Residual Events During Use Of CPAP: Prevalence, Predictors and Detection Accuracy

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Introduction

- Obstructive sleep apnea is common and leads to considerable morbidity & mortality
- CPAP is the treatment of choice
- Modern PAP devices measure and store airflow & pressure data displaying:
  - CPAP efficacy
  - Hours of use
  - Air leak
  - Flow data
Introduction

Diagnostic PSG → PAP titration → PAP prescription & compliance tracking
Introduction

- CPAP adherence tracking systems intuitively seem useful; however, there are few studies...

- CPAP usage can be reliably determined... and should be routinely examined

- ... need to understand the different definitions for apneas and hypopneas... leak from each manufacturer

- The value... for clinical decision making... is unclear... research is indicated

- Current clinical care systems are not optimally configured for examining data

- Nomenclature... $\text{AHI}_{\text{FLOW}}$ should be used
Introduction
Introduction

• Study hypothesis:
  • Device algorithms capture far fewer events than those apparent on manual analysis of flow data

• Study aims:
  • Compare device vs. manual residual events
  • Identify predictors of residual apnea
Methods

- Database:
  - Study conducted at the Beth Israel Deaconess Medical Center, Boston, MA
  - EncoreAnywhere™ online database queried for data between January & June 2013
  - Devices - REMstar Auto, BiPAP Pro, BiPAP Auto, BiPAP Auto SV Advanced

- Subject selection and supportive data:
  - PAP compliance - ≥3 months, ≥4 hours/night (average)
  - Most recent high-resolution flow data sample printed
  - Data divided randomly between 5 physicians and manually scored
  - Baseline data from medical record:
    - Age, gender, race, BMI, comorbidities, medications, baseline PSG/titration
    - Device, mode, O₂ supplementation
Methods

- Scoring
  - Automatic detection - closed/open airway apnea, hypopnea, vibratory snoring, periodic breathing
  - Manual scoring - events scored if clear reduction in signal amplitude (≥30%) or flow limitation with recovery breaths
  - Periodic breathing - nights tagged as present/absent
### Results - Patient characteristics

<table>
<thead>
<tr>
<th>Patient Characteristics (n=217)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>54.7 ± 14.2</td>
</tr>
<tr>
<td>BMI</td>
<td>33.1 ± 7.7</td>
</tr>
<tr>
<td>Male</td>
<td>136 (63%)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>184 (84%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>99 (45.6%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>30 (13.8%)</td>
</tr>
<tr>
<td>Heart failure</td>
<td>8 (3.7%)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>18 (8.2%)</td>
</tr>
<tr>
<td>CPAP use period (days)</td>
<td>218 ± 32</td>
</tr>
</tbody>
</table>
# Results - Polysomonomography variables

<table>
<thead>
<tr>
<th></th>
<th>Baseline PSG</th>
<th>Titration PSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sleep time (minutes)</td>
<td>278.9 ± 144.1</td>
<td>289.2 ± 91.8</td>
</tr>
<tr>
<td>Sleep efficiency (%)</td>
<td>76.7 ± 16.3</td>
<td>77 ± 14.7</td>
</tr>
<tr>
<td>N1 (%)</td>
<td>19.4 ± 15.9</td>
<td>11.1 ± 7.6</td>
</tr>
<tr>
<td>N3 (%)</td>
<td>12.4 ± 11.8</td>
<td>13.4 ± 11</td>
</tr>
<tr>
<td>REM (%)</td>
<td>11 ± 9.1</td>
<td>20.5 ± 10.6</td>
</tr>
<tr>
<td>Arousal index (events per hour)</td>
<td>32.1 ± 31.2</td>
<td>19.3 ± 14.9</td>
</tr>
<tr>
<td>RDI (events per hour)</td>
<td>60.2 ± 31.8</td>
<td>25.9 ± 18.4</td>
</tr>
<tr>
<td>AHI (events per hour)</td>
<td>41.7 ± 31.6</td>
<td>15.9 ± 15.5</td>
</tr>
<tr>
<td>AHI4% (events per hour)</td>
<td>27 ± 28.2</td>
<td>4.3 ± 7.1</td>
</tr>
<tr>
<td>Central apnea index (events per hour)</td>
<td>3.5 ± 8</td>
<td>3.5 ± 6.5</td>
</tr>
<tr>
<td>Oxygen 3% desaturation index (events per hour)</td>
<td>24.5 ± 25.3</td>
<td>8.7 ± 8.8</td>
</tr>
<tr>
<td>Minimum saturation (%)</td>
<td>81.3 ± 8.3</td>
<td>87.3 ± 5.7</td>
</tr>
<tr>
<td>Time under 90% saturation (minutes)</td>
<td>5 ± 11.4</td>
<td>5 ± 19.7</td>
</tr>
<tr>
<td>Periodic Limb Movement Index (events per hour)</td>
<td>17.8 ± 27</td>
<td>15.1 ± 24.1</td>
</tr>
<tr>
<td>PLM arousal index (events per hour)</td>
<td>8.2 ± 15.5</td>
<td>4.1 ± 9</td>
</tr>
</tbody>
</table>
## Results - Database analysis

<table>
<thead>
<tr>
<th>APAP Data</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Nightly use - 4 week average (h)</td>
<td>6.3 ± 1.5</td>
</tr>
<tr>
<td>Fixed pressure</td>
<td>76 (35%)</td>
</tr>
<tr>
<td>Residual apnea - auto detection $AHI_{FLOW}$ (event/hour)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>4.4 ± 3.8</td>
</tr>
<tr>
<td>Auto mode</td>
<td>4.4 ± 3.1</td>
</tr>
<tr>
<td>Fixed mode</td>
<td>7.4 ± 5.4</td>
</tr>
</tbody>
</table>
Results - Database analysis

- Predictors of residual apnea:

<table>
<thead>
<tr>
<th>Predictor of manual $\text{AHI}_{\text{FLOW}} \geq 5/h$</th>
<th>Odds Ratio (CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline PSG CAI</td>
<td>1.5 (1.1-2)</td>
<td>0.01</td>
</tr>
<tr>
<td>Baseline PSG CAI $\geq 5/h$</td>
<td>5 (2.2-13.8)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Predictor of manual $\text{AHI}_{\text{FLOW}} \geq 10/h$</th>
<th>Odds Ratio (CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline PSG CAI</td>
<td>1.14 (1.1-1.3)</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Unchanged adjusting for age, gender, race, baseline N1, sleep efficiency and diagnostic AHI.
Discussion

- **PSG AHI Vs. Device AHI\textsubscript{FLOW}**
  - Overall good correlation however:
    - Vendor algorithms vary, and there are no specific guidelines for detection
    - For a cutoff of AHI>10/h sensitivity 0.58; specificity 0.94
    - Good agreement for apneas less for hypopneas
  - Therefore – auto-detection may overestimate efficacy
  - Inadequate control may lead to poor compliance

Desai 2009
Discussion

- Simultaneous APAP titration and PSG
  - 58% achieved good control of OSA
  - Predictors of PSG AHI were:
    - Hx of cardiac disease
    - Elevated CAI and arousal index on baseline diagnostic study
  - Although AHI median & range (IQR) from device (7.0, 3.9-11.6/h) and PSG (7.8, 3.9-14.4/h) were similar, case-by-case agreement was poor (chi-square < 0.001)

- Conclusion:
  - Close f/u of APAP titration needed
  - Device AHI does not reliably assess control and PSG assessment may be required if clinical response to treatment is poor
Conclusions

- High resolution data on stable compliant CPAP shows that:
  - Residual events are common
  - Events are poorly detected by devices
    - Devices missed
      - ~Half of mild residual apnea patients
      - ~ 3/4 of moderate residual apnea patients
  - Baseline PSG central apnea index the only predictor of residual apnea
Home Sleep Testing in Peds

Classification of portable sleep monitoring:
- Type 1 - Fully attended PSG (≥7 channels)
- Type 2 - Unattended PSG (≥7 channels)
- Type 3 - Respiratory Polygraphy (4-7 channels; airflow, respiratory effort, saturation)
- Type 4 - 1-2 channels only, traditionally at least one is oximetry
Home Sleep Testing in Peds

Type 2 - unattended PSG (≥7 channels)

- 5-12 year old; 162 - 201 subjects
- >91% acceptable, thermistor/press transducer mostly lost
- But:
  - No video, no CO₂
  - Population studies
  - Only 9 compared w/PSG
- Conclusion - possible in the research setting
Home Sleep Testing in Peds

Type 3 - Respiratory Polygraphy

- Hypopneas leading to arousals missed
- TST overestimated
- Compared w/adults, missing several events more significant
- Studies in pediatrics are discordant
- Fair sensitivity & specificity w/high pretest probability for mod-sev disease, mild disease missed

Type 4 - Home oximetry

- High specificity, but low sensitivity, for pediatric OSA
  - A proportion of children have arousals w/preserved oxygenation
  - Restless sleep may result in artifacts mistaken for desaturations
Discussion

Questions?
CPAP for Prevention of Cardiovascular Events in Obstructive Sleep Apnea

R. Doug McEvoy, M.D., Nick A. Antic, M.D., Ph.D., Emma Heeley, Ph.D., Yuanming Luo, M.D., Qiong Ou, M.D., Xilong Zhang, M.D., Olga Mediano, M.D., Rui Chen, M.D., Luciano F. Drager, M.D., Ph.D., Zhihong Liu, M.D., Ph.D., Guofang Chen, M.D., Baoliang Du, M.D., Nigel McArdle, M.D., Sutapa Mukherjee, M.D., Ph.D., Manjari Tripathi, M.D., Laurent Billot, M.Sc., Qiang Li, M.Biostat., Geraldo Lorenzi-Filho, M.D., Ferran Barbe, M.D., Susan Redline, M.D., M.P.H., Jiguang Wang, M.D., Ph.D., Hisatomi Arima, M.D., Ph.D., Bruce Neal, M.D., Ph.D., David P. White, M.D., Ron R. Grunstein, M.D., Ph.D., Nanshan Zhong, M.D., and Craig S. Anderson, M.D., Ph.D., for the SAVE Investigators and Coordinators*

- 2717, 45-75yo, mod-sev OSA & IHD/CVS
- Primary composite end point – CV death, MI, stroke, or hospitalization for unstable angina, HF or TIA
- After 3.7 years – 17 vs. 15.4%
- No sig difference in primary CV endpoints
- EDS, health related QOL and mood improved
Limitations:

- Mean CPAP use - 3.3 hours!
- 9 centers - “for several of the participating countries, the diagnosis and treatment of sleep apnea were not well established in clinical practice when the trial began”
- On treatment vs. intention to treat benefit

Conclusions:

- Secondary prevention not proven
- Screening for asymptomatic OSA
- RCT welcome
Questions?