Community Acquired Pneumonia: Measures to Improve Management and Healthcare Quality

Gonzalo Bearman MD, MPH
Assistant Professor of Internal Medicine
Divisions of Quality Health Care & Infectious Diseases
Associate Hospital Epidemiologist
VCU Health System
Outline

- VHQC Pneumonia collaborative: overview
  - CAP: scope of the problem
  - Baseline indicator rates
- Key process measures
  - Scientific evidence and rationale:
    - Timing and choice of antibiotics
    - Blood cultures
    - Pneumococcal and influenza vaccination
    - Smoking cessation
- Barriers to implementation
- Conclusion
VHQC Pneumonia Collaborative

Mission:

- Improve the quality of healthcare for patients admitted to the hospital for the treatment of community acquired pneumonia.
Scope of the current clinical problem: Community-Acquired Pneumonia

Epidemiology:
- Sixth leading cause of death
  - Number one cause of death from infectious disease
- Up to 5.6 million cases per year
  - >10 million physician visits
  - 1.1 million hospitalizations
- Average rate of mortality for hospitalized patients 12%

Pneumonia Project
Performance Measures

- Increase timely antibiotic administration
- Increase initial antibiotic therapy consistent with current guidelines (IDSA / ATS)
- Decrease smoking by providing cessation advice/counseling
- Increase arterial oxygenation assessment in the first 24 h
- Increase blood culture collection in the first 24 hours
- Increase blood culture collection prior to first antibiotic dose
- Increase screening for influenza & pneumococcal immunization status & vaccinate prior to discharge, if indicated
- Increase state wide immunization rates for influenza & pneumococcal vaccines
## Virginia Baseline Indicator Rates: 2001

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>RATE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antibiotics within 4 hours</td>
<td>59.9%</td>
</tr>
<tr>
<td>Appropriate antibiotic</td>
<td>65.0%</td>
</tr>
<tr>
<td>Blood culture within 24 hours</td>
<td>69.3%</td>
</tr>
<tr>
<td>Blood culture prior to antibiotics</td>
<td>83.9%</td>
</tr>
<tr>
<td>Influenza vaccination</td>
<td>12.6%</td>
</tr>
<tr>
<td>Pneumococcal vaccination</td>
<td>17.5%</td>
</tr>
<tr>
<td>Smoking cessation counseling</td>
<td>N/A</td>
</tr>
</tbody>
</table>
VHQD Pneumonia Collaborative

Performance measures, rationale and supporting data
Timing and Choice of Antibiotics
Timing of antibiotics

Bratzler et al; *Archives of Internal Medicine* 2004. In press

- Retrospective study 13,771 patients from a random Medicare registry sample
  - CAP; Age >65; 7/1998-3/1999
- Outcome Measures
  - Antibiotic administration within 4 hours
  - Mortality (severity-adjusted)
  - Readmission within 30 days
  - Length of stay (LOS)
## First Dose Timing and Outcomes

<table>
<thead>
<tr>
<th>Timing of First Dose</th>
<th>Group 1 Mortality</th>
<th>Group 2 Mortality</th>
<th>Adjusted Odds Ratio</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1 hour vs &gt; 1 hour</td>
<td>12.9%</td>
<td>12.0%</td>
<td>0.99 (.81-1.21)</td>
<td>0.906</td>
</tr>
<tr>
<td>≤ 2 hours vs &gt; 2 hours</td>
<td>12.5%</td>
<td>11.9%</td>
<td>0.94 (.83-1.06)</td>
<td>0.322</td>
</tr>
<tr>
<td>≤ 3 hours vs &gt; 3 hours</td>
<td>11.7%</td>
<td>12.3%</td>
<td>0.88 (.79-.99)</td>
<td>0.030</td>
</tr>
<tr>
<td>≤ 4 hours vs &gt; 4 hours</td>
<td>11.6%</td>
<td>12.7%</td>
<td>0.85 (.76-.95)</td>
<td>0.005</td>
</tr>
<tr>
<td>≤ 5 hours vs &gt; 5 hours</td>
<td>11.6%</td>
<td>13.0%</td>
<td>0.86 (.76-.97)</td>
<td>0.017</td>
</tr>
<tr>
<td>≤ 6 hours vs &gt; 6 hours</td>
<td>11.6%</td>
<td>13.5%</td>
<td>0.84 (.73-.95)</td>
<td>0.008</td>
</tr>
<tr>
<td>≤ 7 hours vs &gt; 7 hours</td>
<td>11.7%</td>
<td>13.5%</td>
<td>0.87 (.76-1.01)</td>
<td>0.060</td>
</tr>
<tr>
<td>≤ 8 hours vs &gt; 8 hours</td>
<td>11.7%</td>
<td>13.8%</td>
<td>0.85 (.73-.99)</td>
<td>0.040</td>
</tr>
<tr>
<td>≤ 9 hours vs &gt; 9 hours</td>
<td>11.8%</td>
<td>13.8%</td>
<td>0.86 (.73-1.02)</td>
<td>0.075</td>
</tr>
<tr>
<td>≤ 10 hours vs &gt; 10 hours</td>
<td>11.9%</td>
<td>13.4%</td>
<td>0.91 (.76-1.09)</td>
<td>0.327</td>
</tr>
</tbody>
</table>

**Retrospective analysis: early antibiotic treatment associated with decreased odds of mortality**

Using multivariate logistic regression [the model included the timing of antibiotic first dose, PSI score, ICU admission, US census region, race/ethnicity, other processes of care (oxygenation assessment, performance of blood cultures, and antibiotic selection)]. Patients who were on antibiotics prior to admission are excluded from this analysis. (Houck PM, Bratzler DW, et al. *Arch Intern Med*. In Press)
## Association between Antibiotic First Dose Timing and Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Within 4 hours</th>
<th>After 4 hours</th>
<th>Adjusted Odds Ratio aOR (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-day mortality</td>
<td>11.6%</td>
<td>12.7%</td>
<td>0.85 (.76-.95)</td>
<td>0.005</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>6.8%</td>
<td>7.4%</td>
<td>0.85 (.74-.98)</td>
<td>0.029</td>
</tr>
<tr>
<td>Length of stay &gt; 5 days</td>
<td>42.1%</td>
<td>45.1%</td>
<td>0.90 (.83-.96)</td>
<td>0.003</td>
</tr>
<tr>
<td>30-day readmission</td>
<td>13.1%</td>
<td>13.9%</td>
<td>0.95 (.85-.1.06)</td>
<td>0.344</td>
</tr>
</tbody>
</table>

Using multivariate logistic regression [the model included the timing of antibiotic first dose, PSI score, ICU admission, US census region, race/ethnicity, other processes of care (oxygenation assessment, performance of blood cultures, and antibiotic selection)].


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Early (within 4 hours) administration of antibiotics associated with decreased mortality and shorter LOS.
Appropriateness of antibiotic

- Appropriate selection of initial antibiotic therapy
  - *Streptococcus pneumoniae* causes two-thirds of all cases of bacteremic pneumonia
  - Need to cover potentially resistant strains of *S. pneumoniae* and atypical organisms for patients admitted to ICU
## Initial Antibiotic Selection

<table>
<thead>
<tr>
<th>Non-ICU</th>
<th>ICU</th>
<th>Pseudomonal Risk*</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-lactam (IV or IM) + macrolide (IV or Oral) or β-lactam (IV or IM) + doxycycline (IV or Oral) or Quinolone monotherapy (IV or Oral)</td>
<td>β-lactam (IV) + macrolide (IV) or β-lactam (IV) + quinolone (IV) If documented β-lactam allergy: Quinolone (IV) + Clindamycin (IV) or Quinolone (IV) + Vancomycin (IV)</td>
<td>*In addition to the antibiotics listed under ICU, if the patient had a secondary ICD-9 code of bronchiectasis, or a positive response to the bronchiectasis question, or malnutrition [as reflected by a serum albumin below 3], these antibiotics would also be considered acceptable: Antipseudomonal β-lactam (IV) + Antipseudomonal quinolone (IV) Or Antipseudomonal β-lactam (IV) + Aminoglycoside (IV) + either a [Macrolide (IV) or Antipneumococcal quinolone (IV)] If documented β-lactam allergy: Aztreonam (IV) + Aminoglycoside (IV) + Antipneumococcal quinolone (IV)</td>
</tr>
</tbody>
</table>

Adapted from IDSA: Practice Guidelines for the Management of Community Acquired Pneumonia in Adults. CID 2000;31:347-82
# Initial Antibiotic Selection

## 30-day mortality - Community-dwelling Patients

(14,150 patients)

<table>
<thead>
<tr>
<th>Initial Antibiotics</th>
<th>30-day mortality N/D (%)</th>
<th>Adjusted Odds Ratio† aOR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd generation cephalosporin*</td>
<td>277/3072 (9.0)</td>
<td>Reference</td>
<td>Ref</td>
</tr>
<tr>
<td>Macrolide monotherapy‡</td>
<td>19/431 (4.4)</td>
<td>0.63 (.39-1.04)</td>
<td>0.069</td>
</tr>
<tr>
<td>2nd generation cephalosporin</td>
<td>73/844 (8.6)</td>
<td>1.13 (.85-1.51)</td>
<td>0.406</td>
</tr>
<tr>
<td><strong>Quinolone monotherapy‡</strong></td>
<td>121/1716 (7.1)</td>
<td><strong>0.78 (.62-.98)</strong></td>
<td><strong>0.037</strong></td>
</tr>
<tr>
<td>At least 1 aminoglycoside</td>
<td>80/445 (18.0)</td>
<td>1.51 (1.11-2.04)</td>
<td><strong>0.008</strong></td>
</tr>
<tr>
<td>Cephalosporin + macrolide‡</td>
<td>231/3618 (6.4)</td>
<td><strong>0.74 (.61-.89)</strong></td>
<td><strong>0.002</strong></td>
</tr>
<tr>
<td>Cephalosporin + quinolone‡</td>
<td>63/723 (8.7)</td>
<td>0.90 (.67-1.22)</td>
<td>0.506</td>
</tr>
<tr>
<td>ß-lactam/ß-lactamase inhibitor + macrolide‡</td>
<td>17/158 (10.8)</td>
<td>1.12 (.65-1.94)</td>
<td>0.689</td>
</tr>
</tbody>
</table>

*monotherapy with cefotaxime or ceftriaxone.

†Results adjusted for age, gender, neoplastic disease, cardiovascular disease, altered mental status, respiratory rate > 30/min, systolic BP < 90 mmHg, temperature < 35C or > 40C, pulse > 125/min, blood pH < 7.35, BUN > 10.7 mmol/L, sodium < 130 mEq/L, hematocrit < 30%, pO2 < 60 mmHg, pleural effusion, admission to ICU in the first 24 hours after arrival, antibiotics administered within the first 4 hours after arrival, and US census region.

‡These antibiotic combinations include patients receiving either oral or parenteral macrolides or quinolones.

Summary: Current Practice Guidelines

Antibiotic timing and antibiotic choice represent practice guidelines based on best available current evidence:

- These are retrospective, observational trials and expert (committee) opinion.
- These guidelines are not based on extensive prospective, randomized controlled trials.
Blood Culture Collection
National CAP Guidelines

- 2 sets of blood cultures should be drawn before initiation of antibiotic therapy
  - Infectious Diseases Society of America, 2000
  - American Thoracic Society, 2001
Blood Culture Collection: Process Indicators

- Increase the collection of blood cultures prior to first antibiotic dose
  - Blood cultures before antibiotics gives highest yield of identifying a pathogen
- Increase the collection of blood cultures during the first 24 hours
  - Better late than never!
Rationale for Obtaining Blood Cultures in Patients with Pneumonia

- Studies have shown that 2-14% of patients with pneumonia have positive blood cultures - *low yield diagnostic test*
- A positive blood culture provides definitive evidence of the cause of pneumonia in most cases; provides greater certainty than sputum cultures or serology
Rationale for Obtaining Blood Cultures in Patients with Pneumonia

- Pneumonia patients with bacteremia have a 3-fold increase in mortality.

- Establishing a microbiologic diagnosis allows streamlining of antibiotic therapy, which decreases potential for antibiotic resistance.

- Collection of blood cultures associated with decreased mortality.
Pathogens Retrieved by Blood Culture

- Prospective study
- 19 Canadian hospitals
- 760 patients
  - 43 with (+) blood cultures

- S. pneumoniae 68%
- Staph. aureus 11%
- Enterobacteriaceae 16%
- Other 5%

Performance of Microbiologic Studies in Pneumonia Patients

- Multicenter (5 hospitals), prospective, observational study, 1991-94; n=2,287

<table>
<thead>
<tr>
<th>Test</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sputum gram stain within 48 hrs of admission</td>
<td>52</td>
</tr>
<tr>
<td>Sputum culture within 48 hrs of admission</td>
<td>58</td>
</tr>
<tr>
<td>Blood culture obtained before antibiotics</td>
<td>71</td>
</tr>
</tbody>
</table>

Fine MJ. Arch Intern Med 1999;159:970.
Performance of Microbiologic Studies in Pneumonia Patients

Multicenter (3,555 hospitals), retrospective cohort study, 1994-95; n=14,069

<table>
<thead>
<tr>
<th>Test</th>
<th>%</th>
<th>Range by state</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood culture within 24 hrs of admission</td>
<td>69</td>
<td>46-83%</td>
</tr>
<tr>
<td>Blood culture obtained before antibiotics</td>
<td>57</td>
<td>32-74%</td>
</tr>
</tbody>
</table>

Blood culture collection within 24 hours of arrival was associated with a 10% lower odds of 30-day mortality

Meehan TP et al. JAMA 1997;278:2080-2084.
Performance of Microbiologic Studies in Pneumonia Patients

Multicenter (38 academic hospitals), retrospective study, 1997-98; n=1,062

<table>
<thead>
<tr>
<th>Test</th>
<th>%</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood culture obtained before antibiotics</td>
<td>72</td>
<td>9-100%</td>
</tr>
<tr>
<td>Blood culture within 24 hrs of admission</td>
<td>82</td>
<td>54-100%</td>
</tr>
</tbody>
</table>

Blood Culture Collection within 24 hrs: Independent Predictors

Multivariate analysis: 14,069 patients >65 years old with pneumonia throughout the US

- **Patient factors**
  - Nursing home
  - Cerebrovascular disease
  - Abnormal mental status
  - Tachycardia
  - Hypotension (BP<90)
  - Fever (T>37.8°C)

- **Hospital Factors**
  - Limited teaching status
  - >100 beds
  - Nurse-bed ratio >0.75
  - ED admission
  - ER volume >10,000 visits/year
  - Northeast region

Pneumococcal & Influenza Vaccine Administration
Leading Health Indicators

- Physical activity
- Overweight & obesity
- Tobacco use
- Substance abuse
- Responsible sexual behavior
- Mental health
- Injury & violence
- Environmental quality
- Immunization
- Access to health care

Increase the proportion of noninstitutionalized adults vaccinated annually against influenza & ever vaccinated against pneumococcal disease

CDC. Healthy People 2010.
Pneumococcal & Influenza Vaccine Administration: Rationale

- These vaccines are effective
- Administration of these vaccines is covered by Medicare
Influenza & pneumococcal vaccines should be administered

- Infectious Diseases Society of America, 2000
  - There is no contraindication for use of either pneumococcal or influenza vaccine immediately after an episode of pneumonia (i.e., before hospital discharge). The vaccines are inexpensive and can be given simultaneously.

- American Thoracic Society, 2001
- Advisory Committee on Influenza Practices (ACIP)
Pneumococcal & Influenza Vaccine Administration: Process Indicators

- Increase the number of inpatients screened for influenza & pneumococcal immunization status & vaccinated prior to discharge, if indicated
- Increase state wide immunization rates for influenza & pneumococcal vaccines
Vaccine Utilization in Virginia
Adults ≥65 years old

% vaccinated

100
90
80
70
60
50
40
30
20
10
0

1993 1997 1999 2001 2010 goal

Influenza Pneumococcal

CDC. Behavioral Risk Factor Surveillance System.
Influenza

- Very common community-acquired infection
- Accounts for 20,000 deaths/year in the US
- Persons ≥65 years old have increased morbidity & mortality
Influenza Vaccine

- Made from egg-grown viruses; inactivated (not a live virus vaccine)
- Contains antigens from 2 A viruses & 1 B virus that are likely to circulate in the upcoming winter
- Annual vaccination is necessary as immunity declines in the year following vaccination
- Should be administered in October-November
- Contraindications: egg allergy or allergy to vaccine components
Vaccine Misconceptions

The following are not vaccine contraindications:

- Previous mild-moderate local tenderness, redness/swelling, fever < 40.5°C
- Mild acute illness with/without low-grade fever
- Current antimicrobial therapy or convalescence from a recent illness
- Pregnancy or household contact with a pregnant woman
- Recent exposure to an infectious disease
- Breast-feeding
- Family history of "allergies," adverse reactions to vaccination, or seizures
Influenza Vaccine Indications

- ≥50 years of age
- Any person wishing to reduce chance of infection
- Nursing home residents
- Chronic cardiopulmonary disorders
- Chronic metabolic disease (e.g., DM), renal dysfunction, hemoglobinopathies, immunosuppression
- Long-term aspirin therapy in children & teenagers

MMWR 2001;49(RR-4):R12
**Influenza Vaccine Indications**

- Household members of persons in high-risk groups
- HIV infection
- Women who will be in 2nd or 3rd trimester of pregnancy during influenza season
- Travelers
  - Persons at high risk for complications of influenza who were not vaccinated during the preceding fall-winter should consider receiving vaccine before travel if they plan to:
    - Travel to the topics
    - Travel w/ large organized tourists groups at any time of year
    - Travel to Southern hemisphere April - September
- HCWs (in/outpatient, nursing home, home care, EMS)

MMWR 2001;50(RR-4):8-12.
### Efficacy of Influenza Vaccine

**Determinants of efficacy:**

- Closeness of match between circulating virus & vaccine strains
- Age
- Immunocompetence

<table>
<thead>
<tr>
<th>Group</th>
<th>Outcome Prevented</th>
<th>Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;65 years, healthy</td>
<td>Illness due to influenza</td>
<td>70-90%</td>
</tr>
<tr>
<td>Elderly in nursing homes</td>
<td>Illness due to influenza</td>
<td>30-40%</td>
</tr>
<tr>
<td></td>
<td>Hospitalization &amp; pneumonia</td>
<td>50-60%</td>
</tr>
<tr>
<td></td>
<td>Death</td>
<td>80%</td>
</tr>
</tbody>
</table>

Influenza Vaccine During Hospitalization

- One study revealed that 39-46% of patients hospitalized during the winter with influenza-related diagnoses had been hospitalized during the preceding autumn.
  - *missed vaccination opportunity*

- Persons of all ages with high-risk conditions & those aged ≥50 years who are hospitalized during September to March should be offered & strongly encouraged to receive influenza vaccine before they are discharged.
  
Pneumococcal Pneumonia

- *Streptococcus pneumoniae* is the most common cause of bacterial pneumonia in adults
- Bacteremia occurs in 20-30%
  - Mortality rate 16-44% in those ≥65 years
  - May be complicated by shock, respiratory failure, empyema, meningitis, septic arthritis, purulent pericarditis, & endocarditis
- *S. pneumoniae* has become increasingly resistant to antibiotics

Impact of S. pneumoniae

- 500,000 cases of pneumonia/year
  - 100,000-135,000 hospitalizations
- 60,000 cases of invasive disease/year
  - 3,300 cases of meningitis
  - 50,000 cases of bacteremia
    - Mortality in those >65 years as high as 40%
- 40,000 deaths/year

http://www.cdc.gov/ncidod/dbmd/diseaseinfo/drugresisstreppneum_t.htm
Pneumococcal Vaccine

- Covers 23 of the 90 serotypes of *S. pneumoniae*
  - These 23 serotypes account for 90% of invasive infections
- Not a live vaccine
- Administered once in those ≥65 years
  - Revaccination only for those vaccinated at <65 years & the immunosuppressed
- Can be administered simultaneously with influenza vaccine
- Overall, 60% effective
- Well tolerated; serious side effects rare
- Contraindication: severe reaction to previous pneumococcal vaccination
Cost Effectiveness of Pneumococcal & Influenza Vaccinations

For persons >60, these vaccines are more cost effective than:

- Mammograms
- PAP smears
- Screening blood for HIV
- B-blocker for survivors of MI
- Cholesterol screening
- Smoking cessation

Standing Orders

A rule from the Centers for Medicare and Medicaid Services (CMS) in 2002 removed the physician signature requirement for the administration of influenza and pneumococcal vaccines to Medicare and Medicaid patients in hospitals, long-term care facilities, & home health agencies.
Effect of Standing Orders on Pneumococcal Vaccination Rates

<table>
<thead>
<tr>
<th></th>
<th>Hospital</th>
<th>Nursing Home</th>
<th>Nursing Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>% vaccinated</td>
<td>78</td>
<td>94</td>
<td>83</td>
</tr>
</tbody>
</table>

Before | After
---|---
0 | 4
2 |
Smoking Cessation
Smoking Cessation Counseling

- Inpatient smoking cessation counseling is not typically part of routine clinical practice
- **However:**
  - The hospital is a unique venue for intervention, given the smoke free environment and the presence of patients who have experienced acute illness due to their smoking habits.
  - This may serve to increase patient motivation
Inpatient smoking cessation and all cause mortality among the elderly

Cooperative Cardiovascular Project (1/94-7/95)

- Retrospective analysis of 788 Medicare beneficiaries
  - Information on smoking cessation abstracted from charts
  - Smoking cessation counseling and association with 5-year mortality was assessed by Cox Proportional Hazards modeling.

Inpatient smoking cessation and all cause mortality among the elderly

**Figure 1.** Age-adjusted survival estimates of 788 smokers, aged ≥65 years, who were admitted and discharged alive with acute myocardial infarction, by smoking cessation counseling status: North Carolina Cooperative Cardiovascular Project. Log-rank test for equality of survival functions, $\chi^2 = 11.78, p<0.001$. 

Barriers to Implementation

Physician and Staff Acceptance
- Quality of the data
  - Most pneumonia outcomes studies are retrospective, observational
    - Lack of randomized controlled trials

Education
- Unfamiliarity with CAP treatment guidelines
- Unfamiliarity with vaccination guidelines
  - Vaccine misconceptions
- Hospital wide education campaigns are logistically difficult
Barriers to Implementation

Lack of automated systems
- Automated decision, clinical support and electronic medical record (EMR):
  - Guide physicians on antibiotic management
  - Guide decisions/management based on admitting diagnosis
    - Blood cultures
    - Sputum gram stain
    - Vaccination prompts: pneumococcal and influenza vaccine
    - Smoking cessation prompts
- Limitations of non-centralized EMR
  - Limitations in accurate patient history: prior vaccination?
  - Limitations in data extraction for quality control
Conclusion:

- Pneumonia collaborative project: improve the quality of healthcare for patients admitted to the hospital for the treatment of community acquired pneumonia.

- Leading process indicators are timing and choice of antibiotics, obtainment of blood cultures, pneumococcal and influenza vaccination, and inpatient smoking cessation counseling.

- Achievement of process indicators will likely require: a collaborative and systems wide approach which includes:
  - Education
  - Acceptance from physicians and staff
    - Participation on multiple provider levels
      - Emergency department
      - Medical ward
      - Intensive care units
  - Assistance from automated hospital information systems: decision support
    - Standing orders
    - Antibiotic recommendations
    - Physician prompts such as vaccination and smoking cessation