Obstructive sleep apnoea syndrome in morbidly obese children with tibia vara

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Morbid obesity and its association with obstructive sleep apnoea syndrome have been increasingly recognised in children. Orthopaedic surgeons are often the primary medical contact for older children with tibia vara, which has long been associated with obesity, but are unfamiliar with the evaluation and treatment of sleep apnoea in children.

We reviewed all children with tibia vara treated surgically at one of our institutions over a period of five years. Thirty-seven patients were identified; 18 were nine years of age or older and 13 of these (72%) had morbid obesity and a history of snoring.

Eleven children were diagnosed as having sleep apnoea on polysomnography. The incidence of this syndrome in the 18 children aged nine years or older with tibia vara, was 61%. All these patients required pre-operative non-invasive positive-pressure ventilation; tonsillectomy and adenoidectomy were necessary in five (45%). No peri-operative complications related to the airway occurred.

There is a high incidence of sleep apnoea in morbidly obese patients with tibia vara. These patients should be screened for snoring and, if present, should be further evaluated for sleep apnoea before corrective surgery is undertaken.

The prevalence of obesity in childhood (body mass index (BMI) greater than the 95th percentile) has more than tripled in the past 30 years and now affects one in five. Comorbid conditions include type-2 diabetes, hypertension, hyperlipidaemia, neurocognitive deficits and psychosocial dysfunction. Tibia vara is associated with obesity in childhood and adolescence and may lead to progressive genu varum and ultimately to degenerative changes. Pain associated with tibia vara can cause problems in the design of regimens for weight loss. Tibia vara is strongly correlated with morbid obesity in African-American children with a prevalence of 2.5% in that population.

Obstructive sleep apnoea syndrome is characterised by nocturnal obstruction of the upper airway leading to snoring, hypoxia and hypercarbia. It has only recently been recognised as a complication of obesity in children in whom it has a prevalence of 2%. When untreated, sleep apnoea has significant health complications including systemic and pulmonary hypertension, attention-deficit hyperactivity disorder, behavioural disorders and stunting of growth. It is also associated with increased peri-operative anaesthetic complications including difficulty with intubation and acute respiratory failure during the induction of anaesthesia. Post-operative complications include hypoxia, airway oedema, obstruction of the upper airway, pulmonary oedema and respiratory failure. Diagnosis may be difficult and polysomnography remains the technique of choice. The severe complications of sleep apnoea in childhood require physicians to have a high index of suspicion. Few orthopaedic surgeons have formal training in the diagnosis of sleep disorders in children.

Our aim was to report the incidence and symptoms, and discuss the management of sleep apnoea in a series of obese children with tibia vara.

Patients and Methods
We reviewed 37 consecutive patients with tibia vara who had undergone surgical treatment between 1 January 1998 and 31 December 2002. This included 18 patients who were nine years of age or older at the time of evaluation. None had previously been diagnosed with a disorder of sleep or breathing. A total of 13 patients (eight boys and five girls) were morbidly obese with a BMI greater than the 95th percentile for age and had a history of snoring. Of the 13, 12 were of African-American origin and their mean age at presentation was 12.7
years (10 to 16). Their mean weight was 142 kg (102 to 188). Eleven had juvenile tibia vara (age of onset 3 to 10 years) and two had adolescent tibia vara (age of onset 11 years or older). Each underwent a detailed sleep history, with questions to both the children and their parents regarding snoring, mouth breathing, enuresis, daytime somnolence and witnessed apnoeic events. Physical examination included measurement of the circumference of the neck, oropharyngeal examination for tonsillar enlargement and lateral neck radiography to evaluate the adenoids. Height, weight and BMI measurements were also obtained.

**Polysonnographic assessment.** A standard overnight multichannel polysomnographic evaluation was performed. No drugs were used to induce sleep. Variables determined include measurement of the movement of the chest and abdominal wall by piezoelectric respiratory belts (Respirronics, Murraysville, Pennsylvania), the heart rate by electrocardiogram, airflow by sidestream end-tidal capnography, which provided breath-by-breath assessment of end-tidal levels of CO₂ (Capnocheck Plus, BCI International, Waukesha, Wisconsin) and temperature using an oronasal thermistor (Respirronics). Arterial oxygen saturation was assessed using pulse oximetry (BCI International) with simultaneous recording of the pulse waveform. Bilateral electro-oculography, an eight-channel electroencephalogram, and analysis of a body position sensor were also monitored. Tracheal sound was monitored using a microphone sensor (Respirronics) and a synchronised video recording was performed. All recordings were digitised using a commercially-available polysomnography system (Alice 3; Respirronics) in which data were acquired, recorded and stored. Raw data were scored manually.

**Sleep variables.** The sleep pattern was assessed using standard techniques. The apnoea index was defined as the number of periods of apnoea per hour of total sleep time. The apnoea index was defined as the absence of airflow with continued movement of the chest and abdominal wall for at least two breath cycles. Hypopnoea was defined as a decrease in nasal airflow of ≤ 50% with a corresponding decrease in arterial oxygen saturation ≥ 4% and/or arousal. The respiratory disturbance index was defined as the number of periods of apnoea and hypopnoea per hour of total sleep time. The mean oxygen saturation and arterial oxygen saturation nadir were determined. Arousals were defined as recommended by the American Sleep Disorders Task Force report. The arousal index included the total number of arousals per hour of total sleep time.

**Results**

All of the patients were above the 99th percentile on the paediatric BMI for age scale and the mean adult BMI was 57.5 kg/m² (44.1 to 114.8). All were in good health with only one (8%) child on medication for hypertension and two (15%) for seasonal allergies. All had nightly snoring, six (46%) having restless sleep and four (31%) with episodes of enuresis. Five (38%) had daytime somnolence and five (38%) had difficulty with schoolwork or behavioural problems. Seven (54%) had difficulty of breathing during sleep and three (23%) had mouth breathing during the day. There were enlarged tonsils and/or adenoids in nine (69%) patients. The mean circumference of the neck was larger than the mean adult neck measurement at 45.5 cm (38 to 53 cm).

<table>
<thead>
<tr>
<th>Table I. Details of the 13 patients and physical findings</th>
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<tbody>
<tr>
<td>Mean age in yrs (range)</td>
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<td>Mean weight in kg (range)</td>
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<tr>
<td>Mean BMI (kg/m²)</td>
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<tr>
<td>Mean neck size in cm (range)</td>
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<tr>
<td>Mouth breathing (%)</td>
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<tr>
<td>Enuresis (%)</td>
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<tr>
<td>Daytime somnolence (%)</td>
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<tr>
<td>Dyspnoea during sleep (%)</td>
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<tr>
<td>Enlarged adenoids and/or tonsils</td>
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<td>Snoring</td>
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* BMI, body mass index

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<tr>
<th>Table II. Polysomnographic data in the 13 patients</th>
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<tr>
<td>Mean (range)</td>
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<tr>
<td>Respiratory disturbance index</td>
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<tr>
<td>Sleep efficiency (sleep time per hour in bed) (%)</td>
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<tr>
<td>REM total sleep time (%)</td>
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<td>Oxygen saturation nadir (%)</td>
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<td>Arousal index per hour</td>
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* REM, rapid eye movement

Eleven (85%) children had sleep apnoea documented by polysomnography. The incidence of sleep apnoea in the total series of children requiring surgical treatment for tibia vara was 30% (11 of 37). When only children nine years of age or older at the time of evaluation were considered, 11 of 18 patients (61%) had sleep apnoea. The 13 children in this series had a mean respiratory distress index of 17.4 events per hour (0.4 to 69). The mean nadir desaturation (normal greater than 90%) was 82.7% (62% to 93%). These apnoea-hypopnoeic events often culminated in cortical awakenings with a mean arousal index of 16.5 awakenings per hour (5 to 28). The normal is less than five awakenings per hour in adults. Sleep patterns showed diminished time spent in the recuperative rapid eye movement stage of sleep, with a mean of 18.5% of rapid eye movement sleep (5% to 29%). The normal value is a total time of rapid eye movement sleep of > 20% (Table II).

All 11 with sleep apnoea were treated by non-invasive positive-pressure ventilation either in the form of continuous positive airway pressure or bilevel positive airway pressure. Five (45%) required tonsillectomy and adenoidectomy to decrease obstruction of the airway in addition to non-invasive positive-pressure ventilation. After treatment for obstructive sleep apnoea surgical correction of the tibia
vara was performed. All 13 patients, 22 affected limbs, had tibial osteotomies with gradual correction using circular external fixation. There were no perioperative pulmonary or anaesthetic complications. Patients with obstructive sleep apnoea have continued follow-up visits at the sleep clinic.

Discussion

Tibia vara and sleep apnoea have each been positively correlated with obesity and African-American race.\(^7,18,53\) However, the incidence of sleep apnoea in patients with tibia vara has not been established. In our series 30% of children requiring surgical treatment for tibia vara had sleep apnoea. This is higher than the estimated prevalence of 2%. When only children aged nine years and over were considered, 61% had sleep apnoea. Identification of patients with morbid obesity and the identification of a history of snoring allowed us to identify a group of children with an extremely high risk (85%) of having sleep apnoea. Sleep apnoea is probably under-diagnosed and when recognised there may be significant complications in relation to anaesthesia.\(^39,42,47,54,59\) The importance of this disorder to orthopaedic surgeons cannot be overemphasised.

A clinical history and physical examination are poor indicators of sleep apnoea.\(^22,34,60\) While daytime somnolence may be a cardinal feature of this condition in adults, it only occurred in 38% of our series. Another 38% had behavioural problems. Only half of the patients presented with difficulty in breathing during sleep and only 23% had mouth breathing while awake. Recognising this growing challenge, the American Academy of Pediatrics has recently set out guidelines to increase awareness of sleep apnoea and to decrease delays in diagnosis and treatment.\(^37\)

Our protocol has included paediatric advice and polysomnography. An electrocardiogram and evaluation for pulmonary hypertension may be considered. Careful preoperative anaesthetic assessment is required. Appropriate supervised weight-reduction programmes are also required. Tonsillectomy and/or adenoidectomy remain the first line of treatment and have a cumulative cure rate of approximately 80%.\(^61\) In our series, although five (45%) of 11 children with sleep apnoea required tonsillectomy and adenoidectomy, follow-up polysomnography showed improvement but some persistent apnoea. All 11 children required positive-pressure ventilation. The timely diagnosis and treatment of sleep apnoea in patients with tibia vara allow proper precautionary measures to be taken and ensure maintenance of the airway, administration of drugs, and cardiorespiratory monitoring.

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References