2nd INTERNATIONAL PEDIATRIC NONINVASIVE VENTILATION CONFERENCE
November 3rd & 4th 2016

High flow nasal cannula for OSAS

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High flow nasal cannula for OSAS in children

Why should we use it?

How does it work?

Does it work in OSAS?

Treatment of pediatric OSAS

WHO

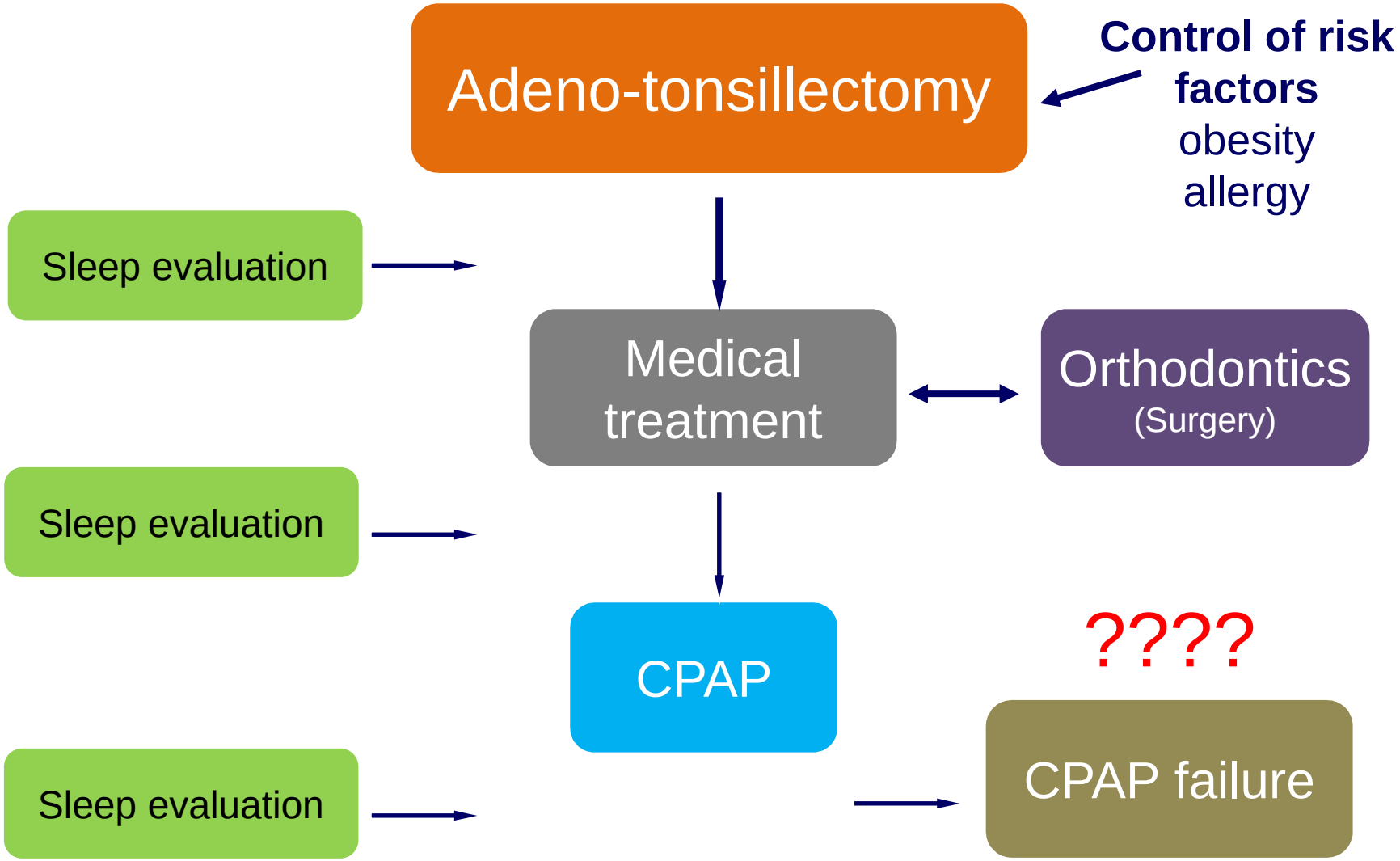
Every child with an AHI > 5/h irrespective of the presence of morbidity,
Or AHI between 1-5/h + comorbidities (cardiovascular, neurological)

HOW

A stepwise treatment approach, tailored on the severity of OSAS and on the presence of underlying diseases/comorbidity

n.b. OSAS treatment is a priority in the presence of: major craniofacial abnormalities; neuromuscular disorders; achondroplasia; Down syndrome; mucopolysaccharidoses; Prader Willi syndrome...

Stepwise treatment approach



Predictors of Positive Airway Pressure Therapy Adherence in Children: A Prospective Study

Natalie DiFeo[1]; Lisa J. Meltzer, Ph.D.[2]; Suzanne E. Beck, M.D., F.A.A.S.M.[1]; Laurie R. Karamessinis[1]; Mary Anne Cornaglia[1]; Joel Traylor[1]; John Samuel[1]; Paul R. Gallagher, M.A.[3]; Jerilynn Radcliffe, Ph.D.[3]; Heidi Beris, B.S.N.[1]; Mary Kate Menello, B.S.N.[1]; Carole L. Marcus, M.B.B.Ch., F.A.A.S.M.[1]

Journal of Clinical Sleep Medicine, Vol. 8, No. 3, 2012

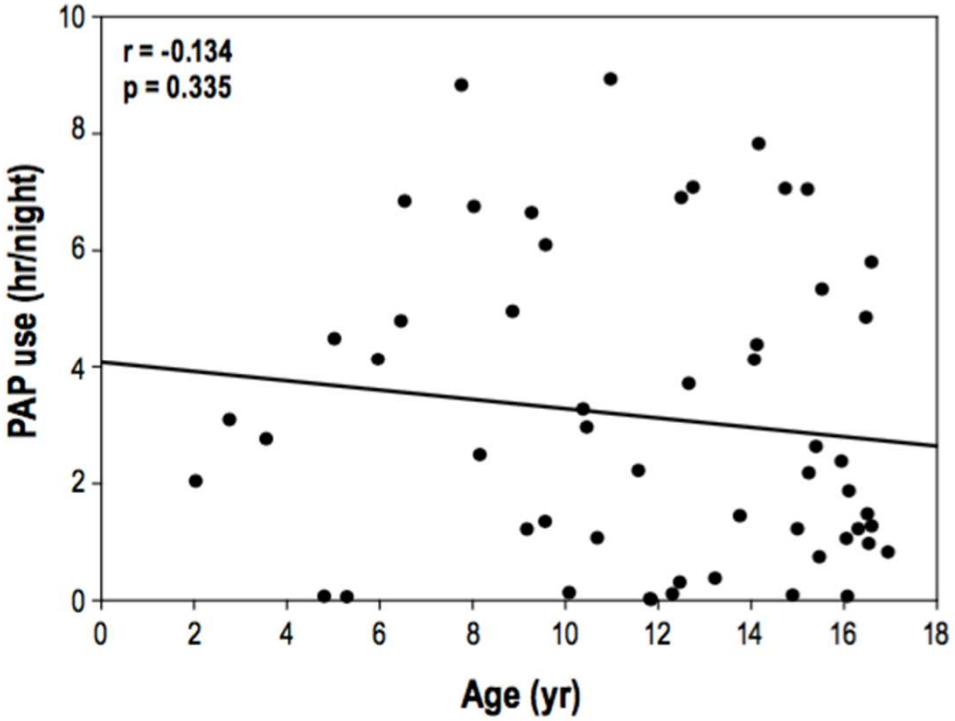
Table 2—Study group

N	56
Age (yr)	12 ± 4
Range	2–16
Males	38 (68)
Race	
African American	33 (59)
Caucasian	20 (36)
More than one race	3 (5)
Hispanic ethnicity	5 (9)
Obese[a]	40 (71)
Other diagnoses[a]	
Genetic syndrome	11 (20)
Central nervous system abnormality	6 (11)
Craniofacial syndrome	3 (5)
Pulmonary disease	3 (5)
Growth hormone deficiency	1 (2)
Neurodevelopmental disability[a]	13 (23)

Low compliance !

mean CPAP use 3 ±3h/night

Figure 3—Correlation between positive airway pressure use and age for month-1



The correlation between mean nightly positive airway pressure (PAP) use and age is shown for month-1. There was no significant correlation.

No correlation between age and CPAP compliance

Factors influencing CPAP compliance

Table 3—Multiple linear regression model results, controlling for positive airway pressure mode (mode forced into the model at step 1)

Independent variable	Unstandardized β coefficient	SE	β coefficient p value	Change in R^2	p-value for change in R^2	Overall R^2	Overall p value
Outcome = Nights Used, Month 1							
Constant	-3.157	7.507	0.676			–	–
PAP mode	1.859	2.479	0.457	0.006	0.585	–	–
Maternal education	3.480	1.026	0.001	0.197	0.001	0.203	0.005
Outcome = Nights Used, Month 3							
Constant	-4.367	6.289	0.491			–	–
PAP mode	-1.412	2.690	0.602	0.006	0.597	–	–
MOSS	5.466	1.399	< 0.0005	0.252	< 0.0005	0.258	0.001
Outcome = Mean Nightly Use (hours/night), Month 1							
Constant	2.442	0.490	< 0.0005			–	–
PAP mode	-0.066	0.840	0.938	0.001	0.831	–	–
Race[a]	1.943	0.732	0.011	0.130	0.011	0.131	0.037
Outcome = Mean Nightly Use (hours/night), Month 3							
Constant	2.707	0.470	< 0.0005			–	–
PAP mode	-1.229	0.870	0.165	0.030	0.240	–	–
Developmental delay[b]	2.401	0.927	0.013	0.126	0.013	0.156	0.022

The unstandardized regression coefficient (β), standard error (SE) of the coefficient, p value of the coefficient, change in R^2 and its p-value as a result of the addition of the new predictor, overall R^2 for the entire model and overall p value for the model are shown for each adherence outcome. Note that the unstandardized regression coefficient (β) reflects the change in the outcome per unit change in the predictor variable. PAP, positive airway pressure. [a]Coded 0 = African American, 1 = other. [b]Coded 0 = No, 1 = Yes.

Sleep Medicine 14 (2013) 1290–1294

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journal homepage: www.elsevier.com/locate/sleep

Original Article

Continuous positive airway pressure and noninvasive ventilation adherence in children

Adriana Ramirez [a,b], Sonia Khirani [b,c], Sabrina Aloui [b], Vincent Delord [d], Jean-Christian Borel [e,f], Jean-Louis Pépin [f,g], Brigitte Fauroux [b,h,i,*]

	Total population ($N = 62$)	Nasal mask ($n = 38$)	Facial mask ($n = 14$)	Nasal cannula ($n = 10$)	*P* value
Underlying disease (n, %)					
OSA	51 (82%)	33	14	4	
Lung disease	5 (8%)	4	0	1	
Neuromuscular disease	6 (10%)	1	0	5	
Gender (female/male)	26/36	12/26	9/5	5/5	
Age (y)	10.0 ± 4.7	7.6 ± 4.0[§]	11.8 ± 4.6	15.0 ± 3.0	<.001
Weight (kg)	31.0 ± 21.0	25.6 ± 20.5[§]	41.9 ± 16.5	47.0 ± 13.4	<.001
CPAP and NIV adherence over the last month					
Average use per night (h:min)	8:17 ± 2:30	8:17 ± 2:16	8:12 ± 3:17	8:23 ± 2:44	.858
Number of patients using treatment >8 h/night (*n*, %)	45 (72%)	25 (65%)	12 (86%)	8 (80%)	.183
Average nights use (*n*)	26 ± 5	27 ± 4	23 ± 8	28 ± 7	.122
Nocturnal gas exchange with CPAP or NIV					
Mean SpO_2 (%)	97 ± 2	97 ± 2	97 ± 3	97 ± 2	.985
Minimal SpO_2 (%)	91 ± 2	91 ± 4	92 ± 2	90 ± 4	.328
% of night time with a SpO_2 <90% (%)	0.3 ± 1.3	0.5 ± 1.7	0.0 ± 0.0	0.0 ± 0.0	.233
4% Desaturation index (events/h)	4 ± 5	5 ± 7	3 ± 3	4 ± 3	.936
Mean $PtcCO_2$ (mmHg)	39 ± 5	39 ± 5	38 ± 3	41 ± 7	.270
Maximal $PtcCO_2$ (mmHg)	45 ± 5	45 ± 5	42 ± 4	48 ± 5[*]	.020
Percent of night time with a $PtcCO_2$ >50 mmHg (%)	1.4 ± 6.3	0.4 ± 2.0	0.0 ± 0.0	8.1 ± 15.2[#]	.016

Weaning of PPC/VNI
59 patients (25%) during 27 months

Age at CPAP/NIV initiation (median), yrs	1.4
CPAP / NIV	51 (86%) / 8 (14%)
Duration of CPAP / NIV (median), yrs	1 / 4
Diagnosis	Laryngeal disease 8 Prader Willi sd 6 Bronchopulmonary dysplasia 6 Treacher Collins 6 Pierre Robin sd 5 Polymalformative sd 5 Idiopathic OSA 5 Achondroplasia 3 Crouzon, Apert 2 Pycnodysostosis 2 Mucoplysaccharidosis 2 Goldenhar sd 1 Other 6
Reason of withdrawal	Improvement 75%**:** spontaneous 2/3, after surgery 1/3 Non compliant, poor tolerance: 25%

IDEAS AND INNOVATIONS

Continuous Positive Airway Pressure for Upper Airway Obstruction in Infants with Pierre Robin Sequence

Amaddeo *et al*. Plastic and Reconstructive Surgery, 2016;137:609

Neonates with PRS evaluated over one year
n=44

Neonates seen as outpatients
n=7

No UAO group

Neonates hospitalized
n=37

No clinical UAO
n=17

No UAO group

Clinical UAO
n=20

Severe clinical UAO
n=9

Immediate CPAP in the NICU

Severe UAO group

Moderate clinical UAO
n=11

Sleep study with gas exchange

Tracheotomy
n=4

CPAP
n=5

Abnormal sleep study
CPAP, n=4

Moderate UAO group

Normal sleep study
n=7

Mild UAO group

Amaddeo *et al*.
Plastic and Reconstructive Surgery, 2016;137:609

Limitations of CPAP

- CPAP is an effective treatment for OSAS but:
  - patients do not tolerate (interface...
  - patients are not compliant: intellectual disability, default of family structure...
  - patients may have too severe OSAS: CPAP dependance > ~ 18/24h
- Therapeutic options ?
  - Surgery: tracheostomy, mandibular distraction...
  - Tolerate OSAS despite associated morbidity
  - …High Flow ?

High flow nasal cannula for OSAS in children

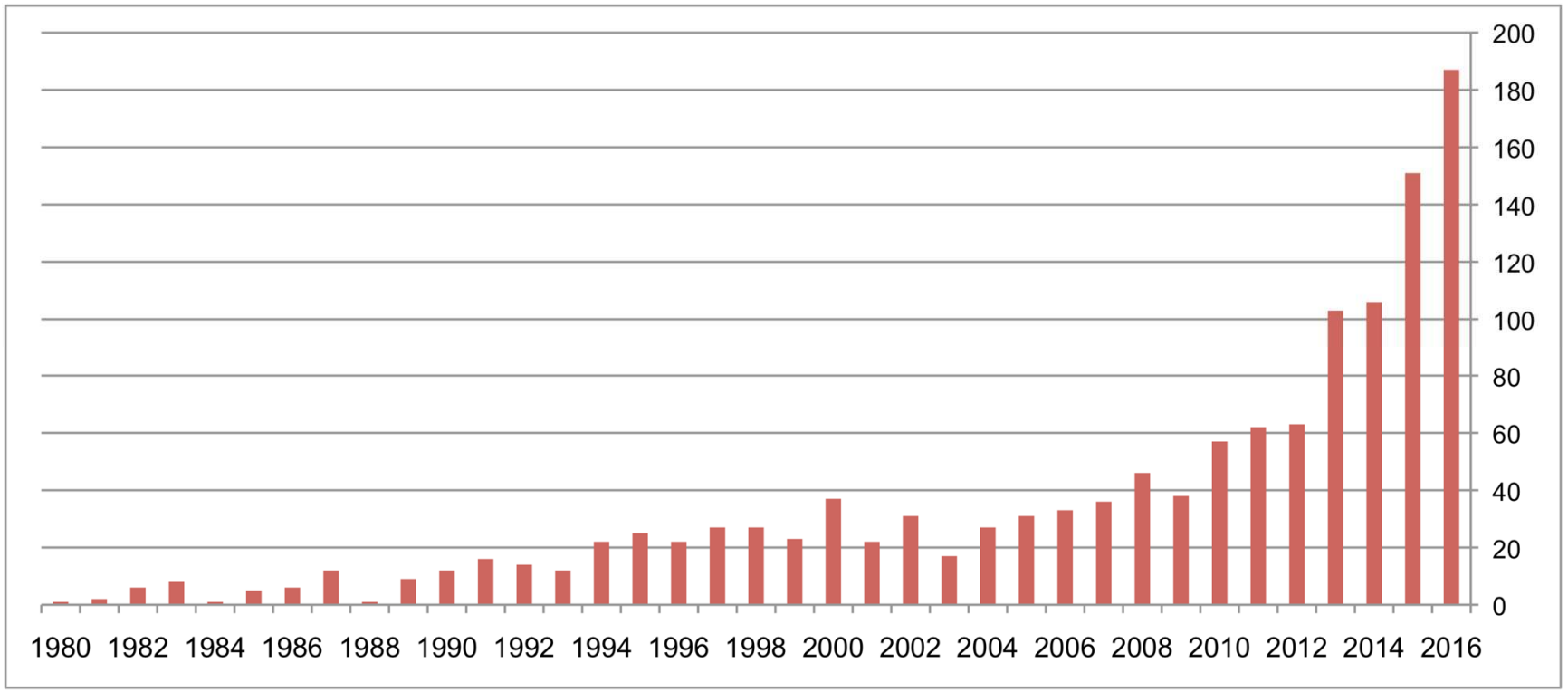
Why should we use it?

How does it work?

Does it work in OSAS?

High flow nasal cannula: a growing (hot) topic

Pubmed citations



N Engl J Med. 2016 Sep 22;375(12):1142-51. doi: 10.1056/NEJMoa1603694.

Nasal High-Flow Therapy for Primary Respiratory Support in Preterm Infants.

Roberts CT[1], Owen LS[1], Manley BJ[1], Frøisland DH[1], Donath SM[1], Dalziel KM[1], Pritchard MA[1], Cartwright DW[1], Collins CL[1], Malhotra A[1], Davis PG[1]; HIPSTER Trial Investigators.

Cochrane Database Syst Rev. 2016 Feb 22;2:CD006405. doi: 10.1002/14651858.CD006405.pub3.

High flow nasal cannula for respiratory support in preterm infants.

Wilkinson D[1], Andersen C, O'Donnell CP, De Paoli AG, Manley BJ.

N Engl J Med. 2015 Jun 4;372(23):2185-96. doi: 10.1056/NEJMoa1503326. Epub 2015 May 17.

High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure.

Frat JP[1], Thille AW, Mercat A, Girault C, Ragot S, Perbet S, Prat G, Boulain T, Morawiec E, Cottereau A, Devaquet J, Nseir S, Razazi K, Mira JP, Argaud L, Chakarian JC, Ricard JD, Wittebole X, Chevalier S, Herbland A, Fartoukh M, Constantin JM, Tonnelier JM, Pierrot M, Mathonnet A, Béduneau G, Delétage-Métreau C, Richard JC, Brochard L, Robert R; FLORALI Study Group; REVA Network.

High flow nasal cannula for OSAS


F&P Optiflow
junior
Nasal Cannula
F&P Optiflow
junior
Nasal Cannula
NEONATAL
F&P Optiflow
junior
Nasal Cannula
QTY: 1 ea UOM: EA
INFANT
F&P Optiflow
junior
Nasal Cannula
QTY: 1 ea UOM: EA
PEDIATRIC

L

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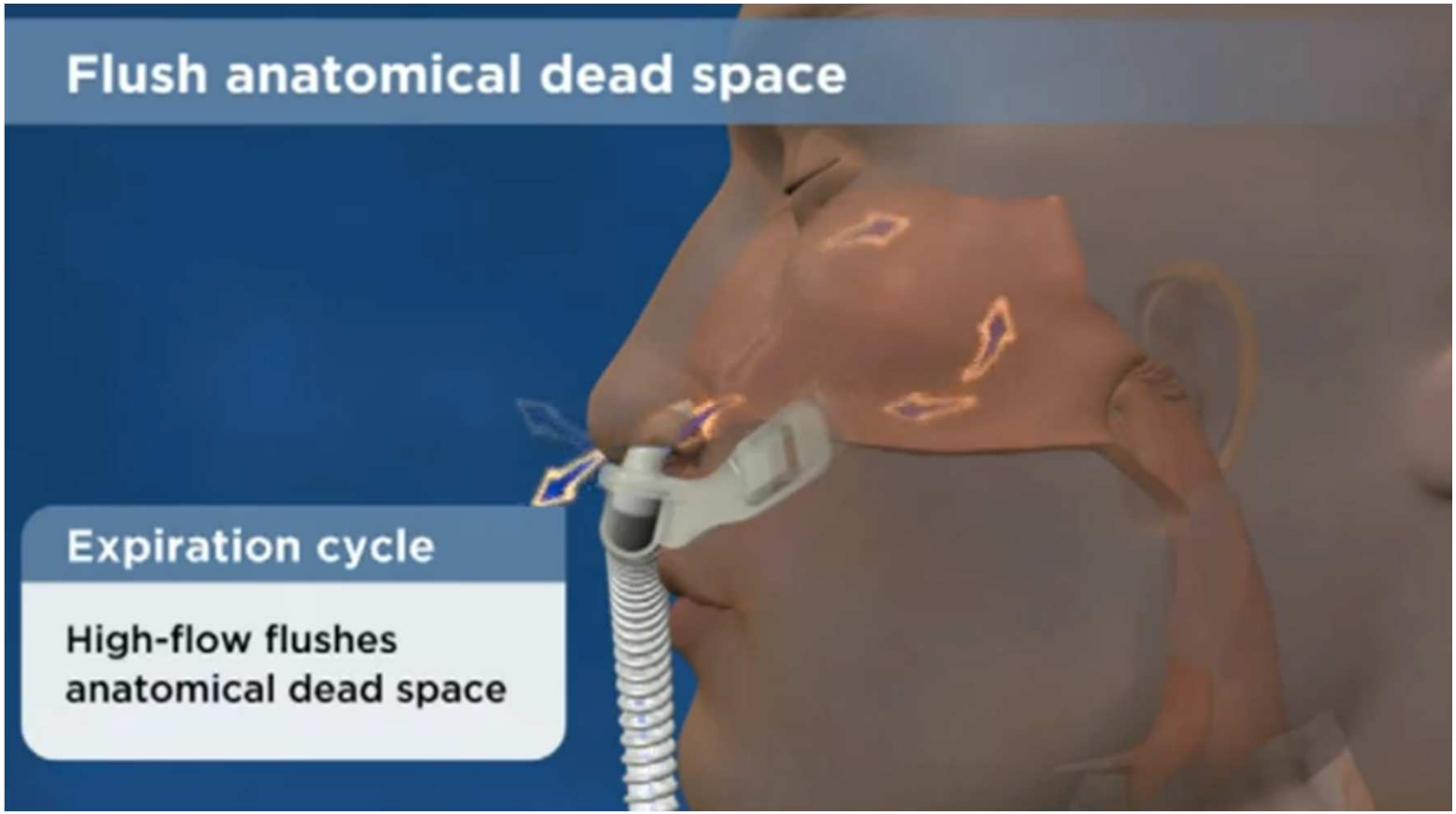
S

HFNC: how does it work?

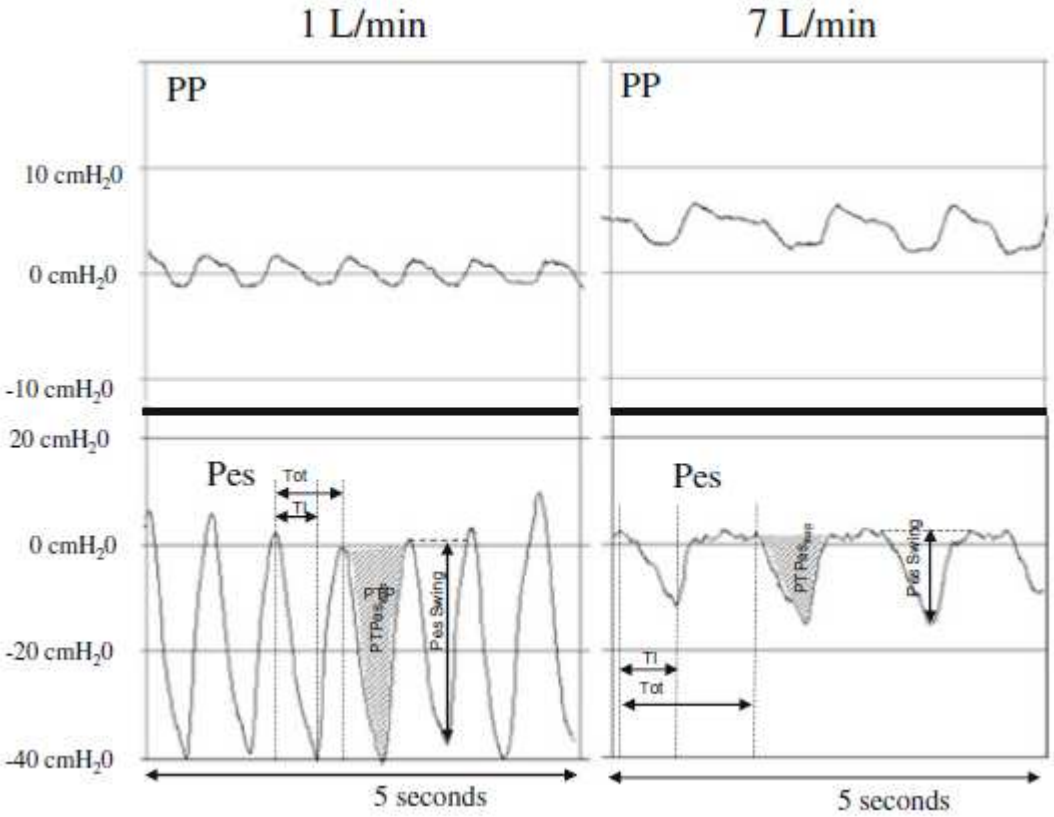
Washout of nasopharyngeal and intrapulmonary dead space through continual gas removal during expiration (enhance CO_2 removal) *Nahum Resp Care Clinic 2002*



HFNC: how does it work?

Reduction of inspiratory resistance (work of breathing)

BE de Jongh, J Perinatol. 2014; Pham TM, Pediatr Pulmonol. 2014

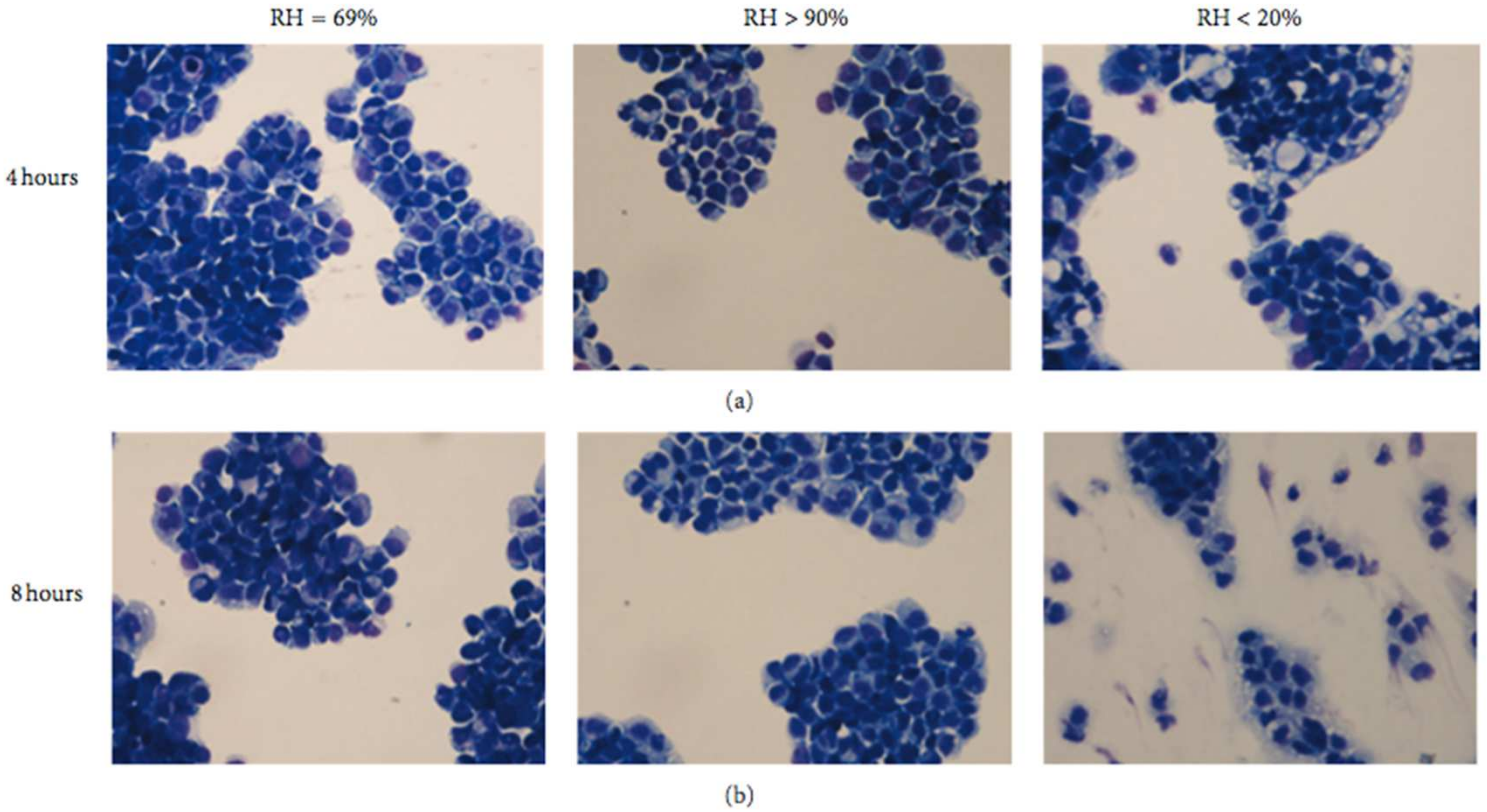


Is treatment with a high flow nasal cannula effective in acute viral bronchiolitis? A physiologic study

Intensive Care Med
DOI 10.1007/s00134-013-2879-y

HFNC: how does it work?

Improve mucociliary clearance (by providing warm and humidified gas) *Chidekel et al, Pulm Med 2012*



HFNC: how does it work?

Provide support pressure *Arora B, Pediatr Emerg Care*

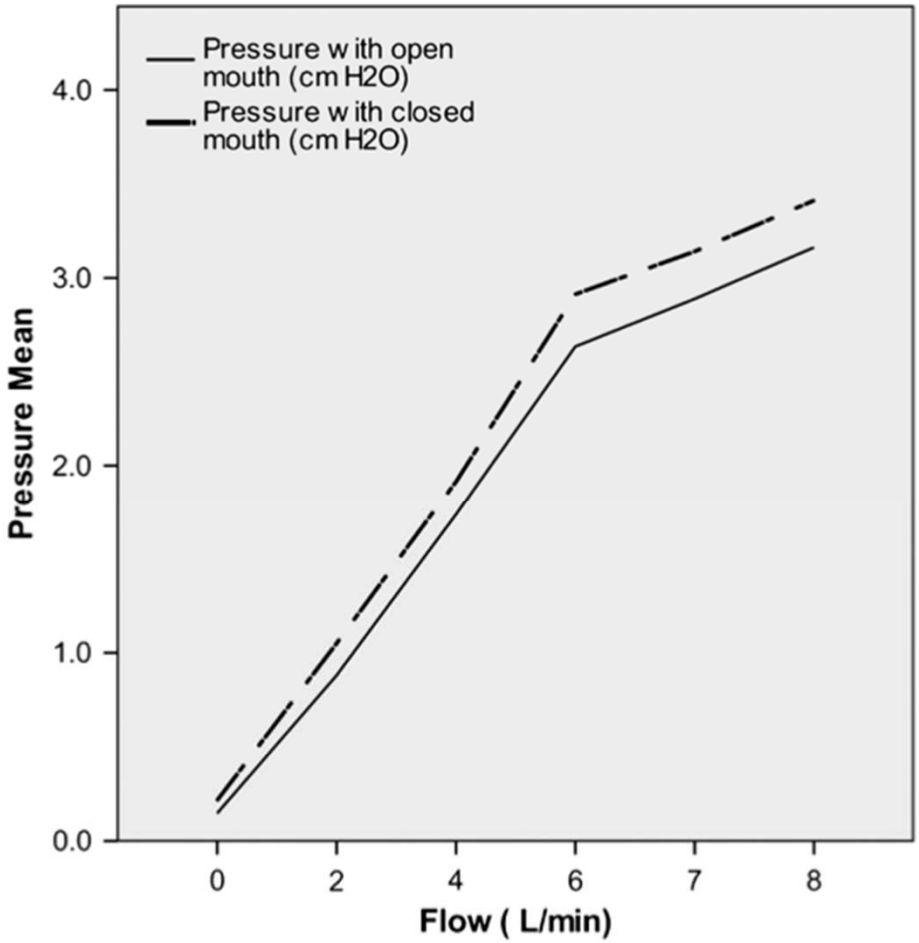


FIGURE 3. Mean pressure at different flow rates for open- and closed-mouth states.

Nasopharyngeal Airway Pressures in Bronchiolitis Patients Treated With High-Flow Nasal Cannula Oxygen Therapy

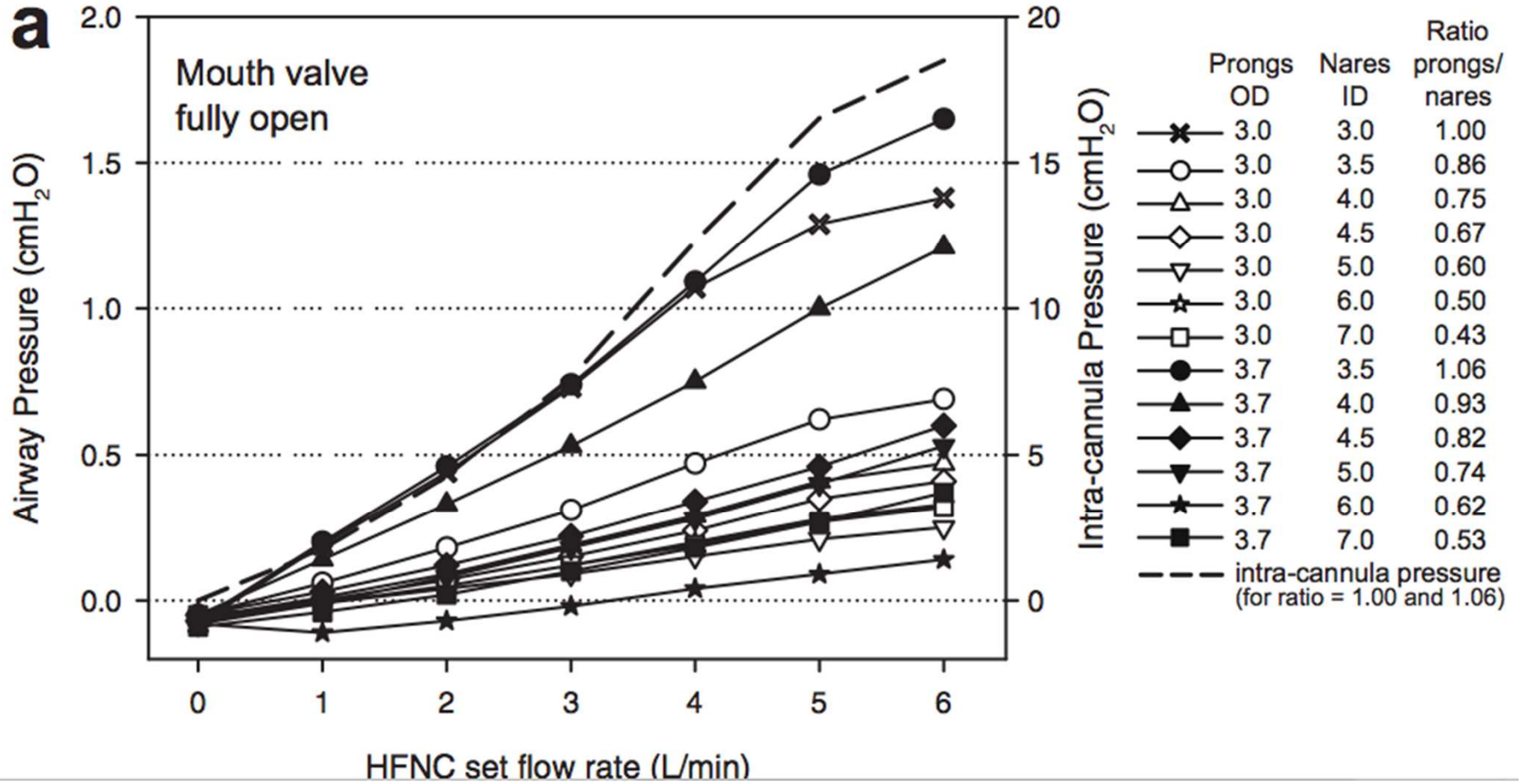
Bhawana Arora, MD, Prashant Mahajan, MD, MPH, MBA,*† Marwan A. Zidan, PhD,‡ and Usha Sethuraman, MD†*

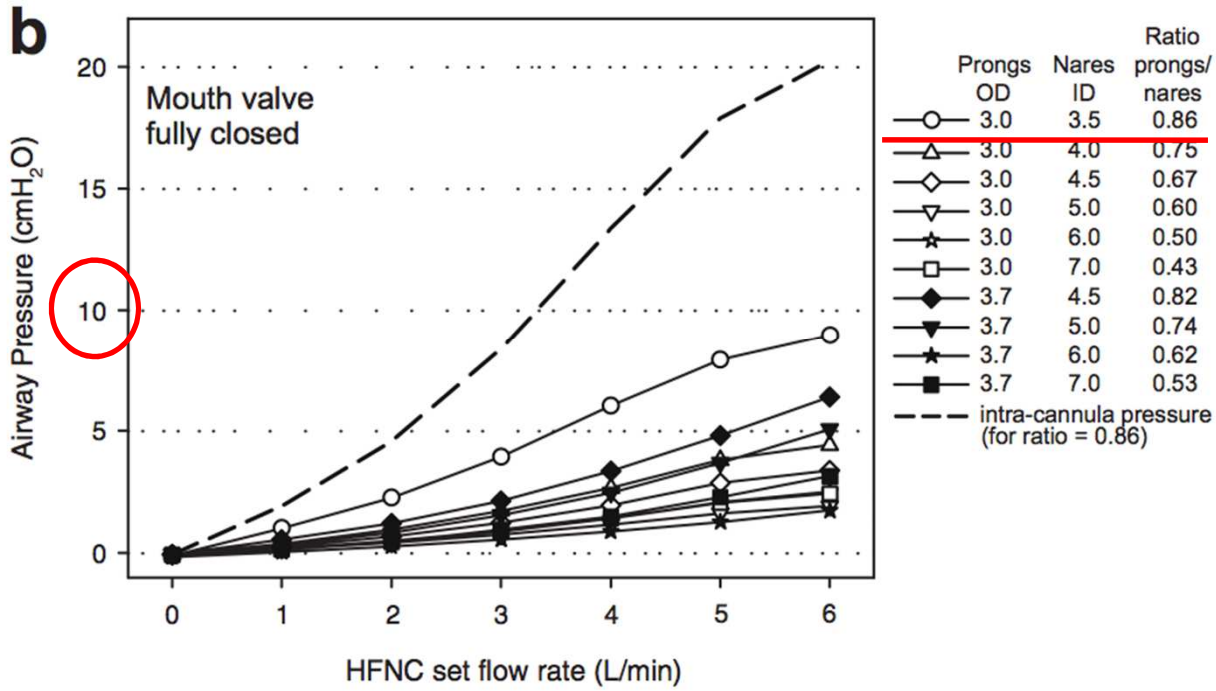
Pediatric Emergency Care • Volume 28, Number 11, November 2012

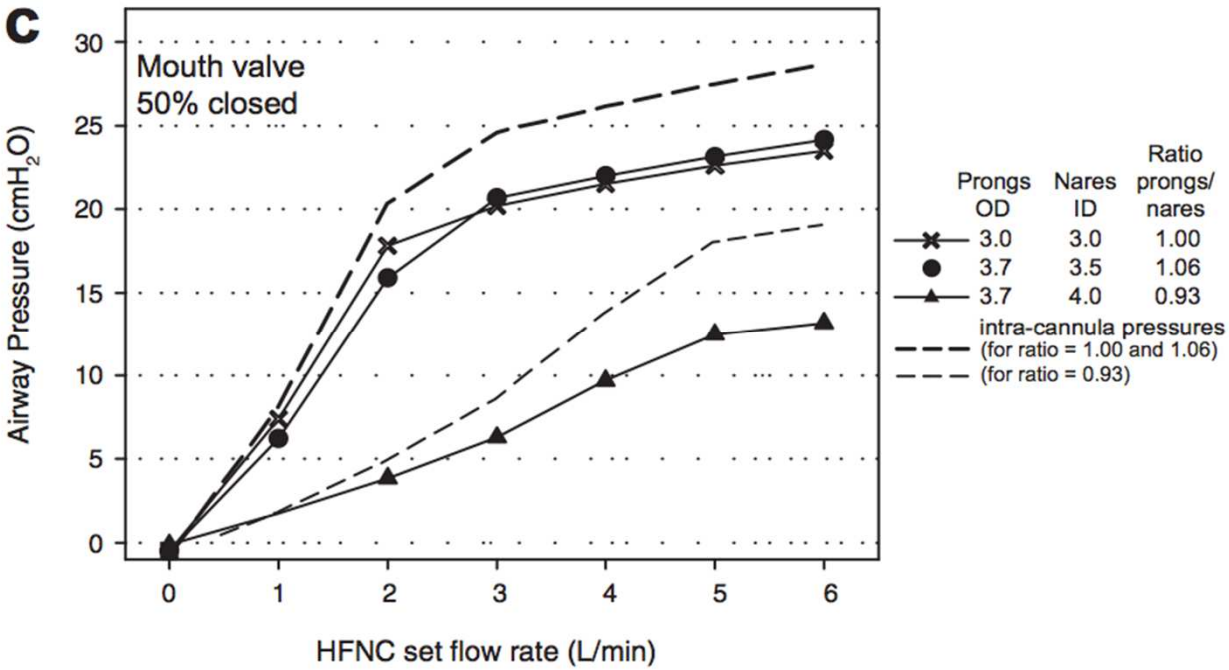
Effect of HFNC Flow Rate, Cannula Size, and Nares Diameter on Generated Airway Pressures: An In Vitro Study

Emidio M. Sivieri, MS.E,[1,2] Jeffrey S. Gerdes, MD,[1,2,3] and Soraya Abbasi, MD[1,2,3]*

Pediatric Pulmonology 48:506–514 (2013)





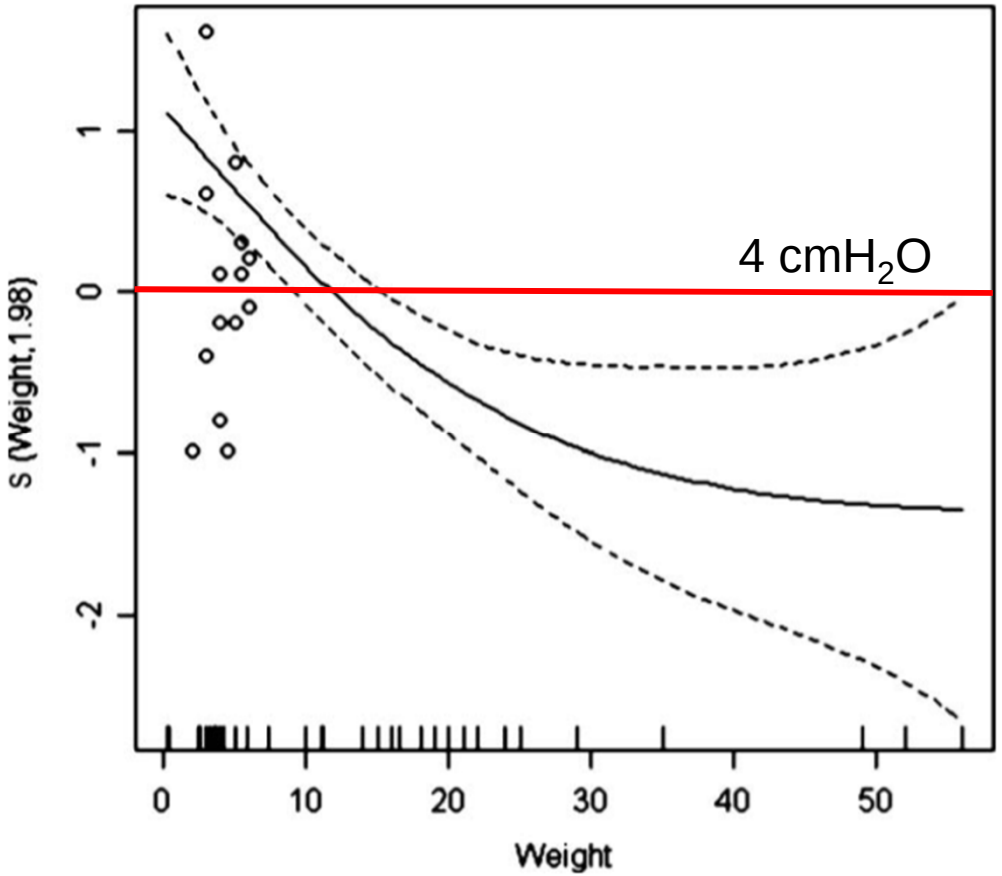


When mouth leaks are reduced a prongs/nares > 0.9 may dramatically increase the delivered pressure

Children With Respiratory Distress Treated With High-Flow Nasal Cannula

Thomas Spentzas, MD, MSc, Milan Minarik, MD, Andrea B. Patters,
Brett Vinson, CRT, LRCP, and Greg Stidham, MD

Journal of Intensive Care Medicine / Vol. 24, No. 5, September/October 2009



End expiratory airway pressure changes during HFNC from the mean airway pressure (4 ± 1.9 cmH_2O)

All patients had a positive end-expiratory pressure, with a direct relation between weight and pressure drop

High flow nasal cannula for OSAS in children

Why should we use it?

How does it work?

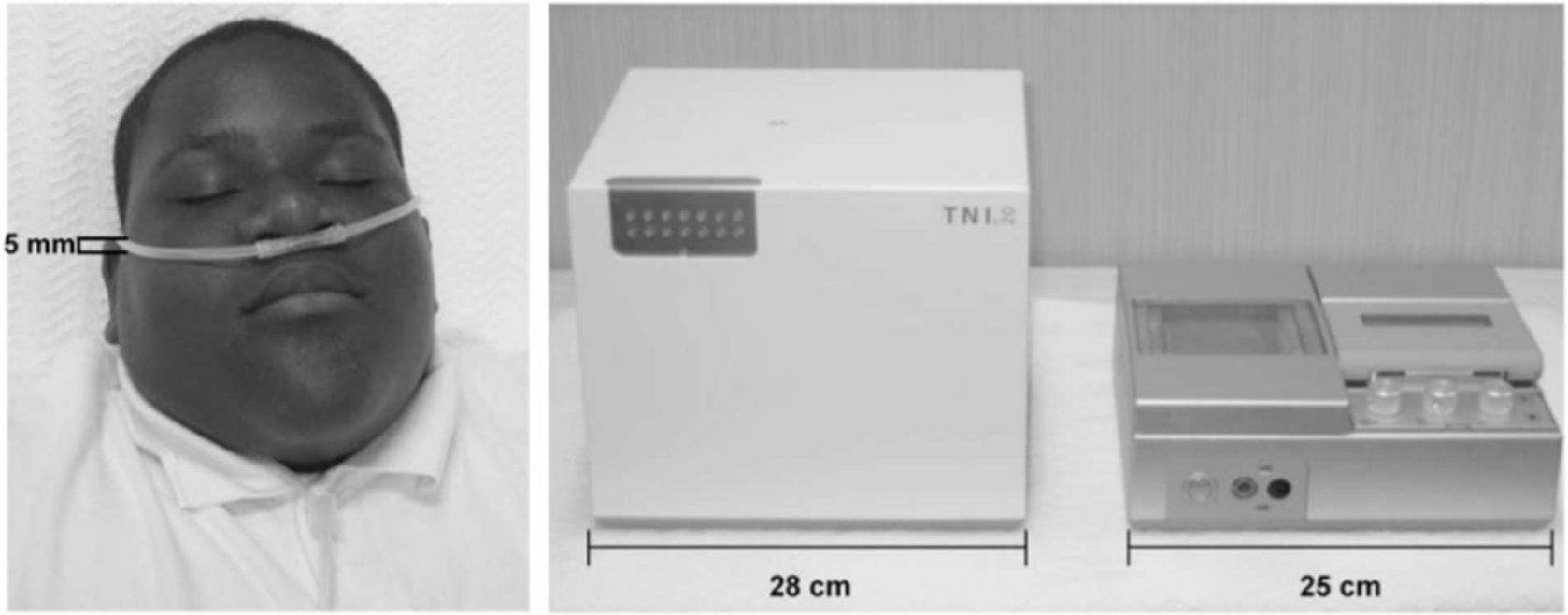
Does it work in OSAS?

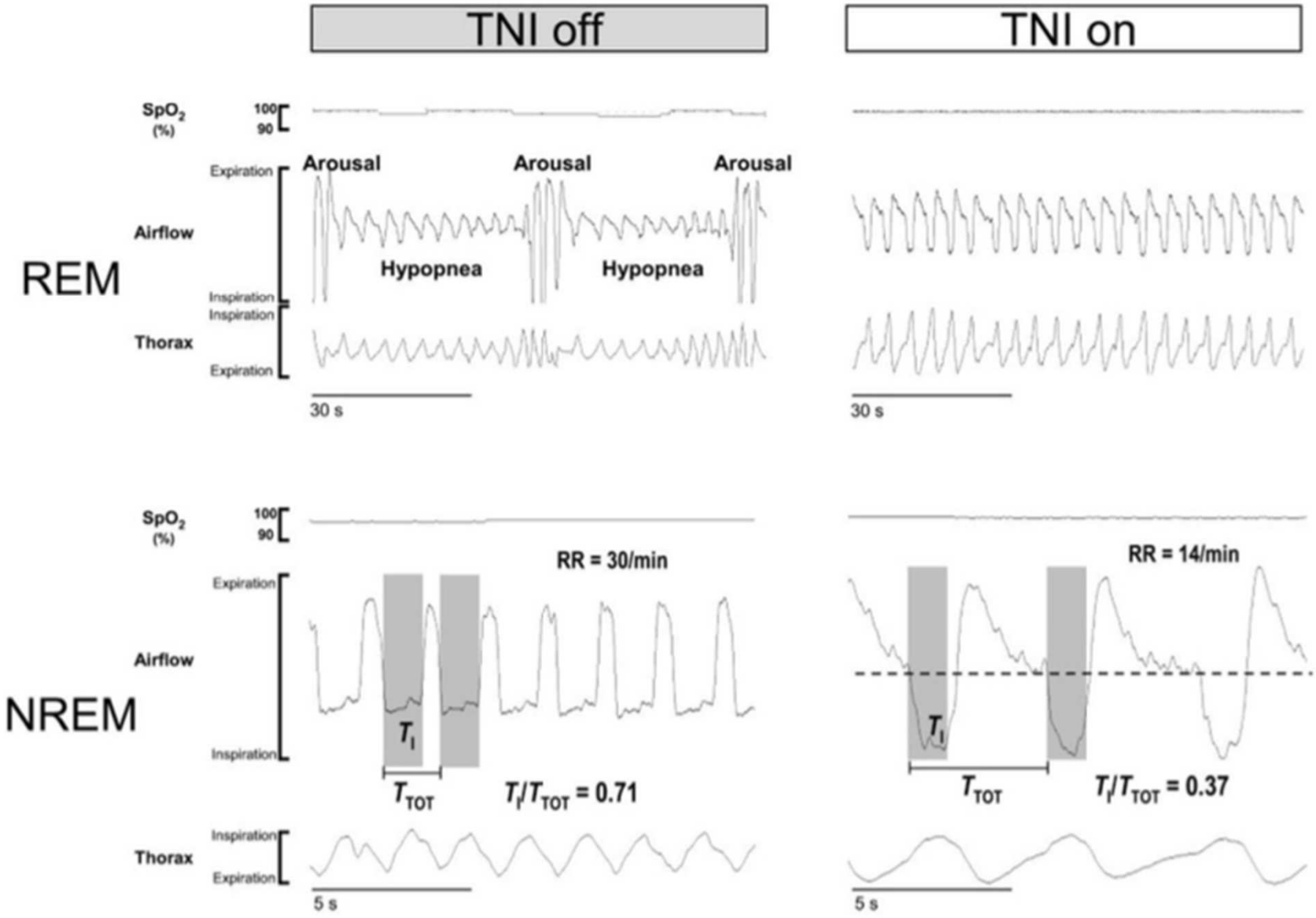
Effect of a High-Flow Open Nasal Cannula System on Obstructive Sleep Apnea in Children

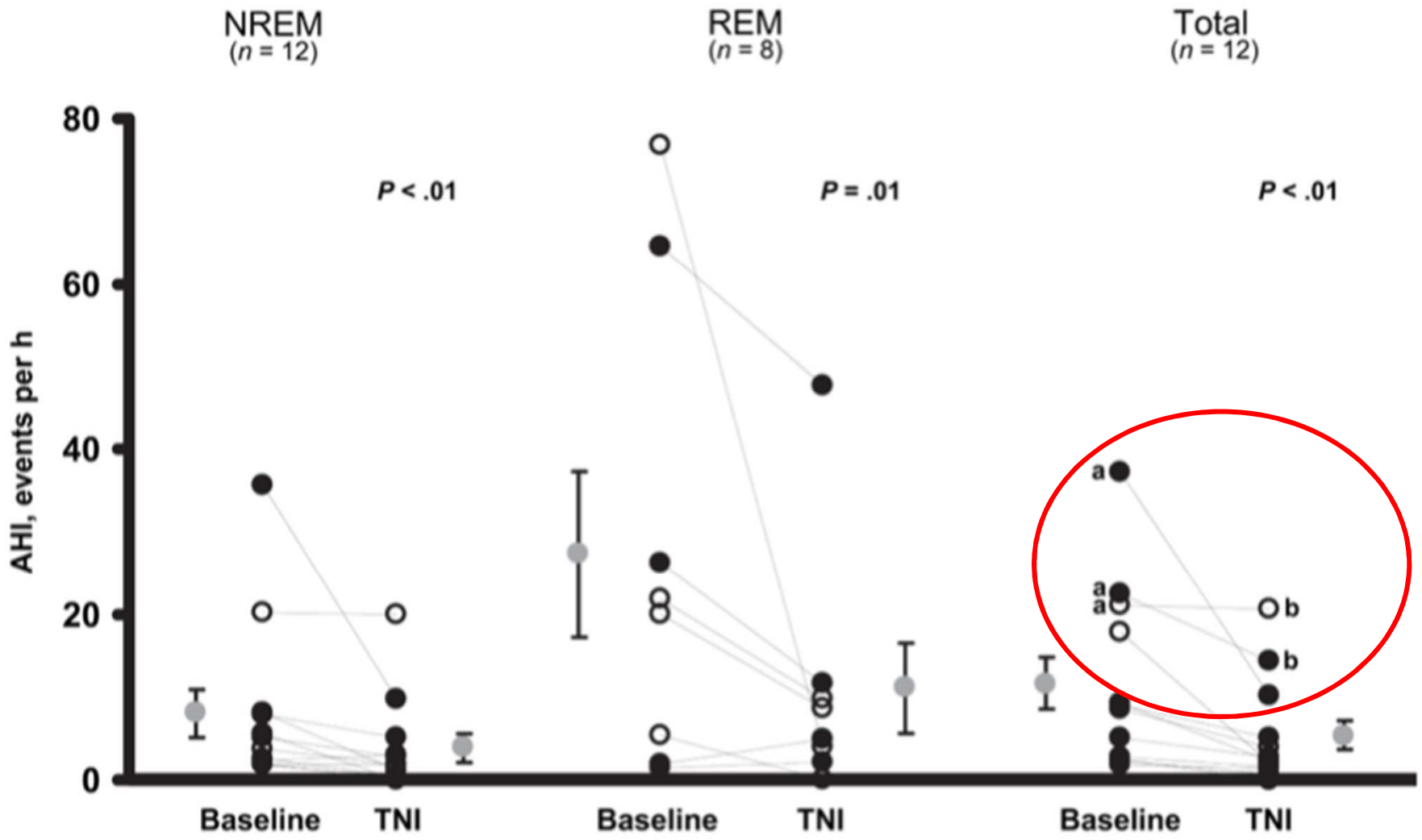
Brian McGinley, MD[a], Ann Halbower, MD[b], Alan R. Schwartz, MD[c], Philip L. Smith, MD[c], Susheel P. Patil, MD, PhD[c], and Hartmut Schneider, MD, PhD[c]

Pediatrics. 2009 July ; 124(1): 179–188. doi:10.1542/peds.2008-2824.

12 children, age 10±2 years, with OSAS + mean BMI of 35 ± 14 kg/m^2
One night titration study with a high flow cannula system




TNI off
TNI on
REM
NREM
SpO2 (%)
100
90
Arousal
Arousal
Arousal
Hypopnea
Hypopnea
Expiration
Airflow
Inspiration
Inspiration
Thorax
Expiration
30 s
30 s
RR = 30/min
RR = 14/min
TI
TTOT
TI/TTOT = 0.71
TI/TTOT = 0.37
5 s
5 s


NREM
(n = 12)
REM
(n = 8)
Total
(n = 12)
P < .01
P = .01
P < .01
AHI, events per h
80
60
40
20
0
a
a
a
b
b
Baseline
TNI
Baseline
TNI
Baseline
TNI

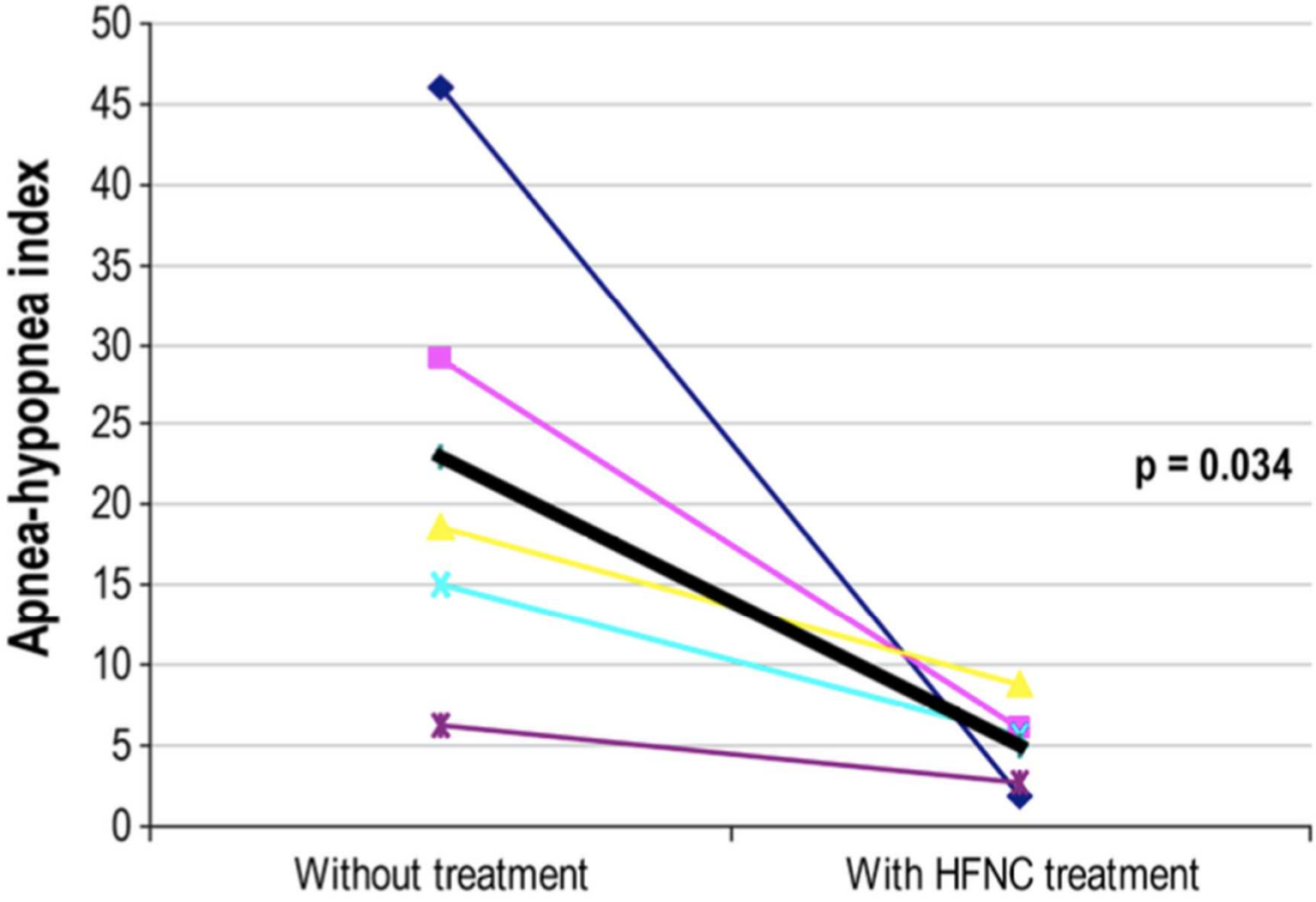
High-Flow Nasal Cannula Therapy for Obstructive Sleep Apnea in Children

Leon Joseph, MB ChB; Shmuel Goldberg, MD; Michal Shitrit; Elie Picard, MD

Journal of Clinical Sleep Medicine, Vol. 11, No. 9, 2015

5 patients with OSAS who did not tolerate CPAP:

1. Prematurity, bronchopulmonary dysplasia, *age 22 months*
2. Severe psychomotor retardation, *age 15 yrs*
3. Polymalformatif syndrome, *age 3 yrs*
4. Hypotonia, retrognatia, *age 2 yrs*
5. Treacher Collins, decanulation after mandibular distraction, age *3 yrs*



➔ No data about objective adherence

High flow nasal cannula for OSAS: Necker protocol

Population

- children aged 0 to 18 yrs with OSAS defined by:
  - AHI>10/hour *and/or*
  - oxygen desaturation index > 15/hour *and/or*
  - minimal SpO_2 <90% *and/or*
  - maximal $PtcCO_2$ >50 mmHg
- non compliant with an optimal CPAP therapy defined by a use < 2 hours/night, after at least 2 weeks of CPAP trial

High flow nasal cannula for OSAS: Necker protocol

Primary endpoint

- objective compliance (number of hours use / night) evaluated on the device after one month as the mean of the device usage time during the 4th week of use (sole option)

Secondary endpoints

- objective compliance after one week as the mean of the device usage time
- correction of OSAS on PG with HF

High flow nasal cannula for OSAS: Necker protocol

Procedure - 1

- High Flow is delivered by the myAIRVO device from Fisher Paykel with appropriate nasal cannula
- The highest tolerable flow and the largest cannula tolerated by the patient are chosen (in order to reach the highest pressure)

High flow nasal cannula for OSAS: our protocol

Procedure - 2

- HF is initiated during a 2 hours outpatient consultation or during hospitalisation
- A control visit is organized 1 week after initiation
- A respiratory polygraphy is performed between 1-3 months after initiation, when the patient tolerates the HFN for at least 6h/night.

High flow nasal cannula for OSAS: Necker experience

	Age (yrs)	Disease	AHI (n/h)	AHI with HFNC (n/h)	Flow (l/min)	Treatment adherence (h/night)
Patient 1	0.1	Pierre Robin sequence	14	6	10	**6.8**
Patient 2	1.8	Down syndrome	11	1	15	**7.5**
Patient 3*	6.4	Pfeiffer syndrome	13	0.5	10	**6.5**
Patient 4	7.6	Down syndrome	64	awaiting control PG	20	
Patient 5	9.2	Down syndrome	8.6	0.5	20	**6.8**
Patient 6	12	Down syndrome	46		20	failure
Patient 7	16.2	Down syndrome	26	awaiting control PG	20	
Patient 8	16.8	Down syndrome	10		20	failure

2 patients with developmental delay and behavior problems did not tolerate HF

* Patient 3 was tracheostomised after developing tracheal stenosis following neurosurgical intervention

Conclusion - 1

- HF seems to be efficient in mild to moderate OSAS in children
- HF may be better tolerated than CPAP, and could represent an alternative to CPAP in non compliant patients
- Future studies
  - patient selection ?
  - optimal flow rate ?

Conclusion - 2

- Limitations of HF
  - no pressure monitoring: risk of high pressure when use with large cannula
  - no battery, alarms (security risk) and no in-built software