Chapter 34
Risk Stratification for Procedural Sedation

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Overview

Sedation, the process of decreasing one's level of consciousness so they can tolerate an uncomfortable or painful procedure, should be done in a setting prepared for the possible adverse events associated with decreased consciousness. The decline in awareness and possible loss of protective reflexes carries an inherent risk, and the healthcare provider must continuously assess the risks versus benefits of sedation. When the patient is being evaluated for a nonurgent procedure, then we must consider if sedating the patient electively is in their best interest.

The three main aspects to consider are the type of procedure, chronic conditions affecting the patient, and any acute change in their usual state of health. While the optimal situation would be a short and non-painful procedure in a previously healthy patient, with no current illness, pediatric patients in need of sedation often present with an acute or chronic illness, and procedures in this population are more technically challenging and hence prolonged, compared to the same procedures in the adult population.

Older agents such as pentobarbital and chloral hydrate not had only a lower safety profile but also diminished patient satisfaction [1–4] due to the need for a longer recovery period and irritability after the procedure. This is partially due to

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P. P. Kamat, J. W. Berkenbosch (eds.), *Sedation and Analgesia for the Pediatric Intensivist*, https://doi.org/10.1007/978-3-030-52555-2_34

their extended half-life as well as the potential for delayed apneic episodes [5]. As the field of sedation has progressed, newer drugs with enhanced safety and satisfaction profiles have appeared, thus allowing the sedation practitioner to provide safe sedation for an expanded patient population and improved patient/family satisfaction due to better recovery profiles.

Location of Procedure

The optimal setting for a planned procedural sedation is an area where all supplies and equipment are available, such as the operating room or the pediatric ICU. Guidelines and minimal required equipment lists have been previously published [6]. However, many sedations occur outside of these setting, such as the radiology suite or a dedicated treatment room, with excellent safety records. This has been demonstrated with both propofol [7] and ketamine [8]. In the study utilizing propofol, serious side effects such as aspiration or CPR were exceedingly rare (four and two episodes, respectively, out of 49,836 sedations – 0.8 aspiration episodes per 10,000 sedation events and 0.4 CPR episodes per 10,000 sedation events). These rates are lower than those observed in patients undergoing general anesthesia (GA): Zgleszewski et al., in a single-center retrospective review, found a rate of 5.1 cardiac arrests per 10,000 GA events [9]; Kelly and Walker reported an aspiration rate of two per 10,000 elective procedures undergoing GA [10]. Less serious side effects such as desaturation or central apnea were more common (154 and 575 per 10,000 sedations, respectively), and while the rate of post-extubation stridor in GA is low [11], it has not been reported in the sedation literature. Other side effects such as laryngospasm were below 100 per 10,000 sedations. In a similar retrospective series, ketamine had an overall adverse event rate of 7.26% or 726 per 10,000 sedation encounters, with a severe adverse event (AE) frequency of 1.77% or 177 per 10,000 sedation encounters. The sedation team must be well aware of all the possible complications and be prepared to manage these events, should they occur. These very rare events must be anticipated, and a system to rehearse and practice for these low-frequency/high-acuity events must be in place, since simulation has been shown to improve tasks related to patient safety during sedation [12].

Procedure Type

Data regarding the procedure type show that even renal biopsies can be performed outside of the OR with sedation [13]. In the study by Kamat et al., which included 174 renal biopsies, 30% required blowby oxygen and 12% required CPAP. The use of fentanyl with propofol had a significantly higher success rate in comparison with other drug combinations. In children undergoing esophagogastroduodenoscopy, colonoscopy, or both, a retrospective study has shown a low overall adverse events

prevalence, less than 5%. One of the independent predictors was the type of procedure, namely, esophagogastroduodenoscopy, hinting that procedures adjacent to the airway involve a higher risk for adverse events when compared to a procedure that did not manipulate the airway [14]. In comparison, a recent retrospective review for pediatric patients undergoing sedation for MRI demonstrated a 2% risk of unplanned intubation [15]. Another review, looking at the AE rate in a freestanding imaging center, demonstrated that desaturations occurred in 11.5% of cases but were handled by the sedation team successfully [16]; it can be assumed that painful procedures are protective for adverse events such as desaturation and apnea because of the stimulation involved, causing increase in motor tone during the procedure.

Chronic Conditions

First, we must consider the child's age and whether they were born at full-term or premature. Infants under the gestational age of 60 weeks are at risk for apnea several hours after the sedation/anesthetic event and hence require prolonged monitoring or overnight admission. Prematurity also confers increased risk that persists throughout childhood and up until early adulthood [17]. It is still unclear if the risk arises from early birth itself and its effects on organ development or the comorbidities and interventions that come with it such as prolonged respiratory support and recurrent airway manipulations.

Research varies regarding the minimal age for undergoing elective sedation outside the OR. In a retrospective study, age below 5 years almost doubled the rate of any AE (7.8% vs. 4% in older than 5). However, the majority of these adverse events were desaturations and airway obstruction, which in the hands of the experienced provider are readily recognized and managed. The authors mention several factors, including the relatively smaller airway and decreased respiratory reserves in small children [14]; other contributing factors to this increased risk are higher basal metabolic rate and larger head size that is more likely to flex forward and obstruct the airway during sedation. Several studies using newer agents such as dexmedetomidine demonstrated excellent safety profiles in younger babies and post-prematurity infants, as summarized by Scherrer [18]. Najafi et al. [19] used IV dexmedetomidine to sedate children with respiratory comorbidities and required smaller doses for children under 1 year of age. Olgun [20] used the intranasal route to administer dexmedetomidine as a single agent to patients 12 months and under, who underwent MRI, with an overall success rate higher than 96% and without any significant AEs. In a retrospective chart review by Jenkins [21], patients under 6 months of age sedated with propofol had a 99% success rate (defined as completion of study using sedation with satisfactory image quality and no motion artifact) but with a 12.7 AE rate, and 4.3% had a serious AE, with airway obstruction being the most common. The authors tie the higher dose required during the sedation of this young population to the relatively high frequency of airway AEs. A recent retrospective study that compared babies undergoing sedation and general anesthesia showed no apneic

events in either preterm or term population post procedure in the sedation group, which used propofol almost exclusively [22]. This implies a possible change in the post-sedation management of this population: the historical "late effects" of sedation such as apnea might not be applicable when IV/IN agents are used compared to prior agents such as chloral hydrate and pentobarbital, which were given via the enteral route.

We recommend that sedation of the premature and former premature infants requires heightened awareness and proficient airway management skills, since airway and respiratory adverse events were most commonly reported in this cohort.

The American Society of Anesthesiologists physical status (ASA-PS) score has also been used to differentiate those children at increased risk for adverse events, but the score was not designed to be used in this manner, and there is a considerable inter-rater variation for the same patient's score between different providers and between different specialties and experience [23] [24]. Newer scores with better predictive ability have been proposed [25] but are not widely used. High Mallampati score was not in itself associated with a higher rate of AEs, including desaturations, apnea, or bag mask ventilation. There was, however, an increased need for patient repositioning [26]. Special consideration should be given to patients with underlying airway anomalies and deviation from normal in any other organ system, such as chronic heart disease, lung diseases [27], bleeding disorders, and neurologic changes such as baseline decreased level of consciousness or poorly controlled seizure disorders.

The child's weight also plays an important role in the pre-procedural assessment. Obese patients, defined as BMI ≥95th percentile for age and gender, are at increased risk for AEs, especially respiratory ones (airway obstruction, desaturation, secretions, and laryngospasm). In addition, they had a higher rate of inability to complete the associated procedure and a longer recovery period. In Scherrer's multivariate analysis of more than 5000 patients, obesity was shown to be independently associated with minor and moderate but not major adverse events [28]. Additionally, Hirsch [29] has shown that children with obesity are almost twice as likely to have a desaturation related to procedural sedation compared with children of other weight status. There is also a tendency to overestimate their sedative requirements, as measured by Chidambaran on 20 patients with BMI greater than the 97th percentile. The authors recommend titrating propofol according to bispectral index (BIS) levels, as the current weight-based dosing is inaccurate [30]. However, BIS monitoring is not a routine practice in pediatric procedural sedation practice. Underweight patients, defined as less than fifth percentile for age, pose a risk as well; a study in oncologic patients showed them to be at increased risk for AEs [31].

We recommend that sedation of the overweight and underweight child requires proficient airway management skills, since weight-based regimens may result in more frequent desaturation events. Use of the ideal body weight for initial dosing in the obese patient with upward titration as needed will help avoid airway-related events related to a deeper than intended level of sedation.

Many obese patients suffer from obstructive sleep apnea (OSA), which can create challenges in maintaining airway patency and excessive body motion due to

snoring while the patient is supine. Enlarged tonsils or underlying disorders such as Down's syndrome can also result in airway obstruction during sleep, independent of the patient's weight. In patients with OSA, dexmedetomidine has been shown to be of benefit, as upper airway reflexes remained active during sedation and patients can compensate for airway obstruction, similar to natural sleep [32]. Of note, both OSA and obesity were found to be risk factors for failed sedation in a single-center study investigating root causes of failed procedural sedation [33].

We recommend that children who require positive pressure airway during sleep either be sedated solely with dexmedetomidine or a combination of dexmedetomidine (induction) and propofol (infusion for maintenance) or be referred to anesthesia. The use of agents other than dexmedetomidine will frequently require placement of an oral airway to maintain airway patency during deep sedation.

The sedation of a child with preexisting acyanotic cardiac disease presents unique challenges. The child with cyanotic disease would preferentially be seen by a cardiac anesthetist in large academic centers. However, in situation where access to cardiac anesthesia is limited or not available, the use of agents such as dexmedetomidine and propofol is preferred. Propofol, despite its negative effect on blood pressure, has not been shown to decrease cerebral tissue oxygenation in a 32 patients' series. The authors speculate this is caused by decreased oxygen consumption of the sedated brain with intact cerebral autoregulation [34]. Although the use of dexmedetomidine has been shown to be safe and effective both during heart surgery [35] and postoperative ICU sedation in patients with acyanotic heart disease [36], evidence is lacking regarding its use in procedural sedation in this patient population. Congenital heart disease could not be evaluated as a predictor of failed sedation in one study, since these patients had been classified as ASA 3 [33]. In addition, as dexmedetomidine depresses nodal function in the heart [37, 38], EKG testing prior to administration in the patients with known heart disease may be prudent. Additionally, dexmedetomidine should not be used for patients with heart block, prolonged QT interval, or ones using digoxin.

We recommend dexmedetomidine as a first-line agent, for its established safety profile for patients with acyanotic heart disease, except for those with preexisting heart block or prolonged QT interval. Propofol can be used in the hemodynamically stable patient, who has a good cardiac output. Patients with cyanotic heart disease should be referred to a cardiac anesthesia team regardless of function or palliation stage.

Autistic spectrum patients, despite their normal physiological responses, require special attention from the sedation team. These measures may include minimizing wait times, avoiding benzodiazepines, additional staff and preparation visits to familiarize the patient with the settings, and minimizing distractions throughout the visit. A practice survey of sedation for autistic spectrum patients undergoing MRI showed significant variation between institutions [39], but no increased frequency of AE, albeit additional personnel requirement before induction. In the series, 10% of patients required four or more providers to ensure patient and provider safety [40]. Regarding the preferred medication regimen in this population, a recent comparative study showed recovery and discharge times were significantly lower when

using propofol, while the use of dexmedetomidine maintained more stable hemodynamics. Both propofol and dexmedetomidine proved to be adequate and safe for procedural sedation [41]. Dexmedetomidine doses were shown to be significantly lower in autistic patients than other patients undergoing MRI sedation, without increase in complications [42].

We recommend avoidance of benzodiazepine and prefer dexmedetomidine as the agent of choice in patients with autistic spectrum disorder. Policies should also be in place to minimize wait time and distractions and provide additional staff as needed.

Another high-risk patient group, who requires frequent sedation, is the oncologic patients. These patients often benefit from aggregation of several procedures during a single sedation, although a retrospective review has shown that these combined procedures require more propofol, and have a higher but manageable risk for AEs [43]. In this patient population, ketamine has been shown to be superior to pethidine (meperidine) in a randomized crossover trial [44], and the combination of propofol and ketamine was better than ketamine alone, as shown in another randomized trial [45]. Another RCT compared propofol to ketamine-midazolam combination; the authors conclude that ketamine-midazolam combination is safer and more effective. Propofol was faster in onset and recovery and had smoother emergence, albeit poor efficacy at recommended initial doses [46]. Of note, ketamine has been associated with laryngospasm [8] and should only be administered by those prepared to deal with this infrequent event.

We recommend ketamine-propofol combination or propofol-fentanyl combination for sedation of oncologic patients. The clinician should be aware of their side effects, namely, laryngospasm for the former and hypotension for the latter, and be ready to manage these, should they appear. A readily accessible record of prior sedative agents and their effect on the sedation event and recovery will also help guide future sedation encounters.

Acute Conditions

The most common illness in our population is upper respiratory infections (URI). These episodes are closely linked to an increase in anesthesia-related adverse events such as breath holding and desaturations but not to laryngospasm or bronchospasm [47]. A single-center evaluation of risk factors for sedation failures identified URI as having increased odds ratio for a failed sedation [33] . A recent observational study in patients undergoing procedural sedation has shown increased rate of airway AE, but overall the risk remained low; the rates of major airway AEs such as laryngospasm, aspiration, emergent airway interventions, unplanned admission, and emergent call for anesthesia all remained <1% regardless of URI status. Current URI and thick secretions (vs. clear) increased the frequency of airway AEs. No relationship between URI status and non-airway AEs was found [48]. We feel it is important to distinguish between increased secretions alone, which may require

increased suctioning frequency, to the presence of cough; as the coughing child is sedated and loses the ability to generate a cough, one can assume the risk of aspiration and airway AE will increase. The presence of a URI in itself does not preclude a patient from undergoing sedation but requires a risk-benefit analysis regarding the length and urgency of the procedure.

We recommend that in the child with URI without cough and baseline saturation > 95%, suctioning be performed shortly after induction of sedation, as this will help decrease desaturation events and minimize the risk of laryngospasm triggered by secretions.

Fever is usually a sign of intercurrent illness, and thus, an assessment of its source should occur and whether this would influence his respiratory or cardiovascular status during the sedation. One review recommends postponing an elective procedure requiring anesthesia 1–3 weeks after vaccination [49]. There is currently not an accepted standard or guideline regarding this.

We recommend that elective sedation be delayed until 1–2 weeks after the illness. Sedation of patients, who cannot be deferred due to protocol adherence, should be evaluated on a case-by-case basis.

Current ASA guidelines dictate a fasting period of 8 hours (excluding human milk and clear liquids) without distinction between general anesthesia and procedural sedation. These guidelines have been used in procedural sedation since any sedation might need manipulation of the airway, but this is not an evidence-based practice; a retrospective review by Beach et al. did not find a significant difference of complications between patients with different NPO status [50]. Another retrospective study in an institution where children scheduled for elective procedures were allowed to drink clear fluids until called to the operating suite found a 0.03% chance of aspiration in more than 10,000 cases [51]. Furthermore, a growing body of evidence question this requirement: a single-center prospective study failed to find an association between a shortened fasting time and increased frequency of vomiting [52], and other studies showed no difference in complication rate [53] [54]. These studies suggest that using shorter fasting time may be a safe alternative for procedure cancellation and rescheduling. Of note, use of nitrous oxide is increasing in our practice. Although associated with a low rate of AEs, the odds of vomiting increased when concomitant opioids were administered and NPO clear fluids <2 hours [55].

We recommend that patients be NPO for 6 hours for light meals, cow's milk, and formula, 4 hours for breast milk, and 2 hours for apple juice, water, and Pedialyte®. Allowing clears up until 2 hours before the procedure helps decrease patient/family concern about prolonged NPO periods.

Pediatric Sedation Service teams are frequently asked to provide procedural sedation for hospitalized patients, but since the patient is hospitalized, a careful review of their respiratory and hemodynamic status along with a physical examination prior to determining sedation is appropriate; if the patient requires supplemental oxygen, has borderline hypotension or airway anomalies, deferring to anesthesia would also be appropriate. However, bedside placement of peripherally inserted central catheter (PICC) lines, short oncologic procedures, and liver or renal biopsies can be readily handled by a well-organized sedation service.

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