MAJOR ARTICLE

Urinalysis in Acute Care of Adults: Pitfalls in Testing and Interpreting Results

Daniel J. Pallin, Clare Ronan, Kamaneh Montazeri, Katherine Wai, Allen Gold, Siddharth Parmar, and Jeremiah D. Schuur

Department of Emergency Medicine, Brigham and Women's Hospital, Boston, Massachusetts

Background. Rapid urine tests for infection (urinalysis, dipstick) have low up-front costs. However, many false positives occur, with important downstream consequences, including unnecessary antibiotics. We studied indications, collection technique, and results of urinalyses in acute care.

Methods. This research was a prospective observational study of a convenience sample of emergency department (ED) patients who had urinalysis performed between June 1, 2012 and February 15, 2013 at an urban teaching hospital. Analyses were conducted via *t* tests, χ^2 tests, and multivariable logistic regression.

Results. Of 195 cases included in the study, the median age was 56 and 70% of participants were female. There were specific symptoms or signs of urinary tract infection (UTI) in 74 cases (38%; 95% confidence interval [CI], 31%–45%), nonspecific symptoms or signs in 83 cases (43%; 95% CI, 36%–50%), and no symptoms or signs of UTI in 38 cases (19%; 95% CI, 14%–25%). The median age was 51 (specific symptoms), 58 (nonspecific symptoms), and 61 (no symptoms), respectively ($P = .005$). Of 137 patients who produced the specimen without assistance, 78 (57%; 95% CI, 48%–65%) received no instructions on urine collection. Correct midstream clean-catch technique was used in 8 of 137 cases (6%). Presence of symptoms or signs was not associated with a new antibiotic prescription, but positive urinalysis (OR, 4.9; 95% CI, 1.7–14) and positive urine culture (OR, 3.6; 95% CI, 1.1–12) were. Of 36 patients receiving antibiotics, 10 (28%; 95% CI, 13%–43%) had no symptoms or nonspecific symptoms.

Conclusions. In this sample at an urban teaching hospital ED, urine testing was not driven by symptoms. Improving practice may lower costs, improve efficiency of care, decrease unnecessary data that can distract providers and impair patient safety, decrease misdiagnosis, and decrease unnecessary antibiotics.

Keywords. antibiotic stewardship; asymptomatic bacteriuria; urinalysis; urine culture; urinary tract infection.

Unnecessary antibiotics cause resistance, *Clostridium difficile* diarrhea, side-effects, and allergic reactions [1–3]. Inappropriate treatment of asymptomatic bacteriuria has been a target of quality improvement efforts, including efforts to promulgate a national quality improvement measure from the Infectious Diseases Society of America [3–7].

The problem of inappropriate treatment of asymptomatic bacteriuria has been studied most in long-term care facilities but less in acute-care settings, such as the emergency department (ED) [6]. There are 130 million US ED visits each year, accounting for 11% of ambulatory healthcare visits and half of hospital admissions [5, 6]. Urinary tract infection (UTI) is the 4th most common diagnosis among women aged ≥65 years [8]. The ED has been identified as an important site for antibiotic stewardship, but these considerations apply to all acute-care settings that perform urine tests [9].

Among the millions of acute-care diagnoses of UTI, it is difficult to know how many are correct and how many courses of antibiotics are justified. One study concluded that 27% of ED patients with positive urine cultures had asymptomatic bacteriuria not UTI [10]. Another study found that the prevalence of positive culture among elderly ED patients with no symptoms was similar to that among those with vague symptoms such as delirium, for which urinalysis is frequently done [11].

We report data from a prospective observational study of ED patients undergoing urinalysis. We describe

Received 4 March 2014; accepted 10 April 2014.

Correspondence: Daniel J. Pallin, MD, MPH, Department of Emergency Medicine, Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115 (dpallin@partners.org).

Open Forum Infectious Diseases

DOI: 10.1093/ofid/ofu019

Table 1. Symptoms of Urinary Tract Infection[a]

UTI Symptoms/Signs Present Testing for UTI Indicated	UTI Symptoms/Signs Nonspecific Indication for Testing for UTI Ambiguous	UTI Symptoms/Signs Absent Testing for UTI Not Indicated
Any of the following symptoms or signs: • Dysuria • Urgency • Frequency • Flank pain • Hematuria • Costovertebral angle tenderness on percussion • Sepsis with no other source • Acute urinary retention • Acute nephrolithiasis • Obstruction of urinary catheter	Any of the following symptoms or signs: • Unexplained acutely altered mental status • Fever with no other explanation • Rigors with no other explanation	All other patients: • For example, urine testing is not indicated "just because the patient is being admitted" or "just because he fell."

Abbreviations: UTI, urinary tract infection.

[a] This schema does not apply to patients with impaired ability to manifest symptoms, such as those with spinal cord injury or those who are comatose.

symptoms and signs, sampling technique, test characteristics, and antibiotic use. Our objective is to look beneath the surface of this deceptively simple test, to identify the complexities that impair quality practice, and to provide a framework that can resolve these complexities to benefit future practice and research.

METHODS

We conducted a prospective observational study in the ED of an urban teaching hospital between June 1, 2012 and February 15, 2013, enrolling a convenience sample of ED patients who had urinalysis performed as part of usual care. Trained research assistants identified cases by monitoring our electronic tracking system, which displays an icon when urine test results are available. This study was reviewed by our institutional review board and was exempted from review because it was determined to have the legal or ethical status of "quality improvement activity" rather than "human subjects research." Nevertheless, each patient who was interviewed gave verbal consent to participate.

Using structured data forms, data were collected by interview of patients and providers. Participants were asked to describe sample collection step-by-step. Females were shown an anatomically correct drawing of the vulva to determine specifically what actions they took in preparing to give the specimen. We define correct midstream clean-catch technique as obtainment of a midstream specimen after wiping the urethral opening with an antiseptic towelette, with separation of labia and wiping from front to back by women, or retraction of foreskin by uncircumcised men.

We define a urinalysis as positive if it contains nitrites, leukocyte esterase, bacteria, or >10 white blood cells per high-power field. We define positive urine culture as >100 000 colony-forming units of a single species (voided) or >100 colony-forming units of a single species (catheterized) [8].

We define UTI as urethritis, cystitis, or pyelonephritis. However, the simplicity of this definition belies some important problems with construct validity. The concept "UTI" has high validity when applied to a healthy young female with no sexual exposures who presents with acute dysuria, pyuria, and bacteriuria on urinalysis, and a positive urine culture. Construct validity is much less clear in the case of an 80-year-old woman with dementia who presents with a slight decline in functional status and happens to have pyuria and a positive culture. Yet both of these patients may receive antibiotics "for UTI" if seen in an acute-care setting. Therefore, we classify patients with positive urine cultures into 3 groups: (1) those with specific symptoms of UTI, (2) those with vague symptoms that are traditionally associated with UTI, and (3) those with no symptoms (Table 1).

We report descriptive results as percentages and 95% confidence intervals (CIs) and P values via χ^2 testing. We used multivariable logistic regression to assess predictors of use of antibiotics, with the following independent variables: urinalysis results, urine culture results, and symptoms. We used SAS 9.2 (Cary, NC) for all analyses.

RESULTS

We enrolled 199 subjects who had urinalysis. Four analyses (2%) were ordered for specific reasons other than detecting UTI and were excluded, leaving 195 as our study sample. Demographic details are provided in Table 2.

There were specific symptoms or signs of UTI in 38% (95% CI, 31%–45%), nonspecific in 43% (95% CI, 36%–50%), and none in 19% (95% CI, 14%–25%). Median ages were 51, 58, and 61, respectively ($P = .005$). This result indicates that urine testing is done for less specific reasons among older patients.

Symptom category did not vary by sex ($P = .18$). However, sex was an effect modifier of the relationship of age to indication. Among women, median ages by indication category were 38 (specific), 58 (nonspecific), and 58 (none), respectively

Table 2. Characteristics of Emergency Department Patients Who Had Urinalysis

Characteristic	n (% of 195)
Age (median, interquartile range)	56 (40–70)
Female sex	137 (70)
Disposition	
Home	106 (54)
Floor	79 (41)
Intensive care unit	6 (3)
Transfer	4 (2)
Long-term care facility resident	10 (5)
Symptoms of urinary tract infection	
Specific	74 (38)
Nonspecific	83 (43)
None	38 (19)
Provider order for the urinalysis?	181 (93)
EM attending or PGY3+ EM resident	40 (21)
PGY1 or 2 EM resident or non-EM resident	55 (28)
Physician Assistant	86 (48)
No order	14 (7)
Collection technique	
Voided	160 (82)
Catheterized	35 (18)
Among 137 unassisted voided specimens, how many received instructions?	78 (57)
Urine culture ordered	82 (42)
Urine culture done	83 (43)
Urine culture positive (% of cultures done)	21 (25)
Main clinical diagnosis for visit	
Was main diagnosis infectious?	43 (22)
Antibiotic given in emergency department?	60 (31)

Abbreviations: EM, emergency medicine; PA, physician assistant; PGY, postgraduate year.

Table 3. Test Characteristics of Urinalysis As a Proxy for Urine Culture Among Patients With Urinalysis and Urine Culture Sent During Routine Care[a]

	Urine Culture Result	
Urinalysis Result	Abnormal	Normal
Positive for infection	17	28
Negative for infection	4	34
Results (Test characteristics [95% confidence intervals])		
Sensitivity: 81% (64%–98%)		
Specificity: 54% (42%–67%)		
Negative predictive value: 89% (80%–99%)		
Positive predictive value: 38% (24%–52%)		
Likelihood ratio negative 0.35 (0.03–0.67)		
Likelihood ratio positive 1.8 (1.2–2.4)		

[a] We define a urinalysis as positive if it contains nitrites, leukocyte esterase, bacteria, or >10 white blood cells per high-power field. We define a urine culture as positive if it results in >100 000 colony-forming units of a single species (voided) or >100 colony-forming units of a single species (catheterized) [8].

($P < .001$); however, among men, there was no significant age variation among the 3 indication groups, with median ages of 67, 61, and 68, respectively ($P = .30$). This finding reveals more specific indications for testing among young women, relative to older women and men.

Of the 195 subjects, there was no order for the urinalysis in 7% of cases (95% CI, 3.5%–11%). As a reminder, our site has no point-of-care testing. A higher rate of tests without orders would be expected at sites with point-of-care testing, because point-of-care testing does not require involvement of a central laboratory.

Urine specimens were voided in 82% of cases and collected via catheterization in the remainder. In-person interviews revealed that, of 137 patients who produced the specimen without assistance, 78 (57%; 95% CI, 48%–65%) received no instructions from ED staff on urine collection. Results were similar for males (51%) and females (59%) and did not vary by age ($P = .77$). Among participants producing a voided specimen without assistance, correct midstream clean-catch technique was used in 8 of 137 cases (6%).

Urinalysis results were positive in 76 cases (39%; 95% CI, 32%–46%). Of the 195 subjects, urine culture was sent in addition to urinalysis in 83 (43%; 95% CI, 36%–50%). Urine culture was sent in 59% of subjects with positive urinalysis, versus 32% of subjects with negative urinalysis ($P < .001$).

Table 3 summarizes the test characteristics of urinalysis as a proxy for urine culture. The sensitivity of urinalysis as a proxy for culture was 81% (false-negative rate, 19%) and the specificity was 54% (false-positive rate, 46%). More importantly, this result describes the accuracy of urinalysis as a proxy for a positive urine culture, not as a predictor of UTI. This distinction is important because UTI is often not present even when the culture is positive, due to contaminated specimens and asymptomatic bacteriuria [1]. If there were a truly accurate test for bona fide UTI, the test characteristics of urinalysis as a proxy for that test would be worse.

We also analyzed the sensitivity and specificity of urinalysis as a proxy for urine culture by symptom category. These results are presented for descriptive purposes only, because the study was not powered to detect differences in test categories among these small subsets of patients, precluding meaningful statistical comparison among these groups. Among patients with specific symptoms of UTI, sensitivity of urinalysis for urine culture was 92% and specificity was 48%. Among those with nonspecific symptoms, sensitivity was 57% and specificity was 58%. Among those with no symptoms of UTI, sensitivity was 24% and specificity was 76%.

Of the 60, 24 received the antibiotics for a non-UTI indication, while 36 received antibiotics with no explanation other

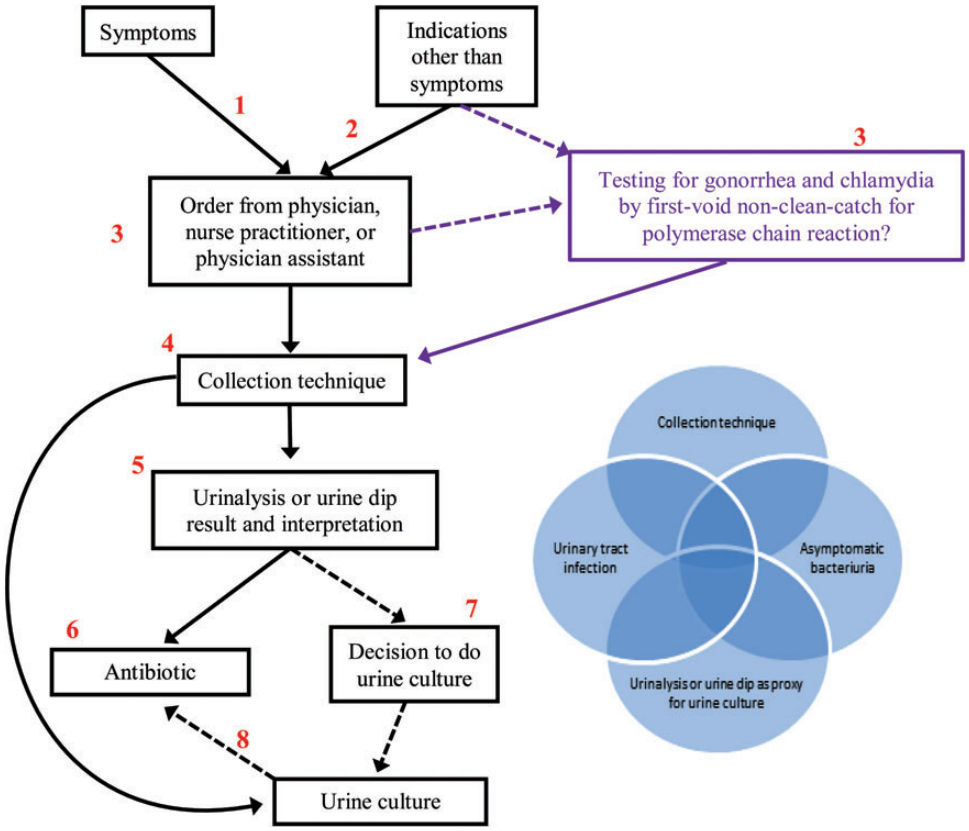

Figure 1. Framework for education and quality improvement regarding rapid urine tests in acute care of adults. © 2013 Daniel J. Pallin, used with permission.

than suspected UTI. In this group of 36, symptoms were associated with the decision to use antibiotics: antibiotics were given to 3% of those with no UTI symptoms, 13% of those with nonspecific symptoms, and 40% of those with specific UTI symptoms (P for trend <.001). However, to control for how urinalysis results influence decision-making irrespective of symptoms, we fit a multivariable model with antibiotic use as the dependent variable and the following predictors: positive urinalysis, positive urine culture, indication (specific, nonspecific, none [see Table 1]). In this controlled analysis, presence of symptoms and signs was not associated with antibiotic use, but positive urinalysis (OR, 4.9; 95% CI, 1.7–14) and positive urine culture (OR, 3.6; 95% CI, 1.1–12) were.

DISCUSSION

Despite low barriers and low up-front cost, rapid urine testing for infection is complex. When rapid urine tests are done without appropriate indications and collection methods, downstream consequences may include misdiagnosis and unnecessary antibiotics. To clarify the complexities of urine testing in the acute-care setting, we studied a convenience sample of adult ED patients who had urinalysis. Our results suggest that testing is not driven by symptoms and that rapid test results, rather than symptoms, drive antibiotic utilization.

To put our results in a context that may be helpful in planning future work, we present a framework that dissects the complexities underlying this deceptively simple process (Figure 1). Step 1 addresses symptoms. When vague symptoms such as decreased functional status are present, there is no good way to differentiate UTI from coincidental asymptomatic bacteriuria, which is present in up to half of elderly female residents of long-term care facilities [1, 6]. These patients risk not only exposure to unnecessary antibiotics, but they also risk having the true diagnosis missed due to the cognitive error known as "premature closure." Older adults bear the brunt of these risks, because the prevalence of asymptomatic bacteriuria increases with age, as does the physical difficulty of correctly producing a midstream clean-catch specimen. In the present sample, just over one third of urinalyses were done without specific symptoms, and urinalysis was done without specific symptoms more commonly. Step 2 addresses which patients with no UTI symptoms should have testing for UTI. There is broad consensus that pregnant women and patients about to undergo urologic surgery should have their urine tested and sterilized [1]. The Infectious Diseases Society of America, the Centers for Disease Control

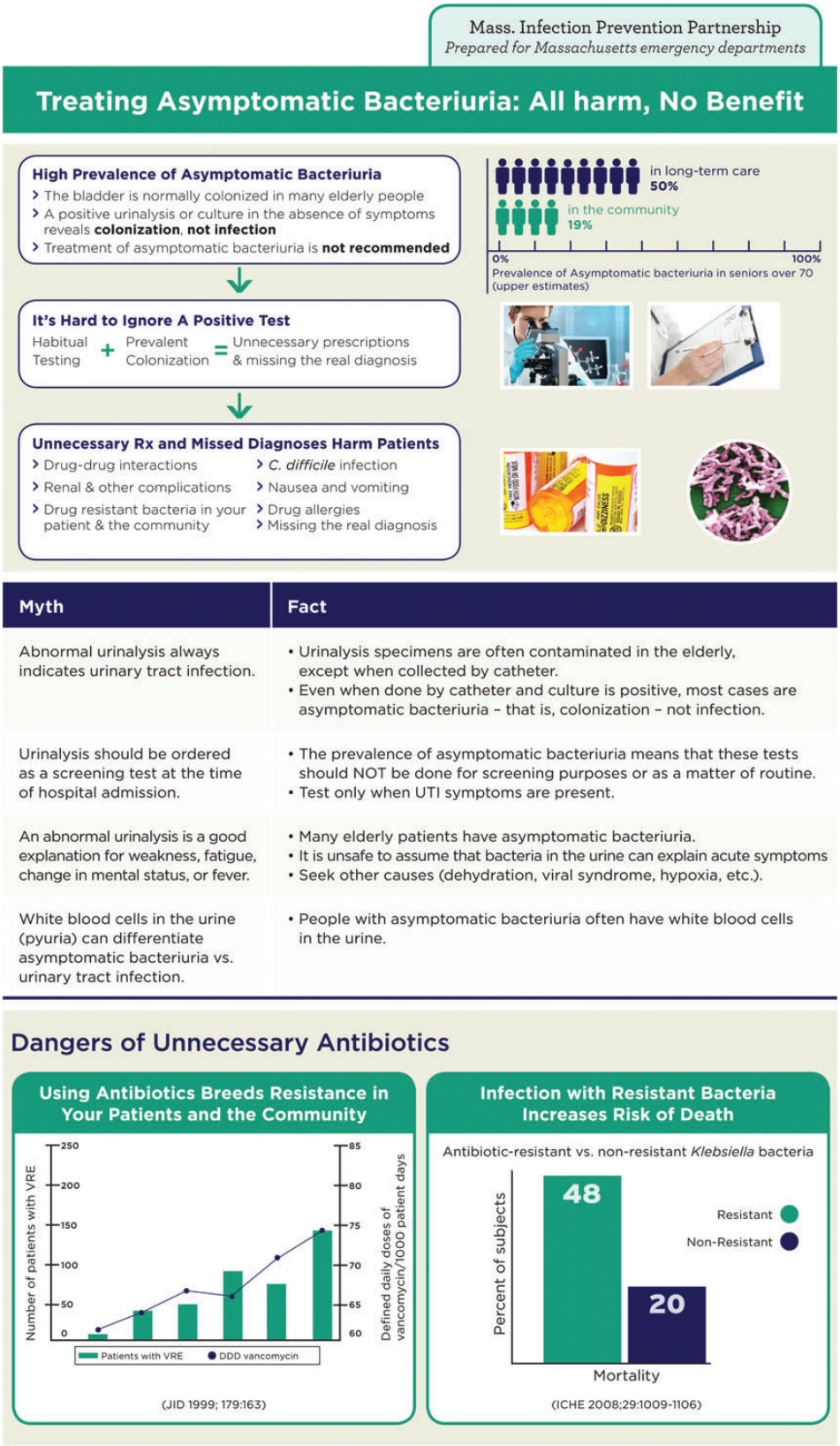

Figure 2. Educational Tools for Improving the Accuracy of Urine Testing. Developed by the *Massachusetts Infection Prevention Partnership*, which includes the Massachusetts Coalition for the Prevention of Medical Errors, Massachusetts Department of Public Health, and Massachusetts Senior Care Association, with its clinical advisors: Ruth Kandel MD, Director Infection Control, Hebrew Senior Life; Daniel Pallin MD, MPH, Director of Research, Brigham & Women's Hospital Department of Emergency Medicine; and Shira Doron MD, Antimicrobial Steward & Associate Hospital Epidemiologist, Tufts Medical Center. Used with permission.

Do Not Test, Do Not Treat Asymptomatic Bacteriuria[1]

No symptoms of UTI
› Do not test urine
› Do not treat if a urine test was done by someone else or for "routine"

Weakness, delirium, or fever without a focus
› Individualize care
› Be mindful of the presence of asymptomatic bacteriuria
› Seek other causes

Specific UTI symptoms
› Test or treat as usual

Challenges	Strategies for Practice Change
I'm admitting the patient and the hospital team insist on urine tests.	• Be sure to get a cath or valid midstream clean-catch specimen. • Specify that you do not suspect UTI on clinical grounds. • Remind the team of asymptomatic bacteriuria's prevalence. • Suggest that the team observe the patient without initiating antibiotics.
The patient's family wants a urine test and antibiotic treatment.	• Educate the family about asymptomatic bacteriuria. • Explain that antibiotics are unnatural chemicals that put the patient at risk for diarrhea, including *C. difficile*, and other adverse effects.
The patient has dementia, so history is limited. I should do diagnostic testing as I would in a 2 month old.	• The difference is that small children normally have sterile urine. • The elderly often do not have sterile urine, even when they are well.
I believe it is better to give an antibiotic even if I'm not sure it is needed. Better safe than sorry.	• Antibiotics can cause adverse drug reactions, c difficile infection, multi-drug resistant organisms. They should not be administered unless clinically indicated. • Consider how practice has changed for viral upper respiratory infections. • If the patient has fever or signs of sepsis, you may need to treat presumptively, but that doesn't mean stable patients require antibiotics for possible colonization.
We've got this abnormal result and we don't even know why the test was done.	• Evaluate the patient clinically. • All providers should communicate about why they are performing tests – especially tests with very high false positive rates. • Observe the patient, rather than rushing to start antibiotics.
I'm not confident the patient will receive the appropriate follow up after returning to their long term care facility or home.	• Document discharge summary clearly regarding observation and follow up. • A call to the resident's facility or provider will facilitate appropriate follow up care. • If a urine test has been done and is abnormal and asymptomatic bacteriuria is suspected, be sure to notify patient and ongoing providers of this result and that no treatment is being given so they can monitor the patient for fever or other signs of urinary tract infection.

References:
[1] CID 2010;50:625-663; CID 2009;48:149-171; ICHE 2001;22:120-124 CID 2005;40:643-54 Can J Emerg Med 2007;9(2):87-92

Massachusetts Infection Prevention Partnership
Massachusetts Coalition for the Prevention of Medical Errors, Massachusetts Department of Public Health, Massachusetts Senior Care Association, Masspro

Clinical Advisors

Ruth Kandel MD, Director Infection Control, Hebrew Senior Life

Daniel Pallin MD, MPH, Director of Research Brigham & Women's Hospital Department of Emergency Medicine, and Chairman, Brigham and Women's Hospital Clinical Investigation Committee

Shira Doron MD, Antimicrobial Steward & Associate Hospital Epidemiologist, Tufts Medical Center

Questions or Copies
froberts @macoalition.org

Figure 2 continued.

and Prevention, and other bodies offer strong guidance that no other patients should be treated for asymptomatic bacteriuria [1, 12]. However, in other areas, the relevance of these recommendations is questioned. For example, most orthopedic surgeons require testing for UTI before open reduction and internal fixation procedures, based on expert opinion, low-quality and conflicting evidence, and despite the fact that these patients will, in any case, receive a large dose of a cephalosporin before the skin incision [13–15]. Likewise, although it may not be recommended in any credible text, many clinicians believe that all patients being admitted to the hospital should have a urinalysis and that positive results should lead to antibiotic treatment, regardless of symptoms.

Step 3, an order for urine testing is a domain particularly relevant to the acute-care setting. Nurses and nurses' aides are efficient when they "hold" samples in anticipation of prescribers' orders, but they communicate with the responsible prescriber before initiating testing. For Step 4, although special collection technique may not be required for accurate urine culture, it is quite important for accurate rapid testing (urinalysis or dipstick) [16, 17]. Patients who are elderly, acutely or chronically ill, or disabled may have difficulty understanding or performing the maneuvers necessary for correct specimen collection [16, 17]. Two assistants may be required to obtain noncontaminated urine in this population. One study reported a 57% false-positive rate for urine cultures collected by midstream clean-catch in elderly hospitalized women [18]. Busy clinicians may not understand the importance of collection technique nor take the time to provide appropriate instructions. Indeed, in our sample, correct midstream clean-catch technique was used in <5% of cases. Evidence suggests that good instructions do improve technique, although we had so few examples of correct technique that statistical comparison was not possible [17]. Step 5 relates to interpretation of rapid urine test results. Prior studies have found a false-negative rate for rapid urine tests of approximately 20% [19], similar to our observed false-negative rate of 19%. Positive results are even more fraught, because of the following: (1) poor collection technique will produce a falsely positive specimen; (2) pyuria is a normal finding in the setting of asymptomatic bacteriuria [20]; (3) pyuria is a normal finding in the setting of acute nephrolithiasis [21]; and (4) positive nitrite is a specific indicator of the presence of bacteriuria but cannot differentiate UTI from poor collection technique or asymptomatic bacteriuria. As seen in the present data, the accuracy of urinalysis as an indicator of a positive urine culture is quite poor; we observed a sensitivity of 81% and a specificity of 54%. Urinalysis as an indicator of UTI is even poorer, because many patients with positive cultures do not have infections but rather have asymptomatic bacteriuria. This problem increases with age and debility, along with the prevalence of asymptomatic bacteriuria [1].

Step 6 addresses therapy. Our analysis suggests that use of antibiotics was determined by tests results, not patients' symptoms. In Step 7, the decision is made whether to obtain a urine culture. In Step 8, the results of the urine culture are obtained and interpreted. In adults residing in long-term care facilities, great progress has been made in discouraging antibiotic use in the absence of relevant symptoms [1, 6]. In the acute-care setting, the first step should be judicious test ordering. However, inevitably, some adults with vague or absent symptoms will be found to have pyuria. In this case, the crucial distinction might be patient stability. Patients with sepsis should be treated aggressively. However, for patients who are stable, the best approach may be observation with mindfulness of the prevalence of asymptomatic bacteriuria.

Improving practice in this area requires education. The most important piece of information is the high prevalence of asymptomatic bacteriuria among the elderly, especially elderly female residents of long-term care facilities. Figure 2 demonstrates educational materials that have been used in seminars around Massachusetts.

Limitations

The data reported in this paper were from a convenience sample, and thus results cannot be presumed representative of all patients. As discussed above, our center has no point-of-care testing; centers with point-of-care testing probably have more frequent testing without orders and worse test performance, due to further separation of symptoms and testing. It would be valuable to repeat this study in a multicenter design, with comprehensive sampling, and include centers with point-of-care urine dipstick testing.

CONCLUSIONS

Urinalysis and urine dipstick tests for infection are easy to obtain and inexpensive initially, but their results are complex to interpret and can have important downstream consequences. In this sample at an urban teaching hospital ED, urine testing was not driven by symptoms.

Some approaches to improving practice include the following. Nurses and aides should communicate with prescribers rather than initiate tests, and, when communication is not immediately possible, they should "collect and hold" rather than perform tests. Appropriate collection techniques should be emphasized. Prescribers should order urine testing only with specific justification, and they should be mindful of the high prevalence of asymptomatic bacteriuria as they decide whether to order tests and how to interpret their results. Watchful waiting and attention to differential diagnosis are important in the setting of positive results, due to poor test specificity.

Improving practice in this area may lower costs, improve efficiency of care, decrease unnecessary data that can distract providers, decrease misdiagnosis, and decrease unnecessary antibiotics.

Notes

Financial support. This work was supported by a Jahnigen Career Development Award funded by grants from John A. Hartford Foundation and the Atlantic Philanthropies (to J. D. S.).

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

All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

References

1. Nicolle LE, Bradley S, Colgan R, et al. Infectious Diseases Society of America guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. Clin Infect Dis **2005**; 40:643–54.
2. Bartlett JG. A call to arms: the imperative for antimicrobial stewardship. Clin Infect Dis **2011**; 53(Suppl 1):S4–7.
3. Gross PA, Patel B. Reducing antibiotic overuse: a call for a national performance measure for not treating asymptomatic bacteriuria. Clin Infect Dis **2007**; 45:1335–7.
4. Zabarsky TF, Sethi AK, Donskey CJ. Sustained reduction in inappropriate treatment of asymptomatic bacteriuria in a long-term care facility through an educational intervention. Am J Infect Control **2008**; 36: 476–80.
5. Linares LA, Thornton DJ, Strymish J, et al. Electronic memorandum decreases unnecessary antimicrobial use for asymptomatic bacteriuria and culture-negative pyuria. Infect Control Hosp Epidemiol **2011**; 32:644–8.
6. Loeb M, Brazil K, Lohfeld L, et al. Effect of a multifaceted intervention on number of antimicrobial prescriptions for suspected urinary tract infections in residents of nursing homes: cluster randomised controlled trial. BMJ **2005**; 331:669.
7. Samore MH, Bateman K, Alder SC, et al. Clinical decision support and appropriateness of antimicrobial prescribing: a randomized trial. JAMA **2005**; 294:2305–14.
8. Gordon LB, Waxman MJ, Ragsdale L, et al. Overtreatment of presumed urinary tract infection in older women presenting to the emergency department. J Am Geriatr Soc **2013**; 61:788–92.
9. May L, Cosgrove S, L'Archeveque M, et al. A call to action for antimicrobial stewardship in the emergency department: approaches and strategies. Ann Emerg Med **2013**; 62:69–77.e2.
10. Khawcharoenporn T, Vasoo S, Ward E, et al. Abnormal urinalysis finding triggered antibiotic prescription for asymptomatic bacteriuria in the ED. Am J Emerg Med **2011**; 0:828–30.
11. Ducharme J, Neilson S, Ginn JL. Can urine cultures and reagent test strips be used to diagnose urinary tract infection in elderly emergency department patients without focal urinary symptoms? CJEM **2007**; 9:87–92.
12. Dudeck MA, Horan TC, Peterson KD, et al. National Healthcare Safety Network (NHSN) report, data summary for 2009, device-associated module. Am J Infect Control **2011**; 39:349–67.
13. Ollivere BJ, Ellahee N, Logan K, et al. Asymptomatic urinary tract colonisation predisposes to superficial wound infection in elective orthopaedic surgery. Int Orthop **2009**; 33:847–50.
14. Glynn MK, Sheehan JM. The significance of asymptomatic bacteriuria in patients undergoing hip/knee arthroplasty. Clin Orthop Relat Res **1984**; 0:151–4.
15. Canale ST, Beaty JH. Campbell's Operative Orthopaedics. Philadelphia, PA, USA: Elsevier/Mosby; **2012**.
16. Das RN, Chandrashekhar TS, Joshi HS, et al. Frequency and susceptibility profile of pathogens causing urinary tract infections at a tertiary care hospital in western Nepal. Singapore Med J **2006**; 47: 281–5.
17. Fisher LA, Johnson TS, Porter D, et al. Collection of a clean voided urine specimen: a comparison among spoken, written, and computer-based instructions. Am J Public Health **1977**; 67:640–4.
18. Kaye D. Urinary tract infections in the elderly. Bull NY Acad Med **1980**; 56:209–20.
19. Goldsmith BM, Campos JM. Comparison of urine dipstick, microscopy, and culture for the detection of bacteriuria in children. Clin Pediatr (Phila) **1990**; 29:214–8.
20. Hooton TM, Scholes D, Stapleton AE, et al. A prospective study of asymptomatic bacteriuria in sexually active young women. N Engl J Med **2000**; 343:992–7.
21. Fogazzi GB, Verdesca S, Garigali G. Urinalysis: core curriculum 2008. Am J Kidney Dis **2008**; 51:1052–67.