The Journal of Emergency Medicine, Vol. 58, No. 6, pp. 864–873, 2020

0736-4679/$ - see front matter

https://doi.org/10.1016/j.jemermed.2020.03.014

Original Contributions

KETAMINE SEDATION AND HYPOXIA: A QUALITY IMPROVEMENT PROJECT TO REDUCE RESPIRATORY EVENTS RECEIVING INTERVENTION

Alexandria J. Wiersma, MD,*† Benjamin Bernier, RN,* Jan Leonard, MSPH,*† Debra Faulk, MD,*† Michael DiStefano, MD,*† and Joseph Wathen, MD*†

*Department of Pediatric Emergency Medicine, Children's Hospital Colorado, Aurora, Colorado and †University of Colorado, School of Medicine, Aurora, Colorado

Reprint Address: Alexandria J. Wiersma, MD, Department of Pediatric Emergency Medicine, Children's Hospital Colorado, 13123 East 16th Avenue, Box 251, Aurora, CO 80045

☐ **Abstract—Background: Ketamine is a well-studied and safe medication used for procedural sedation in the pediatric emergency department (ED). However, in our ED and urgent care (UC), we had higher rates of respiratory events receiving intervention (REs) than has been reported nationally. Objective: A quality improvement (QI) project was initiated to address this problem with the following aim: during a 24-month period, we aimed to decrease REs during i.v. ketamine sedation from > 10% to < 6% in our network of EDs and UCs. Methods: Inclusion criteria included patients in our EDs and UCs who received i.v. ketamine for procedural sedation. We organized a multidisciplinary team to identify key drivers for the primary outcome (i.e., REs) and establish interventions. We based process measures on key interventions and utilized 2 Plan-Do-Study-Act (PDSA) cycles, which we evaluated with Shewhart *P* (provost) charts. Balancing measures included length of sedation, success of sedation, and length of stay. Results: REs decreased from 11.4% to 4.9%; this rate was maintained for 12 months, starting 1 month after PDSA cycle 2 implementation. There was no difference in REs for length of stay, length of sedation, or success of sedation. Conclusions: Using QI methodology, we reduced and maintained rates of RE to < 6%. Due to the nature of the project, it is difficult to link one intervention to the reduction in REs; however, a significant shift occurred just after PDSA cycle 2 interventions. This project can give a guideline for interventions to improve the safety of pediatric ketamine sedations.** © **2020 Elsevier Inc. All rights reserved.**

☐ **Keywords—pediatrics; sedation; ketamine; quality improvement**

INTRODUCTION

Ketamine is a well-studied and safe medication commonly used for procedural sedation in the pediatric emergency department (ED) (1–9). There is good evidence and guidelines to show that these sedations can be performed without an anesthesiologist present, and the American Academy of Pediatrics recognizes the utility of sedation in caring for children undergoing painful procedures (5,6,10). However, there is an increasing number of freestanding EDs, both hospital and non–hospital-affiliated, where sedations are being done. These sites may have limited access to anesthesiologists, other airway experts, or a higher level of care.

The Quebec guidelines define respiratory adverse events as hypoxia, apnea, airway obstruction, or laryngospasm that received an intervention (such as vigorous tactile stimulation, airway repositioning, suctioning, increased O_2, positive airway pressure, nasal/oral airway, and intubation) to resolve (11). Although transient hypoxia is common with any sedation, a respiratory event that receives intervention to resolve (RE) is an indication of deeper sedation and increases the risk of a serious adverse event (10,12). Because an increasing number of

RECEIVED: 7 October 2019; FINAL SUBMISSION RECEIVED: 5 March 2020;
ACCEPTED: 18 March 2020

sedations are being done outside of traditionally resourced operating rooms and tertiary care center EDs, ensuring patient safety by maintaining an appropriate level of sedation—dissociative sedation in the case of ketamine—is an important safety measure.

Our section of pediatric emergency medicine provides care at a main tertiary care ED, as well as an additional five EDs and urgent cares (UCs), four of which perform ketamine sedations. Current education on ketamine sedation includes an online procedural sedation course (which covers all types of sedation) that is required by physicians at the start of employment and has to be retaken every 2 years only if the minimum of five sedations per year is not met. Throughout our entire network, we have found higher rates of REs associated with ketamine sedation than has been reported the national literature (9.3–11.4% vs. 1.4–6.6%) (2,3,6,12,13). The importance of addressing this higher rate of adverse events is further emphasized as we continue to expand our network of freestanding EDs and UCs.

Ketamine has been found to have some affinity to opioid receptors, which could potentiate effects of opioids given prior to sedation (14,15). Previous studies have shown that opioid use prior to sedation increases rates of respiratory events (16). Additionally, body mass index (BMI) has been found to be associated with increased adverse events during pediatric sedation (17). On initial internal review of institutional data, opioids used within 90 min prior to ketamine sedation were found to be associated with REs. These data guided the direction of interventions for this project.

In this Quality Improvement (QI) project, our primary aim was to decrease rates of REs during ketamine sedation from > 10% to < 6% in our network of EDs and UCs. This goal is in line with national rates reported by the Pediatric Sedation Research Consortium (2,6).

Our secondary aim was to determine factors that are most closely associated with REs in order to intervene on those factors and disseminate that information to a broader audience. In addition to improving patient safety by decreasing rates of REs for patients at our institution, these aims together will create a new knowledge base for programs attempting to start, improve, or expand pediatric sedation programs and protocols.

METHODS

Our study was conducted at a freestanding, tertiary care children's center with a main campus ED, as well as four satellite EDs and UCs that all provide sedation. We perform about 750 i.v. ketamine sedations annually in our EDs and UCs. This is a QI project, designed using the classic Plan-Do-Study-Act (PDSA) cycle format aimed at these sedations. Inclusion criterion was the use of i.v. ketamine for procedural sedation. Exclusion criteria included other types of sedation or intramuscular ketamine.

We organized a multidisciplinary team to identify key drivers for the primary outcome. The team included one pediatric emergency fellow, two pediatric emergency physicians, two pediatricians (from our UC sites), two bedside nurses, two nursing educators, two pharmacists who work exclusively in the pediatric emergency department, one pediatric anesthesiologist, and one pediatric sedation specialist. We determined PDSA cycles based on discussion and input from the entire group utilizing several different QI methods (e.g., process mapping, key driver diagrams, stakeholder and barrier analysis, and fishbone diagrams). We found utilization of the key driver diagram, process mapping, and fishbone analysis to be the most helpful in determining root cause and brainstorming interventions (Figures 1–3). An explanation of QI tools used in the project is provided in the Appendix.

To determine best interventions, we reviewed baseline data for the rate of REs, as well other potentially associated factors, including weight and BMI, age, location of sedation, time of day, and use of pain medications prior to sedation. These data showed that only opioids used within 90 min of ketamine sedation were associated with an increased rate of REs ($p = 0.019$). We used these data as well as a review of the literature to define our PDSA cycle interventions. A key driver diagram shows the thought process behind each intervention (Figure 1). For each PDSA cycle, all of our approximately 75 sedating providers received educational interventions, as well as all of the approximately 150 nurses that work in our EDs and UCs. Education included e-mail notification and reminders, in-person presentations at staff meetings and huddles, and visual postings throughout work and break areas.

PDSA cycle 1 interventions included decreasing the initial dose of ketamine in patients who received an opiate within 90 min to 0.75 mg/kg and recommending smaller "top-off" doses of 0.5 mg/kg for maintaining dissociative sedation (this dose was based on literature that lower initial doses with repeat dosing help reduce risk of deeper levels of sedation and the fact that there is no official recommended starting dose for sedation at our institution—anywhere from a 0.5-mg/kg to 2-mg/kg initial dose has been used); requiring documentation of appropriate patient positioning (defined as having a neck roll in place, elevated head of bed, or the most appropriate position for the procedure as determined by the sedating physician); and education in ketamine pharmacodynamics (8,10). Lower dosing of ketamine was only recommended for patients who had received opioids within 90 min. Standard (1–1.5 mg/kg) dosing was recommend for all other patients.

PDSA cycle 2 interventions included recommendation to give ketamine during the appropriate time frame (1–2 min), measured via stopwatch by the charting nurse; recommendation to wait 3–5 min prior to administrating an additional dose (allowing for time for peak effect), height measurement of each patient to evaluate BMI (done by nursing either prior to or after sedation); creation of a sedation "fanny pack" to facilitate these measures, which included a tape measure, stopwatch, "time out" card, and a pictorial example of a proper neck roll. Of note, during this time, we did not ask providers to use the lower dose of ketamine recommended in PDSA cycle 1. We continued to monitor appropriate patient positioning. None of the interventions had been defined as official recommendations previously.

We collected data through Epic query and stored it in a RedCap database, maintained on the server of the approving institution. Data collection began in March 2017 and ran through March 2019. We compared data to pre-intervention data from January 1 through December 31, 2015. The project leads reviewed each chart for accuracy. We reviewed data on a monthly basis and control charts for REs were created using the QI charts 2.0 add-on for Microsoft Excel (Process Improvement Products, Austin, TX). Participating providers (both nursing and physician) were given updates on a monthly or every other month basis. The team met on a quarterly basis to determine need for changes in current interventions. We addressed any significant adverse changes to balancing measures as needed. This project is in maintenance phase, however, if any further interventions are needed, they will be determined through continued PDSA cycles.

Our primary outcome measure was percentage REs. An RE was defined as hypoxia < 88% oxygen (O_2) saturation for > 45 s that does not respond to tactile stimulation and needed supplemental oxygen, apnea or airway obstruction > 30 s even without hypoxia, or laryngospasm that required bagging or additional medications. This definition was based on of the Quebec Guidelines, but modified at our altitude to define hypoxia as an O_2 saturation of < 88% (the standard

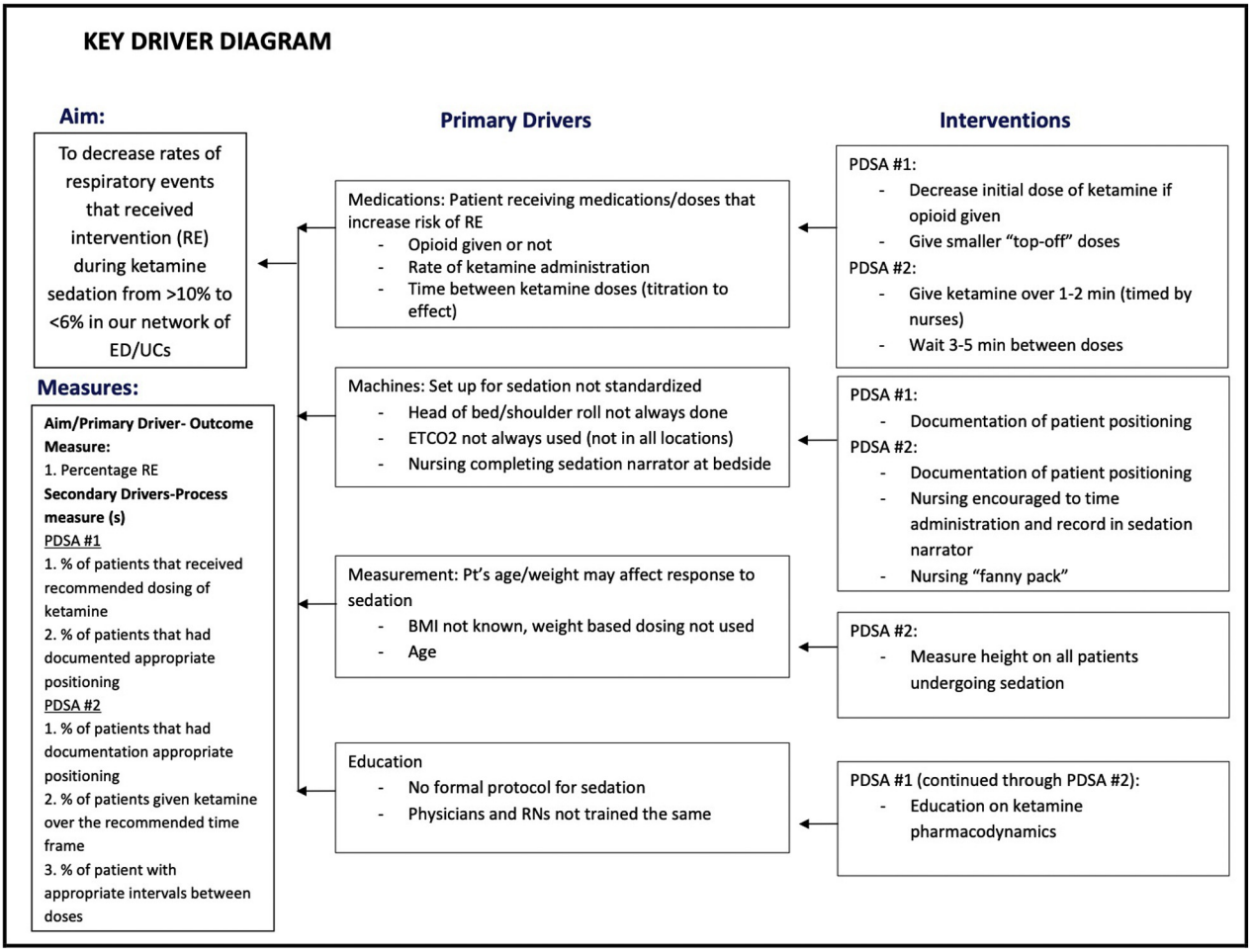

Figure 1. Key driver diagram for interventions in both Plan-Do-Study-Act (PDSA) cycle 1 and PDSA cycle 2. BMI = body mass index; ED = emergency department; ETCO2 = end-tidal carbon dioxide monitoring; RN = registered nurse; UC = urgent care.

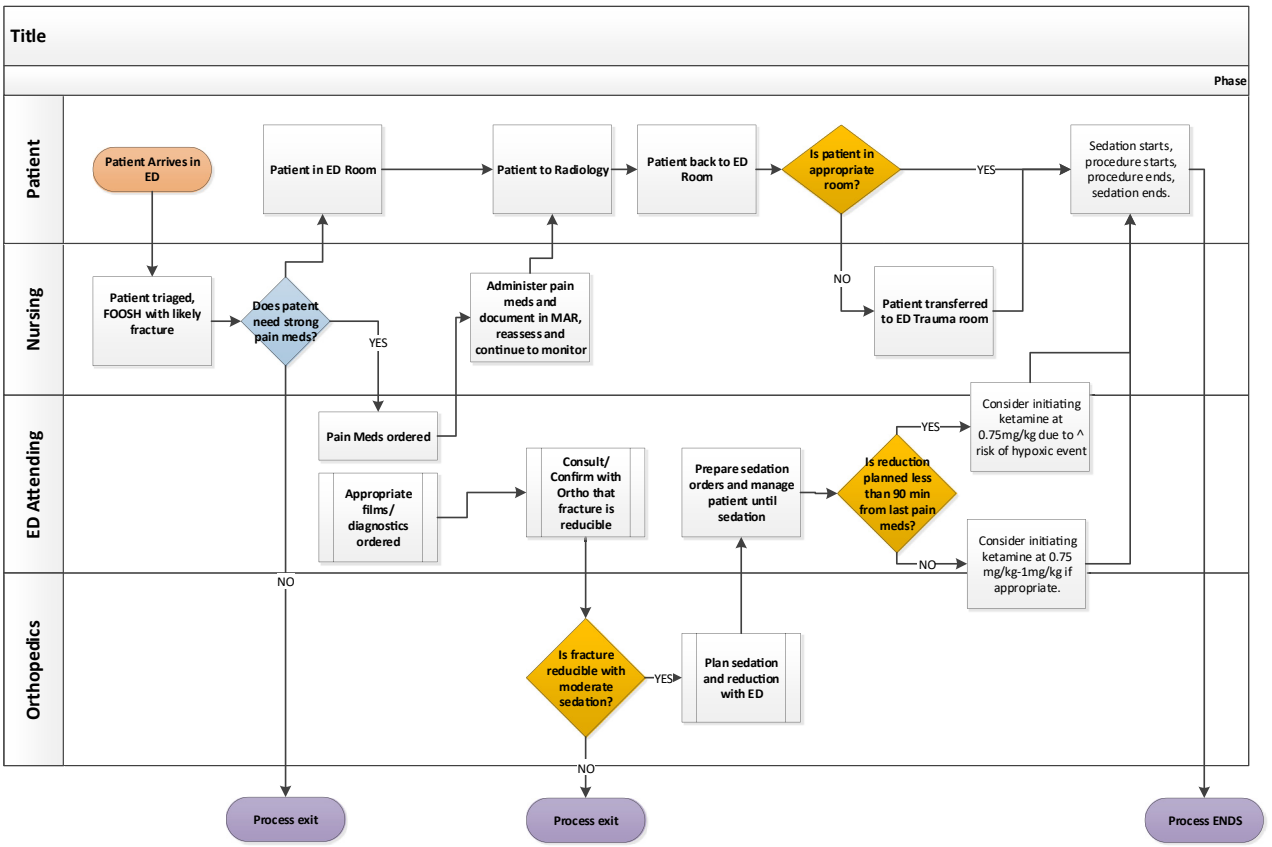

Figure 2. Process map of ketamine use in the emergency department (ED), specifically for use with fracture and sedation. This process map was used as a proxy for ketamine use in general as it represents the majority of ketamine use in the ED or urgent care (UC). FOOSH = fall onto outstretched hand; MAR = medicine administration record.

definition of hypoxia used at our institution) (11). We did not consider airway repositioning or suctioning as an RE, despite their inclusion in the Quebec Guidelines. A secondary outcome measure for PDSA cycle 1 was percentage REs in patients receiving opioid pain medication. There was no defined secondary outcome measure for PDSA cycle 2.

Process measures for PDSA cycle 1 included percentage of patients who received recommended dosing of ketamine (define as < 0.8 mg/kg to account for rounded doses) and percentage of patients who had documented appropriate positioning. Process measures for PDSA cycle 2 included percentage of patients who had documented appropriate positioning, percentage of patients

Figure 3. Photograph of fishbone diagram used during team meetings.

who were given ketamine over the recommended time frame, and percentage of patients who had recommended intervals between doses of ketamine. Balancing measures include length of sedation, success of sedation, and length of stay.

We used Shewhart *P* (provost) charts to continuously evaluate outcome measures during the intervention phase. On each *P* chart, we plotted our primary outcome (i.e., % RE) on the vertical axis vs. time on the horizontal axis. Each data point represented 1 month of ketamine sedations. We annotated the *P* charts with each PDSA cycle intervention and determined special cause variation using established special cause rules (see Appendix for clarification of these rules) (18). When special cause was detected, we calculated a new centerline and control limits, and continued to monitor control charts for sustained improvement.

We described patient characteristics using frequencies and percentages for categorical variables and median and interquartile ranges for non-normally distributed continuous variables. We compared patient characteristics during PDSA cycle 1 to patients during PDSA cycle 2 using χ^2 and Wilcoxon-Mann-Whitney tests for categorical and continuous variables, respectively. We also examined respiratory events by opioid use and by whether the PDSA cycle criteria were followed using χ^2, Fisher's exact, and Wilcoxon-Mann-Whitney tests, as appropriate. Statistical analyses were performed with SAS software, version 9.4 (SAS Institute, Cary, NC).

Ethical Considerations

This project was reviewed and approved by the Children's Hospital Organizational Research Risk and Quality Improvement Review Panel.

RESULTS

During the time period studied for PDSA cycle 1 (March 1, 2017 through March 31, 2018) and PDSA cycle 2 (April 1, 2018 through March 31, 2019), 1059 patients underwent i.v. ketamine sedation and met inclusion criterion. All data were compared to baseline rates from 1094 ketamine sedations done in 2015 (data were not collected in 2016). No patients were excluded from the analysis. There was no difference in the age of patients with an RE between the pre and postintervention group (pre-intervention median age 9.3 years; interquartile range [IQR] 4.4–12.7 years, post-intervention median age 8 years; IQR = 4–12 years; $p = 0.45$). Table 1 shows the baseline characteristic of patients during each phase of the project. There was no difference between PDSA cycle 1 and PDSA cycle 2 in age of patient, BMI (although not all patients had BMI documented), location of sedation, or indication for sedation. There was also no difference in the baseline characteristics for those who had an RE vs. those who did not for these same parameters, aside from location (Table 2). This is likely related to the fact that > 60% of our sedations are done at only one location. The final analysis included 562 patients between PDSA cycle 1 and PDSA cycle 2 (March 2017 through March 2018) and 497 patients after PDSA cycle 2 (April 2018 through March 2019).

Outcome Measures

There was no change in RE after PDSA cycle 1. There was special cause variation noted starting the month that PDSA cycle 2 interventions were implemented (9 consecutive points below the median line), meeting the goal for our project of percentage RE < 6%. This has been sustained for 12 months and the median rate is currently 4.9% (Figure 4). There was one out-of-control point during this time frame (January 2019). On review of these data, there were only 16 sedations performed this month (mean number of sedations per month throughout the project was 45), creating a higher percentage in the context of still very few REs (n = 3), so we did not recalculate baseline after this data point.

For PDSA cycle 1, we found that patients who received opioids had a higher percentage of respiratory events than those who did not, which was statistically significant for both i.v. morphine and i.v. fentanyl, but not intranasal (i.n.) fentanyl or other opioids (Table 3).

Process Measures

PDSA cycle 1. Ninety-eight percent of patients had appropriate positioning documented and 88% of patients had the recommended dosing used (Table 4). Within the PDSA cycle itself, there was no statistical difference in the rate of REs between patients who received an opioid and the lower recommended ketamine dose (7 of 62 [11.3%]), received an opioid but not the lower recommended ketamine dose (1 of 18 [5.6%]), or those who did not receive an opioid (49 of 482 [10.2%]) (Table 5).

PDSA cycle 2. Ninety-eight percent of patients had appropriate positioning documented. Thirty-three percent of patients had documented infusion times for the first dose of ketamine. Of those patients, 99% followed recommendations of administration > 60 s. In the group of patients who were given a second dose of ketamine (49% of all patients), 98% received this dose > 3 min after the first dose. This was noted as an appropriate pause (Table 4). Of those who had a documented infusion time < 60 s or did not receive the recommended time between doses (7 patients total), one had an RE. Within the PDSA cycle itself, there was no statistical difference in

Table 1. Clinical Characteristics of Patients During Each PDSA Cycle

Characteristic	PDSA Cycle 1 (n = 562)	PDSA Cycle 2 (n = 497)
Age, years, median (IQR)	7 (5–11)	7 (4–11)
BMI,* median (IQR)	17.4 (15.6–21.7)	17.6 (15.4–21.9)
Location of sedation, n (%)		
1	375 (66.6)	317 (63.8)
2	81 (14.4)	88 (17.7)
3	58 (10.3)	53 (10.7)
4	42 (7.5)	37 (7.4)
5	6 (1.1)	2 (0.4)
Sedation indication, n (%)		
Fracture reduction	352 (64.2)	319 (65.1)
Dislocation reduction	19 (3.5)	13 (2.7)
I&D	30 (5.5)	31 (6.3)
Laceration	74 (13.5)	72 (14.7)
Dental procedure	49 (8.9)	35 (7.1)
Other	24 (4.4)	20 (4.1)

BMI = body mass index; I&D = incision and drainage; IQR = interquartile range; PDSA = Plan-Do-Study-Act.
* BMI data only recorded for 47% of patients in PDSA cycle 1 and 38% of patients in PDSA cycle 2.

the rate of RE between patients with a documented infusion time ≥ 60 s (10 of 160 [6.3%]) vs. < 60 s (0 of 2 [0%]) vs. those without an infusion time documented (17 of 335 [5.1%]) (Table 5). The relation of opioid use to percentage RE was not measured in our second PDSA cycle in an attempt to streamline data collection, as we were no longer recommending decreased initial doses of ketamine in patients who had received opioids.

Balancing Measures

There was no change in length of sedation or length of stay before or after any interventions. Nearly all sedations were reported as successful (Table 4).

DISCUSSION

This coordinated, multidisciplinary QI project reduced the percentage of REs to < 6%, which was our goal and in line with reported national data (2,6). We sustained this improvement during a 12-month period. Although our first PDSA cycle did not show any improvement, we noticed improvement in our baseline RE rate after our second PDSA cycle. This is an important improvement not only for our tertiary ED site to be in line with national averages, but also for all sites where neither an anesthesiologist nor a higher level of care is immediately available.

Because several interventions occurred at once, it is difficult to link one particular intervention to the reduction in REs. However, our series of interventions, specifically timed dosing from PDSA cycle 2, was likely the most influential at creating and maintaining our change as other measured factors remained stable. Although documentation of our recommendations (both infusion time > 60 s and pause of 3–5 min between doses) was not ideal, there was a general sense of awareness and agreement with the project interventions based on informal polling of sedating providers. It is likely that physicians were being timed and followed recommendations without appropriate documentation of infusion length in the electronic medical record (EMR), partially explaining the significant change in RE that was observed.

It is important to note that we initially found that opioid use prior to sedation was associated with increased rates of RE. This has been described in the literature previously as a risk factor for respiratory adverse events, and our findings here highlight the importance of being mindful about the use of opioids in the setting of ketamine sedation (16). Specifically, we saw a statistically

Table 2. Clinical Characteristics of Patients With and Without a Respiratory Event Receiving Intervention

Characteristic	Airway Complication		*p* Value
	Yes (n = 84)	No (n = 975)	
Age, years, median (IQR)	8 (4–12)	7 (4–11)	0.34
BMI, median (IQR)	17.2 (15.4–21.9)	17.6 (15.6–21.8)	0.88
Location, n (%)			**0.02**
1	60 (71.4)	632 (64.8)	
2	3 (3.6)	166 (17.0)	
3	12 (14.3)	99 (10.2)	
4	8 (9.5)	71 (7.3)	
5	1 (1.2)	7 (0.7)	
Sedation indication, n (%)			0.87
Fracture reduction	54 (64.3)	617 (64.7)	
Dislocation reduction	4 (4.8)	28 (2.9)	
I&D	5 (6.0)	56 (5.9)	
Laceration	10 (11.9)	136 (14.3)	
Dental procedure	6 (7.1)	78 (8.2)	
Other	5 (6.0)	39 (4.1)	

BMI = body mass index; I&D = incision and drainage; IQR = interquartile range. *p* Values of <0.05 given in bold.

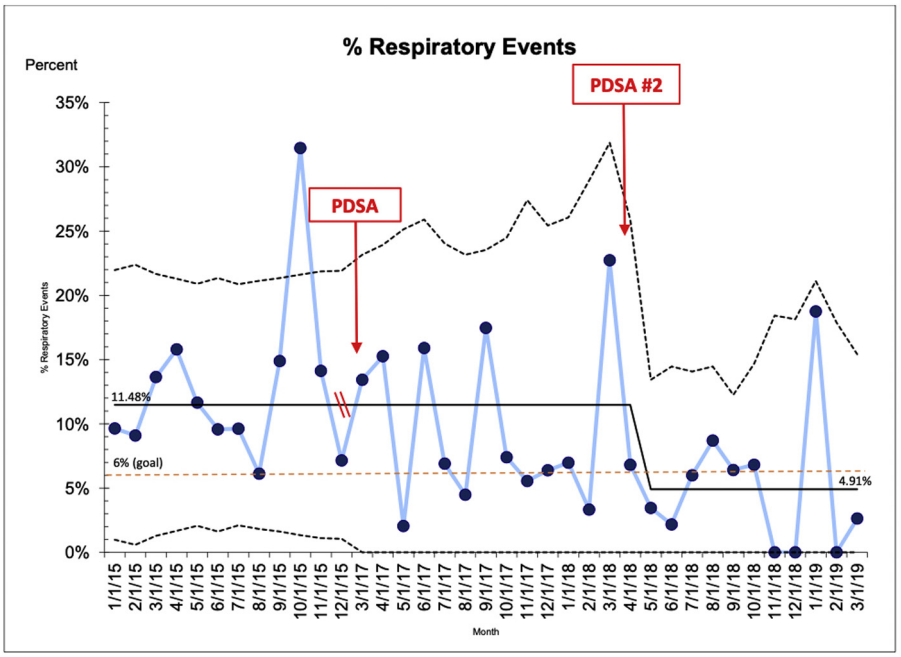

Figure 4. Shewhart *P* (provost) charts of percent respiratory events. The 2015 (pre-intervention data) and 2017 (project start) data are separated by double bars on the *P* chart. The variable hashed lines represent upper and lower control limits for the process, calculated off of 2 standard deviations of that moment in time. The straight hashed line sits at 6% respiratory events, both our goal and the national standard for respiratory events receiving intervention. The solid line represents the median of the process. Each dot represents the median percent respiratory events for that month.

significant increase of RE with the use of i.v., but not i.n., opioids. Given that many patients receiving i.v. ketamine sedation also need prior pain control, our data suggest that i.n. fentanyl is a preferred option. This may be due to the fact that i.n. fentanyl has a lower dose of maximum concentration than i.v. fentanyl (19).

BMI has been reported previously to be associated with adverse events (17). We attempted to gather BMI data on patients undergoing ketamine sedation. Nursing was asked to measure height on these patients at the time of the visit, however, this proved to be a difficult practice change to implement. Only 42% of patients had a documented height within 1 month of ketamine sedation, so additional analysis was not performed. Further work on this aspect, possibly creating ideal body weight–based dosing for ketamine at our institution, is ongoing.

As we did not see any changes in our balancing measures (length of stay, length of sedation, or success of sedation), we felt all of these interventions were safe and did not adversely affect patient care or flow of the department.

There have been many studies looking at the rates of adverse events associated with i.v. ketamine sedation, but to our knowledge, this is the first QI project to

Table 3. PDSA Cycle 1: Percent RE Associated with Opioid Use

Variable	Opioid, n/N (%)	No Opioid, n/N (%)	*p* Value
Any opioid	28/203 (13.8)	29/359 (8.1)	**0.03**
Morphine	14/82 (17.1)	29/359 (8.1)	**0.01**
i.v. fentanyl	7/36 (19.4)	29/359 (8.1)	**0.03**
i.n. fentanyl	13/108 (12.0)	29/359 (8.1)	0.21
Other opioid	1/4 (25.0)	29/359 (8.1)	0.29

i.n. = intranasal; PDSA = Plan-Do-Study-Act; RE = respiratory event receiving intervention. *p* Values of <0.05 are given in bold.

Table 4. Process and Balancing Measures

Variable	PDSA Cycle 1	PDSA Cycle 2	Goal, %
Process measures			
Documented appropriate positioning, %	98	98	>95
Recommended dosing used, %	88	NA	>95
Documented infusion time, %	NA	33	>95
Administered > 60 s, %	NA	99	>95
Appropriate pause between dose 1 and 2, %	NA	98	>95
Balancing measures			
Time sedated, min, median	54	53	No change
ED LOS, h, median	5.0	5.2	No change
Success of sedation, %	99	100	No change

ED = emergency department; LOS = length of stay; NA = not applicable; PDSA = Plan-Do-Study-Act.

Table 5. Respiratory Events by Whether the PDSA Cycle Criteria Were Followed

PDSA Cycle 1: Recommended Dosing Used When Received Opioid in Previous 90 Min	Followed PDSA Cycle Criteria, n (%)			
	Yes (n = 62)	No (n = 18)	Did Not Receive Opioid Within 90 Min (n = 482)	*p* Value
Airway complication				0.78
Yes	7 (11.3)	1 (5.6)	49 (10.2)	
No	55 (88.7)	17 (94.4)	433 (89.8)	
PDSA Cycle 2: Documented Appropriate Infusion Time (≥60 s)	Yes (n = 160)	No (n = 2)	Infusion Time Not Recorded (n = 335)	*p* Value
Airway complication				0.71
Yes	10 (6.3)	0 (0)	17 (5.1)	
No	150 (93.8)	2 (100)	318 (94.9)	

PDSA = Plan-Do-Study-Act.

specifically address decreasing respiratory events associated with ketamine sedation (2,3,6,7,12,13). Given the rise of the freestanding ED, it is important to maintain safety and quality standards throughout all patient encounters, regardless of location. For ketamine sedation specifically, back-up resources (i.e., anesthesia and intensive care unit level care) may not be available in freestanding locations, highlighting the importance of ideal safe practice ketamine administration. This study can help in the development of sedation protocols and guidelines in pediatric emergency care.

Limitations

Our study has several limitations. Our results are not generalizable for several reasons; this is a QI project with the goal of improving our system at a local level, we practice at a higher altitude than most, and our rate of RE was higher than the national average to begin. However, the underlying idea and framework of our study can be applied and tested in other settings. Another limitation was a gap in data collection. This project was based on 2015 data; data from 2016 were not collected. We assumed 2016 data would be similar to the 2015 baseline rate because prior reports on percentage REs from our institution were similar, no changes to our process had been made, and our PDSA cycle 1 intervention saw no change (13).

We acknowledge that simple awareness of the project and refocus on education through signage, multiple e-mails, and knowledge that sedations were being audited may have created other unintended confounders not defined here. It is also possible that our interventions seemed successful because of improved documentation of what was defined as a respiratory event. For example, previously transient hypoxia may have been recorded instead of true hypoxia receiving intervention; however, we would have likely seen improvement in both PDSA cycles if this was a primary factor. Because length of hypoxia is not routinely charted in the ED, and does not have a specific location for documentation in the EMR, it is impossible to retrospectively review this hypothesis. We acknowledge that grouping a respiratory event such as hypoxia with more severe adverse events, such as apnea or laryngospasm, seems broad. We grouped all REs together as done in the Quebec Guidelines and to allow comparison to national rates.

CONCLUSIONS

We were able to use QI methodology through a multidisciplinary team to decrease the percentage of REs at all of our EDs and UCs. We also found that opioid use within 90 min prior to sedation was associated with increased number of adverse airway events, supporting prior literature. As the number of both university-affiliated and freestanding EDs and UCs increases both at our institution and nationally, protocols for sedation are necessary to protect the safety of our patients. This project helps to remind us of important variables surrounding i.v. ketamine sedation and can serve as a framework for the creation of these protocols. Continued efforts will focus on sustaining this improvement and seeking further process interventions that together can lead to an ideal ketamine sedation clinical pathway.

Acknowledgments—The authors thank Timothy Browne, medical student at the University of Colorado School of Medicine, for help with data collection.

Author contributions: Dr. Wiersma conceptualized and designed the study and data collection instruments, coordinated, assisted with and supervised data collection, carried out the initial analysis, drafted the initial manuscript, and reviewed and revised the manuscript. Mr. Bernier conceptualized and designed the study, collected and interpreted baseline data, and

assisted with data collection. Ms. Leonard carried out data analyses and reviewed and revised the manuscript. Dr. DiStefano assisted with design of data collection instruments and critically reviewed and revised the manuscript for important intellectual content. Dr. Faulk and Dr. Wathen conceptualized and designed the study and critically reviewed and revised the manuscript for important intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jemermed.2020.03.014.

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ARTICLE SUMMARY

1. Why is this topic important?

Ketamine sedations are known to be common and safe for pediatric patients; however, adverse respiratory events (defined in this study as respiratory events receiving intervention [REs]) still occur. As the number of freestanding emergency departments increases, ensuring the safest possible sedation is imperative.

2. What does this study attempt to show?

Through quality improvement methodology, the percentage of REs can decrease significantly, improving overall patient safety.

3. What are the key findings?

We were able to decrease our rate of REs from > 11% to < 6% using quality improvement methodology, specifically by standardizing the way that ketamine is administered. Rates of REs are increased when opioids are used prior to sedation. This is less common with intranasal fentanyl than with other i.v. opioids.

4. How is patient care impacted?

This improves patient safety during ketamine sedation. When there are fewer REs, the overall risk of experiencing respiratory deterioration in patients receiving ketamine sedation decreases, which in turn decreases patient harm.