

Advances in surgery in children with obstructive sleep apnea



Ivo Parunov

Division of Otorhinolaryngology, BourgasMed Hospital, city of Bourgas

Abstract:

Severe pediatric obstructive sleep apnea, usually, requires timely conservative and/or surgical management. Recently, several operative techniques are widely used worldwide. Here belong mainly tonsillectomy, adenoidectomy, and adenotonsillectomy. The surgical interventions are characterized by a different effectiveness and safety. The objective of the present review is to identify the new scientific advances in the field of childhood obstructive sleep apnea surgery.

Keywords: obstructive sleep apnea, children, surgery, effectiveness, complications

INTRODUCTION

Obstructive sleep apnea is a socially significant disorder affecting a rising number of children and adults worldwide and in Bulgaria as well. Its severe forms require either a conservative, or an operative treatment following the precise diagnosis. The management of the pediatric patients should be timely and individualized.

During the recent years, a variety of surgical techniques of various effectiveness and safety are applied. The objective of the present review is to identify the new scientific advances in the field of childhood obstructive sleep apnea surgery.

Usage of tonsillectomy and/or adenotonsillectomy in childhood obstructive sleep apnea

Obstructive sleep apnea is the most common indication for adenotonsillectomy in children (1). It is performed frequently worldwide. However, this intervention is associated with several significant complications such as bleeding and respiratory failure. Complication risk depends on a variety of

complex factors such as indications for surgery, demographics, patient's comorbidities, and variations in perioperative techniques.

Obstructive sleep apnea is one of the main indications for tonsillectomy or tonsillectomy, with or without adenoidectomy, which represents one of the procedures most frequently performed in the pediatric population (2). There are controversial criteria for identifying the patients at risk of complications and the level of care required during monitoring. The postoperative respiratory problems are the most feared surgical complications. Recommendations for postoperative monitoring are proposed.

The results from a scoping review of 15 articles abstracted in PubMed database demonstrate a marked improvement of central sleep apnea indexes after adenotonsillectomy in children and adolescents with obstructive sleep apnea (3). Two studies report central sleep apnea resolution in 66.7% and in 73.7% of the patients, respectively. Four studies establish significant reductions of the central sleep apnea indexes in 43.9%–93% of the cases.

The results from a randomized clinical trial of 458 children at a mean age of 6.1 years, 230 girls and 228 boys, in seven American academic sleep centres during the period from June 29, 2016, to February 1, 2021, show that 231 patients, 119 girls

Address for correspondence:

Ivo Parunov, MD
Division of Otorhinolaryngology
BourgasMed Hospital
8000 Bourgas
68 Slivnitsa Street
E-mail: parunov@mail.bg



and 112 boys, undergo early adenotonsillectomy while the rest 227 ones, 116 boys and 111 girls, are on watchful waiting (4). Behavioural problems, sleepiness, symptoms, and quality of life each improve more with adenotonsillectomy than with watchful waiting. Six children (2.60% of the cases) experience a serious adverse event associated with the surgical procedure.

Based on a narrative review of current evidence in systematic reviews, meta-analyses and randomized controlled trials concerning the efficacy of adenotonsillectomy on pediatric obstructive sleep apnea and related outcomes, several conclusions have been drawn (5). This operative intervention is effective in treating the obstructive sleep apnea in children without co-morbidities, despite postoperative residual disease remains in roughly one half of these patients. It is less effective in children with comorbidities such as Down syndrome, Prader-Willi syndrome, sickle cell disease, or cerebral palsy. It is associated with more postoperative complications than in the children without comorbidities. The adenotonsillectomy improves the subjective obstructive sleep apnea-related outcomes such as symptoms, behaviours, and quality of life.

The results from a systematic review and meta-analysis of 22 relevant studies comprising 1287 children with obstructive sleep apnea and retrieved from four databases from inception until October 2022 show significant improvements of central and total sleep apnea parameters, except for central apnea-hypopnea index and mixed apnea index scores after adenotonsillectomy (6). All the respiratory parameters and second and third stages of non-rapid eye movement sleep demonstrate significant postsurgical improvements while the patients with comorbidities present with considerable improvements of the total apnea-hypopnea index, oxygen desaturation index, and minimal oxygen saturation only.

A multidisciplinary international panel of experts determines key unanswered questions concerning the management of the persistent, post-adenotonsillectomy pediatric obstructive sleep apnea based on a systematic review of the relevant literature (7). The Grading of Recommendations, Assessment, Development, and Evaluation approach is applied in order to rate the quality of evidence and the strength of the clinical recommendations. The

panel members consider the strength of each recommendation as well as caregiver's values, the cost of care, and the feasibility and evaluate the benefits and risks of the usage of the surgical intervention. Recommendations are developed for six management options for the persistent pediatric obstructive sleep apnea. Important areas for future research are identified for each recommendation.

Inpatient partial tonsillectomy as an alternative method to treat obstructive sleep apnea is applied in 92 children at a mean age of 44.5 ± 21.9 months within a prospective study during the period between from 2018 to 2020 in Tel Aviv, Israel (8). There are 35 children aged ≤ 3 years, 23 boys and 12 girls, at a mean age of 25.7 ± 6.9 months, and 57 older children, 30 boys and 27 girls, at a mean age of 56.1 ± 20.1 months. Postoperative complications are observed in seven, fever in four, and insufficient oral intake in three children. These events are more common in the older than in the younger group (in five versus in two patients).

The secondary analysis of the Childhood Adenotonsillectomy Trial including 196 children aged between 5.0 and 9.9 years and assigned to early adenotonsillectomy shows that 72 patients with mild obstructive sleep apnea and high sleep quality have a statistically significantly lower average heart rate during sleep than 124 patients with moderate obstructive sleep apnea (81 versus 87 beats/min.; $p < 0.001$) (9). The children in the first group benefit less from this operative intervention than those in the second group.

During a two-centre investigator-blinded randomized controlled trial in Hong Kong, the effect on the arterial blood pressure of adenotonsillectomy in 62 non-obese children with obstructive sleep apnea at a mean age of 7.9 ± 1.3 years, 44 boys and 18 girls, is compared with that of watchful waiting in 47 children with this disease at a mean age of 8.5 ± 1.6 years, 36 boys and 11 girls (10). A 24-hour arterial blood pressure monitoring at baseline and after nine months is carried out. The changes of the parameters such as nighttime systolic and diastolic blood pressure z-scores are similar in both groups. The reduction of nighttime diastolic blood pressure z-score correlates with the improvements of obstructive sleep apnea severity indexes ($r = 0.21 - 0.22$; $p < 0.05$). There is a significant postoperative reduction of the nighttime diastolic blood pres-

sure z-score (-0.43 ± 1.01 ; $p=0.027$) in the patients with severe preoperative obstructive sleep apnea. Following surgery, there is a statistically significant increase of the body mass index z-score ($+0.27 \pm 0.57$; $p<0.001$) which correlates with the elevated daytime systolic blood pressure z-score ($r=0.2$; $p<0.05$).

The effect of tonsillectomy and adenoidectomy on upper airway obstruction patterns detected by means of drug-induced sleep endoscopy is retrospectively assessed in 27 children at a mean age of 7 ± 4 years (range, 2-18 years), 15 boys and 12 girls, with obstructive sleep apnea during the period between June 2016 and June 2018 in Dallas, TX, USA (11). There are six patients, five boys and one girl, at a mean age of 7 ± 4 years with mild, six patients, five boys and one girl, at a mean age of 7 ± 2 years with moderate, and 15 children, five boys and ten girls, at a mean age of 7 ± 4 years with severe obstructive sleep apnea. Among 16 obese patients, there are two, four, and ten children in these three groups, respectively. There is airway obstruction at the levels of the velum and of the oropharynx/lateral walls in 27 patients each, of the tongue in seven, and of the epiglottis in four children prior to surgery, and at the level of the velum in 24, of the oropharynx/lateral walls in 16, of the tongue in six, and of the epiglottis in four children after the operative intervention. The mean percentage of airway obstruction at the level of the velum ($60 \pm 6\%$) and of the oropharynx/lateral pharyngeal walls ($25 \pm 5\%$) after tonsillectomy and adenoidectomy is statistically significantly lower than that before surgery ($80 \pm 3\%$ and $83 \pm 3\%$; $p=0.004$ and $p<0.001$, respectively) (11).

There is a documented respiratory event after tonsillectomy in 131 out of a total of 888 children with severe obstructive sleep apnea (in 14.75% of the cases) within a retrospective single-institution cohort study in Dallas, TX, USA (12). The following most significant risk factors for this complication include percentage of sleep time with oxygen $<90\%$ (odds ratio of 1.10; between 1.07 and 1.14 at 95% confidence interval; $p<0.001$), Black race (odds ratio of 2.34; between 1.53 and 3.58 at 95% confidence interval; $p<0.001$), primary neurologic comorbidity (odds ratio of 3.27; between 1.67 and 6.32 at 95% confidence interval; $p<0.001$), Down syndrome (odds ratio of 2.72; between 1.25 and 5.94 at 95% confidence interval; $p<0.01$), and age

(odds ratio of 0.88; between 0.84 and 0.94 at 95% confidence interval; $p<0.001$).

The results from a retrospective review study of 304 pediatric patients during the period between January and May 2019 in a tertiary-care children's hospital in the USA demonstrate an adherence rate to polysomnography prior to surgical treatment of obstructive sleep apnea of 65.4% (13). There is no significant difference in terms of the adherence or loss to follow-up rates based on patient's sex, age, language, socioeconomic status, state of residence, single-parent status, or polysomnography indication. The children with prior otolaryngology intervention obtain statistically significantly more commonly polysomnography and are less lost to follow-up ($p<0.05$). Median household income shows a statistically significant inverse relationship with time to polysomnography and to definitive surgery as well ($p<0.05$).

Use of intracapsular and extracapsular tonsillectomy and adenoidectomy in childhood obstructive sleep apnea

Within a retrospective investigation at a tertiary care hospital in Houston, TX, USA, during the period between 2016 and 2019, 320 children with developmental delay undergo tonsillectomy for obstructive sleep apnea (14). Intracapsular and extracapsular tonsillectomies are performed in 72 and in 248 patients, respectively. In the intracapsular tonsillectomy group, there is a statistically significantly shorter length of hospital stay (0.97 days versus 1.7 days; $p<0.0001$). These patients receive statistically significantly less post-operative narcotic medication (2.8% versus 35%; $p<0.0001$) and corticosteroids (9.7% versus 64%; $p<0.0001$) in the hospital. Among 180 analyzed patients, the postoperative apnea-hypopnea index improves with both techniques (in 79% versus in 74% of the cases). The rate of the persistent obstructive sleep apnea does not differ between both techniques.

The surgical recovery and impact on obstructive sleep apnea of the intracapsular and extracapsular tonsillectomy and adenoidectomy in a total of 286 pediatric patients with Trisomy 21 are compared during the period between July 1, 2015 and August 15, 2022 (15). The intracapsular and extracapsular tonsillectomy and adenoidectomy are performed in 62 and in 224 patients, respectively. In the



first group, there are statistically significantly lower pain scores ($p < 0.001$), decreased use of narcotics ($p < 0.001$), shorter hospital length of stay ($p = 0.003$), faster return to oral intake ($p = 0.01$) during the postoperative hospital admission, as well as fewer 30-day complications ($p = 0.009$) than in the second group.

The results from a systematic review and a meta-analysis of six studies devoted to the comparative assessment of the intracapsular and extracapsular coblation tonsillectomy in children with obstructive sleep apnea or recurrent tonsillitis and abstracted in MEDLINE, the Cochrane Library and Springerlink databases as well as in other information sources display a statistically significantly less frequent late postoperative pain after the application of the intracapsular technique (standardized mean difference of -0.78 ; between -1.03 and -0.53 at 95% confidence interval) (16). There is, however, no significant difference in terms of the early postoperative pain (≤ 48 hours) between these two techniques (standardized mean difference of -0.18 ; between -0.47 and 0.12 at 95% confidence interval).

Application of other surgical procedures in childhood obstructive sleep apnea

Pediatric patients with persistent obstructive sleep apnea after adenotonsillectomy present with additional sites of upper airway obstruction such as the tongue base or larynx (17). Surgical management of this obstructive sleep apnea can be directed by sleep endoscopy and cross-sectional, dynamic imaging. Lingual tonsillectomy, tongue suspension, and/or posterior midline glossectomy are used to address lingual tonsil hypertrophy and tongue base obstruction while epiglottopexy and/or supraglottoplasty are applied in laryngomalacia and epiglottic prolapse which cause obstructive sleep apnea.

During a retrospective investigation of 174 patients at a mean age of 8.29 ± 3.49 years (range, 1.89–15.62 years) with obstructive sleep apnea, lingual tonsillectomy as a part of drug-induced sleep endoscopy-directed multilevel sleep surgery is carried out (18). There are postoperative complications in 26 patients (in 14.94%) including 14 patients (8.05%) requiring emergency department visit or readmission and 12 patients (6.90% of the cases) experiencing postoperative bleeding. Bron-

chial asthma ($p = 0.033$) and developmental delay ($p = 0.016$) statistically significantly correlate with these complications. Surgical failure defined as postoperative apnea-hypopnea index ≥ 5 events/hour is identified in 30 children (in 17.24% of the cases). It is associated with body mass index z-score > 2 ($p = 0.025$) and Trisomy 21 ($p = 0.005$).

Persistent obstructive sleep apnea after adenotonsillectomy is due to residual obstruction at the nose, nasopharynx, and/or palate (19). Depending on the site of this obstruction, some of the surgical management options include submucous inferior turbinate resection, septoplasty, adenoidectomy, and expansion sphincter pharyngoplasty.

Within a retrospective investigation of 30 children at a mean age of 6.3 ± 5.3 years, 16 boys and 14 girls, with complex obstructive sleep apnea during the period between December 2019 and June 2022, a new technique of fluoroscopic-assisted tongue suspension with the Encore System is made use of (20). Surgical success defined by at least a 50% reduction of the apnea-hypopnea index occurs in 16 of 21 patients (in 76.19% of the cases). The mean postoperative percentage decrease of the obstructive apnea-hypopnea index and of the respiratory disturbance index is 75.6% and 73.8%, respectively.

The supraglottoplasty is compared with non-surgical treatment in 30 children with congenital laryngomalacia and concomitant obstructive sleep apnea confirmed by polysomnography within a retrospective study during the period between January 1, 2014 and December 31, 2019 (21). Eighteen patients (12 boys and six girls) undergo supraglottoplasty, and 12 patients (seven boys and five girls) have non-surgical treatment. The average age of obstructive sleep apnea diagnosis is 13.28 ± 14.22 months in the surgical and 13.42 ± 9.37 months in the non-surgical treatment group. The average obstructive apnea-hypopnea index diminishes statistically significantly only after supraglottoplasty by 12.68 events/hour ($p = 0.0039$) but by 3.3 events/hour ($p = 0.3$) in the non-surgical treatment group. Only one child has residual moderate obstructive sleep apnea after surgery.

The literature review of 26 studies including 224 pediatric patients with obstructive sleep apnea treated with uvulopalatopharyngoplasty demonstrates that 85.6% of the children have subjective

improvement and 25.6% of the cases report a complication (22). Most children with moderate or severe obstructive sleep apnea present with serious medical comorbidities such as neurologic impairment, developmental delay, craniofacial abnormalities, or obesity.

Use of coblation along with tonsillectomy and/or adenoidectomy in childhood obstructive sleep apnea

The application of intracapsular tonsillectomy by coblation technique in children with obstructive sleep apnea in a tertiary-level university hospital in Beirut, Lebanon, during the period between March 2016 and March 2018 results in a statistically significant reduction of the mean Brodsky score evaluating the postoperative tonsil regrowth at 6.1 years by 2.95 ± 0.51 prior to operation to 1.04 ± 0.24 ($p < 0.001$) postoperatively with a mean difference of 1.92 (between 1.80 and 2.04 at 95% confidence interval) (23). The overall regrowth rate is 2.35% and the revision surgery rate is 1.18%.

All the children aged 5–10 years with adenoid hypertrophy causing obstructive sleep apnea are successfully treated by adenoidectomy using endoscope-assisted coblation technique within a multicentre prospective study in Thodupuzha and Muvattupuzha, Kerala, India, during the period from June 2022 to June 2023 (24). The adenoidectomy is a safe, simple, and standalone procedure for symptomatic obstructive sleep apnea patients in childhood.

The efficiency of coblation lingual tonsillectomy as part of a drug-induced sleep endoscopy-directed multilevel surgery is retrospectively assessed in 123 children at a median age of eight years (in the interquartile range of 3–12 years) with complex obstructive sleep apnea during the period from January 2018 to June 2022 in a pediatric tertiary care academic centre in Paris, France (25). This surgery is associated with epiglottoplasty (in 92 or in 74.80%), adenoidectomy (in 78 or in 63.41%), partial tonsillectomy (in 70 or in 56.91%), inferior turbinoplasty/turbinectomy (in 59 or in 47.97%), and/or expansion pharyngoplasty (in two children or in 1.63% of the cases). There is a postoperative hemorrhage and a necessity of transient postoperative reintubation in two patients each.

Conclusion

The results from this review convincingly prove the necessity of an individualized surgical approach to the children with different obstructive sleep apnea severity and comorbidity. The relative share of the postoperative complications is satisfactory. Along the tonsillectomy and adenotonsillectomy, some other promising operative procedures such as supraglottoplasty, uvulopalatopharyngoplasty, septoplasty, expansion sphincter pharyngoplasty, submucous inferior turbinate resection, and fluoroscopic-assisted tongue suspension, are identified, too. A more intensive interdisciplinary research is needed.

Conflict of interests: The author has no conflicts of interest to declare. He certifies that the submission is original work and is not under review at any other publication.

REFERENCES

1. Jaensch SL, Cheng AT, Waters KA. Adenotonsillectomy for obstructive sleep apnea in children. *Otolaryngol Clin North Am.* 2024;57(3):407-419.
2. Leroyer H, De Cock A, Fries S, Guinchard AC. Adéno-amygdalotomie chez les enfants avec syndrome d'apnées obstructives du sommeil. Recommandations pour la surveillance postopératoire. *Rev Med Suisse.* 2023;19(844):1780-1783.
3. Eitan D, Cave T, Scheffler P. Effect of adenotonsillectomy on central sleep apnea: a scoping review. *Int J Pediatr Otorhinolaryngol.* 2024;177:111863. doi: 10.1016/j.ijporl.2024.111863.
4. Redline S, Cook K, Chervin RD, Ishman S, Baldassari CM, Mitchell RB, et al.; Pediatric Adenotonsillectomy Trial for Snoring (PATS) Study Team. Adenotonsillectomy for snoring and mild sleep apnea in children: a randomized clinical trial. *JAMA.* 2023;330(21):2084-2095.
5. Kang KT, Hsu WC. Efficacy of adenotonsillectomy on pediatric obstructive sleep apnea and related outcomes: a narrative review of current evidence. *J Formos Med Assoc.* 2024;123(5):540-550.
6. Almutairi N, Alshareef W, Almakoshi L, Zakzouk A, Aljasser A, Alammam A. Is adenotonsillectomy effective in improving central apnea events in patients with obstructive sleep apnea? A systematic review and meta-analysis. *Eur Arch Otorhinolaryngol.* 2023;280(12):5205-5217.
7. Ehsan Z, Ishman SL, Soghier I, Almeida FR, Boudewyns A, Camacho M, et al. Management of persistent, post-adenotonsillectomy obstructive sleep apnea in children: an official American Thoracic Society clinical practice guideline. *Am J Respir Crit Care Med.* 2024;209(3):248-261.
8. Biadsee A, Nathanson C, Dagan O, Kassem F, Stahl A, Mishali T, et al. Reconsidering routine admission for children under age 3 undergoing partial tonsillectomy: a prospective study. *J Otolaryngol Head Neck Surg.* 2023;52(1):63. doi: 10.1186/s40463-023-00659-0.
9. Magnusdottir S, Witmans M, Hilmisson H. Sleep quality, sleep apnea, and metabolic health in children treated with adenotonsillectomy. *Sleep Breath.* 2023;27(4):1527-1540.
10. Au CT, Chan KC, Lee DLY, Leung NMW, Chow SMW, Kwok KL, et al. Effect of surgical intervention for childhood OSA on blood pressure: a randomized controlled study. *Sleep Med.* 2023;107:9-17.



11. Mothersole K, Ulualp SO, Szmuk P, Liu C. The effect of tonsillectomy and adenoidectomy on upper airway obstruction patterns in children with obstructive sleep apnea. *Int Arch Otorhinolaryngol.* 2023;27(2):e211-e217.
12. Lim J, Garigipati P, Liu K, Johnson RF, Liu C. Risk factors for post-tonsillectomy respiratory events in children with severe obstructive sleepapnea. *Laryngoscope.* 2023;133(5):1251-1256.
13. Sommerfeldt J, Duffy A, Blanco C, Kolb CM, Freeman C, Aaronson NL. Factors affecting polysomnography compliance and delays to surgical treatment of obstructive sleep apnea. *Int J Pediatr Otorhinolaryngol.* 2023;171:111637. doi: 10.1016/j.ijporl.2023.111637.
14. Mukerji SS, Rath S, Zhang WQ, Zhu H, Anand GS, Jones JK, et al. Extracapsular versus intracapsular tonsillectomy: outcomes in children with a focus on developmental delay. *Int J Pediatr Otorhinolaryngol.* 2022 Jan;152:110978. doi: 10.1016/j.ijporl.2021.110978.
15. Timashpolsky A, Aggarwal A, Ruiz R, Devine C. Intracapsular versus total tonsillectomy in patients with trisomy 21. *Laryngoscope.* 2024;134(5):2430-2437.
16. Daskalakis D, Tsetsos N, Karargou S, Goudakos J, Markou K, Karkos P. Intracapsular coblation tonsillectomy versus extracapsular coblation tonsillectomy: a systematic review and a meta-analysis. *Eur Arch Otorhinolaryngol.* 2021;278(3):637-644.
17. Maksimoski M, Li C. Surgical management of pediatric obstructive sleep apnea beyond tonsillectomy & adenoidectomy: tongue base and larynx. *Otolaryngol Clin North Am.* 2024;57(3):431-445.
18. Williamson A, Morrow VR, Carr MM, Coutras SW. Safety and efficacy of lingual tonsillectomy in multilevel airway surgery for pediatric obstructive sleep apnea. *J Clin Sleep Med.* 2024;20(2):189-199.
19. Lenze NR, Bharadwaj SR, Baldassari CM, Kirkham EM. Surgical management of pediatric obstructive sleep apnea beyond adenotonsillectomy: the nose, nasopharynx, and palate. *Otolaryngol Clin North Am.* 2024;57(3):421-430.
20. Valika T. Fluoroscopic-assisted tongue suspension: advancement and innovation in the management of complex pediatric obstructive sleep apnea. *Laryngoscope.* 2024;134 Suppl 6:S1-S9.
21. Casellas NJ, Shah S, Ravikumar S, Vandjelovic ND, Faria J, Allen PD, et al. Polysomnogram outcomes in patients with laryngomalacia and obstructive sleep apnoea treated surgically versus non-surgically. *J Laryngol Otol.* 2024;138(4):436-442.
22. Velu PS, Kariveda RR, Palmer WJ, Levi JR. A review of uvulopalatopharyngoplasty for pediatric obstructive sleep apnea. *Int J Pediatr Otorhinolaryngol.* 2024 Jan;176:111819. doi: 10.1016/j.ijporl.2023.111819.
23. Ahmarani G, El Khoury P, Aoun M, Ahmarani MC, Rassi S. Recurrence of sleep apnea in children after intracapsular coblation tonsillectomy: a comprehensive exploration of tonsil regrowth. *Int J Pediatr Otorhinolaryngol.* 2024;181:111992. doi: 0.1016/j.ijporl.2024.111992.
24. Moideen SP, G M D, Sheriff RM, James F. Effectiveness of adenoidectomy as a standalone procedure in improving the quality of life of children with obstructive sleep apnea. *Indian J Otolaryngol Head Neck Surg.* 2024;76(3):2344-2350.
25. Trandafir C, Couloigner V, Chatelet F, Fauroux B, Luscan R. Lingual tonsillectomy as part of a DISE-directed multilevel upper airway surgery to treat complex pediatric OSA: a safe and appropriate procedure. *Otolaryngol Head Neck Surg.* 2024 Aug 15. doi: 10.1002/ohn.947.



Welcome at the 31st Congress of the Union of the European Phoniaticians website.

<https://www.uep2025.com>