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Early View

Research letter

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F. Trucco, A. Bush, H.-L. Tan

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

Trucco F[1, 2], Bush A[1, 3], Tan H-L[1]

[1]Department of Paediatric Respiratory Medicine, Royal Brompton Hospital, London

[2]University of Genova, Italy

[3]National Heart and Lung Institute, Imperial College, London

Address correspondence to:

Dr Federica Trucco,

Department of Pediatric Respiratory Medicine,

Royal Brompton Hospital,

Sydney St, SW3 6NP, London, UK.

f.trucco@rbht.nhs.uk, federica_trucco@yahoo.it

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 [1-3]. 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<18years 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[5]. 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[6]. 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 (O_2), 1/513 Continuous Positive Pressure (CPAP) and O_2, 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 CO_2 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 CO_2 elevation was 8/73 (11%), 7/14 (50%), 13/20 (65%). The addition of CO_2 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 CO_2 levels (17/20) or elevated CO_2 during REM sleep (3/20) changed management when these results were interpreted in conjunction with the CR Poly data. Median overnight CO_2 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_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_2 to CR poly prompted the safe up-titration of O_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 CO2 levels, therefore the study was performed on increased oxygen levels. Since CO_2 did not increase significantly, the child's home oxygen could be safely increased. In one patient with interstitial lung disease, unexpectedly high CO_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_2 data. Conversely, CO_2 abnormalities, either high mean CO_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_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_2 measurement, can safely be used to diagnose OSA in otherwise healthy children thus saving resources and reducing the need for admission.

References

1. Corral J, Sánchez-Quiroga MÁ, Carmona-Bernal C, Sánchez-Armengol Á, de la Torre AS, Durán-Cantolla J, Egea CJ, Salord N, Monasterio C, Terán J, Alonso-Alvarez ML, Muñoz-Méndez J, Arias EM, Cabello M, Montserrat JM, De la Peña M, Serrano JC, Barbe F, Masa JF; Spanish Sleep Network. Conventional Polysomnography Is Not Necessary for the Management of Most Patients with Suspected Obstructive Sleep Apnea. Noninferiority, Randomized Controlled Trial. Am J Respir Crit Care Med. 2017 Nov 1;196(9):1181-1190.

2. Tan HL, Kheirandish-Gozal L, Gozal D. Pediatric Home Sleep Apnea Testing: Slowly Getting There! Chest. 2015 Dec;148(6):1382-1395.

3. Gozal D, Kheirandish-Gozal L, Kaditis AG. Home sleep testing for the diagnosis of pediatric obstructive sleep apnea: the times they are a changing...! Curr Opin Pulm Med. 2015 Nov;21(6):563-8.

4. Nixon GM, Kermack AS, Davis GM, Manoukian JJ, Brown KA, Brouillette RT. Planning adenotonsillectomy in children with obstructive sleep apnea: the role of overnight oximetry. Pediatrics. 2004 Jan;113(1 Pt 1):e19-25.

5. Berry RB, Budhiraja R, Gottlieb DJ, Gozal D, Iber C, Kapur VK, Marcus CL, Mehra R, Parthasarathy S, Quan SF, Redline S, Strohl KP, Davidson Ward SL, Tangredi MM; American Academy of Sleep Medicine. Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine. J Clin Sleep Med. 2012 Oct 15;8(5):597-619.

6. Kaditis AG, Alonso Alvarez ML, Boudewyns A, Alexopoulos EI, Ersu R, Joosten K, Larramona H, Miano S, Narang I, Trang H, Tsaoussoglou M, Vandenbussche N, Villa MP, Van Waardenburg D, Weber S, Verhulst S. Obstructive sleep disordered breathing in 2- to 18-year-old children: diagnosis and management. Eur Respir J. 2016 Jan;47(1):69-94

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 CO_2 values,

Cardio Respiratory Polygraphy data and management post-sleep study are outlined.

	OSA symptoms (n)	Median CO_2 kPa (IQR)	Changes after adding back CO_2 data (n)	Outcome after adding back CO_2 data
Otherwise Healthy	130/130	5.9 (5.6-6.2)	0/130	N/A
Craniofacial abnormalities	5/7	5.7 (5.4-6.5)	1/7	CPAP (1/1)
Chronic Cough	23/38	5.8 (5.6-6.0)	0/52	N/A
Laryngomalacia	7/14	5.9 (5.4-6.2)	1/14	NIV (1/1)
Asthma/Wheeze	43/80	5.8 (5.5-6.2)	1/80	NIV (1/1)
Interstitial lung diseases	31/63	5.9 (5.6-6.1)	1/63	Further investigation (1/1)
Cystic Fibrosis	9/15	5.8 (5.7-6.3)	0/15	N/A
Congenital heart disease	16/48	5.9 (5.5-6.2)	2/48	Start NIV (1/2) Change O_2 (1/2)
Neurological/neuromuscular syndromes	52/112	6.0 (5.6-6.4)	12/112	Start NIV (12/12)
Obesity	3/6	5.9 (5.7-6.3)	2/6	Start CPAP (2/2)
Total	319/513		20/513	