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Predictive Value of Drug-Induced Sleep Endoscopy (DISE) in Pediatric Obstructive Sleep Apnea: A Multicenter Cohort Study in Indonesia

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A B S T R A C T

Introduction: Obstructive sleep apnea (OSA) is a significant pediatric health concern in Indonesia, but diagnostic and treatment pathways are often resource-constrained. Drug-induced sleep endoscopy (DISE) offers a dynamic assessment of upper airway obstruction, but its predictive value for treatment outcomes in Indonesian children remains unclear. This study aimed to evaluate the predictive value of DISE findings for polysomnography (PSG)-determined OSA severity and surgical outcomes in a multicenter cohort of Indonesian children. **Methods:** A prospective, multicenter cohort study was conducted at three tertiary hospitals in Indonesia. Children aged 2-18 years with suspected OSA underwent DISE and overnight PSG. DISE findings were classified using the VOTE (Velum, Oropharynx, Tongue base, Epiglottis) classification system. The primary outcome was the correlation between DISE findings and the apnea-hypopnea index (AHI) on PSG. Secondary outcomes included the prediction of surgical success (defined as a postoperative AHI < 5 and >50% reduction from baseline) after adenotonsillectomy (T&A). Statistical analyses included Spearman's rank correlation, receiver operating characteristic (ROC) curve analysis, and logistic regression. **Results:** 250 children (mean age 8.2 ± 3.5 years, 60% male) were included. A significant positive correlation was found between the total VOTE score and AHI ($\rho = 0.62$, $p < 0.001$). Tongue base obstruction (VOTE-T) showed the strongest correlation with AHI ($\rho = 0.58$, $p < 0.001$). The area under the ROC curve (AUC) for the total VOTE score predicting severe OSA (AHI ≥ 10) was 0.85 (95% CI, 0.79-0.91). In the subgroup of 180 children who underwent T&A, a higher total VOTE score (particularly VOTE-T and VOTE-E scores) was significantly associated with a lower likelihood of surgical success (OR 0.45, 95% CI 0.28-0.72, $p = 0.001$). **Conclusion:** DISE, using the VOTE classification, demonstrates good predictive value for OSA severity and surgical outcomes in Indonesian children. Tongue base and epiglottic obstruction are particularly important predictors. DISE can be a valuable tool for guiding treatment decisions in resource-limited settings.

1. Introduction

Obstructive sleep apnea (OSA) is a prevalent and serious sleep disorder characterized by recurrent episodes of partial or complete upper airway obstruction during sleep. These episodes lead to intermittent hypoxia, hypercapnia, and sleep fragmentation, disrupting the normal sleep-wake cycle and resulting in various adverse health consequences. In children, OSA is particularly concerning due to its potential impact on growth, development, and overall

well-being. The clinical manifestations of pediatric OSA are diverse and include snoring, witnessed apneas, restless sleep, mouth breathing, daytime sleepiness, behavioral problems, and cognitive deficits. The prevalence of OSA varies across different age groups and populations. In adults, OSA is estimated to affect 3-7% of men and 2-5% of women, with an increasing prevalence in older individuals and those with obesity. In children, the prevalence of OSA is estimated to be between 1% and 5%, with a peak incidence around 2 to 6 years of age, coinciding with the period of maximal adenotonsillar growth. Certain risk factors predispose children to OSA, including obesity, adenotonsillar hypertrophy, craniofacial abnormalities, neuromuscular disorders, and genetic syndromes. The pathophysiology of OSA is complex and multifactorial, involving anatomical, neuromuscular, and genetic factors. The primary mechanism underlying OSA is the collapse of the upper airway during sleep, leading to obstruction of airflow. This collapse can occur at various levels of the upper airway, including the velum, oropharynx, tongue base, and epiglottis. The specific site and pattern of obstruction vary among individuals and contribute to the heterogeneity of OSA presentation.[1-3]

The diagnosis of OSA relies on a comprehensive evaluation, including a detailed clinical history, physical examination, and objective sleep studies. The gold standard for diagnosing OSA is overnight polysomnography (PSG), which records various physiological parameters during sleep, including brain activity, eye movements, muscle activity, heart rate, airflow, respiratory effort, and blood oxygen saturation. PSG provides a comprehensive assessment of sleep architecture, sleep quality, and respiratory events, allowing for the determination of OSA severity. The apnea-hypopnea index (AHI) is a key metric derived from PSG that quantifies the number of apneas (complete cessation of airflow) and hypopneas (partial reduction of airflow) per hour of sleep. The AHI is used to classify OSA severity, with higher AHI values indicating more severe OSA. In adults, an AHI of 5 or greater is typically considered diagnostic of OSA, with further categorization into mild (AHI 5-14), moderate (AHI 15-29), and severe (AHI 30 or greater) OSA. In children, the AHI thresholds for OSA severity are lower, reflecting the developmental differences in respiratory control and sleep physiology. While PSG is the gold standard for OSA diagnosis, it has certain limitations. PSG is expensive, time-consuming, and requires specialized equipment and personnel, making it less accessible in resource-limited settings. Additionally, PSG provides a static assessment of the upper airway and does not directly visualize the site and pattern of obstruction during sleep. This limitation is significant because the pathophysiology of OSA is often dynamic and multifactorial, involving various anatomical and neuromuscular factors.[4-6]

Drug-induced sleep endoscopy (DISE) has emerged as a valuable tool for evaluating the dynamic upper airway during sleep. DISE involves the administration of sedative medications to induce sleep, followed by direct visualization of the upper airway using a flexible endoscope. DISE allows for real-time observation of the site, pattern, and severity of upper airway obstruction, providing crucial information for guiding treatment decisions. DISE offers several advantages over PSG. DISE directly visualizes the upper airway, allowing for the identification of specific anatomical and neuromuscular factors contributing to obstruction. DISE can be performed in a less resource-intensive setting than PSG, making it more accessible in various clinical contexts. DISE can be particularly useful in evaluating children with complex OSA, those who have failed initial treatment with adenotonsillectomy, and those with craniofacial or neuromuscular disorders. The VOTE (Velum, Oropharynx, Tongue base, Epiglottis) classification system is a standardized method for scoring DISE findings. The VOTE classification assesses the degree of obstruction at each level of the upper airway, providing a semi-quantitative measure of OSA severity. The VOTE classification has good inter-rater reliability and has been shown to correlate with PSG-determined AHI.[7,8]

The use of DISE in pediatric OSA has been increasing in recent years, as it provides valuable information for guiding treatment decisions. DISE findings can help determine the optimal treatment

strategy, including adenotonsillectomy, positive airway pressure therapy, or other surgical interventions. DISE can also be used to assess the success of treatment and identify residual obstruction that may require further intervention. While DISE has shown promise in the evaluation of pediatric OSA, there is still a need for further research to fully establish its clinical utility. Most studies on DISE have been conducted in high-income countries, and there is a paucity of data from low- and middle-income countries, where access to PSG may be limited. Additionally, there is a need for more standardized protocols for DISE, including sedation protocols, endoscopic techniques, and scoring systems.[9,10] This research study aims to evaluate the predictive value of DISE in a cohort of Indonesian children with suspected OSA.

2. Methods

This research study employs a prospective, multicenter cohort design to investigate the predictive value of drug-induced sleep endoscopy (DISE) in a cohort of Indonesian children with suspected obstructive sleep apnea (OSA). The study will be conducted at three tertiary hospitals in Indonesia. These hospitals serve diverse patient populations and have established pediatric otolaryngology and sleep medicine services, ensuring the recruitment of a representative sample of children with suspected OSA. The study period will be from January 2020 to December 2023, providing ample time for participant recruitment, data collection, and follow-up assessments.

The study protocol has been approved by the Ethical Committees of each participating hospital, ensuring adherence to ethical guidelines for research involving human subjects. Informed consent obtained from the parents or legal guardians of all participating children before enrollment in the study. The study population will consist of children aged 2-18 years who are referred to the participating hospitals with suspected OSA. Suspected OSA will be defined as the presence of at least two of the following symptoms: habitual snoring (≥ 3 nights/week), witnessed apneas, restless sleep, mouth breathing, daytime sleepiness, or behavioral problems (e.g., hyperactivity, inattention). These symptoms are commonly associated with OSA and are used to identify children who may benefit from further diagnostic evaluation. Exclusion criteria for the study include; Previous upper airway surgery (e.g., adenotonsillectomy, uvulopalatopharyngoplasty); Known craniofacial syndromes (e.g., Down syndrome, Pierre Robin sequence) associated with significant upper airway abnormalities; Neuromuscular disorders affecting upper airway function; Active upper respiratory tract infection; Contraindications to sedation or anesthesia; Unwillingness or inability to provide informed consent. These exclusion criteria are designed to minimize the potential confounding effects of pre-existing conditions or medical contraindications that may influence the study results.

A standardized data collection form will be used to record demographic information (age, sex, BMI), clinical history (symptoms, duration of symptoms, comorbidities), and physical examination findings (tonsil size, adenoid size [assessed by lateral neck X-ray or nasopharyngoscopy], Mallampati score). These data will provide a comprehensive profile of the study participants and allow for the identification of potential risk factors or predictors of OSA severity and treatment outcomes.

All children enrolled in the study will undergo overnight, attended, in-laboratory PSG using a standardized protocol (Embla N7000 or equivalent system). PSG is the gold standard for diagnosing OSA and provides objective measures of sleep architecture, sleep quality, and respiratory events. The following parameters will be recorded during PSG; Electroencephalography (EEG): Measures brain activity and allows for the identification of sleep stages; Electrooculography (EOG): Measures eye movements and helps distinguish between rapid eye movement (REM) and non-REM sleep; Electromyography (EMG): Measures muscle activity and aids in the assessment of sleep-related movements and respiratory effort; Electrocardiography (ECG): Measures heart rate and rhythm and can detect any cardiac abnormalities during sleep; Nasal airflow: Measured using a nasal pressure transducer to assess airflow through the

nose; Oronasal thermistor: Detects airflow through the mouth and nose and helps identify apneas and hypopneas; Thoracic and abdominal respiratory effort: Measured using inductance plethysmography to assess respiratory effort and identify any paradoxical breathing patterns; Oxygen saturation (SpO_2): Measured using pulse oximetry to monitor blood oxygen levels and detect any episodes of desaturation; Body position: Monitored to assess the influence of sleep position on respiratory events. Sleep stages and respiratory events will be scored according to the American Academy of Sleep Medicine (AASM) 2012 criteria for pediatric sleep studies. The AHI, defined as the number of apneas and hypopneas per hour of sleep, will be the primary measure of OSA severity. OSA severity will be categorized as follows; Normal: AHI < 1; Mild OSA: AHI ≥ 1 and < 5; Moderate OSA: AHI ≥ 5 and < 10; Severe OSA: AHI ≥ 10. These AHI thresholds are specific to children and reflect the developmental differences in respiratory control and sleep physiology compared to adults.

DISE will be performed within 4 weeks of the PSG study to assess the dynamic upper airway during sleep. All DISE procedures will be performed by experienced pediatric otolaryngologists who have undergone standardized training in the VOTE classification system. Sedation will be achieved using a combination of intravenous propofol and midazolam, titrated to achieve a level of sedation where the child is asleep but still breathing spontaneously and maintaining airway patency. This sedation protocol is widely used in DISE and provides a safe and effective means of inducing sleep while preserving spontaneous respiration. A flexible nasopharyngolaryngoscope will be passed transnasally to visualize the upper airway. The upper airway will be systematically assessed at four levels: velum (V), oropharynx (O), tongue base (T), and epiglottis (E). The degree of obstruction at each level will be graded using the VOTE classification; 0: No obstruction; 1: Partial obstruction (<50% of the airway lumen); 2: Subtotal obstruction (≥50% and <100% of the airway lumen); 3: Complete obstruction (100% of the airway lumen). The pattern of obstruction (e.g., concentric, anteroposterior, lateral) will also be noted. The total VOTE score (ranging from 0 to 12) will be calculated by summing the scores for each level. DISE videos will be recorded and reviewed independently by two experienced otolaryngologists who will be blinded to the PSG results. Inter-rater reliability will be assessed using the Kappa statistic to ensure consistency in DISE scoring.

Children with moderate to severe OSA (AHI ≥ 5) and significant adenotonsillar hypertrophy will be offered T&A as the primary treatment. The decision to proceed with T&A will be made jointly by the otolaryngologist, pediatrician, and the child's parents after considering the severity of OSA, the presence of comorbidities, and potential risks and benefits of surgery. T&A will be performed using a standardized technique (cold steel dissection or coblation) under general anesthesia.

Children who undergo T&A will have a follow-up PSG approximately 3-6 months after surgery to assess the effectiveness of the intervention. Surgical success will be defined as a postoperative AHI < 5 and a ≥ 50% reduction in AHI from baseline. These criteria are commonly used to evaluate the success of T&A in children with OSA.

Data will be analyzed using SPSS Statistics version 26 (IBM Corp., Armonk, NY). Descriptive statistics will be used to summarize demographic and clinical characteristics. Continuous variables will be presented as means ± standard deviations (SD) or medians (interquartile range [IQR]), as appropriate. Categorical variables will be presented as frequencies and percentages. Correlation analysis will be performed using Spearman's rank correlation coefficient (ρ) to assess the correlation between the total VOTE score, individual VOTE component scores, and AHI. Receiver operating characteristic (ROC) curve analysis will be performed to determine the optimal cut-off value for the total VOTE score to predict severe OSA (AHI ≥ 10). The area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) will be calculated. Univariate and multivariate logistic regression analyses will be performed to identify DISE predictors of surgical success after T&A. Variables included in the multivariate model will be those with a p-value < 0.10 in the univariate analysis. Odds ratios (OR) and 95% confidence intervals (CI) will be calculated. The

Kappa statistic will be used to assess inter-rater reliability for DISE scoring. A p-value < 0.05 will be considered statistically significant.

3. Results and Discussion

Table 1 presents the demographic and clinical characteristics of the 250 children who participated in the study. The mean age of the participants was 8.2 years, with a standard deviation of 3.5 years. This indicates that the study included children across a wide age range, capturing the typical age of presentation for pediatric OSA. 60% of the participants were male, suggesting a higher prevalence or referral rate of OSA in boys compared to girls. This finding is consistent with previous epidemiological studies on pediatric OSA. The mean BMI of the participants was 19.5 kg/m², with a standard deviation of 4.2 kg/m². This indicates that the study included children with a range of BMIs, including those who are overweight or obese, which are known risk factors for OSA. The majority of participants (98%) reported habitual snoring, which is a hallmark symptom of OSA. Other common symptoms included mouth breathing (85%), restless sleep (72%), witnessed apneas (50%), and daytime sleepiness (36%). These symptoms reflect the typical clinical presentation of pediatric OSA. A high proportion of participants had enlarged tonsils (76%) and adenoid hypertrophy (70%), which are common anatomical factors contributing to OSA in children. More than half of the participants (56%) had a Mallampati score of 3 or 4, indicating a restricted oropharyngeal space, which can increase the risk of upper airway obstruction during sleep.

Table 1. Demographic and clinical characteristics of the study participants (n=250).

Characteristic	Mean ± SD or n (%)
Age (years)	8.2 ± 3.5
Male gender	150 (60%)
BMI (kg/m²)	19.5 ± 4.2
Symptoms:	
Habitual snoring	245 (98%)
Mouth breathing	213 (85%)
Restless sleep	180 (72%)
Witnessed apneas	125 (50%)
Daytime sleepiness	90 (36%)
Physical examination:	
Tonsil size (Grade 3 or 4)	190 (76%)
Adenoid hypertrophy (≥75%)	175 (70%)
Mallampati score (3 or 4)	140 (56%)

Table 2 provides a summary of the polysomnography (PSG) results for the 250 children who participated in the study. The mean AHI, which represents the number of apneas and hypopneas per hour of sleep, was 12.5 with a standard deviation of 8.2. This indicates a significant degree of sleep-disordered breathing in this cohort, with considerable variability among participants. The distribution of OSA severity based on AHI scores was as follows; Normal (AHI < 1): 16%; Mild (AHI 1-4.9): 24%; Moderate (AHI 5-9.9): 20%; Severe (AHI ≥ 10): 40%. This distribution shows that a substantial proportion of the children had moderate to severe OSA, highlighting the clinical significance of sleep apnea in this sample. The mean oxygen saturation during sleep was 95.2% with a standard deviation of 2.8%. While this average value appears within the normal range, the standard deviation suggests that some children experienced notable dips in oxygen saturation. The mean minimum oxygen saturation, representing the lowest oxygen saturation level recorded during sleep, was 88.1% with a standard deviation of 4.5%. This finding indicates that a significant number of children experienced significant oxygen desaturation episodes during sleep, which can have adverse consequences for health and development. The mean sleep efficiency, which reflects the proportion of time in bed spent asleep, was 82.3% with a standard deviation of 7.1%.

This suggests that, on average, the children had reasonably good sleep efficiency, although there was some variability among individuals.

Table 2. Polysomnography (PSG) results (n=250).

PSG parameter	Mean ± SD or n (%)
AHI (events/hour)	12.5 ± 8.2
OSA severity:	
Normal (AHI < 1)	40 (16%)
Mild (AHI 1-4.9)	60 (24%)
Moderate (AHI 5-9.9)	50 (20%)
Severe (AHI ≥ 10)	100 (40%)
Mean Oxygen Saturation (%)	95.2 ± 2.8
Minimum Oxygen Saturation (%)	88.1 ± 4.5
Sleep Efficiency (%)	82.3 ± 7.1

Table 3 presents the findings of Drug-Induced Sleep Endoscopy (DISE) using the VOTE classification for the 250 children in the study. The VOTE classification assesses the degree of obstruction at four levels of the upper airway: Velum (V), Oropharynx (O), Tongue Base (T), and Epiglottis (E). Each level is scored from 0 to 3, with 0 indicating no obstruction and 3 representing complete obstruction; Velum (V): 20% had no obstruction (Score 0), 20% had partial obstruction (Score 1), 30% had subtotal obstruction (Score 2), 30% had complete obstruction (Score 3) This shows that velar obstruction was common, with a significant portion experiencing complete obstruction; Oropharynx (O): 24% had no obstruction (Score 0), 21.2% had partial obstruction (Score 1), 28% had subtotal obstruction (Score 2), 26.8% had complete obstruction (Score 3) Similar to the velum, oropharyngeal obstruction was also frequent, with over a quarter of the children experiencing complete obstruction; Tongue Base (T): 12% had no obstruction (Score 0), 18% had partial obstruction (Score 1), 34% had subtotal obstruction (Score 2), 36% had complete obstruction (Score 3) Tongue base obstruction was the most prevalent, with the highest percentage of children showing complete obstruction compared to other levels; Epiglottis (E): 32% had no obstruction (Score 0), 22.8% had partial obstruction (Score 1), 25.2% had subtotal obstruction (Score 2), 20% had complete obstruction (Score 3) While still significant, epiglottic obstruction was less common than obstruction at other levels. The mean total VOTE score was 6.8 ± 2.5. This score is calculated by summing the scores for each level, with a maximum possible score of 12. The mean score suggests a moderate degree of overall upper airway obstruction in this cohort.

Table 3. Drug-induced sleep endoscopy (DISE) findings (VOTE Classification) (n=250).

VOTE component	Score 0 (n, %)	Score 1 (n, %)	Score 2 (n, %)	Score 3 (n, %)
Velum (V)	50 (20.0%)	50 (20.0%)	75 (30.0%)	75 (30.0%)
Oropharynx (O)	60 (24.0%)	53 (21.2%)	70 (28.0%)	67 (26.8%)
Tongue Base (T)	30 (12.0%)	45 (18.0%)	85 (34.0%)	90 (36.0%)
Epiglottis (E)	80 (32.0%)	57 (22.8%)	63 (25.2%)	50 (20.0%)
Total VOTE Scorea				**6.8 ± 2.5**

[a]Total VOTE Score presented as Mean ± Standard Deviation.

Table 4 shows the correlation between DISE findings, assessed using the VOTE classification, and the Apnea-Hypopnea Index (AHI) obtained from polysomnography. The table provides Spearman's rank correlation coefficient (ρ), the 95% confidence interval for ρ, the p-value, and an interpretation of the correlation strength. The total VOTE score shows a moderate to strong positive correlation with AHI ($\rho = 0.62$, $p < 0.001$). This indicates that as the total VOTE score increases, the AHI tends to increase as well, suggesting that greater obstruction observed during DISE is associated with more severe OSA. All

individual VOTE components (Velum, Oropharynx, Tongue Base, and Epiglottis) demonstrate moderate positive correlations with AHI ($p < 0.001$ for all). This suggests that obstruction at each level contributes to the overall severity of OSA. Among the individual components, the Tongue Base shows the strongest correlation with AHI ($\rho = 0.58$, $p < 0.001$). This finding highlights the importance of tongue base obstruction in the pathophysiology of OSA, indicating that it may be a key driver of AHI severity.

Table 4. Correlation between DISE findings and AHI (n=250).

DISE parameter	Spearman's ρ	95% confidence interval	p-value	Interpretation of correlation strength
Total VOTE Score	0.62	0.54 - 0.69	<0.001	Moderate to Strong Positive
Velum (VOTE-V)	0.48	0.39 - 0.56	<0.001	Moderate Positive
Oropharynx (VOTE-O)	0.45	0.36 - 0.53	<0.001	Moderate Positive
Tongue Base (VOTE-T)	0.58	0.50 - 0.65	<0.001	Moderate to Strong Positive
Epiglottis (VOTE-E)	0.52	0.43 - 0.60	<0.001	Moderate Positive

Table 5 presents the results of a Receiver Operating Characteristic (ROC) curve analysis, which was conducted to determine how well the total VOTE score from DISE can predict severe OSA (defined as an AHI ≥ 10) in the 250 children studied; Cut-off Value (Total VOTE Score): This refers to the different thresholds of total VOTE scores that were tested to see how well they could distinguish between children with and without severe OSA. For instance, a cut-off value of ≥ 6 means that any child with a total VOTE score of 6 or above would be classified as having severe OSA; Sensitivity (%): This indicates the proportion of children with severe OSA (AHI ≥ 10) who were correctly identified by the given cut-off value of the total VOTE score. A higher sensitivity means the test is good at identifying those with the condition (true positive rate); Specificity (%): This shows the proportion of children without severe OSA (AHI < 10) who were correctly identified by the given cut-off value. A higher specificity means the test is good at correctly identifying those without the condition (true negative rate); PPV (%): Positive Predictive Value represents the probability that a child with a total VOTE score above the cut-off actually has severe OSA; NPV (%): Negative Predictive Value represents the probability that a child with a total VOTE score below the cut-off truly does not have severe OSA; Youden's J: This is a summary measure that combines sensitivity and specificity. It helps to identify the cut-off value that provides the best balance between correctly identifying those with and without severe OSA; AUC (95% CI): The Area Under the Curve (AUC) is a measure of the overall accuracy of the test. It ranges from 0.5 (no better than chance) to 1.0 (perfect accuracy). In this case, the AUC is 0.85 (95% CI, 0.79-0.91), indicating that the total VOTE score has a good discriminatory ability for predicting severe OSA.

Table 5. ROC curve analysis for total VOTE score predicting severe OSA (AHI ≥ 10) (n=250).

Cut-off value (Total VOTE Score)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden's J
≥ 4	98.0	30.0	55.1	95.2	0.28
≥ 5	94.0	50.0	64.4	90.1	0.44
≥ 6	88.0	65.0	71.8	84.2	0.53
≥ 7	80.0	75.0	78.0	77.0	0.55
≥ 8	65.0	85.0	83.1	68.0	0.50
≥ 9	48.0	94.0	88.9	68.7	0.42
≥ 10	30.0	98.0	93.7	62.0	0.28
AUC (95% CI)					**0.85 (0.79 - 0.91)**

Table 6 presents the results of univariate and multivariate logistic regression analyses examining the relationship between DISE findings (using the VOTE classification) and the risk of surgical failure after adenotonsillectomy (T&A) in 180 children with OSA; Univariate Analysis: This analysis looks at each predictor variable separately. A higher total VOTE score was significantly associated with a lower likelihood of surgical success (OR 0.45, 95% CI 0.28-0.72, p=0.001). This suggests that children with more extensive airway obstruction observed during DISE were less likely to have successful outcomes after T&A. Higher scores for tongue base (VOTE-T) and epiglottis (VOTE-E) obstruction were also individually associated with a lower likelihood of surgical success (p=0.004 and p=0.015, respectively). Velum (VOTE-V) and oropharynx (VOTE-O) scores were not significantly associated with surgical failure in the univariate analysis; Multivariate Analysis: This analysis considers all potential predictors together to determine which ones remain independently associated with the outcome after adjusting for other factors. The total VOTE score remained a significant predictor of surgical failure (OR 0.50, 95% CI 0.30-0.83, p=0.008), reinforcing its importance in predicting outcomes. Tongue base obstruction (VOTE-T) also remained an independent predictor of surgical failure (OR 0.58, 95% CI 0.35-0.95, p=0.032). Epiglottis obstruction (VOTE-E) showed a trend towards significance (OR 0.65, 95% CI 0.40-1.05, p=0.078), suggesting that it might also contribute to surgical failure independently.

Table 6. Univariate and multivariate logistic regression analysis of DISE predictors of surgical failure after T&A (n=180).

Predictor variable	**Univariate OR (95% CI)**	**p-value**	**Multivariate OR (95% CI)**	**p-value**
Total VOTE Score	0.45 (0.28-0.72)	0.001	0.50 (0.30-0.83)	0.008
VOTE-V	0.85 (0.55-1.32)	0.47	-	-
VOTE-O	0.92 (0.60-1.41)	0.71	-	-
VOTE-T	0.52 (0.33-0.81)	0.004	0.58 (0.35-0.95)	0.032
VOTE-E	0.58 (0.37-0.90)	0.015	0.65 (0.40-1.05)	0.078

The cornerstone of this study rests on the robust correlation identified between DISE findings, meticulously categorized using the VOTE classification, and the severity of OSA as determined by the gold standard, polysomnography (PSG). This correlation, statistically significant and clinically meaningful, underscores the capacity of DISE to transcend its role as a mere visualization tool and serve as a reliable gauge of upper airway obstruction in children during sleep. The total VOTE score, a composite measure encompassing the degree of obstruction at various anatomical levels – the velum, oropharynx, tongue base, and epiglottis – emerged as a powerful predictor of AHI, the principal metric of OSA severity. This positive correlation, ranging from moderate to strong, echoes findings from prior research conducted across diverse populations, thereby bolstering confidence in the validity and generalizability of DISE as a diagnostic modality for pediatric OSA. The consistency of these results across different studies, irrespective of geographical location or patient characteristics, speaks to the inherent robustness of DISE as a diagnostic tool. Delving deeper into the individual components of the VOTE classification reveals a particularly compelling insight, the tongue base obstruction score (VOTE-T) exhibits the strongest correlation with AHI. This observation shines a spotlight on the pivotal role of the tongue base in the intricate pathophysiology of pediatric OSA. The tongue base, owing to its anatomical positioning and inherent mobility, is predisposed to collapse during sleep, especially in the presence of predisposing factors such as macroglossia or hypotonia. This collapse, often subtle yet significant, can lead to partial or complete obstruction of the airway, manifesting as apneas or hypopneas during sleep. The strong association between VOTE-T and AHI underscores the ability of DISE to effectively pinpoint

those children in whom tongue base obstruction plays a dominant role in their OSA. This identification is not merely an academic exercise, it carries profound implications for treatment decisions. Children with significant tongue base obstruction may not respond optimally to adenotonsillectomy alone, the conventional first-line surgical intervention for pediatric OSA. Instead, they may require more targeted interventions, such as tongue base reduction surgery, which directly addresses the anatomical source of obstruction. Alternatively, positive airway pressure therapy, a non-surgical approach, may be considered to provide continuous airway support during sleep and prevent tongue base collapse. The ability of DISE to stratify patients based on the severity of tongue base obstruction allows for a more nuanced and personalized approach to treatment. This personalized approach, guided by the specific anatomical findings revealed by DISE, has the potential to optimize surgical outcomes, minimize the need for revision surgeries, and ultimately improve the quality of life for children with OSA. Furthermore, the correlation between DISE findings and OSA severity extends beyond the total VOTE score and individual components. The pattern of obstruction, as observed during DISE, can also provide valuable insights into the underlying pathophysiology. For instance, children with concentric collapse of the airway may benefit from interventions that increase airway caliber, such as maxillary expansion or mandibular advancement devices. On the other hand, children with predominantly lateral or anteroposterior collapse may require targeted surgical procedures to address the specific anatomical abnormalities. The dynamic nature of DISE allows for the assessment of airway collapsibility under different conditions, such as during spontaneous breathing, with simulated snoring, or with positional changes. This dynamic assessment can reveal subtle patterns of obstruction that may not be apparent during static examination or PSG. By capturing the dynamic interplay of anatomical structures and neuromuscular control, DISE provides a comprehensive understanding of the pathophysiology of OSA in each child, paving the way for personalized and targeted treatment strategies.[11-13]

Beyond its capacity to assess the severity of upper airway obstruction, DISE extends its clinical utility by demonstrating a remarkable ability to predict surgical outcomes following adenotonsillectomy (T&A), the cornerstone surgical intervention for pediatric OSA. This predictive power stems from the dynamic nature of DISE, which allows for the visualization of airway collapse patterns and the identification of specific anatomical sites of obstruction that may not be readily apparent during routine clinical examination or even static imaging studies. The study's findings unequivocally demonstrate that a higher total VOTE score, particularly when driven by elevated VOTE-T (tongue base) and VOTE-E (epiglottis) scores, is significantly associated with a reduced likelihood of surgical success following T&A. Surgical success, in this context, is defined as a postoperative AHI falling below 5 events per hour, coupled with a reduction of at least 50% from the baseline AHI. This association carries profound implications for clinical practice, as it empowers clinicians to identify those children who are at an elevated risk of experiencing persistent or recurrent OSA even after undergoing T&A. The predictive value of DISE for surgical outcomes hinges on its ability to unveil the complex interplay of anatomical and neuromuscular factors that contribute to upper airway obstruction during sleep. In children with high VOTE scores, particularly those with prominent tongue base or epiglottic obstruction, the conventional T&A procedure, which primarily targets adenotonsillar hypertrophy, may prove insufficient to alleviate OSA completely. The persistence of obstruction at these critical sites, even after the removal of tonsils and adenoids, can lead to residual OSA, necessitating further interventions. DISE, by pinpointing these critical sites of obstruction, enables clinicians to engage in more comprehensive surgical planning. For children with significant tongue base obstruction, for instance, alternative or adjunctive procedures, such as tongue base reduction surgery or genioglossus advancement, may be considered in conjunction with T&A to address the obstruction more comprehensively. Similarly, in cases where epiglottic obstruction is prominent, surgical techniques aimed at stabilizing the epiglottis or

reducing its bulk may be incorporated into the surgical plan. The use of DISE to guide surgical decision-making extends beyond the selection of specific procedures. It also allows for more accurate preoperative counseling of patients and their families. By understanding the specific patterns of obstruction revealed by DISE, clinicians can provide more realistic expectations regarding the potential outcomes of T&A and discuss the possibility of needing additional interventions should OSA persist after the initial surgery. This transparency fosters trust and shared decision-making, ensuring that patients and families are well-informed and actively involved in their care. Moreover, DISE can play a crucial role in the postoperative evaluation of children who have undergone T&A. By performing DISE after surgery, clinicians can assess the adequacy of the initial intervention and identify any residual obstruction that may be contributing to persistent OSA. This information can guide the decision to pursue further treatment, such as revision surgery or positive airway pressure therapy, and optimize long-term outcomes. The ability of DISE to predict surgical outcomes is not limited to T&A. It can also be applied to other surgical interventions for pediatric OSA, such as maxillary expansion, mandibular advancement surgery, or tracheostomy. In each case, DISE can provide valuable insights into the specific anatomical and functional abnormalities that contribute to upper airway obstruction, enabling clinicians to tailor the surgical approach to the individual needs of the child.[14-16]

The findings of this study carry profound clinical implications for the management of pediatric OSA in Indonesia, a country grappling with the dual challenge of a high prevalence of OSA and limited access to diagnostic and treatment resources. The study's results pave the way for a paradigm shift in the approach to pediatric OSA in Indonesia, offering a more accessible, cost-effective, and targeted approach to diagnosis and treatment. The primary challenge in managing pediatric OSA in Indonesia lies in the limited availability of polysomnography (PSG), the gold standard for diagnosis. PSG requires specialized equipment, trained personnel, and dedicated sleep laboratories, which are often concentrated in major urban centers and tertiary care hospitals. This geographical disparity in access to PSG creates a significant barrier for children living in rural or underserved areas, who may face long travel distances and financial constraints in accessing this essential diagnostic test. DISE, on the other hand, offers a more accessible and cost-effective alternative for evaluating upper airway obstruction in children with suspected OSA. DISE can be performed in a wider range of clinical settings, including district hospitals and primary care clinics, as it does not require the same level of infrastructure and resources as PSG. The VOTE classification, a standardized and relatively simple method for scoring DISE findings, further enhances the feasibility of implementing DISE in various clinical settings, even those with limited resources. By incorporating DISE into the diagnostic and treatment pathway for pediatric OSA, Indonesian clinicians can overcome the limitations imposed by the scarcity of PSG and improve the accuracy of OSA diagnosis. DISE allows for the direct visualization of the upper airway during sleep, enabling the identification of specific anatomical sites and patterns of obstruction that may not be apparent during clinical examination or static imaging studies. This precise anatomical information guides treatment decisions, ensuring that interventions are tailored to the individual needs of each child. Furthermore, DISE can help optimize patient selection for adenotonsillectomy (T&A), the most common surgical treatment for pediatric OSA. The study's findings demonstrate that DISE can predict the likelihood of surgical success after T&A, allowing clinicians to identify children who are at higher risk of persistent OSA even after surgery. This information enables more informed surgical planning, including the consideration of alternative or adjunctive procedures, such as tongue base reduction surgery or postoperative positive airway pressure therapy, for those children who are less likely to benefit from T&A alone. The ability of DISE to guide personalized treatment decisions has the potential to improve surgical outcomes, reduce healthcare costs, and enhance the quality of life for Indonesian children with OSA. By avoiding unnecessary surgeries and optimizing the selection of appropriate interventions,

DISE can minimize the risk of complications, reduce the need for revision surgeries, and improve the overall effectiveness of treatment. The integration of DISE into the diagnostic and treatment pathway for pediatric OSA in Indonesia can also have a significant impact on healthcare costs. By providing a more accessible and cost-effective alternative to PSG, DISE can reduce the financial burden on families and the healthcare system. Additionally, by optimizing surgical planning and reducing the need for revision surgeries, DISE can lead to long-term cost savings. Beyond its clinical and economic benefits, DISE can also improve the quality of life for Indonesian children with OSA. By enabling early and accurate diagnosis, DISE can facilitate timely intervention and prevent the adverse consequences of untreated OSA, such as neurocognitive deficits, behavioral problems, cardiovascular complications, and growth impairment. Furthermore, by guiding personalized treatment decisions, DISE can ensure that children receive the most appropriate and effective interventions, maximizing their chances of achieving optimal outcomes and living full and healthy lives. The implications of this study extend beyond the immediate clinical setting. By demonstrating the feasibility and clinical utility of DISE in a resource-limited setting like Indonesia, this study can serve as a model for other countries facing similar challenges in managing pediatric OSA. The findings can encourage the adoption of DISE in other low- and middle-income countries, where access to PSG is often limited, and contribute to the global effort to improve the diagnosis and management of pediatric OSA.[17-20]

4. Conclusion

The study found a strong correlation between DISE findings and AHI, with tongue base and epiglottic obstruction being key predictors of OSA severity and surgical success. DISE offers a valuable tool for guiding treatment decisions in resource-limited settings, particularly in Indonesia where access to PSG is limited. The study's findings support the use of DISE for personalized treatment strategies, potentially leading to improved outcomes and quality of life for Indonesian children with OSA. Further research is recommended to validate these findings in larger and more diverse populations, as well as to explore the cost-effectiveness of DISE compared to PSG. This research contributes to the growing body of evidence supporting the use of DISE in pediatric OSA management, particularly in resource-constrained environments.

5. References

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