Diagnosis and management of sleep apnea in stroke patients

Prof. Claudio L. Bassetti
Neurology Department
University Hospital, Bern
Switzerland
Role of sleep-disordered breathing and sleep-wake disturbances for stroke and stroke recovery

Dirk M. Herrmann, MD
Claudia L. Busseit, MD

ABSTRACT

Background: Sleep-disordered breathing (SDB) and sleep-wake disturbances (SWD) are highly prevalent in stroke patients. Recent studies suggest that they represent both a risk factor and a consequence of stroke and affect stroke recovery, outcome, and recurrence.

Methods: Review of literature.

Results: Several studies have proven SDB to represent an independent risk factor for stroke. Sleep studies in TIA and stroke patients are recommended in view of the very high prevalence (>50%) of SDB (Class Iib, level of evidence B). Treatment of obstructive SDB with continuous positive airway pressure is recommended given the strength of the increasing evidence in support of a positive effect on outcome (Class Iib, level of evidence B). Oxygen, biphasic positive airway pressure, and adaptive servoventilation may be considered in patients with central SDB. Recently, both reduced and increased sleep duration, as well as hypersomnia, insomnia, and restless legs syndrome (RLS), were also suggested to increase stroke risk. Mainly experimental studies found that SWD may in addition impair neuroplasticity processes and functional stroke recovery. Treatment of SWD with hypnotics and sedative antidepressants (insomnia), activating antidepressants or stimulants (hypersomnia), dopaminergic drugs (RLS), and clonazepam (parasomnia) are based on single case observations and should be used with caution.

Conclusions: SDB and SWD increase the risk of stroke in the general population and affect short- and long-term stroke recovery and outcome. Current knowledge supports the systematic implementation of clinical procedures for the diagnosis and treatment of poststroke SDB and SWD on stroke units. Neurology 2018;87:1-10

Editorial

Sleep and stroke: A bidirectional relationship with clinical implications
EAN/ERS/ESO/ESRS statement on the impact of sleep disorders on risk and outcome of stroke

Claudio L.A. Bassetti*2, Winfried Randerath*1, Luca Vignatelli4, Anne-Kathrin Brili5, Maria R. Bonsignore6, Ludger Grote7, Poul Jennum8, Didier Leys9, Jens Minnerup10, Lino Nobili11, Thomy Tonia12, Rebecca Morgan13, , Walter T. McNicholas16, Joel Kerry14, Luigi Ferini-Strambi**3, Vasileios Papavasileiou**15
*co-shared first authorship ** co-shared senior authorship

Eur J Neurol (in press)
Eur Resp J (in press)
Vignette-Question
Introduction
Frequency of SDB in stroke pts
Consequences of SDB in stroke pts
Diagnostic approach
Treatment
Vignette-Answer
Conclusions
V.C., 70y male

History
acute weakness, slurred speech
PA: diabetes, hypertension, obesity
no excessive daytime sleepiness

Status
dysarthria, hemiparesis, NIH=11
BMI=29

Work-Up
Blood tests: dyslipidemia, HbA1c=6.5
Echocardiography, 24h ECG, doppler: normal
V.C., 70y male

The following statement is correct:

A. A sleep disordered breathing (SDB) is probable
B. The absence of sleepiness makes a SDB unlikely
C. The diagnosis of SDB in the stroke unit is difficult
D. The treatment of SDB in acute stroke patients is usually not possible and has no long-term effects
Vignette-Question

Introduction
Frequency of SDB in stroke pts
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Cheyne-Stokes breathing (CSB)

"On the 10th of April he was found in bed, speechless, and hemiplegic. . . . The only peculiarity in the last period of his illness, which lasted eight or nine days, was in the state of the respiration. For several days, his breathing was irregular; it would cease for a quarter of a minute, then it would become perceptible, though very low, then by degrees it became heaving and quick, and then it would gradually cease again. This revolution in the state of his
Plum and Posner, The diagnosis of Stupor and Coma
Types of SDB in stroke

- Obstructive sleep apnea
- Central sleep apnea (periodic breathing, Cheyne-Stokes)
- Mixed apneas

Modulators
- Sleep stage
- Position
- Interval after stroke
Cheyne-Stokes breathing after supratentorial stroke

SDB and brainstem stroke

n=355, 13 days after stroke, ApneaLink Plus™

<table>
<thead>
<tr>
<th></th>
<th>Apnea–hypopnea index</th>
<th>Obstructive apnea index</th>
<th>Central apnea index</th>
<th>Hypopnea index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstem infarction (n = 38)</td>
<td>20 (11, 38)</td>
<td>3 (1, 11)</td>
<td>1 (0, 3)</td>
<td>11 (6, 15)</td>
</tr>
<tr>
<td>No brainstem infarction (n = 317)</td>
<td>13 (6, 26)</td>
<td>3 (1, 10)</td>
<td>0 (0, 0)</td>
<td>6 (2, 12)</td>
</tr>
<tr>
<td><em>p</em> value</td>
<td>0.007</td>
<td>0.622</td>
<td>0.04</td>
<td>0.002</td>
</tr>
<tr>
<td>Midbrain infarction only (n = 7)</td>
<td>22 (19, 44)</td>
<td>6 (2, 14)</td>
<td>2 (0, 4)</td>
<td>17 (9, 22)</td>
</tr>
<tr>
<td>Pontine infarction only (n = 27)</td>
<td>16 (11, 35)</td>
<td>2 (1, 10)</td>
<td>1 (0, 3)</td>
<td>10 (6, 14)</td>
</tr>
<tr>
<td>Pontine and medullary infarction (n = 3)</td>
<td>37 (24, 38)</td>
<td>7 (4, 15)</td>
<td>1 (1, 4)</td>
<td>15 (13, 19)</td>
</tr>
</tbody>
</table>

Brown, Sleep Med 2014
Vignette-Question
Introduction
Frequency of SDB in stroke pts
Consequences of SDB in stroke pts
Diagnostic approach
Treatment
Vignette-Answer
Conclusions
Frequency of Sleep Apnea in Stroke and TIA Patients: A Meta-analysis

Karin G. Johnson, M.D.; Douglas C. Johnson, M.D.

1Baystate Medical Center, Springfield, MA; 2Massachusetts General Hospital, Boston, MA

Johnson, J Clin Sleep Med 2010

29 studies (until 12.2008)
2343 pts

AHI> 10 in 63% (23 studies)
AHI>30 in 29% (10 studies)
Prevalence of sleep-disordered breathing after stroke and TIA
A meta-analysis

Andrea Seller, MD, Millene Camilo, MD, PhD, Lyudmila Korostovtseva, MD, PhD, Alan G. Haynes, PhD, Anne-Kathrin Brill, MD, Thomas Horvath, MD, Matthias Egger, MD,* and Claudio L. Bassetti, MD*

Neurology® 2019;92;1-7. doi:10.1212/WNL.0000000000006904

Seiler, Neurology 2019

89 studies (until 4.2017)
7096 pts

AHI> 5 in 71%
AHI>30 in 30%
SAS-CARE Study

Sleep-disordered breathing in acute ischemic stroke and transient ischemic attack: effects on short- and long-term outcome and efficacy of treatment with continuous positive airways pressure – rationale and design of the SAS CARE study

Carlo W. Cereda, Liliane Petri, Andrea Azzola, Alfonso Ciccone, Urs Fischer, Augusto Gallino, Sandor Győrik, Matthias Gugger, Johannes Mattis, Lena Lavie, Costanzo Limoni, Lino Nobili, Mauro Manconi, Sebastian Ott, Marco Pons, and Claudio L. Bassetti

Int J Stroke 2012

- Full PSG within 1 week
- AASM 2012 criteria

- 168 consecutive stroke pts
- 74% stroke, 26% TIA
- male 72%, mean age 61±9
- NIHSS: 4±5 (0-40)

- 50% AHI>15
- 30% AHI>30

- obstructive (84%)
- central (13%)

bad outcome at 3 months

- high NIHSS/AHI

Ott (submitted)
SDB improves after acute stroke and TIA

stable phase: after 3 months

Parra, AJRCCM 2000
Vignette-Question
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Detrimental effects of SDB on stroke (short-term)

- Recurrent hypoxemia
- Increased/variable blood pressure
- Increased cardiac arrhythmias (?)
- Cerebral hypoperfusion
- Longer hospitalization (costs)

- Stroke progression?
- Short-term outcome?
Detrimental acute effects of SDB

- oxygen desaturations
- blood pressure swings
- cerebral blood flow velocity swings
- respiratory events

Yaggi and Mohsenin, Lancet Neurol 2004
Detrimental effects of SDB on stroke (longterm)

- Increased mortality
- Increased cardiovascular morbidity
- Poorer stroke outcome
Detrimental long-term effects of SDB

### Severe OSA

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Deaths/Total No. (%)</th>
<th>No. of Deaths/Total No. (%)</th>
<th>Follow-up, y</th>
<th>Apnea-Hypopnea Index Comparison, Group 1 vs Group 2</th>
<th>Hazard Ratio (95% CI)</th>
<th>Favors Group 1</th>
<th>Favors Group 2</th>
<th>Weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young et al,150 2008</td>
<td>12/63 (19.0)</td>
<td>46/1157 (4.0)</td>
<td>13.8</td>
<td>≥30 vs &lt;5</td>
<td>2.70 (1.29-5.65)</td>
<td>13.47</td>
<td></td>
<td>31.27</td>
</tr>
<tr>
<td>Punjabi et al,151 2009</td>
<td>86/341 (25.2)</td>
<td>477/3429 (13.9)</td>
<td>8.2</td>
<td>≥30 vs &lt;5</td>
<td>1.46 (1.14-1.86)</td>
<td></td>
<td></td>
<td>22.66</td>
</tr>
<tr>
<td>Gooneratne et al,147 2011</td>
<td>35/42 (83.3)</td>
<td>59/119 (49.6)</td>
<td>13.8</td>
<td>≥20 and EDS vs &lt;20 and no EDS</td>
<td>2.28 (1.46-3.57)</td>
<td></td>
<td></td>
<td>20.22</td>
</tr>
<tr>
<td>Ensrud et al,144 2012</td>
<td>25/209 (12.0)</td>
<td>155/2296 (6.8)</td>
<td>3.4</td>
<td>≥30 vs &lt;30</td>
<td>1.74 (1.04-2.90)</td>
<td></td>
<td></td>
<td>12.38</td>
</tr>
<tr>
<td>Marshall et al,153 2014</td>
<td>10/18 (55.6)</td>
<td>54/294 (18.4)</td>
<td>20</td>
<td>≥15 vs &lt;5</td>
<td>4.20 (1.91-9.24)</td>
<td></td>
<td></td>
<td>100.0</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.07 (1.48-2.91)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Moderate OSA

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Deaths/Total No. (%)</th>
<th>No. of Deaths/Total No. (%)</th>
<th>Follow-up, y</th>
<th>Apnea-Hypopnea Index Comparison, Group 1 vs Group 2</th>
<th>Hazard Ratio (95% CI)</th>
<th>Weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young et al,150 2008</td>
<td>6/82 (7.3)</td>
<td>46/1157 (4.0)</td>
<td>13.8</td>
<td>15 to &lt;30 vs &lt;5</td>
<td>1.30 (0.51-3.29)</td>
<td>4.04</td>
</tr>
<tr>
<td>Punjabi et al,151 2009</td>
<td>165/727 (22.7)</td>
<td>477/3429 (13.9)</td>
<td>8.2</td>
<td>15 to &lt;30 vs &lt;5</td>
<td>1.17 (0.97-1.42)</td>
<td>95.96</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.17 (0.97-1.42)</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Mild OSA

<table>
<thead>
<tr>
<th>Source</th>
<th>No. of Deaths/Total No. (%)</th>
<th>No. of Deaths/Total No. (%)</th>
<th>Follow-up, y</th>
<th>Apnea-Hypopnea Index Comparison, Group 1 vs Group 2</th>
<th>Hazard Ratio (95% CI)</th>
<th>Weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young et al,150 2008</td>
<td>16/220 (7.3)</td>
<td>46/1157 (4.0)</td>
<td>13.8</td>
<td>5 to &lt;15 vs &lt;5</td>
<td>1.50 (0.80-2.81)</td>
<td>28.94</td>
</tr>
<tr>
<td>Punjabi et al,151 2009</td>
<td>319/1797 (17.8)</td>
<td>477/3429 (13.9)</td>
<td>8.2</td>
<td>5 to &lt;15 vs &lt;5</td>
<td>0.93 (0.80-1.08)</td>
<td>71.06</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.07 (0.70-1.63)</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Jonas, JAMA 2017
The Effect of Sleep Disordered Breathing on the Outcome of Stroke and Transient Ischemic Attack: A Systematic Review

Johannes Birkbak, B.Sc. in Medicine; Alice J. Clark, M.Sc.; Naja Hulvej Rod, Ph.D.
Department of Public Health, University of Copenhagen, Copenhagen, Denmark

Birkbak, J Clin Sleep Med 2014

Obstructive Sleep Apnea and Serious Adverse Outcomes in Patients with Cardiovascular or Cerebrovascular Disease

A PRISMA-Compliant Systematic Review and Meta-Analysis

Wuxiang Xie, MD, PhD, Fanfan Zheng, MD, PhD, and Xiaoyu Song, MD, MPH

Xie, Medicine 2014
Stroke risk in OSA pts after stroke/IHD (ischemic heart disease)

hospital-based cohort studies, OR 1.9 (95%, CI 1.3-2.9)

Xie, Medicine 2014
Vignette-Question

Introduction

Frequency of SDB in stroke pts

Consequences of SDB in stroke pts

Diagnostic approach

Treatment

Vignette-Answer

Conclusions
Predictors of obstructive SDB

TABLE 6. Independent Predictors of AHI

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Wald’s Statistic</th>
<th>P Value</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>14.722</td>
<td>0.000</td>
<td>1.069</td>
</tr>
<tr>
<td>Diabetes</td>
<td>6.056</td>
<td>0.014</td>
<td>4.269</td>
</tr>
<tr>
<td>Nighttime onset of stroke*</td>
<td>4.367</td>
<td>0.037</td>
<td>2.641</td>
</tr>
</tbody>
</table>

Logistic regression analysis, dependent variable: AHI. Nagelkerke $r^2 = 0.295$.

*Onset of stroke between 9:01 PM and 6.00 AM, 25%; between 6:01 AM and 9:00 PM, 75%.

Bassetti, Milanova, Gugger, Stroke 2006
Night-time and wake-up strokes and SDB

Table 6: Independent Predictors of AHI

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Wald’s Statistic</th>
<th>P Value</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>0.000</td>
<td>1.069</td>
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<td>0.037</td>
<td>2.641</td>
</tr>
</tbody>
</table>

Logistic regression analysis, dependent variable: AHI. Nagelkerke $r^2 = 0.295$.
*Onset of stroke between 9:01 PM and 6:00 AM, 25%; between 6:01 AM and 9:00 PM, 75%.

Bassetti, Stroke 2006

Table 4: Clinical differences between patients with and without SRSO

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>With SRSO</th>
<th>Without SRSO</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient (n)</td>
<td>17</td>
<td>57</td>
<td>0.01</td>
</tr>
<tr>
<td>Age (years)</td>
<td>68.8±10.2</td>
<td>62.4±8.9</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>11:6</td>
<td>28:29</td>
<td>0.26</td>
</tr>
<tr>
<td>AHI (no./h)</td>
<td>25.4±18.1</td>
<td>12.5±11.1</td>
<td>0.001</td>
</tr>
<tr>
<td>AHI &gt;10 (%)</td>
<td>82.4</td>
<td>45.6</td>
<td>0.01*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.6±2.7</td>
<td>24.6±3.4</td>
<td>0.65*</td>
</tr>
<tr>
<td>HTN (%)</td>
<td>70.5</td>
<td>50.8</td>
<td>0.14*</td>
</tr>
<tr>
<td>DM (%)</td>
<td>35.2</td>
<td>29.8</td>
<td>0.71*</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>29.4</td>
<td>28.0</td>
<td>0.38*</td>
</tr>
<tr>
<td>Alcohol (%)</td>
<td>52.9</td>
<td>26.3</td>
<td>0.02*</td>
</tr>
</tbody>
</table>

*p value after adjustment of age
SRSO sleep-related stroke onset, AHI apnea–hypopnea index, BMI body mass index, HTN hypertension, DM diabetes mellitus

Joo, Sleep Breath 2010

Figure 3: Presence of moderate-to-severe sleep apnea syndrome in patients with wake-up stroke and non-wake-up stroke (68.8% vs. 29.2%, $p = 0.003$)

Siarnik, J Clin Sleep Med 2016

Nocturnal Desaturation in the Stroke Unit Is Associated With Wake-Up Ischemic Stroke

Tae Jung Kim, MD; Sang-Bae Ko, MD, PhD; Han-Gil Jeong, MD; Ji Sung Lee, PhD; Chi Kyung Kim, MD, PhD; Ye Rim Kim, MD; Kiwoong Nam, MD; Hecjung Mo, MD; Sang Joon An, MD; Huihun Alex Choi, MD; Byung-Woo Yoon, MD, PhD
Predictors of central SDB

Postacute phase
left ventricular ejection fraction

<table>
<thead>
<tr>
<th>Variables</th>
<th>Odds Ratio</th>
<th>p Value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>2.1</td>
<td>0.399</td>
<td>0.4 - 12.2</td>
</tr>
<tr>
<td>Sex</td>
<td>0.3</td>
<td>0.133</td>
<td>0.1 - 1.4</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>0.4</td>
<td>0.278</td>
<td>0.1 - 2.3</td>
</tr>
<tr>
<td>PtcO₂</td>
<td>0.8</td>
<td>0.017</td>
<td>0.7 - 0.9</td>
</tr>
<tr>
<td>LVEF &lt; 40%</td>
<td>8.5</td>
<td>0.040</td>
<td>1.1 - 66.1</td>
</tr>
</tbody>
</table>

Definition of abbreviations: LVEF = left ventricular ejection fraction; PtcO₂ = transcutaneous PCO₂.

Acute phase
stroke topography

n=77
45±26 hours after stroke:
AHI>10 in 53%
CSA >10% of time in 39%

Nopmaneejumruslers, AJRCCM 2005

Hermann, Stroke 2007, Siccoli, J Neurol 2008
48-year-old man moderate hemispheric stroke (NIHSS=12)
sleep study at Day 3
no EDS
Apnea-Hypopnea-Index=44
80% central
min \( \text{SaO}_2 = 86\% \)
SDB and stroke: Diagnosis

- Excessive sleepiness is uncommon in stroke pts with SDB
- Predictors: snoring, age/gender, obesity, night-time onset
- Portable devices*: accurate/validated tools for screening
- Severity often improves in the first few weeks

*ResMed AutoSet®
ApneaLink Plus™

Bassetti, Stroke 1996; Reeves, Sleep Med 2014; Brown, Sleep Med 2014
The NoSAS score for screening of sleep-disordered breathing: a derivation and validation study

Helena Marti-Soler, Camila Hinoitsu, Pedro Marques-Vidal, Peter Vollenweider, Gérard Waeber, Martin Preisig, Mehdi Tufik, Sergio Brasil Tufik, Lia Bittencourt, Sergio Tufik, José Haba-Rubio*, Raphael Heinzer*

---

<table>
<thead>
<tr>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neck circumference</strong></td>
</tr>
<tr>
<td><strong>Obesity</strong></td>
</tr>
<tr>
<td>BMI 25 kg/m² to &lt;30 kg/m²</td>
</tr>
<tr>
<td>BMI ≥30 kg/m²</td>
</tr>
<tr>
<td><strong>Snoring</strong></td>
</tr>
<tr>
<td><strong>Age &gt;55 years</strong></td>
</tr>
<tr>
<td><strong>Sex: male</strong></td>
</tr>
</tbody>
</table>

The patient has a high probability of sleep-disordered breathing if they have a NoSAS score of 8 or higher. BMI=body-mass index.

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Table 2: NoSAS score
Vignette-Question
Introduction
Frequency of SDB in stroke pts
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Conclusions
Early CPAP improves outcome after stroke

n=55, CPAP=16

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Intention-to-Treat</th>
<th>Adherence Analysis†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention (N = 31)</td>
<td>Control (N = 24)</td>
</tr>
<tr>
<td>Stroke severity (NIHSS) median change from baseline to 30-days</td>
<td>-3.0</td>
<td>-1.0</td>
</tr>
<tr>
<td>Vascular events*</td>
<td>1 (3.2)</td>
<td>3 (12.5)</td>
</tr>
</tbody>
</table>

10/16 pts with good adherence to CPAP (>75%, >4 nights)

Bravata, Sleep 2011
Efficacy of continuous positive airway pressure treatment on 5-year survival in patients with ischaemic stroke and obstructive sleep apnea: a randomized controlled trial

OLGA PARRA¹, ÁNGELES SÁNCHEZ-ARMENGOL², FRANCISCO CAPOTE², MARC BONNIN¹, ADRIÀ ARBOIX³, FRANCISCO CAMPOS-RODRÍGUEZ⁴, JOSÉ PÉREZ-RONCHEL⁴, JOAQUÍN DURÁN-CANTOLLA⁵, CRISTINA MARTÍNEZ-NULL⁵, MÓNICA DE LA PEÑA⁶, MARÍA CARMEN JIMÉNEZ⁷, FERNANDO MASSA⁶, IGNACIO CASADÓN⁸, MARÍA LUZ ALONSO⁹ and JOSÉ L. MACARRON⁶

5-year survival stroke pts with AHI≥20

with early nCPAP (n=57) without nCPAP (n=69)
Diagnosing and Treating Sleep Apnea in Patients With Acute Cerebrovascular Disease

Dawn M. Bravata MD; Jason Sico, MD; Carlos A. Vaz Fragoso, MD; Edward J. Miech, EdD; Marianne S. Matthias, PhD; Rachel Lampert, MD; Linda S. Williams, MD; John Concato, MD; Cristina S. Ivan, MD; J. D. Fleck, MD; Lauren Tobias, MD; Charles Austin, MDiv; Jared Ferguson, BS; Radu Radulescu, MD; Lynne Iannone, MS; Susan Ofner, MS; Stanley Taylor, MA; Li Qin, PhD; Christine Won, MD; H. Klar Yaggi, MD

RCT
n=252 enrolled
3 groups
auto-titrating CPAP
follow-up: 12 months
CPA-use>4h in 70%

Bravata, JACC 2018
CPAP as treatment of sleep apnea after stroke
A meta-analysis of randomized trials

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Brill, Neurology 2019

Pubmed, Embase, Cochrane

10 RCT’s
5 <1 week, 5 10–28 days
483 pts

PRISMA statement
Guidelines
CPAP Usage

9 studies, median usage: 4.5h
considerable heterogeneity ($I^2=87\%$)

<table>
<thead>
<tr>
<th>Study</th>
<th>CPAP Usage</th>
<th>N</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bravata 2010</td>
<td>5.60 (5.15 - 6.05)</td>
<td>45</td>
<td>1.59</td>
</tr>
<tr>
<td>Bravata 2011</td>
<td>5.10 (4.49 - 5.71)</td>
<td>31</td>
<td>1.49</td>
</tr>
<tr>
<td>Parra 2011</td>
<td>5.30 (4.99 - 5.61)</td>
<td>71</td>
<td>1.66</td>
</tr>
<tr>
<td>Minnerup 2012</td>
<td>4.20 (3.79 - 4.61)</td>
<td>25</td>
<td>1.61</td>
</tr>
<tr>
<td>Brown 2013</td>
<td>4.50 (2.84 - 6.16)</td>
<td>15</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>5.00 (4.43 - 5.58)</td>
<td></td>
<td>7.13</td>
</tr>
<tr>
<td>Delayed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandberg 2001</td>
<td>4.10 (3.21 - 4.99)</td>
<td>33</td>
<td>1.28</td>
</tr>
<tr>
<td>Ryan 2011</td>
<td>4.96 (4.32 - 5.60)</td>
<td>25</td>
<td>1.47</td>
</tr>
<tr>
<td>Aaronson 2016</td>
<td>2.50 (1.59 - 3.41)</td>
<td>20</td>
<td>1.26</td>
</tr>
<tr>
<td>Khot 2016</td>
<td>3.90 (3.06 - 4.74)</td>
<td>20</td>
<td>1.32</td>
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<tr>
<td></td>
<td>3.90 (2.88 - 4.91)</td>
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<td>5.32</td>
</tr>
<tr>
<td></td>
<td>4.53 (3.97 - 5.08)</td>
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</tbody>
</table>
Neurological outcome

5 studies, NIHSS/CSS
trends to improvement (standardized mean difference 0.53)
considerable heterogeneity ($I^2=82\%$)

<table>
<thead>
<tr>
<th>Study</th>
<th>SMD</th>
<th>CPAP Control</th>
<th>Weight</th>
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</thead>
<tbody>
<tr>
<td>Early</td>
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<td></td>
</tr>
<tr>
<td>Parra, 2011</td>
<td>-0.04 (-0.39 - 0.31)</td>
<td>57</td>
<td>69</td>
</tr>
<tr>
<td>Minnerup, 2012</td>
<td>0.48 (-0.08 - 1.05)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>0.17 (-0.32 - 0.67)</td>
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<tr>
<td>Delayed</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hsu, 2006</td>
<td>0.00 (-0.75 - 0.75)</td>
<td>14</td>
<td>13</td>
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<tr>
<td>Ryan, 2011</td>
<td>1.86 (1.14 - 2.58)</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Aaronson, 2016</td>
<td>0.45 (-0.27 - 1.16)</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>0.77 (-0.33 - 1.87)</td>
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<tr>
<td></td>
<td>0.53 (-0.10 - 1.16)</td>
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</tbody>
</table>
Vignette-Question
Introduction
Frequency of SDB in stroke pts
Consequences of SDB in stroke pts
Diagnostic approach
Treatment
Vignette-Answer
Conclusions
V.C., 70y male

Sleep study

Apnea-Hypopnea-Index: 72/h
85% obstructive events

Desaturations:
178 min <90%
16 min <80%
V.C., 70y male

The following statement is correct:

A. A sleep disordered breathing (SDB) is probable
B. The absence of sleepiness makes a SDB unlikely
C. The diagnosis of SDB in the stroke unit is difficult
D. The treatment of SDB in acute stroke patients is usually not possible and has no long-term effects
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SDB and stroke: Conclusions

- SDB is frequent in acute stroke (30% > 30/h)
- SDB has (probably) a negative effect on outcome
- Risk profile >> symptoms predicts SDB in stroke pts
- CPAP treatment in acute stroke is feasible
- CPAP may have a positive effect on stroke outcome