The Journal of Laryngology & Otology (2018), ***132***, *293–298*.

doi:10.1017/S002221511800021X

REVIEW ARTICLE

Paediatric obstructive sleep apnoea: is our operative management evidence-based?

L PABLA, J DUFFIN, L FLOOD, K BLACKMORE

ENT Department, James Cook University Hospital, Middlesbrough, UK

Abstract

Background: Despite the plethora of publications on the subject of paediatric obstructive sleep apnoea, there seems to be wide variability in the literature and in practice, regarding recourse to surgery, the operation chosen, the benefits gained and post-operative management. This may reflect a lack of high-level evidence.

Methods: A systematic review of four significant controversies in paediatric ENT was conducted from the available literature: tonsillectomy versus tonsillotomy, focusing on the evidence base for each; anaesthetic considerations in paediatric obstructive sleep apnoea surgery; the objective evidence for the benefits of surgical treatment for obstructive sleep apnoea; and the medical treatment options for residual obstructive sleep apnoea after surgical treatment.

Results and conclusion: There are many gaps in the evidence base for the surgical correction of obstructive sleep apnoea. There is emerging evidence favouring subtotal tonsillectomy. There is continuing uncertainty around the prediction of the level of post-operative care that any individual child might require. The long-term benefit of surgical correction is a particularly fertile ground for further research.

Key words: Child; Tonsillectomy; Sleep Apnea, Obstructive; Treatment

Introduction

Obstructive sleep apnoea (OSA) is a disorder of breathing during sleep, characterised by prolonged partial upper airway obstruction, and/or intermittent complete obstruction (obstructive apnoea), which disrupts ventilation during sleep and normal sleep patterns.[1] Between 6 and 12 per cent of children are quoted to show significant snoring, and 1–3 per cent have OSA.[2] Adenotonsillectomy is the most common treatment for children with OSA and generally the first line of therapy.

A recent UK survey investigating the management of paediatric snoring and OSA revealed great heterogeneity in the assessment and management of patients, with only 25 per cent of respondents having a dedicated management protocol for paediatric OSA.[2] In addition, it revealed low follow-up rates, with a mean duration of 6.8 ± 1.2 weeks. This creates uncertainty as to whether the treatment of adenotonsillectomy we are currently performing for OSA actually works and is beneficial in the long term.

Controversy also remains regarding the post-operative management of these patients. For instance, do they require an overnight stay on the ward or paediatric high dependency unit, and can we identify which patients are at increased risk of post-operative cardio-respiratory complications?

Recent surges in research activity have helped us to build on and improve our knowledge base to answer these pertinent questions. This systematic review aimed to assess: the evidence base for tonsillectomy versus tonsillotomy in the management of paediatric OSA, anaesthetic considerations, the evidence for the benefits of treating OSA surgically, and the medical treatments available for residual OSA after adenotonsillectomy.

Materials and methods

In preparation of this systematic review, we followed the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses for Protocols ('PRISMA-P') 2015. We assessed the quality of papers using the National Institute for Health and Care Excellence quality assessment tool, as it allows some analysis of case reports and series (lower level evidence).

We sought high-quality prospective clinical studies, reviews or laboratory work relevant to the definition, diagnosis, classification and non-surgical management of paediatric OSA. We searched Medline, Embase and Cochrane Library databases from inception up to March 2017, using the following key words and combinations thereof: 'obstructive sleep apnoea',

Accepted for publication 16 November 2017 First published online 21 February 2018

'obstructive sleep apnea', 'paediatric', 'pediatric', and 'controlled trials/systematic review/evidence base'.

Abstracts, identified from a review of article titles, were evaluated for inclusion by two authors (LP and KB) working independently, with consensus if opinions differed. Papers were chosen if the abstracts suggested systematic reviews or meta-analyses, prospective controlled studies, or original basic science findings from laboratory studies. Audits, and larger case series and cohort studies, especially those offering any comparative study between groups, or before and after intervention, provided a lower level of evidence. Papers suggesting algorithms and consensus views for treatment, together with case reports suggesting complications and the earliest reports of the condition were also included.

Abstracts were excluded if they suggested isolated case reports or small and uncontrolled series that presented no new insight. No language restrictions were applied.

Results

We selected 35 papers that met the criteria for this review (and which are referred to in the text): 18 systematic reviews;[1,3–19] 5 randomised controlled trials;[20–24] 3 non-randomised controlled or comparative studies;[25–27] 6 case series or cohort studies;[28–33] 3 surveys, consensus documents or questionnaire studies;[2,34,35] 0 historical articles; and 0 case reports.

Discussion

Question one

Tonsillectomy or tonsillotomy? Does adenoid removal confer much added benefit?

Adenotonsillectomy for OSA is the most commonly performed procedure and treatment of choice for paediatric OSA, to reduce the obstruction caused by large tonsils and adenoids. There is good evidence that adenotonsillectomy is efficacious in children with OSA and adenotonsillar hypertrophy. The majority of children show marked improvement in their polysomnography parameters, with a success rate, in otherwise healthy and non-obese children, of 75 per cent.[13] In addition, this treatment is associated with a significant reduction in healthcare utilisation.[27] Recent research activity and debate has focused on whether tonsillotomy is a safer alternative to the traditional approach of extracapsular tonsillectomy and how much added benefit is offered by adenoidectomy.

Tonsillectomy versus tonsillotomy. Tonsillotomy, also known as subtotal tonsillectomy, intracapsular tonsillectomy or partial tonsillectomy, aims to remove approximately 90 per cent of tonsillar tissue, leaving a thin rim laterally to avoid disruption of the tonsillar capsule and prevent damage to the surrounding pharyngeal muscles. This proposes to reduce the severity and duration of post-operative pain, with less frequent post-operative bleeding and an efficacy equal to that of total tonsillectomy for the treatment of sleep-disordered breathing.[8,21]

A meta-analysis comparing 10 prospective studies (1029 participants) directly compared tonsillotomy and tonsillectomy in the management of paediatric sleep-disordered breathing.[10] It found that tonsillotomy may be advantageous over tonsillectomy in short-term measures, with lower haemorrhage rate, shorter operation time and faster recovery to a pain-free state. Long-term follow up showed no clinically significant differences between the tonsillotomy and tonsillectomy groups in terms of: resolution of upper airway obstructive symptoms (including polysomnography outcomes), quality of life or post-operative immune function. However, a subgroup analysis showed a difference with regard to the rate of sleep-disordered breathing recurrence between the tonsillotomy and tonsillectomy groups, where the risk ratio of sleep-disordered breathing recurrence was found to be 3.33 (95 per cent confidence interval = 1.62, $p = 0.001$), favouring tonsillectomy at an average follow-up time of 31 months.

A retrospective cohort study of 52 children comparing extracapsular and intracapsular tonsillectomy with adenoidectomy found comparable short-term outcomes (improved post-operative polysomnography findings) with both treatment modalities.[32] However, in a subset of patients with asthma and obesity, intracapsular tonsillectomy was associated with residual OSA. Obesity and other co-morbidities such as asthma are independent risk factors for the development of OSA, and, when they co-exist, the additive effects can contribute to treatment failure. There is thus a need for more extensive studies, especially into the long-term follow up, to allow better assessment of the maintenance of treatment effects.[14,31,35]

There have been recent advances in Coblation® technology. In addition, Hoey *et al*. reported on its positive application in tonsillotomy for OSA.[33] These authors described a case series of 500 children (mean age of 5.1 years) who underwent Coblation intracapsular tonsillectomy for obstructive and/or infective symptoms. Long-term follow-up data (pre- and post-operative parent-reported outcome questionnaire findings) revealed highly significant improvements in the scores post-operatively in patients with obstructive symptoms, with minimal pain control requirements and low haemorrhage rates (there were no primary bleeds, and two patients had a secondary bleed, managed conservatively). Of the patients, 2.4 per cent required revision tonsil surgery (10 for obstructive symptoms, 2 for infective symptoms), with the majority being very young children. Further studies with greater sample sizes would help to establish the role and advantages of Coblation intracapsular tonsillectomy for OSA treatment.

Adenoidectomy alone? Although adenotonsillectomy is successful in treating OSA, there are concerns

https://doi.org/10.1017/S002221511800021X Published online by Cambridge University Press

regarding the risk of post-operative bleeding in children aged less than three years. In addition, the role of adenoidectomy alone, in the presence of small tonsils, has been investigated. A systematic review and meta-analysis yielded a total of three studies of adenoidectomy alone with pre- and post-operative sleep study data (47 patients, level 4 evidence).[15] It concluded that adenoidectomy alone can significantly improve obstructed breathing during sleep, as determined by the improved apnoea/hypopnoea index and lowest oxygen saturation level. However, given the small number and low quality of the studies, adenoidectomy alone is an area for additional research rather than being the current standard practice in children.

Summary points. Current screening tests show a relatively high sensitivity but a low specificity. Most are better at detecting moderate-to-severe rather than mild OSA. Emerging evidence suggests that even mild forms of OSA (and possibly even primary snoring) carry associated morbidity. There are limited studies investigating the threshold at which the apnoea/hypopnoea index predicts morbidity, focusing on cardiac and neurocognitive disorders. The ability of screening tests other than polysomnography to predict post-operative complications after adenotonsillectomy is unclear.

Question two

Anaesthetic management. What level of post-operative care is required? What are the indications for paediatric intensive care unit admission and ventilation? Can it be predicted?

Children with OSA are at risk of respiratory complications following adenotonsillectomy, so it is important that they are appropriately identified and pre-assessed.[11] Children with an apnoea/hypopnoea index of 5 or more events per hour are seven times more likely to have a post-operative respiratory complication. Moreover, an obese child with OSA has been shown to experience significantly more respiratory complications after adenotonsillectomy compared with children of normal weight.[34]

Adenotonsillectomy for OSA is one of the most commonly performed paediatric surgical procedures. In order to reduce practice variability and increase post-operative safety, the American Academy of Otolaryngology – Head and Neck Surgery (AAO-HNS) published clinical practice guidelines for the assessment and management of paediatric adenotonsillectomy.[6] However, there is limited guidance, and little research on the duration and level of monitoring in such paediatric OSA patients after adenotonsillectomy. Also, in children without co-morbidities, there is still a risk of significant residual obstruction on the first post-operative night. Therefore, it is important to establish the duration and level of monitoring required, even in this subset of OSA patients, because of significant variability in practice.[34]

Pre-operative management. The AAO-HNS guidelines advocate polysomnography prior to adenotonsillectomy. This is particularly important in children with the following co-morbidities: obesity, Down syndrome, craniofacial abnormalities, neuromuscular disorders, sickle cell disease or mucopolysaccharidosis.[6] Given the co-morbid profile of these patients, they can often undergo anaesthesia for several simultaneous procedures, and therefore may have additional post-operative needs.[5]

There is much evidence to show that OSA has an impact on various physiological processes in the body, and the anaesthetist must be vigilant in assessing for these disturbances. Though cardiovascular evaluation is not routine, children who show signs of cardiac involvement, such as right ventricular dysfunction or systemic hypertension, should have a cardiac evaluation, with echocardiography recommended. However, research is lacking in substantiating this guidance.[5,12]

Children with OSA are at high risk of airway obstruction, desaturation and laryngospasm during anaesthetic induction. Those children identified as having severe OSA or cardiovascular complications associated with OSA should be considered for pre-operative continuous positive airway pressure (CPAP) or bilevel positive airway pressure therapy, which potentially improves airway patency and pulmonary hypertension.[3,5]

Intra-operative management. Pre-operative sedation should be used cautiously, as medications such as benzodiazepines, barbiturates, propofol and opioids can persist into the post-operative period, and cause respiratory complications that include airway collapse and respiratory depression, a significant risk in children with OSA.[11] Agents such as ketamine and dexmedetomidine are less likely to cause post-operative complications as they help to preserve pharyngeal muscle tone and airway reflexes.[12] If obstruction occurs, the use of manual manoeuvres including the jaw thrust and an oral airway, with positive pressure delivered through a facemask, may relieve the obstruction.

Post-operative management. Other complications include laryngospasm, pulmonary oedema, pulmonary hypertensive crisis and pneumonia, which raises the question as to the duration of post-operative monitoring.[5] Most studies have found that children younger than three years are at greatest risk, though some studies have quoted under two years.[3] A retrospective review of 2315 children demonstrated a 2-fold increase in respiratory complications after adenotonsillectomy for sleep-disordered breathing children younger than 3 years, and a national survey found that 95 of 234 of respondents were using 3 years as the cut-off criteria for admission.[34] After adenotonsillectomy, even when children have been fully extubated and are awake, they carry a 16–27 per cent risk of respiratory

https://doi.org/10.1017/S002221511800021X Published online by Cambridge University Press

complications. There is also a small risk of post-obstructive pulmonary oedema developing in those with severe obstruction, which may require reintubation and ventilation.[3] Patients with disorders of pharyngeal tone or craniofacial anatomy may have residual airway obstruction and will require close observation.

It is recommended that overnight oximetry is monitored on the first night post-operatively in those patients considered high risk (young or with co-morbidities), in a setting which can respond effectively to drops in oxygen saturation levels and with non-invasive ventilation facilities.[34] There is no definitive guidance on whether children should be monitored on the ward, a step-down unit or a paediatric intensive care unit. However, a small retrospective chart review found that children without a post-anaesthesia care unit event after prolonged post-anaesthesia care unit monitoring were unlikely to later develop an adverse event.[11]

A cross-sectional survey conducted in the USA and Canada investigated the peri-operative practice for children undergoing adenotonsillectomy in tertiary care units.[34] Of the 48 respondents, 44 per cent reported that they had no official admission policy for children with sleep-disordered breathing. The AAO-HNS polysomnography criteria for severe OSA were used by 40 per cent of the respondents and 15 per cent used the American Academy of Pediatrics criteria (apnoea/hypopnoea index of more than 24 events per hour or oxygen saturation nadir of less than 80 per cent). A minimum time for observation was reported by 90 per cent of the centres, with a median of 2 hours and a range of 1–6 hours. Though this study noted the wide variation in the length of the post-operative period, it failed to identify the most common practice in this regard and rightly calls for the need for more research in this area.

Summary points. Children with OSA are an anaesthetic risk, and they require careful assessment and management in the peri-operative period. Despite guidelines, there is still varying practice regarding peri-operative anaesthetic management. There is a consensus as to pre-operative risk assessment, but more research into post-operative management is needed.

Question three

What evidence is there for the benefits of surgical intervention? Does early intervention give better results than delayed intervention?

Neurocognitive effects of adenotonsillectomy. Neurobehavioural deficits related to childhood OSA are well established, with more recent studies suggesting some impairment of cognition and behaviour across the whole spectrum of sleep-disordered breathing.[30] These deficits can be wide-ranging, and include attention, executive functions, language, memory, and behavioural components such as hyperactivity, anxiety, depression and aggression.[26]

Multiple studies have shown that adenotonsillectomy can improve neurocognitive function in children with OSA, but many are limited by small sample sizes, lack of randomisation, and reliance on parent questionnaires rather than formal neuropsychological testing.[16,28]

In order to address these mixed results of the effect of adenotonsillectomy on restoring neurocognition, a recent systematic review and meta-analysis of neurocognitive outcomes after paediatric adenotonsillectomy for OSA was conducted. It found an improvement in neurocognitive function and intelligence quotient after paediatric adenotonsillectomy, especially in pre-school aged children.[17] However, of the 19 prospective studies included, the findings of neurocognitive improvement after adenotonsillectomy were not generalisable to children of all age groups, and few studies assessed pre-school-aged children or included follow-up data beyond one year. Only three studies evaluated pre-school children, all of which found improved neurobehavioural parameters, suggesting that earlier intervention strongly influences the efficacy of surgery. The only randomised, multicentre, controlled study was the Childhood Adenotonsillectomy Trial ('CHAT'), but this included older children (aged five to nine years).[22] This study showed that adenotonsillectomy did not significantly improve attention or executive function, as measured by a change in Developmental Neuropsychological Assessment ('NEPSY') scores – a domain shown to be sensitive to intermittent hypoxaemia related to OSA. This may suggest that there is a possible fixed neurocognitive deficit after a threshold age, which is yet to be defined and requires further investigation.

Furthermore, there is no consistent use of a standardised assessment tool to facilitate the interpretation of results across studies.[17] The Neuropsychological Developmental Assessment and the Stanford Binet Intelligence Scales are recommended for future studies, as they are both normed and well-validated instruments, with robust validity and reliability. However, a suggested disadvantage of using the Developmental Neuropsychological Assessment is that it is a more clinically orientated objective test which does not reflect 'real-world settings', whereas the Behaviour Rating Inventory of Executive Function ('BRIEF') scoring system may be better suited as an assessment tool.[19,22] Therefore, further consensus is required on the most appropriate assessment tool for evaluating the neurobehavioural and cognitive effects, in order to standardise assessment and drive research quality.

Post-adenotonsillectomy effects on growth. Growth failure has been frequently reported in children with OSA due to dysregulation in insulin-like growth factor 1, which reduces growth potential. These effects are reversed with adenotonsillectomy.[25] A

https://doi.org/10.1017/S002221511800021X Published online by Cambridge University Press

systematic review addressing weight gain after adenotonsillectomy found that the only randomised controlled trial investigated short-term weight gain after adenotonsillectomy, with a number of possible reasons for post-operative weight gain.[18] If a child is underweight prior to adenotonsillectomy, attaining their normal weight potential could be considered beneficial. However, as shown in a subset of patients in the Childhood Adenotonsillectomy Study, adenotonsillectomy in children with OSA who are also overweight pre-operatively leads to further weight gain post-operatively, with further risks of obesity.[23]

Cardiovascular effects of adenotonsillectomy. Although it is well documented that treatment of OSA in adults leads to significant improvements in cardiovascular function, there is a lack of research and understanding of long-term outcomes in children. In the short-term, there is evidence for the improvement of cardiovascular parameters such as blood pressure, heart rate, cardiac morphology and cardiac function in children undergoing adenotonsillectomy for OSA.[7] Furthermore, a systematic review and meta-analysis of echocardiographic findings in OSA children after adenotonsillectomy showed improvements in right-sided heart structure and function around six months post-treatment.[9] Despite these findings, there is still a paucity of well-designed and powered studies.

The Childhood Adenotonsillectomy Trial secondary outcomes also addressed cardiometabolic health, evaluating the effect of adenotonsillectomy for OSA on blood pressure, heart rate, lipids, glucose, insulin and C-reactive protein.[24] They found no significant change in these parameters over the seven-month interval in the adenotonsillectomy group, compared to the watchful waiting group. Overnight heart rate appeared to be a sensitive marker of OSA severity and a measure of responsiveness to OSA treatment. This suggests a need for further research to clarify the role of adenotonsillectomy and its cardiovascular effects.

Summary points. A consensus on a standard method for evaluating the neurobehavioural and cognitive effects of OSA would help drive research standards and data validity. The effects of adenotonsillectomy on growth and its relation to a child's pre-operative weight need further investigation. There is some good evidence to show short-term improvement in cardiovascular parameters following adenotonsillectomy in children with OSA, but long-term data are lacking.

Question four

What medical treatment options are there for residual OSA after adenotonsillectomy?

Although adenotonsillectomy is the primary treatment of choice for paediatric OSA, complete resolution of OSA reportedly occurs in only 75 per cent of affected children.[13] A suggested possible reason for residual disease is the presence of a multilevel obstruction, particularly common in children with comorbidities such as Down's syndrome, obesity and craniofacial abnormalities.[4] Depending on the severity of the residual OSA, treatment options vary from conservative management to CPAP, anti-inflammatory medication, oral appliances, orthodontic treatment and surgery.[19]

If adenotonsillectomy fails, second-line treatment would include investigations to identify another site of obstruction (e.g. laryngomalacia) and potentially treat surgically. Continuous positive airway pressure is another option for persistent symptoms following surgery, but adherence rates are low in children.[20] Nasal CPAP is another alternative increasingly used in children with residual OSA, with success rates of up to 50–100 per cent, coupled with a focus on parent education and motivation for use.[29]

There is currently no consensus regarding the optimal methods for identifying sites of obstruction or treating children with persistent disease after surgery. Drug-induced sleep endoscopy and cine magnetic resonance imaging are the most commonly used tools reported in the literature to identify the site of obstruction in persistent OSA in children, but with no clear linkage to outcomes.[19] Furthermore, evidence for further surgical intervention is very limited and involves mainly lingual tonsillectomy and supraglottoplasty.[19]

Summary points. Nasal CPAP may be a potential alternative to traditional CPAP for children with residual OSA after adenotonsillectomy, as it may be better tolerated. However, significant parent education and motivation is required.

Conclusion

The expansion in literature addressing the many facets of paediatric OSA has presented an opportunity for better evidence-based management of this condition for clinicians. One such example is the emerging evidence base for intracapsular tonsillectomy, in particular Coblation tonsillectomy, with its benefits of reduced haemorrhage rates and lower post-operative pain requirements. However, there still remain important questions, such as the effects of adenotonsillar regrowth and recurrence rates of OSA in the long term.

Children with OSA may pose a significant anaesthetic risk. Pre-operatively, there is a clear consensus on how best to stratify children according to their risk and we can use this to help plan post-operative care. However, there is little evidence to support best practice post-operatively, with wide variations in practice. It is clear that there is a need for more research in this area.

In addition, although there is good evidence for the benefits of surgical intervention, such as improvement in neurocognitive and behavioural outcomes, a standardised method of evaluating these will help improve the validity of the data and research standards.

https://doi.org/10.1017/S002221511800021X Published online by Cambridge University Press

References

1 Marcus CL, Chapman D, Ward SD, McColley SA, Herrerias CT, Stillwell PC *et al*. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics* 2002;**109**:704–12
2 Sharma SD, Kanona H, Kumar G, Kotecha B. Latest trends in the assessment and management of paediatric snoring and sleep apnoea. *J Laryngol Otol* 2016;**130**:482–9
3 Leong A, Davis J. Morbidity after adenotonsillectomy for paediatric obstructive sleep apnoea syndrome: waking up to a pragmatic approach. *J Laryngol Otol* 2007;**121**:809–17
4 Friedman M, Wilson M, Lin HC, Chang HW. Updated systematic review of tonsillectomy and adenoidectomy for treatment of pediatric obstructive sleep apnea/hypopnea syndrome. *Otolaryngol Head Neck Surg* 2009;**140**:800–8
5 Schwengel DA, Sterni LM, Tunkel DE, Heitmiller ES. Perioperative management of children with obstructive sleep apnea. *Anesth Analg* 2009;**109**:60–75
6 Baugh RF, Archer SM, Mitchell RB, Rosenfeld RM, Amin R, Burns JJ *et al*. American Academy of Otolaryngology-Head and Neck Surgery Foundation. Clinical practice guideline: tonsillectomy in children. *Otolaryngol Head Neck Surg* 2011; **144**(1 suppl):S1–30
7 Teo DT, Mitchell RB. Systematic review of effects of adenotonsillectomy on cardiovascular parameters in children with obstructive sleep apnea. *Otolaryngol Head Neck Surg* 2013; **148**:21–8
8 Wood JM, Cho M, Carney AS. Role of subtotal tonsillectomy ('tonsillotomy') in children with sleep disordered breathing. *J Laryngol Otol* 2014;**128**(suppl 1):S3–7
9 Weber SA, Pierri Carvalho R, Ridley G, Williams K, El Dib R. A systematic review and meta-analysis of cohort studies of echocardiographic findings in OSA children after adenotonsillectomy. *Int J Pediatr Otorhinolaryngol* 2014;**78**:1571–8
10 Wang H, Fu Y, Feng Y, Guan J, Yin S. Tonsillectomy versus tonsillotomy for sleep-disordered breathing in children: a meta analysis. *PLoS One* 2015;**10**:e0121500
11 Wood KL, Besecker BY. Perioperative issues and sleep-disordered breathing. *Crit Care Clin* 2015;**31**:497–510
12 Harper P, Rawling L, Brown Z. Update on ENT anaesthesia. *Anaesthesia and Intensive Care Medicine* 2015;**16**:635–40
13 Dehlink E, Tan HL. Update on paediatric obstructive sleep apnoea. *J Thorac Dis* 2016;**8**:224–35
14 Anderson IG, Holm JC, Homoe P. Obstructive sleep apnoea in obese children and adolescents, treatment methods and outcome of treatment – a systematic review. *Int J Pediatr Otorhinolaryngol* 2016;**87**:190–7
15 Reckley LK, Song SA, Chang ET, Cable BB, Certal V, Camacho M. Adenoidectomy can improve obstructive sleep apnoea in young children: systematic review and meta-analysis. *J Laryngol Otol* 2016;**130**:990–4
16 Konstantinopoulou S, Tapia IE. Neurocognitive and behavioural outcomes following intervention for obstructive sleep apnoea syndrome in children. *Paediatr Respir Rev* 2016;**20**:51–4
17 Song SA, Tolisano AM, Cable BB, Camacho M. Neurocognitive outcomes after pediatric adenotonsillectomy for obstructive sleep apnea: a systematic review and meta-analysis. *Int J Pediatr Otorhinolaryngol* 2016;**83**:205–10
18 Van M, Khan I, Hussain SS. Short-term weight gain after adenotonsillectomy in children with obstructive sleep apnoea: systematic review. *J Laryngol Otol* 2016;**30**:214–18
19 Manickam PV, Shott SR, Boss EF, Cohen AP, Meinzen-Derr JK, Amin RS *et al*. Systematic review of site of obstruction identification and non-CPAP treatment options for children with persistent pediatric obstructive sleep apnea. *Laryngoscope* 2016; **126**:491–500
20 Marcus CL, Rosen G, Davidson Ward SL, Halbower AC, Sterni L, Lutz J *et al*. Adherence to and effectiveness of positive airway pressure therapy in children with obstructive sleep apnea. *Pediatrics* 2006;**117**:442–51
21 Wilson YL, Merer DM, Moscatello AL. Comparison of three common tonsillectomy techniques: a prospective randomized, double-blinded clinical study. *Laryngoscope* 2009;**119**:162–70
22 Marcus CL, Moore RH, Rosen CL, Giordani B, Garetz SL, Taylor HG *et al*. Childhood Adenotonsillectomy Trial. A randomized trial of adenotonsillectomy for childhood sleep apnea. *N Engl J Med* 2013;**368**:2366–76
23 Katz ES, Moore RH, Rosen CL, Mitchell RB, Amin R, Arens R *et al*. Growth after adenotonsillectomy for obstructive sleep apnea: an RCT. *Pediatrics* 2014;**134**:282–9
24 Quante M, Wang R, Weng J, Rosen CL, Amin R, Garetz SL *et al*. Childhood Adenotonsillectomy Trial. The effect of adenotonsillectomy for childhood sleep apnea on cardiometabolic measures. *Sleep* 2015;**38**:1395–403
25 Bar A, Tarasiuk A, Segev Y, Phillip M, Tal A. The effect of adenotonsillectomy on serum insulin-like growth factor-I and growth in children with obstructive sleep apnea syndrome. *Pediatrics* 1999;**135**:76–80
26 Row BW, Kheirandish L, Neville JJ, Gozal D. Impaired spatial learning and hyperactivity in developing rats exposed to intermittent hypoxia. *Pediatr Res* 2002;**52**:449–53
27 Tarasiuk A, Simon T, Tal A, Reuveni H. Adenotonsillectomy in children with obstructive sleep apnea syndrome reduces health care utilization. *Pediatrics* 2004;**113**:351–6
28 Goldstein NA, Post J, Rosenfeld RM, Campbell TF. Impact of tonsillectomy and adenoidectomy on child behavior. *Arch Otolaryngol Head Neck Surg* 2000;**126**:494–8
29 Massa F, Gonsalez S, Laverty A, Wallis C, Lane R. The use of nasal continuous positive airway pressure to treat obstructive sleep apnoea. *Arch Dis Child* 2002;**87**:438–43
30 Bourke R, Anderson V, Yang JS, Jackman AR, Killedar A, Nixon GM *et al*. Cognitive and academic functions are impaired in children with all severities of sleep-disordered breathing. *Sleep Med* 2011;**12**:489–96
31 Ross KR, Storfer-Isser A, Hart MA, Kibler AM, Rueschman M, Rosen CL *et al*. Sleep-disordered breathing is associated with asthma severity in children. *Pediatrics* 2012;**160**:736–42
32 Mukhatiyar P, Nandalike K, Cohen HW, Sin S, Gangar M, Bent JP *et al*. Intracapsular and extracapsular tonsillectomy and adenoidectomy in pediatric obstructive sleep apnea. *JAMA Otolaryngol Head Neck Surg* 2016;**142**:25–31
33 Hoey AW, Foden NM, Hadjisymeou Andreou S, Noonan F, Chowdhury AK, Greig SR *et al*. Coblation intracapsular tonsillectomy (tonsillotomy) in children: a prospective study of 500 consecutive cases with long-term follow-up. *Clin Otolaryngol* 2017;**42**:1211–17
34 Nardone HC, McKee-Cole KM, Friedman NR. Current pediatric tertiary care admission practices following adenotonsillectomy. *JAMA Otolaryngol Head Neck Surg* 2016;**142**:452–6
35 Chng SY, Goh DY, Wang XS, Tan TN, Ong NB. Snoring and atopic disease: a strong association. *Pediatr Pulmonol* 2004; **38**:210–16

Address for correspondence:
Miss Lakhbinder Pabla,
ENT Department,
James Cook University Hospital,
Marton Road,
Middlesbrough TS4 3BW, UK

E-mail: Lakh.pabla.bal@gmail.com

Miss L Pabla takes responsibility for the integrity of the content of the paper
Competing interests: None declared

https://doi.org/10.1017/S002221511800021X Published online by Cambridge University Press