Noninvasive Ventilatory Monitoring in Children With Obstructive Sleep Apnea Following Adenotonsillectomy

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Background

Respiratory depression is a potentially catastrophic consequence of analgesia, anesthesia, and surgery. Pulse oximetry (SpO_2) and impedance pneuomography (respiratory rate [RR]) monitoring may miss airway obstruction and/or hypoventilation. [1] Capnography is the gold standard in non-invasive ventilatory monitoring, but capnography cannulae are poorly tolerated by children,[2] and may not be accurate when airway obstruction is present.

Hypothesis

Quantitative thoracic impedance plethysmography (TV, RR, and MV) (ExSpiron, Respiratory Motion, Waltham MA),[3] and digital transcutaneous CO_2 (TC-CO_2) monitoring (SenTec AG, Switzerland)[4] will detect episodes of respiratory insufficiency not identified by standard monitoring in children with obstructive sleep apnea (OSA) after adenotonsillectomy (T&A).

Methods

Children with moderate-to-severe OSA undergoing adenotonsillectomy and scheduled for overnight observation were studied.

At the end of surgery while still intubated:
- ExSpiron pad set attached to patient and monitor calibrated to the anesthesia machine MV

In PACU:
- Routine monitoring (SpO2, RR, HR) initiated
- SenTec probe placed and calibrated
- Actigraphy watch placed on wrist
- Supplemental oxygen administered to maintain S_pO_2 > 93%

Data were collected during the first post-operative night and data streams were overlaid using a common timestamp. For analysis, MV was normalized to % predicted (MV_P = body surface area x 4 [males] or 3.5 [females]). Data are presented as mean $\pm$ standard error.

Results

14 subjects (8 F: 6 M) averaging 7.2$\pm$0.8 yrs and 40.9$\pm$6.8 kg were monitored for 8.4$\pm$1.3 hrs (SenTec) and 12.8$\pm$1.3 hrs (ExSpiron).

- Desaturation (S_pO_2 < 93%) was observed in 10 subjects (0.5$\pm$0.2% MT).
- Mild hypoventilation (MV_p < 75% predicted) was seen in all subjects (56$\pm$5% MT). Periods of more severe hypoventilation (MV_p < 25%) were observed in 11 subjects (2.9$\pm$1.3% MT).
- Moderate hypercarbia (TC-CO_2 $\geq$ 50 mm Hg) was observed in 4 subjects of whom 3 experienced periods of TC-CO_2 $\geq$ 60 mm Hg ranging from 2 to 5.4 hrs. 2 patients with severe hypercarbia maintained MV_p $\geq$ 0.4 and S_pO_2 $\geq$ 93% for > 95% of MT.
- In patients in whom late hypercarbia was noted, elevated TC-CO_2 was seen within the first 4 hours of the observation period.

Subject	Gender	Age	Weight	BMI	RDI	Monitored Hours Exspiron	Monitored Hours Sentec	MV_p	MV_p (L/min) <25%	MV_p (L/min) <40%	MV_p (L/min) <75%	RR (breaths/min) < 6	RR (breaths/min) < 8	RR (breaths/min) <10	TC-CO_2 (mm Hg) ≥40	TC-CO_2 (mm Hg) ≥50	TC-CO_2 (mm Hg) ≥60	S_pO_2 (%) <93	S_pO_2 (%) <90
T01	F	5	13.3	13.3	13	4.5	3.9	2.1	0.3	0.7	56.8	0.2	0.7	2.0	61.9	0	0	0	0
T02	M	6	23.3	16.7	3	19.4	7.6	3.5	8.0	31.6	83.8	0.0	0.2	0.5	13.2	0	0	0.1	0.1
T03	M	8	46.6	26.5	28	20.5	17.5	5.1	0.3	2.4	45.1	0	0.0	0.1	11.5	0	0	2.6	0
T04	F	4	15.3	12.9	17	4.0	3.8	2.4	1.8	17.0	62.1	0.1	0.2	0.9	16.2	0	0	0.3	0
T05	M	3	15.6	17.7	15	16.5	6.7	2.5	0.3	1.6	44.7	0.1	0.1	0.4	26.2	0	0	2.1	1.3
T06	F	3	13.5	16.2	25	9.7	5.7	2.0	0	4.4	50.4	0	0.0	0.3	100	100	94.1	1.5	1.5
T07	M	6	50.4	32.8	8	2.9	2.6	5.0	0.9	5.0	45.4	0.6	1.2	2.7	46.4	0	0	0	0
T08	F	5	23.3	15.2	20	16.6	6.3	3.2	18.3	56.4	93.0	0.2	1.2	3.5	99.9	73.5	31.4	0	0
T09	M	8	23.1	15.8		3.7	15.3	3.5	0	0.0	68.8	0	0.1	0.8	45.2	0	0	0	0
T10	F	9	69.2	30.3	11	17.4	12.6	5.8	0	0.0	14.2	0	0.1	0.5	97.6	69.0	32.6	0.2	0.1
T11	M	10	53.1	26.3	27	15.6	2.8	5.7	5.4	29.3	61.1	0.5	0.9	1.7	66.0	0	0	0.3	0.2
T15	F	11	87.9	37.8	12	15.5	10.7	6.5	1.0	2.5	36.5	0.2	0.4	0.9	90.2	3.9	0	0.2	0.2
T16	F	10	56.7	23.9	12	18.0	15.7	5.4	0.4	2.1	59.7	0.0	0.2	0.5	47.2	0	0	0.1	0.1
T17	F	13	81.6	27.6		14.3	6.3	6.8	4.0	17.3	62.6	0.0	0.1	0.6	28.4	0	0	0.1	0.1
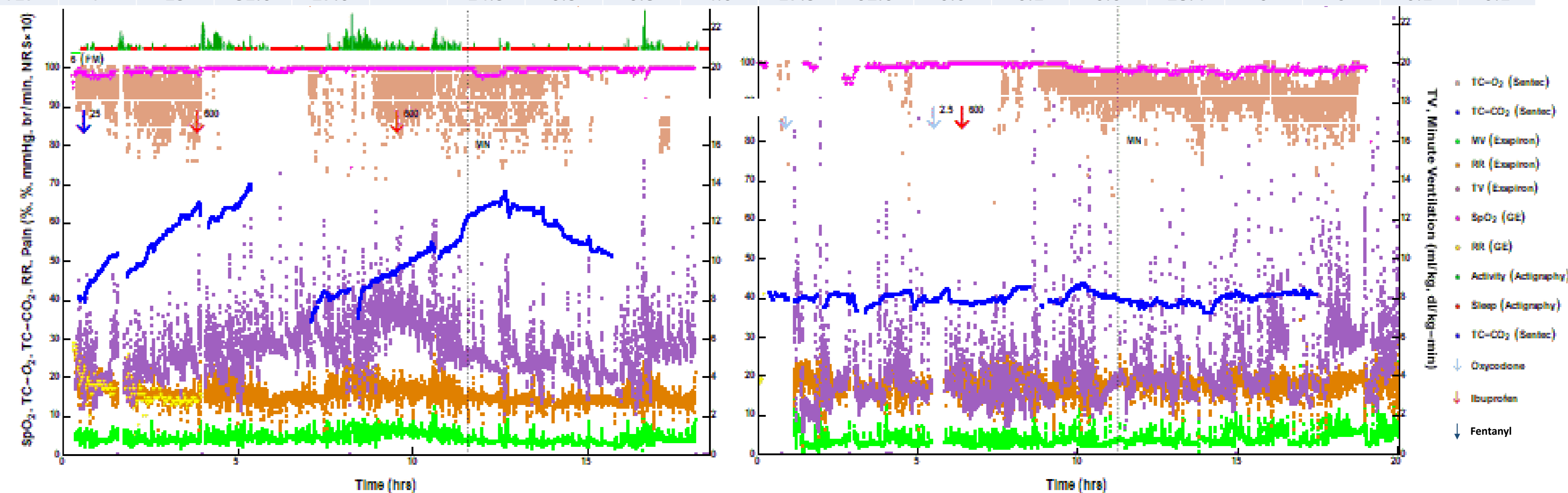
Representative patients monitored for respiratory insufficiency following T&A. Patient T10 (left) had prolonged periods of elevated TC-CO_2 largely without associated hypoxemia or hypopnea. Patient T16 (right) maintained relatively stable TC-CO_2 throughout the observation period.

Conclusion

In children with moderate-to-severe OSA undergoing T&A , TC-CO_2 monitoring detected episodes of early, severe hypercarbia often in the absence of hypoxemia or hypoventilation in 3 of 14 subjects (14.3%). Our findings support a potential role for early post-operative TC-CO_2 monitoring in children at risk for respiratory depression as a result of obstructive sleep apnea.

References
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