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Reducing the need for CO$_2$ monitoring in the investigation of paediatric sleep disordered breathing

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Summary
Overnight cardio-respiratory polygraphy without CO$_2$ monitoring is adequate in children investigated for uncomplicated obstructive sleep apnoea
To the Editor;

There is increasing interest in the use of home sleep studies to diagnose paediatric sleep disordered breathing (SDB) as they are potentially more cost–effective, convenient and may be more representative of the child’s typical nights’ sleep. One concern is that most home sleep study equipment does not include measurement of CO$_2$.

There are no current clear recommendations as to which subset of patients can be assessed using a home study, and to date, no studies have specifically addressed the question of whether CO$_2$ monitoring needs to be included in paediatric SDB assessment. Home studies rely on the same CR Polygraphy (CR Poly) data as in-patient sleep studies (nasal cannulae and/or mouth thermistor for flow and snoring, thoracic and abdominal bands for respiratory effort, SpO2 and pulse rate sensor, body position detector) but often without CO$_2$ sensor. Therefore, we aimed to determine how often the addition of overnight CO$_2$ monitoring changed the clinical management of patients when added to CR Poly data. We hypothesized that CO$_2$ data does not change management in otherwise healthy children who are being investigated for obstructive sleep apnoea (OSA), but is important in those with pre-existing medical conditions or co-morbidities, when added to cardio-respiratory polygraphy data.

We carried out a two year, retrospective analysis of children age<18 years who were referred to the Paediatric Sleep and Ventilation Unit at Royal Brompton Hospital for investigation of sleep disordered breathing and who underwent a baseline CR Poly with measurement of transcutaneous CO$_2$. We first made management recommendations blinded to the patient details and CO$_2$ data, and then re-assessed after considering transcutaneous CO$_2$. Age, gender, underlying disease and OSA symptoms were recorded. The same CR Poly equipment (SOMNOScreen™ plus, Polygraphy set, SOMNOmedics, Germany) was used throughout the study period. Mean CO$_2$ was obtained through transcutaneous capnography (TCM CombiM® monitor, Radiometer, Copenhagen, Denmark) and was considered abnormal if >6.7kPa (50mmHg). Hypoventilation was defined as CO$_2$>6.7 kPa (50mmHg) >25% of recorded night as per American Association of Sleep Medicine rules. As per European Respiratory Society guidelines, OSA was defined as an Apnoea Hypopnoea Index (AHI)>1 in the presence of OSA symptoms and OSA severity was classified as mild, moderate or severe according to AHI. The presence of symptoms of OSA such as snoring or witnessed apnoea was also recorded.
Patients’ pre-existing medical conditions or co-morbidities were classified as: craniofacial abnormalities, chronic cough, laryngomalacia, asthma/wheeze, interstitial lung diseases, cystic fibrosis, congenital heart diseases, neurological/neuromuscular disorders and other syndromes, and obesity (Table 1). Data were analysed by GraphPad Prism® software version 7.02. Descriptive statistics were generated on each measure. For all the reported variables a test of normality was performed. For non-parametric data, median (IQR 25th-75th centiles) was reported. Multiple comparisons were performed via ANOVA or Kruskall-Wallis test according to data distribution.

There were 513 patients, 311 (61%) male, median age 4.5 years (IQR 2.3-7.9). 13/513 were prescribed overnight oxygen (O2), 1/513 Continuous Positive Pressure (CPAP) and O2, and 1/513 non-invasive ventilation (NIV). 130/513 were otherwise healthy children being investigated for OSA. 383/513 had pre-existing medical conditions or co-morbidities, respectively craniofacial abnormalities (n=7), chronic cough (n=38), laryngomalacia (n=14), asthma/wheeze (n=80), interstitial lung diseases (n=63), cystic fibrosis (n=15), congenital heart disease (n=48), neurological/neuromuscular syndromes (n=112), and obesity (n=6). 189 of 383 (49%) had clinical symptoms of OSA, respectively 5/7 (71%) with craniofacial abnormalities, 23/38 (61%) with chronic cough, 7/14 (50%) with laryngomalacia, 43/80 (54%) with asthma/wheeze, 31/63 (49%) with interstitial lung diseases, 9/15 (60%) with cystic fibrosis, 16/48 (33%) with congenital heart diseases, 52/112 (46%) with neurological/neuromuscular syndromes and 3/6 (50%) with obesity.

107/130 (82%) otherwise healthy patients were diagnosed with OSA from the baseline CR Poly results; 23 had a normal study. In these children without comorbidities with respectively mild, moderate and severe OSA the prevalence of high mean CO2 was 0/73 (0%), 2/14 (14%) and 5/20 (25%), the prevalence of hypoventilation was 13/73 (18%), 7/14 (50%) and 12/20 (60%), and the presence of REM-related CO2 elevation was 8/73 (11%), 7/14 (50%), 13/20 (65%). The addition of CO2 data did not change assessment in any of these 107 children.

Conversely, in 20/383 (5%) children with pre-existing medical conditions or co-morbidities, either abnormally high mean CO2 levels (17/20) or elevated CO2 during REM sleep (3/20) changed management when these results were interpreted in conjunction with the CR Poly data. Median overnight CO2 levels did not differ significantly across diagnostic groups (p=0.73) and did not significantly differ between children with or without pre-existing medical conditions or co-morbidities (p= 0.44).
In the group of children with pre-existing medical conditions or co-morbidities, there were changes in recommendation after including CO\textsubscript{2} data to information from the CR Poly respectively in 1/7 (14%) patients with craniofacial abnormalities, 0/38 with chronic cough, 1/14 (7%) with laryngomalacia, 1/80 (1%) with asthma/wheeze, 1/63 (2%) with interstitial lung diseases, 0/15 with cystic fibrosis, 2/48 (4%) with heart disease, 12/112 (11%) with neurological/neuromuscular syndromes and 2/6 (33%) with obesity. Overall, in 18/20 (90%) children, CPAP or NIV was established. NIV was started in 1/1 with laryngomalacia, 1/1 with asthma/wheeze, 1/2 patients with heart diseases, 12/12 patients with neurological/neuromuscular syndromes; CPAP was established in 1/1 patient with craniofacial abnormalities and 2/2 patients with obesity. Finally, the addition of CO\textsubscript{2} to CR poly prompted the safe up-titration of O\textsubscript{2} flow in 1 patient with heart disease and low baseline saturations. There were concerns that increasing oxygen therapy might result in an increase in his CO\textsubscript{2} levels, therefore the study was performed on increased oxygen levels. Since CO\textsubscript{2} did not increase significantly, the child’s home oxygen could be safely increased. In one patient with interstitial lung disease, unexpectedly high CO\textsubscript{2} levels lead to the instigation of further investigations.

In summary, in otherwise healthy patients suspected of having OSA, none had changes in clinical management with additional CO\textsubscript{2} data. Conversely, CO\textsubscript{2} abnormalities, either high mean CO\textsubscript{2} values or elevation during REM, can occur in patients with pre-existing medical conditions or co-morbidities (20 out of 383, 5%), particularly neurological/neuromuscular, even without significant changes in the CR Poly. In 18 out of 20 patients, respiratory support was initiated as a result. A strength of this study is the large sample size (>100). The main limitation of this study is the retrospective nature, and we acknowledge, that confirmatory prospective studies are needed. In conclusion, overnight CO\textsubscript{2} monitoring is not necessary for the diagnosis of SDB in otherwise healthy children, but is crucial for the management of paediatric patients with pre-existing medical conditions or co-morbidities. This is important, because it means home CR Poly, without transcutaneous CO\textsubscript{2} measurement, can safely be used to diagnose OSA in otherwise healthy children thus saving resources and reducing the need for admission.
References


Table 1 Clinical characteristics of study population.

Patients are classified as “otherwise healthy” or “having pre-existing medical conditions or co-morbidities”.

A breakdown of patients’ pre-existing medical conditions or co-morbidities, their overnight CO₂ values, Cardio Respiratory Polygraphy data and management post-sleep study are outlined.

<table>
<thead>
<tr>
<th>Condition</th>
<th>OSA symptoms (n)</th>
<th>Median CO₂ kPa (IQR)</th>
<th>Changes after adding back CO₂ data (n)</th>
<th>Outcome after adding back CO₂ data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otherwise Healthy</td>
<td>130/130</td>
<td>5.9 (5.6-6.2)</td>
<td>0/130</td>
<td>N/A</td>
</tr>
<tr>
<td>Craniofacial abnormalities</td>
<td>5/7</td>
<td>5.7 (5.4-6.5)</td>
<td>1/7</td>
<td>CPAP (1/1)</td>
</tr>
<tr>
<td>Chronic Cough</td>
<td>23/38</td>
<td>5.8 (5.6-6.0)</td>
<td>0/52</td>
<td>N/A</td>
</tr>
<tr>
<td>Laryngomalacia</td>
<td>7/14</td>
<td>5.9 (5.4-6.2)</td>
<td>1/14</td>
<td>NIV (1/1)</td>
</tr>
<tr>
<td>Asthma/Wheeze</td>
<td>43/80</td>
<td>5.8 (5.5-6.2)</td>
<td>1/80</td>
<td>NIV (1/1)</td>
</tr>
<tr>
<td>Interstitial lung diseases</td>
<td>31/63</td>
<td>5.9 (5.6-6.1)</td>
<td>1/63</td>
<td>Further investigation (1/1)</td>
</tr>
<tr>
<td>Cystic Fibrosis</td>
<td>9/15</td>
<td>5.8 (5.7-6.3)</td>
<td>0/15</td>
<td>N/A</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>16/48</td>
<td>5.9 (5.5-6.2)</td>
<td>2/48</td>
<td>Start NIV (1/2) Change O₂ (1/2)</td>
</tr>
<tr>
<td>Neurological/neuromuscular syndromes</td>
<td>52/112</td>
<td>6.0 (5.6-6.4)</td>
<td>12/112</td>
<td>Start NIV (12/12)</td>
</tr>
<tr>
<td>Obesity</td>
<td>3/6</td>
<td>5.9 (5.7-6.3)</td>
<td>2/6</td>
<td>Start CPAP (2/2)</td>
</tr>
<tr>
<td>Total</td>
<td>319/513</td>
<td>5.9 (5.7-6.3)</td>
<td>20/513</td>
<td></td>
</tr>
</tbody>
</table>