Improving the Management of Vaso-Occlusive Episodes in the Pediatric Emergency Department

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abstract

OBJECTIVES: Vaso-occlusive episodes (VOEs) account for the majority of emergency department (ED) visits for children with sickle cell disease (SCD). We hypothesized that addressing key barriers to VOE care would improve receipt of analgesics and outcomes.

METHODS: A quality improvement (QI) initiative was conducted from September 2010 to April 2014 to streamline VOE care in an urban pediatric ED. Four interventions were used: a standardized time-specific VOE protocol; intranasal fentanyl as the first parenteral pain medication; an SCD pain medication calculator; and provider and patient/family education. Data were collected for 3 outcome measures (mean time from triage to first parenteral opioid and admission/discharge decision, and proportion discharged from the ED); 1 process measure (mean time from triage to initiation of patient-controlled analgesia); and 4 balancing measures (mean time from triage to second intravenous opioid dose, 24-hour ED readmission, respiratory depression, and length of stay).

RESULTS: There were 289 ED visits in the study period. Improvements were seen in mean time to: first dose of parenteral opioid (56 to 23 minutes); second opiate intravenous dose (106 to 83 minutes); admission and discharge decisions (163 to 109 minutes and 271 to 178 minutes, respectively); and initiation of patient-controlled analgesia (216 to 141 minutes). The proportion discharged from the ED increased from 32% to 48% (χ^2 = 6.5402, P = .01). No increase in 24-hour readmission, respiratory depression, or inpatient length of stay was observed.

CONCLUSIONS: Using VOE-specific interventions, we significantly improved VOE care for children. Studies are needed to determine if these results can be replicated.

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Drs Kavanagh and Moses conceptualized and designed the study; were involved in the design, revision, and implementation of the interventions; performed data analyses; and drafted the initial manuscript and its revision. Ms Wolfgang assisted in the design and revisions of the interventions used; performed data collection and data analyses; and contributed to the final manuscript. Dr Killius, Dr Sprinz, Dr Sobota, Ms Champigny, Ms Miner, Ms Barry, and Dr Dorfman assisted in designing and revising the interventions used; provided feedback on data analyses; and contributed to the final manuscript as submitted. All authors approved the final version of the manuscript.

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Approximately 100 000 people are living with sickle cell disease (SCD) in the United States.[1,2] Vaso-occlusive episodes (VOEs) are a significant cause of morbidity for subjects with SCD and account for the majority of emergency department (ED) visits and hospitalizations among both adults[3,4] and children.[5] The National Heart, Lung, and Blood Institute and the American Pain Society recommend rapid evaluation and treatment of VOEs in the acute care setting, with timely pain assessments and repeat analgesia as needed to control pain.[6,7] In addition, quality-of-care indicators for children with SCD include the receipt of parenteral analgesia within 30 minutes of triage in the ED or comparable setting to treat VOEs.[8]

Despite these recommendations, studies of children with SCD presenting to the ED for VOE management have reported wait times of 65 to 90 minutes for the first dose of parenteral analgesia.[9–11] These findings are supported by a qualitative study of adolescents with SCD and parents of children with SCD, who reported delays

in receiving pain medications in the ED.[12] According to a report from the Institute of Medicine, 1 reason for the suboptimal management of pain is inadequate provider knowledge.[13] Other studies have shown that unfounded provider beliefs about addiction also contribute to delays in providing analgesia, including for SCD-related pain.[14]

To address these concerns, we conducted a quality improvement (QI) initiative to improve the timeliness of VOE management for children with SCD in the pediatric ED. Our specific aims were to decrease the mean time to first parenteral pain medication to ≤30 minutes, improve the timeliness of subsequent pain medications, and decrease the time to disposition decision.

METHODS

Setting

This QI initiative was conducted in an urban pediatric ED designated as a Level II trauma center. The center receives 28 000 visits annually in patients aged ≤21 years, including ~180 children and young adults with SCD followed up in our institution's pediatric hematology clinic. A multidisciplinary team was created that met biweekly, consisting of: pharmacy, nursing, and physician staff from the pediatric ED; pediatric hematologists and a social worker; a pediatric hospitalist with QI expertise; the parent of a child with SCD; and a project coordinator.

Patient Population

For this initiative, patients with SCD presenting with moderate or severe VOE pain (eg, ≥5 of 10 on the Numeric Pain Rating Scale[15]) were included. Patients were excluded if they presented with non-VOE pain, headache, atypical (non-VOE) chest pain or asthma exacerbation, abdominal pain, extremity pain or swelling concerning for deep vein thrombosis, pain due to trauma or musculoskeletal causes, or fever. Also excluded were visits for patients who had an implanted port (because they followed a separate protocol), patients with individualized pain plans addressing both VOE pain and concomitant psychosocial issues, and those transferred from outside EDs.

Interventions

Key drivers of streamlined care for VOEs in the pediatric ED were identified (Fig 1). Four rate-limiting steps were identified: (1) lack of knowledge and wide variation of care for VOEs; (2) establishing intravenous (IV) access; (3) calculating and confirming appropriate pain medication doses; and (4) misconceptions about the presentation and treatment of VOEs and future behaviors in this population regarding pain management. Using Plan-Do-Study-Act cycles based on the Model for Improvement,[16] 4 interventions were developed: (1) a standardized time-specific VOE protocol; (2) intranasal fentanyl as the first parenteral pain medication; (3) an SCD pain medication calculator; and (4) provider and patient/family education.

Standardized VOE Algorithm

We developed a standardized algorithm for those presenting with moderate to severe VOE pain: 2 doses of intranasal fentanyl 5 to 10 minutes apart, followed by 2 doses of IV opioids every 20 to 30 minutes (Appendix). For children aged ≥7 years requiring admission, patient-controlled analgesia (PCA) was initiated in the ED, which was an accepted practice but not uniformly implemented before this QI initiative. Those discharged were observed for 1 hour after receiving oral opioids to ensure appropriate pain control. Physicians were permitted to tailor care for individual patients but were asked to explain any deviations made.

Intranasal Fentanyl

Intranasal fentanyl was chosen as the first parenteral pain medication for VOE treatment because of delays associated with obtaining IV access. Intranasal fentanyl has been shown to be safe and efficacious in the pediatric ED, including our own, for conditions such as long bone fractures.[17,18] We believed that intranasal fentanyl could provide rapid relief for VOEs as IV access was established while minimizing the risk of opioid overdose given its quick onset of action and short duration.[19] This expanded indication was approved by our institution's pharmacy and therapeutics committee for children with SCD weighing ≥10 kg to include 2 doses, each 1.5 μg/kg (maximum single dose: 100 μg) administered 5 to 10 minutes apart.

SCD Pain Medication Calculator

Subjects with SCD often need higher doses of opioids to achieve adequate analgesia due to the higher pain intensity associated with VOEs, tolerance to opioids, and increased renal and hepatic clearance.[7] During this initiative, the electronic health record used in the pediatric ED did not provide age- and weight-based dosing for children with SCD. Through a collaborative effort of the pediatric ED, hematology, and pharmacy staff, an online SCD pain medication calculator was therefore developed for the analgesics commonly used for VOEs; an age- and weight-based dosing scheme was employed (Appendix). This tool was completed at the time of care initiation and then used by nurses to check medication dosing.

Provider and Patient/Family Education

The Institute of Medicine has cited the limited education of US medical students and physicians as a major challenge in the treatment of pain.[13] We therefore held trainings for pediatric ED providers on the VOE

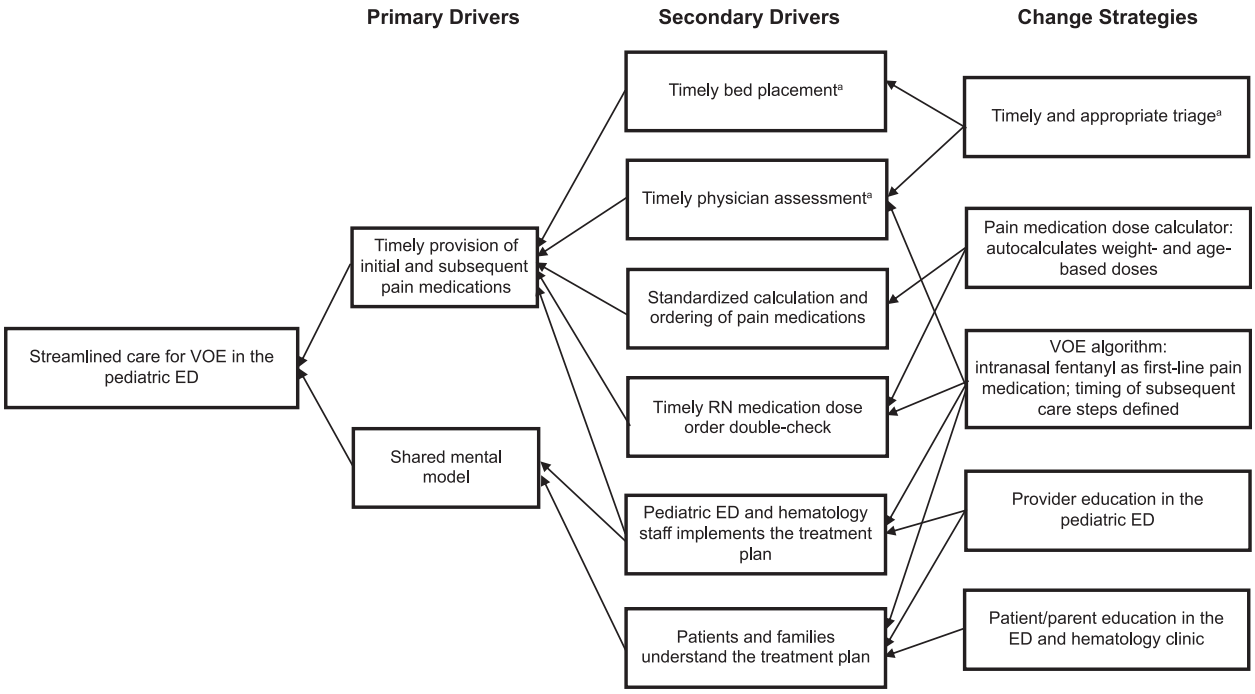

FIGURE 1

Streamlined care for uncomplicated SCD VOE in the pediatric ED. [a]Baseline data indicated that patients were already being triaged upon arrival and placed into an acute bed. RN, registered nurse.

protocol, the use of the pain medication calculator, and useful tips on the assessment and treatment of VOEs. These sessions also addressed common misperceptions, such as assuming that a sleeping child with VOE had adequately controlled pain or that normal vital signs could not be present in those experiencing significant pain. We also discussed that self-reported pain scores were the gold standard and debunked myths, including that there is no increased risk of addiction or aberrant drug-seeking behavior in this population.[20,21] Education was also provided to patients and parents in the pediatric hematology clinic and ED to explain the care steps for VOEs, especially the use of intranasal fentanyl as the first treatment provided. In addition, from May through September 2011, the pediatric hematology social worker surveyed a convenience sample of patients and/or parents to assess their experiences and provide feedback to the multidisciplinary team.

Project Timeline

This initiative lasted from September 2010 to April 2014. At baseline (September 2010–May 2011), data on the timing of first and subsequent pain medications for children with SCD presenting with VOE were collected. In phase 1 (May–November 2011), intranasal fentanyl as the first-line parenteral opioid was introduced. In phase 2 (December 2011–November 2012), the goal was to streamline VOE care from triage to disposition decision. We revised the VOE algorithm to recommend 2 doses of intranasal fentanyl, 2 doses of IV opioids, and then a disposition decision; we then introduced the SCD pain medication calculator. In phase 3 (December 2012–April 2014), the sustainability of the improvements seen in phase 2 was determined. We also revised the VOE algorithm in May 2013 to initiate PCA for patients with severe pain (≥7 of 10 on the Numeric Pain Rating Scale[15]) following the first dose of IV opioid after determining that 95% of these patients required admission.

Outcome, Process, and Balancing Measures

Our primary outcome measures were mean time from triage to first parenteral (IV or intranasal) opioid and mean time from triage to admission or discharge decision. In addition, mean time from triage to PCA initiation was tracked for patients requiring admission as a process measure to limit the gap between receipt of intermittent IV opioids and PCA. Finally, the proportion of visits for VOEs that led to discharge before and after streamlined care (baseline + phase 1 vs phase 2 + phase 3) was determined.

Our balancing measures included mean time from triage to the second IV opioid dose to ensure that the use of intranasal fentanyl as the first-line intervention was not delaying subsequent IV dosing. In addition, we monitored the safety of our efforts by collecting data on 3

measures: (1) those who returned to the ED within 24 hours of discharge; (2) episodes of respiratory depression in the ED or during hospitalization; and (3) inpatient length of stay.

Data Analysis

Statistical process control charts were used to determine how pediatric ED processes of VOE care changed over time, namely, times to: (1) administration of the first parenteral opioid; (2) admission or discharge decision; (3) initiation of PCA; and (4) second IV opioid dose. These charts consist of upper and lower limits, set at 3 SDs from the mean (depicted as the central line on the graphics). The statistical process control charts displayed variations noted in results generated by a process[22,23] and quickly identified patterns as changes were made (including sustained improvements) as the sample size increased over time.[22] To assess if significant differences existed in the proportion discharged from the ED and inpatient length of stay between the before and after streamlined care periods, χ^2 analyses were used. This study was approved by the Boston University Medical Campus Institutional Review Board.

RESULTS

From September 2010 to April 2014, a total of 1093 visits were made to the pediatric ED by children with SCD; 672 (61.5%) visits were for the treatment of pain. We excluded 247 visits for non-VOE pain or pain complicated by fever. Also excluded were 61 visits in which the VOE protocol was not used (eg, mild pain). Finally, 44 visits for patients with a port, 18 visits for 4 patients managed with individualized treatment plans, and 13 ED transfers were excluded. Thus, 289 visits were analyzed for moderate to severe VOEs, representing 83 patients with a median of 2 visits (range: 1–34 visits) who ranged in age from 2 to 21 years; 64% of visits were made by those aged ≥18 years. The mean number of patients per month and the percent with hemoglobin SS disease did not differ for each time period (Table 1).

Outcome Measures

Mean time to first dose of parenteral opioid improved from 56 to 23 minutes (Fig 2). The percentage of visits in which the first dose of parenteral opioid was provided in ≤30 minutes increased from 41% to 75%, paralleling the increase of intranasal fentanyl given as the first opioid, from 39% to 75%. Mean time to admission and discharge decisions decreased from 163 to 109 minutes and from 271 to 178 minutes, respectively (Figs 3 and 4). In addition, the proportion of children discharged from the ED before and after the introduction of streamlined care in December 2012 increased significantly, from 32% to 48% (χ^2 = 6.54, P = .01). Notably, the proportion of young adults aged 18 to 21 years, who often have high rates of ED utilization, did not significantly differ between these periods (70% vs 61%; χ^2 = 2.28, P = .13).

Process and Balancing Measures

Time to PCA initiation declined from 216 to 141 minutes over the study period. In addition, time to second opioid IV dose decreased from 106 to 83 minutes, despite the addition of intranasal fentanyl (Fig 5). In addition, 9 repeat ED visits occurred within 24 hours of discharge; 4 were due to the inability to fill prescriptions for oral pain medications, and only 1 occurred after the introduction of streamlined VOE care. Hypoxia occurred in 3 ED visits in 3 different patients, once each at baseline, phase 1, and phase 3; none developed respiratory depression or acute chest syndrome during their subsequent inpatient stay. Finally, median inpatient length of stay before and after streamlined VOE care remained the same at 5 days.

DISCUSSION

In this QI initiative, we reported significant improvements in the care of children with SCD presenting to the pediatric ED with moderate to severe VOEs by using interventions designed to streamline care. These interventions included the use of a VOE algorithm with explicitly defined care steps and intranasal fentanyl as the first parenteral opioid, a pain calculator, and education of pediatric ED providers, patients, and family members. These interventions addressed key barriers to appropriate pain management, including obtaining timely IV access, medication dose determination and confirmation, and a lack of a shared mental model among providers, patients, and families. By addressing these barriers, we successfully provided initial parenteral pain medication in ≤30 minutes of triage (per national guidelines)[6,7] and

TABLE 1 Demographic Information on the Intervention Population

Characteristic	Baseline	Phase 1: Introduction of Intranasal Fentanyl	Phase 2: Streamlined Care	Phase 3: Maintenance
No. of visits	49	51	76	113
No. of patients	22	28	41	37
Age, median (range), y	18 (10–21)	18 (2–21)	19 (4–21)	20 (2–21)
% of children aged ≥18 y	82	59	57	65
HbSS genotype, %	83.7	84.3	80.3	81.4

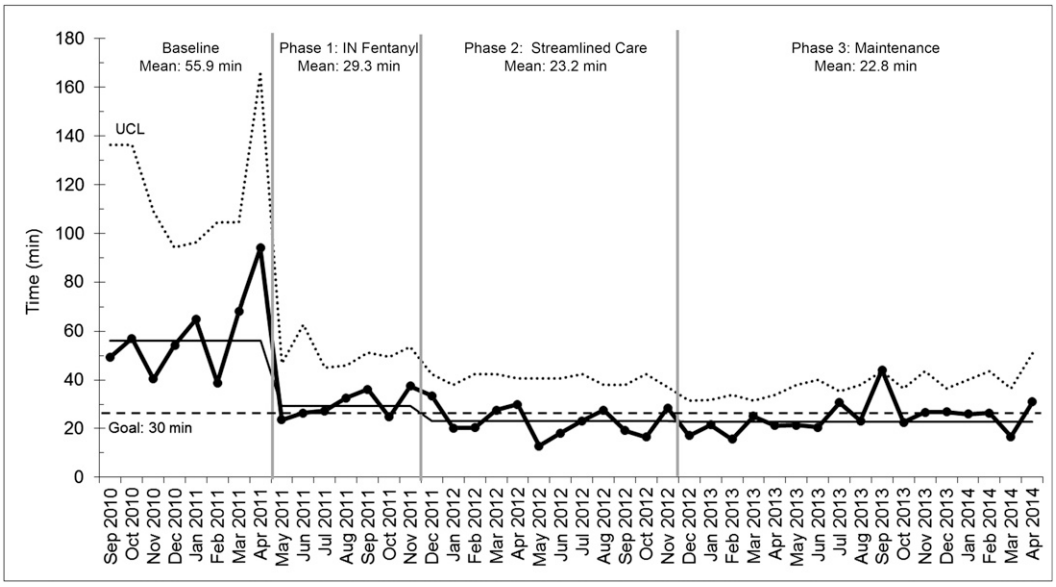

FIGURE 2
Mean time from triage to first parenteral opioid (intranasal [IN] or IV route). UCL, upper control limit.

observed significant improvements in the average time to second IV pain medication, disposition decision, and PCA initiation for those admitted. Moreover, these improvements have been sustained for >3 years, and we did not find any change in negative outcomes. From these data, we believe that our interventions were both effective and safe in the management of VOEs for children with SCD.

Previous studies have demonstrated the benefit of using guidelines to standardize care for VOEs, including decreasing hospital admissions[24] and establishing more consistent pain assessments, use of weight-based dosing, and time to PCA initiation.[10,25] However, in these studies, the timeliness of parenteral pain management did not meet recommendations by national experts (eg, first parenteral analgesic in ≤30 minutes).[6–8] A key difference in our study was the focus on explicitly defining the care steps and time goals for the entire ED visit. By creating a standardized approach, we defined the roles and expectations for all providers on the care team to ensure timely and effective pain management.

To our knowledge, there are no published studies on the use of

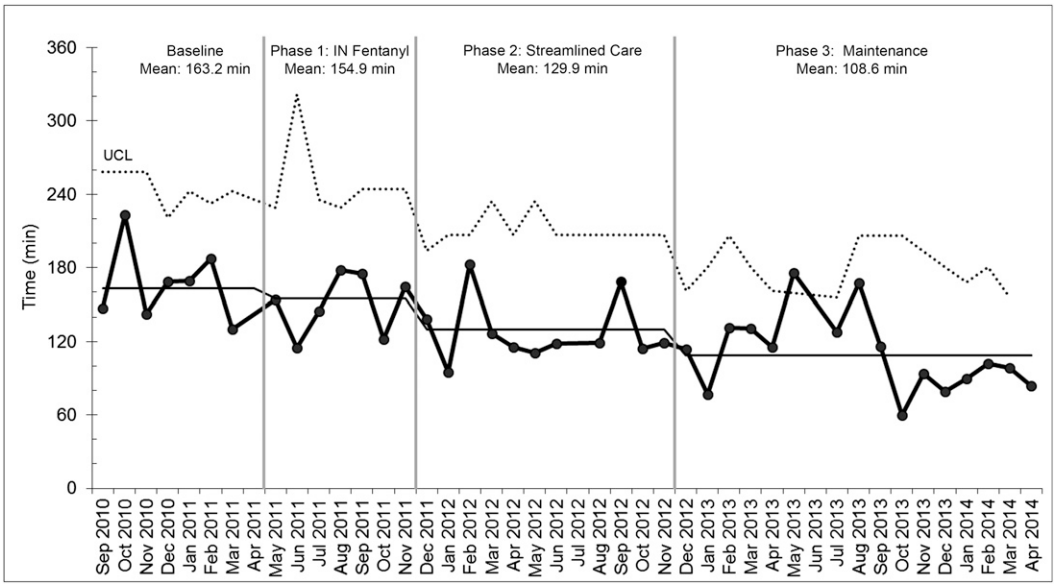

FIGURE 3
Mean time from triage to admission decision. There were no admissions in April 2011, July 2012, and June 2013 and only 1 admission in May 2013. The upper control limit (UCL) was not calculated for these time points. IN, intranasal.

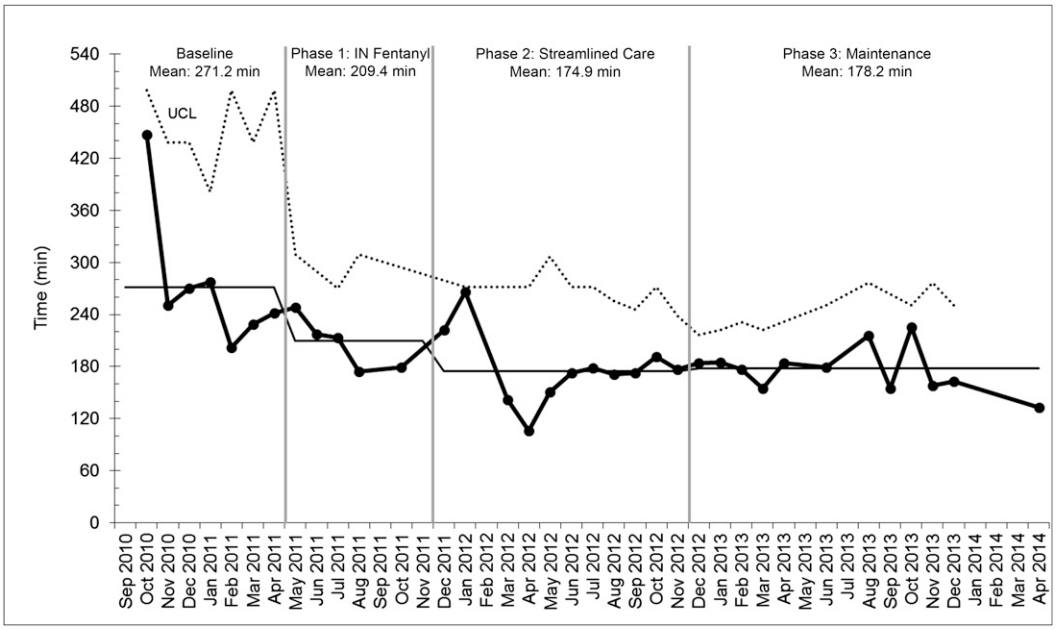

FIGURE 4

Mean time from triage to discharge decision. There were no discharges in September 2010, September 2011, November 2011, February 2012, May 2013, July 2013, January 2014, February 2014, and March 2014; and there was only 1 discharge in April. Therefore, no upper control limit (UCL) limit was calculated after December 2013. IN, intranasal.

intranasal fentanyl in the ED for children with SCD presenting with VOEs, although a protocol for a randomized trial has been published.[26] A single-center study demonstrated an improvement in time to initial analgesic administration with the use of intranasal fentanyl for pediatric patients presenting with moderate to severe pain, similar to the improvement seen with our study.[27] We join others in advocating for the use of alternative routes in those with SCD to provide rapid analgesia, including intranasal fentanyl, because IV access becomes more challenging due to scarring as these patients age.[28] In addition, intranasal fentanyl's rapid onset and short duration[19] provide pain relief and

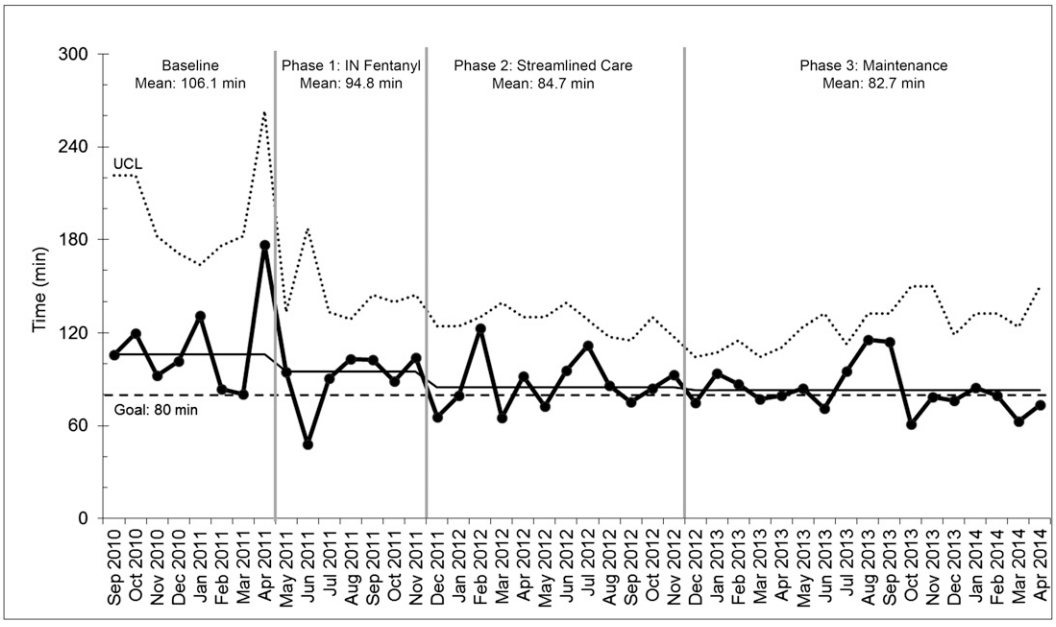

FIGURE 5

Mean time from triage to second IV opioid (after most received 2 intranasal [IN] and 1 IV dose of opioids). UCL, upper control limit.

limit the potential "stacking" with subsequent IV opioids, thereby limiting the occurrence of respiratory depression associated with repeat dosing.

At the time of the present study, the electronic health record used in our pediatric ED did not provide age- or weight-based calculations for analgesics commonly used in VOE treatment. By creating a tool that provided appropriate age- and weight-based dosing ranges, we facilitated the ordering process and dose verification. Electronic health records are now used in 95% of hospitals in the United States.[29] As these systems continue to be refined for care settings and patient populations, special attention needs to be paid to the care of children with SCD presenting with VOE so that their pain is managed appropriately.

There were several limitations to our study. First, our effort was a QI initiative, and several of the lessons learned are drawn from 1 local care setting and context and, therefore, are not generalizable. However, we believe the interventions described here may be useful in other institutions, as the barriers to timely care are likely similar. Second, we did not consistently track when the algorithm was used for individual patients throughout this QI initiative. However, the sustained use of intranasal fentanyl and provision of timely care suggest that these tools were used routinely to manage VOE. Third, we did not record any adverse events in the course of this study; however, we did not power the study to formally assess this outcome. Close monitoring is therefore warranted for all children receiving this level of care. Fourth, the maximum dosing of intranasal fentanyl is 100 μg per dose due to concentration and volume constraints; therefore, subtherapeutic doses were administered to those weighing >65 kg. However, we may have achieved greater pain capture in these patients by providing rapidly acting analgesia sooner during the ED visit. Finally, we did not use change in pain scores as an outcome measure because documentation of pain scores was problematic in the first year of our study, as previously described in published reports.[30,31] We did find a significant increase in the proportion of children discharged from the ED, and we therefore believe that a clinically significant improvement in pain was achieved as a result of our interventions.

CONCLUSIONS

We used QI methods to improve the care of children with SCD presenting to the ED for VOEs. Through the use of a standardized algorithm that included intranasal fentanyl, improving pain medication ordering and verification, and educating providers, patients, and families, we have met and exceeded national recommendations and sustained these gains over time. Future research is needed to determine if these results can be replicated in other pediatric EDs. In addition, examination of each intervention used in this study is needed to determine how each contributed to our results. Finally, perspectives of providers, patients, and families are needed to understand how these efforts impact VOE care and to identify additional areas that require improvement.

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ABBREVIATIONS

ED: emergency department
IV: intravenous
PCA: patient-controlled analgesia
QI: quality improvement
SCD: sickle cell disease
VOE: vaso-occlusive episode

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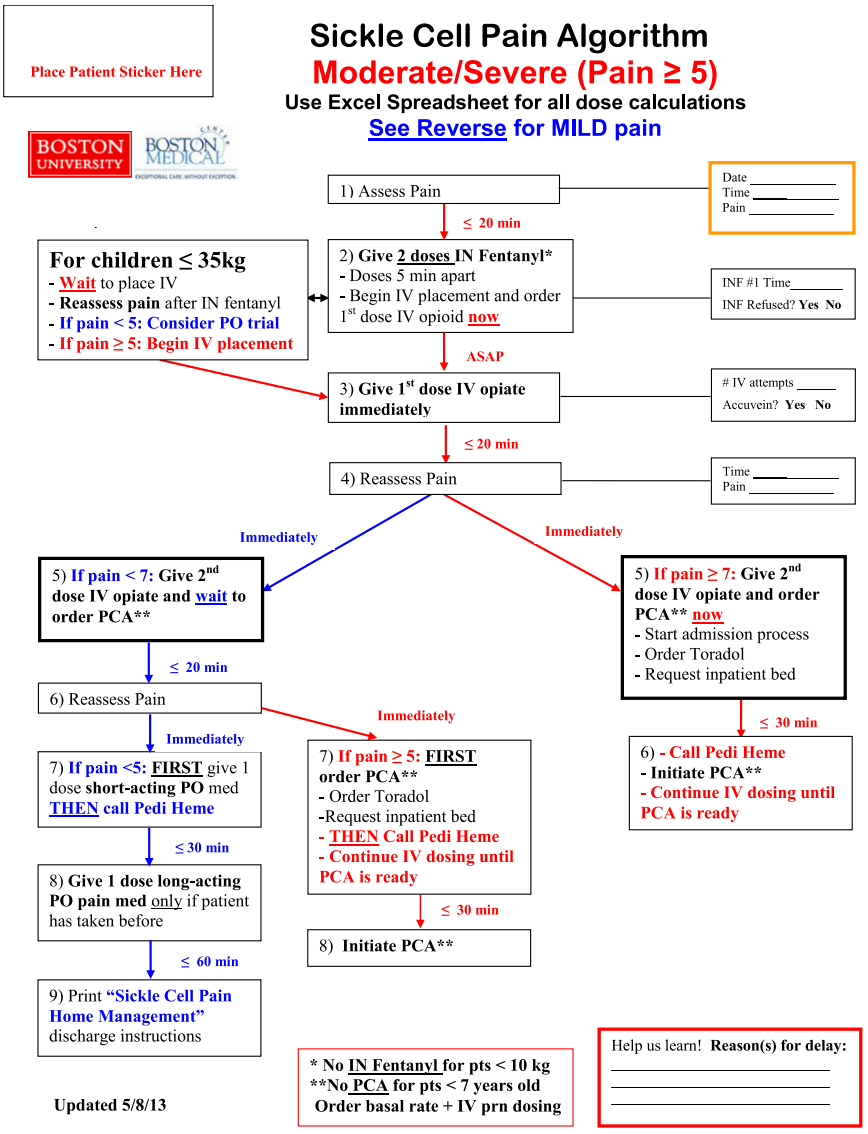


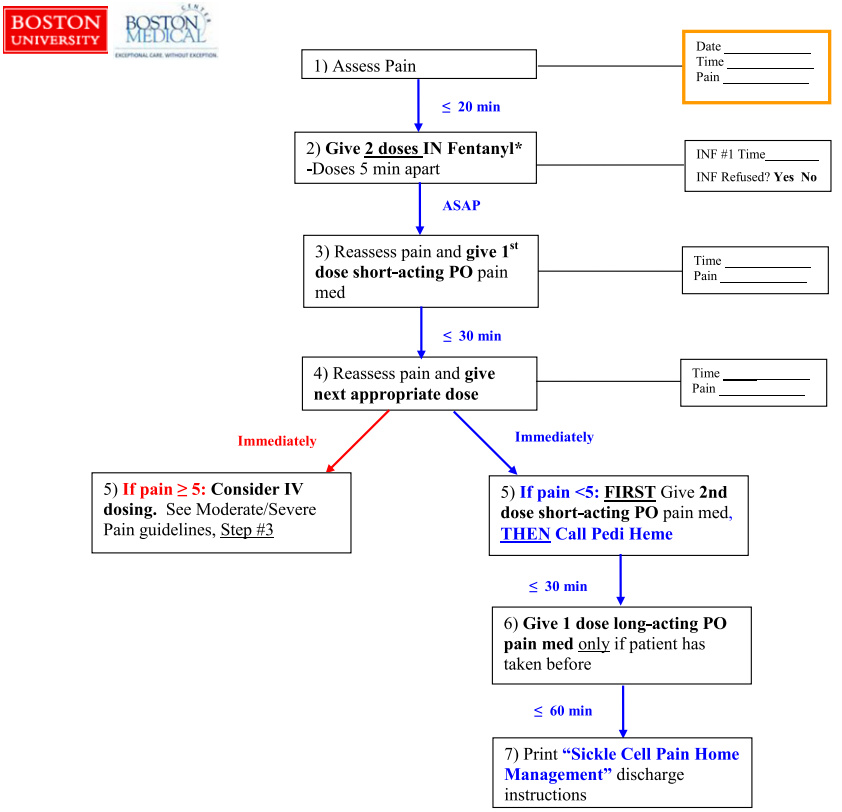
Place Patient Sticker Here

Sickle Cell Pain Algorithm

Mild (Pain < 5)

Use Excel Spreadsheet for all dose calculations

See Reverse for Moderate/Severe Pain



Help us learn! **Reason(s) for delay:**

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Updated 5/8/13

*** No IN Fentanyl for pts < 10 kg**

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