

Increasing ED Use of Jet Injection of Lidocaine for IV-Related Pain Management

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BACKGROUND AND OBJECTIVE: Venipuncture is a leading cause of procedural pain for children. Jet injection of lidocaine (JIL; J-Tip) has been demonstrated to be effective in controlling intravenous (IV) placement-related pain and, due to its rapid onset, is particularly suited to emergency department (ED) use. Our objective was to increase JIL use with IV placements in our ED from 11% at baseline to 50% within 12 months.

METHODS: We initiated the project at our urban, tertiary pediatric ED in July 2014. We surveyed medical and nursing teams to identify barriers to JIL use. We initiated changes at monthly intervals: (1) order set changes, (2) online education, (3) hands-on workshops, (4) improved accessibility, (5) standing order policy revision, and (6) reminders. We collected biweekly data on IV placements for all ED patients, except level 1 (critical) triage patients. We used standard quality improvement methodology and statistical process control for statistical analysis.

RESULTS: JIL use with IV placement increased to 54% over 7 months and has remained >50% for >12 months. For all eligible IV placements ($n = 12\ 791$), 76.4% of those where JIL was used were successful on the first attempt compared with 75.8% without JIL ($\chi^2_{1\text{degrees of freedom}} = 0.33, P = .56$), with no significant difference in the success at IV placement.

CONCLUSIONS: We sustainably increased JIL use with IV placement. The use of JIL was not associated with a difference in first-attempt IV placement success rates. We are expanding the project to other parts of the institution.

Elimination or relief of pain, whenever possible, is an important responsibility of all health care providers caring for children. Many pediatric patients in the emergency department (ED) either present with a painful condition or undergo painful procedures as a part of their evaluation and management. Resolution of both pain and caregiver perception of pain have been identified as important indicators of patient and parent satisfaction in the ED.¹ Improvement in pain control has been associated with

significantly improved clinical and practice outcomes.² In contrast, poor pain control has been demonstrated to have a variety of short- and long-term complications, including hyperalgesia and needle phobia.^{3,4} In addition to patient-related outcomes, poor pain control in the pediatric patient also has been shown to affect the vital signs of caregivers.⁵

Anand et al⁶ first demonstrated the importance of adequate pain management in infants. Pain management has since been increasingly recognized as an important

abstract

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Dr Jain conceptualized and designed the study, acquired, analyzed, and interpreted the data, and drafted the manuscript; Drs Hegebarth, Humiston, and Giovanni assisted in designing the study, supervised all phases of the study, and reviewed and revised the manuscript; Ms Gunter and Ms Anson assisted in designing the study and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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part of high-quality patient care. In 2001, the American Academy of Pediatrics recognized acute pain to be a serious issue, with the potential to lead to physiologic and psychological adverse effects, and reaffirmed this statement in 2015.⁷⁻⁹ Additionally, the Joint Commission on Accreditation of Healthcare Organizations introduced standards requiring pain assessment and management.¹⁰ However, studies continue to demonstrate insufficient pain management, particularly for children in EDs.¹¹ Commonly reported barriers to optimal pain management include poor assessment of pain, inadequate education about pain and pain control measures, and perceived time constraints to administer the analgesic measure.^{7,8,12}

Venipuncture and intravenous (IV) cannulation are common procedures performed in the emergency care of pediatric patients and are increasingly recognized as the leading cause of procedure-related pain in pediatric hospital and ED settings.¹³ Fortunately, there are several pharmacologic and nonpharmacologic measures available to provide analgesia for needlestick procedures. Recently, several topical anesthetic options have been studied for use with venipunctures in the ED (see Table 1). Pershad et al¹⁴ analyzed commonly available options and concluded that jet injection of lidocaine (JIL; J-Tip) provided rapid onset of maximal analgesia with the lowest cost-effectiveness ratio.¹⁴ JIL delivers 1% buffered lidocaine into the subcutaneous tissue using pressurized carbon dioxide and has been demonstrated to be superior to topical anesthetic creams, such as eutectic mixture of local anesthetics and liposomal lidocaine, for ED use.^{15,16} The rapid onset of effect is particularly helpful in the ED setting, where providers and patients are frequently unwilling to wait for longer-acting agents to work.

TABLE 1 Common Topical Anesthetics for Venipunctures

Anesthetic	Brand Names
Vapocoolant spray	Pain-Ease
Eutectic mixture of local anesthetics: lidocaine and prilocaine	EMLA
4% liposomal lidocaine cream	AneCream, L.M.X.4
JIL device	J-Tip, Zingo
Lidocaine and tetracaine topical patch	Synera

At baseline, measured over 6 months, JIL was used with only 11% of IV placements at our urban, tertiary care children's hospital ED. We used a multimodal and multidisciplinary quality improvement (QI) initiative to address the suboptimal use of this agent. Our objective was to increase use of JIL with IV placements in noncritical ED patients from 11% to 50% within 12 months (outcome measure). Our process measure was to compare, over time, the number of orders initiated by the medical team with the number of nurse-initiated orders. For our balancing measure, we assessed whether the use of JIL was associated with a reduced success rate in first-attempt IV placement.

METHODS

Ethical Aspects

The project was reviewed by our institutional review board, which determined that it met criteria to be classified as a QI project.

Setting and Population

Our institution's main campus is a 317-bed pediatric tertiary care referral center serving patients from western Missouri, all of Kansas, and eastern Colorado. Our QI project was initiated at this urban ED, which is a 39-bed facility with an annual census of ~70 000 patients. For staffing purposes, this ED is divided into 5 spatially distinct zones with nursing staff assigned to a specific zone. The patients are triaged according to the Emergency Severity Index¹⁷ (ESI) from levels 1 (most urgent) to 5 (least urgent). In 2013, among noncritical

patients (ESI categories 2-5), ~25 IV placements were ordered per day (~750 per month). All ED patients who had orders for peripheral IV placement were included unless they (1) had a documented history of allergy to lidocaine, or (2) were triaged as "critical" (ESI triage level 1).

Improvement Team

The team was multidisciplinary and included a pediatric emergency medicine (PEM) fellow (Dr Jain), 3 PEM faculty members (Drs Hegenbarth, Giovanni, and Humiston), an ED nurse (Ms Gunter), and a pain management nurse (Ms Anson). A QI specialist (Ms Hunter), child life specialist (Ms DePhillips), nurse educator (Mr Winfrey), and statistician (Ms Sherman) provided additional assistance. We initiated the project in July 2014 and used the Institute for Healthcare Improvement model for improvement.¹⁸

Planning the Interventions

From the hospital's electronic medical record system, we collected baseline data for the 6 months before launch (January to June 2014). Based on the consensus of the improvement team, we created process maps to illustrate the current process from considering to administering JIL with IV placement, as illustrated in Fig 1. The improvement team identified key drivers and used process maps to run failure mode and effects analysis.¹⁹

Before planning the intervention, we conducted an electronic, anonymous survey of ED physicians and nurses to assess their knowledge, attitudes, and

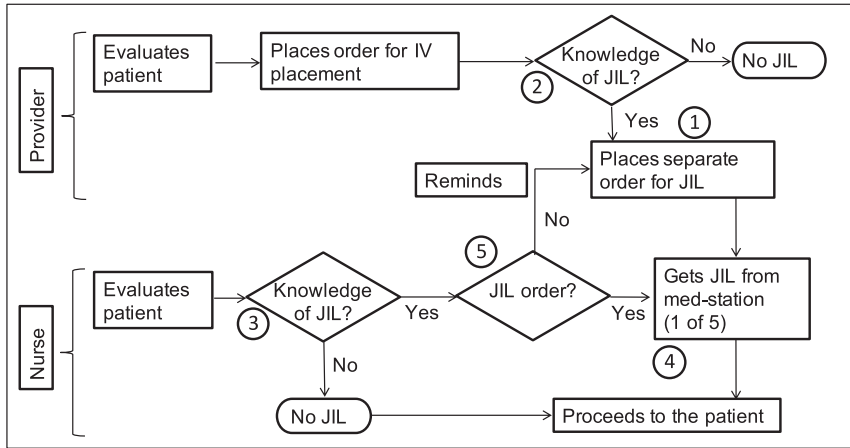


FIGURE 1
Process map and opportunities for intervention.

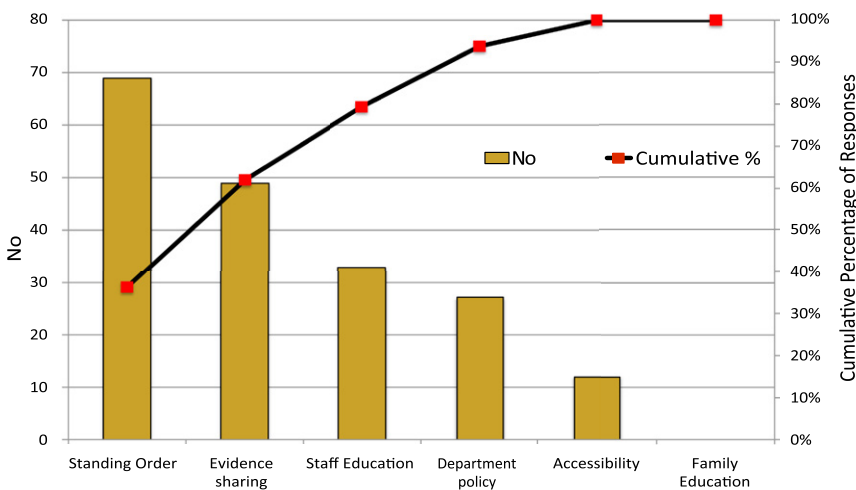


FIGURE 2
Pareto chart: combined nurse and physician survey results to the question, “What is the one intervention that would lead you to use JIL (J-Tip) with IV placements?”

practices related to IV placement pain management in general and JIL use in particular. We analyzed data obtained from 85 nurses (80% response rate) and 105 medical providers (72% response rate; respondents included 43 residents, 7 fellows, 31 PEM faculty, and 24 nurse practitioners). Among the nurses, the leading barriers were the physician ordering process, noise with JIL administration, and concern for “blown veins” or IV placement failure. Among providers, the leading barriers were lack of knowledge, the complicated ordering process, and nursing staff’s reluctance to use JIL. We also asked, “What is the one intervention that would lead you

to use JIL with IV placements?” The cumulative responses to the question are illustrated in a Pareto chart (Fig 2).

Interventions

We designed the interventions with the aim of increasing JIL use for IV placements in the ED. We planned our interventions based on expert opinion, improvement team input, including the process map (Fig 1), and ED personnel responses to the survey, including those depicted in the Pareto chart (Fig 2). We identified 6 opportunities for improvement and translated them into interventions, conducting multiple plan–do–study–act cycles

and tests of change to modify and spread the interventions within the ED. The project run chart in Fig 3 is annotated with the start dates of each intervention. A detailed description of the 6 interventions in order of launch date follows.

(1) Order Set Changes: August 2014

Our ED uses order sets to help clinicians easily order tests, procedures, etc for common chief complaints and diagnoses. In collaboration with the medical informatics team managing the hospital’s electronic medical record system (Cerner Corporation, Kansas City, MO), the option to order JIL was included in all order sets that had an IV placement option so that ordering JIL with each IV placement would be easier for the provider and, thus, occur more reliably.

(2) Online Education: September 2014

The improvement team created an online resource document about JIL that was posted on the hospital internal Web page and also shared in emails with the ED staff. This document included facts about JIL and IV-related pain, Web links to individually selected videos with instructions on using JIL, and answers to common concerns identified on the preintervention survey.

(3) Workshops: October 2014

The improvement team recruited 10 experienced ED nurses and trained them to be JIL super users. With their assistance, we scheduled workshops for nurses and physicians to provide hands-on experience. Workshops were brief (5–10 minutes) and held at convenient locations and times (eg, in the break room during lunch or occasionally at nurses’ workstations between patient care tasks) to minimize impediments to the ED workflow.

(4) Accessibility: November 2014

JIL devices need refrigeration for storage. At our ED, JIL was initially

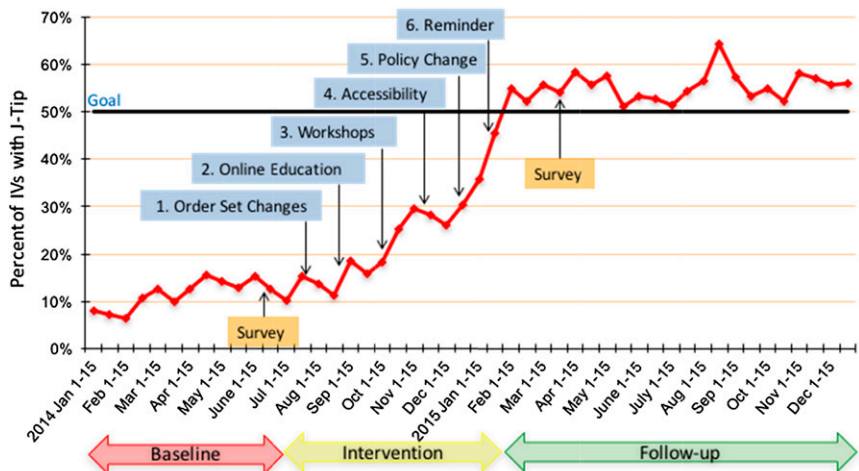


FIGURE 3
Outcome measure: run chart annotated with interventions.

stocked in only 1 of 5 zones, making access inconvenient for much of the ED and causing a barrier to wider use. Wall refrigerators were installed with assistance from the ED pharmacy and administration so JIL could be stocked in all ED zones.

(5) Policy Change: December 2014

At baseline, the hospital had a standing order policy in place that allowed nurses to place specific orders (eg, oral antipyretics, topical anesthetics for needlesticks) to improve efficiency. However, these standing order policies applied only until a medical provider evaluated the patient. This was a major barrier to JIL use because the need for most IV placements is determined after the

initial medical evaluation. Providers often forgot to place the order, and nurses found it burdensome to find and ask providers to request JIL orders. The standing order policy was modified to allow orders for topical anesthetics by the nurse even after the medical evaluation had taken place.

(6) Reminders: January 2015

Our last intervention was to place a small placard on all ED workstations to remind staff to consider ordering/using JIL with every IV. To emphasize the changes and provide positive feedback, we also sent reminder emails that included recognition for the nurse with the highest number of IVs placed with JIL.

After the final intervention, we administered a follow-up survey to ED physicians and nurses to obtain feedback on the interventions as well as on self-reported knowledge and satisfaction.

Data Collection

Table 2 highlights the data sources. For the outcome and balancing measures, the improvement team obtained pooled and deidentified data from electronic order entries through the hospital's division of medical informatics and corroborative data on JIL ordering from the pharmacy department. Data collected included age, number of IV placement attempts, and JIL use on the same visit as IV placement. We selected biweekly data collection and review to ensure sampling strategy adequacy for analysis of the effects of the changes. Because we initiated the changes at monthly intervals, the biweekly measurement cycles also enabled us to analyze, modify, and spread the intervention before the initiation of the next step.

Planning the Study of the Intervention: Measures

- For our outcome measure, we assessed the proportion of ED patients in ESI triage levels 2 through 5 requiring IV placement who had JIL associated with IV placement.

TABLE 2 Measures and Data Sources

Measure	Data Collected Biweekly	Data Source
Outcome measure	JIL use rate	
Numerator	Total No. of JIL orders placed	Medical informatics
Numerator (<i>Corroborative</i>)	Total No. of JIL dispensed	Pharmacy
Denominator	Total No. of IV placement orders	Medical informatics
Process Measure	Comparison of orders from medical providers and nurses JIL orders by medical provider (MD/DO/NP) JIL orders by nurse (RN)	Medical informatics
Balance measure	Comparison of success of first-attempt IV placement when a JIL was used versus not used	
Numerator	No. of IVs placed at first attempt When a JIL was used When a JIL was not used	Medical informatics
Denominator	Total No. of IVs placed When a JIL was used When a JIL was not used	Medical informatics

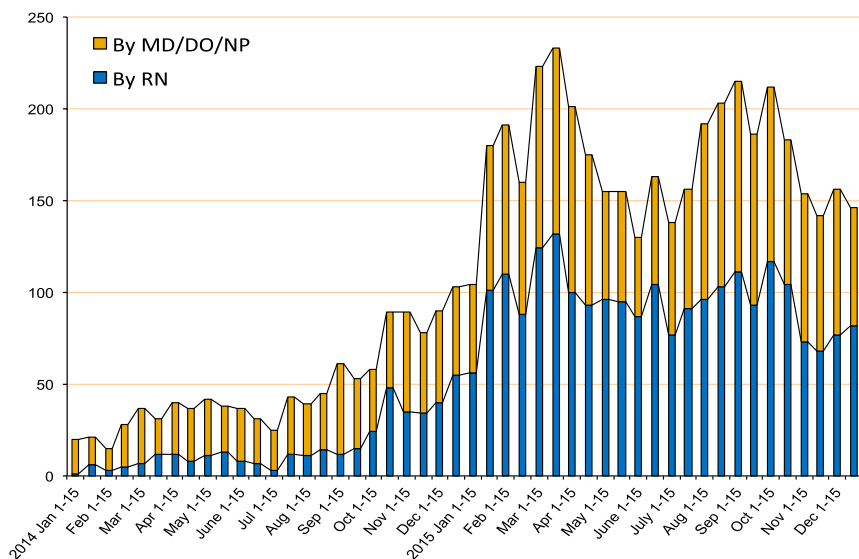


FIGURE 4
Process measure: trend of JIL orders by personnel, medical versus nursing.

- For our process measure, we compared the number of JIL orders placed by medical staff (physicians and nurse practitioners) versus nursing staff.
- Our balancing measure assessed whether the use of JIL was associated with a reduction in the success rate of placing IVs at first attempt. The perception of reduced IV placement success rate with JIL was one of the barriers to JIL use.

Data Analysis

We evaluated data for 12 measurement cycles (6 months) before the interventions, 14 cycles (7 months) during the interventions, and 24 cycles (12 months) after the final intervention. We used the following outcome-directed tools to study our measures: (1) run charts for

quantitative analysis of biweekly data for the outcome measure; (2) time series of the proportion of JIL orders based on the originating personnel; and (3) the χ^2 test to compare the success rates for all IV placements with and without the use of JIL.

RESULTS

Outcome Measure

Before the initiative, only 11% of IV placements were associated with JIL use. Within 14 measurement cycles (7 months) of the first intervention, 54% of IV placements were associated with JIL use. During the monitoring period after the final intervention (24 cycles, 12 months), the proportion of IV placements with JIL remained $\geq 50\%$. The results for the outcome measure are depicted in a run chart in Fig 3.

Process Measure

We observed an increase in nurse-initiated JIL orders from 15% during the baseline period to 60% of all JIL orders after the interventions, as illustrated in Fig 4. The number of JIL devices ordered by providers also increased during this period.

Balance Measure

We reviewed data on all eligible IVs during the baseline, intervention, and follow-up periods, categorized by patient age groups. For the total IV placements during the observation period ($n = 12\,791$), there was no statistically significant difference in the proportion of successful placements on the first attempt between those associated and not associated with JIL orders at the same visit (76.4% vs 75.8%, respectively, $\chi^2_{1\text{degrees of freedom}} = 0.33, P = .56$). Similarly, there was no statistically significant difference when the data were stratified by age, as shown in Table 3.

DISCUSSION

In a busy pediatric ED, we used QI methodology to sustainably increase JIL use with IV placements from 11% to $>50\%$. This improvement was effected over 14 measurement cycles (7 months) with multiple plan-do-study-act cycles. We modified and spread the intervention within the pediatric ED with tests of change with each measurement cycle. The improved usage rate of $\geq 50\%$ remained sustained for 24 measurement cycles (12 months) after the last intervention. Implementation of a standing order

TABLE 3 Balancing Measure: Comparison of IV Placement First-Attempt Success Rates With And Without JIL Order, by Patient Age

Age, y	IV Without JIL			IV With JIL			P
	On First Attempt	Total	Success Rate, %	On First Attempt	Total	Success Rate, %	
<2	1925	2870	67.1	365	527	69.3	.33
2-4.9	1258	1632	77.1	392	498	78.7	.45
5-7.9	967	1183	81.7	363	460	78.9	.19
8-11.9	1116	1402	79.6	473	604	78.3	.51
12-18	2154	2706	79.6	696	909	76.6	.05
Total	7420	9793	75.8	2289	2998	76.4	.56

policy that allowed JIL ordering by nurses resulted in an increase in nurse-initiated orders to 60% of all JIL orders within 6 cycles (3 months). There were no significant differences in the first-attempt success rates for IV placements with or without the use of JIL overall or for any age group.

We used robust measurements, included assessment of corroborative data for our outcome of primary interest, and determined the sustainability of the effort for many months after the last change. Our results were strikingly positive and were followed by the adoption of similar methods by other areas of the organization. This has also been regarded as a sentinel project for a culture change to improve procedural pain management at the ED and the institution. The improvement team has assisted with education in other areas and sharing our methods, enabling a successful increase in JIL use at 2 pediatric urgent care centers. At the ED, we are working to better address pain related to other procedures and painful states, including sickle cell disease and long-bone fractures.

The interventions and the order of their application allowed us to affect our key drivers and reach our goal of increased JIL use. We arranged our interventions based on the results of the needs assessment survey, failure mode and effects analysis, and system factors, including the convenience of implementation.

- We started with electronic medical record order set changes to simplify the JIL ordering process while planning the educational intervention.
- Educational interventions included online education and hands-on workshops. We believe the educational component was key to the success of the project because it laid out the rationale and methodology for increasing JIL use. We know that the education was effective at increasing knowledge

based on the comparison of the pre- and postintervention survey data.

- With assistance from ED management and the pharmacy department, we were able to improve accessibility by stocking JIL devices in all the ED zones.
- Implementation and promotion of standing orders for topical anesthetic agents appeared to be a substantial driver of the improvement in JIL usage rates, as reflected by a significant and sustained increase in the proportion of JIL devices ordered by nurses.
- We posted reminder placards on computers and, for 8 months, sent reminder emails, with nurse recognition for the highest number of IVs with JIL. Because much work had preceded this step, it is difficult to assess if this change had an additional effect.

Our study should be viewed in the context of identified limitations. First, we did not measure the reduction in pain from JIL usage with the placement of IVs. However, increased use of JIL seems a good proxy for reduced pain, because numerous previous studies have demonstrated significant improvement in pain level across all age groups with preprocedure use of JIL, as well as JIL's superiority over other commonly available options.^{15, 16,20} We used a QI methodology, and did not aim to study the comparative efficacy of various topical analgesic options. Second, we did not investigate the cost implications of wider use of JIL, as Pershad et al¹⁴ have previously demonstrated the superior cost-effectiveness of JIL compared with other commonly used options.

Last, there could be data reporting limitations. We analyzed data on the number of JIL devices ordered on the same ED visit as an IV placement order. We used the net number of JIL devices dispensed from the pharmacy (total dispensed minus returned) as a corroborative measure. However, we did not have a reliable measure of

actual administration. We also did not obtain any variable other than age and ESI triage score that may have affected JIL use.

CONCLUSIONS

The deleterious effects of pain in the acute care setting are being increasingly acknowledged, and pain management needs to be urgently addressed. Our project significantly increased JIL use for IV placement-related pain, and this increase has been sustained at our busy tertiary care pediatric ED. There was no change in the success of first-attempt IV placement using JIL. The results of this project are likely generalizable to other institutions and clinical settings. Locally, we have partnered with champions at 2 urgent care centers and successfully improved JIL use in these settings. Several areas at Children's Mercy Hospital, including the ambulatory clinics and laboratories, are acknowledging and addressing venipuncture-related pain management in a similar fashion. Institutions wishing to initiate similar changes will likely need to individualize their interventions depending on local factors, such as specific identified barriers to JIL use.

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ABBREVIATIONS

ED: emergency department
ESI: Emergency Severity Index
IV: intravenous
JIL: jet injection of lidocaine
PEM: pediatric emergency medicine
QI: quality improvement

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

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