Nurse-Implemented Goal-Directed Strategy to Improve Pain and Sedation Management in a Pediatric Cardiac ICU

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Objectives: To assess the impact of a nurse-implemented goal-directed sedation strategy on patient care and nursing practice in a pediatric cardiac ICU.

Design: Quality improvement project with a pre-post interval measurement plan.

Setting: Thirty-one bed pediatric cardiac ICU in a freestanding tertiary care children's hospital.

Patients: Postoperative pediatric cardiac surgery patients.

Interventions: The implementation of cardiac-Randomized Evaluation of Sedation Titration for Respiratory Failure (RESTORE), a nurse-implemented goal directed strategy to improve pain and sedation management in a pediatric cardiac ICU which included daily team discussion of the patient's trajectory of illness (acute, titration, or weaning phase), prescription of a sedation target score based on the patient's trajectory of illness, arousal assessments, and opioid and/or sedative titration. Withdrawal Assessment Scores were used to assess and manage iatrogenic withdrawal symptoms.

Measurements and Main Results: Data related to opioid and sedation use, pain and sedation scores, and the occurrence and management of iatrogenic withdrawal symptoms were reviewed on 1,243 patients during four separate time periods: one pre-implementation and three discontinuous post-implementation time intervals. Patient age and complexity were consistent across the data collection periods. Post-implementation opioids and benzodiazepines use was reduced about 50% without a concomitant increase in the use of other sedative classes. Few post-intervention patients were discharged from the pediatric cardiac ICU or to home on methadone (pediatric cardiac ICU: pre 19% to post 3%; hospital: pre 12% to post 1.3%). Documentation of pain, sedation, and withdrawal scores became more consistent and nurses reported satisfaction with their patient's comfort management.

Conclusions: The implementation of a nurse-driven goal-directed plan such as cardiac-RESTORE to manage pediatric cardiac ICU patient pain and sedation is possible, sustainable, and associated with reduced sedative and methadone use. (*Pediatr Crit Care Med* 2020; 21:1064–1070)

Key Words: benzodiazepine weaning; iatrogenic withdrawal syndrome; opioid weaning; RESTORE clinical trial; State Behavioral Scale; Withdrawal Assessment Tool-version 1

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Pain and agitation management in critically ill pediatric cardiac patients is complex. These patients typically receive pain and sedative medications for comfort, patient safety, and to help maintain hemodynamic stability (1). Some pediatric cardiac patients follow a short, acute course of illness from which they quickly recover. However, others endure an extended time of critical illness requiring mechanical ventilation and inotropic support and undergo multiple surgeries or cardiac interventions (2). These patients have limited cardiac reserve and typically require prolonged exposure to opioids and sedatives. Over time with repeated administration of these types of medications, drug tolerance occurs, requiring increased dosing. With recovery comes the risk of iatrogenic withdrawal syndrome (IWS) when opioid and sedation medications are reduced (3).

Practice variation when managing the comfort of critically ill children may lead to excessive opioid and sedation exposure and is stress-provoking for both families and clinicians alike. Data from the Randomized Evaluation of Sedation Titration for Respiratory Failure (RESTORE) trial showed that critically ill intubated pediatric patients with acute respiratory failure could be safely managed in a more awake and calm state with a nurse-implemented goal-directed sedation strategy (4). Associated benefits from this approach included fewer days of opioid exposure and use of fewer sedative classes without an increase in clinically significant pain, agitation, or iatrogenic withdrawal (4). Reducing sedative exposure is important given the increasing concern that sedatives, commonly used during critical illness, may be neurotoxic during the period of early brain development. Animal studies found that even transient administration of benzodiazepines and other sedatives during periods of developmental synaptogenesis (5) caused widespread neuronal apoptosis and residual learning and memory deficits (6–10).

Here we report the results of a quality improvement project that applied a modified version of the RESTORE protocol for pain and sedation management of children recovering from cardiac surgery in our pediatric cardiac ICU (PCICU). The goals of cardiac-RESTORE, a nurse-implemented goal-directed strategy to improve pain and sedation management in a PCICU, were to decrease practice variation in pain and sedation management, as evidenced by reduced patient exposure to opioid and sedation medications, including methadone, "without" clinically important increases in pain, agitation, or withdrawal symptoms.

MATERIALS AND METHODS

Our unit, a 31-bed PCICU, is located in a freestanding children's hospital associated with a major medical school and research facility. We provide care to medical and surgical patients, newborns through adolescents, with congenital or acquired heart disease. Approximately 160 registered nurses provide care in the unit with a nurse-patient ratio of 1:1 or 1:2. Medical providers, including nurse practitioners (NPs), cardiology fellows, and attending physicians staff the unit 24/7.

Cardiac-RESTORE, a nurse-implemented, goal-directed plan to manage patient pain and sedation was a replication of the previously published RESTORE protocol with the addition of a fast-track section to manage the immediate postoperative period in cardiac surgical patients. Similar to the original RESTORE work, cardiac-RESTORE included daily team discussion of the patient's trajectory of illness (acute, titration, or weaning phase); daily prescription of a sedation target per phase of illness using the State Behavioral Scale (SBS); arousal assessments if the patient is too sedate (reducing sedative infusions by 50% until the patient's SBS matches the sedation target); titration of sedatives to achieve the prescribed sedation target at least every 8 hours; discontinuation of opioids and benzodiazepines when no longer necessary (if opioid/sedative exposure < 5 d) or weaned per target Withdrawal Assessment Tool-version 1 (WAT-1) score; and if opioid/sedative exposure greater than or equal to 5 days (4). When titrating sedatives, the nurse increased or decreased the continuous infusion(s) based on the number of as needed bolus doses administered in the previous 8 hours; for example, sedative infusions were increased if three total nonprocedural rescue bolus sedatives were administered within 8 hours or less from the last titration; sedative infusions were decreased if one or two nonprocedural rescue bolus sedatives were administered in 8 hours from the last titration. A written sedation weaning plan was developed and accompanied the patient upon PCICU transfer to the inpatient unit. Primary medications prescribed in cardiac-RESTORE included morphine and midazolam administered via intermittent bolus if expected to be extubated within 24 hours or by continuous infusion. Fentanyl was preferred over morphine for newborns, hemodynamically unstable patients and those with reactive airway disease. Secondary agents included dexmedetomidine for inadequate response to the primary sedative agents and propofol infusion to facilitate endotracheal extubation (4). The patient's cardiac physiology was considered with analgesia and sedation choices and for dosing decisions. Pain assessments were performed using age and developmentally appropriate instruments; specifically, the Face, Legs, Activity, Cry, Consolability scale in nonverbal children 0 to 6 years old; the Individualized Numeric Rating Scale in nonverbal cognitively impaired children 6 years old or older; and the Wong-Baker Faces Pain Scale in verbal children 3 years old or older (11–13). All pain scales range from 0 to 10, with higher scores indicating more pain. The SBS was used to describe patient sedation levels (14). The presence of IWS was assessed with the WAT-1 (15) and first managed with the administration of enteral clonidine. Methadone was prescribed only if WAT-1 scores continued to be above target after sedative weaning intervals and/or other sedative dosages adjusted (4).

Implementation Plan

We designed an implementation plan to address anticipated barriers. Project planning was initiated 1 year prior to the go-live date. An interdisciplinary implementation team included a PCICU clinical nurse specialist, a NP, a PhD prepared nurse scientist, PCICU physicians, and attending cardiac surgeons. Other participants included a clinical pharmacist, respiratory therapy, and clinical informatics specialists who managed data extraction from electronic medical records (EMRs). Furthermore, a quality improvement consultant and a biostatistician provided data management and analytical support, respectively. The hospital's Institutional Review Board determined that the project did not meet the regulatory criteria for human subjects' research and was classified as a quality improvement activity.

Educational modules were developed for PCICU nursing and physician staff. These modules included the cardiac-RESTORE algorithm and two online modules with post-tests; one reviewing the pain, sedation, and IWS assessment instruments and the other, a scenario-based review of the algorithm. An electronic order set for initiation and management of sedation and analgesia was created for our computerized order entry system. The PCICU NPs assumed responsibility for deploying the order set. Each day on patient care rounds, the

trajectory of illness and targeted SBS scores were updated to drive sedation decision-making based on the algorithm.

The clinical informatics team embedded key elements of cardiac-RESTORE into the EMR. Examples included the introduction of the "Illness Trajectory" field in the comfort/neurology assessment section of the EMR and the addition of a patient WAT-1 for assessment IWS. This allowed auto-capture and data extraction for quality monitoring.

Each staff nurse in our PCICU was assigned to a nurse champion who presented cardiac-RESTORE in huddles and met with staff individually to answer questions. Every nurse completed an online module that required a 90% passing score. A PCICU NP champion led 1:1 NP training that included review of the order set. The project's physician lead coordinated all physician training and communication. All training was completed over 1 month period of time.

Following the go-live start date, all new surgical patients admitted to the PCICU were started on cardiac-RESTORE. Project leads or champions monitored cardiac-RESTORE compliance daily and documented the clinical rationale for any practice variation. Nurse champions, assigned every shift and provided additional real-time support and teaching reinforcement. Other continued educational support included weekly updates, implementation of "Question of the Week" sent via email, and signage containing sedation management advice throughout the unit. Finally, cardiac-RESTORE education was included in both nursing and physician orientation classes and reviewed monthly in "Cardiac-RESTORE Challenging Case" discussions.

Given the expanse of this practice change, we planned a phased roll-out to allow for close monitoring and attention to clinician concerns. In March 2015, we implemented cardiac-RESTORE in postoperative cardiac surgery patients admitted to one of three provider teams. We then, in 2-week increments, expanded cardiac-RESTORE to include the remaining two teams. One year later, we expanded the use of cardiac-RESTORE to include all PCICU patients including nonsurgical patients (data not reported here).

Monitoring Plan

We monitored practice variation at a macro level because we designed cardiac-RESTORE to supplement, not replace, clinicians' clinical judgment. Clinicians could over-write sedation order sets based on their clinical judgment, and we purposely monitored the net effect of their interventions and not clinician-level adherence to this quality improvement project.

Data, auto extracted from our EMR, was validated by the team's clinical nurse specialist. We prospectively implemented new comfort metrics that integrated assessment-intervention-reassessment comfort scores with time to critical intervention data. These new metrics captured the extent to which patients were assessed/reassessed, and the duration of time out of target scores were brought into an acceptable range. Specifically, pain scores greater than or equal to 4 to be reduced below 4 in 1 hour, SBS scores greater than or equal to 1 to be less than or equal to 0 in 1 hour, and WAT-1 scores greater than or equal to 3 to be reduced below 3 in 4 hours. We monitored all Safety Event Reporting System data for sedation-related events, for example, sedation-related self-extubation. We collected data on the use of all comfort medications as well as the use of methadone and clonidine at PCICU transfer and hospital discharge, duration of mechanical ventilation, and PCICU and hospital lengths of stay. Surgical procedure complexity was categorized using the Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery (STAT) score (16). A separate Research Electronic Data Capture (REDCap) database (17), hosted by Boston Children's Hospital, was developed to capture nurse satisfaction with their patient's comfort management. Specifically, PCICU nurses were asked "how satisfied are you with this patient's sedation management on a scale of 1 (least satisfied) to 10 (most satisfied)?" Parent satisfaction data were collected by adding two questions to an existing postdischarge survey: 1) during the hospitalization for heart surgery, did your child receive medication or treatment for pain? (yes/no) and 2) if yes, how often was your child's pain controlled? (never, sometimes, usually, always).

All surgical patients who received mechanical ventilation and had a PCICU length of stay (LOS) greater than 24 hours were tracked. The pre-implementation interval included patients hospitalized between December 2014 and February 2015. Post-implementation interval included three discontinuous time periods; interval one included patients from May 2015 to July 2015, interval two included patients from September 2015 to February 2016, and interval three included patients from September 2016 to February 2017. These time periods supported wash-in periods and pre-post and sustainability measurement.

Statistical Analysis

Categorical variables were summarized as frequency (percent), and continuous variables as median (25–75th percentile) unless otherwise specified. Comparisons across the four cohorts were performed using the chi-square test for categorical variables and the Kruskal-Wallis test for continuous variables. Comparisons of mechanical ventilation time, postoperative PCICU LOS, and hospital LOS are adjusted for age and STAT category using linear regression analysis; because these outcomes had skewed distributions, a natural logarithm transformation was used. All analyses were performed in SAS Version 9.4 (SAS Institute, Cary, NC).

RESULTS

In total, data were collected on 1,243 postoperative cardiovascular surgical patients during one pre or three post-intervention time intervals. As reviewed in **Table S1** (Supplemental Digital Content 1, http://links.lww.com/PCC/B416), patient age and Risk Adjustment for Congenital Heart Surgery (RACH-1) categories were similar across the four time intervals. Median patient age ranged from 1.7 years (interquartile range [IQR], 0.3–9.5 yr) to 2.8 years (IQR, 0.4–9.8 yr); the most common RACHS-1 category was category 3 followed by category 2. More patients in post-implementation interval one scored in STAT category 1 (May 2015 to July 2015) and fewer in categories 4–5 relative to other three time intervals.

TABLE 1. Comfort Medication Utilization Across Four Time Intervals

Characteristics	Pre-RESTORE	Post-RESTORE 1	Post-RESTORE 2	Post-RESTORE 3	*p*
Patients with medication data, *n*	212	240	374	397	
Morphine					
Any exposure, *n* (%)	208 (98)	231 (96)	371 (99)	386 (97)	NS
Cumulative dose[a]	1.12 (0.28–5.92)	0.57 (0.25–2.23)	0.86 (0.26–3.19)	0.60 (0.25–2.23)	0.008[e]
Average dose[b]	0.21 (0.10–0.62)	0.14 (0.08–0.39)	0.18 (0.08–0.50)	0.15 (0.07–0.38)	0.005[e]
Peak dose[b]	0.51 (0.15–2.15)	0.29 (0.14–1.25)	0.36 (0.14–1.37)	0.29 (0.15–0.95)	0.007[e]
Fentanyl					
Any exposure, *n* (%)	75 (35)	43 (18)	94 (25)	99 (25)	< 0.001[f]
Cumulative dose[c]	8.97 (1.40–36.6)	1.55 (0.34–8.98)	2.00 (0.35–7.46)	2.73 (0.39–12.2)	< 0.001[f]
Average dose[d]	1.15 (0.46–3.03)	0.45 (0.14–1.67)	0.66 (0.22–1.67)	0.93 (0.31–2.41)	0.023[f]
Peak dose[d]	2.95 (0.94–6.97)	1.14 (0.21–4.19)	1.33 (0.31–3.70)	1.99 (0.39–5.16)	0.002[f]
Midazolam					
Any exposure, *n* (%)	199 (94)	217 (90)	344 (92)	366 (92)	NS
Cumulative dose[a]	0.60 (0.12–3.68)	0.29 (0.09–1.41)	0.40 (0.10–1.85)	0.25 (0.08–1.09)	< 0.001[g]
Average dose[b]	0.13 (0.05–0.50)	0.09 (0.04–0.30)	0.11 (0.05–0.39)	0.08 (0.04–0.23)	< 0.001[g]
Peak dose[b]	0.32 (0.08–1.45)	0.17 (0.05–0.76)	0.24 (0.07–1.00)	0.15 (0.05–0.52)	< 0.001[g]
Lorazepam					
Any exposure, *n* (%)	85 (40)	66 (28)	110 (29)	114 (29)	0.014[h]
Cumulative dose[a]	0.32 (0.15–9.09)	0.20 (0.08–0.62)	0.18 (0.09–0.67)	0.17 (0.07–0.93)	0.007[h]
Average dose[b]	0.17 (0.07–0.61)	0.09 (0.05–0.17)	0.11 (0.06–0.23)	0.09 (0.06–0.24)	0.011[h]
Peak dose[b]	0.17 (0.08–1.13)	0.14 (0.06–0.33)	0.14 (0.06–0.30)	0.14 (0.07–0.38)	0.010[h]
Clonidine, *n* (%)					
Any exposure	24 (11)	16 (7)	48 (13)	40 (10)	NS
Dexmedetomidine, *n* (%)					
Any exposure	87 (41)	89 (37)	158 (42)	153 (39)	NS

NS = not significant, RESTORE = Randomized Evaluation of Sedation Titration for Respiratory Failure.

[a]mg/kg/visit.

[b]mg/kg/d.

[c]µg/kg/visit.

[d]µg/kg/d.

[e]Morphine doses for post-RESTORE 1 and 3 are lower than for pre-RESTORE.

[f]Fentanyl exposure is lower in all three post-RESTORE cohorts compared to pre-RESTORE; when fentanyl is used, the doses are lower for post-RESTORE 1 than for pre-RESTORE.

[g]When midazolam is used, doses are lower for post-RESTORE 1 and 3 than for pre-RESTORE.

[h]Lorazepam exposure is lower for all three post-RESTORE cohorts compared to pre-RESTORE; when lorazepam is used, the doses are lower for all three post-RESTORE cohorts than for pre-RESTORE.

Values are expressed as median (interquartile range) unless otherwise stated.

Comfort medication data across the four time intervals are presented in **Table 1**. In summary, post-implementation opioid and benzodiazepine dosing was reduced by 50% and post-implementation use of alpha antagonists did not increase. When compared to the pre-implementation interval, post-implementation morphine dosing (interval 1 and 3) was significantly lower (cumulative, average, and peak dosing); fentanyl exposure was also significantly lower during the three post-implementation time intervals with lowest doses prescribed during post-intervention interval one. When midazolam was used, post-implementation doses in interval one and three were lower than the pre-implementation period. Compared to the pre-implementation interval, lorazepam exposure was also lower during all three post-implementation intervals. Cumulative doses of clonidine were lower for post-implementation interval one than for any other time interval and, when compared to the pre-intervention interval, cumulative doses of dexmedetomidine were lower in all three post-intervention intervals.

TABLE 2. Risk-Adjusted Patient Outcomes Across Four Time Intervals

Characteristics	Pre-RESTORE	Post-RESTORE 1	Post-RESTORE 2	Post-RESTORE 3	*p*
Total *n*	231	241	374	398	
Duration of mechanical ventilation, hr[a]	16 (5–47)	11 (4–29)	22 (9–75)	18 (8–60)	< 0.001[b]
Postoperative CICU LOS, d[a]	3 (2–8)	2 (1–5)	2 (1–5)	2 (1–5)	< 0.001[c]
Postoperative hospital LOS, d[a]	8 (5–17)	6 (4–9)	7 (5–12)	7 (5–11)	< 0.001[d]
At CICU discharge, *n* (%)					
Prescribed methadone	43 (19)	6 (2)	16 (4)	12 (3)	< 0.001[e]
Prescribed benzodiazepines	136 (59)	140 (58)	173 (46)	148 (37)	< 0.001[f]
Prescribed clonidine	9 (4)	8 (3)	36 (10)	30 (8)	0.007[g]
At hospital discharge, *n* (%)					
Prescribed methadone	28 (12)	3 (1)	9 (2)	4 (1)	< 0.001[h]
Prescribed benzodiazepines	40 (17)	8 (3)	46 (12)	45 (11)	< 0.001[i]
Prescribed clonidine	11 (6)	6 (3)	24 (6)	19 (5)	Not significant

CICU = cardiac ICU, LOS = length of stay, RESTORE = Randomized Evaluation of Sedation Titration for Respiratory Failure.
[a]*p* values adjusted for age and Society of Thoracic Surgeons-European Association for Cardio-Thoracic Surgery category; median (interquartile range).
[b]Duration of mechanical ventilation is shorter for post-RESTORE 1 than for any other cohort.
[c]Postoperative pediatric CICU LOS is shorter post-RESTORE.
[d]Postoperative hospital LOS is shorter post-RESTORE; postoperative hospital LOS is shorter for post-RESTORE 1 than for post-RESTORE 2 or 3.
[e]Methadone use at CICU discharge is lower post-RESTORE than pre-RESTORE.
[f]Benzodiazepine use at CICU discharge is lower for post-RESTORE 2 and 3 than for pre-RESTORE or post-RESTORE 1.
[g]Clonidine use for post-RESTORE 2 is higher than for post-RESTORE 1.
[h]Methadone use at hospital discharge is lower post-RESTORE than pre-RESTORE.
[i]Benzodiazepine use at hospital discharge is lower for post-RESTORE 1 than at any other time.

Table 2 summarizes risk-adjusted patient outcomes including duration of mechanical ventilation and lengths of PCICU and hospital stay. Mirroring the STAT category, the risk-adjusted duration of mechanical ventilation was significantly shorter in post-implementation interval one than any other time interval. When compared to the pre-intervention time period, PCICU and hospital LOS was significantly shorter in every post-implementation time interval. No sedation-related serious adverse events occurred during the four time intervals.

Table 2 also presents data on the use of methadone, benzodiazepines, and clonidine prescribed at PCICU and hospital discharge. Compared to the pre-implementation interval, fewer patients have prescribed methadone at PCICU and hospital discharge at every post-implementation time interval. Compared to the pre-implementation and post-interval one, fewer patients were PCICU discharged on benzodiazepines during post-implementation interval two and three; fewer patients were discharged from the hospital on benzodiazepines during post-implementation interval one than any other time interval. Compared to post-implementation interval one, clonidine use at PCICU discharge was significantly higher during post-implementation interval two. There were no significant differences in clonidine use at hospital discharge across the four time intervals.

There were no significant differences in pain scores across the four time intervals (**Fig. 1*A***). Nursing time to critical intervention for elevated pain scores progressively improved in post-implementation intervals two and three. SBS scores were significantly lower for post-implementation interval two than for the remaining three intervals (**Fig. 1*B***). Compared to the pre-intervention interval, nursing time to critical intervention for agitation improved significantly for all post-implementation time intervals. Documentation of WAT-1 scores to assess for iatrogenic withdrawal was systemically implemented with cardiac-RESTORE; thus, WAT-1 score distributions and compliance with time to critical intervention across the four cohorts cannot be compared. Of note, patients did not experience more IWS symptoms after cardiac-RESTORE was implemented (**Fig. S1**, Supplemental Digital Content 2, http://links.lww.com/PCC/B417; legend: WAT-1 scores [median, IQR] and % of WAT-1 scores ≥ 3 successfully managed within 4 hr).

Post-implementation of cardiac-RESTORE, PCICU staff nurses were satisfied with their patient's comfort management; specifically, 112 nurses were surveyed over 18 months and their median satisfaction score were 8.5 with an IQR of 10–8. Parent satisfaction with their child's pain management also remained high post-implementation of cardiac-RESTORE, with an average of 88% of parents reporting that their child's pain was usually or always well controlled during PCICU stay.

DISCUSSION

We successfully implemented a nurse-implemented standardized approach to pain and sedation management in a large PCICU, documenting reduced patient exposure to opioid and

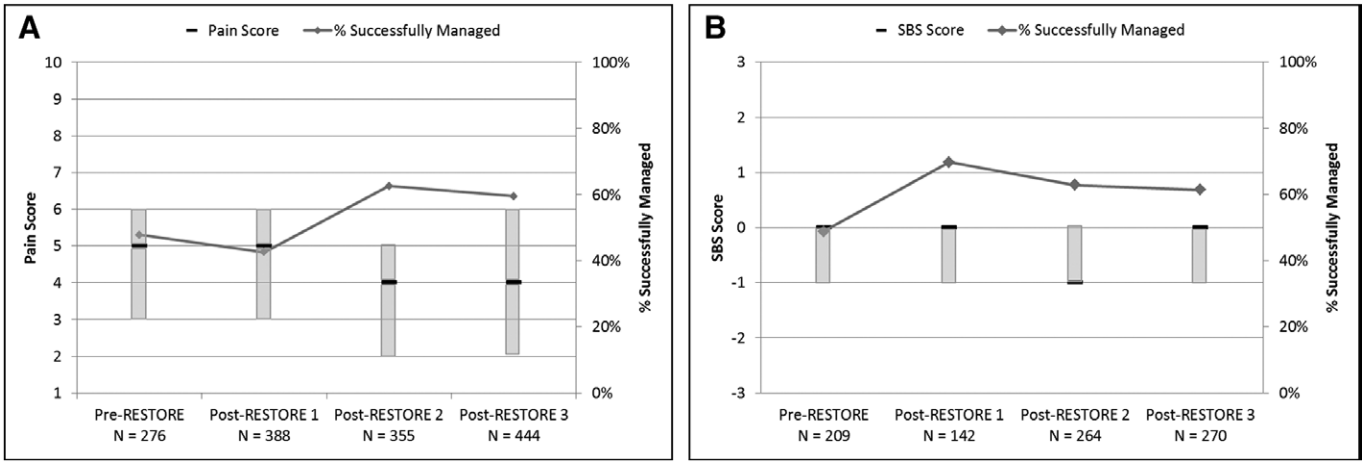

Figure 1. Comfort scores across four time intervals. **A**, Pain scores (median [interquartile range (IQR)]) and % of pain scores greater than or equal to 4 successfully managed within 1 hr. **B**, State Behavioral Scale (SBS) scores (median [IQR]) and % of SBS scores greater than or equal to 1 successfully managed within 1 hr. RESTORE = Randomized Evaluation of Sedation Titration for Respiratory Failure.

sedation medications and nearly eliminating the use of methadone "without" an increase in pain, agitation, and withdrawal symptoms. Decreasing sedative exposure in at-risk children who are also undergoing major neurodevelopmental changes could potentially impact their long-term outcomes (18, 19).

Implementation of a sedation management plan such as cardiac-RESTORE is possible and sustainable; however, it requires the collaboration and the commitment of the entire interprofessional team. Data are essential to demonstrate that any change in practice is worth the time commitment necessary for implementation. Much foundational work was done with leaders across the cardiac medical and surgical departments. This assured the commitment to and acceptance of the potential change in unit culture from all disciplines at all levels, from unit leadership to direct care providers. Compensation for protected time for project development, training, and patient care monitoring was also provided. The nurse champion assigned to daily cardiac-RESTORE walk rounds was not assigned a patient during the first 4 hours of their shift. This allowed time for individualized teaching and bedside nurse support during patient rounds. Early identification of data sources and the ability to auto-extract data streamlined the process for obtaining information for staff updates and recognizing areas for further education.

An important collateral effect of implementing a nurse-implemented intervention was increased nurse autonomy and satisfaction related to acknowledging their expertise in managing patient comfort. PCICU nurses used validated comfort assessment tools and, together with cardiac-RESTORE, safely managed patient pain and sedation around prescribed goals—communicating their actions to the provider team.

Experienced PCICU nurses can distinguish iatrogenic withdrawal symptoms from cardiac-related symptoms to facilitate patient weaning. The pediatric patient with limited cardiac output is fragile and often intolerant of changes in their care, including pain and sedation medication management. However, time interval modifications or smaller dose adjustments are the focus of care decisions, rather than inactivity. Ensuring a systematic plan for weaning and the reduction of variation in sedation management effect both family and hospital caregiver satisfaction.

There is overlap in symptoms of both pain and agitation in pediatrics and in the medications used for treatment. Nursing clinical judgment is key in differentiating between these symptoms. For example, a patient experiences pain in the first 24 to 48 hours after open heart surgery attributed to a sternotomy incision and a chest drain placement. However, the presence of an endotracheal tube may cause discomfort in the patient who remains intubated for days, and although the patient's chest drain has been removed and their sternotomy incision is healing, similar symptoms occur. PCICU patients might also experience altered sleep/wake patterns which may result in behavior to pain and agitation. The use of widely accepted pain and agitation assessment scores and standardization of pharmacologic response to changes in these assessments following the implementation of cardiac-RESTORE resulted in less variability in managing pain and agitation. Furthermore, the use of cardiac-RESTORE was associated with high levels of nursing and parent satisfaction.

EMR order sets and power plans helped support the use of cardiac-RESTORE. Our protocol required that a written opioid and sedation weaning plan be developed and accompany the patient upon PCICU transfer to the inpatient unit. The written plan helped ensure continuity in patient management during changes in care providers and location of service.

This was a single center quality improvement project which took place in a freestanding children's hospital associated with a major university and research facility. The results obtained may not be generalizable to other practice settings. We collected limited patient-level data in this project which prevented us to control for all potential baseline differences; specifically, lower STAT scores in post-implementation interval one. In addition, we did not address delirium as a cause of agitation in our protocol. We plan to address this in future iterations of

the protocol. Furthermore, post cardiac-RESTORE implementation we are better positioned to implement novel sedation strategies, for example, using alpha 2 antagonist infusions as a primary sedative agent given the potential impact of benzodiazepine exposure on brain development and the occurrence of ICU delirium. Finally, prior to cardiac-RESTORE, we did not systematically monitor staff or parental satisfaction with comfort management so our post-implementation data have no baseline comparison.

CONCLUSIONS

In conclusion, cardiac-RESTORE provides a reproducible method that decreases variation surrounding pain and sedation management in the care of pediatric cardiac surgical patients. We were able to reduce both opioid and benzodiazepines use without a concomitant increase in the use of other sedative classes. Few post-intervention patients were discharged from the PCICU or to home on methadone. The implementation of a nurse-driven goal-directed plan such as cardiac-RESTORE to manage PCICU patient and sedation is possible, sustainable, and associated with reduced sedation and methadone use.

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