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ORIGINAL ARTICLE

Inpatient Urine Cultures Are Frequently Performed Without Urinalysis or Microscopy: Findings From a Large Academic Medical Center

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OBJECTIVE. To describe the frequency of urine cultures performed in inpatients without additional testing for pyuria.

DESIGN. Retrospective cohort study.

SETTING. A 1,250-bed academic tertiary referral center.

PATIENTS. Hospitalized adults.

METHODS. This study included urine cultures drawn on 4 medical and 2 surgical wards from 2009 to 2013 and in the medical and surgical intensive care units (ICUs) from 2012 to 2013. Patient and laboratory data were abstracted from the hospital's medical informatics database. We identified catheter-associated urinary tract infections (CAUTIs) in the ICUs by routine infection prevention surveillance. Cultures without urinalysis or urine microscopy were defined as "isolated." The primary outcome was the proportion of isolated urine cultures obtained. We used multivariable logistic regression to assess predictors of isolated cultures.

RESULTS. During the study period, 14,743 urine cultures were obtained (63.5 cultures per 1,000 patient days) during 11,820 patient admissions. Of these, 2,973 cultures (20.2%) were isolated cultures. Of the 61 CAUTIs identified, 31 (50.8%) were identified by an isolated culture. Predictors for having an isolated culture included male gender (adjusted odds ratio [aOR], 1.22; 95%; confidence interval [CI], 1.11–1.35], urinary catheterization (aOR, 2.15; 95% CI, 1.89–2.46), ICU admission (medical ICU aOR, 1.72; 95% CI, 1.47–2.00; surgical ICU aOR, 1.82; 95% CI, 1.51–2.19), and obtaining the urine culture ≥1 calendar day after admission (1–7 days aOR, 1.91; 95% CI. 1.71–2.12; >7 days after admission aOR, 2.81; 95% CI, 2.37–3.34).

CONCLUSIONS. Isolated urine cultures are common in hospitalized patients, particularly in patients with urinary catheters and those in ICUs. Interventions targeting inpatient culturing practices may improve the diagnosis of urinary tract infections.

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Differentiating asymptomatic bacteriuria from urinary tract infection (UTI) is a common diagnostic challenge among hospitalized patients. Data on the epidemiology of bacteriuria and pyuria in the inpatient setting are limited. For patients with urinary catheters, the incidence of bacteriuria is 3%–8% per day, with nearly all catheterized patients becoming bacteriuric after 1 month.[1–3] In a study of hospitalized patients, the rate of bacteriuria in catheterized patients was 51% versus 18.6% among noncatheterized patients.[4]

Because the diagnosis of UTI relies on clinical and laboratory findings, a positive urine culture alone is insufficient. Urine culture interpretation in hospitalized patients is complicated by concurrent illnesses; thus, findings from urinalysis and/or urine microscopy can be a useful diagnostic aid. In a study of outpatient women with uncomplicated UTI symptoms, the combination of negative leukocyte esterase and nitrite on urinalysis had a negative predictive value of 98.3% for bacteriuria of $\geq 10^5$ colony-forming units (CFU)/mL.[5] In another study of inpatients and outpatients, the same combination had a 100% negative predictive value for bacteriuria of $\geq 10^5$ CFU/mL.[6]

Guidelines support the use of urinalysis and/or urine microscopy to help differentiate UTI from asymptomatic bacteriuria.[1,7] However, data on the use of these tests in

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inpatients are limited. Most studies have been performed either among outpatients or catheterized inpatients, populations that differ significantly from the general inpatient population.[8–14] Here, we describe the frequency of urine cultures performed in inpatients without additional testing for pyuria by urinalysis or urine microscopy.

METHODS

Study Design and Participants

We conducted a retrospective, cohort study at Barnes-Jewish Hospital (BJH), a 1,250-bed academic hospital in St Louis, Missouri. The study cohort comprised patients who had at least 1 urine culture performed during admission. Patients were selected from 4 general medical wards, 2 surgical wards, the medical intensive care unit (MICU), and the surgical intensive care unit (SICU). We included patients admitted to the medical or surgical wards between January 2008 and December 2013, or to the MICU or SICU between January 2012 and December 2013.

Data Collection

We abstracted urine diagnostic data from the BJH electronic medical informatics database, including culture collection date, location (the unit on which the culture was obtained), culture result, and specimen type (clean catch versus catheterized), as well as any urinalysis and urine microscopy with test date, location, and results. For cultures with accompanying urinalysis or microscopy, the difference in calendar days between the culture and urinalysis and/or microscopy was calculated. The presence of a urinary catheter at the time of culture was identified based on specimen type per the hospital's computerized provider order entry (CPOE) system.

Patient data abstracted from the medical informatics database included demographic data and length of stay. Admission-associated comorbidities and genito-urologic procedures were identified by abstracted *International Classification of Diseases 9th Revision Clinical Modification* (ICD-9-CM) codes (Supplementary Table).

Outcomes and Definitions

The primary study outcome was the proportion of urine cultures obtained as isolated cultures. We defined an isolated urine culture as a one without an associated urinalysis and/or urine microscopy performed within 1 calendar day before or after the culture. The secondary outcome was the proportion of catheter-associated urinary tract infections (CAUTIs) identified among ICU patients with isolated urine cultures.

The first urine culture obtained from the patient during the hospital admission was termed the "initial" culture. Urine cultures performed after the first culture of an admission were "subsequent" cultures. A positive culture was defined as any bacterial or fungal growth according to routine hospital laboratory protocols. The primary analysis included both initial and subsequent cultures.

CAUTI surveillance was conducted by the hospital's infection prevention department and was initiated in BJH ICUs in January 2012. CAUTI was defined according to National Healthcare Safety Network definitions.[15,16]

Statistical analysis

Data were analyzed using SAS version 9.3 software (SAS Institute, Cary, NC). Descriptive statistics described the proportion of isolated urine cultures in patient subgroups. For categorical variables, between-group differences were analyzed using χ^2 or univariable logistic regression where appropriate. For continuous variables, differences were assessed using the Student *t* test and the Wilcoxon signed-rank test.

To determine independent risk factors associated with performance of isolated urine cultures, we conducted a per-patient analysis. We categorized patients based on their initial culture of the admission to limit bias from overrepresentation of patients with multiple urine cultures. Forward, stepwise, multivariable logistic regression analysis was used to identify risk factors for isolated culture. A P value $\leq .15$ was used to allow variable entrance into the model, and a P value $\leq .05$ was required to remain in the final model.

We determined the proportion of CAUTIs identified by an isolated urine culture within the MICU and SICU. For the CAUTI assessment, we again only used the initial culture of the admission to avoid bias from overrepresentation.

P values $< .05$ were considered statistically significant for all tests. The Washington University Human Research Protection Office approved this study.

RESULTS

During the study period, 11,826 admissions met the inclusion criteria. We excluded 6 admissions due to incomplete data. In total, 14,743 cultures (11,820 initial and 2,923 subsequent cultures) performed during 11,820 admissions were analyzed (range, 1–12 cultures per admission) (Figure 1).

Subsequent cultures were more likely to be ordered for patients with urinary catheters than were initial cultures (27.1% vs 12.2%; $P < .001$). Of the 14,743 urine cultures obtained, 6,452 (43.8%) were positive for microbial growth. Initial cultures were more likely to be positive than subsequent cultures (44.4% vs 41.2%; $P = .002$).

The overall urine culture rate was 63.5 cultures per 1,000 patient days. The MICU had the greatest frequency of urine cultures (133.5 per 1,000 patient days), followed by the medical wards (63.5 per 1,000 patient days), the SICU (53.8 per 1,000 patient days), and the surgical wards (53.6 per 1,000 patient days). ICUs had a higher incidence of urine cultures than non-ICU units (85.7 vs 58.8 per 1,000 patient days;

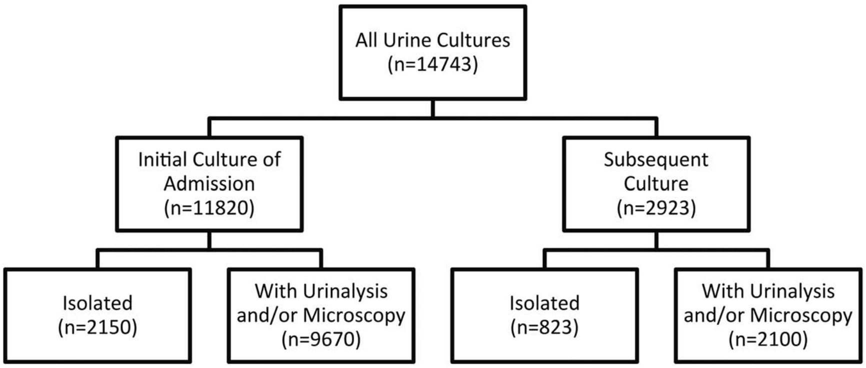

FIGURE 1. Summary of urine cultures performed in the study units.

$P < .001$), as did medical versus surgical units (63.5 vs 53.6 per 1,000 patient days; $P < .001$).

In total, 2,973 urine cultures (20.2%) were isolated cultures, (ie, sent without urinalysis and/or urine microscopy), for a rate of 12.8 isolated cultures per 1,000 patient days (Table 1). Isolated cultures were most common in the SICU (37.9% of urine cultures obtained), followed by the MICU (32.9%), surgical wards (18.9%), and medical wards (15.9%). Subsequent cultures were more likely to be isolated cultures than initial cultures (28.2% vs 18.2%; $P < .001$). In catheterized patients, 878 cultures (39.3%) were isolated, and 30 cultures (25.6%) in patients with genitourologic procedures were isolated. Of the 2,973 isolated cultures, 1,050 (35.3%) were positive for microbial growth.

We identified 2,150 (18.2%) initial urine cultures of each admission as isolated cultures (Table 2). Several factors were independently associated with isolated initial urine culture: male sex, white race, ICU admission, urinary catheterization, and culture sent ≥1 calendar day after admission. Older age and diabetes mellitus conferred a lower risk of isolated urine cultures being obtained. We performed a sensitivity analysis comparing isolated urine cultures redefined as those without a urinalysis and/or microscopy sent within 2 calendar days to the original definition of 1 calendar day. This resulted in a slight decline in the proportion of isolated cultures (1,984 [16.8%] vs 2,150 [18.2%]). We also compared patients who had only isolated cultures obtained during their admission to those having at least 1 culture sent with accompanying urinalysis or microscopy, with no significant change in our findings (data not shown).

Infection prevention surveillance identified 61 CAUTIs in the ICUs during the study period, representing 2.2% of all ICU cultures performed. The SICU had significantly more CAUTIs identified per culture than the MICU (37 of 1,031 vs 24 of 1,710, $P = .002$). Of the 61 CAUTIs identified, 31 (50.8%) were based on an isolated culture. There was no significant difference between the MICU and SICU in the proportion of isolated urine cultures identified as CAUTIs (14 of 562 [2.5%] vs 17 of 391 [4.3%]; $P = .112$).

DISCUSSION

Urine culturing was a frequent practice in our study units. Although the majority of urine cultures were accompanied by orders for urinalysis and/or urine microscopy, 1 in 5 cultures was sent without additional workup. Among catheterized patients, more than one-third of cultures were sent without an associated urinalysis or microscopy. Approximately 50% of CAUTIs identified in the ICUs during the 2-year study period were identified on the basis of an isolated culture.

Urine culture rates varied by unit type, with higher rates noted on medical versus surgical units. The MICU had a urine culture rate more than double the composite rate. A recently published study from 2 Veterans Affairs hospitals reported baseline urine culture rates of 41.2 and 43.9 per 1,000 patient days, respectively, while a study of adult ICUs at an academic medical center in Maryland found a baseline rate of 139 cultures per 1,000 patient days.[17,18] These reports demonstrate the high variability in culture rates among and within institutions.

In our study, male sex, white race, ICU admission, catheterization, and culture performed ≥1 calendar day after admission were all independent risk factors for an isolated urine culture, with the largest differences seen in the latter 3 categories. Interventions targeted to ICUs, catheterized patients, and postadmission cultures may therefore have the greatest effect in decreasing isolated culture rates. Positive urine cultures were more common among initial cultures versus subsequent cultures, and in cultures sent with urinalysis and/or microscopy. Our analysis of this finding was limited by the inability to assess the clinical indications for culture. However, these data suggest a potential positive relationship between the clinical assessment of UTI and the ordering of an appropriate workup.

The odds of a culture being performed without urinalysis or microscopy may also be affected by the structure of the hospital's CPOE system. The presentation of testing options to the provider by the CPOE system may alter ordering practices. For example, at the time of the study, the medicine service's

TABLE 1. Characteristics of 14,743 Urine Cultures Obtained From Patients on Study Units

Variable	Total Cultures, No. (%) (n = 14,743)	Urine Cultures With Urinalysis and/or Microscopy, No. (%) (n = 11,770)	Isolated Urine Cultures, No. (%) (n = 2,973)[a]	*P* Value
Male	6,829 (46.3)	5,300 (45.0)	1,529 (51.4)	<.001
Age, y, mean ± SD	60 ± 18.4	60 ± 18.3	57 ± 18.3	<.001
Race				
White	8,812 (59.8)	6,876 (58.4)	1,936 (65.1)	<.001
Other	5,931 (40.2)	4,894 (41.6)	1,037 (34.9)	<.001
Congestive heart failure	1,098 (7.4)	892 (7.6)	206 (6.9)	.23
Chronic obstructive pulmonary disease	1,641 (11.1)	1,342 (11.4)	299 (10.1)	.04
Malignancy	1,174 (8.0)	898 (7.6)	276 (9.3)	.003
HIV infection	165 (1.1)	129 (1.1)	36 (1.2)	.60
Diabetes mellitus	2,991 (20.3)	2,483 (21.1)	508 (17.1)	<.001
Cirrhosis	581 (3.9)	417 (3.5)	164 (5.5)	<.001
End-stage renal disease	678 (4.6)	571 (4.9)	107 (3.6)	.004
Urinary catheterization	2,234 (15.2)	1,356 (11.5)	878 (29.5)	<.001
Genito-urologic procedure[b]	117 (0.8)	87 (0.7)	30 (1.0)	.14
Positive urine culture[c]	6,450 (43.7)	5,400 (45.9)	1,050 (35.3)	<.001
Service				
Medical	8,220 (55.8)	6,914 (58.7)	1,306 (43.9)	Reference
Surgical	3,782 (25.7)	3,068 (26.1)	714 (24.0)	<.001
Medical ICU	1,710 (11.6)	1,148 (9.8)	562 (18.9)	<.001
Surgical ICU	1,031 (7.0)	640 (5.4)	391 (13.2)	<.001
Days from admission to culture				
Same day	5,798 (39.3)	5,136 (43.6)	662 (22.3)	Reference
Within 1–7 d	7,022 (47.6)	5,394 (45.8)	1,628 (54.8)	<.001
>7 d	1,923 (13.0)	1,240 (10.5)	683 (23.0)	<.001

NOTE. SD, standard deviation; HIV, human immunodeficiency virus; ICU, intensive care unit.
[a]Cultures without associated urinalysis or urine microscopy performed within 1 calendar day of the culture.
[b]As defined by the National Healthcare Safety Network[15,16] based on ICD-9-CM procedure codes; includes kidney and prostate procedures, and vaginal hysterectomy.
[c]Culture positive for bacterial or fungal growth.

admission order set for non-ICU patients contained check boxes for urine microscopy and urine culture, potentially prompting providers to order both tests simultaneously. We were unable to assess specific methods of order entry in our study, such as the use of order sets or provider responses to presented order options. However, further research on provider behaviors within CPOE systems could improve the design of such interventions.

With the increasing focus on reimbursement of healthcare-acquired infections, it is concerning that half of the CAUTIs identified in study ICUs were based on an isolated urine culture. Even adjusting for catheterization status, ICU patients were at greater risk of having isolated cultures. Without chart review, we cannot comment on the concordance between CAUTI surveillance definitions and clinical illness, nor can we infer how performing urinalysis or microscopy may impact CAUTI rates. Also, we could not directly assess a provider's rationale for ordering an isolated culture in the ICU. Given the higher proportion of ICU patients with urinary catheters and the surveillance focus on ICU CAUTIs, a better understanding of provider practices in this context is needed.

Our study was limited by the absence of chart review, which prevented us from evaluating testing indications, treatment, provider characteristics (eg, level of training), and other aspects of provider behavior. Certain cultures may have been performed for reasons other than UTI diagnosis, as in pregnant women and in certain preprocedure protocols. Although we attempted to limit such cultures by excluding gynecologic, obstetric, and urology wards, we were unable to assess all cultures for these indications. Additionally, comorbidities and genito-urologic procedures were identified based only on ICD-9-CM codes. CAUTI surveillance was not routine on medical and surgical floors during the study period, so CAUTI rates for these units were unavailable. We did not include data on antibiotic use; thus, we were unable to assess the impact of a positive culture with or without urinalysis on treatment. The setting of a single academic hospital also limits the generalizability of results. Strengths of our study include a large sample size and the inclusion of key clinical data, such as catheterization status and recent genito-urologic procedures. Using electronically available data, automated tracking of future interventions is feasible.

TABLE 2. Comparison of Patient Risk Factors for Isolated Initial Urine Cultures

Variable	Initial Urine Culture With Urinalysis and/or Microscopy, No. (%) (n = 9,670)	Isolated Initial Urine Cultures, No. (%) (n = 2,150)[a]	*P* Value	Multivariable Analysis[b] aOR (95% CI)	Multivariable Analysis[b] *P* Value
Male sex	4,338 (44.9)	1,113 (51.8)	<.001	1.22 (1.11–1.35)	<.001
White race[c]	5,606 (58.0)	1,410 (65.6)	<.001	1.22 (1.10, 1.35)	<.001
Age, y, mean ± SD	60 ± 18.5	57 ± 18.4	<.001	0.990 (0.987–0.992)	<.001
CHF	746 (7.7)	139 (6.5)	.05		
COPD	1,133 (11.7)	220 (10.2)	.05		
Malignancy	764 (7.9)	199 (9.3)	.04		
HIV	111 (1.1)	28 (1.3)	.55		
Diabetes mellitus	2,057 (21.3)	374 (17.4)	<.001	0.87 (0.77–0.99)	.03
Cirrhosis	328 (3.4)	102 (4.7)	.003		
ESRD	476 (4.9)	94 (4.4)	.28		
Urinary catheterization	921 (9.5)	520 (24.2)	<.001	2.15 (1.89–2.46)	<.001
Genito-urologic procedure[d]	62 (0.6)	24 (1.1)	.02		
Positive urine culture[e]	4,512 (46.7)	735 (34.2)	<.001	NA	NA
Service					
Medical	5,845 (60.4)	984 (45.8)	Reference	Reference	NA
Surgical	2,576 (26.6)	585 (27.2)	<.001	1.10 (0.98–1.24)	.15
MICU	787 (8.2)	327 (15.2)	<.001	1.72 (1.47–2.00)	<.001
SICU	462 (4.8)	254 (11.8)	<.001	1.82 (1.51–2.19)	<.001
ICU admission	1,249 (12.9)	581 (27.0)	<.001	NA	NA
Days from admission to culture					
Same day	4,850 (50.1)	636 (29.6)	Reference	Reference	NA
1–7 d	4,247 (43.9)	1,210 (56.3)	<.001	1.91 (1.71–2.12)	.02
>7 d	573 (5.9)	304 (14.1)	<.001	2.81 (2.37–3.34)	<.001

NOTE. aOR, adjusted odds ratio; SD, standard deviation; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ESRD, end-stage renal disease; HIV, human immunodeficiency virus; ICU, intensive care unit; MICU, medical intensive care unit; NA, not applicable; SICU, surgical intensive care unit.

[a]Isolated cultures were defined as cultures without associated urinalysis or urine microscopy performed within 1 calendar day of the culture. Initial cultures were defined as the first culture drawn in a given admission.

[b]Variables with a significance of ≤0.15 were considered for entry into the model, with a significance level of ≤0.05 required to stay in the model. The variables "positive urine culture" and "ICU admission" were not used in constructing the model. All other variables without adjusted odds ratios reported were not included in the final model. See the Methods section for a full description.

[c]Other races, as number (%) of total initial urine cultures: 3,982 (33.7%) black, 695 (5.9%) other unspecified, 104 (0.9%) Asian, 17 (0.1%) Native American, 4 Hispanic, 1 Pacific Islander, 1 Alaskan Native.

[d]As defined by the National Healthcare Safety Network,[15,16] based on ICD-9-CM procedure codes. Includes kidney and prostate procedures, and vaginal hysterectomy.

[e]Culture positive for bacterial or fungal growth.

Our data suggest that interventions aimed at improving culturing practices may result in better diagnosis of inpatient UTIs. Knowledge of the variability of culturing practices across wards and patients assists in identifying those groups where interventions may be most beneficial. Further research is needed on testing practices across institutions, provider-related variables impacting urine culturing practices, and the effects of testing variability on antibiotic usage and clinical outcomes.

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supplementary material

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