

ORIGINAL RESEARCH

Pediatrics

Reducing infant catheterization in the emergency department through clean-catch urine collection

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Abstract

Objective: Our emergency department (ED) traditionally relied on urethral catheterization to obtain urine cultures when evaluating infants for urinary tract infections (UTIs). Catheterization is associated with adverse effects, and recent studies have demonstrated clean-catch urine methods can be successfully used to obtain urine cultures. We pursued a quality improvement (QI) initiative aimed at decreasing the frequency of urethral catheterizations in our ED by using an established clean-catch technique to obtain infant urine cultures.

Methods: We implemented a clean-catch urine collection method, which we entitled "Bladder Massage," for infants 0–6 months of age needing a urine culture in our ED. Exclusions included critical illness, known urologic abnormality, or prior UTI diagnosis. Our primary interventions were educational initiatives. We retrospectively collected data regarding the use of bladder massage. Our balancing measure was the contamination rate of urine cultures obtained via bladder massage technique compared to catheterization.

Results: In our first-year post-implementation, we identified 334 eligible patients. Bladder massage was attempted on 136/334 (40.7%) eligible infants, with 87/136 (64%) successful attempts, thus avoiding catheterization in 26.1% of patients. Our baseline contamination rate from catheterization was 8/488 (1.6%), compared to 10/87 (12%) using bladder massage ($P < 0.001$), with 9/10 contaminants from female patients.

Conclusion: We successfully introduced a method for clean-catch urine cultures in our pediatric ED, averting the need for urethral catheterization in many well-appearing infants. Ongoing efforts must focus on reduction of contamination in females, increased technique usage, and electronic health record changes to facilitate documentation to continue method use.

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1 | INTRODUCTION

1.1 | Background

Urinary tract infections (UTI) are a common source of infection among infants, accounting for 5%–14% of all emergency department (ED) visits.^{1,2} The American Academy of Pediatrics (AAP) Clinical Practice Guidelines for febrile infants recommends obtaining both urinalysis and urine culture to evaluate for pyuria and the presence of at least 50,000 colony-forming units per milliliter (CFU/mL) of a uropathogen to diagnose a UTI.¹ Transurethral catheterization or supra-pubic aspiration are recommended to obtain a urine specimen for UTI diagnosis.¹

Both urinary catheterization and supra-pubic aspiration are invasive procedures. Supra-pubic aspiration can be perceived as unacceptably invasive by physicians and parents¹ and has been demonstrated to be more painful than urethral catheterization.³ Catheterization is also associated with adverse effects in over 20% of patients including dysuria, genital pain, urinary retention, and gross hematuria,⁴ and can cause “extreme distress” in parents observing their child’s catheterization.⁵

Instead, some EDs routinely place urine bags to avoid an intrusive procedure. Although this method is non-invasive, urine bags have a high contamination rate, making it unreliable for culture.^{1,6,7} The use of urine bags in the ED may increase ED length of stay^{8,9} and removal of the bag can cause significant pain.¹⁰ A positive urinalysis collected via urine bag requires that a sterile urine sample be obtained via catheterization to fully evaluate for a UTI, which also may delay care as well as cause the adverse effects as listed above.

The AAP Clinical Practice Guidelines state that if an infant spontaneously voids during urethral catheterization attempts, collecting mid-stream urine is acceptable, and urinalysis testing can be performed on any urine specimen no matter the method of collection.¹ Urinalysis is useful to rule out UTI in young children, as a child with a negative urinalysis has a <1% chance of having a UTI.¹¹

1.2 | Importance

Recently, multiple studies have demonstrated the success of using non-invasive bladder stimulation to induce spontaneous voiding for clean-catch urine collection in infants.^{11–14} Additionally, urine cultures obtained from clean-catch methodology have been demonstrated to be accurate when compared to paired catheterized urine cultures in the same patient.^{15–18} Many of these studies demonstrated that the various techniques used to obtain clean-catch urine did not significantly increase urine culture contamination.^{7,11,13,15} Furthermore, certain international clinical guidelines currently recommend clean catch urine collection in pre-continent children; however, that is not the standard of care in the United States.¹³ Using such methods can decrease the necessity for painful procedures while also providing a specimen that is suitable for urine culture, improving the patient’s and parent’s clinical encounter.

The Bottom Line

This quality improvement study explored the feasibility of implementing a proven bladder stimulation method to collect clean catch urine samples to reduce the number of infant catheterizations for UTI investigation. The study showed that this technique was feasible, but the rate of contaminated specimens in female infants was concerning. These findings have provided some direction for other institutions and providers interested in pursuing a similar clean-catch urine collection technique.

1.3 | Goals of this investigation

Our objective was to implement an established method of clean-catch urine collection for well-appearing infants being evaluated for UTI in our pediatric ED. Our goal was to collect 25% of urine cultures by this clean-catch method, therefore reducing the frequency of infant urethral catheterization.

2 | METHODS

2.1 | Study design and setting

This quality improvement project took place in the pediatric ED of a tertiary care, freestanding children’s hospital with ~50,000 annual ED visits. Providers involved in the project included all those whom care for patients in our institution’s ED: pediatric emergency medicine (PEM) physicians, pediatric hospitalist medicine physicians, pediatric nurse practitioners (NP), pediatric residents, and emergency medicine residents. Our institution has a dedicated ED nursing, paramedic, and emergency medical technician staff, as well as float pool nurses who work in the ED.

2.1.1 | Techniques and definitions

Our initiative used the noninvasive clean-catch urine stimulation techniques as described in prior studies by Labrosse et al and Herreros et al.^{11,12} For internal reference and discussion, we labeled the method “Bladder Massage.” We distributed a reference card to ED staff that provided an overview of the method and collection instructions. This reference card included images of collection as previously published by Labrosse et al and Herreros et al.^{11,12}

The steps to bladder massage were as follows. Parents were instructed to feed infants 15–30 minutes prior to the attempt. Nursing staff performed standard genital cleaning with a castile soap towelette. A parent or staff member held the infant upright under the arms, with leg positioning varying by sex. A trained staff member alternated between gentle tapping over the supra-pubic region for 30 seconds

TABLE 1 Definitions of urine results

Definition	Urinalysis result	Urine culture results	
		Organism(s) Cultured	Colony Threshold ^a
No growth	Negative	No growth	No growth
UTI	Positive ^b	1 Uropathogen ^c	≥100,000 CFU/mL
	Positive	1 Uropathogen	10,000–100,000 CFU/mL ^d
Contaminated	Negative	1 Non-uropathogen	≥100,000 CFU/mL
	Negative	≥2 Organisms (≥1 non-uropathogen)	Any colony count
	Negative	Mixed bacterial flora ^e	≥100,000 CFU/mL
Insignificant Growth	Positive or negative	1 Non-uropathogen	≤10,000 CFU/mL
	Negative	1 Non-uropathogen	≤100,000 CFU/mL

^aUrine culture colony counts had the same thresholds regardless of the method used to obtain the urine specimen (ie, urethral catheterization or bladder massage).

^bUrinalysis indicative for UTI-labeled positive: positive leukocyte esterase test and/or nitrite test, in addition to evidence of pyuria with >10 white blood cells per microliter. Urinalysis results that do not meet criteria for positive are considered negative.

^cThe identified organism is considered a uropathogen based on clinical judgment of the provider caring for the patient.

^dFor this range, providers must consider the patient's clinical presentation and whether the urinalysis supports the diagnosis of a UTI.

^eNomenclature indicating growth of 3 or more organisms.

and then massaging the lumbar region in a circular pattern with his or her thumbs for 30 seconds. Tapping and massaging was alternated and repeated until spontaneous void, or for a maximum of 3 minutes. If micturition occurred, a staff member collected midstream urine in a sterile sample cup. If unsuccessful after 3 minutes, urine specimens were then obtained via catheterization.

Table 1 provides our definitions for UTI, contamination, and insignificant growth. These criteria were created by experts in pediatric infectious diseases and microbiology at our institution, and are used throughout our hospital. These differ slightly from the AAP's definition, which recommends at least 50,000 CFU/mL for diagnosis of a UTI, because our institution's microbiology laboratory does not report growth at the 50,000 CFU/mL threshold.^{1,19}

2.2 | Selection of participants

All infants 0–6 months of age were potentially eligible. Exclusion criteria were: a non-well-appearing infant per provider's discretion, a known anatomic or urologic abnormality, or a previously diagnosed UTI. Exclusion criteria were taught to all ED staff and providers as well as included on the distributed reference materials.

Because the AAP recommends invasive imaging after a second diagnosis of a UTI in an infant¹, we excluded infants with a prior diagnosis

of UTI due to concern that bladder massage could lead to unnecessary invasive imaging. Examples of known anatomic/urologic abnormalities in children that were excluded from the study included SPICA cast, lumbosacral defect, supra-pubic catheter, or a patient followed by a urologist for previously diagnosed congenital urinary tract defects.

We classified a patient as “non-well appearing” based on chart review. Specific documentation included the following clinical words: shock, altered mental status, toxic, sepsis, lethargic, or ill-appearing. We also excluded patients if the attending physician documented for “critical care time,” or if the patient was admitted to any ICU at our hospital.

2.3 | Interventions

The study team was constituted of 1 PEM attending and 2 pediatric residents, with assistance provided by a nursing champion and pediatric residents to train nursing staff on the technique. The project was executed through 2 plan-do-study-act cycles (Table 2).

2.3.1 | Provider and nursing education

The study team presented drivers of project success and eligibility criteria for infants based on similar published studies to all involved ED provider groups to solicit and incorporate feedback and build support for the initiative launch.

A total of 62 registered nurses (RNs), 16 paramedics, and 8 emergency medical technicians received in-person training by the study team within the first month of the project's launch, representing every ED staff member whose primary clinical role is in our ED.

During our initial implementation, the study team participated in direct observation and feedback was obtained from RNs and providers. A reference card was given to every trained staff member, made available on our intranet with other institutional guidelines, and was posted in key workareas throughout our ED. The nurse champion provided education and encouragement to other ED staff.

2.3.2 | Sharing results of plan-do-study-act cycles

Results were shared quarterly with ED staff, and at 7 months (October 2018) and 1 year (February 2019) after the intervention to all provider groups. Monthly emails were sent to the resident group rotating in the ED to serve as a reminder of the ongoing initiative.

Subsequent educational efforts focused on improving frequency of use of the technique and decreasing urine culture contamination by emphasizing proper cleaning and catching of mid-stream urine. Monthly flyers as well as emails with up-to-date data including bladder massage attempts and success rate were posted in highly visible locations within our ED.

TABLE 2 Plan-do-study-act cycles to implement bladder massage

Plan-do-study-act cycle	Intervention description
Plan-do-study-act 1: introduction to method	<ul style="list-style-type: none"> • Deliver presentations to physician and nurse practitioner groups • Provide in-person training to all ED staff regarding bladder massage technique and documentation • Develop reference card for ED staff use • Visual reminders placed in provider workareas • Direct observation and feedback regarding bladder massage of RNs and providers
Plan-do-study-act 2: refresher and updates	<ul style="list-style-type: none"> • Update all provider groups and ED staff with outcome data via email, flyers, and in-person discussion • Refresher training for ED staff to promote proper technique usage and decrease chances of contamination • Targeted emails to residents rotating in the ED to remind of ongoing project and to encourage bladder massage use

TABLE 3 Characteristics of infants who received urine cultures

	Baseline July 2016– June 2017 (n = 488)	Bladder massage eligible Feb. 2018– Feb. 2019 (n = 334)	Bladder massage ineligible Feb. 2018– Feb. 2019 (n = 162)
Age—no. (%)			
<1 month	134 (27.5)	116 (34.7)	48 (29.6)
1–3 months	266 (54.5)	187 (56.0)	101 (62.4)
4–6 months	88 (18.0)	31 (9.3)	13 (8.0)
Sex—no. (%)			
Male	224 (45.9)	161 (48.2)	72 (44.4)
Female	264 (54.1)	173 (51.8)	90 (55.6)
Contaminated rate—no. (%)	8 (1.6)	13 (3.9)	13 (8.0)
UTI diagnosis—no. (%)	29 (5.9)	21 (6.3)	9 (5.6)

2.4 | Study of the interventions

2.4.1 | Baseline data

Prior to this effort, data regarding urine culture contamination was not collected at our institution. Our study team performed chart review of data from July 2016–June 2017 (1 calendar year) to determine a baseline urine culture contamination rate (Table 3). During this time, there were 488 cultures obtained via catheterization; 8/488 (1.6%) showed contamination, 78/488 (16.0%) showed insignificant growth, and 29/488 (5.9%) showed UTI. The remainder had no growth on culture.

2.4.2 | QI initiative

We report the first year of data from our initiative, from February 15, 2018–February 14, 2019. Data from our institution's electronic health record was queried for analysis by the study team. Data regarding bladder massage attempt, success, and contamination was reviewed

monthly by the study team in conjunction with planning and implementing plan-do-study-act cycles.

2.4.3 | Data abstraction

We obtained a list of all patients 0–6 months of age in our ED who had a urine culture obtained. We performed manual chart review to obtain patient demographics, details of the ED encounter, urine collection method, and urine culture results. We relied primarily on nursing documentation in the electronic health record to determine the method of urine collection, because documentation of the collection method is part of their expected workflow, and infrequently documented by ED providers.

Patients in whom we could not determine the method of urine collection were excluded from our analysis. In June 2018, our institution switched electronic health records; this transition significantly changed nursing documentation, which decreased documentation of the modality of urine collection and precluded our ability to determine the modality of urine collection in many patients.

2.5 | Measures

2.5.1 | Outcomes

The primary outcome was the proportion of eligible patients having urine cultures obtained by bladder massage. Our goal was to collect 25% of urine cultures by bladder massage, therefore reducing the use of urethral catheterization for culture collection in our ED. Our secondary outcome was the proportion of eligible patients who had a bladder massage attempt when eligible.

2.5.2 | Balancing measures

Our primary balancing measure was the rate of urine culture contamination of urine specimens obtained via bladder massage compared to our baseline rate using catheterization. We also examined the outcomes of patients with contaminated cultures.

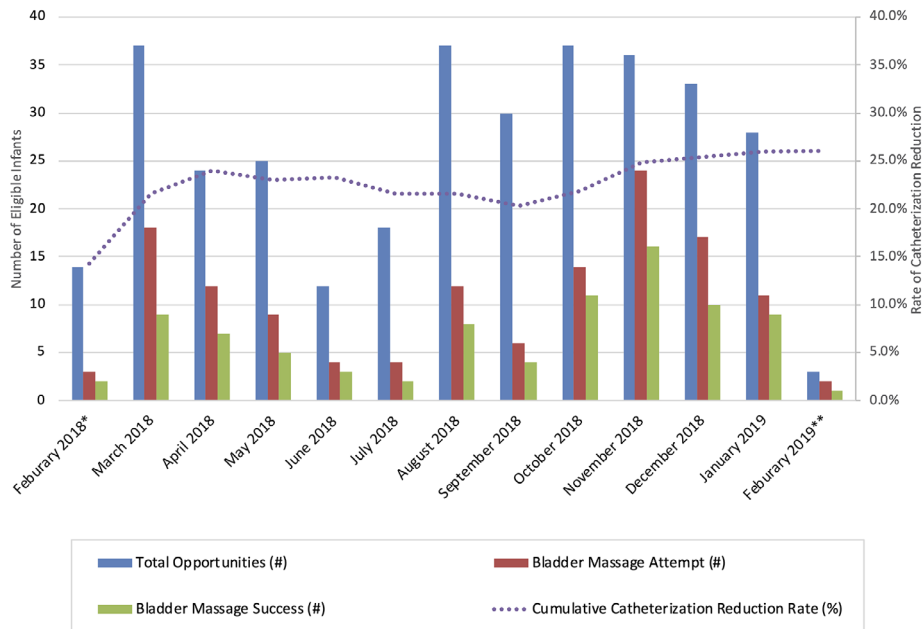


FIGURE 1 Implementing bladder massage—highlighting the total opportunities, attempts, and successes by month. This graph also demonstrates the cumulative catheterization reduction rate of infants requiring urine culture collection over the course of our initiative. The initiative began February 15, 2018* and ended February 14, 2019**

2.6 | Analysis

Data were analyzed by SAS (SAS Institute Inc., Cary, NC) 9.4 version. Chi-square test or Fisher's exact test (if any expected cell count <5) was used to test associations between 2 categorical variables, odds ratio (OR) and its 95% confidence interval (CI) were calculated for 2 × 2 contingency table with significant *P*-values. Univariate and multivariate logistic regression analyses were performed to detect associations between bladder massage attempt/success and potential predictors (ie, age and sex), and generalized linear mixed effect model was used for the analyses at nurse level. A *P*-value <0.05 was considered significant.

2.7 | Ethical considerations

This project was reviewed and approved by our institutional review board and classified as non-human subject research. Use of the bladder massage technique was guided by provider discretion and shared decisionmaking between parents and providers in the ED.

3 | RESULTS

3.1 | Characteristics of study subjects

A total of 496 infants <6 months of age had urine cultures obtained in our institution's ED between February 15, 2018–February 14, 2019. Of these, 162 were excluded, leaving 334 cultures in the final analysis (Table 3). A total of 57 patients were excluded based on clinical cri-

teria, and an additional 105 were excluded from analysis due to lack of electronic health record documentation regarding urine collection method used. Exclusion due to clinical criteria included critical illness (34), urine bag used for culture (10), known urologic abnormality (7), prior UTI diagnosis (5), and a neural tube defect complicating collection (1). None of the 57 patients excluded based on clinical criteria had bladder massage attempted on them. The 162 ineligible patients appear similar to eligible patients regarding age, sex, and UTI diagnosis (Table 3). The subset of 105 patients excluded solely due to lack of documentation was similar to the overall cohort of eligible and ineligible patients.

3.2 | Main results

In the year prior to our intervention, all 488 urine cultures were obtained via catheterization. Overall in the post-intervention year, 247/334 (73.9%) urine cultures were obtained via catheterization, a reduction of catheterizations by 26.1% (95% CI = 23.1–29.1), as illustrated in Figure 1. Of 334 eligible infants, 136/334 (40.7%) had bladder massage attempted. Table 4 provides characteristics of those who did and did not have it attempted. We did not observe significant differences in age or sex. Out of the 62 trained ED staff members, 45/62 (73%) attempted bladder massage at least once, of which 9/45 (20%) attempted it 5 or more times.

Bladder massage cultures were successfully obtained in 64% (87/136) of attempts. Table 4 provides additional information on successful versus failed attempts. We did not observe significant associations based on age or sex. On multivariate analysis we did not observe any association between age, gender, and likelihood of success.

TABLE 4 Characteristics of bladder massage, February 2018–February 2019

	No bladder massage attempt (n = 198)	Bladder massage attempt (n = 136)	<i>P</i> [*]	Bladder massage unsuccessful (n = 49)	Bladder massage success (n = 87)	<i>P</i> ^{**}
Age—no. (% by age group)			0.58			0.49
<1 month	73 (63)	43 (37)		14 (33)	29 (67)	
1–3 months	108 (58)	79 (42)		28 (35)	51 (65)	
4–6 months	17 (55)	14 (45)		7 (50)	7 (50)	
Sex—no. (% by sex)			0.92			0.18
Male	95 (59)	66 (41)		20 (30)	46 (70)	
Female	103 (59)	70 (41)		29 (41)	41 (59)	
Age and sex combination—no. (% of sex by age group)						
<1 month			0.81			0.59
Male	34 (62)	21 (38)		6 (29)	15 (71)	
Female	39 (64)	22 (36)		8 (36)	14 (65)	
1–3 months			0.87			0.58
Male	56 (58)	40 (42)		13 (33)	27 (68)	
Female	52 (57)	39 (43)		15 (39)	24 (62)	
4–6 months			>0.99			0.27
Male	5 (50)	5 (50)		1 (20)	4 (80)	
Female	12 (57)	9 (43)		6 (67)	3 (33)	

**P*-value derived from a chi-square analysis examining the relationship between the subset groups and bladder attempts.

***P*-value derived from a chi-square analysis examining the relationship between the subset groups and bladder successes.

3.3 | Secondary results

3.3.1 | Urine culture contamination

Of the 87 urine cultures successfully obtained via bladder massage, 10/87 (12%) were contaminated, significantly higher than our baseline ($P = 0.001$). The odds of a bladder massage culture being contaminated were 10.6 times higher than the odds of a catheterized urine culture being contaminated (95% CI = 2.8–39.4). We noted a significant sex bias with bladder massage contamination, with 1/46 (2%) of males having a contaminated culture, versus 9/41 (22%) of females ($P = 0.02$). Cultures from females were 12.7 times more likely to be contaminated than male cultures (95% CI = 1.5–104.9). The contamination rate in females increased in October 2018–January 2019, during which the study team began plan-do-study-act cycle 2.

3.3.2 | Contamination impact

We reviewed the charts of the 10 patients with contaminated bladder massage cultures. Of these, 3 were discharged from the ED and 7 were hospitalized. Of the 3 infants discharged home, none required a repeat evaluation in our ED. The 7 admitted patients were admitted before their urine culture results were available for other reasons including sepsis rule-out (3), dehydration (2), respiratory distress (1), and obser-

vation due to young age (1). One admitted patient had a repeat culture by catheterization, which had no growth.

3.3.3 | Insignificant growth and UTI diagnosis

Bladder massage had more cases of insignificant growth than catheterized cultures, 42/87 (42%) versus 49/247 (19.8%), $P < 0.001$. Bladder massage cultures were 3.8 times more likely to have insignificant growth than catheterization cultures (95% CI = 2.2–6.4).

There was no significant difference in the prevalence of UTI diagnosis between the baseline and initiative periods (Table 3). Additionally, there was no significant association between UTI diagnosis and method of collection during our initiative ($P > 0.99$). Of the 87 bladder massage cultures, 5/87 (5.8%) were diagnosed with UTI compared to 16/247 (6.5%) of the catheterization cultures.

4 | LIMITATIONS

A significant limitation of our initiative was lack of collection method documentation after our institution's electronic health record transition. A large proportion of urine cultures had to be excluded from analysis as the method of urine collection was unable to be determined. Although the excluded patient characteristics were similar to

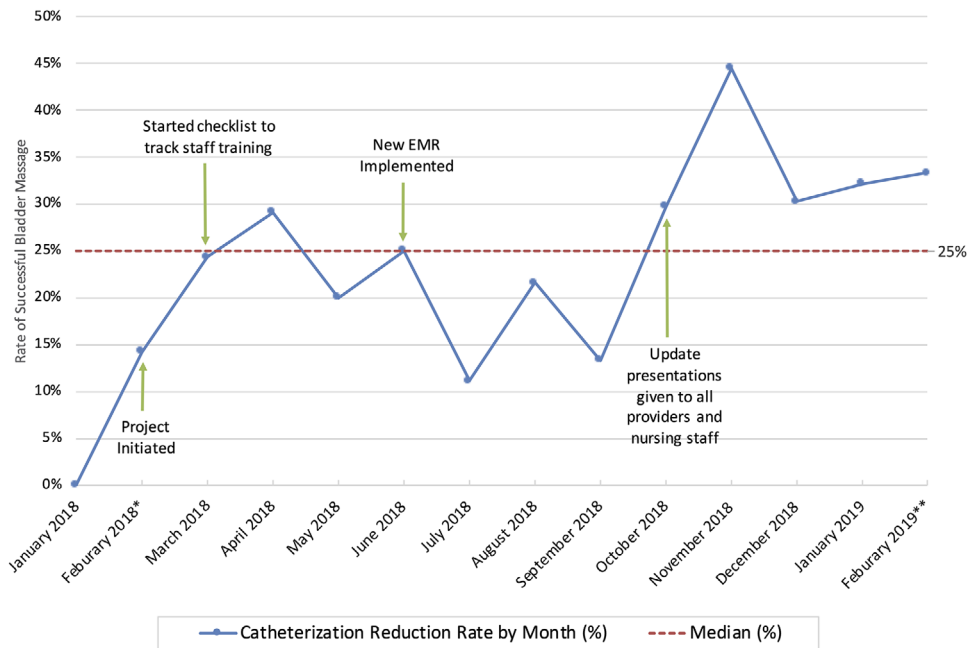


FIGURE 2 Run chart of proportion of eligible patients with successful bladder massage through our initiative (beginning February 15, 2018* and ending February 14, 2019**)

those included, we do not know how inclusion would have impacted our results. We did not collect data regarding ED staff perception of the technique, nor did we survey parents to assess their satisfaction with the technique.

5 | DISCUSSION

We successfully introduced a previously established non-invasive technique for clean-catch urine culture collection in well-appearing infants <6 months of age, avoiding the need for catheterization in many patients. While the bladder massage attempt rate was lower than anticipated, we reached our goal of reducing catheterizations by having 25% of urine cultures obtained via bladder massage (Figure 2). We did observe hesitation from some ED staff to begin using the technique. Through dissemination and ongoing education with continued plan-do-study-act cycles, we believe use of bladder massage will increase.

Our success rate of 64% is slightly higher than other published reports of non-invasive bladder stimulation techniques of infants with success rates of 49% and 55.6%.^{11,14} Although some studies have published higher success rates > 80%, these studies only included patients under 1 month of age.^{15,20} Although this is higher than our 67% success rate in this age group, non-invasive bladder stimulation techniques have been previously demonstrated to be more successful in younger infants.¹¹

Prior studies have reported similar rates of clean-catch contamination (5.0%–16.0%) compared to what was found during the bladder massage initiative; however, the differences in contamination rates between the 2 collection methods were not significant.^{7,11,15,21} Our

institution's urethral catheterization contamination rate (1.6%) was much lower than some reported studies, where urethral catheterization contamination ranged from 6%–14%.^{6,7,13,22,23} This low baseline rate could have made our balancing measure more difficult to achieve. Additionally, due to institutional variations of urine culture growth and defining contamination, comparison of results from similar studies can be challenging.

This initiative was the first to examine our EDs prevalence of UTI diagnosis and culture contamination. Our ED's rate of UTI diagnosis appears to be consistent with prior published rates of UTI in febrile infants.^{1,2} Culture contamination was an important balancing measure to assess the utility of cultures obtained. During our initiative the contamination rate of bladder massage urine cultures was significantly higher than in catheter-collected urine cultures, differing from prior studies that demonstrated no significant difference between the 2 methods.^{11–14} This includes no significant differences between male and female patients. Although we observed a high proportion of contaminated cultures in female patients, some of these may have occurred due to collection of first-void urine instead of mid-stream urine, an event which was observed by the study team. This has been associated with contamination in prior studies.^{24,25} In 1 instance, the study team learned of urine collected after it had dribbled down a female patient's leg, likely increasing the chance of contamination. Future efforts must focus on reducing contamination through additional staff education and training to continue the use of bladder massage on female infants.

Method proficiency may also improve the contamination rate. Prior studies such as Labrosse et al or Herreros et al^{11,12} had a small number of dedicated staff perform their clean-catch urine collection, compared to our initiative in which all ED staff were encouraged to use

bladder massage. Although we had several contaminated cultures during our first year of data collection, no harm related to contamination was observed. We believe that additional educational measures and further plan-do-study-act cycles should be completed to improve contamination rates, particularly in females.

Future directions of the initiative include plan-do-study-act cycles to increase use, decrease contamination, and improve nursing documentation by optimizing the new electronic health record system. We hope to engage nurses through positive deviance—a process of cultural change by using individuals whose practices generate better outcomes than their peers.²⁶ Continuing to collaborate with our nurse champion, and identifying additional champions, may assist in these efforts.

We successfully introduced the Bladder Massage technique in our institution's pediatric ED, significantly reducing the use of urethral catheterization in well-appearing infants 0–6 months of age in need of urine cultures. Unfortunately, we did see an increase in urine culture contamination among female patients. The focus of ongoing plan-do-study-act cycles must address culture contamination for the QI initiative to become successful. Practitioners in other acute care settings, such as urgent cares or primary care offices, could consider exploring use of this method to obtain urine cultures in patients being evaluated for UTI. This may be of particular use in settings where training or resources for infant catheterization are more difficult to provide. We hope this QI study provides guidance on implementing a non-invasive urine collection method in the pediatric setting and highlights the potential difficulties that may arise when doing so.

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AUTHOR CONTRIBUTIONS

AEM, MP, and FAA all conceptualized and designed the study, collected data, carried out the initial analyses, drafted the initial manuscript, and revised the manuscript. All authors reviewed and approved the final manuscript as submitted and agree to be accountable for all aspects of the work. FAA takes final responsibility for all aspects of the work.

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