Individual QI projects from single institutions

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Optimizing Analgesic Use During Infant Lumbar Puncture in the Emergency Department

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Introduction: Lumbar puncture (LP) for the collection of cerebrospinal fluid is an important diagnostic tool for the evaluation of febrile or ill-appearing infants. This invasive procedure is painful for patients; inadequate analgesia may have lasting effects. The American Academy of Pediatrics recommends analgesia during all LP procedures, and oral sucrose alone does not offer sufficient analgesia. Our objective was to identify analgesic use trends during infant LP in our emergency department and create a system of analgesic administration. We aimed for complete compliance with one method of analgesia and an increase in our use of 2 or more methods to 85% over 12 months. **Methods:** We utilized Plan-Do-Study-Act cycle methodology and retrospective chart review. Five interventions focused on staff communication, collaboration, and education. Inclusion criteria: infants <60 days who underwent LP procedure due to fever >38°C, hypothermia <36.5°C of unknown origin, or ill-appearance. **Results:** One hundred infant LPs analyzed: 52 preintervention and 48 intervention. The use of one analgesic increased from 98% preintervention to 100%. The use of 2 or more analgesics increased from 58% preintervention to 87%. Topical lidocaine use increased from 56% preintervention to 73%. LP success rates were high in both groups, with no statistically significant change in the success rate. **Conclusion:** We created a streamlined process to ensure all infants undergoing lumbar puncture received at least 1 analgesic and increased the proportion of infants treated with 2 or more analgesics. This work could be expanded to improve analgesia during other invasive procedures in the emergency department. *(Pediatr Qual Saf 2020;2:e292; doi: 10.1097/pq9.0000000000000292; Published online April 14, 2020.)*

INTRODUCTION

Lumbar puncture (LP) for the collection of cerebrospinal fluid is an important diagnostic tool for the evaluation of the febrile or ill-appearing infant. However, this invasive procedure is potentially painful for patients, and there is concern that the performance of this procedure in a young infant may have lasting emotional effects if appropriate analgesia is not utilized.[1] Evidence suggests that neonates exhibit responses to their perception of painful stimuli that are both reproducible and enduring and that they may be more sensitive to noxious stimuli than older children.[1] Repetitive noxious stimuli experienced in the early stages of development have been associated with impacts later in life including behavioral and emotional difficulties during childhood, the tendency toward major psychosis, intractable pain syndromes, and altered responses to pain.[2–4] A prospective study in France in 2008 demonstrated that the majority of young infants undergoing painful procedures did not receive analgesia before or during procedures.[5] Additionally, the American Academy of Pediatrics recommends the use of pain control during all LP procedures in infants to minimize both physical and emotional distress.[6]

Oral sucrose is advocated as a valuable analgesic for newborn infants undergoing painful procedures, with the potential to decrease crying time and improve observational pain scores.[7,8] However, despite these observations, some evidence suggests that oral sucrose may not significantly affect neonatal brain nociceptive circuits and thus may not offer adequate analgesia unless used in conjunction with other analgesic methods.[3,8] Common additional forms of analgesia for the LP procedure include topical anesthetics, injectable lidocaine, and intranasal opioids.

The purpose of this quality improvement (QI) project was to identify current trends of analgesic use during infant LP in our ED and to create and implement a system of procedural analgesic administration offering both improvement in pain management and a high level of provider compliance during LP procedures. We initiated this

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project to obtain complete compliance with the utilization of at least 1 method of analgesia during LP procedures, to increase the frequency of use of 2 or more methods to at least 85%, and to demonstrate a 25% improvement from baseline over 12 months. Additionally, we examined the effect of the number of analgesics on the procedural success rate as a secondary study outcome.

METHODS

We utilized the Plan-Do-Study-Act (PDSA) cycle methodology[9] to initiate a multifaceted interventional approach involving providers, nursing staff, and the Electronic Medical Record (EMR). We initiated this project in a 10-bed pediatric ED with a total volume of 16,000 pediatric ED visits per year, located in a tertiary care pediatric teaching hospital. ED staff at the time of project initiation included 9 pediatric emergency medicine physicians, 23 ED registered nurses, and rotating pediatric and emergency medicine resident coverage from 9 AM to 3 AM. Our QI workgroup consisted of two pediatric emergency medicine physicians, a pediatric resident, an ED nurse manager, and a staff ED registered nurses.

Context Assessment

Before study initiation, we distributed an electronic survey to staff physicians and ED nurses to determine current perspectives on infant LP analgesia, barriers to use of analgesics, and opportunities for improvement; we administered a similar survey after study completion for comparison. The QI workgroup used the results of this study to develop a key driver diagram to guide intervention implementation (Fig. 1). Analgesic options commonly used in the ED during this period as indicated by our provider and nursing survey included topical lidocaine (TL) (LMX4: Eloquest Healthcare; Ferndale, Mich.), oral sucrose solution (Sweet-Ease: Philips Healthcare; Cambridge, Mass.), J-tip lidocaine (1% buffered lidocaine prepared by pharmacy and administered via J-tip Needle-Free Jet Injector: Medline Industries; Northfield, Ill.), locally injected 1% lidocaine, and fentanyl (delivered intranasally via a MAD Nasal intranasal mucosal atomization device: Teleflex Medical; Morrisville, N.C.). We set an improvement goal of 85%, demonstrating at least a 25% improvement of 2 forms of analgesia use from baseline. We considered this improvement to be substantial yet attainable at our institution in 12 months.

Interventions

PDSA cycle 1 involved 5 interventions, initiated over 4 months in early 2018. Intervention 1 was an educational infographic posted in the triage area and provider workspaces to encourage the use of multiple analgesics during LP procedures. This handout detailed inclusion criteria for patients eligible for the early application of TL during the triage process, as well as the analgesic options for the LP procedure (Fig. 2). Intervention 2 focused on staff engagement. Through electronic communication, we asked all ED staff members to acknowledge the department-wide goal of utilizing 2 forms of analgesia during the LP procedure. Interventions 3 and 4 targeted staff education. Resident physicians received educational materials regarding project goals and rationale for analgesic use during the LP procedure as part of their monthly onboarding process.

Additionally, we educated the nursing staff on patient identification and application of TL cream during the triage procedure. Finally, intervention 5 consisted of a modification of the required standardized procedure note template in the EMR to include analgesic choices. This intervention intended to act as a reminder of available methods to encourage the use of multiple analgesics during the next procedure and to improve our ability to track usage over time.

PDSA cycle 2 targeted continuous improvement and maintenance education. We distributed a 6-month project and performance update via electronic communication during the ninth month of the intervention period to all ED providers and nursing staff. This invention's purpose was to maintain group engagement in analgesic improvement strategies. In this update, we included the percentage of patients receiving 1, 2, and more analgesic methods during the LP procedure. Also, during the ninth month of the intervention period, we re-educated the nursing staff via electronic communication on the proper inclusion of patients and TL application during triage.

Data Collection

Data collection took place over 12 months from January 1, 2018, to December 31, 2018. Preintervention (historical) data were collected from January 1, 2017, to December 31, 2017 (Fig. 3).

We extracted all patients' data using EMR procedure codes 62270, 62272, 87070, and 87205, corresponding to lumbar puncture and cerebral spinal fluid cultures, respectively. Individual patient encounters were analyzed for patients meeting inclusion criteria. Patients included in the analysis were infants less than 60 days old who underwent LP procedure due to fever >38°C (100.4°F), hypothermia <36.5°C (97.7°F) of unknown origin, or ill-appearance regardless of temperature. We excluded patients that lacked an LP procedure note or underwent LP at a referring ED before arrival. Data abstracted included are patient date of birth, age at the time of the procedure, parties involved in the procedure (resident, attending), number of attempts, analgesics used during the procedure, and outcome of the procedure. We obtained data through a review of provider procedure notes and from the medication administration report completed by nursing staff.

Data Analysis

We compared intervention and historical control groups by the number and type of analgesics, the procedural

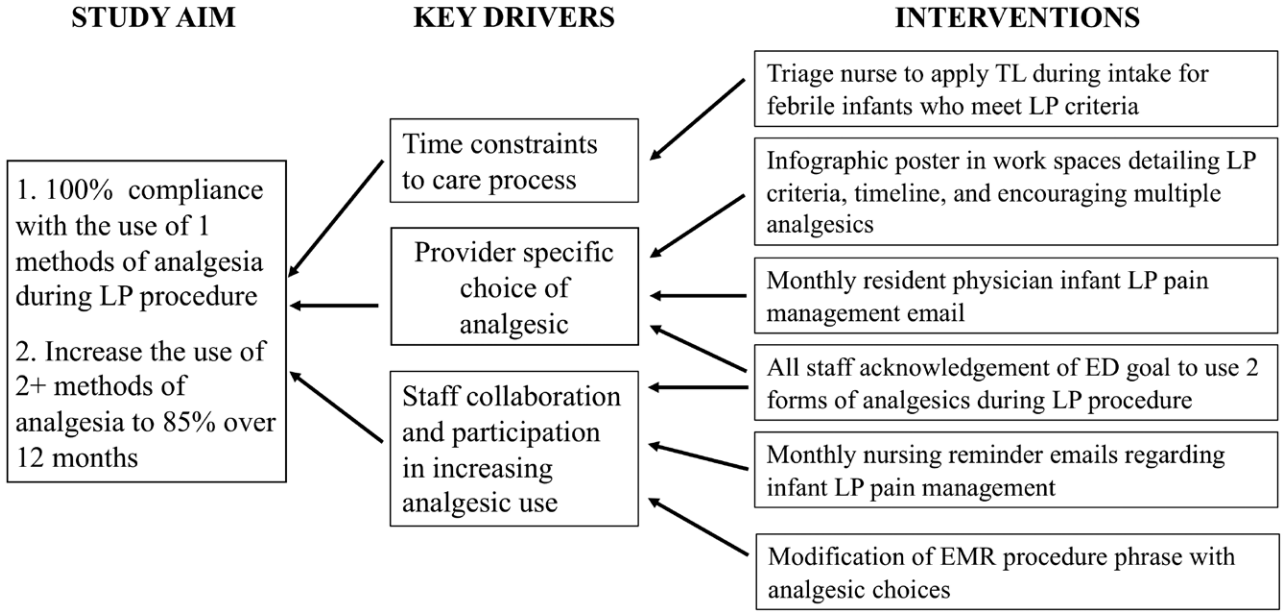

Fig. 1. Key driver diagram developed by the QI work group based on information provided from the preintervention provider and nursing survey.

success rates between the groups, and the procedural success by the number of analgesics used. We pooled the preintervention and intervention groups for analysis of the success rate by the number and type of analgesics. We defined LP procedural success as the collection of sufficient cerebrospinal fluid for culture analysis.

We used the 2-sided student's t test and χ^2 test to calculate statistical significance for changes in values of continuous and categorical variables, respectively. We used Fisher's exact test to evaluate the statistical significance of procedural success rates by the number of analgesics used. We evaluated statistical significance using P values at the 5% testing level with a 95% confidence interval. We conducted all statistical analyses using Microsoft Excel 2019 (Microsoft; Redmond, Wash.). A P chart for statistical process control was created used QIMacros software (KnowWare International, Denver, Colo.). The university's Institutional Review Board approved this retrospective QI study. The informed consent requirement was waived as it was not determined to constitute human subject research.

RESULTS

Our analysis included 100 infant LPs performed in the ED; 52 procedures during the 12-month preintervention period and 48 procedures during the 12-month intervention period. Intervention and preintervention group comparison demonstrated no significant differences in mean age, gender, a resident attempt at LP, or the number of puncture attempts (Table 1).

In the 100 LP procedures evaluated, all forms of analgesic described in the provider survey, including TL, injectable lidocaine, oral sucrose solution, J-tip lidocaine, and intranasal fentanyl, were used at least once. TL use during the LP procedure increased from 56% to 73% ($P = 0.039$). Injectable lidocaine use remained effectively unchanged, at 58% preintervention and 57% in the intervention group ($P = 0.9$). Oral sucrose use increased from 44% to 77% ($P < 0.001$). J-tip lidocaine use increased from 0% to 6%. Intranasal fentanyl use was rare, at 2% preintervention and 0% in the intervention groups.

Figure 4 demonstrates the change in the number of methods used from the preintervention to the intervention periods. The use of at least one analgesic increased from 98% to 100%. The use of 2 or more analgesics increased from 58% to 87% ($P < 0.001$), and the use of 3 or more analgesics increased from 12% to 31% ($P = 0.015$). Figure 5 depicts the increase in the proportion of LP procedures performed with more than 1 analgesic over the intervention period.

The success rates were high in both preintervention and intervention groups, with no significant difference between the 2 ($P = 0.54$; Table 1). Success rates were similar with the use of 1, 2, 3, or more analgesics; use of 1 analgesic elicited a 93% success rate ($P = 1.0$), 2 elicited a 94% success rate ($P = 0.72$), and 3 or more elicited a 91% success rate ($P = 0.63$). Success rates were highest with injectable lidocaine + TL (100%, N = 11) and TL alone (100%, N = 7). Success rates were lowest with injectable lidocaine + sucrose (90%, N = 10) and sucrose alone (50%, N = 2).

Twenty-four individuals responded to the prestudy survey, and 25 individuals responded to the poststudy survey, with response rates of 45% and 47%, respectively. The most common barriers to the use of analgesic methods identified in the prestudy survey included provider and nursing time constraints and provider choice

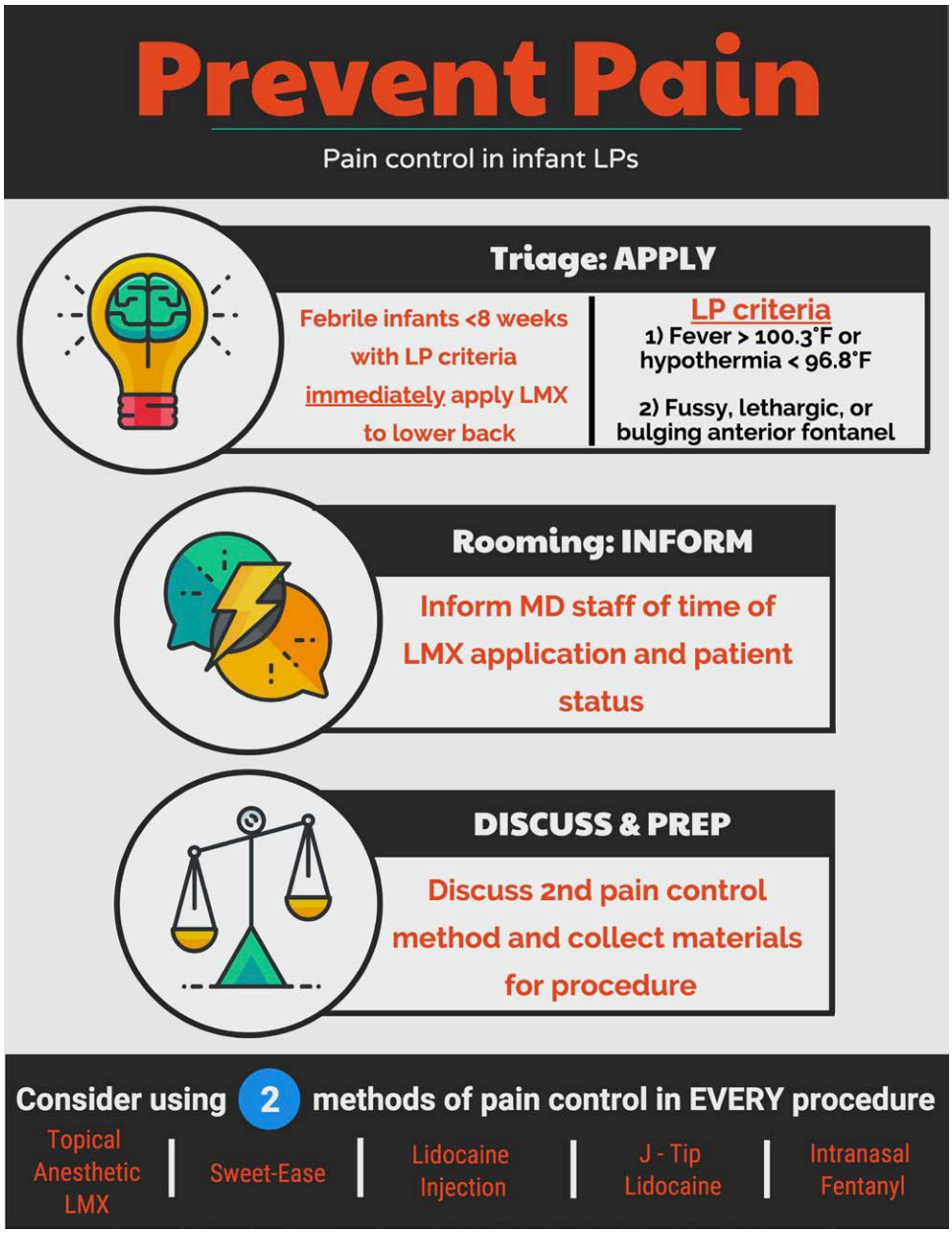

Fig. 2. Informational poster detailing inclusion criteria for patients eligible for early application of topical lidocaine during the triage process, as well as the analgesic options for the LP procedure. Posted in provider and nursing work spaced during the intervention period. LMX, topical lidocaine product used in our emergency department.

and quantity of analgesics used. The poststudy survey indicated that after project completion, 68% of respondents were aware that this QI project was conducted in our ED. Furthermore, nurses stated that they applied TL during the triage process for qualifying patients 64% of the time, demonstrating success in addressing the barrier of provider time constraints by initiating the analgesic process during triage. They also reported that TL cream and sucrose solution were the 2 most common forms of analgesia used during LP procedures.

Similarly, providers reported using TL cream and sucrose most commonly, with 100% of respondents choosing these as their primary form of analgesia, followed by lidocaine injections at 47% and intranasal fentanyl at 27%. These findings demonstrate that through provider education, we improved attitudes toward using multiple methods of analgesia during LP procedures, overcoming the barrier of provider choice of analgesic without mandating which analgesics must be used during the procedure. When asked if 1 specific method of analgesia leads to higher procedural success rates, 73% of providers responded affirmatively; 45% chose TL cream, 36% chose lidocaine injection, 18% chose intranasal fentanyl, and 9% chose sucrose solution. Twenty-seven percent of respondents did not believe 1 form leads to higher procedural success rates.

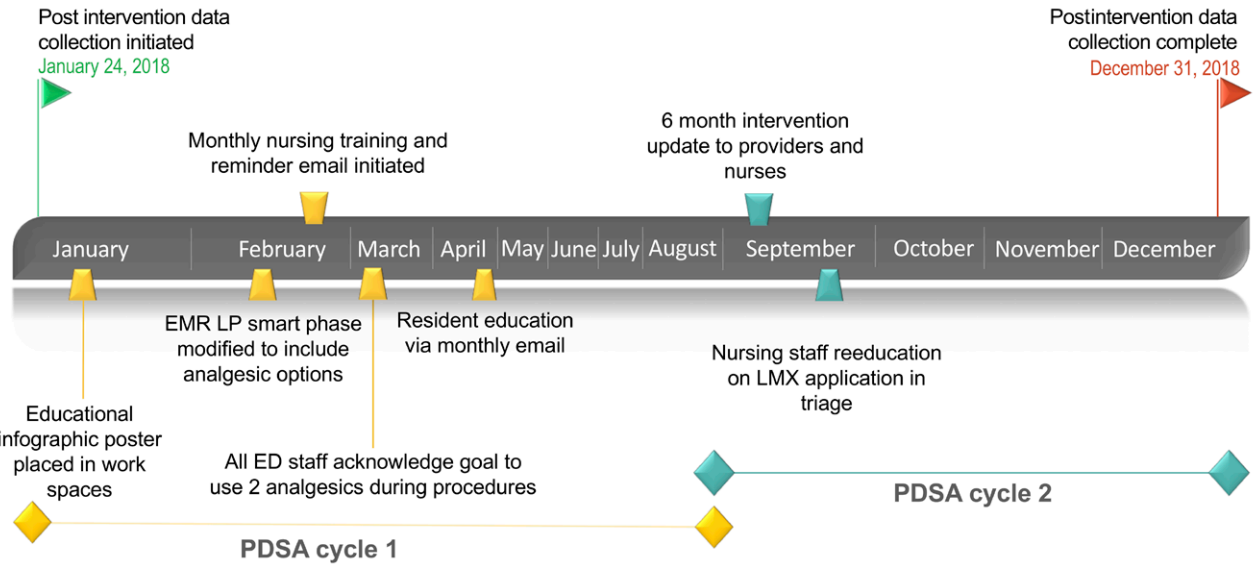

Fig. 3. Timeline of PDSA cycles and key intervention events, January 2018 to December 2018.

Table 1. Baseline Patient Characteristics Demonstrating No Significant Difference between Groups

	Preintervention	Intervention	*P*
Subjects, N	52	48	
Age (d)			
Mean (range)	23 (2–56)	22 (2–54)	0.39
Median	25	18	
Gender			0.19
Male	28 (54%)	32 (32%)	
Female	24 (46%)	16 (33%)	
Resident attempt			0.29
Yes	34 (65%)	36 (75%)	
No	18 (35%)	12 (25%)	
No. attempts			0.20
1	32	24	
2	9	16	
3+	11	9	
Mean (range)	1.67 (1–5)	1.75 (1–4)	
LP outcome			0.54
Success	47 (90%)	45 (93%)	
Failure	5 (10%)	3 (7%)	

LP success rate between groups.

DISCUSSION

LP is a commonly completed procedure in the pediatric ED. The American Academy of Pediatrics guidelines recommend pain management during this invasive procedure, and it is recognized as an important part of the patient care process. It is well established that analgesia during painful procedures is beneficial for patients in the short and long term.[2–4,8]

Baxter et al[10] demonstrated an improved success rate for resident physician-completed LPs with the use of local anesthesia, and Nigrovic et al[11] have suggested that the failure to use local anesthetic is a modifiable risk factor for traumatic or unsuccessful LP in children. Caltagirone et al[12] reported that J-tip lidocaine improved success of the procedure 2-fold when compared to the topical anesthetic, although they did not find it superior for pain management. Despite these findings, there is no clear consensus regarding the types of analgesia that are most effective for pain management and maximal procedural success.

Additionally, to date, there is minimal literature considering the dependence of procedural success rates on the number of analgesic methods utilized during the LP procedure. Published guidelines indicate that some commonly used analgesic measures, including oral sucrose and topical lidocaine, may not be sufficient when used alone.[3,6,8] Given the potential weaknesses of common monotherapies, we targeted the use of at least 2 forms of analgesia as an accessible proxy outcome for appropriately addressing infant pain management during the LP procedure and sought to determine if this approach affected procedural success rates.

Through the implementation of educational interventions and collaboration between healthcare providers, including nurses, physicians, and support staff, we created a successful environment for improving the care of febrile infants during LP procedures in our ED. Our findings indicate that interventions such as triage nurse education and empowerment produced an increase of 30% in the use of 2 or more analgesics. Through this project, our staff became familiar with a staged process for pain management during the infant LP and testified to increased awareness and interest in preventing pain in this population.

As TL is a widely accepted product utilized for pain management during minor procedures throughout the healthcare environment,[7] we initiated interventions to increase the use of this product during infant LP procedures. The increase in TL cream use before the LP procedure was directly related to the triage nursing intervention encouraged through the educational infographic and staff training. Before this intervention, the use of TL during the

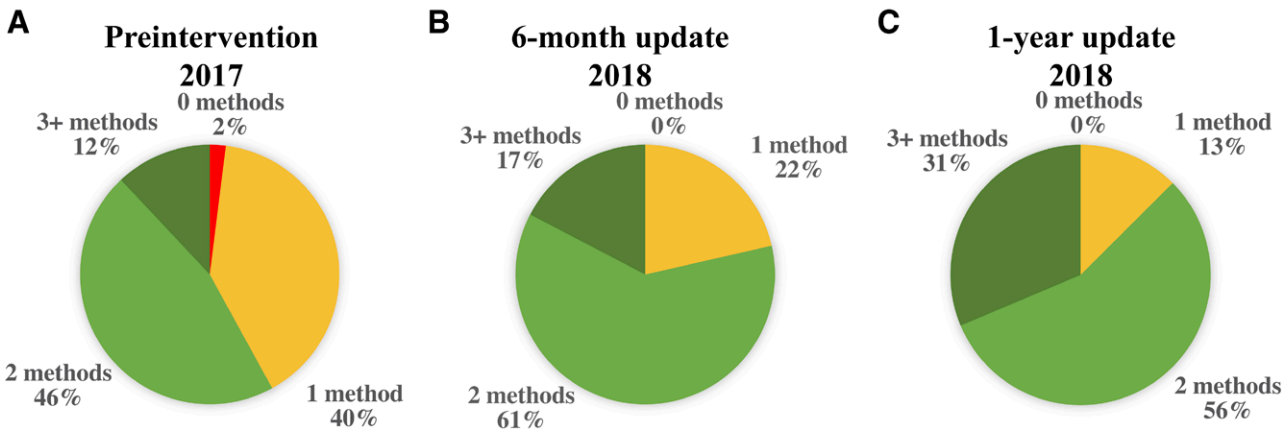

Fig. 4. Percentage of patients receiving 0, 1, or 2+ methods of analgesic during the preintervention (A), 6-month intervention (B), and 12-month intervention period (C). The use of 1 method met 100% compliance. The use of 2 or more methods increased by 30% after the interventions, a statistically significant increase ($P < 0.001$).

LP procedure may have been hindered by considerations of timeliness, given that this product takes 20–30 minutes to take a full analgesic effect. However, through centering our intervention in the triage stage of the visit, we created a streamlined care process, thus increasing analgesic utilization. Our postintervention survey supports this finding and indicates the value and perceived efficacy of TL, along with demonstrating that a significant portion of TL was applied during the triage process. Furthermore, we established that this intervention did not produce a negative effect on the use of more traditional methods such as injectable lidocaine, thus furthering our project aim of utilizing multiple analgesics during the procedure. Due to the limitations of retrospective chart review, we were unable to establish the number of patients who received TL during the triage process but did not undergo an LP procedure, limiting our assessment of this as a balancing measure for this intervention.

Length of stay for patients who received multiple analgesics during the procedure represents an additional potential balancing measure. We did not assess the length of stay in this analysis; however, we would not expect this intervention to affect it adversely. The analgesics utilized in our study are all commonly used within the emergency department; obtaining or administering them to the patient would not be expected to

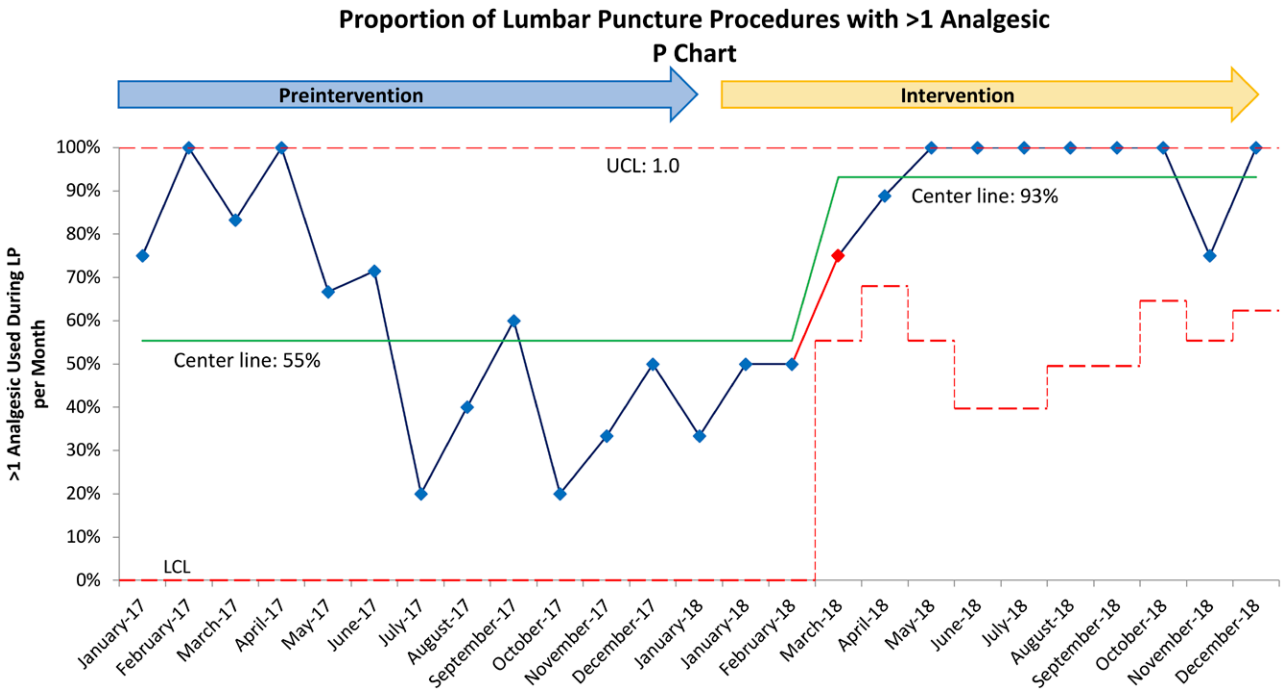

Fig. 5. P chart demonstrating the proportion of LP procedures performed using more than one analgesic during the preintervention and intervention periods. LCL, lower control limit; UCL, upper control limit.

have a significant effect on the time to procedure or recovery time. Furthermore, our focus on increasing the TL usage in triage and optimizing staff education and communication before the procedure could be expected to streamline the visit of a febrile infant, with potential positive impacts on time to antibiotics and treatment outcomes. Additionally, we do not anticipate that the use of additional types of procedural analgesia would harm patients, individuals in the department, or the healthcare system, as these methods are accepted as cost-effective measures for pain management. Detailed consideration of these balancing measures would be a potential area for future research.

Given the limited literature describing the effects of multiple analgesics on procedural success rates, we investigated whether the use of multiple methods improved the number of successful LP procedures in our ED. Although our findings demonstrate a small increase in the overall success rate during our intervention process and slightly superior success rates with 2 methods of analgesia compared with 1 and 3 methods, these findings were not statistically significant.

We did not identify an increase in the department's already high procedural success rate; however, this project did successfully improve the provision of multiple effective means of analgesia to this nonverbal patient population. The success of this project depended on staff collaboration and communication regarding pain management for this vulnerable group of children. Our interventions increased awareness and discussion of the project. Through this, we were able to reach 100% compliance with the use of at least 1 form of analgesia and demonstrate a significant increase in the use of 2 forms, meeting project goals. We attribute this success to the multiple forms of communication utilized, including electronic messages, infographics in work-spaces, and individual educational opportunities, allowing us to reach staff members in various ways. The creation of a collaborative effort limited the single provider burden and ensured both the efficacy and the sustainability of the interventions. Future research assessing objective measurements of infant pain scores during LP procedures with the use of each type and combination of analgesic to optimize pain control strategies would be helpful, as would additional, larger studies to clarify the relationship between the number of analgesic methods used and success rate.

Limitations of this study include those related to retrospective EMR data extraction, including information bias and missed cases. We attempted to minimize missed cases by utilizing multiple procedural codes for encounter identification. One investigator performed all data entry, which could have led to data entry errors. However, significant errors were unlikely given the relatively small dataset, the development of a manual of operations detailing data variables for entry, and comprehensive training. Finally, our retrospective data collection did not allow us to obtain objective measures of infant discomfort or family satisfaction, nor to ascertain whether parents remained present in the room, a possible source of additional comfort. Although these findings would be helpful in a comprehensive assessment of pain associated with infant lumbar puncture, they were not necessary for the demonstration of our primary outcome, an increase in the provision of recognized pain control methods. Due to these limitations and structural factors varying by institution, our study results may not be generalizable to EDs with larger volumes.

CONCLUSIONS

In our study, we created a streamlined process to ensure that all infants undergoing the LP procedure are treated with at least 1 form of pain control. Furthermore, we increased the proportion of infants treated with 2 or more forms of analgesia at our institution. Additional impacts of this project include improved communication of pain management options between nursing staff, providers, and residents, both before and during procedures.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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REFERENCES

1. Lago P, Garetti E, Merazzi D, et al; Pain Study Group of the Italian Society of Neonatology. Guidelines for procedural pain in the newborn. *Acta Paediatr*. 2009;98:932–939.
2. Krauss BS, Calligaris L, Green SM, et al. Current concepts in management of pain in children in the emergency department. *Lancet*. 2016;387:83–92.
3. Committee on Fetus and Newborn and Section on Anesthesiology and Pain Medicine. Prevention and management of procedural pain in the neonate: an update. *Pediatrics*. 2016;137:e20154271.
4. Kaur G, Gupta P, Kumar A. A randomized trial of eutectic mixture of local anesthetics during lumbar puncture in newborns. *Arch Pediatr Adolesc Med*. 2003;157:1065–1070.
5. Carbajal R, Rousset A, Danan C, et al. Epidemiology and treatment of painful procedures in neonates in intensive care units. *JAMA*. 2008;300:60–70.
6. Fein JA, Zempsky WT, Cravero JP; Committee on Pediatric Emergency Medicine and Section on Anesthesiology and Pain Medicine; American Academy of Pediatrics. Relief of pain and anxiety in pediatric patients in emergency medical systems. *Pediatrics*. 2012;130:e1391–e1405.

7. Abad F, Díaz-Gómez NM, Domenech E, et al. Oral sucrose compares favourably with lidocaine-prilocaine cream for pain relief during venepuncture in neonates. *Acta Paediatr*. 2001;90:160–165.
8. Slater R, Cornelissen L, Fabrizi L, et al. Oral sucrose as an analgesic drug for procedural pain in newborn infants: a randomised controlled trial. *Lancet*. 2010;376:1225–1232.
9. Institute for Healthcare Improvement. Science of improvement: how to improve. 2019. Available at http://www.ihi.org/resources/Pages/HowtoImprove/ScienceofImprovementHowtoImprove.aspx. Accessed February 1, 2019.
10. Baxter AL, Fisher RG, Burke BL, et al. Local anesthetic and stylet styles: factors associated with resident lumbar puncture success. *Pediatrics*. 2006;117:876–881.
11. Nigrovic LE, Kuppermann N, Neuman MI. Risk factors for traumatic or unsuccessful lumbar punctures in children. *Ann Emerg Med*. 2007;49:762–771.
12. Caltagirone R, Raghavan VR, Adelgais K, et al. A randomized double blind trial of needle-free injected lidocaine versus topical anesthesia for infant lumbar puncture. *Acad Emerg Med*. 2018;25:310–316.