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Research Brief

Impact of electronic alerts on repeat urine culture testing: Analysis from a large academic medical center

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Urine cultures are commonly ordered among hospitalized patients, and they are often ordered repeatedly, leading to laboratory overutilization and increased cost.[1,2] Positive urine cultures are a major driver of unnecessary antibiotic use.[3–5] Previous studies have used multiple methods to prevent unnecessary urine testing including education, reflex urine culture cancellation and 2-step urine-culture ordering,[6,7] Prior interventions at our institution to prevent unnecessary urine cultures, including modification of "reflex" urine-culture criteria for specimens submitted for urinalysis and modifications of emergency department and inpatient electronic order sets, decreased urine cultures performed by 46.6% and 45%, respectively.[8,9] However, data on the effect of changes in electronic order sets and its role on repeated urine testing practices are limited.

We evaluated the impact of duplicate order alerts for urine culture orders in a computer physician order entry (CPOE) system on urine culturing practices in a large urban, academic medical center (Supplementary Fig. 1 online).

Methods

We included patients admitted to Barnes-Jewish Hospital (BJH) between June 2, 2018, and December 31, 2021, who had ≥1 urine culture ordered during their hospitalization. Patients admitted during the study period but who did not have a urine culture ordered during their stay were excluded.

Intervention

To prevent providers from ordering duplicate urine cultures, a notice that a laboratory-generated urine culture was in process, based upon urinalysis results (ie, as part of a urinalysis reflexed to urine culture order), began to appear in the urinalysis results section of the electronic medical record (EMR) starting on April 25, 2019. A second intervention was initiated on October 28, 2020. If a provider attempted to order a urine culture and a culture had been collected and processed within the past 72 hours, a duplicate order alert appeared that displayed the status of the in-lab culture. Providers had the option of overriding the alert (Supplementary Fig. 2 online). E-mail notification was sent to providers prior to intervention implementation. We compared the daily number of inpatient urine cultures performed, the daily number of positive urine cultures, and daily isolated urine culture count before and after the changes: period 1 (June 2, 2018, to April 24, 2019) versus period 2 (April 25, 2019, to October 28, 2020) versus period 3 (October 29, 2020, to December 31, 2021).

Patient and laboratory data were abstracted from the hospital informatics database. Data included patient demographics, urine culture results including specimen type and order type (reflex, based upon urinalysis results, vs standalone or isolated). For patients with multiple urine cultures during an admission, each sample was treated as an independent observation. This study was approved by the Washington University Human Research Protection Office.

Results

During the 42-month period, 104,965 urine cultures were performed at BJH, of which 31,134 (29.7%) were from inpatient locations (mean, 24 cultures per day). Of the inpatient urine cultures, 7,661 (24.6%) were abnormal: 7,049 (22.6%) were reported as positive and 865 (2.8%) were reported as contaminated. Most of the cultures (62.1%, n = 19,325) were ordered and performed as part of a reflex algorithm, based upon abnormal urinalysis results, and 33.0% (n = 10,259)were isolated or were standalone cultures. The most common indication selected by providers for isolated urine cultures was a recent positive urinalysis (43.3%). Significant reductions in the mean daily urine cultures per 100 inpatients (3.34 vs 2.34; $P < .001$; 3.34 vs 2.22; $P < .001$), mean daily positive urine cultures per 100 inpatients (0.80 vs 0.49; $P < .001$; 0.80 vs .52; $P < .001$), and mean daily isolated urine cultures per 100 inpatients (1.05 vs 0.86; $P < .001$; 1.05 vs 0.66; $P < .001$) were noted after EMR notification of laboratory-generated urine-culture orders (period 2) on April 25, 2019, and after repeated urine culture alerts (period 3) went live on October 28, 2020 (reference period, June 2, 2018, to April 24, 2019). The median duration of time to repeated

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Table 1. Urine Culture Testing Before and After Changes in the Hospital CPOE System

Variable	Period 1 June 2, 2018, to April 24, 2019 (N = 9,555), No. (%)	Period 2 April 25, 2019, to October 28, 2020 (N = 12,005), No. (%)	*P* Value[a]	Period 3 October 29, 2020, to December 31, 2021 (N = 9,574), No.	*P* Value[b]
Daily urine cultures per 100 inpatients, mean[c]	3.34	2.34	<.0001	2.22	.138
Daily positive urine cultures per 100 inpatients, mean[c]	0.8	0.5	<.0001	0.5	.091
Positive urine cultures[d]	2,303 (24.1)	2,505 (20.8)	<.0001	2,244 (23.4)	<.0001
Isolated urine cultures[d]	2,992 (31.3)	4,435 (36.9)	<.0001	2,832 (29.6)	<.0001
Specimen type					
Clean catch/other	8,559 (89.6)	9,669 (80.5)	Reference	7,942 (83.0)	Reference
Catheterized	759 (7.9)	1,823 (15.2)	<.0001	1,239 (12.9)	<.0001
Procedure related[e]	237 (2.5)	513 (4.3)	<.0001	393 (4.1)	.311
Indication for culture among isolated urine cultures (n = 10,259)	(N = 2,992)	(N = 4,435)		(N = 2,832)	
Recent positive UA[d]	1,494 (49.9)	1,966 (44.2)	<.0001	993 (35.1)	<.0001
Urology patient[d]	383 (12.8)	691 (15.6)	0.001	568 (20.1)	<.0001
Pregnant patient[d]	181 (6.5)	424 (9.6)	<.0001	304 (10.7)	<.0001
Other[d]	934 (31.2)	1354 (30.5)	0.53	967 (34.2)	.017
Median duration of time to repeat urine culture among isolated urine cultures	24 hours	96 hours	<.001	120 hours	<.001

Note. Average daily urine cultures for period 1, period 2 and period 3 were 29.2, 21.8 and 22.2 cultures, respectively. Average daily positive urine cultures for Period 1, Period 2 and Period 3 were 7.0, 4.5 and 5.2 cultures, respectively. Laboratory-generated urine culture orders to appear on the hospital computer physician order entry (CPOE) system went live on April 25, 2019, and repeated urine culture alert went live on October 28, 2020. The hospital used EPIC (Epic Systems, Verona, WI) as its CPOE system.

[a]*P*-value comparison for period 1 vs period 2.

[b]*P*-value comparison for period 2 vs period 3.

[c]Tested by autoregressive integrated moving average (ARIMA) analysis.

[d]Logistic regression analysis with June 2, 2018, to April 24, 2019, as a reference period.

[e]Includes specimen collection by suprapubic aspiration, kidney aspiration, percutaneous nephrostomy tube placement, ileal loop, and cystoscopy.

urine culture significantly increased during the intervention periods: 24 hours versus 96 hours ($P < .001$) and 24 hours versus 120 hours ($P < .001$). No significant differences in mean daily, isolated, and positive urine cultures were observed when comparing period 2 with period 3. However, median time to repeated urine culture was significantly increased for period 3: 96 hours versus 120 hours ($P < .001$) (Table 1). Our intervention resulted in $83,194 savings in laboratory costs for urine cultures avoided, based on the Medicare Clinical Laboratory Fee Schedule using a national median Medicare payment rate of $16.16 per urine culture.[10]

Discussion

We observed a significant reduction in the mean daily urine cultures and positive urine cultures per 100 inpatients and a significant increase in the median duration of time to repeated urine culture in the postintervention periods versus the preintervention period. During period 2, the urine cultures per 100 inpatient days and the proportion of positive cultures decreased and the proportion of isolated cultures increased. This finding suggests that urine cultures were being ordered on patients with a lower pretest probability for a positive culture during this period.

This study had several limitations. The study had a retrospective design. These results may not be generalizable to facilities with different CPOE systems. The metric of daily cultures per 100 inpatients was chosen to adjust for wide swings in hospital census seen because of the COVID-19 pandemic; however, we cannot rule out unrelated temporal changes, which might have influenced our results.

In conclusion, relatively minor changes in the order notification system could have significant impact on provider ordering practices. The CPOE system plays an important role in diagnostic stewardship, and continued optimization, along with antimicrobial stewardship efforts, can reduce the incidence of unnecessary urine cultures as well as lower healthcare costs and improve the use of diagnostic tests. Ongoing monitoring and surveillance is required to identify areas of improvement and to prevent unintended consequences.

Supplementary material. For supplementary material accompanying this paper visit https://doi.org/10.1017/ice.2022.283

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