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An Updated Review of Pediatric Drug-Induced Sleep Endoscopy

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Objectives: Drug-induced sleep endoscopy (DISE) involves assessment of the upper airway using a flexible endoscope while patients are in a pharmacologically-induced sleep-like state. The aim of this article is to review the current literature regarding the role of DISE in children with obstructive sleep apnea (OSA). The indications, typical anesthetic protocol, comparison to other diagnostic modalities, scoring systems, and outcomes are discussed.

Methods: A comprehensive review of literature regarding pediatric DISE up through May 2017 was performed.

Results: DISE provides a thorough evaluation of sites of obstruction during sedation. It is typically indicated for children with persistent OSA after tonsillectomy, those with OSA without tonsillar hypertrophy, children with risk factors predisposing then to multiple sites of obstruction, or when sleep-state dependent laryngomalacia is suspected. The dexmedotomidine and ketamine protocol, which replicates non-REM sleep, appears to be safe and is often used for pediatric DISE, although propofol is the most commonly employed agent for DISE in adults. Six different scoring systems (VOTE, SERS, Chan, Bachar, Fishman, Boudewyns) have been used to report pediatric DISE findings, but none is universally accepted.

Conclusions: DISE is a safe and useful technique to assess levels of obstruction in children. There is currently no universally-accepted anesthetic protocol or scoring system for pediatric DISE, but both will be necessary in order to provide a consistent method to report findings, enhance communication among providers and optimize surgical outcomes.

Key Words: DISE, drug-induced sleep endoscopy, obstructive sleep apnea, pediatric.

Level of Evidence: N/A.

INTRODUCTION

Obstructive sleep apnea (OSA) has an estimated prevalence of 1–4% in children in the United States.[1] Those affected may suffer from daytime somnolence, academic difficulties, behavioral and neurocognitive problems,[2–6] enuresis, cardiovascular complications,[7,8] poor growth, and metabolic disorders. Additionally, children with OSA have been shown to have significant reductions in overall and disease-specific quality of life.[9] Adenotonsillar hypertrophy is recognized as the most significant contributor to OSA in otherwise healthy children. Thus, adenotonsillectomy (T&A) is first-line therapy for pediatric OSA, typically resulting in resolution of symptoms in the majority of affected children, improved respiratory sleep parameters, and better quality of life.[10–12] However, several studies have shown that anywhere from 20–75% of children may have some degree of persistent sleep disordered breathing despite undergoing T&A.[13–17] Studies suggest that children under age 3 years of age or over age 7 years may suffer from disproportionally high rates of persistent OSA.[13,18] While there is no difference in the rate of persistent OSA after adenotonsillectomy in children with apnea- versus hypopnea-predominant OSA,[19] several other factors have been shown to predict residual disease. These include the presence of severe sleep apnea on initial polysomnogram (PSG),[13,19,20] obesity,[13,20,21] craniofacial anomalies, hypotonia,[22] and Down syndrome.[23,24]

An attended, in-laboratory, nighttime PSG remains the gold standard for diagnosis of OSA both before and after T&A[25–27]; however, it does not provide information on the site of obstruction, direct further therapies, or predict which children would benefit from surgical and/or medical interventions for persistent OSA. Continuous positive airway pressure (CPAP) is a widely accepted therapy for persistent OSA, but is often poorly tolerated in children with 50% or fewer adherent to therapy.[28–30] Additional surgical intervention may also be considered when a site of obstruction is identified. In-office flexible fiberoptic nasopharyngoscopy is often used to assist in identification of potential sites of obstruction.[24] While this may be helpful in circumstances of adenoid regrowth, lingual tonsil hypertrophy, tongue base prolapse, and awake laryngomalacia, this evaluation is limited by several factors[24]; children may not cooperate and the exam is performed in an upright position on awake

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patients and therefore may not capture the dynamic upper airway collapse that may occur exclusively during sleep.[24,31] Finally, there is no predictable association between awake and sleep endoscopy to reliably negate the need for one based on the results of the other.[32,33] The utility of other conventional assessments, such as the Müeller maneuver, lateral cephalometry, computed tomography (CT) scans or x-rays, are also hindered by many of these issues.[31]

In light of these limitations, Croft and Pringle first described "sleep nasendoscopy," for use with adults and children, in the early 1990s.[31,34] The name was changed to "drug-induced sleep endoscopy" (DISE) by Kezirian and Hohenhorst in 2005 to better reflect the key elements of the procedure.[35] This technique involves assessment of the upper airway, using a flexible endoscope, while patients are in a pharmacologically-induced sleep-like state. DISE has been shown to be safe,[24,36] to have good test-retest reliability,[37] and moderate-to-substantial inter-rater reliability.[38,39] DISE is now routinely used to assess for site(s) of upper airway obstruction after T&A in children[40,41]; it is also frequently used to assess children with complex upper airway disorders.[23] Ideally, DISE is used to identify a surgical target or targets and allows for intervention(s) that alleviate obstruction. Very little, however, has been published regarding pediatric DISE-directed surgical outcomes. The aim of this article presents a review of the most current literature regarding the role of DISE in children with OSA, including the indications, typical anesthetic protocol, a comparison to other diagnostic modalities, scoring systems, and outcomes.

DISCUSSION

DISE Indications

While the indications for DISE in children are still evolving, most practitioners agree that DISE is appropriate for those with persistent OSA after T&A[41–44] in order to direct surgical intervention. In a 2017 survey regarding pediatric DISE practice, the majority of respondents required a PSG-confirmed diagnosis of OSA prior to employing DISE.[42] A 2016 systematic review revealed that at least one site of obstruction was identified in 100% of children who underwent DISE ($n = 162$).[41] The most commonly described sites of obstruction were the tongue base, adenoids (secondary to regrowth), inferior turbinates, velum, and the lateral oropharyngeal walls.[41] However, there is currently no recognized DISE phenotype that predicts a successful outcome after surgery.[41] Similar to findings in adults, the majority of these children were noted to have multilevel obstruction with one study showing that 97% of children with persistent OSA had multilevel obstruction and over 80% had at least three levels of obstruction.[36]

While DISE is commonly described for children who have undergone previous T&A, it has also been performed prior to T&A. Typically this occurs for children who are at high-risk for persistent OSA including those with obesity, severe OSA, Down syndrome, craniofacial anomalies (i.e., Pierre Robin sequence, Treacher Collins syndrome), hypotonia, and neurologic impairment.[13,17,21,22,41,45,46] For these children, DISE is often performed in conjunction with another procedure or immediately prior to the T&A. Proponents of this indication suggest it may be useful to guide management of residual disease after T&A; however, opponents argue that airway dynamics change significantly after T&A making this evaluation low yield while adding unnecessary cost and operative time.[42]

DISE has also been used to evaluate children with significant symptoms of SDB or a diagnosis of OSA in children with small tonsils and adenoids.[44] One study of children undergoing DISE prior to T&A reported a significant correlation between the Brodsky tonsil score and the degree of tonsillar obstruction noted during DISE ($r=0.68$, $p=0.01$).[47] A 2016 study by Miller et al. also reported a positive correlation ($r=0.55$, $p<0.001$) between tonsil size and DISE scores for lateral pharyngeal wall collapse. Specifically, they found that 60% of children with 1+ tonsils ($n = 65$) had no lateral pharyngeal wall collapse and that there was a linear, 0.7-point increase in lateral pharyngeal wall collapse score for each 1-point increase in tonsil size. These authors suggested that DISE may be appropriately performed during the initial surgical evaluation, prior to performing T&A, in these children.[48]

In addition, DISE may also benefit children with concern for occult or sleep-state dependent laryngomalacia. While traditionally recognized as a disease of infants, sleep-state dependent laryngomalacia was described in TIME and is estimated to cause upper airway obstruction in 3.9% of children with OSA assessed prior to T&A.[49] Richter et al. described seven such children with a mean age of 6.3 years at time of diagnosis; only 33% had parent-reported stridor and they generally did not have typical findings of shortened aryepiglottic folds or retroflexed epiglottis. They did, however, demonstrate arytenoid redundancy and prolapse during DISE; and they all had a significant improvement in their symptoms after supraglottoplasty.[50] Another study by Chan et al. demonstrated that nine children with sleep-state dependent laryngomalacia who underwent isolated supraglottoplasty had a significant reduction in their mean AHI from 10.4 preoperatively to 2.9 events/hour ($p = 0.01$)[51]; 78% had mild or no residual OSA after surgery. While knowing when to have a high suspicion for sleep-state dependent laryngomalacia is difficult, DISE-directed supraglottoplasty has been shown to be an effective intervention.[51,52]

Lastly, DISE is indicated when considering hypoglossal nerve stimulator treatment. As of 2017, the Food and Drug Administration requires DISE to rule out concentric collapse at the level of the velum in order to be considered an appropriate candidate.[53] Table I summarizes the potential DISE indications.

DISE has no specific contraindications as long as children can undergo anesthesia.[35] There is also concern that DISE may not be as useful in children with isolated REM obstructive disease as no anesthetic agents are currently able to replicate REM sleep.[42] However, a recent study found that sites of obstruction were routinely identified for children with REM predominant

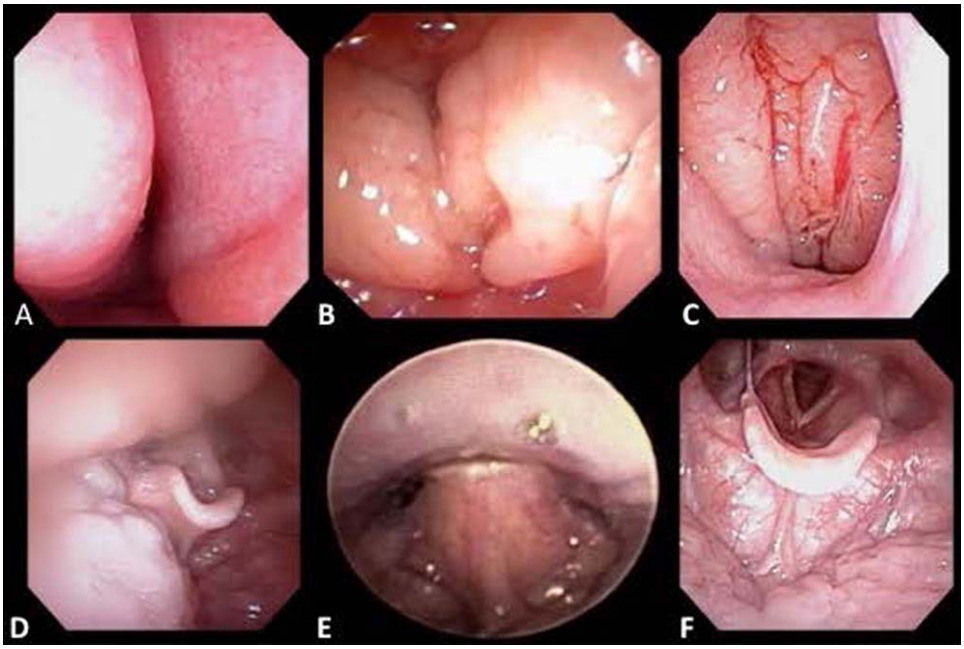

Fig. 1. Images of findings in drug-induced sleep endoscopy. A) Inferior turbinate hypertrophy. B) Adenoid hypertrophy with horizontally-oriented palate. C) Normal adenoids with vertically-oriented palate. D) Lingual tonsillar hypertrophy with partial vallecular effacement. E) Epiglottic retroflexion with complete anterior-posterior collapse. F) Normal supraglottis and glottis without lingual tonsillar hypertrophy.

disease who underwent DISE evaluation using dexmedetomidine and ketamine anesthesia.

DISE Protocol

During DISE, anesthesia is given in order to induce a sleep-like state. While there is concern that anesthesia may not accurately reproduce the obstruction seen during natural sleep, it has been shown that light sedation does not produce marked changes in the AHI or oxygen saturations when compared to natural sleep.[54] There is significant variation, however, in the anesthetic agents, extent of the evaluation, and scoring systems used to document sites of obstruction.[42]

A typical protocol is illustrated by the one used at the Cincinnati Children's Hospital Medical Center. Patients undergo DISE in the supine position with no pillow under the head and neutral positioning while undergoing cardiopulmonary monitoring. For children who require an initial mask induction for intravenous catheter placement, inhaled sevoflurane is used and then immediately discontinued after the catheter is placed. Dexmedetomidine (DEX) is administered with a loading dose of 3 mcg/kg over 10 minutes followed by a 2 mcg/kg infusion. Ketamine at 1 to 2 mg/kg is given concurrently with the start of the loading dose of DEX. No decongestants or topical anesthetics are given. Topical lidocaine is not given because of concerns that it may exaggerate the findings associated with laryngomalacia, reduce upper airway reflexes, and impair the arousal response resulting in increased sleep apnea severity.[55] During the infusion, an oral airway and oxygen supplementation are typically used but are discontinued prior to beginning the endoscopic evaluation. At the conclusion of the loading dose, a nasal suction catheter is introduced into the bilateral nasal cavities, both to remove secretions and to ensure that the depth of sedation is appropriate for DISE.

A flexible fiberoptic endoscope is then inserted into the nose and passed into the rest of the upper airway; although the scope may be introduced while the child is still awake, this is often not well tolerated. The following sites are assessed and findings documented: the internal nasal valve, nasal septum, inferior turbinates, nasopharynx (including adenoid tissue), palate/velum position, oropharynx, tongue base, lingual tonsils, epiglottis, supraglottis, and the true vocal folds (Figs. 1A-F). The trachea may also be assessed. Levels of obstruction are recorded as "none," "partial," or "complete." A summary of the sites of obstruction most commonly reported in children undergoing DISE for OSA after T&A are documented in Table II.[22,23,56–60]

A 2016 survey [43] regarding pediatric DISE practices revealed that almost all US surgeons performing DISE examined the upper airway sites listed in the previous

TABLE I.
Proposed Drug-Induced Sleep Endoscopy (DISE) Indications

Proposed DISE Indications
• Persistent OSA after T&A
• Prior T&A for patients at high-risk for persistent OSA
◦ Obesity
◦ Down Syndrome
◦ Craniofacial anomalies (eg, Pierre-Robin sequence)
◦ Neurologic impairment
• Significant symptom of SDB or OSA with small tonsils and adenoids
• Occult or sleep-state dependent laryngomalacia
• Prior hypoglossal nerve stimulator treatment

OSA = obstructive Sleep Apnea; T&A = tonsillectomy and adenoidectomy; SDB = sleep-disordered breathing

TABLE II.
Summary of Studies Using DISE to Identify Sites of Obstruction in Children with Persistent OSA after Adenotonsillectomy

Author	Year	N	Mean Age (Years)	Percentage of Children with Persistent OSA	Preop AHI (SD)	Postop AHI (SD)	Children with Identified Site of Obstruction	Primary Site of Obstruction (%)	Percentage of Children with Multilevel Obstruction
Boudewyns	2017	28	1.5‡	28.5%	13.8	<2	28/28 (100%)	Adenoids (89.8%)	50%
Park	2016	78	5.3	100%	20.1 (3.4)	11.8 (2.8)	NR	Tongue base (64%)	49%
Maris	2016	25*	10.2	52%	11.4	5.5	25/25 (100%)	Adenotonsillar (75.6%)	85.4%
Lan	2016	9†	8.7	NR	8.44	NR	9/9 (100%)	Velum (100%)	66.6%
Boudewyns	2014	37	4.1	9%	9.0	1.0	33/37 (89%)	Adenotonsillar (89%)	56.7%
Durr	2012	13	7.8	69%	7.9 (7.3)	NR	13/13 (100%)	Tongue base (84.6%)	84.6%
Fung	2012	23*	7.1	NR	NR	NR	23/23 (100%)	Lingual (91.6%)	NR
		23§	7.6	NR	NR	NR	12/23 (52%)	Lateral pharynx (60%)	NR
Myatt	1999	20	NR	NR	48 (15.5)	4.6 (4.5)	8/8 (100%)	Tongue base and pharynx (35%)	20%

*Down Syndrome patients only
†Prader-Willi patients only
‡Children <2 years old
§Controls
DISE = drug-induced sleep endoscopy; OSA = obstructive sleep apnea; NR = not reported; LOE = level of evidence; AHI = apnea-hypopnea index; SDL = state-dependent laryngomalacia

paragraph; however, only 30% typically examine the trachea and bronchi. It was commonly advocated for children with severe OSA or for children with hypotonia due to the concern for multilevel collapse to examine the trachea and bronchi while performing a DISE. The majority of respondents also incorporated a chin lift or jaw thrust during the procedure to assess closed-mouth breathing and mandibular-repositioning, respectively. Jaw thrust while the scope is at the level of the choanae may assist in determination of the impact of the hypopharyngeal anatomy on the palate; this is especially true when there are large tonsils or a large tongue. DISE may also be combined with other diagnostic procedures, such as microlaryngoscopy and bronchoscopy (MLB), or sleep cine magnetic resonance imaging (MRI).[24,64]

Anesthetic Considerations

Controversy remains regarding the choice of anesthetic agents for DISE. An ideal agent would provide predictable analgesia, which simulates a natural sleep-state without causing respiratory depression, cardiovascular effects, or airway collapse beyond those seen during natural sleep. In adults, DISE is typically performed with propofol anesthetic titrated to a bispectral index (BIS) between 50–75.[65,66] Propofol, however, has been criticized for its potential to cause excessive muscle relaxation and airway collapse. One study showed that propofol administration to BIS scores of 50 to 60, indicative of deeper sedation, were associated with increased airway collapse and more complete collapse at affected sites.[65] A systematic review by Ehsan et al. described the dose-dependent effects of propofol on the upper airway which may manifest as narrowing uniformly throughout the pharyngeal airway in infants and at the level of the epiglottis in older children.[55]

A combination of DEX and ketamine is preferred by many pediatric sleep surgeons due to the lower risk of respiratory depression and upper airway obstruction as compared with other agents.[24,55,67,68] DEX has been shown to replicate non-rapid eye movement (non-REM) sleep.[43,67,69] In addition to these agents, most children, require inhalational anesthetic at the beginning of the procedure in order to insert an intravenous (IV) line. Because inhalational anesthetics have been shown to decrease upper airway muscle activity and can confound findings during DISE,[42] it is recommended that inhalational agents be discontinued as soon as IV access is obtained and DISE delayed until the agent is out of the patient's system. Good communication with the anesthesia providers is also particularly important as children with OSA are at greater risk for airway obstruction and oxygen desaturation when sedated and over-sedation can result in airway compromise and/or central apnea.[44] Table III summarizes the most commonly used anesthetic agents and their reported effects on the upper airway.[42,55,67,70]

Comparison of DISE and cine MRI

Cine MRI is another modality used to identify the site of obstruction for patients with obstructive sleep apnea. Similar to DISE, cine MRI evaluates for sites of obstruction during sedation and spontaneous ventilation.[41] One advantage of cine MRI over DISE is the ability to simultaneously assess multiple levels of obstructions including the impact of the tongue on the palate.[41] It has also been reported that cine MRI allows for a better overall view of the airway and allows one to observe both primary and secondary causes of obstruction.[71] In addition, cine MRI is a better able to quantify the size of the lingual tonsils and distinguish base of tongue obstruction from lingual tonsillar hypertrophy.

TABLE III.
Summary of Common Anesthetic Agents Used in Pediatric DISE.

	Propofol	Midazolam	DEX	Ketamine	Inhalational agents
Mechanism	Poorly understood–GABA receptor agonist, NMDA receptor antagonist	GABA receptor agonist	Selective Alpha-2a adrenergic receptor agonist	NMDA receptor antagonist	Poorly understood–affect neurotransmitter release in the CNS
Anesthetic effects	Global central nervous system depression	Sedative, anxiolytic, amnestic	Sedative, anxiolytic, analgesic	Dissociative amnestic, analgesic, trance-like state	Global central nervous system depression
Onset	Rapid (within 30 seconds)	Short (1–3 minutes)	Moderate (5–10 minutes after IV loading dose)	Short (<5 minutes)	Varies
Duration	Short-acting (3–10 minutes)	15–60 minutes	2–4 hours	10–20 minutes	Varies
Effect on airway cross-sectional area	Decrease	Decreased	Minimal effect	Minimal to increased	Decreased
Other upper airway effects	-Increased obstruction at the level of the base of tongue -Decreased EMGgg activity	-Increased nasal resistance -Higher risk of obstruction in children with OSA	-Less likely to cause upper airway obstruction than propofol	-Bronchial smooth muscle relaxant -Minimal effects on central respiratory drive	-Suppressed responses to tracheal stimulation (sevoflurane and desflurane)
Potential side effects	-Hypotension -Respiratory depression	-Hypotension -Respiratory depression	-Hypertension with bolus dose -Hypotension during infusion -Bradycardia -Dry mouth	-Tachycardia -Hypertension -Hypersalivation -Hallucinations	-Hypotension -Respiratory depression
Effects on sleep architecture	-Reduced N1 sleep -Sustained N2 sleep -Increased N3 sleep -Absence of REM	-No REM sleep -Decreased duration of N3 sleep	-Results in NREM sleep	-Reduced REM sleep	-Suppressed slow wave sleep - Increased N2 sleep

DEX = dexmedotomidine; GABA = gamma-aminobutyric acid; NMDA = N-methyl-D-aspartate; EMGgg = genioglossus electromyogram; BP = blood pressure; HR = heart rate; CNS = central nervous system; REM = rapid eye movement; NREM = non-REM, N1 = stage 1 of sleep, N2 = stage 2 of sleep, N3 = stage 3 of sleep

TABLE IV.
Pediatric Scoring Systems for Drug-Induced Sleep Endoscopy (DISE)

	SERS	VOTE	Chan	Boudewyns	Fishman	Bachar
General obstruction grading	0: No obstruction/ widely patent +1: Partial +2: Complete	0: None 1:Partial (vibration) 2: Complete (collapse) X: Not visualized	0: None 1: 0–50% 2: 50–99% 3: Complete	Fixed 0: None 1: <50% 2: 50–75% 3: >75% Dynamic 0: Absent 1: Present	0: None 1: Mild 2: Moderate 3: Severe	1: Partial 2: Complete for each site for a total score up to 10
Nasal airway	X		X		X	X (N)
Nasopharynx	X		X		X	
Adenoids			X	Fixed		(P)
Velum	X	Pattern: Anteroposterior Lateral Concentric	X	Dynamic		
Oropharynx	X	Pattern: Lateral	X	Fixed	X	
Lateral walls						
Tongue base	X	Pattern: Anteoposterior	X	0: None 1: Partial 2: Complete	X	X (T)
Epiglottis	X	Pattern: Anteroposterior Lateral		Dynamic		
Supraglottis	X		X	Dynamic	X	
Lingual tonsils	X		Present/Absent			
Larynx						X (L)
Hypopharynx						X (H)
Adjunct airway needed for support			Jaw thrust Oral airway Other			
Comments		Widely used		General assessment on 0: No hypotonia 1: Hypotonia	Consider: primary site, severity of OSA, confidence in findings, quality of examination	NPTLH staging index per total score

An "X" signifies that site of obstruction is evaluated by the scoring system, while a shaded box signifies that the site of obstruction is not evaluated
SERS = Sleep endoscopy rating scale; VOTE = velum oropharynx tongue-base epiglottis

Although cine MRI has gained popularity, this technique is not widely used.[42,72] Advantages of DISE include the ability to see in 3 dimensions, as well as the ability to perform surgical correction concurrent with the DISE, thus limiting anesthesia exposure.[73] However, in cases where DISE-directed surgery is carried out with DISE, surgeons must either discuss the findings while the child remains anesthetized or obtain consent for multiple possible intervention which may be performed after DISE. Both of these options make operative planning difficulty and reduce the input that families have in the decision-making process. Despite this, increased convenience and reduced anesthesia exposure drive many families and providers to consider pairing the diagnostic DISE with therapeutic surgery. Other institutions, perform the cine MRI and DISE under the same anesthetic (typically the DISE is carried out in the MRI induction room) to minimize anesthesia exposure.

DISE Scoring Systems

The previously mentioned 2016 survey of pediatric DISE practices reported that was no consensus regarding the scoring system used for DISE.[42] Several scoring systems for pediatric DISE have been published,[74] however, none is universally accepted. The goal of a validated and universally accepted scoring system would be to standardize research and communication between clinicians and provide a reproducible clinical assessment of the upper airway.[72]

Six different scoring systems (VOTE, SERS, Chan, Bachar, Fishman, Boudewyns) have been used to report pediatric DISE findings (Table IV).[32,38,47,61–63] Unlike in

the adult scoring systems, obstruction at the nasopharynx (including adenoids) and supraglottis are commonly incorporated into these scales. Some may also include the effect of maneuvers such as a jaw thrust or a chin lift, which are performed to determine the primary site of obstruction.

The VOTE (velum, oropharynx, tongue base, epiglottis) classification is the most frequently used system for both adults and children.[62] This classification allows qualitative evaluation of four sites of obstruction and classifies them from no obstruction to complete collapse. One major downside to this system is the exclusion of the nasopharyngeal and supraglottic sites.[61] Subsequently, Chan et al. proposed a pediatric grading system that included both sites.[61] The VOTE and Chan scoring systems both evaluate each level of obstruction individually. The SERS scale (Sleep Endoscopy Rating Scale)[38] and the Bachar grading system[63] provide similar information but incorporate an overall score for upper airway obstruction severity. The clinical significance of these scores is yet determined as there are no published studies reproducing these results.

Boudewyns et al. published a classification system with six possible sites of obstruction (adenoids, tonsils, tongue base, palate, epiglottis, laryngomalacia) characterized as fixed or dynamic, in addition to a general assessment of hypotonia.[47] Fishman et al. evaluated five upper airway subsites (nasal, nasopharynx, lateral walls, tongue base, supraglottis) and considered the quality of their examination, their confidence in the findings, the identified primary site of obstruction and OSA severity.[32,47] In our opinion, the use of a single scoring system will be necessary to move the field of pediatric sleep surgery forward. This system should reliably characterize the most important sites of collapse, and it should drive outcomes, similar to the TNM system in head and neck cancer, in order to facilitate comparisons between management techniques and strategies.

DISE Outcomes

Ideally, DISE has the potential to affect both surgical decision making and direct management in order to improve the obstructive sleep apnea which is typically measured with the obstructive apnea-hypopnea index (oAHI). Wootten et al. retrospectively assessed the impact of DISE-directed surgical intervention in 26 children with persistent OSA after T&A. Therapeutic surgeries were performed at the same time as the DISE. These authors reported an overall family satisfaction rating of 92%, indicative of decreased symptoms after surgery, along with a decrease in the mean oAHI from 7.0 ± 5.8 events per hour to 3.6 ± 1.8 events per hour after surgery ($n = 11$); only one of these patients had complete normalization of the oAHI.[36] A more recent study by Shan et al., reported the results of DISE-directed surgical intervention in 56 patients with either persistent OSA after T&A or infant OSA. They found a significant improvement in both oAHI and oxygen saturation nadir ($p < 0.001$) with the most frequently performed surgeries being adenoidectomy (41%), supraglottoplasty (38%), tonsillectomy (27%), lingual tonsillectomy (13%), nasal surgery (9%), and palatoplasty (5%).[76] Gazzaz et al. recently demonstrated that DISE affects decision-making in surgically naïve children with snoring and sleep-disordered breathing in up to 35% of children.[75] This finding is in agreement with Hybaskova et al. who found that the surgical plan was changed in 60.8% of patients with obstructive sleep apnea undergoing DISE which often allowed the surgeon to address multiple levels of airway obstruction.[77]

CONCLUSIONS

DISE provides a comprehensive evaluation of sites of obstruction during sedation. It is typically indicated for children who have persistent OSA after adenotonsillectomy, those with OSA but without tonsillar hypertrophy, children with risk factors predisposing to multiple sites of obstruction, or when sleep-state dependent laryngomalacia is suspected. The DEX and ketamine protocol, which replicates non-REM sleep, appears to be safe and is often used for pediatric DISE, although propofol is the most commonly employed agent for DISE in adults. There is currently no universally-accepted pediatric scoring system for DISE, but this will be necessary in order to provide a consistent method to report findings, enhance communication among providers and optimized surgical outcomes.

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