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MAJOR ARTICLE

Impact of *Streptococcus pneumoniae* Urinary Antigen Testing in Patients With Community-Acquired Pneumonia Admitted Within a Large Academic Health System

Adam Greenfield,[1] Kassandra Marsh,[1] Justin Siegfried,[1] Ioannis Zacharioudakis,[2] Nabeela Ahmed,[2,3] Arnold Decano,[2,3] Maria E. Aguero-Rosenfeld,[4] Kenneth Inglima,[4] John Papadopoulos,[1] and Yanina Dubrovskaya[1,2]

[1]Department of Pharmacy, New York University Langone Health, New York, New York, USA, [2]Division of Infectious Diseases, Department of Medicine, New York University Langone Health, New York, New York, USA, [3]Department of Pharmacy, New York University Langone Hospital–Brooklyn, Brooklyn, New York, USA, and [4]Department of Pathology, Grossman School of Medicine, New York University, New York, New York, USA

Background. Limited data support use of pneumococcal urinary antigen testing (PUAT) for patients with community-acquired pneumonia (CAP) as an antimicrobial stewardship tool. At our institution, CAP guidelines and admission order set were standardized to include universal PUAT.

Methods. This was a retrospective study of adults hospitalized in 2019 who had PUAT performed. We compared incidence and timing of de-escalation in PUAT- positive vs -negative groups and described patients' outcomes.

Results. We evaluated 910 patients, 121 (13.3%) of whom were PUAT positive. No difference in baseline characteristics, including severity of illness, was observed between groups. Initial de-escalation occurred in 82.9% and 81.2% of PUAT-positive and -negative patients, respectively (P = .749). Median time to de-escalation was shorter in the PUAT-positive group (1 [interquartile range {IQR}, 0–2] day vs 1 [IQR, 1–2] day, P = .01). Within 24 hours of PUAT, more patients in the PUAT-positive group had atypical coverage discontinued (61.3% vs 47.2%, P = .026) without difference in methicillin-resistant *Staphylococcus aureus* (MRSA) agent discontinuation (or antipseudomonal de-escalation). Among the PUAT-positive group, unadjusted analysis demonstrated shorter median length of stay in patients who were de-escalated compared to those who were not (6 [IQR, 4–10] vs 8 [IQR, 7–12] days, P = .0005), without difference in the incidence of *Clostridioides difficile*, in-hospital mortality, or 30-day infection-related readmission.

Conclusions. We observed earlier de-escalation in the PUAT-positive group. This seems to be due to discontinuation of atypical rather than anti-MRSA or antipseudomonal coverage. Further antimicrobial stewardship interventions are warranted.

Keywords. antimicrobial stewardship; community-acquired pneumonia; pneumococcal urinary antigen test.

Community-acquired pneumonia (CAP) remains a major cause for acute hospitalization, particularly among older adults. The incidence of hospitalization due to CAP ranges from 24.8 to 26.9 per 10 000 adults, carrying an average cost of $9686 per visit, along with an average in-hospital mortality of 4% to 6.5% [1–3]. *Streptococcus pneumoniae* remains the most common cause of CAP among bacterial sources despite the recommendation for pneumococcal vaccination in adults aged 65 years and older since 1984 [1]. Due to the heterogeneity of pathogens that lead to CAP, current treatment guidelines from the American Thoracic Society (ATS) and Infectious Diseases Society of America (IDSA) recommend empiric coverage for bacterial pathogens, and in some individuals with given risk factors, antipseudomonal and anti–methicillin-resistant *Staphylococcus aureus* (MRSA) coverage may be warranted [4].

The evolution of novel genomic sequencing assays has greatly impacted the ability to identify organisms and increase pathogen-directed therapies. The pneumococcal urinary antigen test (PUAT) is a noninvasive assay that can be utilized to aid in the diagnosis of CAP as a result of *S pneumoniae* infection, with a pooled sensitivity and specificity of 74% and 97.2%, respectively, compared to reference culture data [5]. The efficiency and specificity of the PUAT coupled with results in as little as 15 minutes make PUAT a useful rapid diagnostic tool. Increasing evidence has signaled the opportunity for PUAT as an antimicrobial stewardship tool to aid in reducing broad-spectrum antimicrobial use; however, PUAT remains largely underutilized [6–8]. Current ATS IDSA CAP

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Correspondence: Adam Greenfield, PharmD, NYU Langone Health, 545 First Ave, GBH-SC2-097, New York, NY 10016, USA (greenfield.adam136@gmail.com).

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guidelines do not routinely recommend the use of PUAT, except in patients presenting with severe CAP. Real-world usage of PUAT, however, may vary from guideline recommendations as represented by Schimmel et al [6]. Recognized potential concerns include disease relapse after early de-escalation, and a lack of clinical benefit derived from randomized trial data [4]. Although PUAT has the potential for quicker time to pathogen recognition and initiation of targeted antimicrobial regimens, and has demonstrated reduction in mortality in observational studies, questions remain regarding the optimal patient population for PUAT [9–11].

At New York University Langone Health (NYULH), CAP guidelines (included in the Supplementary Materials) were developed by the Antimicrobial Stewardship Program (ASP) in December 2016. A third-generation cephalosporin, ceftriaxone, with cefpodoxime as oral switch, plus azithromycin was recommended as the empiric treatment of choice during the study period. The ASP team collaborated with Infectious Diseases, Internal Medicine, and the Clinical Microbiology Laboratory to advise PUAT for all patients presenting with CAP. Additionally, a CAP admission order set was developed to standardize diagnostic testing, including universal PUAT. Given the efficiency and quick turnaround time for the PUAT, we hypothesize that the use of PUAT can improve the time to targeted therapies for *S pneumoniae* CAP, including de-escalation of broad-spectrum antibiotics. Therefore, the objective of our study was to utilize antimicrobial use data to describe patients with both positive and negative PUAT, describe antimicrobial use during admission for CAP, and evaluate patients' outcomes.

METHODS

Study Design and Population

This study was a retrospective chart review of adult patients admitted to the NYULH System, Tisch (800-bed) and Brooklyn (450-bed) campuses, between January and December 2019, who were hospitalized for the treatment of CAP and had a PUAT performed as part of the diagnostic workup. Patients were identified through a database of microbiological testing results and were excluded if they did not have a primary admitting diagnosis of pneumonia, did not receive antibiotics during their index admission, and had a PUAT performed >7 days into the admission. Patients who did not require hospital admission (eg, emergency department [ED] and/or observation unit stay only) were not included. Patients with a blood culture positive for *S pneumoniae* in the setting of negative PUAT were excluded. Additionally, patients with infections due to non–*S pneumoniae* pathogens identified through blood, urine, and sputum cultures as well as patients with positive *Legionella* urinary antigen and *Mycoplasma pneumoniae* immunoglobulin M antibodies were also excluded.

Study Variables

Baseline demographic and clinical characteristics were collected including age, sex, race, comorbidities, and severity of presentation, as measured by the Pneumonia Severity Index (PSI) and Charlson Comorbidity Index (CCI). Time to PUAT from admission and inpatient antimicrobial exposure defined as days of therapy (DOT) during entire admission were also assessed and described. The primary outcome was incidence and timing of de-escalation of antimicrobials following PUAT result. Secondary outcomes evaluated hospital length of stay (LOS), development of *Clostridioides difficile* infection (CDI) and infection-related readmission within 30 days of index admission and in-hospital mortality in patients with a positive PUAT.

Study Definitions

Initial de-escalation was assessed within the first 3 DOT and defined as (1) a change in the antimicrobial regimen to a narrower-spectrum agent (ie, de-escalation of antipseudomonal coverage), (2) discontinuation of MRSA coverage, or (3) discontinuation of atypical coverage. *Pseudomonas aeruginosa* coverage included use of antipseudomonal β-lactams (piperacillin-tazobactam, cefepime, meropenem), amikacin, or aztreonam. For the purpose of this study, fluoroquinolones were not included as antipseudomonal coverage given their primary use per NYULH CAP guidelines as alternatives to ceftriaxone in patients with severe penicillin or cephalosporin allergies. MRSA coverage was defined as the use of vancomycin or linezolid, and atypical coverage was defined as the use of azithromycin or doxycycline.

Of note, ED patients who trigger sepsis alert criteria (ie, presence of both infection and a systemic inflammatory response) are promptly initiated with broad-spectrum (often anti-MRSA and antipseudomonal) coverage per the NYULH sepsis protocol. Traditionally, at our institution, piperacillin-tazobactam is considered the workhorse antipseudomonal agent. During the time of the study period, ceftriaxone/cefpodoxime had been the most common agent for de-escalation in our clinical practice, including narrowing from piperacillin-tazobactam. Common barriers to use of penicillin, ampicillin, or ampicillin-sulbactam include multiple daily doses, higher fluid volume, and sodium content.

Statistical Analyses

The initial cohort was divided on the basis of positive PUAT and negative PUAT for comparison. Categorical data were expressed as frequency and percentage and continuous data as median and interquartile range (IQR). Comparisons between positive and negative PUAT groups were conducted using χ^2 or Fisher exact test for categorical variables and the Mann-Whitney *U* test for continuous variables. Last, among PUAT-positive patients, a univariate analysis was conducted to assess differences in characteristics and outcomes between patients who were

de-escalated and those patients who were not de-escalated or required escalation. All analyses were performed using SPSS version 25 software (IBM, Armonk, New York).

RESULTS

Patient Characteristics

A total of 3666 PUATs were performed during the study period resulting in 135 positive PUATs (3.7%) and 3531 negative PUATs (96.3%). Ultimately, 910 patients admitted with a primary diagnosis of CAP were included. Of those, 121 (13.3%) patients had a positive PUAT and 789 (86.7%) patients had a negative PUAT (Figure 1). Demographic and clinical characteristics of included patients are summarized in Table 1. No significant differences between groups were observed with regards to race, treating hospital, CCI, and underlying comorbidities. Distribution of PSI score was similar between groups (P = .396), with 64 (52.9%) PUAT-positive patients and 375 (47.5%) PUAT-negative patients presenting with moderate/high-risk disease.

PUAT testing occurred shortly after presentation to the hospital in both the PUAT-positive and -negative groups (median [IQR], 16 [16–27] hours vs 13 [8–22] hours, P = .140). Significantly more patients in the negative PUAT group had a *Legionella* urinary antigen test performed (101 [83.5%] vs 729 [92.4%], P = .002) with negative results, whereas no significant differences were observed between groups with respect to performance of additional diagnostic tests including MRSA/methicillin-susceptible *S aureus* nasal swab, sputum culture, blood culture, and influenza and respiratory viral panel.

Inpatient Antimicrobial Exposure

Exposure to antimicrobials by agent and class at any time during the admission are presented in Table 2. Azithromycin was the most frequently used agent for atypical coverage and utilization was similar between PUAT-positive and -negative groups (66.9% vs 73.4%, P = .171), respectively. Piperacillin-tazobactam (43% vs 37.4%, P = .281) and vancomycin (50.4% vs 46.4%, P = .466) use was common and similar between groups.

Antimicrobial-specific durations of therapy during entire admission can be found in Table 3. The median (IQR) DOT of atypical coverage was significantly shorter in the PUAT-positive group compared to the PUAT-negative group (2 [1–3] vs 3 [2–4] days, P = .007). No difference in MRSA coverage DOT was observed between groups (2 [1–4] vs 2 [2–4], P = .625). Numerically shorter *P aeruginosa* coverage days was observed in the PUAT-positive group (3 [2–5] vs 4 [2–6], P = .315). Additionally, ceftriaxone DOT was significantly longer in the PUAT-positive group compared to the PUAT-negative group (median [IQR], 4 [2.5–7] vs 2 [3–4] days, P < .001).

Primary Outcome: Antimicrobial De-escalation Following PUAT Result

Overall, initial de-escalation was similar between the PUAT-positive and -negative groups (97/117 [82.9%] vs 629/775 [81.2%], P = .746) (Table 4). Patients with a positive PUAT

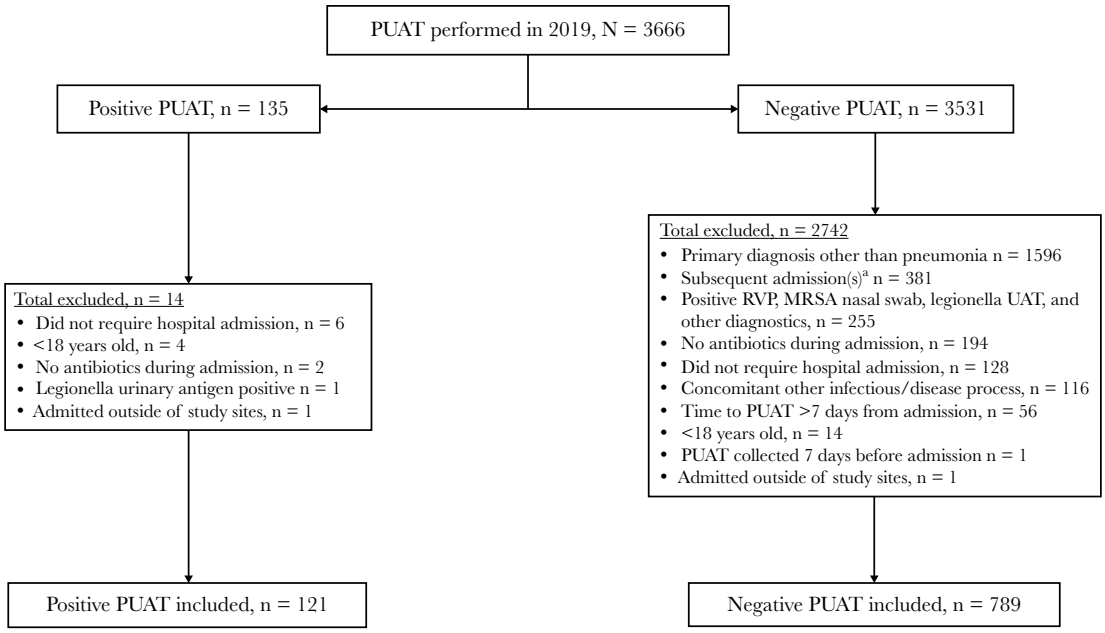

Figure 1. Study population screening. [a]If a patient had multiple negative urinary antigen testing during different admissions, only the first one was included.
Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; PUAT, pneumococcal urinary antigen testing; RVP, respiratory viral panel; UAT, urinary antigen testing.

Table 1. Baseline Characteristics

Characteristic	All Patients (N = 910)		
	Positive PUAT (n = 121)	Negative PUAT (n = 789)	*P* Value
Age, y, median (IQR)	72 (60-83)	73 (58-83)	.591
Male sex	57 (47.1)	443 (56.1)	.078
Race			.986
White	68 (56.2)	449 (56.9)	
Black	12 (9.9)	75 (9.5)	
Asian	12 (9.9)	83 (10.5)	
Other	28 (23.1)	182 (23.1)	
Hospital			.234
Tisch	61 (50.4)	447 (56.7)	
Brooklyn	60 (49.6)	342 (43.3)	
Admitting service			.283
Medicine	86 (71.1)	585 (74.1)	
Surgery	4 (3.3)	21 (2.6)	
Critical care	7 (5.8)	27 (3.4)	
Oncology	5 (4.1)	25 (3.2)	
Time from hospital presentation to PUAT, h, median (IQR)	15.8 (7.8–27.2)	13.1 (8.0–22.2)	.140
Charlson Comorbidity Index, median (IQR)[a]	3 (2–4)	3 (2–4)	.993
Pneumonia Severity Index class distribution[b]			.396
Class 1 (<51)	9 (7.4)	90 (11.4)	
Class 2 (51–70)	18 (14.9)	132 (16.7)	
Class 3 (71–90)	30 (24.8)	192 (24.3)	
Class 4 (91–130)	43 (35.5)	280 (35.5)	
Class 5 (>130)	21 (17.4)	95 (12.0)	
Comorbidities			
COPD	19 (15.7)	76 (9.6)	.061
Congestive heart failure	10 (8.3)	79 (10)	.661
Diabetes mellitus	11 (10.1)	47 (6)	.765
Malignancy	2 (1.7)	40 (5.1)	.151
HIV	4 (3.3)	11 (1.4)	.248
Legionella UAT[c]	101 (83.5)	729 (92.4)	.002
MRSA/MSSA nasal swab[c]	87 (71.9)	585 (74.1)	.601
Sputum culture[c]	37 (30.6)	237 (30)	.989
Streptococcus pneumoniae detected	4 (3.3)	…	
Blood culture[c]	22 (18.5)	201 (25.5)	.105
Streptococcus pneumoniae detected	7 (5.7)	…	
Influenza[c]	27 (22.3)	194 (24.6)	.668
Respiratory viral panel[c]	23 (19.0)	155 (19.6)	.869

Data are presented as No. (%) unless otherwise stated.

Abbreviations: COPD, chronic obstructive pulmonary disease; HIV, human immunodeficiency virus; IQR, interquartile range; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; PUAT, pneumococcal urinary antigen test; UAT, urinary antigen test.

[a]The Charlson Comorbidity Index is a 1-year survival prediction tool in patients with multiple comorbidities [17].

[b]The Pneumonia Severity Index is a risk-stratification tool for patients with CAP. Classes 1–3 represent low risk for CAP-related mortality, class 4 moderate risk, and class 5 high risk [18].

[c]Indicates test performed.

experienced a shorter median (IQR) time to de-escalation from performance of the PUAT (1 [0–2] vs 1 [1–2] days, $P = .01$).

Atypical coverage was initiated in 103 (85.1%) PUAT-positive and 722 (91.5%) PUAT-negative patients. Discontinuation of atypical coverage was similar between the PUAT-positive and -negative groups (77.7% vs 70.5%, $P = .165$). Patients with a positive PUAT had a shorter median (IQR) time to discontinuation of atypical coverage (1 [1–2] vs 2 [1–2] days, $P = .04$). Similarly, discontinuation of atypical coverage within 24 hours of PUAT was significantly more common among PUAT-positive patients (49/80 [61.3%] vs 240/509 [47.2%], $P = .026$).

MRSA coverage was initiated in 64 (52.8%) PUAT-positive and 368 (46.6%) PUAT-negative patients. *Pseudomonas aeruginosa* coverage was initiated in 61 (50.4%) of PUAT-positive and 368 (46.6%) of PUAT-negative patients. No differences in overall discontinuation/de-escalation nor time to discontinuation/de-escalation were observed between PUAT-positive and -negative groups. Additional characteristics of antimicrobial de-escalation can be found in Table 4.

Table 2. Exposure to Antimicrobials by Agent and Class During Admission

	All Patients (N = 910)		
Antimicrobial	Positive PUAT (n = 121[a])	Negative PUAT (n = 789)	*P* Value
Azithromycin	81 (66.9)	579 (73.4)	.171
Doxycycline	43 (35.5)	216 (27.4)	.081
Vancomycin	61 (50.4)	366 (46.4)	.466
Piperacillin-tazobactam	52 (43.0)	295 (37.4)	.281
Cefepime	7 (5.8)	80 (10.1)	.177
Aztreonam	5 (4.1)	25 (3.21)	.780
Amikacin	3 (2.5)	45 (5.7)	.383
Fluoroquinolone	4 (3.3)	12 (1.5)	.698
Linezolid	6 (5.0)	5 (0.6)	.001
Ceftriaxone	89 (73.6)	573 (72.6)	.917
Ampicillin-sulbactam	3 (2.5)	31 (3.9)	.599
Meropenem	8 (6.6)	18 (2.3)	.018
Atypical coverage[b]	103 (85.1)	722 (91.5)	.038
MRSA coverage[c]	64 (52.9)	368 (46.6)	.236
Pseudomonas aeruginosa coverage	61 (50.4)	368 (46.6)	.499

Data are presented as No. (%) unless otherwise stated; antimicrobial exposure was determined throughout entire admission.

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; PUAT, pneumococcal urinary antigen test.

[a]No. (%) may not add up to 121 (100%), as patients may have received multiple agents.

[b]Patients may have received both azithromycin and doxycycline on different calendar days; atypical coverage reflects overall atypical agent use per patient.

[c]Patients may have received both vancomycin and linezolid on different calendar days; MRSA coverage reflects overall MRSA agent use per patient.

Secondary Outcomes: Length of Stay, CDI, In-Hospital Mortality, and Readmission Rates

Among patients with a positive PUAT result, an unadjusted analysis demonstrated that patients who were de-escalated experienced significantly shorter overall hospital LOS compared to those who were not de-escalated (median, 6 [IQR, 4–10] days vs 7 days [IQR, 8–12], $P < .001$). Incidence of CDI was numerically less common in patients who were de-escalated (2.1% vs 3.7%; odds ratio [OR], 0.56 [95% confidence interval {CI}, .05–6.5], $P = .535$). Similar findings were observed for 30-day infection-related readmission (2.1% vs 3.7%; OR, 0.56 [95% CI, .05–6.5], $P = .535$). No differences in in-hospital mortality were observed (4 [4.3%] vs 3 [11.1%], $P = .185$). Of note, there were no differences in patients' characteristics representing severity of illness (eg, PSI, CCI, need for initial

Table 3. Antimicrobial Days of Therapy During Entire Admission

Antimicrobial	Positive PUAT (n = 121)	Negative PUAT (n = 789)	*P* Value
Azithromycin	2 (1–3)	3 (1–4)	.024
Doxycycline	2 (1–3)	3 (2–4)	.027
Vancomycin	3 (1–4)	2 (2–4)	.908
Piperacillin-tazobactam	3 (2–6)	4 (3–7)	.053
Cefepime	1 (1–4)	1 (1–4)	.370
Ceftriaxone	4 (3–7)	2 (3–4)	.0005
Fluoroquinolone	2 (1–9)	2 (1–4)	.649
Linezolid	1 (1–2)	2 (1–8)	.272
Meropenem	3 (1–12)	5 (3–8)	.397
Ampicillin-sulbactam	1 (1–1)	1 (1–2)	.564
Broad-spectrum days of therapy			
Atypical coverage	2 (1–3)	3 (2–4)	.007
	n = 103	n = 722	
MRSA coverage	2 (1–4)	2 (2–4)	.625
	n = 64	n = 368	
Pseudomonas aeruginosa coverage	3 (2–5)	4 (2–6)	.315
	n = 61	n = 368	

Data are presented as median (interquartile range) unless otherwise stated; Antimicrobial exposure was determined throughout entire admission and patients may have received multiple agents.

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; PUAT, pneumococcal urinary antigen test.

Table 4. Comparison of De-escalation Between Pneumococcal Urinary Antigen Test–Positive and –Negative Groups

	All Patients (N = 910)		
Characteristic	Positive PUAT (n = 121)	Negative PUAT (n = 789)	*P* Value
Overall initial de-escalation	97/117 (82.9)	629/775 (81.2)	.746
Time to de-escalation from PUAT, d, median (IQR)	1 (0–2)	1 (1–2)	.01
Atypical coverage	n = 103	n = 722	
Discontinuation	80/103 (77.7)	509/722 (70.5)	.165
Within 24 h of PUAT	49/80 (61.3)	240/509 (47.2)	.026
Time to discontinuation, median (IQR)	1 (1–2)	2 (1–2)	.04
MRSA coverage	n = 64	n = 368	
Discontinuation	45/64 (70.3)	265/368 (72)	.898
Within 24 h of PUAT	24/45 (53.3)	127/265 (47.9)	.610
Time to discontinuation, d, median (IQR)	1 (1–2)	2 (1–2)	.131
Pseudomonas aeruginosa coverage	n = 61	n = 368	
De-escalation[a]	35/61 (57.4)	177/368 (48.1)	.228
Within 24 h of PUAT	20/35 (57.1)	99/177 (55.9)	.895
Time to de-escalation, d, median (IQR)	1 (1–2)	1 (1–2)	.621

Data are presented as No. (%) unless otherwise stated.

Abbreviations: IQR, interquartile range; MRSA, methicillin-resistant *Staphylococcus aureus*; PUAT, pneumococcal urinary antigen test.

[a]De-escalation defined as ≤3 days of therapy (discontinued within 3 days from initiation of antibiotic).

intensive care unit [ICU] admission) between patients who were de-escalated and not de-escalated/required escalation (Table 5).

DISCUSSION

In this retrospective review of patients admitted with a primary diagnosis of CAP, universal use of PUAT resulted in earlier time to de-escalation of antimicrobials in patients with a positive test (median [IQR], 1 [0–2] day vs 1 [1–2] day, $P = .01$). Time to atypical coverage discontinuation, specifically, was shorter in the PUAT-positive group, likely contributing most to the observed differences. Overall, fewer patients in the PUAT-positive group had *Legionella* urinary antigen testing performed, and although we are unable to discern provider rationale for atypical discontinuation, true coinfection confirmed by urinary antigen testing remains rare [12]. Conversely, we did not observe a difference in the discontinuation of anti-MRSA or antipseudomonal coverage. Use of MRSA (46.6%–52.9%) and pseudomonal coverage (46.6%–50.4%) in our patient population was slightly lower than in the recent study by Schimmel et al [1] that reported early antimicrobial therapy with combined anti-MRSA/antipseudomonal coverage in 53.5% of the 25 932 patients who received PUAT. In our study we observed high overall initial de-escalation rates of 82.9% in PUAT-positive patients and 81.2% of PUAT-negative patients. This is in contrast to a large database review of 159 894 patients admitted with CAP or healthcare-associated pneumonia, in which Schimmel et al describe low de-escalation rates at day 3 of therapy of 38.4% in PUAT-positive cases compared to 17% with a negative PUAT and 14.6% without PUAT performed. Of note, de-escalation

Table 5. Characteristics and Unadjusted Outcomes Among Pneumococcal Urinary Antigen Test– Positive Patients

	PUAT-Positive Patients (n = 121)			
Characteristic	De-escalated (n = 94)	Required Escalation or Not De-escalated (n = 27)[a]	OR (95% CI)	*P* Value
PSI category V	16 (17)	5 (18.5)	0.91 (.276–2.74)	.856
PSI, median (IQR)	98 (74–123)	92 (76–116)	…	.881
CCI, median (min, max)	1 (1, 2)	1 (1, 3)	…	.774
Age, y, median (IQR)	72 (58–83)	72 (63–84)	…	.261
Hospital LOS, median (IQR)	6 (4–10)	8 (7–12)	…	.0005
Initial ICU admission	5 (5.3)	2 (7.4)	0.71 (.128–3.85)	.652
Incidence of CDI	2 (2.1)	1 (3.7)	0.56 (.05–6.48)	.535
30-d infection-related readmission	2 (2.1)	1 (3.7)	0.56 (.05–6.48)	.535
In-hospital mortality	4 (4.3)	3 (11.1)	0.26 (.009–1.7)	.185

Data are presented as No. (%) unless otherwise stated.

Abbreviations: CCI, Charlson Comorbidity Index; CDI, *Clostridioides difficile*; CI, confidence interval; ICU, intensive care unit; IQR, interquartile range; LOS, length of stay; OR, odds ratio; PSI, Pneumonia Severity Index; PUAT, pneumococcal urinary antigen test.

[a]Nine of 27 required escalation after 3 days of initial therapy; 18 of 27 were not de-escalated during hospital stay.

in this study was defined as a narrowing of therapy to a single agent with activity against *S pneumoniae* [6]. Additionally, the de-escalation rates we observed were higher than the 63% observed by West et al in a review of 7 hospitals within a large healthcare system, whose definition of de-escalation included a decreased number and/or spectrum of antimicrobial activity [7]. While variability in our findings may be attributed to differences in de-escalation definitions, it is also possible that the routine use of PUAT in combination with MRSA and *Legionella* urinary antigen screening, antimicrobial stewardship education for house staff, and PUAT integration within the computerized physician order entry CAP admission order set have led to improved de-escalation rates. In addition to high de-escalation rates, we observed an increased usage of ceftriaxone in PUAT-positive patients, represented by significantly more DOT compared to PUAT-negative patients. These results indicate adherence to our local institutional CAP guidelines which, during the study period, recommended third-generation cephalosporin use for treatment of CAP in general but also for the treatment of *S pneumoniae* CAP specifically.

Similar to the *Legionella* urinary antigen test, which has drastically improved the diagnosis of Legionnaire's disease, and the rapid group A *Streptococcus* test to identify streptococcal pharyngitis, PUAT has shown potential as a point-of-care microbiology tool to timely identity *S pneumoniae* and improve time to targeted therapies [13, 14]. Routine blood and sputum cultures can take days to result. In our study, PUAT was performed at a median 15.8 hours from presentation in the PUAT-positive group and 13.1 hours from presentation in the PUAT-negative group. Patients with a positive PUAT were also less likely to have antimicrobials escalated (77.7% de-escalated vs 22.3% required escalation/not de-escalated). In order to have the greatest impact, testing should be considered on all patients admitted with a diagnosis of CAP, and coordinated efforts should be made with microbiology personnel to ensure that appropriate workflows are established for timely PUAT results.

Cost-effectiveness of routine PUAT use remains unclear. Dinh et al, in a French ED, demonstrated a very low positivity rate (5.2%) over a 3-year time span, inferring an estimated potential cost savings of €8748 per year had testing not been performed. It should be noted, however, that there was no guideline for the use of PUAT in their ED population [15]. In contrast, we were able to show a higher PUAT positivity rate (13.3%) in our targeted population. As previously mentioned, the average cost of a hospital admission associated with a CAP diagnosis is $9686, compared to $16 per PUAT. Although not formally performed, increased cost savings may be inferred.

Furthermore, concerns have been raised that antimicrobial de-escalation to therapy targeting *S pneumoniae* following a positive PUAT may lead to a need for escalation of care or clinical relapse [16]. In our study, among the PUAT-positive group, unadjusted analysis showed shorter hospital LOS in patients de-escalated compared to those who were not de-escalated/required escalation without difference in *C difficile* infection, in-hospital mortality, or 30-day infection-related readmission. Clinical characteristics and baseline severity of illness including PSI class 5 determination, median PSI score, and need for initial ICU admission did not differ between patients who were de-escalated and those which required escalation or were not de-escalated, indicating that baseline severity of illness was balanced.

Our study has several limitations that should be considered. The results highlight the incidence and timing of de-escalation of antimicrobials for patients admitted to 2 large academic medical centers in the New York City metropolitan area and therefore generalizability could be hindered. Additionally, this study describes inpatient antimicrobial use in patients admitted for a diagnosis of CAP. We therefore were unable to evaluate the impact of PUAT on antimicrobial use in patients not requiring hospital admission as well as with patients with a primary diagnosis other than pneumonia. No formal cost analysis was performed; therefore, cost savings must be inferred. Due to the observational nature of the study, we were unable to describe clinical rationale for empiric or definitive therapies that patients received. Last, outcomes comparisons among PUAT-positive patients remain unadjusted and therefore provider rationales for de-escalation could be due to undetermined patient characteristics.

In conclusion, we observed in our study earlier de-escalation in patients with positive PUAT. This seems to be due to discontinuation of atypical rather than anti-MRSA or antipseudomonal coverage. Our findings support PUAT as a potential opportunity for improvement in antimicrobial use with additional stewardship interventions.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

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Patient consent. This study did not include factors necessitating patient consent. The New York University Langone Health Institutional Review Board approved this study, which conforms to current standards.

Potential conflicts of interest. All authors: No reported conflicts of interest.

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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