Pediatric sedation
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Abstract

Purpose of review: Pediatric sedation continues to evolve. It is an area of practice that involves a variety of pediatric subspecialties, the practitioners of many of which are not fully aware of what is being done by others involved in this care. The purpose of this review is to consider the current status of pediatric sedation in general and to discuss the most recent literature concerning this practice. Specifically we will discuss the use of new medications for pediatric sedation, issues concerning fasting status, issues surrounding the effectiveness of sedation, and discharge criteria after sedation.

Recent findings: Propofol sedation is growing rapidly outside of the operating room environment. Emergency-medicine and intensive-care providers are regularly employing propofol for procedural sedation and reporting its effective use in their hands. Also in the emergency-medicine field, evidence is emerging that fasting status is not a particularly important factor in the genesis of critical events during sedation. Anesthesiologists are evaluating the use of dexmedetomidine for sedation of children and new reports describe the advantages of deep sedation and anesthesia over moderate sedation for painful procedures. Finally an important study shows that a patient's condition on discharge after sedation can be improved through the implementation of specific criteria using objective scoring techniques.

Summary: Anesthesiologists and those outside of anesthesia are employing new potent sedative hypnotic agents to accomplish effective pediatric sedation. At the same time, the consensus-generated sedation guidelines - particularly with respect to fasting guidelines - are being questioned. All of this is occurring in the face of mounting evidence that sedation depth needs to be adequate to provide optimal operating conditions and patient satisfaction. Regardless of sedation method used, recovery criteria need to be carefully considered in order to optimize patient safety.

Introduction

It is difficult to fully review the current status of pediatric sedation because the reports concerning this practice are published in such a wide range of journals and the outcome measures used vary so greatly. What is clear is that each year millions of infants and children require sedation and pain control for medical procedures. Hospitals and offices struggle with the logistical and medical difficulties associated with providing this service. There is often heavy demand for pediatric sedation services.
throughout the usual work day as well as off hours, and these cases must be performed in a wide variety of locations involving many different services: radiology, dentistry, pediatric inpatient service, emergency department, nuclear medicine, etc. The difficulty in meeting these demands was pointed out in a recent study that found that centers in the United States were much less likely to offer sedation for painful procedures than similar centers in Europe [1]. Thirty percent of US respondents to this mail survey reported performing bone marrow biopsies in children without significant sedation more than 50% of the time as compared with 0% of European centers who offered sedation this infrequently.

Attempts to accommodate the need for pediatric sedation have led to the formulation of a wide variety of possible solutions. Some sedation services have opted for direct physician involvement while others are directed by trained nursing personnel [2-4]. Still others have developed the concept of a 'sedation room' or a 'sedation team' combining provider types [5-9]. The physicians involved in sedation services for children span the spectrum of pediatric specialties, but most recently the field is dominated by anesthesiologists, intensivists, and emergency physicians. The nonanesthesiologists in this group are adapting all the currently available potent sedatives and analgesics to their practice in order to optimize depth of sedation, procedural conditions, and recovery characteristics for their patients. In this review the focus will be on recent information on the use of propofol (in particular) by nonanesthesiologists, the use of dexmedetomidine by anesthesiologists, the emerging thinking of fasting status prior to sedation outside the operating room, the optimal depth of sedation for painful procedures, and new information on discharge criteria after sedation.

**Propofol use by nonanesthesiologists**

Propofol sedation delivered by nonanesthesiologists is a growing practice. This is particularly true in the intensive-care environment and the emergency department. Most of the literature regarding this practice exists in the intensive-care literature where the virtues of propofol's rapid onset and recovery are extolled. A common model that is being promoted is that of the intensive-care-unit sedation team headed by an intensivist using some portion of the pediatric intensive-care unit to run a pediatric sedation service [8-10-12]. This practice is made more attractive by the fact that many of these practitioners can be credentialed in the hospital to deliver this care and will bill under anesthesia codes [13]. A recent study from one intensive-care-unit sedation team catalogued the use of bolus dose versus continuous infusion of propofol for painful procedures [14]. Other models such as the initiation of propofol sedation in the intensive-care unit - sending patients with sedation-trained registered nurse to other locations in the hospital - have also been reported [5]. Use in dentistry, oral surgery, endoscopy, and radiology has also been advocated by nonanesthesiologists [15-22].

In the past 12 months several authors have described the use of propofol by nonanesthesiologists in the emergency department. Guenther et al. [23a-c] studied the use of propofol by emergency physicians in children undergoing brief painful procedures, which were primarily oncology-related. In this study 291 procedures were undertaken on 89 separate patients. An average dose of 3.5 mg/kg was required and all procedures were reported to be completed. In terms of safety, the authors reported a 4% incidence of requirement for airway support (jaw thrust) and a 1% incidence of a requirement for bag-mask ventilation because of respiratory depression. Protocol-driven propofol sedation in the emergency department was evaluated in a case series involving the painful procedures by Bassett and colleagues [24a-c]. Interventions were largely orthopedic (mostly fracture reductions). According to the protocol used, propofol was administered 1 min after a dose of opiate. A total of 393 cases were included. As with the previous study there was a low but significant incidence of hypoxia requiring airway adjustment (3%) and a 0.8% requirement for bag-mask ventilation due to respiratory depression.

In one other recent evaluation of propofol use by nonanesthesiologists, Barbi et al. [15] reported on their experience sedating children for 1059 procedures in a tertiary-care teaching hospital pediatric sedation unit. Procedures performed in this study included brief painful interventions as well as gastroenterological evaluations such as upper endoscopies and colonoscopies. Sedation was successful in all cases and the procedure was completed in all but one case. The authors divided their analysis of safety by procedure type. When providing sedation for upper endoscopy, serious oxygen desaturation requiring bag-mask ventilation was required in 0.8% of cases. Even more concerning, laryngospasm was noted in 2.1% of these patients. On the other hand, for the lowest risk procedures such as colonoscopy, there were no such requirements for airway intervention in 289 cases.

These three studies are typical of the propofol literature that has been published in the last few years. The numbers involved are relatively small. If we assume that critical complications associated with propofol sedation should not be more frequent than those associated with operative anesthesia, the critical incident rate for otherwise well children should be no more frequent than 1 per 10,000. With this in mind it is hard to understand how authors can conclude that any technique is 'safe' when they have only evaluated several hundred or one thousand patients. While these studies give insight into the use of propofol, they are simply underpowered to evaluate this, the most important outcome.

The studies also tend to minimize the importance of the airway interventions that were undertaken to 'rescue' patients from hypoxia or apnea. It is critical that these situations are recognized and treated as described by the authors. These studies
come from tertiary care centers where airway expertise and backup is readily available at any time of the day or night. Previous investigators have noted that the availability of this type of support is critical to safe delivery of any type of sedation to pediatric patients [25,26]. In this sense it is critical that readers do not try to generalize the findings in studies such as these to very different practice settings since we cannot be sure that the outcomes would be as reassuring.

In terms of effectiveness, these studies fail to catalogue the actual state of the patients during the procedure. We are only told that 'purposeful movement was tolerated' or the 'procedure was completed'. This factor is very important when one begins to consider using propofol sedation for procedures where movement control is very important. The depth of sedation required to attain acceptable procedural conditions will vary greatly depending on how important movement control is, and how much discomfort is involved. Ideal studies evaluating the use of propofol would compare its use in a randomized manner with other agents commonly used for the same procedural sedation and catalogue the outcomes in terms of side effects, speed of induction/recovery, and the conditions present during the procedure itself.

These studies are important in that they point out the continued growth of the use of propofol outside of the operating room by nonanesthesiologists. This trend will undoubtedly continue as the advantages of propofol over traditional sedatives are highlighted in journal articles and pediatric subspecialty conferences. Large, multicenter, prospective trials involving the use of propofol outside the operating room by nonanesthesiologists would be extremely helpful in establishing the true 'safety' of its use. Anesthesiologists could play a critical role in advocating for safe use of propofol and will need to help establish critical competence areas and training for those who plan to use it.

Dexmedetomidine

Dexmedetomidine has been used for several years by adult anesthesiologists and intensivists for sedation and anesthesia. The characteristics of this drug are remarkable for its production of a smooth sedated state with good analgesia and little decrease in respiratory drive. This drug is an α2 agonist with a short half life that is generally given in a bolus followed by constant infusion. In the last year reports of its use in pediatric sedation by anesthesiologists have started to emerge, and the growth of its use (as reported at anesthesia meetings) appears to be exponential. Effective use of dexmedetomidine has been reported for sedation of children on ventilators in the pediatric intensive-care unit and as a sedative for invasive procedures [27-31]. Notably, Ard et al. [28] reported its use for sedation during awake craniotomies in children with remarkably good outcomes. In addition it has been reported for use in the treatment of acute withdrawal symptoms in children and for controlled hypotension [29].

While the total reports of the use of dexmedetomidine are still relatively few in number, the possibilities for its use are exciting. Caution is warranted as there is a possibility of decreased blood pressure and bradycardia with this drug and greater numbers are needed before anything can be said about its safety; still, the incidence of side effects seems to be relatively infrequent in children. Its effectiveness in the intensive care unit as an alternative to opiates and benzodiazepines is becoming established. Just as enticing is the possibility of its use for procedural sedation either alone or in combination with some of the agents we already employ. Expect many reports of its use in the next year.

Sedation and fasting

The debate concerning the need for fasting prior to sedation in the emergency department was recently revisited. Agrawal et al. [30,31] followed a prospective 11-month experience in an emergency department. Of 905 patients who were sedated, 509 did not meet current fasting guidelines for sedation according to the American Academy of Pediatrics. There were no episodes of aspiration in any of the patients and the incidence of adverse events was no higher in the fasting cohort than the nonfasting cohort. This paper was accompanied by an editorial which lauded this paper as a first step toward putting science on the subject of fasting states and sedation [31]. The author of this editorial points out that the recommendations currently put forth by the ASA and the American Academy of Pediatrics are based on 'consensus' and not hard data; therefore fasting status should be a consideration when undertaking sedation of a child, but certainly is not a prerequisite.

Once again we must be careful in interpreting the data from the Agrawal study [30]: aspiration should be a very rare event and the study was underpowered to detect this low-frequency occurrence. In addition, close evaluation of the data from Agrawal et al.’s study [30] shows that most of the patients in the nonfasted group were, in fact, fasted for solid foods for several hours prior to their sedation and that none were fasted for less than 2 h. While Agrawal et al. [30] should be complimented for reporting this experience, other providers should be cautious in assuming that this data can be generalized to more recently fed patients.

In another evaluation of stomach contents and sedation outcome, Ziegler et al. [32] retrospectively evaluated the data on 367 patients who received oral (Hypaque) contrast 1-2 h prior to computerized tomography (CT) scans of the abdomen. Thirty of the patients received chloral hydrate oral sedation (70-100 mg/kg) and 337 received intravenous pentobarbital sedation (3-7
mg/kg). No problems with emesis under sedation or aspiration were noted. The study could be criticized in the same way as Argawal et al.‘s report [30â€¢], but this does represent one of the first reports on experience with standard sedation on this group of patients, which represent a vexing problem for almost all pediatric radiology centers.

Both of these studies concerning fasting status show that there is now a willingness to test the traditional guidelines which have been based primarily on expert opinion and extrapolated from other areas of practice. In the emergency department and the radiology suite, semielective sedation (without airway protection) has been administered to thousands (or millions) of patients who do not meet fasting guidelines and reports concerning this practice are long overdue. In the future much larger cohorts of nonfasted sedation experiences from the emergency department may well influence the direction of our practice recommendations.

Sedation depth and satisfaction with procedural sedation Top

In designing sedation services for children, one choice that must be made relates to what ‘depth’ of sedation or anesthesia will be provided for painful procedures in children. In particular, one must address the question as to whether there is a significant advantage to providing anesthesia services for these procedures, or is moderate sedation sufficient? The answer must take into account the availability of anesthesiologists or other deep-sedation providers as well as the acceptable rate of ‘failed’ sedation, and the expectations of the patients and family who are being served. When sedation fails, procedures are carried out on children who are crying, struggling, and requiring significant restraint. This situation leads to unwanted stress in the child and family, adverse procedure outcomes, and care that is generally less effective [33â€¢]. Two recent studies have evaluated this question and come to very different conclusions.

Crock et al. [33â€¢] reported on a total of 96 children with neoplastic disorders who received either general anesthesia with sevoflurane, or sedation with oral or nasal midazolam as part of their routine preparation for bone marrow biopsies or lumbar punctures. For the 102 procedures performed under sevoflurane anesthesia restraint was needed only rarely (4%), minimal pain was reported, and children were reported as distressed 25% of the time. During the 80 midazolam sedation procedures, restraint was required in 94%, firm restraint was required in 66%, the child could not be restrained in 14%. As expected, pain scores were high among these sedated patients as compared with general anesthesia. Ninety percent of families wanted general anesthesia for future procedures and many families reported dissatisfaction with the sedation regime and raised concerns about the restraint used on their child.

The findings of this study stand in stark contrast to those of Skoglosa et al. [34â€¢] concerning the experience of patients undergoing small-bowel biopsy. In this case a questionnaire was used to evaluate experiences of two cohorts of patients cared for at two different institutions; one where patients received deep sedation and parents were not allowed to stay for the procedure and another where moderate sedation was administered and parents were present during the procedure. The results of this investigation found no difference in general satisfaction levels between families. There was little correlation between the perception of the endoscopist concerning the experience of the procedure and that of the family.

The differing findings between these two studies point out the difficulty in this type of investigation. It could well be that the families studied in the Crock report [33â€¢] were biased by the fact that they experienced both types of ‘sedation’-delivery system, and clearly preferred the deeper sedation/anesthesia option. On the other hand, the families in the Skoglosa study [34â€¢] only observed one type of sedation system - either deep or moderate - and had no basis for comparison. Their conclusions did not match those of the health-care providers who could easily be biased by their knowledge of the difference between these two options. Future evaluations of these two types of systems will need to consider all the factors influenced by the choice of anesthesia versus sedation, including procedural conditions, efficiency of care, and safety, in order to weigh the advantages or disadvantages of either choice. Patient-satisfaction data need to be considered on the basis of previous experience for the individual answering the inquiry.

Discharge criteria Top

One of the most difficult decisions to make concerning children who have been sedated for a procedure is when to discharge them to home. Several critical incidents have been described when children are discharged while still sedated and subsequently experience airway obstruction when positioned in a car seat [26]. In order to clarify how well different discharge criteria correlate with a ‘return to baseline mental status’, Malviya et al. [35â€¢] recently compared bispectral index scores with two sedation scales [University of Michigan sedation score (UMSS) and the modified maintenance of wakefulness test (MMWT)] in assessing children after sedation for echocardiographic examination. In terms of condition at discharge, the authors found that when specific criteria were put in place (in terms of UMSS and MMWT scores at discharge) there was a much higher percentage of patients who were back to their baseline consciousness (bispectral index scores of >90) at the time of discharge when compared with traditional subjective assessment. This paper was accompanied by an editorial written by Dr Charles CotÅ© lauding this work as the kind of scientific investigation that will aid in bringing pediatric sedation safety
improvements in the future [36\[c\[e\]]

**Conclusion**

Pediatric sedation practice involves a large number of pediatric subspecialists using a variety of sedation strategies and tools. Propofol sedation delivered by nonanesthesiologists is rapidly increasing and, like all new strategies, the effectiveness and safety of this practice needs to undergo careful scrutiny. Sedation providers should push for large cohort studies that look closely at important outcome measures and hold everyone who delivers propofol or other potent sedatives and analgesics to the same high standards that anesthesia has used in improving safety over the last 20 years. Similarly, dexmedetomidine for pediatric sedation, while promising, will require careful study as use increases. Also in this context of maximizing safety, the evolving standards for fasting status before sedation that are being suggested in the emergency medicine literature must be carefully evaluated and sedation providers should be encouraged to report their outcomes in nonfasted children.

Recent studies concerning depth of sedation have forced a reconsideration of systems that employ the use of moderate sedation for painful procedures in children. More importantly, the definition of what defines 'failure' in sedation of children needs to be reexamined. The simple act of completing a procedure may no longer be the milestone that defines 'successful' sedation. Finally, discharge criteria for children who have been sedated should advance along with the drugs and techniques used for sedation during a procedure. The application of specific criteria in this realm is a significant improvement over subjective measures that have been used in the past.

**References and recommended reading**

**Papers of particular interest, published within the annual period of review, have been highlighted as:**

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sedation; children; propofol; dexmedetomidine; discharge criteria; fasting guidelines

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