Pharmacoeconomic Considerations Associated with the Use of Intravenous-to-Oral Moxifloxacin for Community-Acquired Pneumonia

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Background. Intravenous-to-oral (iv/po) conversion is one cost-effective approach to the management of community-acquired pneumonia (CAP).

Methods. Consecutive patients with CAP were enrolled during 3 study periods (January–March of 2001, 2002, and 2004) with different pharmacy intervention (PI) strategies: iv β-lactam plus a macrolide (no PI), iv β-lactam plus a macrolide with iv/po PI (PI switch), and iv moxifloxacin with pharmacist-initiated automatic po moxifloxacin conversion (PI sequential). Costs and outcomes were compared among groups.

Results. Two hundred fifty-one patients were enrolled. The average Fine score was 75, and the mean age of patients was 51 years. In the PI groups, the duration of treatment with iv antibiotics was decreased. Clinical success on day 3 of therapy was improved in the PI sequential group but was similar in all 3 groups on day 7 of therapy and at the end of therapy. The length of stay in the hospital was similar for patients in all 3 groups (mean, 4.39 days). Antibiotic costs were significantly reduced, by $110/patient, in the PI sequential group.

Conclusions. Conversion from iv to po therapy was accomplished more quickly when converting to the same agent with pharmacist-initiated automatic iv/po conversion, thus reducing the associated cost without compromising efficacy.

Community-acquired pneumonia (CAP) is consistently ranked as 1 of the top 5 reasons for hospital admission and is responsible for ∼4 million visits to hospitals, emergency departments, and outpatient clinics annually [1]. The cost of inpatient treatment for an episode of pneumonia has been estimated as $7500 for an inpatient visit [2] or $836/day [3]. Increasing medical costs are an ever-growing concern for many hospitals. Institutions face the challenge of providing high-quality health care in a cost-effective manner. Antibacterials administered intravenously (iv) are considered to be the standard of care for patients with serious infections who require hospitalization. One approach to reducing hospital costs and decreasing the length of stay (LOS) is to use oral (po) therapy, instead of iv therapy, whenever possible [4–10]. The conversion from iv to po antibacterials has been shown to dramatically decrease costs incurred by the hospital without compromising efficacy or safety [4, 6, 8, 11–14].

The timing of the switch to po antibacterials should be based on both patient factors and drug factors. The frequent requirement for patients to experience clinical improvement in their condition before conversion is based on the incorrect assumption that all po agents are not able to achieve the same activity achieved by an iv agent. However, many antimicrobial agents, including the fluoroquinolones, attain 80% to 100% bioavailability and produce nearly equivalent concentrations in serum, regardless of the route of administration. It has been proposed that having a functional gastrointestinal tract and hemodynamic stability are the only criteria necessary for po treatment with a fluoroquinolone [15]. The current formulary and CAP treatment pathway at Detroit Receiving Hospital (Detroit, MI) contain recommendations for moxifloxacin as the antipneumococcal fluoroquinolone of choice. On the
basis of the potential benefit of a pharmacist-initiated, “sequential” (i.e., the same drug administered both iv and po) treatment for CAP, we compared the differences in associated costs and outcomes between patients prospectively targeted for iv/po sequential moxifloxacin, historical control subjects treated with the combination of a β-lactam plus a macrolide (2001), and patients who were treated with combination iv therapy and then were “switched” (from one iv regimen to a different po drug) to oral levofloxacin (2002).

It was our hypothesis that initiation of iv moxifloxacin monotherapy can facilitate earlier transition to oral moxifloxacin than can a change to the use of a different agent for oral therapy. It was also hypothesized that a change from iv to po therapy initiated by the pharmacist would expedite change and result in the greatest potential cost savings.

METHODS

The present study provides an assessment of a prospective pharmacy intervention (PI) involving sequential iv/po therapy for patients with CAP, compared with 2 groups of historical control subjects; the data evaluated were for consecutive adult patients admitted with a diagnosis of CAP from January through March of 2001, 2002, and 2004. Data from 2003 were not assessed, because this period included no targeted intervention but encompassed a time when a formulary conversion of fluoroquinolones was performed. In 2001, patients were not specifically targeted for intervention by pharmacists for transition from iv to po therapy (no PI [NPI], historical group). In 2002, the institutional CAP treatment guidelines recommended iv combination therapy with ceftriaxone and erythromycin, and pharmacists targeted patients for intervention to attempt early conversion to oral levofloxacin (PI with therapy switched from an iv β-lactam with or without a macrolide to po levofloxacin [PI switch]). In 2004, consecutive patients treated for CAP for a 3-month period were targeted by an intervention to initiate iv moxifloxacin, with conversion to oral moxifloxacin recommended by an infectious diseases pharmacist when specific criteria for conversion were met (PI with sequential iv/po moxifloxacin [PI sequential]). The study received full approval from the board of the Wayne State University Human Investigation Committee.

In all 3 study periods, consecutive patients (18–89 years old) admitted to Detroit Receiving Hospital and University Health Center (a 279-bed, university-affiliated, urban, level I trauma center for adult patients in Detroit, MI) with a diagnosis of CAP were eligible for evaluation. The diagnosis of CAP, as defined in previous studies [5], was determined by the presence of a new pulmonary infiltrate plus at least 2 of the following criteria: fever (temperature, ≥37.8°C), a new-onset cough or an increase in cough and sputum production, or a WBC count >10,000 or <4000 cells/mm³. Patients were excluded from the study if they were pregnant, had been transferred from a nursing home or long-term care facility, had been hospitalized within the past 30 days, or had received antibiotics within 48 h of presentation to the emergency department.

During the prospective study periods, physician interventions included both educational presentations and direct interaction. An educational in-service presentation was given at the beginning of each study period during internal medicine and emergency medicine morning reports. The in-service presentation to physicians consisted of an overview of the treatment pathway for CAP and the potential benefits of conversion to po therapy, from both a clinical and an economic standpoint.

Patients were identified through daily monitoring of new patients who were admitted to the hospital with a diagnosis of pneumonia or who initiated treatment with iv antibacterials prescribed for pneumonia. When patients met the institution’s defined criteria for receipt of po therapy during study periods 2 (i.e., 2002) and 3 (i.e., 2004) (Appendix), the use of an oral fluoroquinolone was recommended or automatically converted by the reviewing pharmacist. During the PI sequential period only, when a patient was prescribed iv moxifloxacin, the pharmacist approached the physician to review the iv/po conversion recommendations, and an order for automatic conversion could be obtained at that time.

Demographic data collected from medical records of the patients included sex, age, comorbid diseases (if applicable), allergies, and LOS (in days) in both intensive care and non-intensive care units, if applicable. Concurrent use of an antimicrobial agent and the number of doses received, Fine criteria, APACHE II score, maximum temperature (for 24 h), oxygenation content (PO₂), mechanical ventilation status, WBC count, culture results and sensitivity, results of chest radiography, and dietary intake were reviewed for each day of antibacterial treatment. Clinical status was evaluated in a blinded fashion by 2 independent reviewers on each day of antibacterial treatment and was assessed for outcomes on days 3 and 7 of therapy and at the end of therapy (EOT). “Clinical success” was defined as an improvement in temperature, WBC count, and mechanical ventilation status. “Clinical deterioration and/or failure” was defined as an increase in temperature, WBC count, and/or a decline in mechanical ventilation status. The date and time when the patient met criteria for po therapy, the patient’s gastrointestinal status, and the physician/pharmacist interaction date and the time of conversion were also documented.

Economic analysis. Antibacterial acquisition costs and costs of hospitalization were assessed. Ancillary costs of drug preparation, administration, and monitoring were also included; however, fixed costs, such as pharmacist and nursing labor, were not included in the analysis. Drug preparation and administration costs were $7.75/iv dose [16] and $0.82/po dose [17]. Data on medications or procedures not directly related
Table 1. Demographic and clinical characteristics of 251 patients with community-acquired pneumonia, by treatment protocol.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>NPI (n = 79)</th>
<th>PI switch (n = 81)</th>
<th>PI sequential (n = 91)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, median, years</td>
<td>50.42</td>
<td>49.9</td>
<td>52.5</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>57.0</td>
<td>60.5</td>
<td>51.6</td>
<td>NS</td>
</tr>
<tr>
<td>Clinical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>APACHE II score, median</td>
<td>7.8</td>
<td>6.9</td>
<td>8.8</td>
<td>.12</td>
</tr>
<tr>
<td>Fine score, median</td>
<td>67.0</td>
<td>67.0</td>
<td>75.0</td>
<td>NS</td>
</tr>
<tr>
<td>Risk class I or II</td>
<td>58.2</td>
<td>61.7</td>
<td>48.3</td>
<td>NS</td>
</tr>
<tr>
<td>Risk class III</td>
<td>16.5</td>
<td>14.8</td>
<td>18.7</td>
<td>NS</td>
</tr>
<tr>
<td>Risk class IV or V</td>
<td>25.3</td>
<td>23.5</td>
<td>33.0</td>
<td>NS</td>
</tr>
<tr>
<td>COPD</td>
<td>16.5</td>
<td>9.9</td>
<td>33</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Asthma</td>
<td>20.3</td>
<td>24.7</td>
<td>15.4</td>
<td>NS</td>
</tr>
<tr>
<td>IDU</td>
<td>13.9</td>
<td>9.9</td>
<td>12.1</td>
<td>NS</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>32.9</td>
<td>33.3</td>
<td>19.3</td>
<td>.08</td>
</tr>
</tbody>
</table>

NOTE. Data are percentage of patients, except where noted. COPD, chronic obstructive pulmonary disease; IDU, injection drug user; NPI, no pharmacy intervention; PI sequential, intravenous (iv) moxifloxacin with pharmacist-mediated automatic conversion of therapy to oral moxifloxacin; PI switch, iv β-lactam plus a macrolide with pharmacy intervention to switch therapy to an oral quinolone.

to treatment for CAP were not included. For the economic evaluation, total hospitalization costs from the onset of pneumonia were estimated at $836/day [3]. The antibacterial-related LOS was used to define the duration of the hospital stay attributed to treatment for CAP, and, in most cases, this was equivalent to the total LOS. Costs for all medications were obtained from the average wholesale prices (AWPs) listed in the Drug Topics Red Book [18].

Cost was compared between the 3 treatment groups by use of standard parametric or nonparametric tests, as determined by the variance in the data. Costs were analyzed on 3 levels. Level 1 costs included drug-acquisition costs only. Level 2 costs included other antibacterial-related costs, such as therapeutic drug monitoring, preparation, and administration and any additional resources used to manage antibacterial-related adverse events or therapeutic failures. Level 3 costs included the cost of hospitalization. Because costs were evaluated for the same time period, costs and outcomes were closely temporally related, and adjustment for inflation and discounting was not necessary.

Statistical analysis. Dichotomous data were compared by use of the χ² statistic and Fisher’s exact test. Continuous variables were compared by use of the Student’s t test, for independent samples, or the Mann-Whitney U test, for nonparametric data. Differences in economic data between prospectively collected data and historical data were analyzed using Kruskal-Wallis 1-way analysis of variance. Outliers were removed from comparisons of cost and LOS by deleting extreme values that were ≥2 times the SD of the mean. All statistical analyses were performed using SPSS for Windows (version 10.0.5; SPSS). Sensitivity analyses were also performed to determine whether varying antibacterial prices (±50%) would change the economic outcome and to account for the variance in antibacterial prices between institutions. For all analyses, P ≤ .05 was considered to be significant.

RESULTS

Clinically evaluable results were available for 251 patients recruited during the 3 study periods: 79 patients in the NPI group, 81 patients in the PI switch group, and 91 patients in the PI sequential group. The patients in the 3 groups were similar in terms of age, sex, severity of illness, and most comorbid conditions (table 1). Significantly more patients treated in 2004 were found to have chronic obstructive pulmonary disease (COPD; 33% of patients in the PI sequential group vs. 16.5% of patients in the NPI group and 9.9% of patients in the PI switch group; P <.001).

Microbiological sputum or blood samples were obtained from 85% of patients, and organisms were isolated from 34% of patients. The most common organisms isolated were Staphylococcus aureus (31% [3.5% of these isolates were methicillin-resistant S. aureus]), Streptococcus pneumoniae (27%), and Haemophilus influenzae (11%), with no differences noted between study periods.

The predominant antibacterial therapy used in all groups is shown in table 2. In both the NPI and the PI switch groups, the predominant iv regimen was a β-lactam plus a macrolide, whereas all patients in the PI sequential group received iv moxifloxacin. The NPI and PI switch groups showed considerable
variability with regard to the oral agents chosen (table 2). In the PI sequential group, all patients had treatment converted to oral therapy, whereas patients in the hospital received oral moxifloxacin. At discharge, 2 patients received clindamycin, 1 received clarithromycin, and 2 did not have oral therapy prescribed.

Clinical outcomes. Clinical success rates on day 3 of therapy and at the EOT were similar in all 3 groups; however, the success rate at day 3 of therapy was significantly improved in the PI sequential group (table 3). Although detection of adverse effects was not a primary end point of the study, no adverse events that were possibly or probably attributed to study medications were observed in any study period.

Patients in all groups were assessed to determine the day that they met criteria for iv/po conversion and the time from when criteria were met to the time that treatment with oral antibacterials was actually started. Patients who met criteria for oral antibacterial use had treatment converted to oral therapy sooner in both PI groups (table 4). In the NPI group, patients received iv therapy for an average of 2.14 days after meeting criteria for po therapy, compared with 0.96 days for patients in the PI switch group and 0.35 days for patients in the PI sequential group. No significant differences in LOS were observed across the 3 study periods. Rates of infection-related readmission to the hospital within 30 days after discharge were similar among all groups (3.8% for the NPI group, 4.9% for the PI switch group, and 4.4% for the PI sequential group). Patients were readmitted for COPD (3 patients) and pneumonia (7 patients), with no documented respiratory pathogens isolated during repeat admissions.

Costs. Drug-acquisition costs during the PI sequential period were significantly lower than during both prior periods, because of an increase in the use of oral antibacterials. The costs of iv antibacterials in the NPI, PI switch, and PI sequential periods were $222, $215, and $108, respectively (P<.0001). Corresponding total antibacterial costs were $230, $233, and $119, respectively (P<.0001); therefore, the PI sequential period resulted in a drug acquisition cost savings of ~$110/patient (figure 1).

The results for all 3 levels of cost, outliers were removed, are shown in table 5, whereas the relative contribution of each level of cost is depicted in figure 2. Health resources used for the treatment of adverse events were not estimated for the economic analysis, since no adverse events were attributed to treatment for CAP.

The sensitivity analysis of level 1 costs was performed by comparing the PI sequential group with both the NPI and PI switch groups, varying the antibacterial acquisition cost by ±50% of the AWP for each study period (figure 3). The expected cost (in US dollars) for a course of treatment is depicted along the Y-axis of figure 3, and the percentage of the AWP is depicted along the X-axis. The intersection of the lines indicates that, under the assumption that success rates were similar (which was demonstrated in the population), antibacterial costs during the PI sequential period would have to be increased to ~135%, and costs during the NPI or PI switch periods would have to be decreased to ~65% for the cost-effectiveness to favor the NPI or PI switch strategies.

**DISCUSSION**

Although no differences in overall efficacy were observed between the 3 study periods, the patients in the PI sequential group improved at a faster rate. Ninety-four percent of patients demonstrated clinical improvement by day 3, compared with 83% of patients in the NPI group and 84% of patients in the PI switch groups, in which the predominant iv regimens were a β-lactam plus a macrolide. Faster rates of improvement associated with fluoroquinolone-based regimens have been reported in other published studies. In an analysis of the TARGET study, which compared iv/po moxifloxacin with iv/po amoxi-

### Table 2. Antibiotic regimens for 251 patients with community-acquired pneumonia, by treatment protocol.

<table>
<thead>
<tr>
<th>Type of therapy, antibacterial agent</th>
<th>NPI (n = 79)</th>
<th>PI switch (n = 81)</th>
<th>PI sequential (n = 91)</th>
</tr>
</thead>
<tbody>
<tr>
<td>iv Therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β-Lactam + macrolide</td>
<td>94.9</td>
<td>96.3</td>
<td>0</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>1.3</td>
<td>3.7</td>
<td>0</td>
</tr>
<tr>
<td>Moxifloxacin</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>None (oral therapy only)</td>
<td>3.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oral therapy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>β-lactam monotherapy</td>
<td>12.7</td>
<td>6.2</td>
<td>0</td>
</tr>
<tr>
<td>Macrolide monotherapy</td>
<td>11.4</td>
<td>19.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Levofloxacin</td>
<td>25.3</td>
<td>40.7</td>
<td>0</td>
</tr>
<tr>
<td>Moxifloxacin</td>
<td>0</td>
<td>0</td>
<td>94.5</td>
</tr>
<tr>
<td>Other</td>
<td>3.8</td>
<td>3.7</td>
<td>2.2</td>
</tr>
<tr>
<td>None (iv therapy only)</td>
<td>46.8</td>
<td>29.6</td>
<td>2.2</td>
</tr>
</tbody>
</table>

**NOTE.** Data are percentage of patients. NPI, no pharmacy intervention; PI sequential, intravenous (iv) moxifloxacin with pharmacist-initiated automatic conversion of therapy to oral moxifloxacin; PI switch, iv β-lactam with a macrolide with pharmacy intervention to switch therapy to an oral quinolone.

### Table 3. Clinical success of treatment of 251 patients for community-acquired pneumonia, on days 3 and 7 of therapy and at the end of therapy.

<table>
<thead>
<tr>
<th>Clinical success</th>
<th>NPI (n = 79)</th>
<th>PI switch (n = 81)</th>
<th>PI sequential (n = 91)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>On day 3 of therapy</td>
<td>83.4</td>
<td>84</td>
<td>94.5</td>
<td>0.045</td>
</tr>
<tr>
<td>On day 7 of therapy</td>
<td>96.2</td>
<td>92.6</td>
<td>95.6</td>
<td>NS</td>
</tr>
<tr>
<td>At the end of therapy</td>
<td>98.7</td>
<td>98.8</td>
<td>97.8</td>
<td>NS</td>
</tr>
</tbody>
</table>

**NOTE.** Data are percentage of patients. NPI, no pharmacy intervention; PI sequential, intravenous (iv) moxifloxacin with pharmacist-initiated automatic conversion of therapy to oral moxifloxacin; PI switch, iv β-lactam plus a macrolide with pharmacy intervention to switch therapy to an oral quinolone.
Table 4. Mean no. of days of intravenous (iv) therapy (actual and excess) and infection-related length of stay (LOS) for 251 patients with community-acquired pneumonia, by treatment protocol.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NPI (n = 79)</th>
<th>PI switch (n = 81)</th>
<th>PI sequential (n = 91)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual days of iv therapy</td>
<td>3.89</td>
<td>3.63</td>
<td>2.67</td>
<td>.005</td>
</tr>
<tr>
<td>Excess days of iv therapy</td>
<td>2.14</td>
<td>0.96</td>
<td>0.35</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Infection-related LOS</td>
<td>4.23</td>
<td>4.57</td>
<td>4.39</td>
<td>.846</td>
</tr>
</tbody>
</table>

NOTE. NPI, no pharmacy intervention; PI sequential, iv moxifloxacin with pharmacist-initiated automatic conversion of therapy to oral moxifloxacin; PI switch, iv β-lactam plus a macrolide with pharmacy intervention to switch therapy to an oral quinolone.

cillin-clavulanate with or without clarithromycin, patients who received moxifloxacin were afebrile 1 day sooner (at day 2 vs. day 3) and demonstrated a higher rate of clinical cure (93% vs. 85% in the intent-to-treat population) [19]. Similarly, Dunbar et al. [20] compared 2 regimens of levofloxacin for CAP: 750 mg/day for 5 days versus 500 mg/day for 10 days. The higher daily dose given for 5 days was as effective as the more traditional 10-day course of levofloxacin, which suggests that, with appropriate dosing of fluoroquinolones, shorter courses of therapy are possible. This increased rate of clinical response may be due, in part, to the rapid concentration-dependent killing exhibited by the fluoroquinolones [21].

In this investigation, pharmacist-initiated iv/po conversion of moxifloxacin resulted in significantly reduced drug costs. This result is consistent over a wide range of antibacterial acquisition costs, per sensitivity analysis. Much of the cost savings can be attributed to the finding that 80% of patients in the PI sequential group received iv antibacterials for ≤3 days. This result is similar to that of the study by Drummond et al. [19], which demonstrated that patients receiving moxifloxacin had fewer days of iv therapy (4.02 vs. 4.81 days) and fewer days of total antibacterial therapy (6.86 vs. 7.36 days), compared with patients receiving amoxicillin-clavulanate with or without clarithromycin. One-half of the patients who received moxifloxacin received iv therapy for ≤3 days.

Other studies have attempted to evaluate the clinical and economic impact of iv/po conversion of antimicrobials for the treatment of CAP [4, 7, 8, 10, 22–27]. In a study of ≥200 patients, Ramirez et al. [22] showed that conversion from iv to po therapy can be implemented safely when cough and respiratory distress lessen, the patient is afebrile for at least 8 h, the patient’s WBC count is returning to normal, and the patient can tolerate oral medications. The effects of this early conversion were shown to be a clinical cure rate of 99% and a mean decrease in length of hospital stay of 2 days.

In the present study, although patients in the PI sequential group did have reduced level 1 and level 2 costs, the level 3 cost was the same as that for the NPI and PI switch groups. This result is not surprising, considering that the length of the hospital stay was not affected and that the majority of the cost of care is due to hospitalization, not drug cost (figure 2). What is surprising, however, is that, in the PI sequential group, patients continued to be cared for as inpatients even after they were tolerating oral antibacterials and after signs and symptoms of infection were resolving. In general, tolerance of oral antibacterials is one factor to be considered when a patient is able to be discharged from the hospital. The reason that our patients remained in the hospital is likely multifactorial. First, there are comorbidities and socioeconomic conditions that may preclude discharge from the hospital that are unrelated to po tolerance and clinical improvements, such as substance abuse or homelessness [28]. In this study sample, the incidence of alcoholism was 28% (71/251), and that of injection drug use was 12% (30/251). We did not specifically assess homelessness among our patients; however, it is not an infrequent social condition in urban settings.

Conversion from iv to po therapy was accomplished most efficiently in the PI sequential group, with 80% of patients in...
Table 5. Level 1, 2, and 3 costs (in US dollars) for treatment of 251 patients with community-acquired pneumonia, by treatment protocol.

<table>
<thead>
<tr>
<th>Treatment protocol</th>
<th>Level 1 cost</th>
<th>Level 2 cost</th>
<th>Level 3 cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPI</td>
<td>$230</td>
<td>$306</td>
<td>$3409</td>
</tr>
<tr>
<td>PI switch</td>
<td>$233</td>
<td>$314</td>
<td>$3631</td>
</tr>
<tr>
<td>PI sequential</td>
<td>$119&lt;sup&gt;a&lt;/sup&gt;</td>
<td>$145&lt;sup&gt;a&lt;/sup&gt;</td>
<td>$3547</td>
</tr>
</tbody>
</table>

**NOTE.** Cost levels are defined in Methods. NPI, no pharmacy intervention; PI switch, intravenous (iv) β-lactam plus a macrolide with pharmacy intervention to switch therapy to an oral quinolone; PI sequential, iv moxifloxacin with pharmacist-initiated automatic conversion of therapy to an oral moxifloxacin.

Figure 2. Levels of cost, in US dollars. Levels are defined in Methods. NPI, no pharmacy intervention; PI sequential, intravenous (iv) moxifloxacin with pharmacist-initiated automatic conversion to oral moxifloxacin; PI switch, iv β-lactam plus a macrolide, with pharmacy intervention to switch therapy to an oral quinolone.

this group receiving iv therapy for ≤3 days. Although the PI sequential group had the highest and fastest conversion rate, both PI groups demonstrated a faster switch than did the NPI group. Therefore, it is likely that both PI and the sequential nature of the pathway had an effect on the faster rate of conversion.

The effect of using "sequential" iv/po therapy with the same agent versus changing agents when transitioning from iv to po therapy was assessed by Dresser et al. [29]. In that study, cost-effectiveness was demonstrated for iv/po gatifloxacin therapy, compared with iv ceftriaxone (with or without erythromycin) transitioned to po macrolide. Overall, an LOS that was 1 day shorter was observed for the patients treated with the sequential fluoroquinolone regimen. Cost savings were ~$1800 for each effectively treated patient [29]. The decrease in the LOS may be due, in part, to enhanced potency of the fluoroquinolone-containing regimen or to the fact that physicians may feel more comfortable with the oral transition when the same agent is used.

The effect of a pharmacist-initiated iv/po transition has also been assessed previously. Kuti et al [30] evaluated a pharmacist-initiated iv/po conversion of levofloxacin, compared with conventional therapy, in a group of patients with a number of diagnoses of infectious diseases, 60% of whom had CAP. Patients in both the interventional and observational groups met the criteria for conversion by day 2 of therapy, but patients in the group with PI were converted to oral agents by day 3 of therapy, on average, compared with day 7 of therapy in the observational arm. This study found that pharmacist-initiated iv/po conversion decreased level 1, 2, and 3 costs in the subset of patients who did meet criteria for conversion. Within that subset, LOS was reduced from 9.5 to 6 days. For all patients who were clinically evaluable at follow-up, there was a 100% success rate in both the intervention and the observational group. That study also supports our assertion that a PI to automatically convert fluoroquinolones from iv to po can reduce cost without compromising clinical outcome [30].

Our investigation does have important limitations. Most importantly, because the study periods differed on the basis of 2 separate interventions (iv/po “switch” vs. “sequential” and pharmacy recommendation vs. automatic conversion), it is impossible to attribute the improvement in the iv/po conversion rate to one strategy more than the other. Second, the economic analysis used estimates for components of cost identified in the literature. We did not assess indirect cost, but because LOS was not different, we can infer that indirect costs should be equivalent among groups. Our results may have limited generalizability to some populations, because approximately one-half of our patients who were admitted with CAP had ad clinical pulmonary infection score of risk class I or II. Finally, it is possible that iv/po conversion rates were influenced by outside factors. The switch from iv to po therapy is becoming more frequently used in all settings. It is possible that the faster rate of conversion seen in the present study was the result of physicians becoming more comfortable with iv/po conversion over time and choosing to independently switch patients to oral medications.

**CONCLUSION**

Sequential therapy with a fluoroquinolone offers the advantage of enhanced potency, and using the same drug facilitates physician acceptance of early iv/po conversion. No differences in clinical outcomes were noted when pharmacists were responsible for iv/po conversion of antibacterials. Clinical outcomes in the automatically converted group were at least as
Figure 3. Sensitivity analysis of varying costs (in US dollars) of antibiotic therapy. AWP, average wholesale price; NPI, no pharmacy intervention; PI sequential, intravenous (iv) moxifloxacin with pharmacist-initiated automatic conversion to oral moxifloxacin; PI switch, iv β-lactam plus a macrolide with pharmacy intervention to switch therapy to an oral quinolone.

successful as those in the other study groups. Therefore, automatic iv/po conversion of antibacterials facilitated by an infectious diseases pharmacist is clinically reasonable and economically advantageous.

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APPENDIX

CRITERIA FOR CONVERSION FROM PARENTERAL TO ORAL/ENTERAL MEDICATIONS

Conversion from parenteral to oral/enteral medications is considered only when ≥1 of the following clinical conditions exist:

1. the patient can tolerate at least a full liquid diet for a minimum of 24 h;
2. the patient has a feeding tube in place; and
3. the patient is taking other oral or enteral medications.

The following criteria are considered to be indications for the use of parenteral medications:

1. the patient’s status is NPO (nothing by mouth), meaning that at least one of the following criteria is present:
   a. NPO order in the chart;
   b. all medications given by the nonoral route;
   c. no oral dietary or fluid intake;
   d. risk of aspiration;
   e. decreased level of consciousness;
   f. coma;
   g. uncontrolled seizures;
   h. inadequate gag reflex;
   i. gastrointestinal obstruction;
   j. complete bowel rest;
   k. inflammatory bowel disease;
   l. acute pancreatitis;
   m. fistula; and
   n. preoperative or postoperative fast;
2. the patient’s response to oral medications may be unreliable because of any of the following:
   a. severe nausea, vomiting, or diarrhea;
   b. continuous nasogastric suction;
   c. malabsorption syndromes;
   d. gastrointestinal motility disorders;
   e. unresponsiveness to previous oral therapy;
   f. short-bowel syndrome; and
   g. hemodynamic instability;
3. the patient has active upper gastrointestinal bleeding; and
4. the patient refuses to take oral medications.

In addition, for all antimicrobials, the following antimicrobial criteria for oral conversion must be considered:

1. an indication of antimicrobial therapy is present; and
2. signs and symptoms relating to infection are resolving, including all of the following:
   a. cough and shortness of breath are lessening;
   b. the patient is afebrile for at least 24 h;
   c. WBC count is returning to normal;
   d. the patient’s mental status is improving;
   e. vital signs are returning to normal; and
   f. pain and inflammation are improving.

Patients with the following infectious indications generally do not meet criteria for oral/enteral therapy:

1. most CNS infections;
2. persistent febrile neutropenia;
3. endocarditis;
4. persistent bacteremia;
5. necrotizing pneumonia;
6. necrotizing fasciitis;
7. severe or life-threatening infections;
8. severe cellulitis; and
9. active gastrointestinal bleeding.

Other disease states should be judged on an individual basis.

References