Successful Development and Implementation of Pediatric Sedation-Analgesia Curriculum for Residents

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Abstract

Pediatric residency graduates are increasingly asked to provide procedural sedations. Currently, most programs provide minimal exposure to residents outside of PICU for procedural sedations. We describe the pediatric sedation and analgesia (PSA) evolution and resident experience over the past 6 years at our institution (fiscal year 2010–2015). Administrative database of the PSA team and resident evaluations obtained by respective residency programs were analyzed and presented with standard descriptive analysis. Commutative or where appropriate year-by-year data were analyzed. Over the past 6 years, 100 residents performed 1,742 sedations with 17 ± 6.4 sedations per resident. Lumbar puncture and MRI were the most frequent procedures for sedations performed by residents. There was no statistical difference in complication rates in sedations performed by residents (28.6 ± 16.6) versus those by attending only (36.2 ± 31.2). Overall, residents were satisfied with the educational experience with an average score of 6.1 ± 0.17 out of maximum 7. Resident involvement in PSA is well liked by residents and does not lead to an increase in sedation-related complications.

Keywords

- ▶ pediatric sedation
- ▶ resident
- ▶ education

Introduction

Pediatric sedation–analgesia (PSA) is becoming an increasingly popular and needed specialty due to increased awareness of its availability by parents, general physicians, and specialists and the widespread availability of advanced diagnostic and imaging techniques.¹ Most hospitals are using PSA to perform several invasive and noninvasive studies such as bone-marrow aspiration and biopsy, lumbar puncture with intrathecal administration of chemotherapy agents, magnetic resonance imaging (MRI), computed tomography (CT) scans, peripherally inserted central catheter (PICC) lines. Sedation providers vary across the country and depending on institution preference can include anesthesia, intensivist, or hospitalist. Infants and children represent a vulnerable and fragile population of patients due to their airway anatomy, cardiorespiratory phy-

siology, and response to sedation–analgesia medications and are at high risk of sedation-related complications.²

Guidelines for pediatric procedural sedation by non-anesthesiologists have been published in 1985 and revised in 2006 by the American Academy of Pediatrics (AAP).^{3,4} Adherence to such guidelines and performance of structured risk assessments have shown to decrease the risk associated with pediatric procedural sedation.⁵ The practitioner needs to be aware of, and follow these guidelines to provide safe and effective procedural sedation for pediatric patients. Currently, most of the teams do not incorporate residents as sedation providers. Residents receive a limited experience with procedural sedation–analgesia, and occurring only during pediatric intensive care unit or emergency department rotations. Society for Pediatric Sedation (SPS) provides multidisciplinary leadership in advancement of quality and

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safety of pediatric sedations. Existing training efforts include provider courses organized by SPS to provide sedation practitioners with basic knowledge and competency to ensure patient safety and effective sedation delivery.

In our institution, the PSA team members, as well as residents, felt that training residents in sedation–analgesia would augment their experience with planning of sedation–analgesia for their patients, improve their knowledge of medications, monitoring of the patients for adverse events, and airway assessment and management skills. With this perceived need and request from some of the residents, we developed a PSA elective rotation, in which residents could learn under direct supervision of an attending physician (intensivists/hospitalists), the safe and effective use of medications, monitoring of patients, and practice common airway maneuvers, for example, head positioning, jaw thrust, or bag-mask ventilation when needed. This educational need is confirmed by the recent study published in *Pediatric Emergency Care Journal*, where the authors noted significant inadequacies during the preparation phase of procedural sedations as well as delay in performance of critical tasks during an airway event phase in simulation pediatric scenarios.⁶ Authors of the article recommended development of a training curriculum that would improve the shortcomings in the overall performance during procedural sedation. We implemented such a curriculum in October 2007 to benefit the residents from different specialties including pediatrics, combined internal medicine–pediatrics, and emergency medicine. We have not come across any report of similar structured training curriculum in pediatric sedation. The objective of this article is to share our experience about the PSA curriculum that was implemented 9 years ago at our institution.

Methods

Children's Hospital, affiliated with University of Illinois College of Medicine at Peoria, currently has a Pediatric Residency Program with 10 residents per year, Combined Internal Medicine and Pediatric Program with 8 residents per year, and Emergency Medicine Program with 12 residents per year. A comprehensive 2-week curriculum was designed with a focus on six core ACGME competencies adapted for PSA practice. ▶ **Table 1** demonstrates different competency domains reviewed and evaluated during this elective. The curriculum was approved by the Curriculum Committee of the Department of Pediatrics and Program Directors of Combined Internal Medicine and Pediatrics as well as Emergency Medicine. We created an orientation folder containing a document explaining their duties and responsibilities, three review articles for self-read,^{3,7,8} a procedure log and pre- and post-test. One resident is scheduled per 2-week elective. Resident responsibilities include obtaining an informed consent from families, performing presedation assessment, categorizing patients per the American Society of Anesthesiologists (ASA) risk criteria, discussing the sedation plan with the attending physician and a nurse, administering medications, and monitoring. They are also involved in recovering and discharging the patient once discharge criteria have been met. Presedation assessments

include AMPLE history (Allergies, Medications, Past Medical History, Last Meal and Events leading to procedure) and airway evaluation including Mallampati Classification. Attending physicians supervise the residents directly and assist in developing the sedation plan, administering medications, monitoring, and managing any complications/adverse events related to sedation–analgesia procedure. Attending physicians were present either at the bedside or in immediate vicinity throughout the duration of the sedation/procedure. Patient could be directly visualized by attending physicians at all times during the procedure. After completion of the procedure, residents documented the procedural sedation in electronic medical records (EMRs) which is reviewed and cosigned by the attending physician. The residents maintained the log of sedations performed by them for submission to program director as a part of their procedural record. Accreditation Council for Graduate Medical Education (ACGME) duty hours as well as didactic and continuity clinic attendance were strictly adhered to by all residents. At the start of curriculum, we had prepared a pre- and post-test questionnaire for the evaluation of the residents. Residents were required to solve a pre-test prior to start of their rotation and complete the post-test at the end of the rotation. However, the attempts to address knowledge with tests were not successful as there were significant changes in the practice of sedation over the years, which required changes in pre- and post-test questions. Faculty for PSA included a combination of pediatric intensivist and hospitalist. To get credentialed as an attending sedation provider in our hospital, all physicians who do not have formal training in critical care, have to go through the SPS sedation course and are required to demonstrate proficiency in performing sedations under mentored practice. Attending physicians had the ultimate responsibility for patient safety. All attending physicians had credentials for resuscitation and airway management in the hospital. The percentage of hospitalist versus intensivist has varied over the years, with turnover of the faculty, but overall has remained close to 50% hospitalist and 50% intensivist with combined leadership. PSA team was only consulted for providing deep sedations; so, all procedures either with or without residents were deep sedations.

PSA office maintained detailed records of all sedations performed by the service including those performed by the residents. Medications administered, complications and interventions were charted in real time by the nurse assisting in sedation and entered into the sedation database by the clerical staff. A priori definitions (for sedation failures, complications, etc.) were established by the sedation team leadership. These definitions have changed and evolved over the course of the past 10 years, particularly after joining the Society for Pediatric Sedation (SPS) and implementing Pediatric Sedation Research Consortium (PSRC) Database. While over the years the clinical team has tried to maintain consistency in reporting, for the purpose of this study, we did not attempt to cross validate the records. The administrative record of all sedations was maintained by one of the authors (D.B.) since inception of sedation team. This dataset included patient demographics, diagnoses, indications, medications, routes, start and finish and discharge times, and all complications. There was no

Table 1 ACGME competency domains as applied to pediatric sedation–analgesia elective rotation

Essential learning objectives	Primary competency domain	Teaching methods	Evaluation method
Actively participate in performance of pediatric sedations	PC	Direct observation, hands-on practice	Evaluation form, direct feedback
Gain knowledge and experience in indications, dosages, contraindications, and safety profiles of various sedation–analgesia medications and adjuvant	MK	Reading material, direct observation	Evaluation form, direct feedback, post-test
Gain proficiency in obtaining and performing a focused history and physical examination	PC, IPCS, PRO	Direct observation and practice	Evaluation form, direct feedback
Become knowledgeable and proficient in assigning an ASA classification for pediatric patients undergoing procedural sedation	PC, MK	Reading material, direct observation	Evaluation form, direct feedback, post-test
Become knowledgeable and proficient in evaluating the airway of the child and identify high-risk patients for sedation	PC, MK	Reading material, direct observation, and practice	Evaluation form, direct feedback, post-test
Learn and possibly gain proficiency in airway maneuvers such as airway positioning, jaw-thrust, bag-mask ventilation when needed	PC, MK	Reading material, direct observation, hands-on practice	Evaluation form, direct feedback, post-test
Become familiar with safety issues concerning pediatric procedural sedation, including presedation screening and discharge criteria	MK, PBLI	Reading material, direct observation, practice	Evaluation form, direct feedback, post-test
Gain experience in working with the sedation team to assure safe and effective sedation–analgesia	PRO, IPCS, SBP, PC	Discussion, direct observation	Evaluation form, direct feedback
Gain understanding with issues concerning sedation credentialing	PRO, SBP	Discussion, direct observation	Evaluation form, direct feedback
Become familiar with equipment, personnel and environment necessary to perform effective and safe procedural sedation	MK, SBP, PBLI	Discussion, direct observation	Evaluation form, direct feedback, post-test
Develop proficiency in communication with family about consenting process, as well as plan of sedation and be able to discuss complications if any arise	PRO, MK, ISC	Discussion, direct observation	Evaluation form, direct feedback, post-test

Abbreviations: IPCS, interpersonal and communication skills; MK, medical knowledge; PC, patient care; PBLI, practice-based learning and improvement; PRO, professionalism; SBP, systems-based practice.

missing or ambiguous data due to manual entry. Due to consistency in the data entry over the years, the data from the administrative records were utilized. Individual patient EMRs were not assessed as part of this study. Successful sedation was defined as successful completion of the procedure for which sedation was planned and provided.

Pediatric and Combined Internal Medicine–Pediatric Program changed their evaluation system from E-value to New Innovations in 2013 and Emergency Medicine Residency Program continued to use E-value for reporting of their resident evaluations. All evaluation records were sought from various program directors for the data analysis for curriculum evaluation. However, only detailed anonymous information was available from the Pediatric Residency Program and was utilized for analysis of this study. Standard descriptive statistical analysis was performed with data represented as mean and standard deviation wherever applicable. Mean complication rates between sedation with and without residents were compared with student *t*-test. Analysis was done utilizing JMP statistical program (SAS Institute, North Carolina, United States). This retrospective study (from fiscal year [FY] 2010 to FY 2015) was evaluated

by the IRB and was deemed as exempt research. Data review and analysis were conducted in 2017.

Results

PSA curriculum was approved by the Pediatric Department Curriculum Committee in Oct 2006 and implemented in Feb 2007. Since then, more than 100 residents have completed this rotation (sedation records available starting from FY 2010) with a total of 4,127 sedations performed by PSA team from FY 2010 to FY 2015 out of which 1,742 were performed by residents (► **Table 2**).

While the number of residents doing this elective has varied over the years, the number of sedations/resident/year (total yearly rate calculated as mean of monthly rates) has increased consistently year after year (from 12.4 ± 5.1 in FY 2010 to 22.9 ± 7.9 in FY 2015). Percentage of sedations performed by residents ranged from 31.9 ± 24.4 in FY 2011 to 51.0 ± 11.3 in FY 2013 with an overall average of 41.8 ± 24.9 % sedations performed by residents (► **Table 2**). Among the 100 residents since 2010, EM residents accounted for 45.2%, pediatric residents accounted for 29.2%, and

Table 2 Total number of sedations performed by residents with sedation team over 6 years

Year	Total sedations	Sedations performed by residents	Percent sedations performed by residents ^a	Number of residents doing sedation elective	Number of sedations per resident
2010	501	274	50.6 ± 29.2	22	12.4 ± 5.1
2011	612	192	31.9 ± 24.4	14	13.3 ± 2.9
2012	675	294	43.6 ± 23.9	17	17.2 ± 5.0
2013	801	408	51.0 ± 11.3	21	20.1 ± 4.4
2014	767	273	35.0 ± 27.1	13	20.6 ± 6.4
2015	771	301	38.9 ± 28.1	13	22.9 ± 7.9
	N = 4127	N = 1742	41.8 ± 24.9	N = 100	17.8 ± 6.4

^aYearly rates calculated as mean of monthly rates/100 sedations.

med/peds accounted for 25.5%. PSA team performed sedations for a very wide variety of procedures and no procedure was excluded from residents. The lumbar puncture/intra thecal drug administration for which sedation was performed by residents were LP/IT (374), MRI (364), and auditory brainstem responses (ABRs) (160) (data not shown).

As sedation providers, residents managed all minor and major complications associated with sedation. PSA team has a 97% successful completion rate for procedures and no change was observed after implementation of resident involvement. Different procedures and medications have their unique risk of adverse events and residents received exposure to all these events and managed them successfully under direct supervision of attending physician (data not shown). Most common procedures for which complications were managed by residents were LP/IT (135), MRI (87), and bone marrow aspiration (BMA) (43). Complications related to propofol use were most common (469) followed by fentanyl (255). Hypoxia, apnea, and airway obstruction were the most common sedation-related complication managed by residents utilizing interventions such as oxygen therapy, jaw thrust, and repositioning of airway (→Table 3). Failed IV attempt was considered as a failed sedation. We did not have any arrhythmias or hypotension requiring interventions.

→Table 4 shows the comparison of percentage of sedations with any complication noted by nursing team for

Table 4 Complication rate in sedations with and without resident involvement

Year	Complication rate in sedations without residents ^a	Complication rate in sedations with residents ^a	p-Value
2010	18.6 ± 16.2	17.8 ± 13.5	0.9
2011	33.0 ± 14.6	37.9 ± 16.7	0.47
2012	36.4 ± 17.5	31.5 ± 8.3	0.40
2013	30.7 ± 14.3	16.4 ± 7.3	0.007
2014	41.2 ± 13.8	35.6 ± 11.5	0.32
2015	54.7 ± 35.5	35.5 ± 24.7	0.39
Overall average	36.2 ± 31.2	28.6 ± 16.6	0.07

^aMean of monthly rates/100 sedations.

sedations performed by residents versus those without residents over the study duration (yearly complication rates calculated as mean of monthly rate/100 sedations). Overall, a lower proportion of sedations, averaged monthly over the course of the study, performed by residents had complications (28.6 ± 16.6 vs. 36.2 ± 31.2%). This difference was not statistically significant by student's *t*-test.

Table 3 Common indications, medications, complications, and interventions associated with procedural sedation performed by residents

Indications	Medications	Complications	Interventions
LP/IT (N = 135)	Propofol (N = 469)	Hypoxia (N = 399)	Supplemental oxygen (N = 367)
MRI (N = 87)	Fentanyl (N = 255)	Apnea (N = 59)	Jaw thrust (N = 156)
BMA (N = 43)	Versed (N = 53)	Airway obstruction (N = 36)	Head repositioning (N = 134)
ABR (N = 38)	Ketamine (N = 20)	Hypotension (N = 34)	Shoulder roll (N = 74)
PICC (N = 38)			Head tilt (N = 43)

Abbreviations: ABR, auditory brainstem responses; BMA, bone marrow aspiration; LP/IT, lumbar puncture/Intrathecal drug administration; MRI, magnetic resonance imaging; PICC, peripherally inserted central catheter.

Residents were overall very satisfied with the rotation in PSA and gave an average score of 6.1 ± 0.17 for curriculum, 5.9 ± 0.24 for learning experience, 5.8 ± 0.9 for balance between education and service, and 5.9 ± 0.46 for overall educational value of the rotation in a scale of 1 to 7 where 1 is “strongly disagree” and 7 is “strongly agree” for positive experience ($N = 29$, Data not shown). Inconsistency in number of cases each day and unpredictability of schedule were identified as weaknesses of this rotation.

Discussion

PSA is a constantly evolving field as an increasing number of minor procedures are performed on children outside of the operation theater.¹ Parental satisfaction has been shown to be high when sedation is delivered in an organized and efficient manner.⁹ Increasing demand for PSA has to be met with production of nonanesthesiologist graduates well trained in providing such a service. Coté et al² in the comprehensive review of adverse events in pediatric sedation state the need for rigorous training and development of skills for practitioners who sedate children. Our curriculum offers a focused training for 2 weeks involving PSA under direct supervision of the attending physician. Our overall rate for all complications was 28.6 ± 16.6 with residents and 36.2 ± 31.2 without residents. Rates quoted in the literature for deep sedations similar to our service averaged around 12%.^{10,11} Since there is no widely accepted definition of a “complication” in sedation, we do not believe a direct comparison of rates would be meaningful. With efforts of the SPS toward standardization of definitions in pediatric sedation, interinstitutional comparison might be feasible in future.¹²

This educational need is also confirmed by the recent study published in *Pediatric Emergency Care Journal*, where the authors noted significant inadequacies during preparation phase of procedural sedation as well as delay in performance of critical tasks during airway event phase in simulation pediatric scenarios.⁶

To provide safe and effective delivery of PSA, the practitioner needs to receive comprehensive and hands-on training in this field. Shavit et al¹³ showed in their recent study that nonanesthesiologist with specific training in PSA performed tasks associated with safer outcomes in simulated environment, compared with their nontrained counterparts. They used a web-based, cognitive distant learning component, followed by a workshop with lectures ending in comprehensive and hands-on sessions using simulators. Schneeweiss and Ratnapalan¹⁴ showed improvement in multiple-choice knowledge-based tests in the group that had received formal 4-hour didactic and case-based education than the group that was assigned self-study for 2 weeks, showing personal interaction and education from faculty is more effective in understanding or retention of knowledge of sedation guidelines and practices than unstructured, self-directed learning.

We offer this PSA elective to the residents after their first year residency, thus ensuring that they have received basic training in assessment of pediatric patients as well as certifi-

cation in pediatric advanced life support (PALS) provider course. The residents work with a sedation team nurse during their assessment and planning phase and are always directly supervised by the attending physician during sedation administration. The attending physician and residents work together until the procedure is complete and patient has recovered. The residents are allowed to titrate the medications as needed, are expected to identify and intervene any potential or actual adverse event in a supervised fashion. The training offered in this manner has been found to be practical for the residents and safe for the patients, thus making it an effective teaching tool. Although not statistically significant, the complication rate was lower with residents performing sedation under direct guidance of an attending physician, compared with attending alone. This could be explained by chance alone, or that the residents intervened or titrated the medications down earlier than the attending physician would have, or that the individual attending physicians may have elected to sedate high-risk patients themselves, even though residents were exposed to all procedures

Limitations: While our study provides a detailed rendition of implementation of sedation training curriculum, it is primarily descriptive with data extraction from an administrative database. We could not analyze the pre- and post-test data for multiple reasons, including noncompletion of either or both tests, changes in practice without change in the test questions as well as flux in the number of attendings. In the near future, we plan to prepare web-based questionnaires making it easier for residents to access and attending physicians to track.

Assessment of complications and interventions was subjective and may be influenced by bias. Finally, the level of independence in managing sedations may have varied with the attending physician, and a strict standardized definition of a resident performed sedation was not maintained. While there was a trend toward increased complication in sedations performed by attending physicians without involvement of residents, limitation of database prevented us from analyzing the potential causes of this trend. Similarly, while patient/parent satisfaction is very important for any patient centered care model like ours, we did not track this information in our database and cannot compare if resident involvement in providing sedation affected family satisfaction

Conclusion

Resident involvement in PSA does not lead to an increase in sedation-related complications or rate of unsuccessful sedations while providing a valuable educational experience. Such a rotation, even as an elective, is highly sought after by residents and has consistently received high satisfaction scores.

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