetes</td>
<td>25 (22)</td>
<td>22 (32.8)</td>
<td>1.7 (0.9 – 3.4)</td>
<td>0.116</td>
</tr>
<tr>
<td>CKD</td>
<td>16 (14.2)</td>
<td>13 (19.4)</td>
<td>1.5 (0.7 - 3.2)</td>
<td>0.357</td>
</tr>
<tr>
<td>Active Cancer</td>
<td>15 (13.3)</td>
<td>12 (17.9)</td>
<td>1.4 (0.6 – 3.3)</td>
<td>0.401</td>
</tr>
<tr>
<td>Smoker</td>
<td>29 (28.2)</td>
<td>9 (14.3)</td>
<td>0.4 (0.2 – 1)</td>
<td>0.042</td>
</tr>
<tr>
<td>Bronchodilators</td>
<td>36 (32)</td>
<td>23 (34.3)</td>
<td>1.1 (0.6 - 2.1)</td>
<td>0.733</td>
</tr>
<tr>
<td>Ace inhibitor</td>
<td>11 (9.8)</td>
<td>15 (22.4)</td>
<td>2.7 (1.2 - 6.2)</td>
<td>0.023</td>
</tr>
<tr>
<td>Abx in months prior</td>
<td>24 (21.2)</td>
<td>15 (22.4)</td>
<td>1.1 (0.5 - 2.2)</td>
<td>0.856</td>
</tr>
<tr>
<td>≥ 2 comorbidities</td>
<td>51 (45.1)</td>
<td>46 (68.7)</td>
<td>2.7 (1.4 – 5)</td>
<td>0.003</td>
</tr>
</tbody>
</table>
### Clinical Presentation

<table>
<thead>
<tr>
<th></th>
<th>CAP group n 113 (%)</th>
<th>Misdiagnosis gr. n 67 (%)</th>
<th>OR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Pain</td>
<td>42 (37.7)</td>
<td>24 (35.8)</td>
<td>0.94 (0.5 – 1.8)</td>
<td>0.9</td>
</tr>
<tr>
<td>SOB</td>
<td>83 (73.5)</td>
<td>48 (71.6)</td>
<td>0.91 (0.5 - 1.8)</td>
<td>0.8</td>
</tr>
<tr>
<td>Cough</td>
<td>98 (86.7)</td>
<td>53 (79.1)</td>
<td>0.58 (0.3 - 1.3)</td>
<td>0.182</td>
</tr>
<tr>
<td>Fever</td>
<td>80 (70.8)</td>
<td>39 (58.2)</td>
<td>0.57 (0.3 – 1.1)</td>
<td>0.09</td>
</tr>
<tr>
<td>Confusion</td>
<td>25 (22.1)</td>
<td>12 (17.9)</td>
<td>0.768 (0.4 – 1.7)</td>
<td>0.5</td>
</tr>
<tr>
<td>Dizziness/Falls</td>
<td>14 (12.4)</td>
<td>14 (20.9)</td>
<td>1.87 (0.8 - 4.2)</td>
<td>0.132</td>
</tr>
<tr>
<td>Abn. Chest exam.</td>
<td>106 (93.8)</td>
<td>62 (92.5)</td>
<td>0.82 (0.3 - 2.7)</td>
<td>0.742</td>
</tr>
<tr>
<td>RR &gt; 20</td>
<td>87 (77)</td>
<td>50 (74.6)</td>
<td>0.88 (0.4 - 1.8)</td>
<td>0.72</td>
</tr>
<tr>
<td>Sat &lt; 90</td>
<td>35 (31)</td>
<td>20 (29.9)</td>
<td>0.94 (0.5 - 1.8)</td>
<td>0.874</td>
</tr>
<tr>
<td>BP &lt; 100</td>
<td>26 (23)</td>
<td>14 (20.9)</td>
<td>0.88 (0.4 - 1.8)</td>
<td>0.74</td>
</tr>
<tr>
<td>HR &gt; 100</td>
<td>64 (56.6)</td>
<td>30 (44.8)</td>
<td>0.62 (0.3 - 1.1)</td>
<td>0.13</td>
</tr>
<tr>
<td>T &gt; 37.9 or &lt; 35.4</td>
<td>66 (58.4)</td>
<td>32 (47.8)</td>
<td>0.65 (0.4 - 1.2)</td>
<td>0.167</td>
</tr>
<tr>
<td>CORB ≥ 2 (severe)</td>
<td>37 (32.7)</td>
<td>16 (23.9)</td>
<td>0.64 (0.3 - 1.2)</td>
<td>0.209</td>
</tr>
<tr>
<td>CRP (med, IQR)</td>
<td>167 (75 – 262)</td>
<td>76 (33 – 149)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WCC (med, IQR)</td>
<td>11.8 (8.8 – 15.4)</td>
<td>9.4 (6.5 – 13.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Pathogens Isolated

<table>
<thead>
<tr>
<th>Pathogens Isolated</th>
<th>CAP Group</th>
<th>Misdiagnosis Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus pneumoniae</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Moraxella catarrhalis</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mycoplasma Pneumoniae</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Legionella spp.</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Neisseria meningitis</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Escherichia Coli</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Klebsiella spp.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Serratia marcescens</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Moulds</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Myobacterium avium complex</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Influenza</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Resp viruses non influenza</td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>
CXR and Diagnosis

N = 180

67 misdiagnosed

Concordance Treating Doctors and Radiologist: 55%

49: CXR normal or not consistent with pneumonia
18: CXR infiltrates but alternate pathology found

113 Correctly Diagnosed

Concordance Treating Doctors and Radiologist: 92%

106: had CXR consistent with pneumonia
7: had normal CXR, but pneumonia confirmed on CT

Alternate Diagnosis

<table>
<thead>
<tr>
<th>Category</th>
<th>n 67 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viral: Influenza, Resp Virus, LRTI</td>
<td>21 (31.3)</td>
</tr>
<tr>
<td>Exacerbation: COPD, Asthma, Bronchiectasis</td>
<td>13 (19.4)</td>
</tr>
<tr>
<td>Cardiopulmonary: APO, PE, CCF, Pleural disease, Pulmonary Fibrosis</td>
<td>12 (18)</td>
</tr>
<tr>
<td>Other Infection: Sepsis, prostatitis, TB</td>
<td>9 (13.4)</td>
</tr>
<tr>
<td>Malignancy</td>
<td>5 (7.5)</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3 (4.5)</td>
</tr>
</tbody>
</table>
Treatment

**CAP Group**
- n 117
- (Median, IQR)
- Time to abx: 2.5h (1.32 -3.88)
- Duration of Inpatient Abx: 5d (4-8)
- Duration of Discharge Abx: 5d (4-7)

**Misdiagnosis Group**
- n 67
- (Median, IQR)
- Time to abx: 2.6h (1.65 – 3.97)
- Duration of Inpatient Abx: 4d (3-7)
- Duration of Discharge Abx: 5d (4-7)

**Misdiagnosis Group n 67**

- Abx appropriate
  - 46%
  - Abx Duration (median)
    - 9.5 days

- Abx inappropriate
  - 54%
  - Abx Duration (median)
    - 7 days
## Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>CAP group n 113 (%)</th>
<th>Misdiagnosis group n 67 (%)</th>
<th>OR (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU/HDU admission</td>
<td>18 (15.93)</td>
<td>5 (7.46)</td>
<td>0.42 (0.2 – 1.2)</td>
<td>0.108</td>
</tr>
<tr>
<td>Length of Stay (med, IQR)</td>
<td>5 (3-8)</td>
<td>4 (3-10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Readmission within 30 days</td>
<td>10 (8.85)</td>
<td>4 (5.97)</td>
<td>0.65 (0.2 – 2.1)</td>
<td>0.488</td>
</tr>
<tr>
<td>Died during admission</td>
<td>8 (7.08)</td>
<td>8 (11.94)</td>
<td>1.8 (0.6 – 5)</td>
<td>0.273</td>
</tr>
<tr>
<td>30 day mortality</td>
<td>10 (8.85)</td>
<td>11 (16.42)</td>
<td>1.8 (0.7 – 4.7)</td>
<td>0.203</td>
</tr>
</tbody>
</table>

### Limitations

- Single Centre
- Retrospective
- Small Sample Size
  - ? Lack of distinctions between groups, or not powered to detect them
  - Prevents demonstration of harms from delay to alternate diagnosis or unnecessary antibiotics
The Evolution of an Error

**Clinical**
- Vague presentation esp. in elderly
- Many Mimics
- Poor Sensitivity/Specificity of Clinical findings
- High interobserver variation

**Diagnostics**
- No gold standard
- Poor sensitivity of CXR ~70%
- Barriers to HRCT
- Confirmation bias
- Delay to CXR report
- Interobserver variation

**System Factors**
- Time linked KPIs for admission to hospital
- Requirement for ED diagnosis for admission
- Time linked KPIs for antibiotic treatment (USA)
- Provisional Diagnosis often unchallenged

Future Directions

- Identification of common diagnostic error
  - Poses potential harm to patients with unnecessary exposure to antibiotics and delay to alternate diagnosis

- Challenge to antibiotic paradigm of “longer + broader”
  - But ceasing antibiotics may also pose risk

- How can we challenge this diagnostic momentum without posing new and unforeseen risks to our patients?
Opportunities to improve?

### Clinical
- Develop Diagnostic Models rather than prognostic models?
- Get better at clinical examination and history taking??

### Diagnostics
- Improved access to HRCT
- Wider uptake of lung ultrasound in ED
- Repeat CXR at 48 hrs
- Train clinicians in CXR interpretation
- More timely access to radiology reports
- Use of new and novel biomarkers

### System Factors
- Change KPIs
- ? Reward Diagnostic Accuracy
- Paradigm shift: admit patients without diagnosis e.g. ‘fever and respiratory symptoms’
- Recognise and challenge diagnostic momentum

Conclusion

- High rate of misdiagnosis of CAP of 37% according to strict evidence based criteria
- Difficult to distinguish clinically whether patients truly have Community Acquired Pneumonia
- Many patients misdiagnosed w CAP have symptoms of an acute respiratory infection without accompanying radiological changes consistent with pneumonia.
- High rate of unnecessary antibiotic use
- Future Research
  - Prospective study using repeat CXR at 48 hours to help exclude CAP, cease antibiotics and trigger search for an alternate diagnosis
References


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