Update on Sedation:

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Start with the assumption – providing sedation for minor diagnostic and therapeutic procedures for children is generally easy for anesthesiologists – especially pediatric anesthesiologists. Actually the things we do everyday are considered "reportable" by other specialists. For instance it is not uncommon to find reports in the literature concerning the use of propofol, or pentobarbital, or etomidate for sedation in children undergoing minor procedures in the intensive care literature. An experience with 50 to several hundred of these procedures is considered worthy of a case series report by some specialists – for anesthesiologists this would be "all in a days work" and certainly not worthy of writing up. This update will begin with what I consider the most important issues involved in delivering pediatric sedation for diagnostic and therapeutic procedures and some sedation strategies. The second portion of the lecture will include a very brief consideration of the current status and trends in providing sedation.

Pain vs. No Pain.

The Painless Procedure:
The most important distinguishing feature for any sedation is the anticipation of pain (or not) during the procedure. This issue is lost on many non-anesthesiologists. I will use the MRI scan as the prototypical "non-painful" procedure – we find (and the literature supports) MRI sedation with pure propofol sedation works wonderfully. The sedation provided at moderate infusion rates of this agent (150-200mcg/kg/minute) provides good movement control and the emergence is fast and (usually) smooth. [1] [2, 3]There is no significant nausea. Similarly, agents such as pentobarbital, midazolam, and even chloral hydrate can be employed for similar non-painful diagnostic procedures [4, 5] however for the anesthesiologist they offer no real advantages and the emergence profile does not come close to propofol in terms of rapidity or side effect profile. [6, 7] These agents are primary sedatives with minimal or no analgesic component in the sedation dosage range.

Group discussions with anesthesiologists across the country providing sedation for MRI scans indicates that the most common technique involves propofol infusion with nasal cannula or a face mask and no artificial airway. Unfortunately there is not a lot of literature comparing the use of ET tube, LMA, or nasal cannula/face mask O2 for this kind of case. Our experience at Dartmouth (I think) is typical of others. For ASA I – II patients without airway issues, we have followed 500 patients having MRI scans – 99.5% are successful with a 1% rate of some type of airway adjustment during the case when we start out with a plan for propofol with "no airway". For the large majority, simple positioning the child with the head tilted back will provide for appropriate air exchange. Because there is little stimulation from this technique (other than the irritation of the propofol infusion) a relatively low dose infusion rate can be used. LMA and endotracheal tubes can be reserved for special circumstances. We have evaluated the need for adjunctive airway support in our cohort at DHMC. In general a history of severe obstructive sleep apnea and/or significant parental smoking was associated with a higher rate of need for an oral airway or constant airway support.

Note: For neonates (I offer this as anecdote and nothing else) I find that moderate doses of midazolam work really well for non-painful diagnostic studies. For instance, if a 3 week old who fails simple comfort measures and *really* needs sedation for an MRI, instead of using propofol I will give one dose of 0.05-0.09 mg/kg midazolam by slow infusion. We maintain spontaneous ventilation providing O2 and monitoring CO2 through a face mask. In the 32 neonates we have done this with, we have found good

sedation for the procedures with rapid emergence as soon as the neonate is stimulated when the study is completed. So far, no airway obstruction or apnea issues have been encountered. We find that when propofol is used in this age group it can result in rather prolonged sedation and the requirement to use high doses to obtain sedation. Airway obstruction can be an issue as well. While providing general anesthesia for these patients is not that difficult, we believe that sometimes less IS more.

Dexmedetomidine (0.5-1.0mcg/kg over 10 minutes followed by infusion 1.0mcg/kg/hour) has been described as an agent to use for non-painful procedures such as MRI scans. [8, 9] We are not sure what to say as of yet. The literature is relatively new. In the Pediatric Sedation Research Consortium we have collected almost 1000 cases where dex has been used as the primary sedative. Low heart rates appear to be the biggest risk associated with this technique.[10] Having said this, the numbers remain really small. Possible advantages over propofol include the lack of respiratory depression although we find respiratory depression a minimal risk as long as head positioning is monitored and high risk groups are avoided.

The Painful Procedure:

Painful procedures offer a completely different challenge for the sedation provider. Whereas we feel comfortable that for the anesthesiologist – nothing at this point beats propofol for the brief painless procedure, the situation for painful procedures is not so clear.

As always we would warn against reading into the reports of sedation practice in the pediatric literature. Most of the studies available do not include an assessment of patient "condition" during the procedure. The procedure is a success simply by the fact that it is completed. So the screaming kicking child is a success just as the child who sleeps perfectly for the study. Clearly we need more detail to evaluated the effectiveness of practice.

Perhaps most important when approaching the painful procedure is the need to determine how much intervention is needed. In order to expedite the process of screening patients, we use our Child Life Specialist to interview parents and patients. Given the experience of our CLS we trust her assessment. Interventions will include everything from music/DVD distraction – to deep sedation/anesthesia. Factors involved will include age, previous experience, and developmental level. After 4 years of running an independent sedation service we find that this relatively low cost FTE more than pays for itself if it can be used to "triage" patients prepare families for procedural sedation.

Sedation literature is replete with reports of the use of propofol as a sole agent for painful procedures. As with our general anesthesia practice we find that a more balanced technique is useful. Propofol when used alone for a bone marrow biopsy (for example) requires a huge dose to achieve movement control and good operating conditions. We prefer to combine propofol (100-150mcg/kg/min) with a small dose of fentanyl (1-2mcg/kg) or remifentanyl (0.2-0.2mcg/kg/min) – which improves conditions for the procedure, seriously decreases the dose of propofol required for the procedure, and has not been show to significantly increase side effects after the procedure. Remifentanil (0.4 +/- 0.2 mcg/kg/min) has been reported in combination with midazolam for brief painful procedures in children – effectiveness is good but (depending on the study) need for assisted ventilation is pretty high[11, 12].

As stated above – dexmedetomidine has emerging applications but at this point there is really not enough experience reported in order to recommend its use. There is potential for its use in minor painful procedures as a single drug. Interestingly most of the reports of its use to date are from non-anesthesiologists who want to avoid the possible respiratory depressant effects of the propfol combinations mentioned above.

Ketamine (1-2mg/kg IV or 3-4mg/kg IM) remains a useful adjunct for painful procedures although enthusiasm varies from location to location. We use it commonly for fracture relocation in the ED. As

always, issues with diplopia, disturbing dreams, and nausea/vomiting limit wider application. We often supplement with midazolam (0.050mg/kg) or propofol (50-100mcg/kg/min) with good result and smooth emergence.

Providers:
In addition to the difference between painful and non-painful procedures – the drugs used in pediatric sedation clearly vary with the providers involved in monitoring and delivering pediatric sedation.. When anesthesiologists are delivering sedation, any of the currently available sedative hypnotics and analgesics can be brought to bear on a given case. When a sedation system is configured with nurse providers, drugs with a very wide safety margin such as chloral hydrate and pentobarbital are usually selected. The willingness and ability of non-anesthesiologist MDs to use potent sedative hypnotics is an area of evolution at this time, but the published trend is clearly toward expansion of the use of these drugs outside of anesthesiology. [13-18] Please see Table I for some current sedation regimens.

Current Challenges and Systems:
It is difficult to fully comprehend 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 we do know 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 centers in the United States were much less likely to offer sedation for painful procedures than similar centers in Europe. [19] 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 to 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. [4, 12, 20] Still others have developed the concept of a “sedation room” or a “sedation team” combining provider types. [7, 16, 21-23] While JCAHO no longer mandates that anesthesia departments oversee all of these programs, anesthesia departments are almost always involved in several of ways: 1) most of these programs involve pediatricians who have gone through significant training in sedation – anesthesia departments being the primary trainer of sedation providers either through OR experience or simulation training. 2) These teams are generally trained to shunt the most complicated patients to the anesthesia department – and a reliable system for doing this must be developed. 3) anesthesia personnel have the experience to help other providers understand the process of intake/sedation/recovery – and how to do this efficiently and safely. The most successful programs operate in a cooperative manner (such as the one now operational at CHOP) and have had significant anesthesia input and ongoing guidance.

There continue to be some programs that run nurse-delivered sedation with physician oversight (intensive care, radiology, or anesthesiology) – although data on this practice is once again difficult to come by. While not largely reported, there is a clear trend toward the use of potent medications such as propofol and dexmedetomidine delivered by RN’s with physician oversight.

Discussions with non-anesthesia sedation providers indicate that most of these providers bill anesthesia codes – which is possible as long as the hospital credentials these individuals to deliver this care. A current effort to redefine pediatric sedation CPT codes may change this practice in the near future. From

the financial standpoint, the most successful sedation systems employ their own "sedation unit". The use of a separate space improves efficiency of intake and recovery. It enables the sedation group to charge a separate "technical fee" to recover the cost of nursing personnel and supplies that is not possible if the sedation team uses other clinics or OR space. Our experience at Dartmouth has shown us that we can support a physician FTE and two nurses plus a patient care technician and child life specialist as long as the schedule includes between 7-10 sedations per day for a variety of diagnostic and therapeutic procedures. Other similarly organized sedation systems (Denver Children's Hospital, Oregon Health Systems) report a positive margin on this work as well.

Table 1. Sedation Regimens for Children

DrugRegimen	***Dose/Route of Administration***	***Comments (general citations at end of text)***
Propofol	100-200 mcg/kg/min IV	Ideal agent for non-painful diagnostic procedures. Only for use by expert airway managers with good back-up systems.[13, 24, 25]
Pentobarbital	4-6 mg/kg IV or PO	Long history of effective use in radiology imaging. Emergence can be prolonged. [4, 26]
Midazolam	0.5-0.75 mg/kg PO 0.025-0.5 mg/kg IV 0.2mg/kg intranasal	Track record of safe use both PO and IV. Paradoxical reactions are not infrequent. Intranasal route is so irritating we do not recommend it. [27-29]
Chloral Hydrate	50-100mg/kg PO	Still the most popular agent for radiologic sedation in community hospitals. Prolonged sedation and paradoxical reactions are reported. Monitoring required.[24, 26, 30]
Etomidate	0.1-0.4mg/kg IV	Emerging use in emergency medicine for brief painful procedures – although no intrinsic analgesic effect.[17, 31, 32] Post sedation nausea reported. Little effect on heart rate and blood pressure in most cases.
Methohexital (not readily available at this time)	0.25 – 0.50mg/kg IV 20-25mg/kg Rectal	Effective sedation in IV form. Rectal route is not recommended due to high frequency of apnea/desaturation events.[33-35]
Propofol with fentanyl	Fentanyl 1 – 2 mcg/kg IV with Propofol 50-150 mcg/kg IV	Best for deep sedation/anesthesia – risk of requiring advanced airway management is high. [12, 36]
Midazolam with fentanyl	Midazolam 0.020mg/kg IV Fentanyl 1-2mcg/kg IV	Most common combination for painful procedures in the emergency department – risk of apnea and hypoxia is significant [37, 38]
Ketamine	3-4 mg/kg IM 1-2 mg/kg IV	Effective sedation and analgesia for painful procedures. Relatively common nausea and vomiting post procedure. Layngospasm reported. [14, 39, 40] Best if combined with an anticholinergic for control of secretions. Combination with midazolam is common although effectiveness in treating emergence dysphoria is debated.
Remifentanil	0.1mcg/kg/min	Emerging use in pediatric sedation – exclusively by anesthesiologists at this point – apnea a significant risk. [11, 12, 41, 42]

Summary

Pediatric sedation practice trends remain dynamic. Anesthesiologists continue to be the ideal provider of these services, however (increasingly) other pediatric specialists are being viewed as the leaders in the field because they tend to report their results more often. The techniques used for sedation will vary with the type of procedure the patient is undergoing – most importantly painful vs. non-painful – and the providers available to perform the sedation. The increasing demand for pediatric sedation provision has driven many innovative solutions to the difficulty in finding enough providers of sedation. Anesthesiologists should (and will) remain key player in the solutions to pediatric sedation provision regardless of the specialty of the individuals who deliver this service.

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