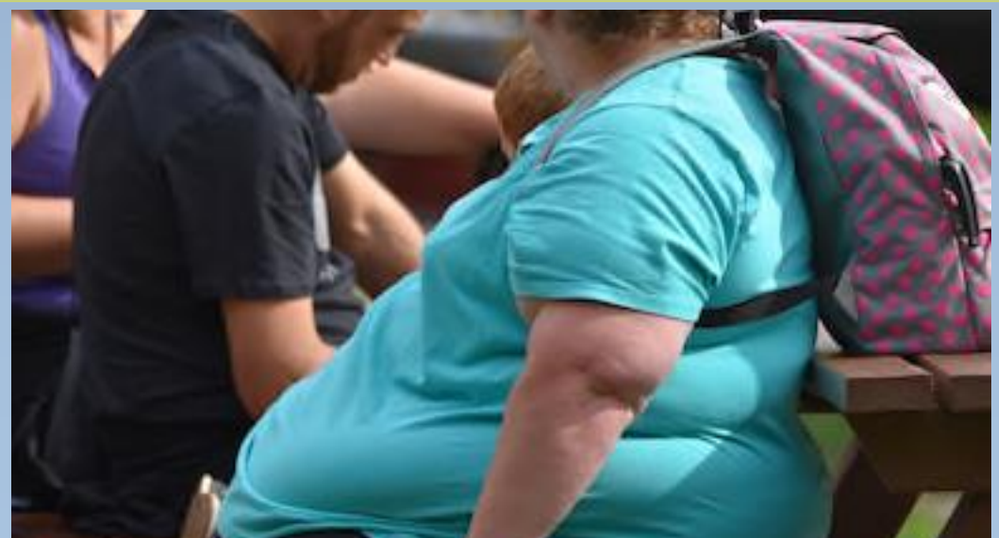
AN INTEGRATED APPROACH TO OBESITY HYPOVENTILATION SYNDROME IN THE SURGICAL SETTING



Rainer Lenhardt

IFSO 2024

ifso2024.org

Agenda
Obesity Hypoventilation Syndrome

- Prevalence of OHS
- Definition, clinical presentation
- Comparison OSA and OHS
- Complications and outcomes
- Mainstay of therapy: CPAP or BIPAP

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Obesity Hypoventilation Syndrome Prevalence (Masa Eur Respir Rev 2019, Balachandran Sleep Med Clin 2014)

Obesity Hypoventilation Syndrome

Prevalence in patients awaiting bariatric surgery

Overall prevalence 8% (7-22%)
In patients with known OSA 11%

Lecube A, et al. Obes Surg 2010; 20:454

Obesity Hypoventilation Syndrome

Definition

Obesity (BMI > 30 kg/m^2)
Hypoxemia (< 70 PaO_2, nadir SpO_2 < 80 %)
Hypercapnia (daytime > 45 $PaCO_2$)
Serum bicarbonate >27 mmol/L
Obstructive Sleep Apnea (90%)
Absence of other causes of hypoventilation

Bingol et al. Respire Care 2015; 60: 666
Chau E, et al. Anesthesiology 2012; 117: 188

Malignant Obesity Hypoventilation Syndrome

Definition

Obesity (BMI > 40 kg/m^2)
Hypoxemia (< 70 PaO_2, nadir SpO_2 < 80 %)
Hypercapnia (daytime ≥ 45 $PaCO_2$)
Serum bicarbonate ≥ 27 mmol/L
Obstructive Sleep Apnea
Metabolic syndrome (central obesity, HTN, HLP, insulin resistance)
Multiorgan dysfunction related to obesity (e.g pulmonary hypertension)

Mario et al. J Intensive Care Med 2012; 28:124
Masa et al. Eur Respir Rev 2019; 28:180097

Obesity Hypoventilation Syndrome

Clinical Presentation

excessive daytime sleepiness

Obesity Hypoventilation Syndrome

Clinical Presentation

- Fatigue

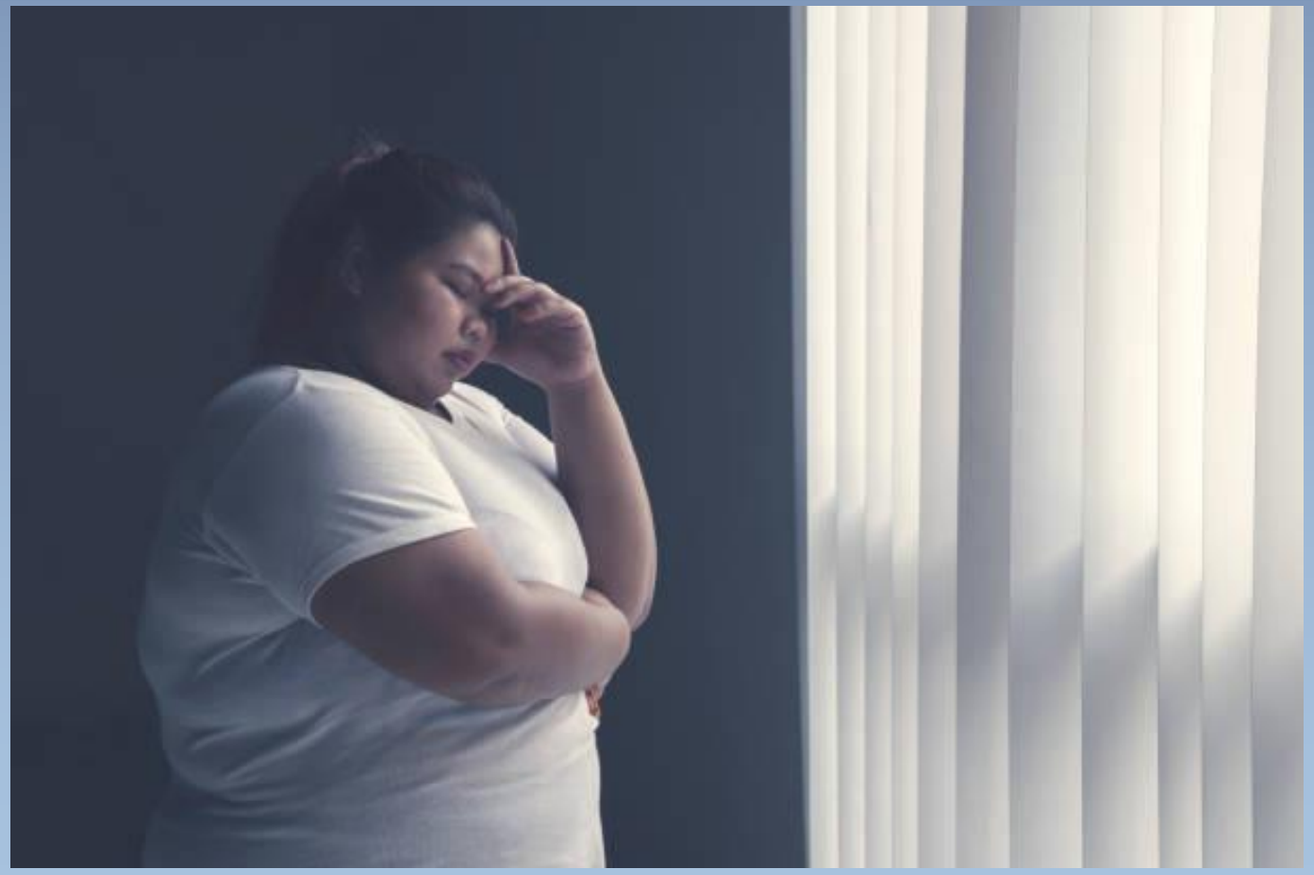
Obesity Hypoventilation Syndrome

Clinical Presentation

nocturnal choking episodes

Obesity Hypoventilation Syndrome

Clinical Presentation

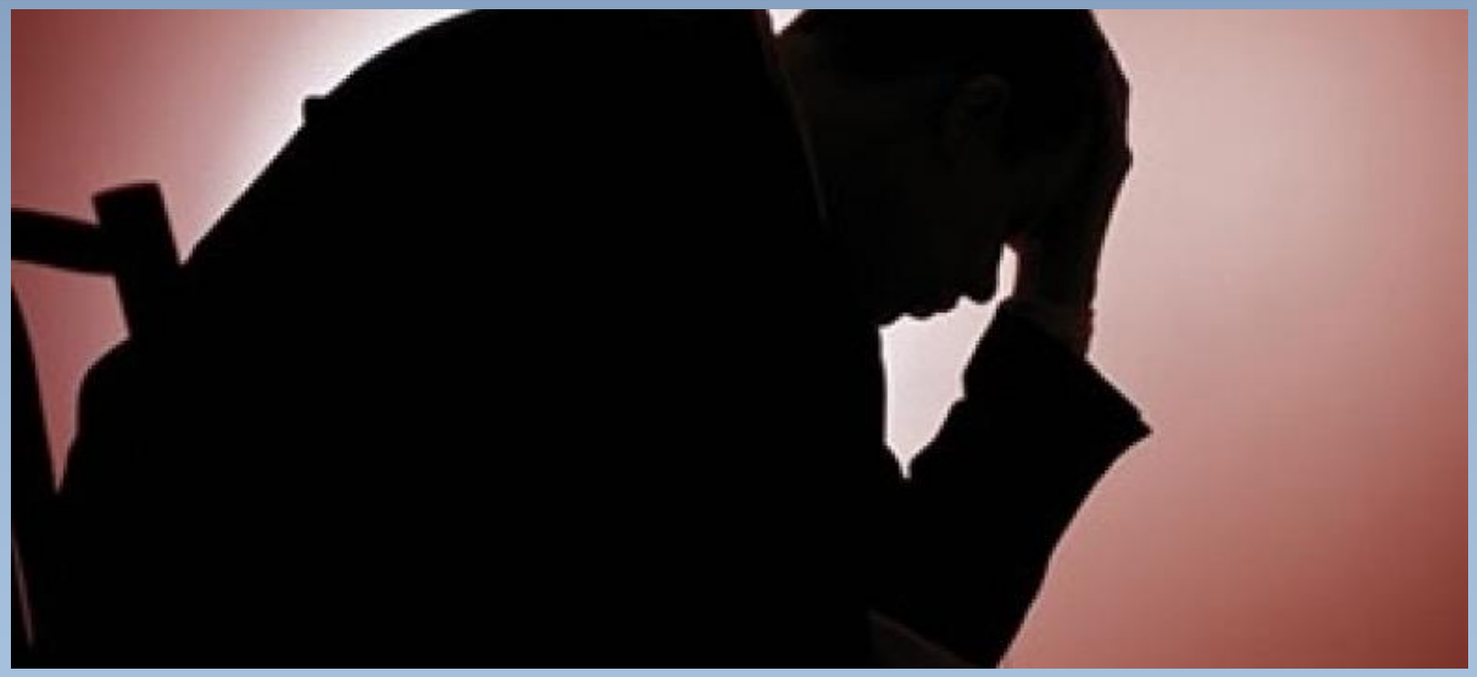


morning headaches

de Athayde et al. J Braz Pneumol 2018;44:510

Obesity Hypoventilation Syndrome

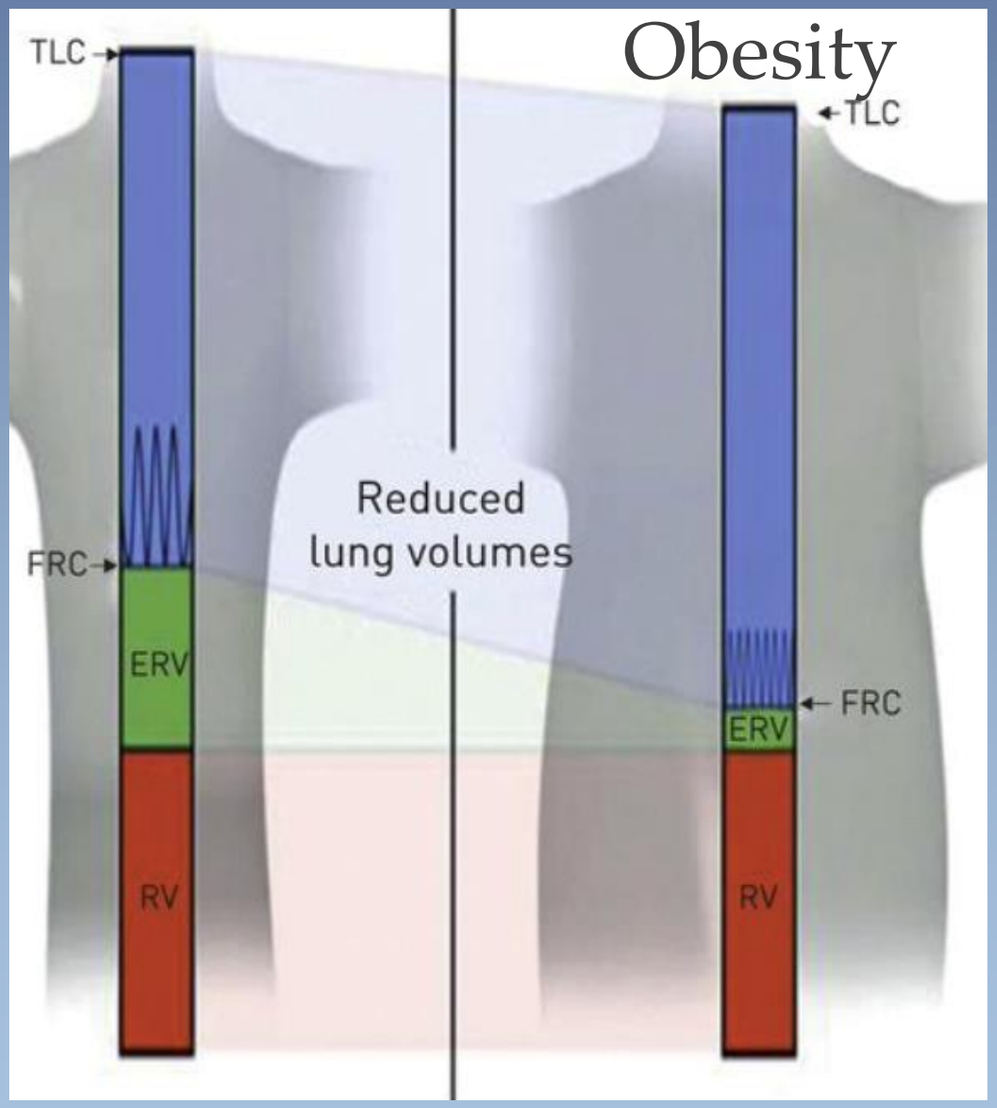
Clinical Presentation

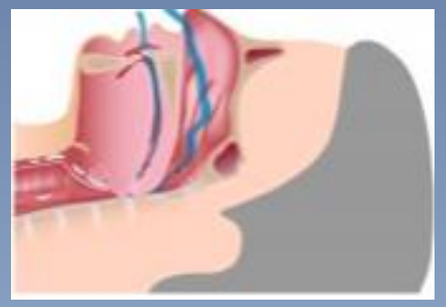


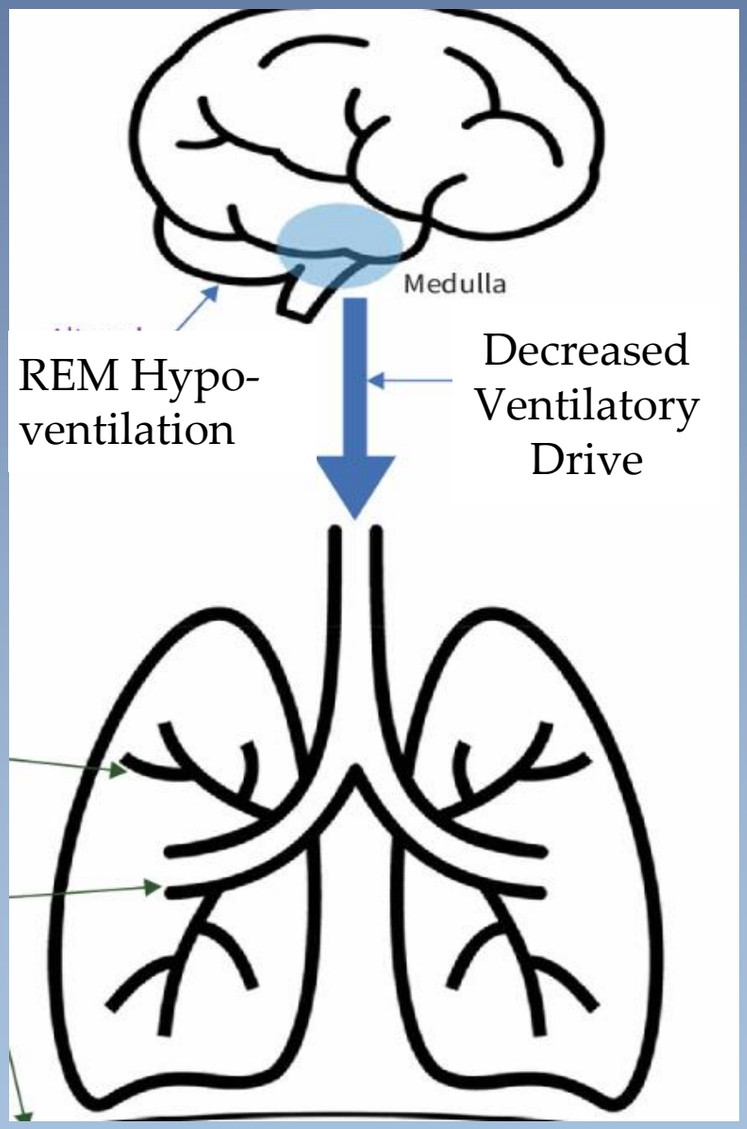
Depression

Obesity Hypoventilation Syndrome

Pathophysiology



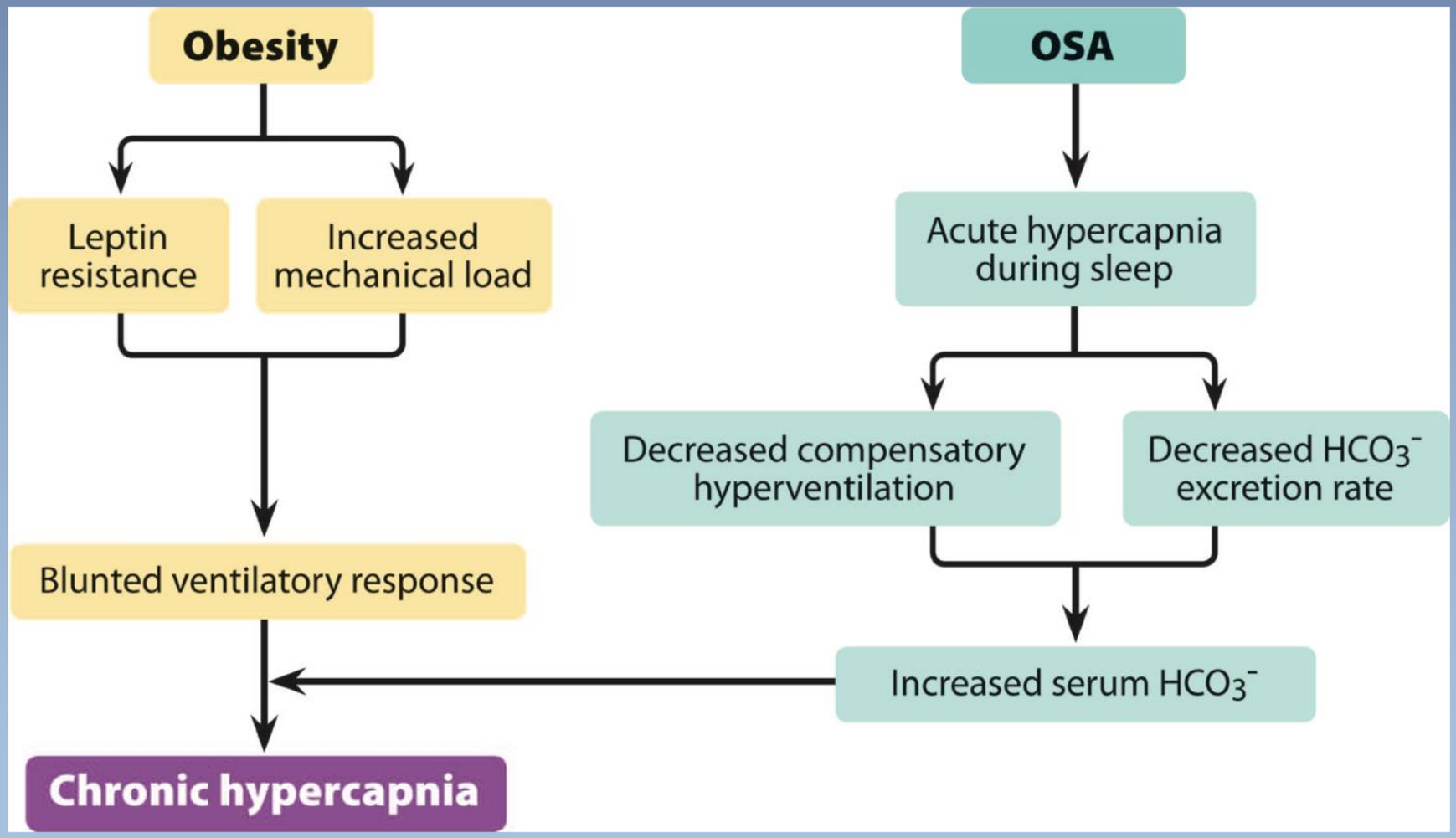




Masa et al. Eur Respir Rev 2019; 28:180097

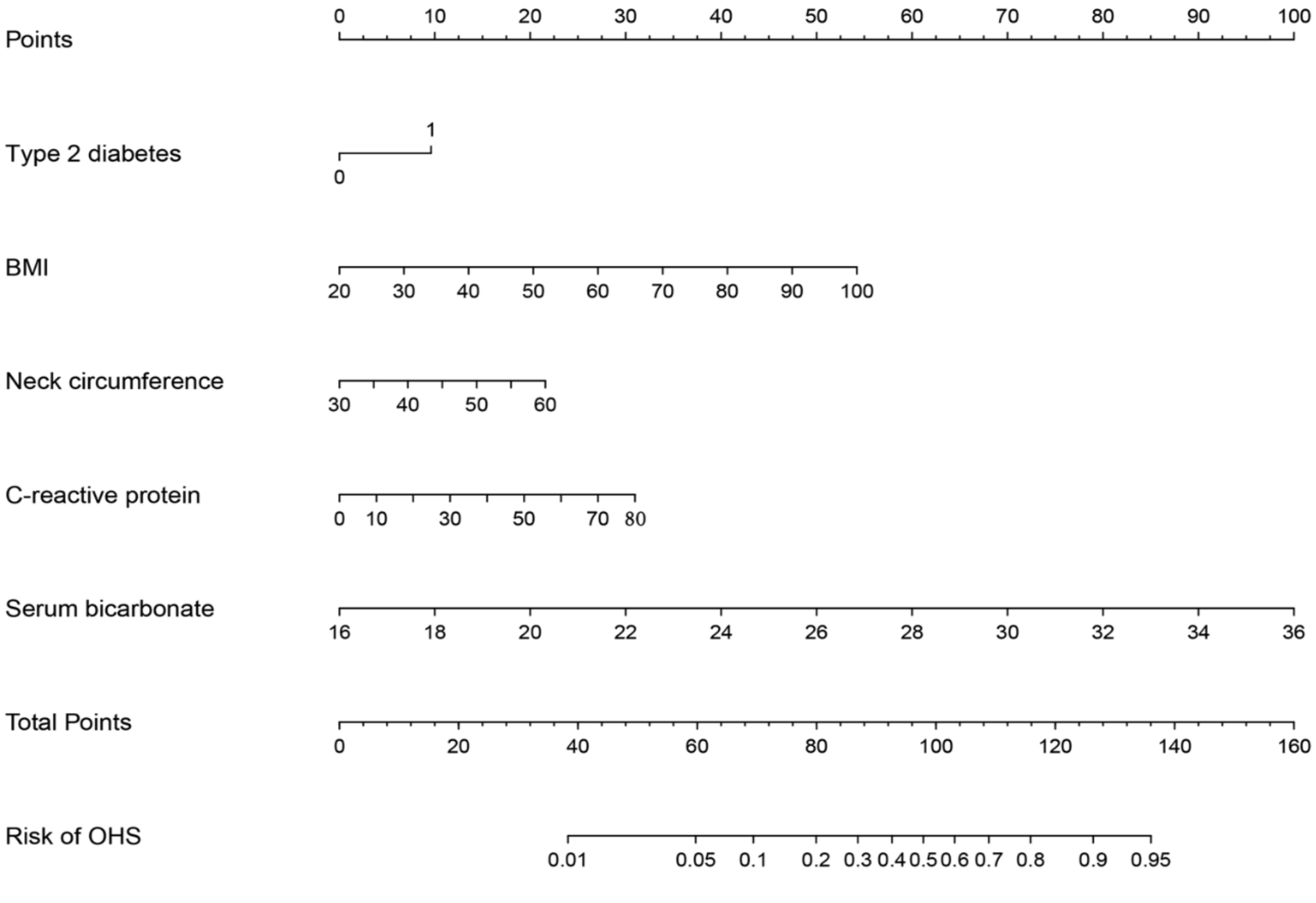
Obesity Hypoventilation Syndrome

Pathophysiology



Raveendran et al. Curr Opin Anesthesiol 2017; 30:146

Obesity Hypoventilation Syndrome Prediction



Chen et al. Obes Surg 2023; 33:68

Comparison Obese Patients with Eucapnia and OHS

Parameters*	OHS (Mean ± SD)	Eucapnic obesity (Mean ± SD)	*P* Value
N	741	2,972	—
Age (yr)	50.1 ± 9.3	51.3 ± 8.5	<0.0001
Male (%)	70.5	78.6	N/A
Female (%)	29.5	21.4	N/A
BMI (kg/m^2)	39.6 ± 7.7	33.4 ± 5.9	<0.0001
Neck circumference (cm)	47 ± 6	44 ± 5	0.01
Waist-to-hip ratio	1.0 ± 0.06	0.9 ± 0.1	<0.0001
Gas exchange	—	—	—
Pa_{O_2} (mmHg)	66.8 ± 8.7	78.7 ± 8.0	<0.0001
Pa_{CO_2} (mmHg)	49.8 ± 6.4	39.7 ± 2.7	<0.0001
HCO_3^- (mM)	30.9 ± 3.8	25.9 ± 3.4	<0.0001
Pulmonary function	—	—	—
FEV_1 (% pred)	71.0 ± 13.1	87.8 ± 13.2	<0.0001
FVC (% pred)	80.3 ± 12.4	92.8 ± 10.4	<0.0001
FEV_1/FVC	79.4 ± 7.2	80.7 ± 5.3	<0.0001
FRC (% pred)	80.8 ± 7.3	83.5 ± 3.6	0.0156
TLC (% pred)	77 ± 14.7	95 ± 11.5	<0.0001
Sleep-disordered breathing	—	—	—
AHI (events/h)	66.4 ± 21.6	47.5 ± 18.2	<0.0001
TST Sp_{O_2} <90% (%)	49.2 ± 31.8	17.1 ± 21.1	<0.0001
Min nocturnal Sp_{O_2} (%)	65.1 ± 10.4	74.5 ± 7.7	<0.0001
Central respiratory drive to CO_2	—	—	—
CO_2 sensitivity (l/min/mmHg)	1.2 ± 0.8	2.4 ± 1.5	<0.0001

Basoglu, et al. The Clinical Respiratory Journal 2014

Chau E, et al. Anesthesiology 2012; 117: 188

Complications of OHS

compared to OSA

- Heart failure OR 9(2-35)
- Angina pectoris OR 9(1-57)
  and/or
- Cor pulmonale OR 9(1-57)

Kaw et al. Chest 2016; 149:84

Complications of OHS

compared to OSA

Cardiometabolic comorbidities lead to increased mortality (24% at 1.5–2 years)

Pulmonary hypertension (> 40 mmHg) 52%

Masa et al. Am J Respir Crit Care Med 2020;201:586
Jennum et al. Thorax 2011;66:560

Postoperative Complications of OHS

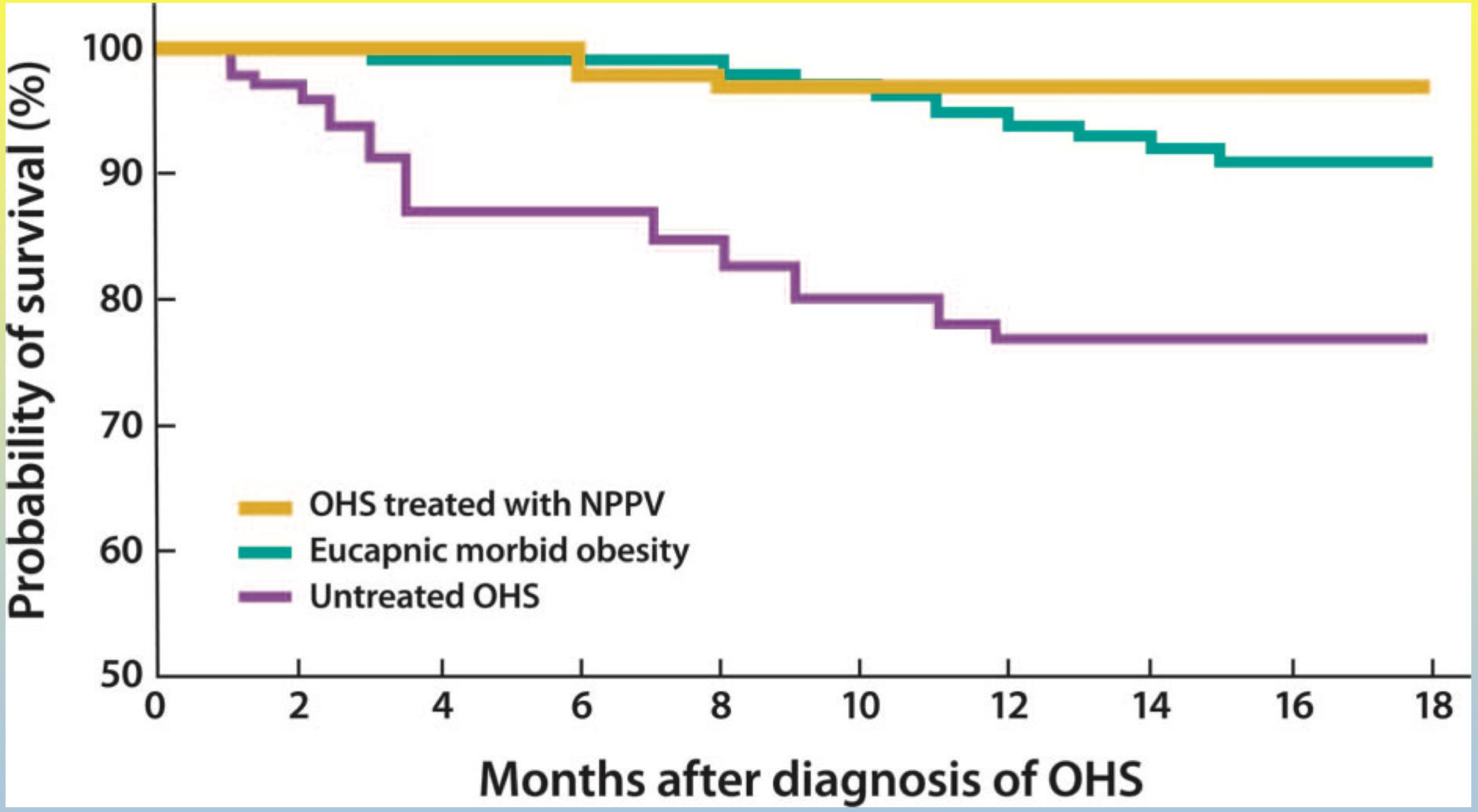
compared to OSA

- Postop. respirator. failure OR 11(4-32)
- Prolonged intubation OR 3.1(0.6-15)
- Postop. ICU transfer OR 10.9(4-32)

Kaw et al. Chest 2016; 149:84

Positive Airway Pressure Therapy

PAP Therapy long term



Mokhlesi, et al. Proceedings Am Thor Soc 2008; 5: 218

Masa, et al. Lancet 2019; 393: 1721

PAP Therapy

improves:

- Gas exchange (PaO_2, $PaCO_2$)
- Pulmonary function (FVC, FEV_1)
- Sleep-disordered breathing (AHI decreases)
- Pulmonary hypertension

Storre, et al. Chest 2006; 130: 815
Heinemann et al. Respir Med 2007;101:1219
Corall et al. Thorax 2018;73:361

PAP Therapy

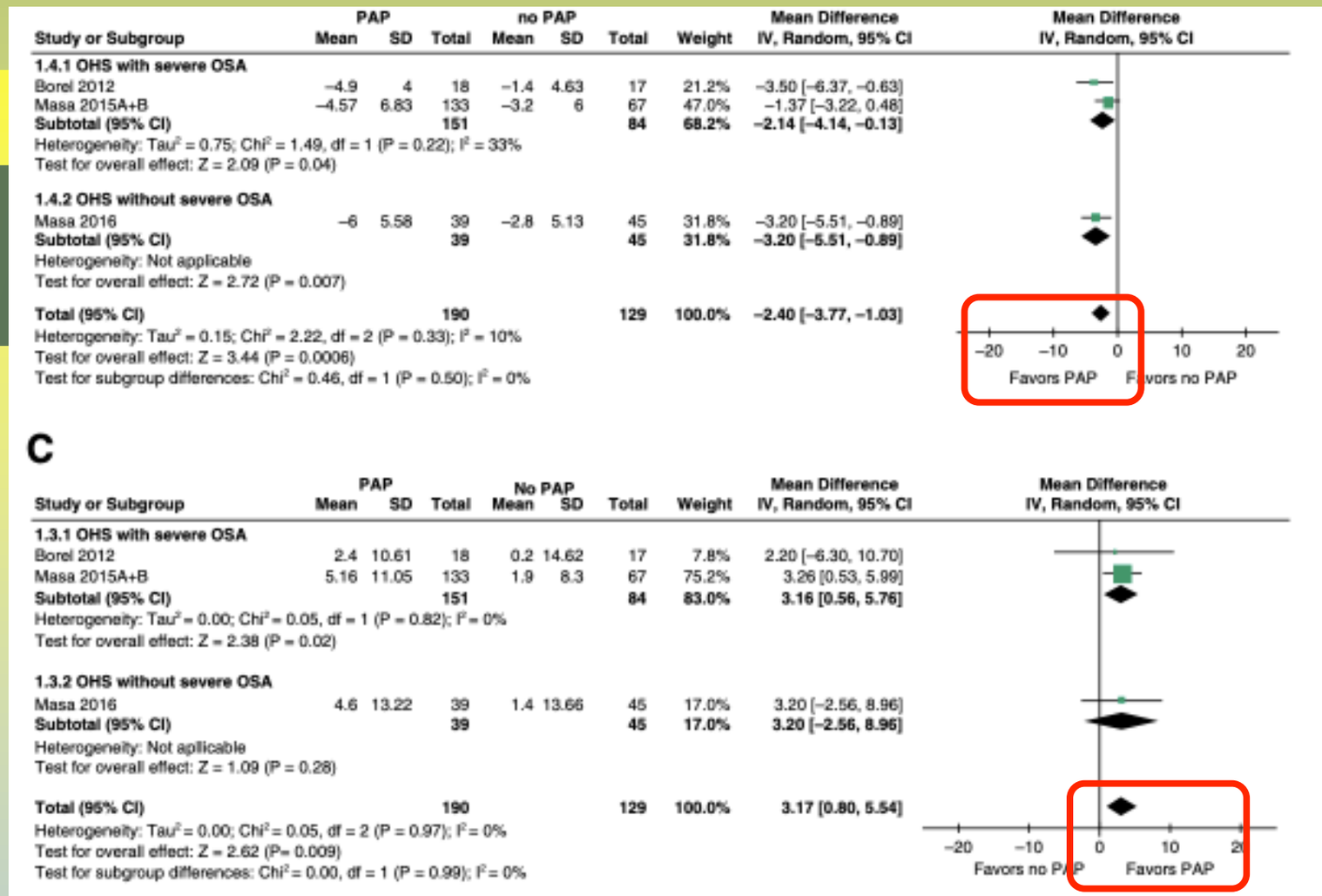
Afshar, et al. AnnalsATS 2020; 17:344

improves:

Awake hypercapnia

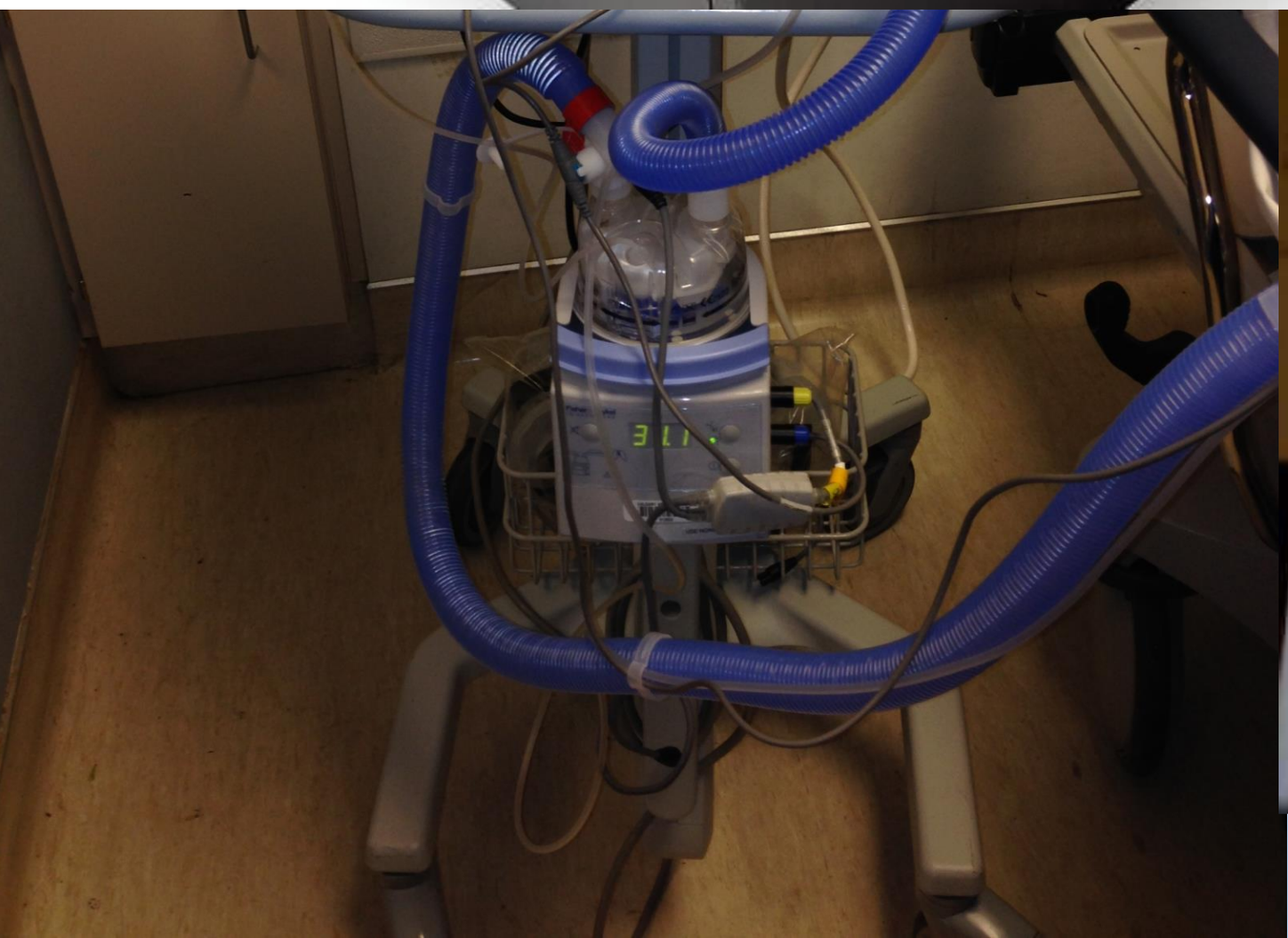
Awake hypoxemia

Resolution of the need for supplemental oxygen




RESPIRONICS
BiPAPAuto
M SERIES
5.0 INCH
3.2 INCH
7.5 INCH


RESPIRONICS
BiPAPAuto
M SERIES
2.2 LBS




PHILIPS

PAP Therapy short term

Author	Design	N	Type	Duration (Weeks)	Pao_2 (mmHg) Pretreatment	Pao_2 (mmHg) Posttreatment	$Paco_2$ (mmHg) Pretreatment	$Paco_2$ (mmHg) Posttreatment
Short-term Therapy								
Chouri-Pontarollo *et al.* 2007[70]	Prospective	15	Bilevel PAP	<1	77.3 ± 6.8	74.3 ± 6.8	47.3 ± 2.3	41.3 ± 3‡
Perez de Llano *et al.* 2008[72]	Prospective	13	Bilevel PAP	<1	49.9 ± 7.7	63.3 ± 10.6*	58.1 ± 5.9	44.3 ± 5.5*
		11	CPAP	<1	51.3 ± 6.7	68.9 ± 3.8*	59.6 ± 11	41.6 ± 4.5*
Perez de Llano *et al.* 2005[63]	Retrospective	54	Bilevel PAP	1	45.8 ± 9.1	55.9 ± 5.6†	60.3 ± 9.9	50.4 ± 4.7†
Piper *et al.* 1994[73]	Prospective	13	Bilevel PAP	1–3	50	66†	62	46‡
Lin 1994[71]	Prospective	30	CPAP	2	75 ± 5.2	90.7 ± 5.2*	47.2 ± 1.5	39 ± 3.00*
			CPAP	4	75 ± 5.2	90.7 ± 5.2*	47.2 ± 1.5	39 ± 3.00*
Long-term Therapy								
Mokhlesi *et al.* 2006[83]	Retrospective	75	CPAP 80%/ Bi-level PAP 20%	4	59 ± 11	64 ± 11†	54 ± 7	49 ± 7†
Storre *et al.* 2006[82]	Prospective Crossover	10	Bi-level PAP	6	73.3 ± 6.3	76.3 ± 12.4	47.4 ± 2.0	45.9 ± 3.7[ns]
			Bi-level PAP + AVAPS	6	73.3 ± 6.3	72.8 ± 9.1	47.4 ± 2.0	42.0 ± 5.2*
Piper *et al.* 2008[78]	Prospective	18	CPAP	12	N/A	N/A	52	46.2*
		18	Bilevel PAP	12	N/A	N/A	49	42.1*
Budweiser *et al.* 2007[76]	Retrospective	126	Bilevel PAP	24	57.8 ± 11.5	65.6 ± 10.4†	55.5 ± 7.7	42.1 ± 5.5†
Priou *et al.* 2010[79]	Retrospective	130	Bilevel PAP	24	63.5 ± 13	72.5 ± 9.4‡	55.9 ± 10.5	45.3 ± 5.3‡
Redolfi *et al.* 2007[80]	Retrospective	6	Bi-level PAP	40	51.3 ± 6.7	75.0 ± 10.3§	55.5 ± 4.8	43.7 ± 1.2§
De Lucas-Ramos *et al.* 2004[77]	Prospective	13	Bilevel PAP	48	55.9 ± 6.4	64 ± 8.6*	49.9 ± 3.67	40.3 ± 3.37*
Heinemann *et al.* 2007[84]	Prospective	32	Bilevel PAP	52	50.1 ± 6.2	63.6 ± 9.3	51.9 ± 3.6	41.6 ± 6.2†
Berger *et al.* 2001[75]	Retrospective	8	CPAP	56 ± 76	N/A	N/A	56 ± 7	41 ± 5§
		10	Bilevel PAP		N/A	N/A	58 ± 4	42 ± 4§

Chau E, et al. Anesthesiology 2012; 117: 188

Can Postoperative Pulmonary Complications in Patients with OHS be Reduced?

Limited evidence demonstrating reduction in postoperative complications with PAP

Initiate PAP therapy
immediately after extubation
following bariatric surgery

Ebeo et al.; Respir Med. 2002;96:672

Summary
Obesity Hypoventilation Syndrome

- Definition: class III obesity with OSA and hypercapnia, serum bicarbonate >27 mmol/L
- Prevalence: 8% in patients awaiting bariatric surgery

Respiration and Sleep Medicine

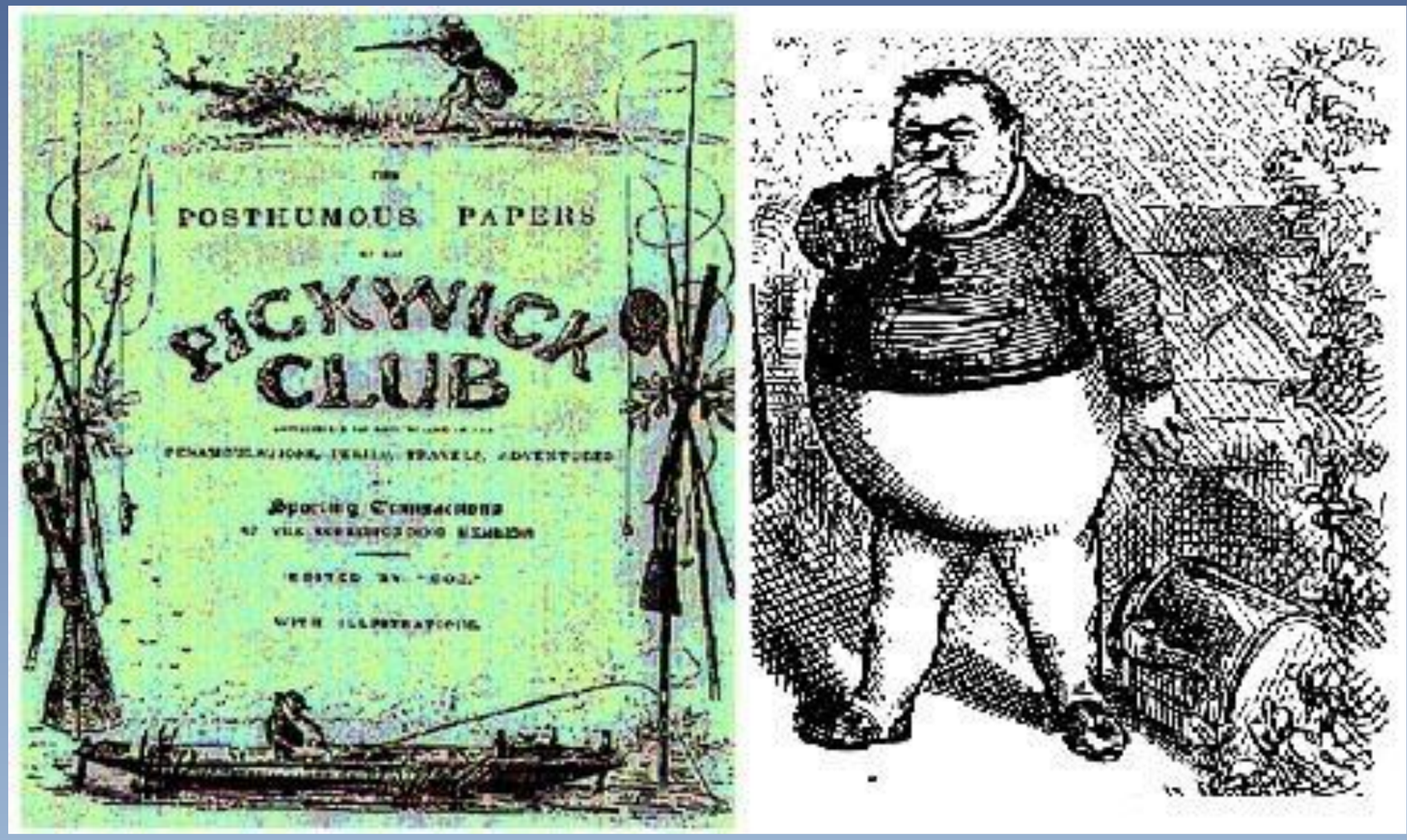
NARRATIVE REVIEW ARTICLE

Obesity and Obesity Hypoventilation, Sleep Hypoventilation, and Postoperative Respiratory Failure

Roop Kaw, MD,* Jean Wong, MD, FRCPC,†‡§ and Babak Mokhlesi, MD‖

Kaw, et al. Anesth Analg 2021; 132:1265

Thank you



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Supplemental Oxygen

40% of patients < 90% SpO_2 during sleep on CPAP/BIPAP

Moderate concentrations of supplemental oxygen worsen hypercapnia in obesity hypoventilation syndrome (randomized crossover study)

- CO_2 increased by 5.0 mmHg (100% O_2 vs room air)
- Decreased minute ventilation by 1.4 L/min

Hollier et al. Thorax 2014;69:346

Obstructive Sleep Apnea

Cessation of breathing for >10 seconds
Total events per hour sleep
Measured in overnight stay at sleep lab with polysomnography

Apnea/Hypopnea index (AHI)

AHI	Rating
<5	Normal
5 to 15	Mild
15 to	Moderate
>30	Severe

14.5 % of the adult US population

Benjafield et al. Lancet Respir Med 2019; 7:687

Obstructive Sleep Apnea

Cessation of breathing for >10 seconds
Total events per hour sleep
Measured in overnight stay at sleep lab with polysomnography

Apnea/Hypopnea index (AHI)

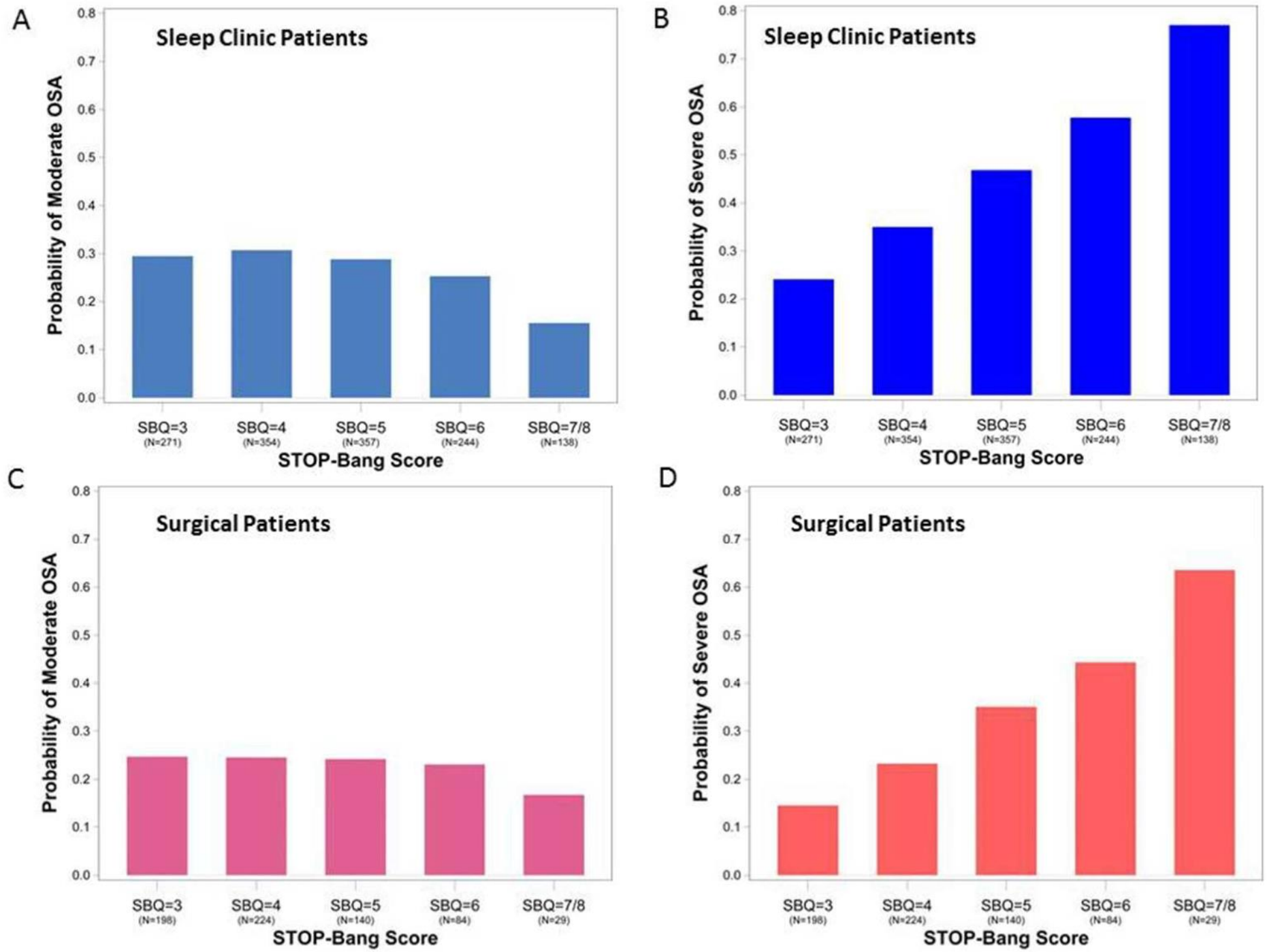
STOP Bang QUESTIONNAIRE

Snoring - *Do you Snore Loudly (loud enough to be heard through closed doors or your bed-partner elbow you for snoring at night)?*	o Yes	o No
Tired - *Do you often feel Tired, Fatigued, or Sleepy during the daytime (such as falling asleep during driving)?*	o Yes	o No
Observed - *Has anyone Observed you Stop Breathing or Choking/Gasping during your sleep?*	o Yes	o No
Pressure - *Do you have or are being treated for High Blood Pressure?*	o Yes	o No
Body Mass Index - *more than 10% over ideal range.*	o Yes	o No
Age - *Older than 50?*	o Yes	o No
Neck Size - *(Measure around Adams apple) Male is your shirt collar 17" or larger? Female, is your shirt collar 16" or larger?*	o Yes	o No
Gender = Male?	o Yes	o No

After you have completed the STOP-BANG questionnaire, please return it to the front desk for a quick risk assessment of possible sleep apnea.

Chung F, et al. Chest 2016; 149:631

Obstructive Sleep Apnea



Chung F, et al. Br J Anaesth 2012; 108: 768-75

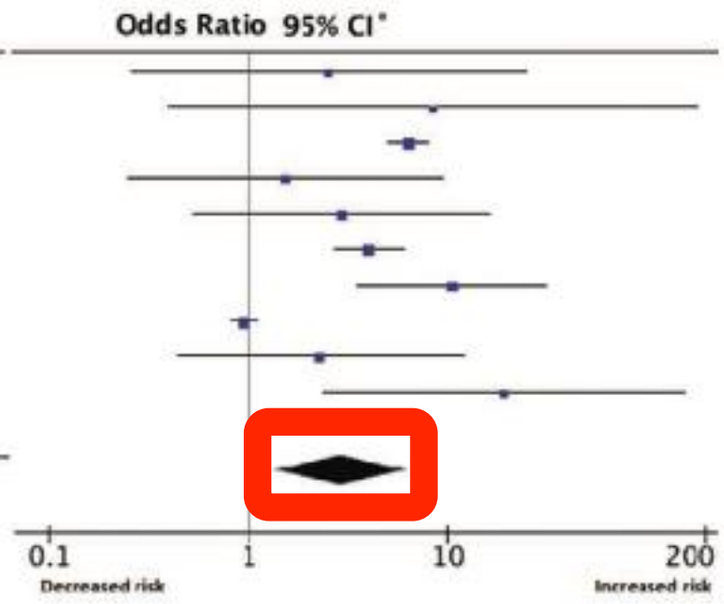
Obstructive Sleep Apnea

A **Postoperative Complications**

Study	STOP-BANG SCORE GROUP High		STOP-BANG SCORE GROUP Low		Weight	Odds Ratio 95% CI
Chudeau2016	3	104	1	85	7.1%	2.50 [0.25, 24.43]
Gokay 2016	2	48	0	78	5.1%	8.44 [0.40, 179.65]
Seet2015	131	485	272	4947	13.9%	6.36 [5.03, 8.04]
Xara2015	3	59	2	59	8.7%	1.53 [0.25, 9.49]
Acar2014	4	83	2	117	9.1%	2.91 [0.52, 16.28]
Carso 2014	41	455	72	2997	13.6%	4.02 [2.70, 5.98]
Proczko2014	17	182	4	412	11.4%	10.51 [3.48, 31.70]
Lockhart2013	324	6226	372	6797	14.0%	0.95 [0.81, 1.10]
Pereira 2013	5	179	2	161	9.3%	2.28 [0.44, 11.94]
Vasu 2010	11	56	1	79	7.8%	19.07 [2.38, 152.58]
Total	541	7877	728	15732	100.0%	
Bayesian Random-Effects with MCMC, 95% Credible Interval						**3.93 [1.85, 7.77]**
D-L Random-Effects						**3.75 [1.57, 8.95]**

Heterogeneity: $Tau^2 = 1.40$; $Chi^2 = 213.57$, df = 9 ($P < 0.00001$); $I^2 = 96\%$

Test for overall effect: $Z = 2.98$ ($P = 0.003$)

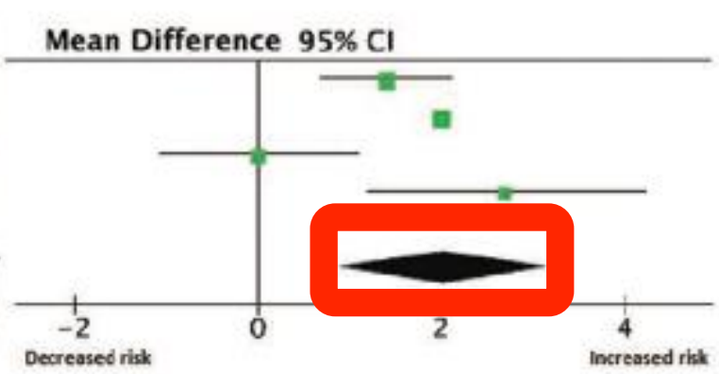


B **Length of Hospital Stay**

Study	STOP-BANG SCORE GROUP High Mean	SD	Total	STOP-BANG SCORE GROUP Low Mean	SD	Total	Weight	Mean Difference 95% CI
Pereira 2013	5	4.5	182	3.6	3	412	27.5%	1.40 [0.68, 2.12]
Proczko2014	4.5	0.5	179	2.5	0.6	161	34.0%	2.00 [1.88, 2.12]
Xara2015	3.6	3	59	3.6	3	59	22.0%	0.00 [-1.08, 1.08]
Chudeau2016	7	6.7	104	4.3	3.7	85	16.5%	2.70 [1.19, 4.21]
Total			524			717	100.0%	
Bayesian Random-Effects with MCMC, 95% Credible Interval								**2.01 [0.77, 3.24]**
D-L Random-Effects								**1.51 [0.66, 2.36]**

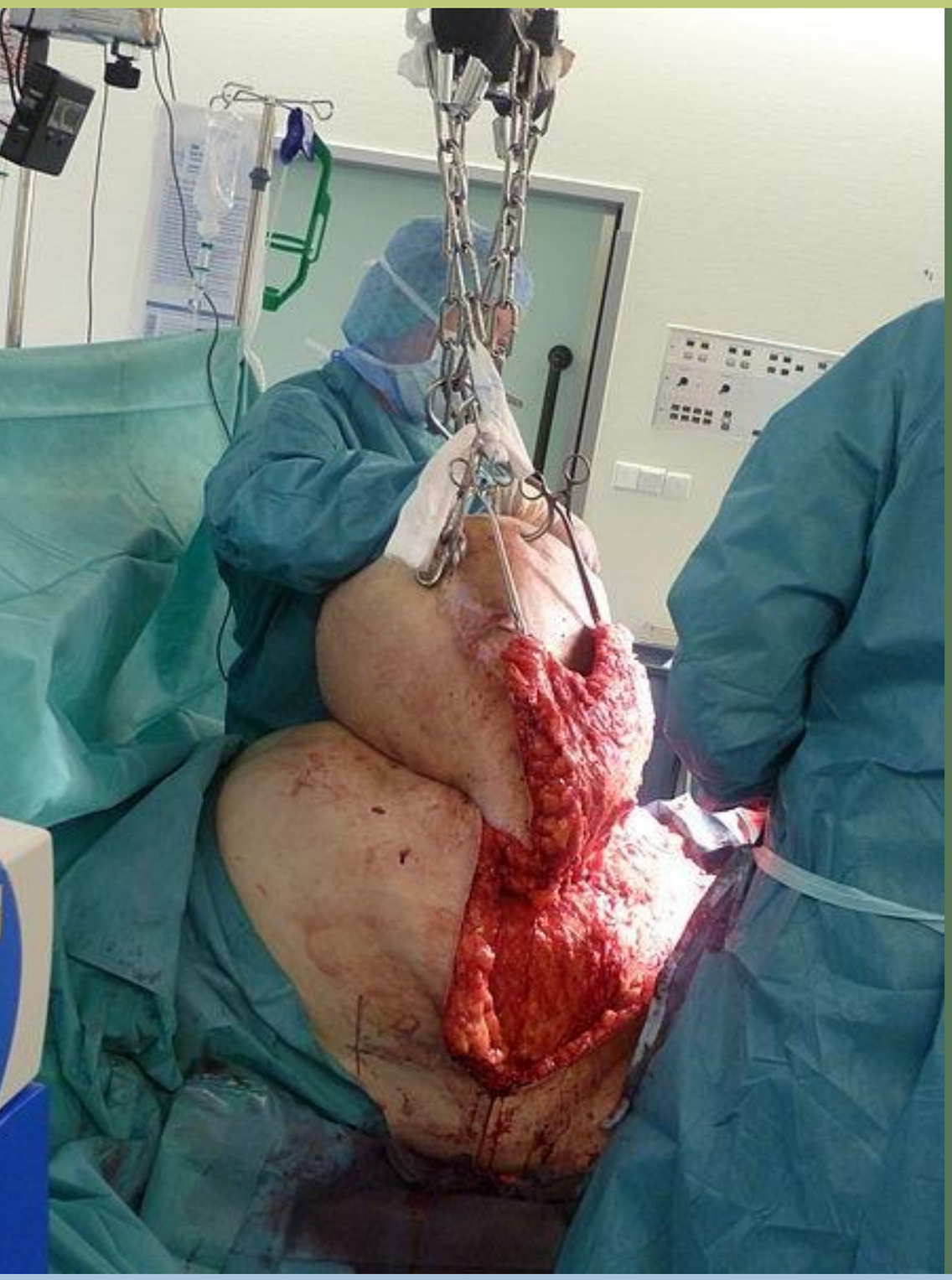
Heterogeneity: $Tau^2 = 0.55$; $Chi^2 = 16.30$, df = 3 ($P = 0.0010$); $I^2 = 82\%$

Test for overall effect: $Z = 3.48$ ($P = 0.0005$)



Nagappa, et al. Anesth Analg 2017; 125:1301

Weight Reduction Surgery



Dramatic reductions in body mass index and apnea- hypopnea index

Average apnea-hypopnea index after surgical weight loss consistent with moderately severe OSA

Greenburg et al. Am J Med 2009; 122: 535

Pharmacologic Respiratory Stimulants

Medroxyprogesterone acetate
Acetazolamide

Acetazolamide improves:

- AHI↓
- PaO_2↑
- $PaCO_2$↓
- Increased hypercapnic drive response

Raurich et al. Respir Care 2010; 55: 1442

PAP Therapy

Ventilator settings:

- CPAP titration to effect
- If patient intolerant to high CPAP levels, switch to BIPAP
- Inspiratory PAP 16-18 cm H_2O
- Expiratory PAP 9-10 cm H_2O

Mokleshi et al.,American J Respire Crit Care Med, 2019;200:e6–e24

Advanced Modes of Non-Invasive Positive PressureVentilation

CPAP

- Auto-adjusting PAP

BIPAP

- Auto-titrating BIPAP (IPAP/EPAP adjusted)
- Adaptive Servo-Ventilation (IPAP adjusted)
- Volume assured Pressure Support (IPAP adjusted)

Ryden, et al. Semin Respir Crit Care Med 2014;35:593

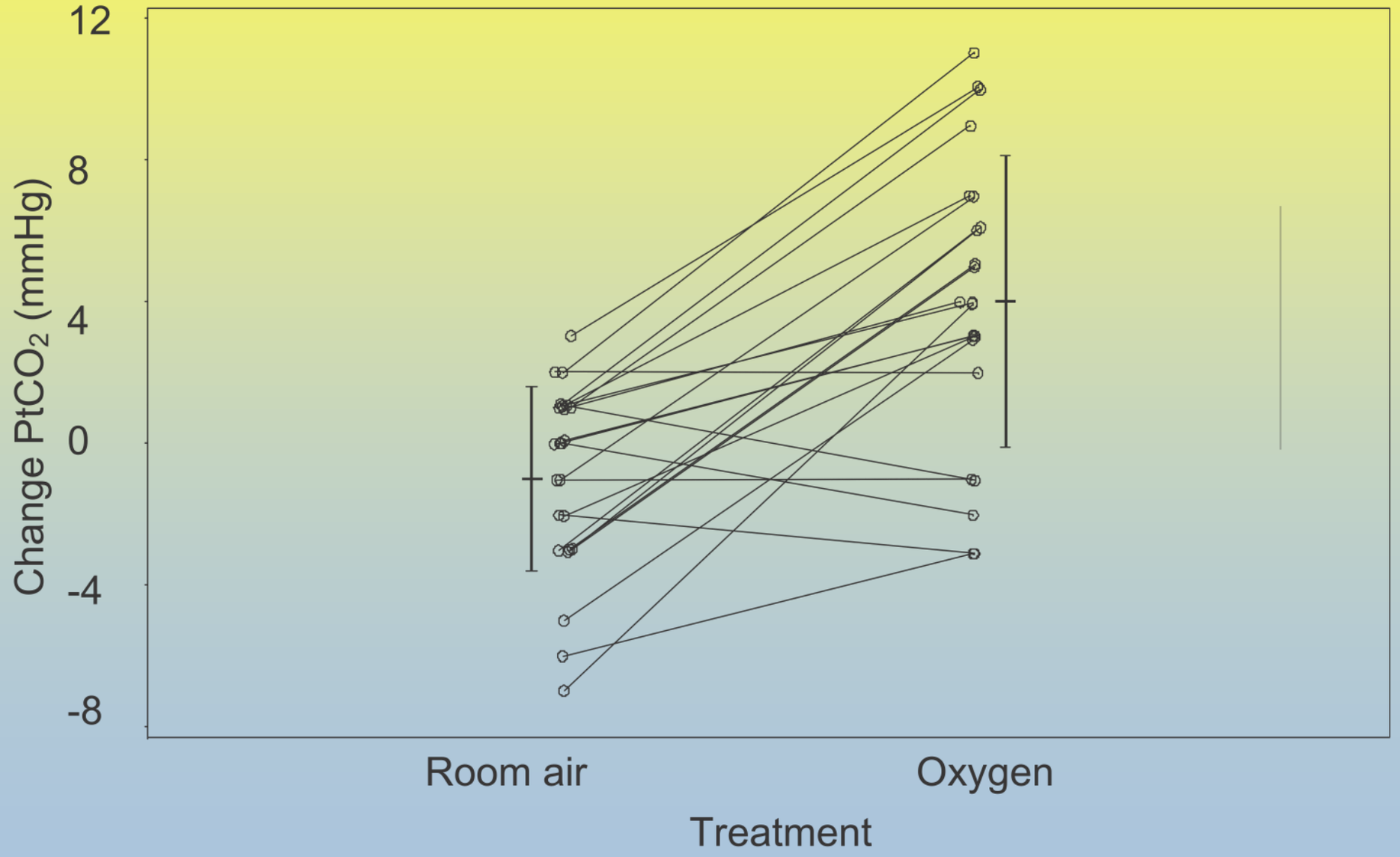
Supplemental Oxygen

40% of patients < 90% SpO_2 during sleep on CPAP/BIPAP

Banerjee et al. Chest 2007; 131: 1678
Hollier et al. Thorax 2014;69:346

Supplemental Oxygen

40% of patients < 90% SpO_2during sleep on CPAP/BIPAP



Wijesinghe, et al. Chest 2011; 139: 1018