Can you sedate this neonate, but please don't intubate…

Arlyne K Thung MD and Joshua C. Uffman MD
Nationwide Children's Hospital/OSU Wexner Medical Center, Columbus, Ohio

You are reviewing your assignment for tomorrow in which you will be the remote location Anesthesiologist. You scan the schedule and see that you will be covering an MRI of the brain in a 4 day old neonate with the note "Anesthesia-please do not intubate". Perplexed but intrigued, you decide to contact the ordering physician to get additional information. Discussion with the primary service reports that the patient is a full term 3.2 kg male with stable stridor. An awake bedside flexible nasal endoscopy performed the day prior by ENT showed findings suggestive of vocal cord paralysis, leading to the MRI order to rule out a Chiari malformation. When you ask if a "wrap and feed" was attempted they respond that a "wrap and feed" was not feasible due to the patient being kept NPO for a video/swallow study assessing for aspiration which they were supposing was low probability. An awake MRI was attempted and aborted due to excessive motion artifact.

Following the conversation with the primary service, you decide to contact the ENT service for their input. When you question the necessity of the scan and whether neurosurgical intervention at this time would even be indicated for a Chiari malformation, the Pediatric Otolaryngologist responds that it would be "nice to know" and feels the MRI is an essential component of the patient's work up. Further, he expresses his concern that airway instrumentation and an endotracheal tube may lead to complete airway obstruction requiring an unnecessary tracheostomy at this point in time. He asks if you could "just sedate" the patient.

The next morning the patient is transported down to the MRI scanner. He is bundled with a peripheral intravenous in place. At hand off the nurse reports morning vitals of BP 76/40, HR 146, RR 32, SpO2 97% on room air. She mentions that he has been stable overnight but becomes stridorous when agitated or with excessive movement with associated oxygen desaturation.

Goals

1. Upon completion of this learning activity, participants should be able to understand the unique challenges of deep sedation in a neonate.
2. Upon completion of this learning activity, participants should be able to describe both pharmacological and non pharmacological options for neonates needing diagnostic imaging.
3. Upon completion of this learning activity, participants should be able to review the current controversies surrounding the increase demand for diagnostic imaging in the pediatric population.

Would you proceed with this case? What are current trends in diagnostic imaging in the pediatric population?

Although multiple reports show trends of overall growth in the use CT/MRI in the adult population over the last decade, limited data exists regarding the pattern of use of magnetic resonance imaging in the pediatric or neonatal population. In a retrospective study examining brain and spine MRI utilization patterns over a 6 month period, Winckworth et al[1] reported that 181 scans were performed on 141 patients in a U.K. tertiary university center serving a pediatric population of 60,000 patients. Scan frequency had a bimodal distribution with respect to patient age (peaks under 1 year and 11-15 years) and the highest positive predictive rate (PPR) of abnormal scans requested through the intensive care unit (61%) versus general pediatric requests (17%). However, with rapid advances in MR technology, the absence of radiation exposure and increased accessibility/physician study ordering, further increases in neonatal/pediatric patients undergoing MRI are anticipated.

Would you consider this an emergent scan or would you considering delaying the MRI after the video swallow study?

Vocal cord paralysis is the second leading cause of neonatal stridor after laryngolmalacia and has been reported to account for 10% of congenital anomalies affecting the larynx. Chiari malformation is the most common congenital CNS anomaly associated with bilateral vocal cord paralysis. The prevailing theory accounting for vocal cord paralysis in patients with Chiari malformation is vagal traction caused by herniation of the cerebellum or brain stem through the foramen magnum. In these patients, early surgical intervention resulted in recovery of vocal cord function.

Is this a case that a non-anesthesia sedation provider should undertake? If the patient did not have vocal cord paralysis but still required sedation for the MRI, is a non-anesthesia sedation provider appropriate?

The choice of who should provide sedation is complicated but often dictated by the sedation/ anesthesia plan. Couloures et al[2] examined the complication rates from pediatric sedation by provider type and reported no significant differences between general pediatrician, pediatric intensivist, emergency medicine and anesthesiologist in cases reported to the Pediatric Sedation Research Consortium. However, application of Couloures study in the neonatal patients with stridor may be challenging as patients aged 6 months or less in the study represented 6% of cases and patients with an ASA classification >2 only 15% of the cases. Further, while age and ASA >2 were not confounding variables, the study was not able to eliminate selection bias of cases to each type of provider type in each institution.

With little or no data to support or refute whether a patient of this age and medical history is suitable for a particular provider type, the practice of who is the sedating individual becomes institutionally dependent based on levels of expertise, support and set up. Most institutions may refer the neonatal patient with a medical issue to the anesthesia service. In the absence of significant comorbidities, the answer is less clear-cut and even more dependent on the institutional comfort level in sedation.

You decide to proceed with the MRI. What are your pharmacological options for sedation assuming a functional IV is in place?

Propofol

Commonly used as an agent for procedural sedation, Propofol is highly lipid soluble with clearance dependent on hepatic metabolism. The recommended dosing range for pediatric patients from 2 months of age is 125-300mcg/kg/min. Data regarding the use of propofol infusion in the neonatal population however is limited. Dose adjustments may be needed due to inter-individual variability of propofol clearance leading to accumulation with either continuous infusion or repeated bolus dosing.

Dexmedetomidine

An α2 adrenergic agonist with analgesic and sedative properties, dexmedetomidine has gained increasing popularity for the sedation of pediatric patients undergoing radiological imaging. When given intravenously, loading doses of 0.5 to 3μg/kg and maintenance infusions of 0.5 to 2μg/kg/hr are used. Increased anesthesia induction time, emergence time and PACU time have been associated with pediatric patients presenting for MRI who were administered dexmedetomidine versus those given propofol. Intramuscular and intranasal dexmedetomidine routes have also been used in pediatric patients for radiologic imaging. Mason et al[3] reported the use of intramuscular dexmedetomidine in pediatric patients undergoing sedation for MRI and CT with the MRI group receiving a mean dose of 2.9μg/kg and Li et al[4] reported successful rescue sedation with intranasal dexmedetomidine following failed chloral hydrate sedation in pediatric patients undergoing CT, auditory brainstem responses or visual evoked potentials. Intranasal dexmedetomidine at doses of 2 μg/kg was noted to have the highest rescue success rate (96.2%).

Studies looking at the sedative use of dexmedetomidine in the neonate undergoing MRI are limited, although recently, Chrysostomou et al examined the safety, efficacy and pharmacokinetic profile when dexmedetomidine was the primary sedative agent in ventilated preterm and term neonates[5]. Subjects were grouped into gestational age ($\geq$28 to <36 weeks and $\geq$36 to $\leq$44 weeks) and then assigned to 1 of 3 escalating dose levels with respect to loading dose (0.05, 0.1, 0.2 μg/kg) and maintenance dose (0.05, 0.1, 0.2 μg/kg/hr). The authors reported that no significant hemodynamic or respiratory changes occurred which warranted intervention or discontinuation of dexmedetomidine. However, the authors concluded dose adjustments should be made particularly in preterm neonates due to significantly increased $t_{1/2}$ and AUC (area under the concentration curve) values. Prolonged $t_{1/2}$ and increased AUC were attributed

to increased free unbound dexmedetomidine from immature glucuronidation (pathway largely responsible for metabolism) and lower protein/albumin levels.

Pentobarbital

A short acting barbiturate, pentobarbital has been successfully used for sedation when administered to the pediatric patient for radiological imaging with oral dosing ranging from 4 to 8 mg/kg and intravenous dosing 2 to 3 mg/kg to a maximum of 5-8mg/kg. When compared with oral chloral hydrate and intravenous propofol infusion in infants requiring sedation for MRI studies, IV pentobarbital has been associated with prolonged recovery time, a finding also seen in older pediatric patients.

Chloral Hydrate

A sedative agent with an active metabolite trichloroethanol (TCE), chloral hydrate has been successfully used in the sedation of neonates and infants undergoing MRI. In looking at 411 infants (median age 42 weeks and weight 3600g) undergoing MRI, oral chloral hydrate was an effective sedative agent when given in doses ranging from 20-80 mg/kg[6]. In 17 patients (3.1%), self-limited desaturations occurred that were responsive to supplemental oxygen whereas in 3 patients (0.7%) desaturations led to an aborted scan.

If the patient did not have an IV or require contrast, are there any non-pharmacological interventions that would facilitate a successful MRI study?

If tolerating oral feeds, a "wrap and feed" technique is often attempted in the neonate undergoing radiological imaging in order to avoid sedation and general anesthesia. In addition, an immobilizing device may be combined with the “wrap and feed” technique to avoid excessive motion artifact. Patients can be fasted prior to the scan and fed immediately before initiation of imaging in the adjoining room or be given a pacifier dipped in sucrose. Following standard monitoring placement consisting of pulse oximetry and EKG lead placement, ear muffs or plugs are placed and the infant swaddled and positioned within an immobilizing device such as a CFI MedVac bag (Fenton, MI) which has shown success in the neonate.

What are your airway options for this patient? Would you consider a face mask? LMA?

Options for managing the airway in the neonate presenting for MRI may include but not be limited to nasal or face mask oxygen, supraglottic devices and endotracheal intubation. Moderate and deep sedation may be a challenge and a less attractive option for the practitioner due to decreased ability of the neonate to maintain airway tone in the face of sedative agents. In a study looking at 640 infants aged from 1 day to 12 months[7], MRI imaging was successfully performed (97.9% of cases) with subjects spontaneously breathing 1.5-2% sevoflurane by face mask. One episode of vomiting was noted and 12 cases of desaturations ($SP0_2$ ranging from 90-94%).

While supraglottic airway devices are produced for the neonate age group, anesthesiologists may limit their use due to suboptimal placement and propensity for dislodgement. Mathis et al[8]

looked at LMA failure in children 18 years and younger and found an overall failure rate of 0.86%. While patients 6 months or less represented a small portion of their population (n=66, 0.6% cases), there were only 2 failures, representing a 3% failure rate. They noted, however, a statistically significance increased failure rate for of size 1 and 1.5 LMAs across ages. Kim et al[9] compared two supraglottic devices, i-gel™ and LMA™ classic in 54 children (aged less than one year and 10kg) having elective surgery. In this study, they found that the i-gel™ was easier to insert and had a better fit, based on fiberoptic view with all but one child being able to complete the surgery without changing to an alternative airway (ETT). Despite study limitations, namely the small number of children enrolled, the results provided evidence that supraglottic devices like the i-gel™, may be a viable airway option for neonates and infants in select cases.

A supraglottic device could be an option for the above patient thus avoiding intubation. However, neither a natural airway with nasal cannula/ facemask, nor supraglottic airway would alleviate the need for intubation should the vocal cord paralysis cause significant obstruction in the face of sedation or general anesthesia. If airway edema is a true concern, placement with a smaller sized, uncuffed, endotracheal tube should be considered.

What should your post MRI preparations be if any?

There is little to suggest that one plan for post-operative care should be chosen over another. However a few options may be considered based on the clinical status of the patient during the pre and intra-operative periods. Some of which includes ENT presence and fiberoptic airway examination to assess vocal cord function during emergence, and presence of heliox and CPAP/BiPAP. In addition, consideration for post operative disposition needs to be considered in term of whether admission to the intensive care unit is warranted.

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