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Original Article

Assessment and treatment of pediatric obstructive sleep apnea in Canada: history and current state of affairs

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ABSTRACT

Aim: To highlight Canada's contributions to the assessment and treatment of pediatric obstructive sleep apnea as well as outline the current state of pediatric obstructive sleep apnea in Canada.
Methods: A search was conducted in MEDLINE (Ovid) using Medical Subject Headings (MeSH) and free-text terms for 'child' and 'obstructive sleep apnea' with subsequent 'human' limit. The results were reviewed to identify publications where any author's listed a Canadian institution.
Results: Canadian contributions to the field of pediatric obstructive sleep apnea have grown over the last 30 years with an increase in number of contributors and centres. Much of the early work stemmed from McGill University with important contributions in examining alternatives to polysomnography and post-adenotonsillectomy respiratory compromise. Today, contributors from centres across the country are engaged in the field and come from a greater diversity of disciplines. With continued challenges and opportunities, Canada will continue to help advance the field of pediatric OSA.
Conclusion: Canada has a strong community of people invested in continuing to work to improve the lives of Canadian children with pediatric OSA.

1. Introduction

The field of pediatric OSA in Canada has grown substantially over the last 30 years. In the first 10 years, much of the contribution stemmed from McGill University with work examining alternatives to polysomnography and post-adenotonsillectomy respiratory compromise including the identification of heighten opioid sensitivity. Both Canadian and international trainees received clinical and research training at McGill spreading this expertise across Canada and the world. Over the subsequent 20 years, the number of centers and contributors has grown substantially as have the training opportunities and disciplines interested in pediatric OSA. Today, contributions to the field stem from universities across Canada with multiple centres with established multi-disciplinary pediatric sleep medicine program. The aim of this review is to highlight Canada's contribution to the field as well as outline the current state of pediatric OSA in Canada.

2. Methods

A search was conducted in MEDLINE (Ovid) using Medical Subject headings (MeSH) and free-text terms for child and obstructive sleep apnea and then limited to original research and reports (including case reports and methods of data synthesis). The results were reviewed to identify publications where any author's listed institution included a Canadian institution. This review summarizes the results of that search under the broad headings of assessment and treatment of pediatric obstructive sleep apnea.

3. Assessment of pediatric obstructive sleep apnea

Canadian research has contributed to the identification of risk factors for pediatric OSA as well as questionnaire development, identification of potential biomarkers, and the role of overnight

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; MOS, McGill oximetry score; NIV, non-invasive ventilation; OSA, obstructive sleep apnea.

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oximetry, home sleep apnea testing, and polysomnography in the assessment of children with suspected OSA.

3.1. Identifying risk factors and questionnaire development

Canadian publications have highlighted disorders associated with an increased risk of pediatric OSA or sleep disordered breathing including craniofacial malformations [1], Down syndrome [2–4], Apert syndrome [5], oculomandibulofacial syndrome [6], mucopolysaccharidosis [7], obese adolescents with craniopharyngioma [8], syndromic craniosynostosis [9], nocturnal enuresis [10], CHARGE syndrome [11,12], myelomingocele [13,14], Duchenne muscular dystrophy [15], Prader–Willi syndrome [16,17], neuromuscular disease [18], cardiomyopathy [19], cleft lip and/or palate [20,21], chronic kidney disease [22], Robin sequence [23], sickle cell disease [24] and obesity [8,25]. Risk factors for pediatrics OSA identified in Canadian publications include neighborhood disadvantage [26], growth hormone for Prader–Willi syndrome [27–30], and African ethnicity [31]. Factors identified as potentially protective for OSA included treatment with hydroxyurea for children with sickle cell disease [24], and breast feeding [32]. The investigation of physical features as risk factors for pediatric OSA has included examination of craniofacial features [33,34], obesity [25], neck and waist circumference [35], neck-to-waist ratio [36,37], neck-to-height ratio [37,38], waist-to-height ratio [37], and body composition including neck-to-abdominal fat percentage and total fat mass [39]. The results of this work support a broad range of risk factors for pediatric OSA.

Contributions to questionnaires for pediatric OSA have included a systematic review of existing questionnaires as well as development of two related questionnaires. The systematic review demonstrated that only one existing questionnaire showed diagnostic accuracy sufficient for screening, but not diagnosis, of OSA [40]. Questionnaire development include the independently scored parent and child IF SLEEPY questionnaires, screening tools for pediatrics OSA, and [41] modification of this scale by replacing 'F' (fidgets) with 'M' (BMI > 85% percentile) to create I'M SLEEPY [42].

3.2. Biomarkers

Canadian researchers have been part of the teams who have completed two scoping reviews and one systematic review with meta-analysis summarizing the data on biomarkers associated with the pediatric OSA [43–45]. Together, the results identified 21 individual potential biomarkers as well as groups of markers associated with OSA in children. The results highlight, that while promising, further work is needed to explore the role of potential biomarkers as part of the assessment of pediatric OSA.

3.3. Overnight oximetry

The McGill oximetry score (MOS) was developed by a team at McGill University to formalize a scoring system for overnight oximetry with the goal of developing a system that could be easily applied, reflect gradations in OSA severity, and used by a broad range of clinicians to prioritize children who require adenotonsillectomy [46,47]. Subsequent studies using the MOS demonstrated consistency in MOS results over two nights of recording [48] and predicted cost savings if used as a screening test for OSA and <90% of children went on to have polysomnography [49]. The MOS has subsequently been used by research groups around the world.

Additional studies of overnight oximetry by other Canadian groups have looked at technical considerations, interpretation, comparison with polysomnography results, and its use for the detection of pulse rate variability. Comparison of different oximeters demonstrated the importance of averaging time and movement artifact detection in the results of oximetry testing [50]. Expert readers have poor agreement on interpretation of graphic trends for event classification though agreement can be improved with training [51]. Comparison of home oximetry monitoring with in-laboratory polysomnography showed poor agreement between oximetry desaturation index and polysomnography apnea hypopnea index (AHI) despite good agreement between home oximetry and polysomnography oxygen desaturation index; the authors concluded this precludes the use of home overnight oximetry as a substitution for polysomnography [52]. A study of autonomic cardiac regulation used data collected from the Phone Oximeter™ to measure pulse rate variability in children with and without sleep disordered breathing and demonstrated differences in the parasympathetic and sympathetic indices relative to respiratory events in the majority of children with sleep disordered breathing [53]. While overnight oximetry is an accessible test, its role in the screening and diagnosis of pediatric OSA remains controversial.

3.4. Home sleep apnea testing

The McGill University group was one of the first groups worldwide to investigate home testing for OSA. This group initially developed a method of classification of movements/arousals using a combination of limited channel cardiorespiratory monitoring and video during in-laboratory polysomnograhic recording [54] with expansion of these methods to distinguish sleep and wakefulness [55]. Subsequent studies of this method at home in children with suspected OSA secondary to adenotonsillar hypertrophy demonstrated feasibility of performing home studies with similar respiratory parameters and more favorable sleep parameters when compared to in-laboratory polysomnography [56,57].

Studies of portable monitoring devices from other Canadian investigators have demonstrated feasibility [58] and high sensitivity but low specificity for the diagnosis of OSA or sleep disordered breathing when compared to polysomnographic diagnosis [15,59]. A recent position statement from the American Academy of Sleep Medicine (with a Canadian pediatric sleep medicine expert as the lead author), however, states that, in contrast to adults, home sleep apnea testing is not recommended for the diagnosis of OSA in children [60].

3.5. Polysomnography

Canadian researchers have contributed to methods for polysomnography. In 1993 Morielli and colleagues, at McGill University, described the use of end tidal and transcutaneous carbon dioxide monitoring added to 12-channel polysomnography recorded on a polygraph [61]. A comparison of full night and 4 h evening polysomnography in children under two years of age showed a high level of agreement for respiratory parameters suggesting 4 h studies with scoring of the studies in the second half of the night may be a means of improving sleep laboratory efficiency [62]. Results of a large study of polysomnography in children under two years of age showed that applying current criteria for pediatric polysomnography OSA classification to this younger age group leads to over estimation of OSA severity when compare to experienced sleep physician classification of severity [63].

4. Treatment of pediatric obstructive sleep apnea

Canadians have made important contributions to our understanding of surgical management, non-invasive ventilation, including continuous positive airway pressure (CPAP) and bi-level

positive airway pressure (BPAP), corticosteroids, as well as craniofacial surgery and orthodontic appliance for OSA in children.

4.1. Systematic review of treatments for pediatric OSA

Canadians have contributed to systematic reviews summarizing the available data relevant to treatment options for pediatric OSA. A 2009 review highlighted a relative paucity of randomized controlled trials relevant to interventions for OSA in children including only five trials investigating seven treatment options [64]. A systematic review of anti-inflammatory therapy for pediatric OSA, published in 2011, identified three randomized controlled trials; the only study that was methodologically rigorous demonstrated a short term beneficial effect of intranasal fluticasone compared to placebo [65]. A more recent meta-analysis, published in 2015, demonstrated benefit of intranasal mometasone over placebo for reduction in OSA grading though with high heterogeneity of results between studies [66].

4.2. Surgical management

Researchers at McGill University identified that children with OSA undergoing adenotonsillectomy have distinct post-operative risks with greater risk for respiratory complications [67]. One important factor contributing to this risk is an increased sensitivity to opioids related to exposure to recurrent hypoxaemia [68], a phenomena that has been confirmed in animal studies [69]. Children with an oxygen saturation nadir during sleep <85% were found to require half the analgesic morphine dose post-operatively when compared to those with a nadir ≥85% [68]. Increase opioid sensitivity, along with continued risk of upper airway obstruction, put children with OSA undergoing adenotonsillectomy at increased risk of respiratory compromise and death on the first post-operative night [70,71]. Post-operative anesthetic protocols where opioids are reduced or eliminated reduced the risk of respiratory medical intervention for respiratory compromise in children undergoing adentonsillectomy [72,73]. Given there is an increased prevalence of symptoms of OSA in children awaiting common day surgeries [74], unrecognized OSA may complicate the post-operative course for children undergoing any surgery. In addition to a low oxygen saturation nadir, post-operative respiratory complications are associated with more severe OSA and greater associated medical comorbidity [75,76]. OSA increases the risk for unanticipated hospital admission after ambulatory surgery [77]. Timing of surgery is also important as children who undergo surgery in the morning have less post-operative oxygen desaturation when compared to those operated on in the afternoon [78]. While adentonsillectomy can improve sleep, breathing, quality of life and reduce cardiovascular stress for children with OSA [79,80], this work highlights post-operative risks for respiratory compromise.

Additional work relevant to surgical management by Canadian researchers have examined tools to supported decision making specific to adenotonsillectomy [81], identified risk factors for residual OSA [2,82], and examined additional surgical options for residual OSA post-adenotonsillectomy [83].

4.3. Non-invasive ventilation

Canadians contributed to early reports of the success of long-term NIV, including CPAP and BPAP modalities, for the treatment of pediatric OSA. Long-term nasal CPAP relieved OSA and was associated with improved weight gain and growth in an 8-year-old with oculomandibulofacial syndrome and failure to thrive [6]. One of the initial studies of nasal CPAP for the treatment of OSA in children included data from 11 major sleep disorders centers, including one in Canada [84]. A recent scoping review identified a large body of work relevant to the use of long-term NIV for children and highlighted overall low methodological quality of studies as well as use of long-term NIV for a large diversity of pediatric patient groups despite limited evidence of efficacy for many of these groups [85]. Additional contributions from Canadian groups include studies of compliance [86], facilitators and barriers [87], titration studies [88], craniofacial growth [89], as well as NIV use in infants [90–92], children and youth with obesity [93,94], and children with neuromuscular disease [95].

4.4. Corticosteroids

Canadian trials have highlighted the role of corticosteroids in the treatment of pediatric OSA. A small non-randomized trial of a short course of systemic steroids found that systemic steroids were ineffective in reducing adenotonsillar hypertrophy or improving OSA respiratory events on home polysomnography [96]. A subsequent randomized, triple-blinded, placebo controlled, parallel-group trial of nasal fluticasone for 6-weeks in children with polysomnography proven mild to moderate OSA and adentonsilar hypertrophy showed an improvement in polysomnographic measures of OSA and a reduction in the time spent in paradoxical respiration [97].

4.5. Craniofacial surgery and orthodontic appliances

Canadian authors have contributed to the investigation of craniofacial surgery and orthodontic appliances for the treatment of pediatric OSA. A systematic review of mandibular distraction osteogenesis for the treatment of airway obstruction in children with mandibular hypoplasia showed successful treatment in 89% of children with an overall complication rate of 24% [98]. A systematic review of mandibular advancement appliance use for the treatment of OSA in children showed short-term improvements but not complete normalization of AHI [99]. A third systematic review, aimed at investigating the efficacy of orthopedic mandibular advancement and/or rapid maxillary expansion for the treatment of pediatric OSA, suggests that orthodontic treatments may be effective in managing snoring and OSA in children though limited outcome data is available [100]. A study of bi-maxillary expansion therapy for pediatric sleep disordered breathing showed improvement in sleep scores and symptoms for 66% of children with the greatest improvement in AHI in children with normal mandibular length [101].

5. Current state of affairs

The growth of the field of pediatric OSA in Canada has not only increased knowledge about pediatric OSA but also improve access to care. The increase in awareness of pediatric OSA and recognition of associated risk factors means that more children with suspected OSA are being identified which presents some challenges and new opportunities.

Despite the growing knowledge about pediatric OSA, there remain some gaps in healthcare education in Canada. Investigation of healthcare training demonstrated that 1% of Canadian healthcare practitioners receive training in pediatric sleep as undergraduates and 3% during post-graduate training yet one-third estimate that 25–50% of their patients' suffer from sleep disorders and most think that sleep disorders significantly impact health and daytime function of children [102]. Most healthcare practitioners rarely or never order a sleep study for children with suspected OSA, and most are familiar with surgical and weight loss management but are unfamiliar with the benefits of CPAP revealing significant gaps

in the care of children with suspected OSA. The Royal College of Physicians and Surgeons of Canada, the national body that regulates subspecialty training, has recently approved Sleep Medicine as an area of focused competency which will provide a pathway for accredited post-graduate training in Sleep Medicine for Canadian physicians. Additional investments are needed to enhance pediatric sleep medicine education, including pediatric OSA, at the undergraduate level and to provide training opportunities across healthcare disciplines.

Canada has a publically funded healthcare system for universal access with provincial administration of healthcare services yet access to pediatric sleep services vary greatly across the country. As of 2014, when a survey of sleep facilities was completed, there were pediatric sleep practitioners in six of 10 provinces and none of three territories [103]. The survey identified 67 practitioners who see children with sleep concerns with only 36 of these seeing children <12 years of age and 23 seeing children <8 years of age; there were considerable variation in the number of children per practitioner across the country. A joint position consensus statement developed for pediatricians, family physicians, and other health professionals and adapted for psychiatrists with endorsement from the Canadian Academy of Child and Adolescent Psychiatry, College of Family Physicians of Canada, and the Canadian Sleep Society highlights the role of polysomnography in establishing the diagnosis of OSA and the titration of NIV [104]. Access to testing for polysomnography in children varies widely across Canada with access in six of 10 provinces and none of three territories, and wait times where testing is available ranging from <1 month to 1.5–2 years [103]. Current standards with respect to home sleep apnea testing in children differ by province with restriction to limit use to older adolescents or adults in at least some provinces. To support improvements in access and clinical care, a joint initiative of the Canadian Thoracic Society and Canadian Sleep Society is underway to develop national guidelines for the diagnosis of pediatric OSA. In addition to national standards, some centres are looking at ways to streamline access and improve efficiency [105].

Once the diagnosis of pediatric OSA has been made, there are some challenges with access to treatment. Adenotonsillectomy accounts for 30% of all surgeries performed in children in one Canadian province with higher post-operative risks then other surgeries [106]. This has likely contributed to long and variable wait times. Funding for CPAP and BPAP differs by province with the provincial health systems providing funding for BPAP but not CPAP in most jurisdictions. While some jurisdictions provide CPAP funding support for seniors, low income, and other vulnerable groups, this funding does not extend to all children. At least one provincial lung association has a program to fund CPAP for children based on financial need. Medication and orthodontic appliances are currently not funded by the health system for the majority of children.

With the increase in interest in pediatric OSA across Canada, there has been a growth in initiatives to foster collaborations. The Canadian Sleep & Circadian Network (CSCN) is a Canadian Institute of Health Research funded national network with the goal of generating new knowledge and translation of that knowledge into healthier sleep. Current work of the CSCN includes a project to identify children with obesity who are most at risk of OSA. The CSCN also provides funding for trainees who are interested in pursuing research related to sleep and sleep disorders. The Pediatric Sleep Interest Group of the Canadian Sleep Society provides another forum to support collaboration. These are but two examples of initiatives to foster greater collaboration and support for researchers interested in advancing the science of pediatrics OSA.

6. Conclusion

The field of pediatric OSA in Canada has grown over the last 30 years with evidence that this growth is poised to continue. Canadian researchers have made important contribution to the field of pediatric OSA and, with important questions that still need answers, will continue to do so. While there are challenges to be addressed, recognition of these issues and a strong community of people invested in improving care provides a strong incentive to continue to tackle these challenges to improve the lives of Canadian children with pediatric OSA.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2019.01.011.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2019.01.011.

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