Asincronie

Prof. MA Pennisi

Physiological parameters

- Respiratory rate
- SaO_2
- ABG (pH, $PaCO_2$, PaO_2)
- Transcutaneous CO_2
- End-tidal CO_2

Review

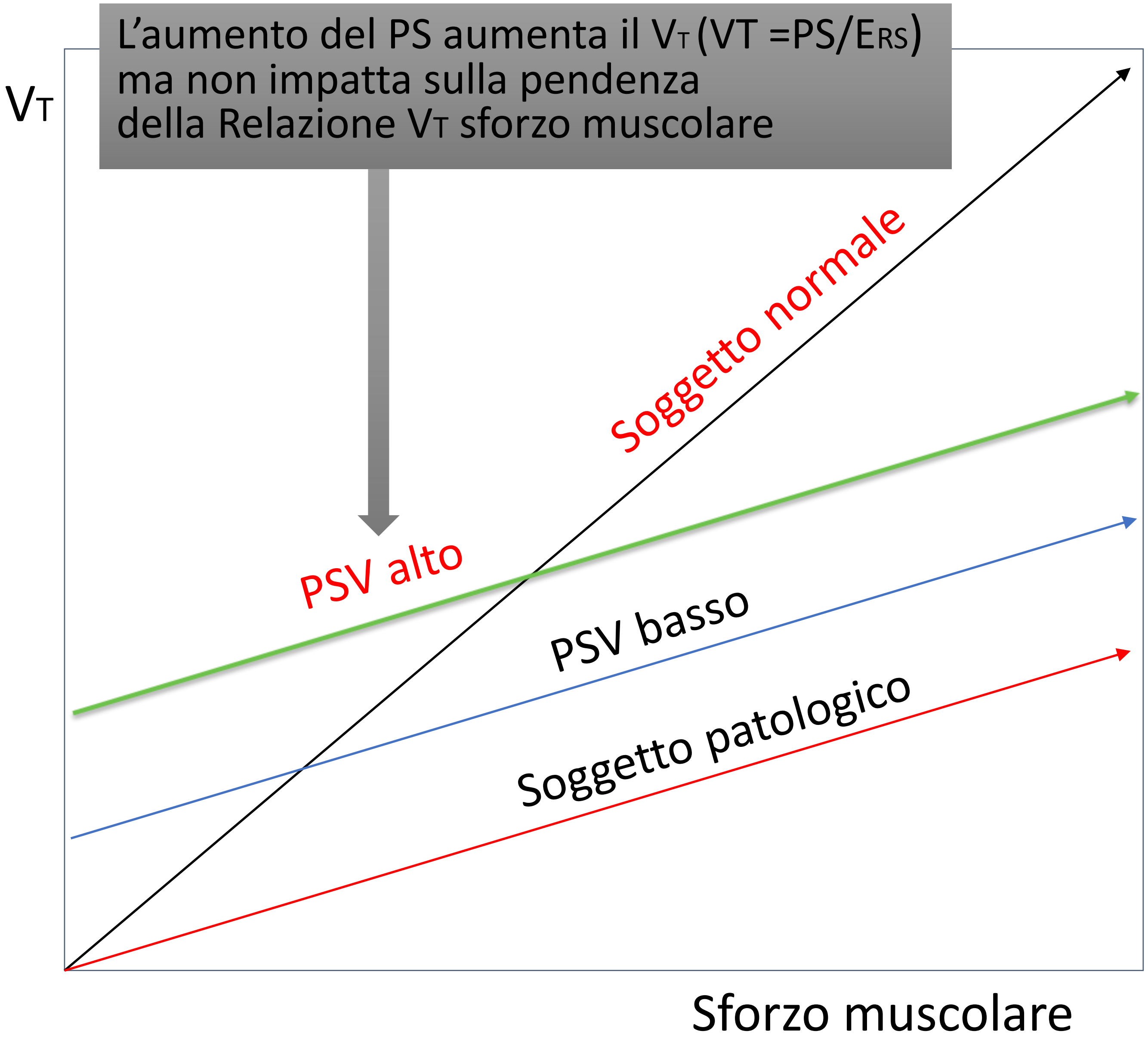
Non-invasive ventilation in acute respiratory failure

Stefano Nava, Nicholas Hill

Panel 4: How to apply NIV during first few hours

- Explain technique to patient (if competent)
- Choose correct interfaces and size
- Set pressures starting from low levels (ie, pressure support about 8 cm H_2O and external PEEP 4–5 cm H_2O)
- Place interface gently over face, holding it in place and start ventilation
- When patient tolerant, tighten straps just enough to avoid major leaks, but not too tight
- Set F_iO_2 on ventilator or add low-flow oxygen into the circuit, aiming for SO_2>90%
- Set alarms—low pressure alarm should be above PEEP level
- Be mindful of and try to optimise patent's comfort
- Reset pressures (pressure support increased to get expired tidal volume 6 mL/kg or higher—raise PEEP external to get oxygen saturation 90% or higher).
- Protect site of skin pressure from the interface (ie, artificial skin, wound-care dressing, or rotating interfaces)
- Consider use of mild sedation if patient is agitated
- Monitor comfort, respiratory rate, oxygen saturation, and dyspnoea every 30 min for 6–12 h then hourly
- Measure arterial blood gases at baseline and within 1 h from start
- Humidification advised for applications longer than 6 hours

NIV=non-invasive ventilation; PEEP=end-expiratory positive pressure; FIO2=fraction of inspired oxygen; SO2=oxygen saturation.

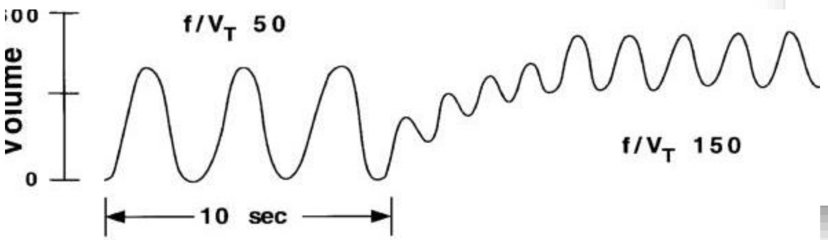

L'aumento del PS aumenta il VT (VT =PS/ERS)
ma non impatta sulla pendenza
della Relazione VT sforzo muscolare
VT
Soggetto normale
PSV alto
PSV basso
Soggetto patologico
Sforzo muscolare

Original Research

The Rapid Shallow Breathing Index as a Predictor of Failure of Noninvasive Ventilation for Patients With Acute Respiratory Failure

Katherine M Berg MD, Gerald R Lang RRT, Justin D Salciccioli, Eske Bak, Michael N Cocchi MD, Shiva Gautam PhD, and Michael W Donnino MD

An a RSBI of> 105 is associated with need for intubation and increased in-hospital mortality. Whether pts with an elevated aRSBI could also have benefitted from an increase in NIV settings remains unclear



RR 25 breaths/min Vt tidal 250 mL/breath RSBI of (25 breaths/min)/(0.25 L) = 100 breaths/min/L

Table 2. Multivariate Analysis for aRSBI as a Predictor of Intubation*

	Intubation		
	Odds Ratio	95% CI	*P*
aRSBI ≥ 105	3.70	1.14–11.99	.03
Age	0.96	0.93–0.99	.02
Pneumonia	3.56	1.38–9.18	.009
COPD exacerbation	0.23	0.06–0.88	.03

* Variables were included in multivariate analysis if univariate $P < .10$.
aRSBI = assisted rapid shallow breathing index

Table 3. Multivariate Analysis for aRSBI as a Predictor of In-Hospital Mortality*

	In-Hospital Mortality		
	Odds Ratio	95% CI	*P*
aRSBI ≥ 105	4.51	1.19–17.11	.03
Age	1.06	1.01–1.11	.03
Sepsis	3.10	0.68–14.13	.14

* Variables were included in multivariate analysis if univariate $P < .10$.
aRSBI = assisted rapid shallow breathing index

Respir Care 2012;57(10):1548–1554.

Intensive Care Med (2017) 43:192–199
DOI 10.1007/s00134-016-4601-3

ORIGINAL

Assessment of heart rate, acidosis, consciousness, oxygenation, and respiratory rate to predict noninvasive ventilation failure in hypoxemic patients

Jun Duan*, Xiaoli Han, Linfu Bai, Lintong Zhou and Shicong Huang

Methods: The test cohort comprised 449 patients with hypoxemia who were receiving NIV. This cohort was used to develop a scale that considers heart rate, acidosis, consciousness, oxygenation, and respiratory rate (referred to as the HACOR scale) to predict NIV failure, defined as need for intubation after NIV intervention. The highest possible score was 25 points. To validate the scale, a separate group of 358 hypoxemic patients were enrolled in the validation cohort.

Demographics	Test cohort		p^a	Validation cohort		p^a	p^b
	NIV failure ($N = 215$)	NIV success ($N = 234$)		NIV failure ($N = 141$)	NIV success ($N = 217$)		
Age (years)	66 ± 17	65 ± 17	0.51	67 ± 17	65 ± 17	0.38	0.86
Male gender (%)	161 (75%)	153 (65%)	0.03	99 (70%)	156 (72%)	0.81	0.70
Diagnosis							
Pneumonia	104 (48%)	141 (60%)	0.01	74 (53%)	132 (61%)	0.13	0.43
ARDS	61 (28%)	24 (10%)	<0.01	27 (19%)	18 (8%)	<0.01	0.02
Pulmonary cancer	30 (14%)	16 (7%)	0.02	21 (15%)	16 (7%)	0.03	>0.99
Pulmonary embolism	6 (3%)	15 (6%)	0.08	3 (2%)	12 (6%)	0.18	0.86
Heart failure	2 (1%)	13 (6%)	<0.01	4 (3%)	16 (7%)	0.10	0.16
Others	12 (6%)	25 (11%)	0.25	12 (9%)	23 (11%)	0.59	0.46
Data collected at NIV initiation							
APACHE II score	19 ± 6	16 ± 5	<0.01	18 ± 5	14 ± 4	<0.01	<0.01
Systolic blood pressure (mmHg)	131 ± 25	132 ± 25	0.65	133 ± 28	134 ± 30	0.77	0.20
Diastolic blood pressure (mmHg)	79 ± 17	80 ± 15	0.35	79 ± 17	80 ± 17	0.85	0.85
Heart rate (beats/min)	124 ± 24	110 ± 24	<0.01	120 ± 23	113 ± 24	<0.01	0.67
Respiratory rate (breaths/min)	34 ± 8	30 ± 7	<0.01	34 ± 7	31 ± 7	<0.01	0.85
pH	7.40 ± 0.11	7.44 ± 0.08	<0.01	7.42 ± 0.10	7.43 ± 0.08	0.09	0.53
$PaCO_2$ (mmHg)	38 ± 17	38 ± 13	0.77	37 ± 13	37 ± 12	0.57	0.19
PaO_2/FiO_2	137 ± 65	179 ± 83	<0.01	146 ± 68	165 ± 63	<0.01	0.79
GCS	14.4 ± 1.7	14.8 ± 0.8	<0.01	14.3 ± 1.6	14.8 ± 0.6	<0.01	0.84

Heart rate, Acidosis (pH), Consciousness (GCS), Oxygenation, and Respiratory rate (HACOR) were independent predictors of NIV failure in the test cohort.

Intensive Care Med (2017) 43:192–199
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ORIGINAL

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Jun Duan*, Xiaoli Han, Linfu Bai, Lintong Zhou and Shicong Huang

HACOR scale
- Heart rate,
- Acidosis,
- Consciousness,
- Oxygenation
- Respiratory Rate

Variables	Category (j)	Assigned points
Heart rate, beats/min	≤120	0
	≥121	1
pH	≥7.35	0
	7.30–7.34	2
	7.25–7.29	3
	<7.25	4
GCS	15	0
	13–14	2
	11–12	5
	≤10	10
PaO_2/FiO_2	≥201	0
	176–200	2
	151–175	3
	126–150	4
	101–125	5
	≤100	6
Respiratory rate, breaths/min	≤30	0
	31–35	1
	36–40	2
	41–45	3
	≥46	4

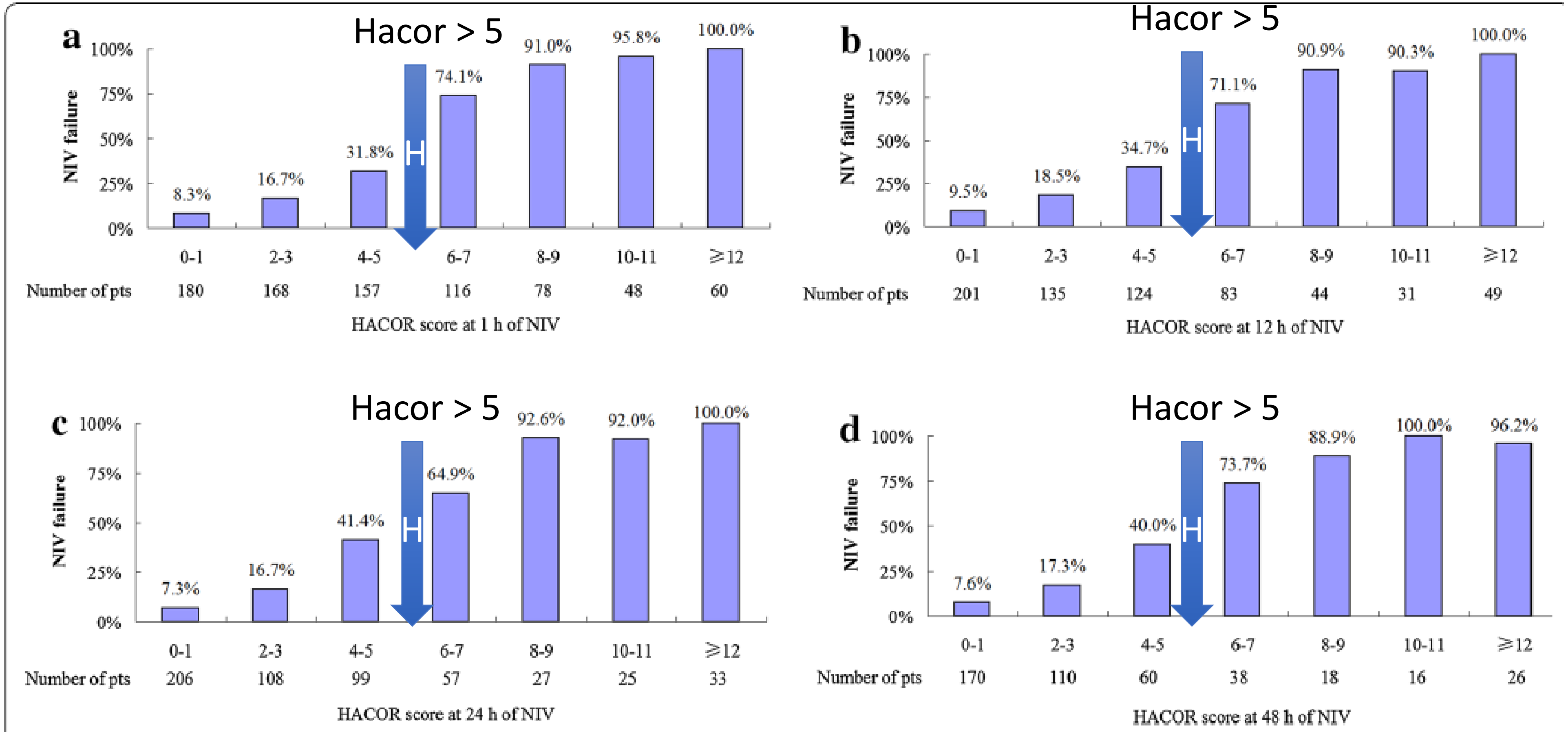

Fig. 1 Noninvasive ventilation (*NIV*) failure rate in patients with different HACOR (heart rate, acidosis, consciousness, oxygenation, and respiratory rate) scores at 1, 12, 24, and 48 h of NIV

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ORIGINAL

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Jun Duan*, Xiaoli Han, Linfu Bai, Lintong Zhou and Shicong Huang

HACOR score improves in pts with NIV success and remains unaltered in patients with NIV failure.

Variables	Category (j)	Assigned points
Heart rate, beats/min	≤120	0
	≥121	1
pH	≥7.35	0
	7.30–7.34	2
	7.25–7.29	3
	<7.25	4
GCS	15	0
	13–14	2
	11–12	5
	≤10	10
PaO_2/FiO_2	≥201	0
	176–200	2
	151–175	3
	126–150	4
	101–125	5
	≤100	6
Respiratory rate, breaths/min	≤30	0
	31–35	1
	36–40	2
	41–45	3
	≥46	4

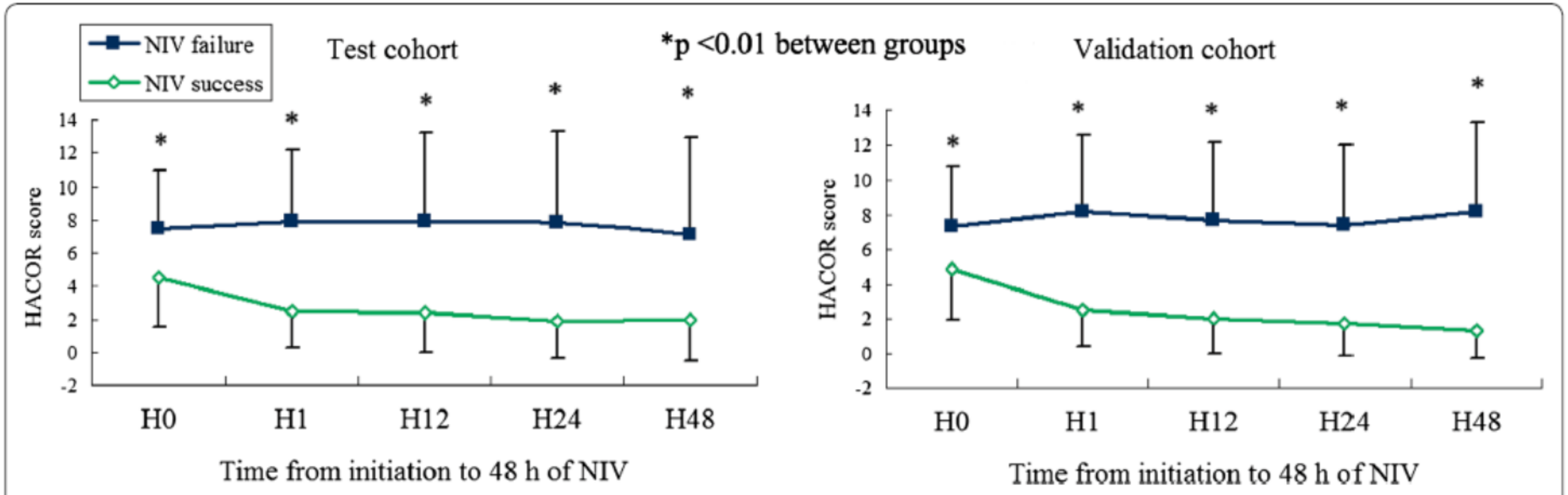

Fig. 2 The HACOR score in patients with NIV failure and success from initiation to 48 h of NIV

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ORIGINAL

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Jun Duan*, Xiaoli Han, Linfu Bai, Lintong Zhou and Shicong Huang

The diagnostic accuracy for NIV failure of a HACOR score > 5 at 1 hour of NIV was 81.8% (test cohort) and 86% (validation cohort).

Table 4 Predictive power of noninvasive ventilation failure diagnosed by the HACOR score assessed at 1 h, 12 h, 24 h and 48 h of NIV

NIV time points	AUC (95% CI)	Cutoff point	SE (%)	SP (%)	PPV (%)	NPV (%)	Diagnostic accuracy (%)	LR+	LR−
1 h of NIV ($N = 807$)	0.89 (0.87–0.91)	>5	73.9	91.4	87.1	81.6	83.7	8.54	0.29
12 h of NIV ($N = 667$)	0.87 (0.85–0.90)	>5	66.9	92.3	85.0	81.0	82.3	8.72	0.36
24 h of NIV ($N = 555$)	0.88 (0.85–0.90)	>5	61.5	93.4	83.1	82.1	82.3	9.30	0.41
48 h of NIV ($N = 438$)	0.87 (0.83–0.90)	>5	60.3	95.6	86.7	83.5	84.2	13.8	0.42

HACOR heart rate, acidosis, consciousness, oxygenation, and respiratory rate, *AUC* area under the curve of receiver operating characteristics, *CI* confidence interval, *SE* sensitivity, *SP* specificity, *PPV* positive predictive value, *NPV* negative predictive value, *LR+* positive likelihood ratio, *LR−* negative likelihood ratio, *NIV* noninvasive ventilation

The diagnostic accuracy for NIV failure remained above 80% regardless of NIV duration, diagnosis, age, or disease severity (APACHE 2 score).

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HACOR scale

- Heart rate,
- Acidosis,
- Consciousness,
- Oxygenation
- Respiratory Rate

Table 5 Early versus late intubation in patients with a HACOR score of >5 at 1 h of noninvasive ventilation

NIV time points and hospital mortality	Intubation at ≤12 h (*N* = 88)	Intubation at >12 h (*N* = 175)	*p*
HACOR score at NIV initiation	8.9 ± 3.9	7.7 ± 3.0	<0.01
HACOR score at 1 h of NIV	11.4 ± 4.0	8.8 ± 3.1	<0.01
HACOR score before intubation	12.2 ± 4.7	11.4 ± 5.0	0.22
Time from NIV initiation to intubation (h)	5 (2–10)	53 (23–132)	<0.01
Hospital mortality	58 (66%)	138 (79%)	0.03

Values in table are p… dian with the IQR in parenthesis, or as a number with the percentage in parenthesis, as appropriate
HACOR heart rate, a… , and respiratory rate, *NIV* noninvasive ventilation

Among pts with a HACOR score >5, early ETI improved hospital mortality

ASINCRONIE VENTILATORE-PAZIENTE IN VENTILAZIONE NON INVASIVA

- "Synchrony between the patient and ventilator can be defined as the **adequacy of matching of patient demand with support** provided by the ventilator **in terms of synchronization of time, volume, or flow".**

Tobin MJ – Principles and practice of mechanical ventilation

Patient-ventilator asynchrony

Diagnosis

Gold standard

- EMG
- esophageal pressure monitoring

Clinical practice

- Clinical examination
- Flow and pressure traces

ASINCRONIE VENTILATORE-PAZIENTE IN VENTILAZIONE NON INVASIVA

- Several forms of asynchrony can be identified by **inspecting the airway pressure and flow curve**s on ventilators.
- It is often **possible to rule out the problem by modifying ventilator settings** or undertake other remedial steps.

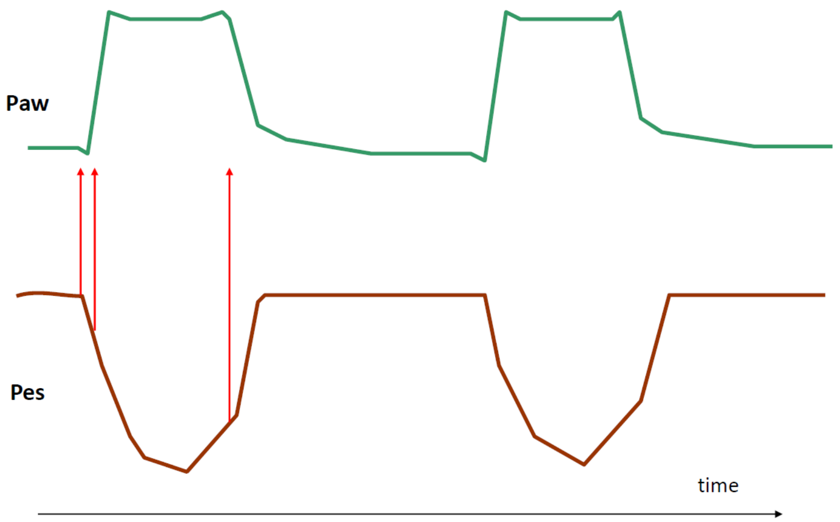
Tobin MJ – Principles and practice of mechanical ventilation

Ventilatory Failure, Ventilator Support, and Ventilator Weaning

Martin J. Tobin, Franco Laghi, Amal Jubran

Physician's ability to align the rhythm of the machine with the rhythm of the patient's respiratory centers becomes the **primary determinant of the level of rest accorded to the respiratory muscles.**

Compr Phisiol. 2012 Oct;2(4):2871-921.



Good Synchrony: Paw follows Pes

Kondili *et al.*

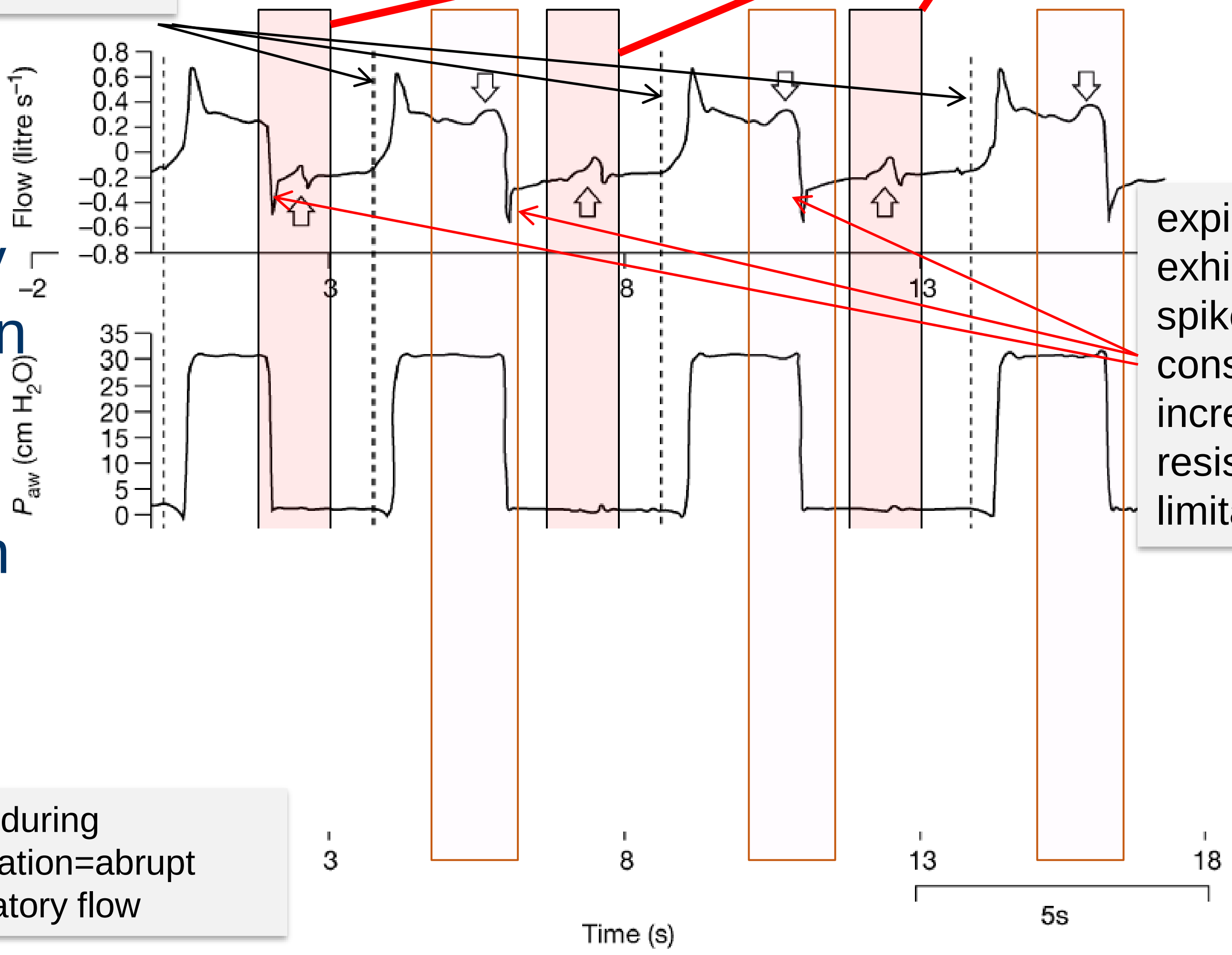
Kondili *et al.*

Inspiratory efforts that Triggered the ventilator

Ineffecctive efforts during mechancal expiration= abrupt decrease in expiratory flow

Ventilatory rate 12/min

Patient RR 35/min



expiratory flow exhibits an initial spike, a sign of considerably increased airflow resistance and flow limitation

Ineffective efforts during Mechanical inspiration=abrupt increase in inspiratory flow

Fig 3 Flow and airway (P_{aw}) and oesophageal (P_{oes}) pressures in a patient with severe chronic obstructive pulmonary disease ventilated with pressure support. Dotted vertical lines indicate the beginning of inspiratory efforts that triggered the ventilator. Closed arrows indicate ineffective efforts. Notice the time delay between the beginning of inspiratory effort and ventilator triggering. Observe also that ineffective efforts occurred during both mechanical inspiration and expiration. These ineffective efforts may be identified easily using the flow tracings; ineffective efforts during mechanical inspiration result in an abrupt increase in inspiratory flow, whereas during expiration they result in an abrupt decrease in expiratory flow (open arrows in flow tracing). The ventilator frequency is 12 bpm and that of the patient is 33 inspiratory efforts min^{-1}.

Asynchrony: patient-related factors

- Respiratory mechanics
  - resistance,
  - elastance,
  - dynamic hyperinflation/PEEPi
- Minute ventilation
- Respiratory muscle capacity
- Respiratory drive

Asynchrony: Ventilator related factors

Ventilator

- Inspiratory trigger (flow, pressure)
- Site of triggering (ventilator, trachea, NAVA);
- Inspiratory flow delivery (flow rate and pattern)
- Breath-termination (cycling criteria)
- Level and mode of ventilatory support (pressure vs volume control);
- Applied PEEP.

- Interface
    - endotracheal tube,
    - mask
    - Helmet
- Ventilator circuitry
- Humidification system (HME vs active humifiers)

Intensive Care Med (2009) 35:840–846
DOI 10.1007/s00134-009-1416-5

ORIGINAL

Laurence Vignaux
Frédéric Vargas
Jean Roeseler
Didier Tassaux
Arnaud W. Thille
Michel P. Kossowsky
Laurent Brochard
Philippe Jolliet

Patient–ventilator asynchrony during non-invasive ventilation for acute respiratory failure: a multicenter study

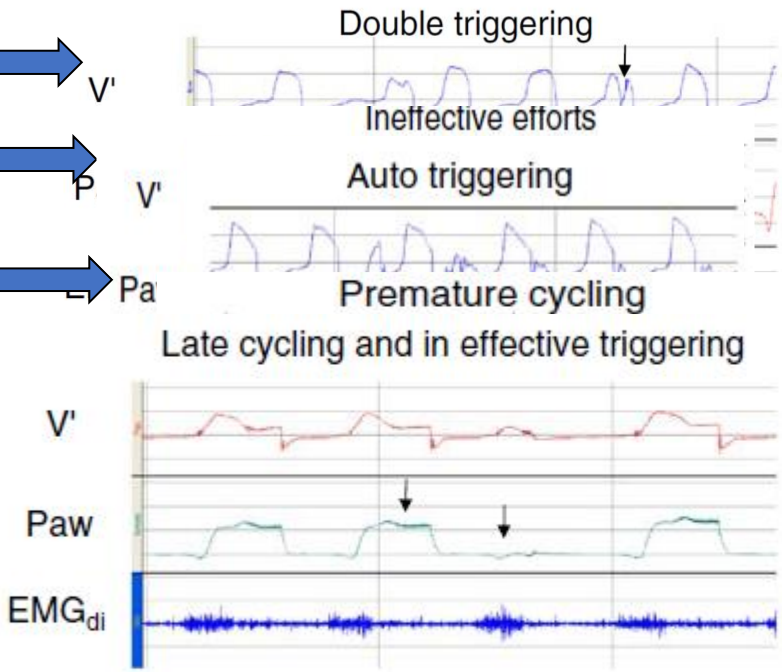
Vignaux et al., Intensive Care Med 2009; 35: 840-846

60 NIV pts (55%Hypercapnic)

Asynchrony prevalence in NIV:

AI > 10% in 26 pts (43%) median AI 26 (15-54%)

- -9 pts (15%) double triggering
- -8 pts (13%),ineffective breaths
- -8 pts (13%) auto-triggering
- -7 pts (12%) premature cycling
- -14 pts (23%) late cycling



Intensive Care Med (2009) 35:840–846
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ORIGINAL

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Philippe Jolliet

Patient–ventilator asynchrony during non-invasive ventilation for acute respiratory failure: a multicenter study

Prospective study on 60 NIV pts

26 pts (43%) asinchrony index (AI) > 10%

Multivariate analysis associated with the presence of an AI>10%

the level of PS (OR: 1.32 per additional cmH2O of pressure support, 95% CI: 1.10–1.58; P = 0.003)

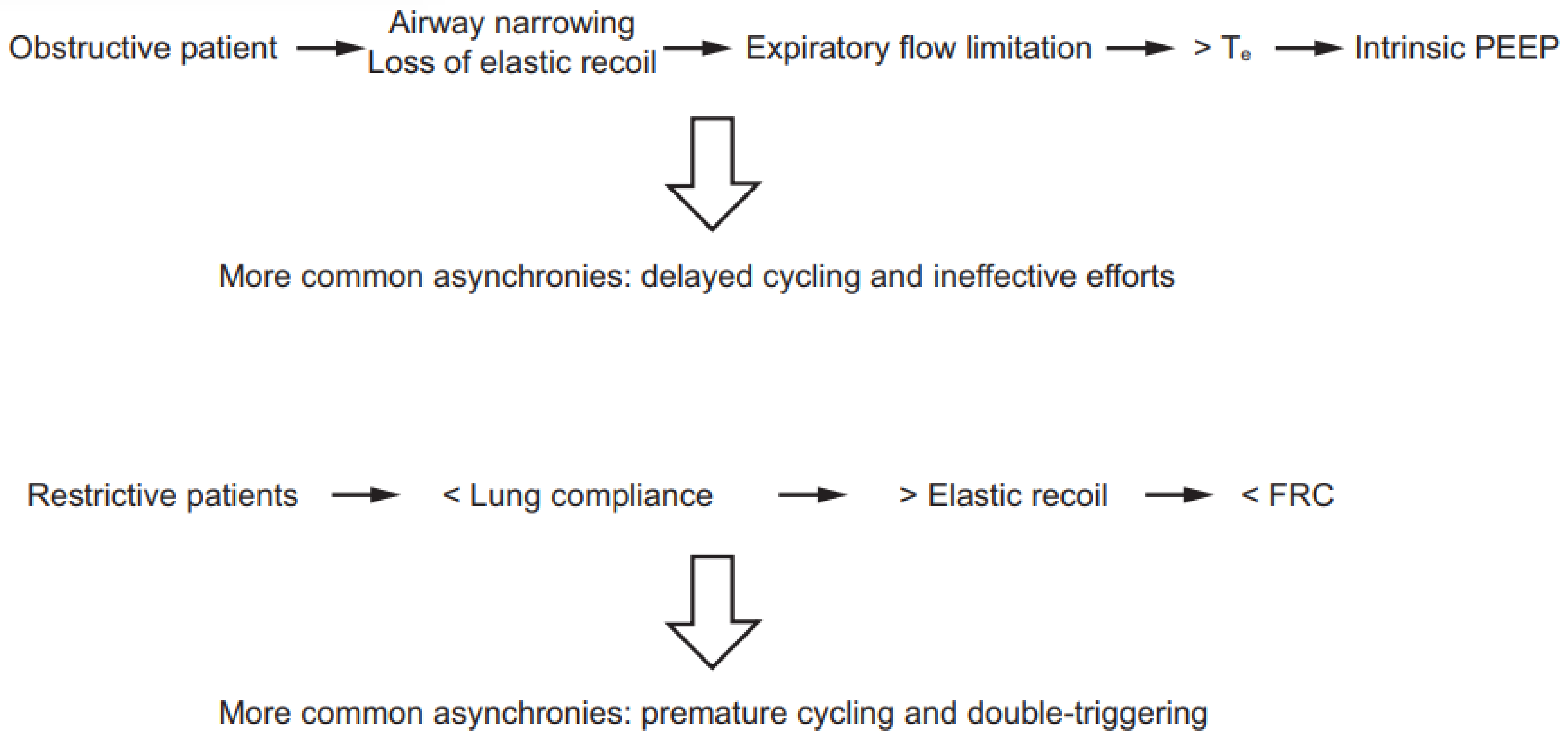
the magnitude of leak (OR: 1.24 per additional l/min of leak, 95% CI: 1.03 1.48; P = 0.019) were.

Vignaux et al., Intensive Care Med 2009; 35: 840-846

Patient-Ventilator Asynchronies: Clinical Implications and Practical Solutions

Lucia Mirabella, Gilda Cinnella, Roberta Costa, Andrea Cortegiani, Livio Tullo, Michela Rauseo, Giorgio Conti, and Cesare Gregoretti

Asynchrony according to patient respiratory mechanics



Patient-ventilator asynchrony adverse effects

- Higher/wasted work of breathing,
- Worsen mechanics (PEEPi)
- ↓ efficiency of mechanical ventilation (gas exchange)
- Patient discomfort,
- Sleep fragmentation
- Increased need for sedation,
- problems during the weaning process,
- prolonged mechanical ventilation,
- ultrastructural injury to respiratory muscles
- ↑ ICU LOS,
- possibly ↑ mortality.

Asynchrony Index (AI)

% of breaths that are asynchronous

$$\frac{\text{Number of Asynchrony Events}}{\text{Total Respiratory Rate}} \times 100$$

$$\frac{IEE + IEI + DT + AT}{\text{Ventilator breaths} + \text{Ineffective efforts}} \times 100$$

Asynchrony Index ≥ 10% → High

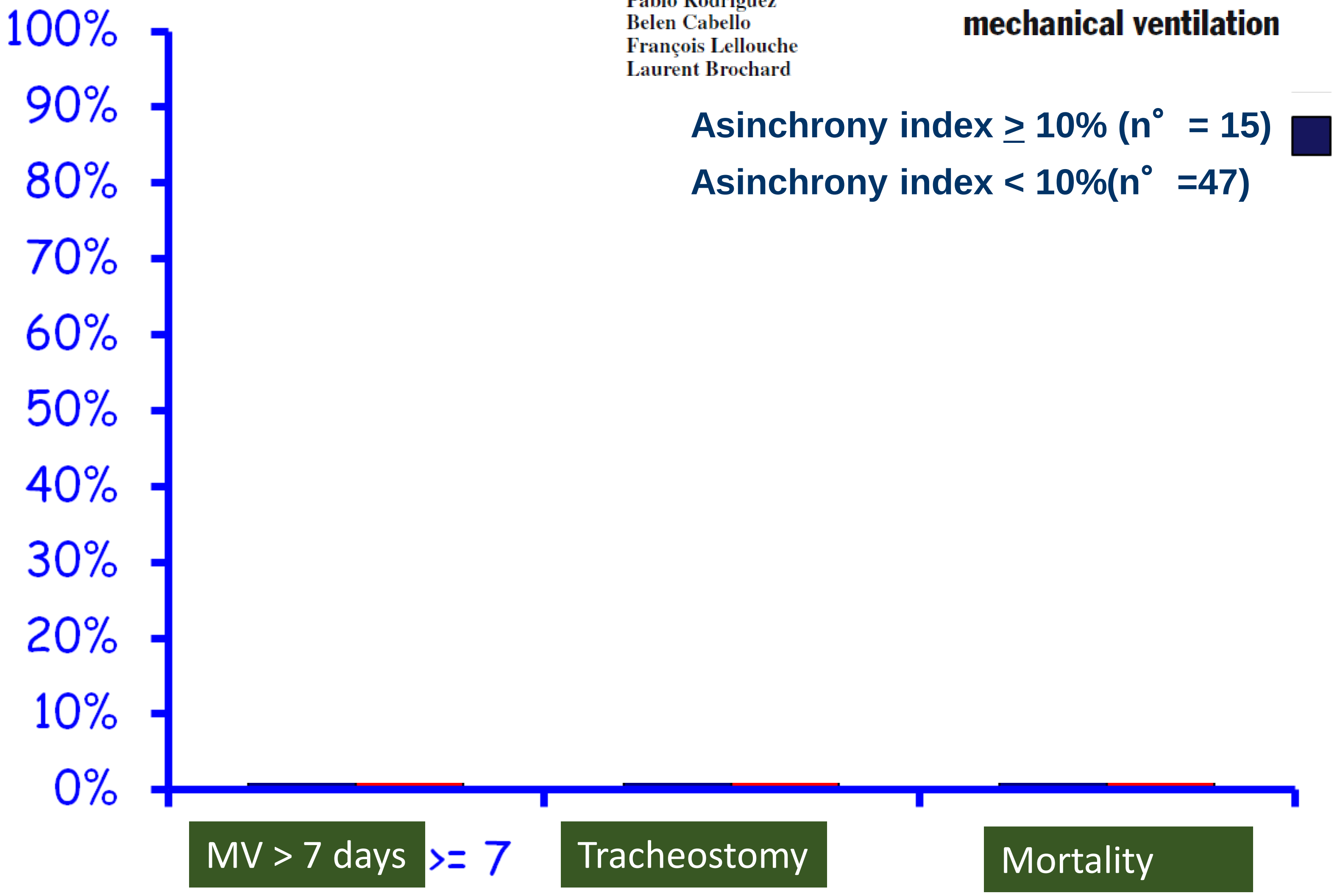
Vitacca, M. Chest (2004) 126: 851-859
Thille, A. Intensive Care Med (2006) 32:1515-1522

Intensive Care Med (2006) 32:1515–1522
DOI 10.1007/s00134-006-0301-8

ORIGINAL

Arnaud W. Thille
Pablo Rodriguez
Belen Cabello
François Lellouche
Laurent Brochard

Patient-ventilator asynchrony during assisted mechanical ventilation



Thille et al. ICM 2006; 32: 1515-22

Intensive Care Med
DOI 10.1007/s00134-015-3692-6

ORIGINAL

Lluís Blanch
Ana Villagra
Bernat Sales
Jaume Montanya
Umberto Lucangelo
Manel Luján
Oscar García-Esquirol
Encarna Chacón
Anna Estruga
Joan C. Oliva
Alberto Hernández-Abadia
Guillermo M. Albaiceta
Enrique Fernández-Mondejar
Rafael Fernández
Josefina Lopez-Aguilar
Jesús Villar
Gastón Murias
Robert M. Kacmarek

Asynchronies during mechanical ventilation are associated with mortality

Prospective noninterventional observational study of 50 pts
software detecting IEE, double trigger
Shorted and prolonged cycling to compute asynchrony index

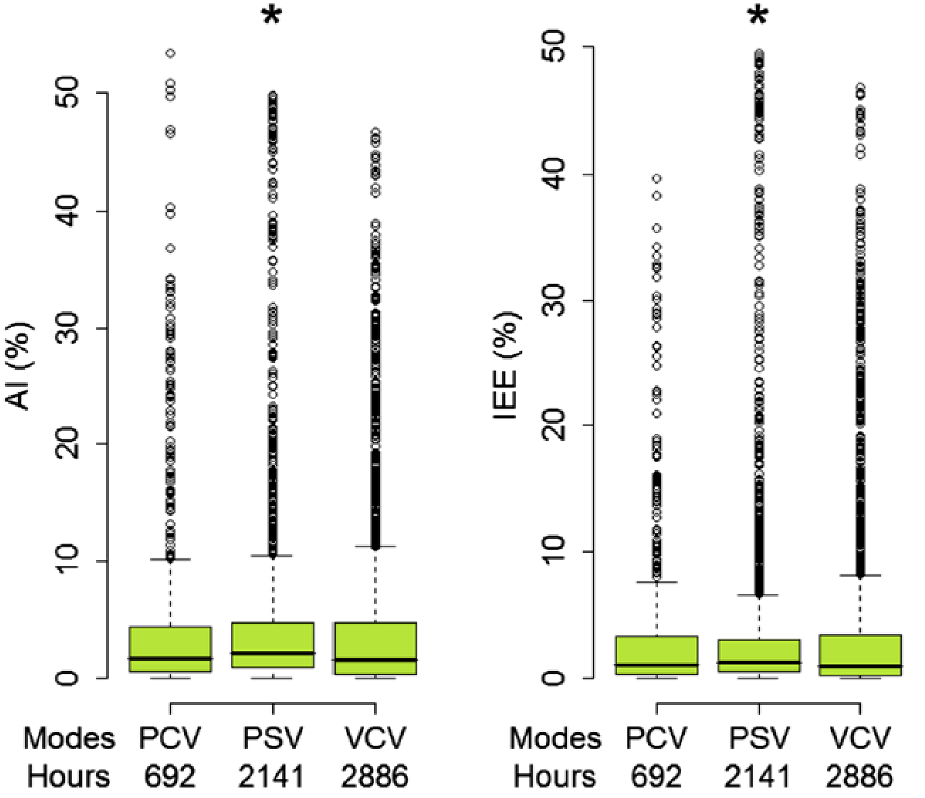


Table 2 Relationship between AI and duration of MV, reintubation, tracheostomy, and ICU and hospital mortality by comparing patients AI ≤ 10 vs AI > 10 %

	AI ≤ 10 % (*n* = 44)	AI > 10 % (*n* = 6)	*p* value
Length of MV (days)	6 [5.0; 15.0]	16 [9.7; 20.0]	0.061
Reintubation	9 (20 %)	0 (0 %)	0.57
Tracheostomy	14 (32 %)	2 (33 %)	0.999
ICU mortality	6 (14 %)	4 (67 %)	0.011*
Hospital mortality	10 (23 %)	4 (67 %)	0.044*

Data are expressed as numbers and percentages or as medians and interquartile ranges
MV mechanical ventilation, *ICU* intensive care unit, *AI* asynchrony index
* Significant at $p < 0.05$

Efficacy of ventilator waveforms observation in detecting patient–ventilator asynchrony*

Davide Colombo

	Breath Analysis		
	Ex	N-Ex	*p*
Sensitivity (95% CI)	28% (19–36)	16% (9–23)	.03
Specificity (95% CI)	88% (83–93)	93% (84–97)	.10
Positive predictive value (95% CI)	31% (24–42)	32% (28–41)	.77
Negative predictive value (95% CI)	87% (85–88)	86% (84–86)	.10
Positive likelihood ratio (95% CI)	2.96 (1.72–4.20)	2.99 (2.17–3.81)	.96
Negative likelihood ratio (95% CI)	0.82 (0.72–0.90)	0.89 (0.84–0.94)	.10

Ex, expert; N-Ex, nonexpert; 95% CI, 95% confidence interval.

Crit Care Med 2011 Vol. 39, No. 11

Classificazione generale

1. Asincronie di trigger inspiratorio

a. Trigger delay → Sforzi inefficaci
b. Autotrigger

2. Asincronie di ciclaggio espiratorio

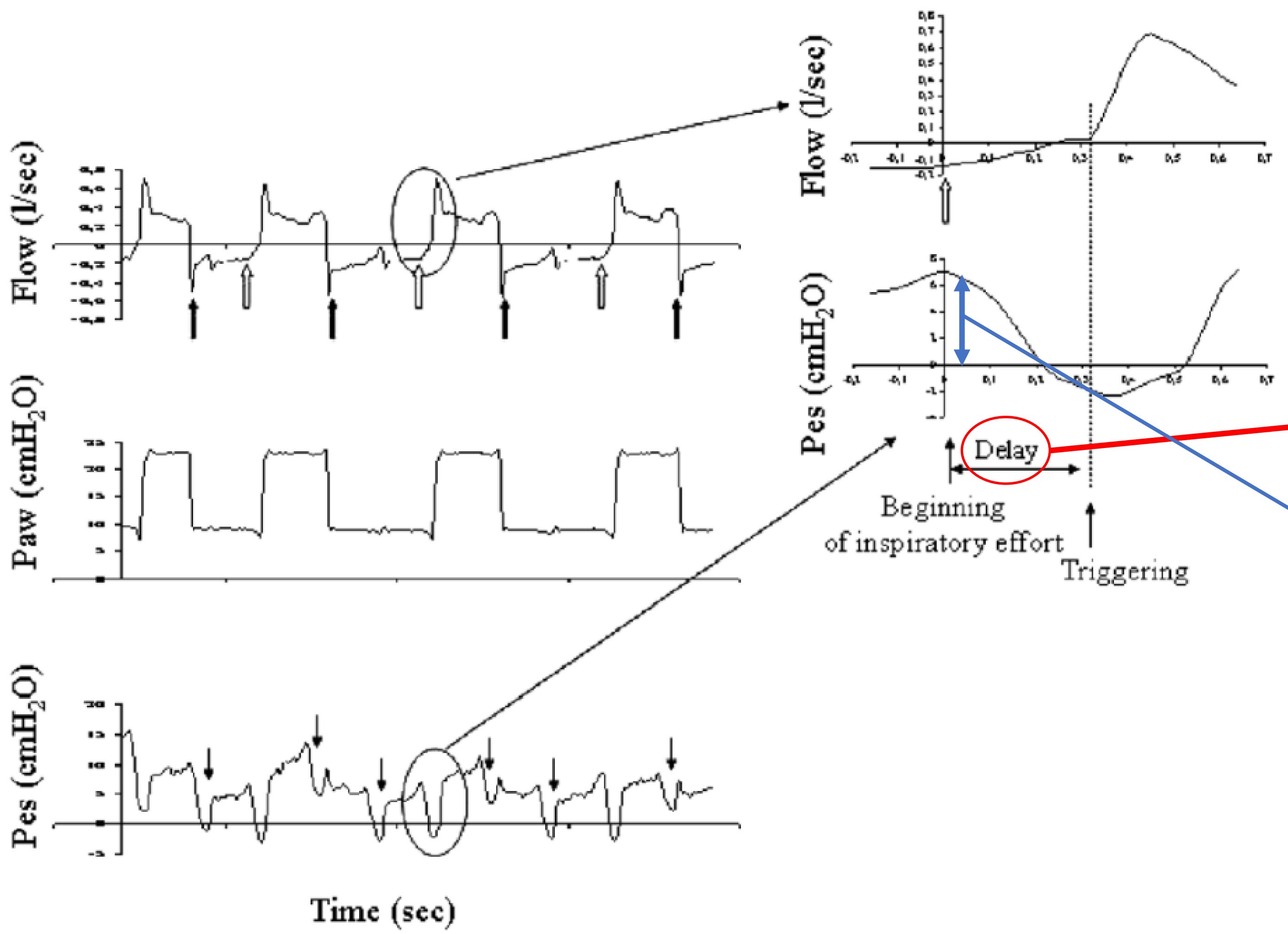
a. Ciclaggio espiratorio precoce (Short cycle) → Doppio trigger
b. Ciclaggio espiratorio tardivo → Ciclaggio a tempo *(hang-up)*

3. Altre asincronie

a. Flow starvation
b. Reverse triggering non armonico

Asincronie di trigger inspiratorio

Trigger delay

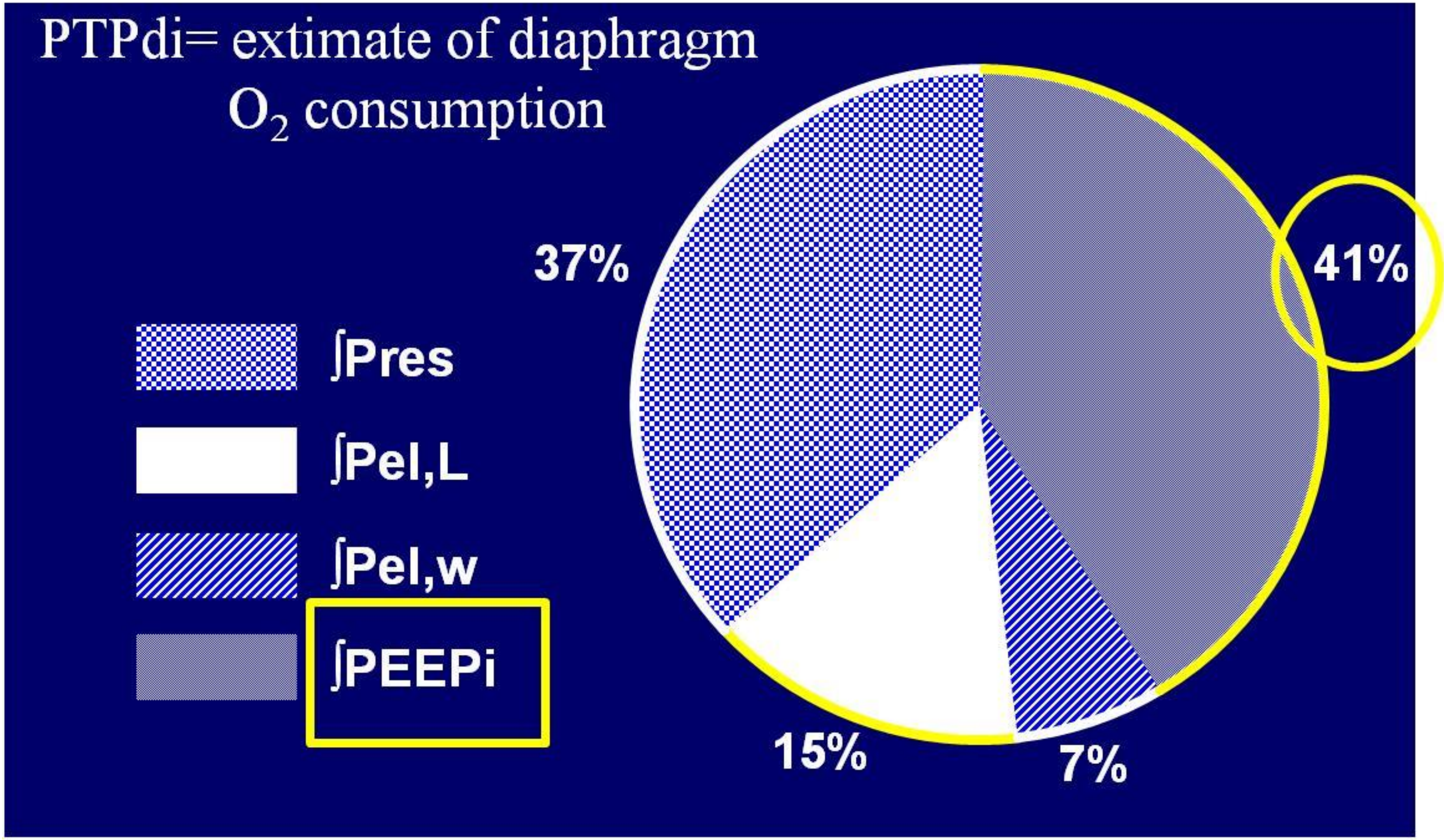


Pmus (+ Paw) = Pres + Pel + PEEPi

Il flusso inspiratorio (pos.) inizia solo quando il carico dato dalla PEEPi viene controbilanciato dallo sforzo inspiratorio (deflessione sul tracciato Paw)

= PEEPi !

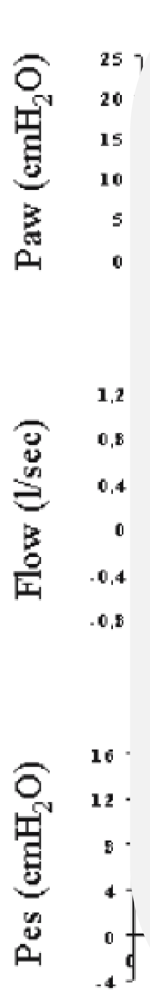
Work of Breathing for intrinsic PEEP in COPD patients



Appendini L. et al. AJRCCM 1996; 154:1301-1309

Asincronie di trigger inspiratorio

Sforzi

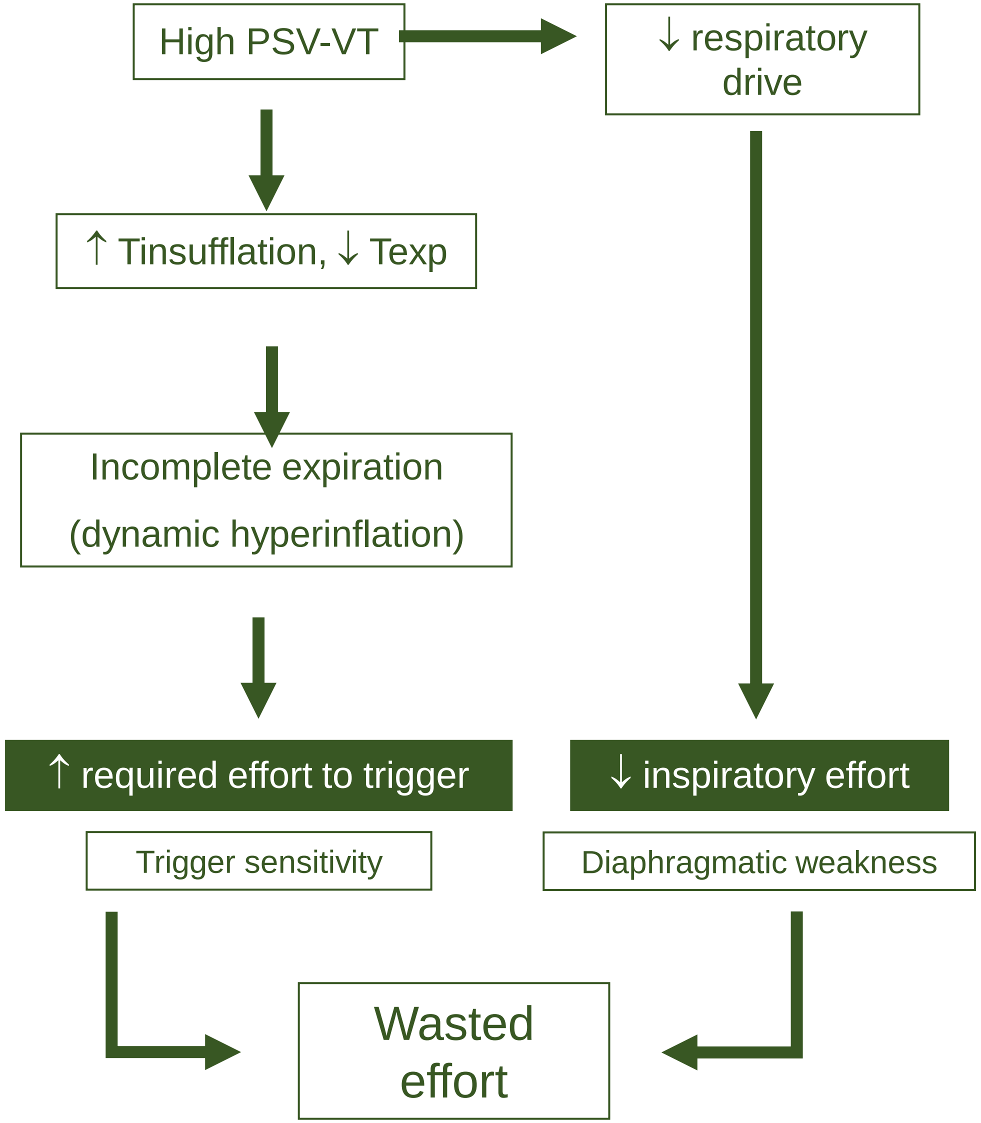


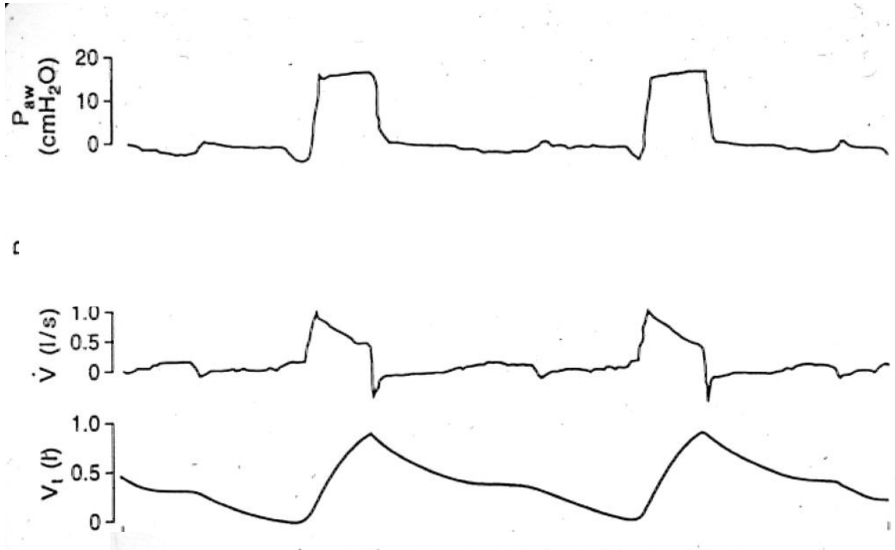
Diagnosi: distorsione del flusso (++) o deflessione Paw (>0.5 cmH_2O) non seguiti dall'erogazione dell'atto, FR ventilatore > FR paziente

Cause: PEEPi, ↑↑ Psupp, basso drive respiratorio, ↓↓ sensibilità trigger inspiratorio

Soluzioni: ↑ tempo espiratorio (↑ % trigger exp. → ↓ tempo espiratorio), ↓ Psupp, ↑ sensibilità trigger inspiratorio, PEEPe 80% della PEEPi?

NB: se coesistono sforzi inefficaci e doppi trigger, priorità alla correzione degli sforzi inefficaci (fame d'aria dovuta agli sforzi inefficaci → ↑↑ drive inspiratorio negli atti successivi → doppi trigger!)



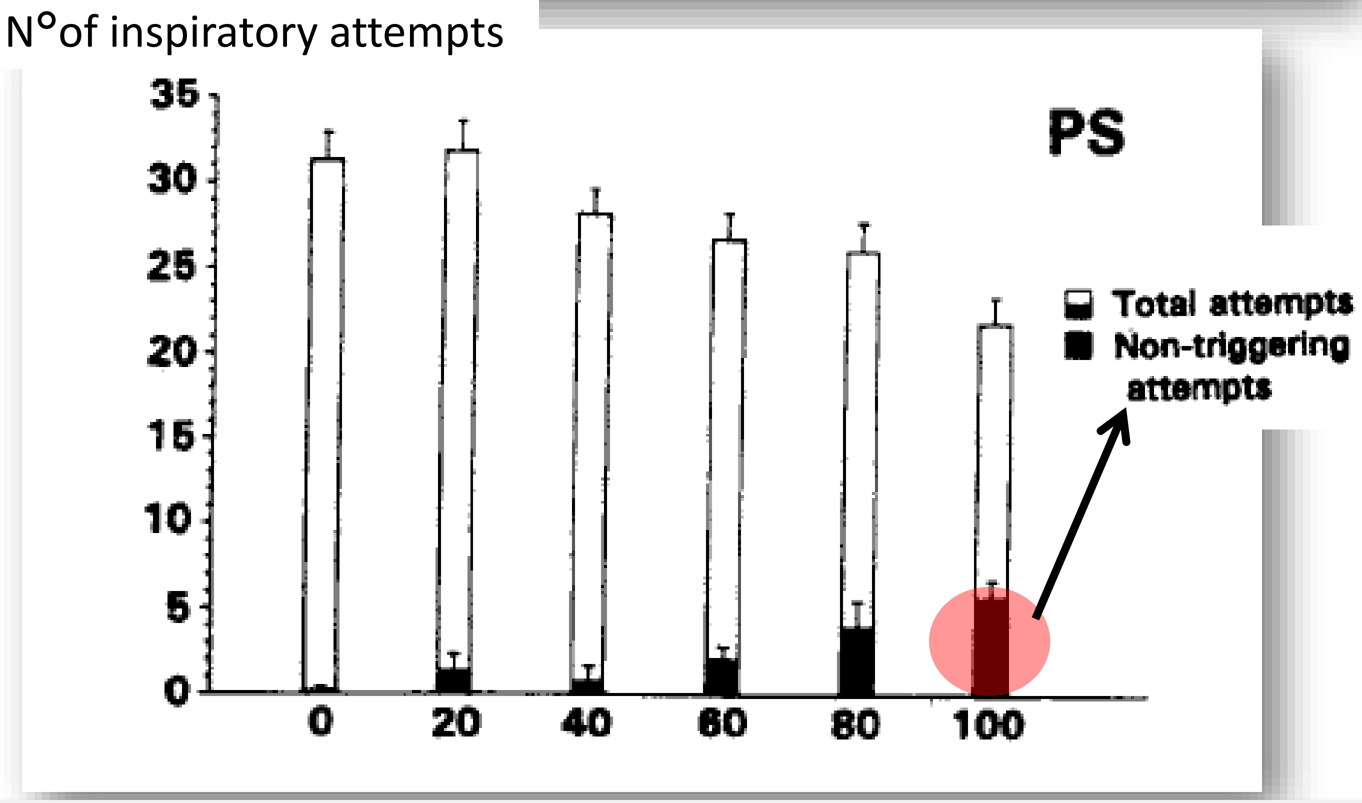


Nava S, et al. ICM 1995;21:871-9

Comparison of Assisted Ventilator Modes on Triggering, Patient Effort, and Dyspnea

PHILIP LEUNG, AMAL JUBRAN, and MARTIN J. TOBIN

Division of Pulmonary and Critical Care Medicine, Edward Hines Jr., Veterans Administrative Hospital, Loyola University of Chicago Stritch School of Medicine, Hines, and Suburban Hospital, Hinsdale, Illinois

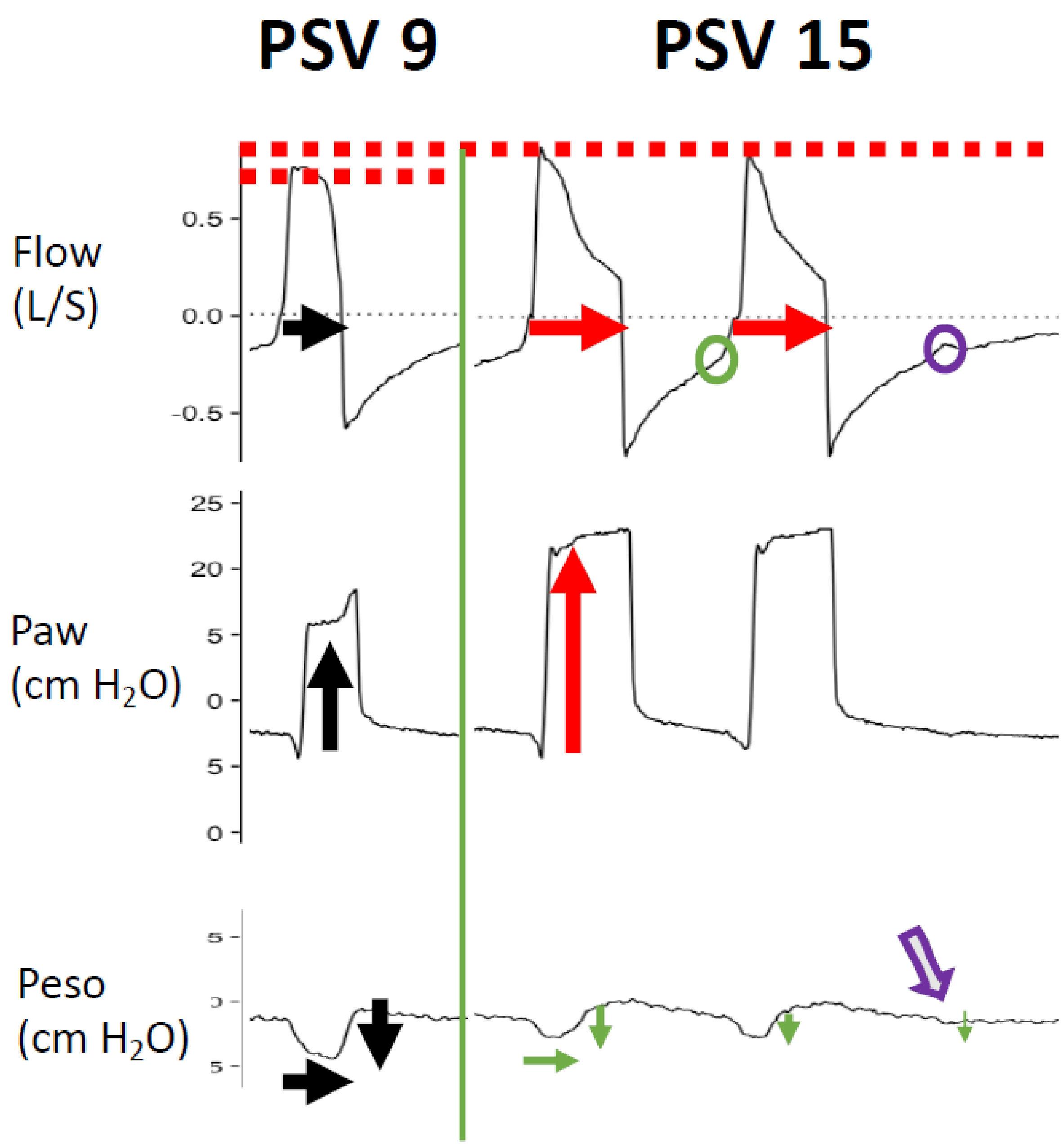


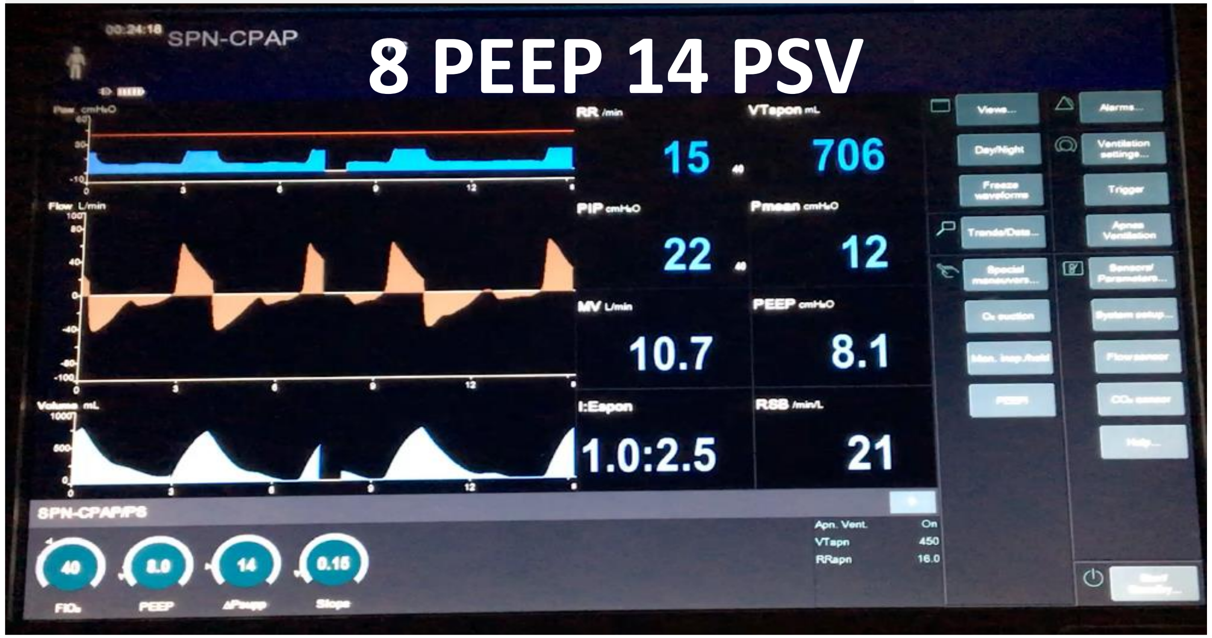
With increasing levels of PS, the total number of inspiratory attempts decreased ($p < 0.001$), whereas the number of nontriggering attemptsn increased ($p < 0.001$).

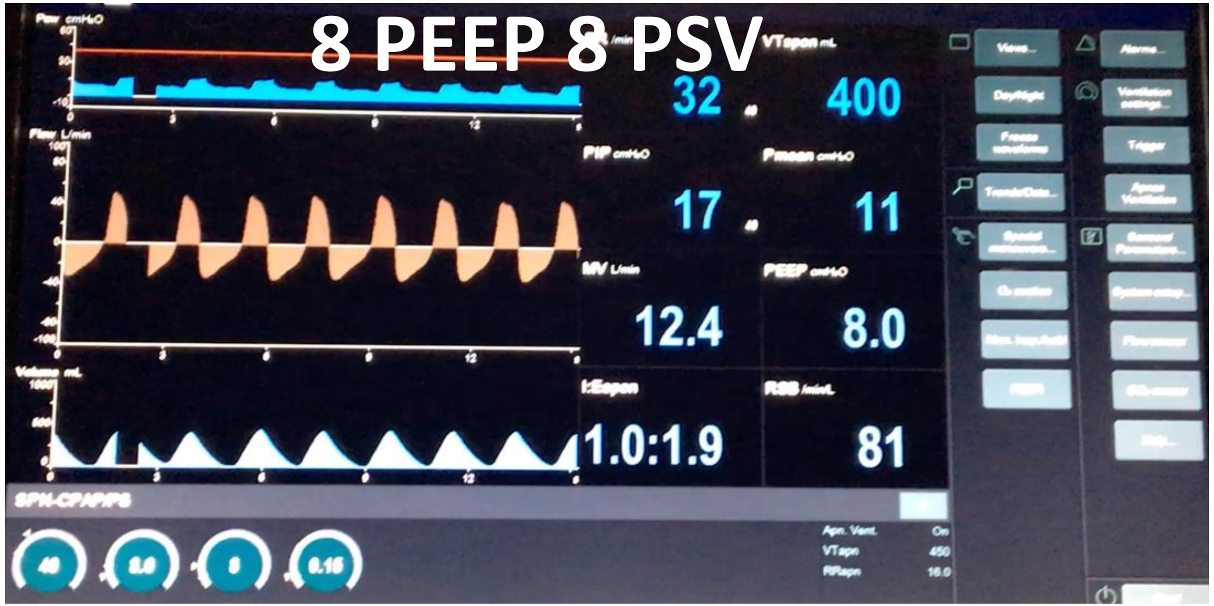
AM J RESPIR CRIT CARE MED 1997;155:1940-1948.

Sforzi inefficaci

Meccanismi







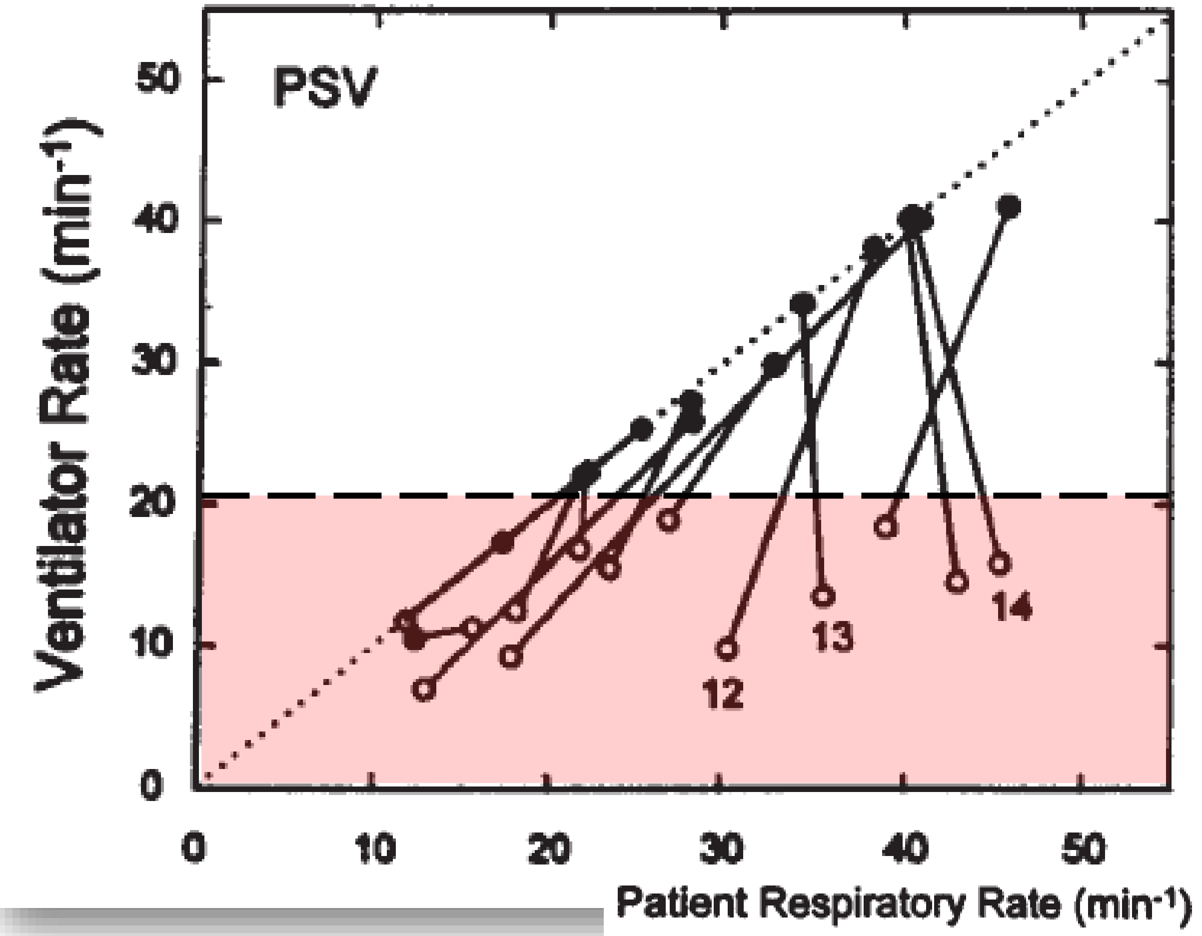
Response of Ventilator-dependent Patients to Different Levels of Pressure Support and Proportional Assist

ELENI GIANNOULI, KIM WEBSTER, DAN ROBERTS, and MAGDY YOUNES

Sections of Respiratory and Critical Care Medicine, Department of Medicine, University of Manitoba, Winnipeg, Manitoba, Canada

At low level of support, the data points (*solid dots*) fall near the line of identity.

With high-level PSV the data points (*open circles*) deviate from the line of identity in all but two patients.

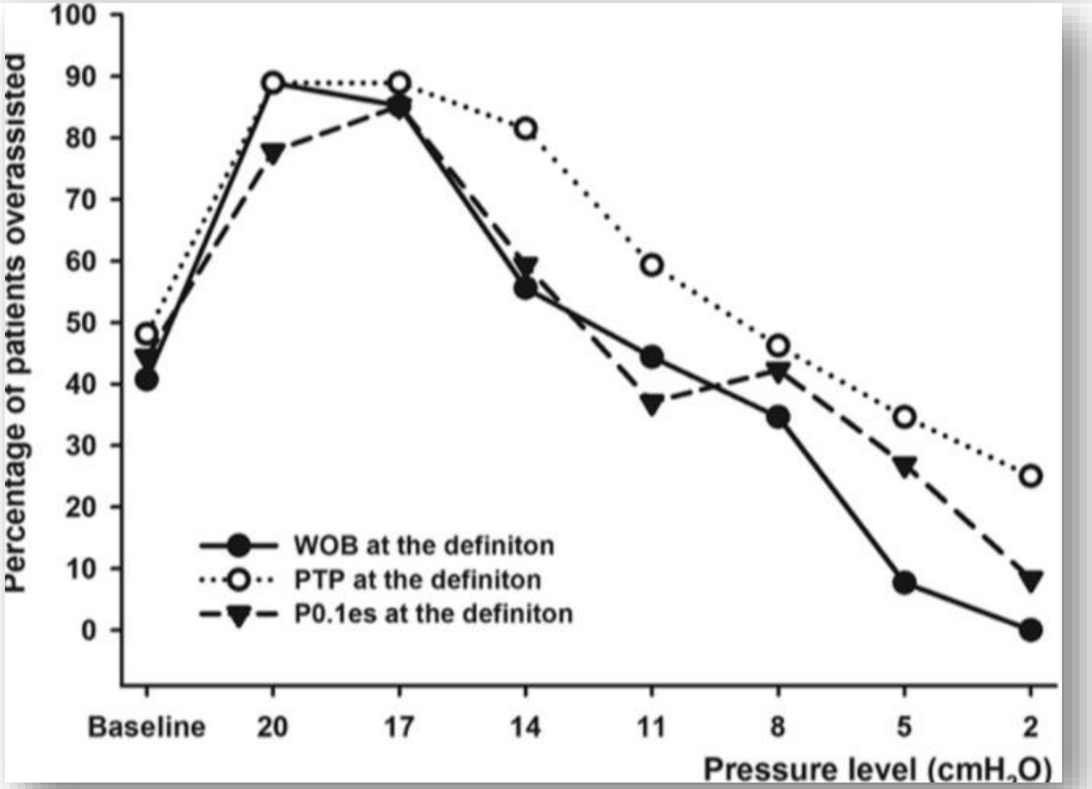


Accuracy of Invasive and Noninvasive Parameters for Diagnosing Ventilatory Overassistance During Pressure Support Ventilation*

Renata Pletsch-Assuncao, RT, PhD[1]; Mayra Caleffi Pereira, RT, MSc[1]; Jeferson George Ferreira, RT[1,2]; Letícia Zumpano Cardenas, RT, PhD[1,2]; André Luis Pereira de Albuquerque, MD, PhD[1,3]; Carlos Roberto Ribeiro de Carvalho, MD, PhD[1]; Pedro Caruso, MD, PhD[1,2]

Overassistance was defined as:

- work of breathing less than 0.3 J/L or ≥10% of ineffective inspiratory effort.
- inspiratory esophageal pressure-time product of less than 50 cm H_2O s/min
- esophageal occlusion pressure of less than 1.5 cm H_2O.



Pletsch-Assuncao, R. Critical Care Medicine: March 2018 - Volume 46 - Issue 3 - p 411-417

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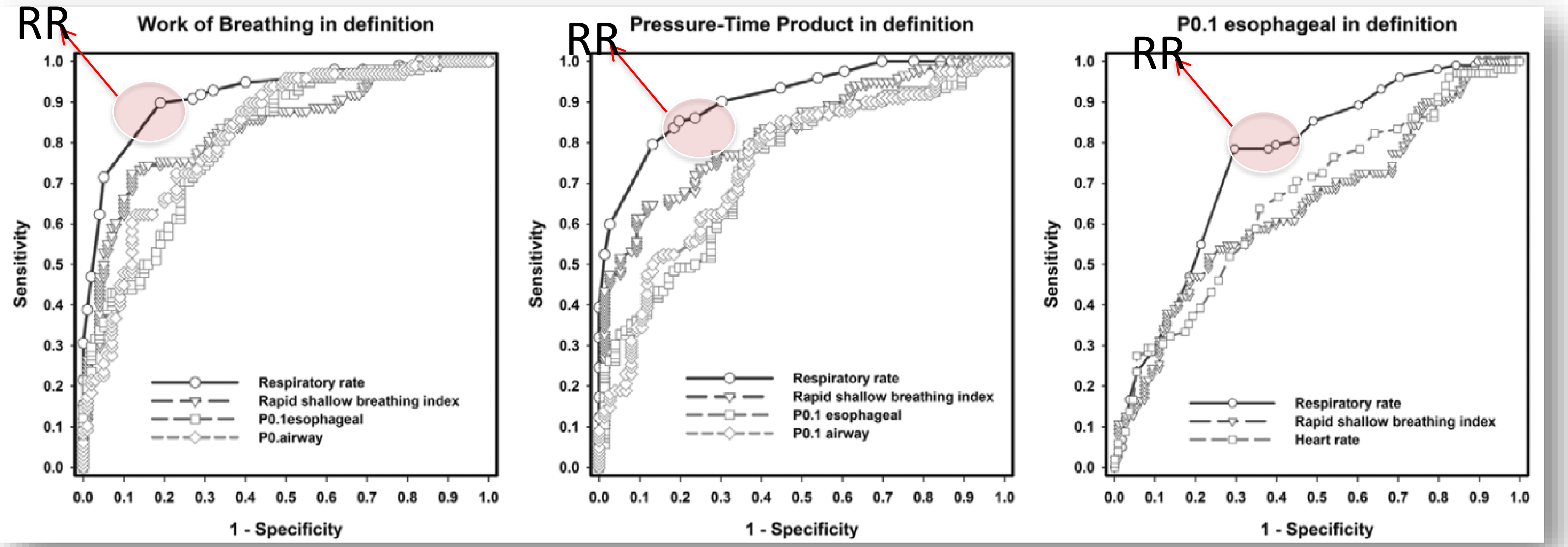


In all definitions, the RR had the greatest accuracy for diagnosing overassistance (ROC area = 0.92; 0.91 and 0.76 for work of breathing, pressure-time product and esophageal occlusion pressure in definition, respectively) and always with a cutoff of 17 incursions per minute.
In all definitions, a RR ≤ 12 confirmed overassistance (100% specificity), whereas a RR ≥ to 30 excluded overassistance (100% sensitivity).

Pletsch-Assuncao, R. Critical Care Medicine: March 2018 - Volume 46 - Issue 3 - p 411-417

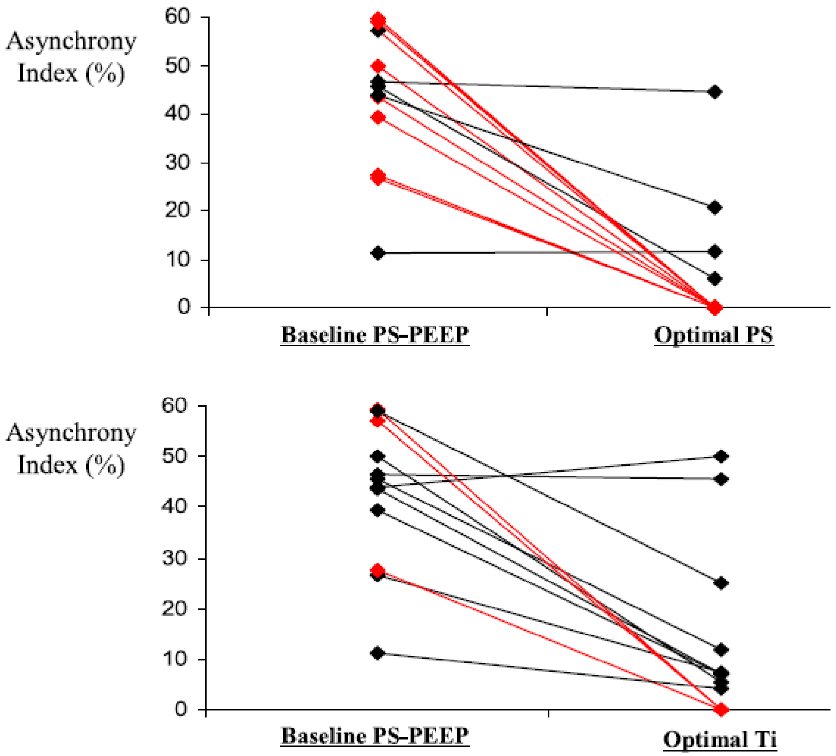
Intensive Care Med (2008) 34:1477–1486
DOI 10.1007/s00134-008-1121-9

ORIGINAL

Arnaud W. Thille
Belen Cabello
Fabrice Galia
Aissam Lyazidi
Laurent Brochard

Reduction of patient-ventilator asynchrony by reducing tidal volume during pressure-support ventilation

Fig. 4 Individual values of the asynchrony index under the baseline condition and after optimization of the pressure-support level (*top*) and ventilator insufflation time (*bottom*). Among the 12 patients ineffective triggering events were completely eliminated (*red line*) in eight patients using optimal PS and in three patients using optimal Ti. *PEEP*, Positive end-expiratory pressure; *PS*, pressure-support; *Ti*, ventilator insufflation time



12 ETI pts with >10% of ineffective breaths in PSV

To decrease ineffective triggering the following ventilator setting adjustments were randomly adjusted:

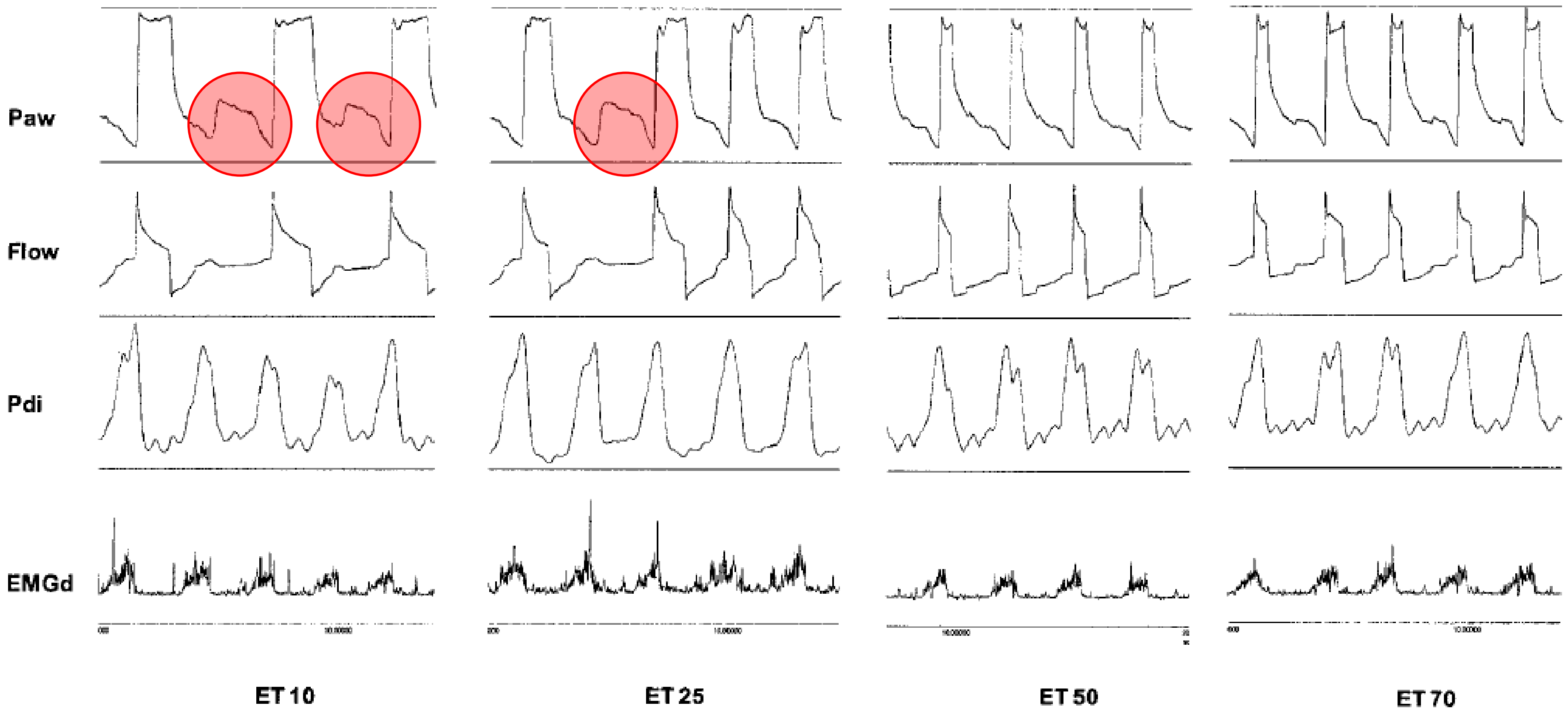
- PS reduction,
- insufflation time reduction,
- change in end-expiratory pressure.

no influence on asynchrony

eliminated ineffective triggering in 2/3 of pts with weaning difficulties and a high percentage of ineffective efforts

Impact of Expiratory Trigger Setting on Delayed Cycling and Inspiratory Muscle Workload

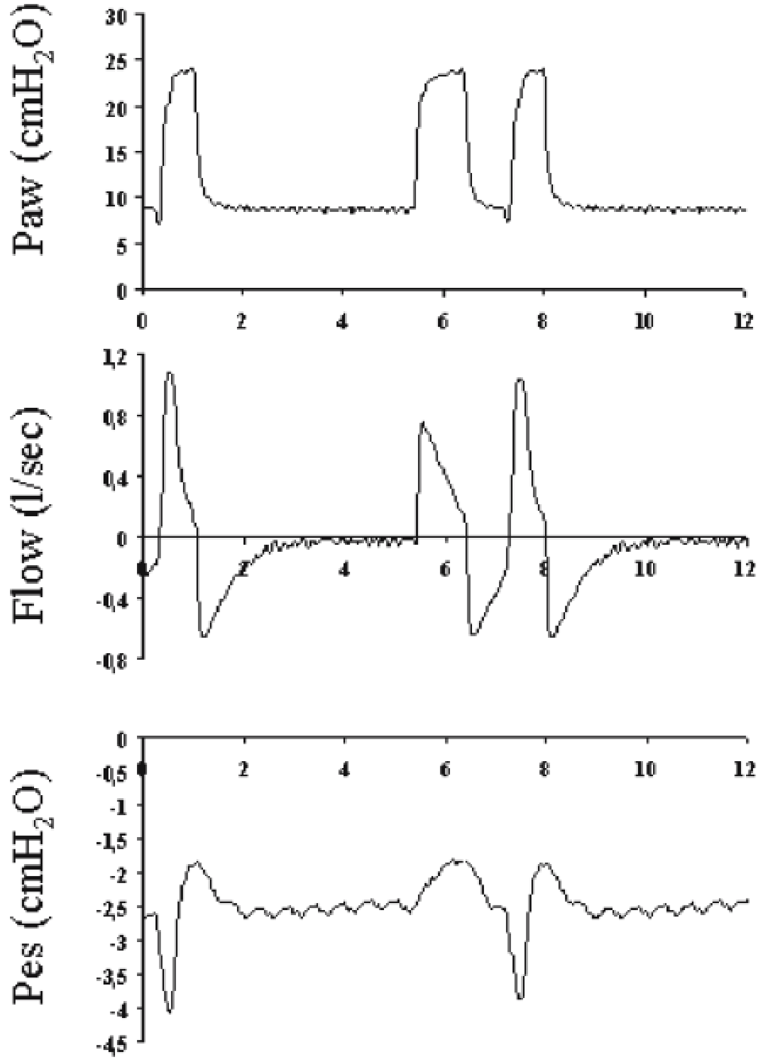
Didier Tassaux



Am J Respir Crit Care Med Vol 172. pp 1283–1289, 2005

Asincronie di trigger inspiratorio

Autotrigger

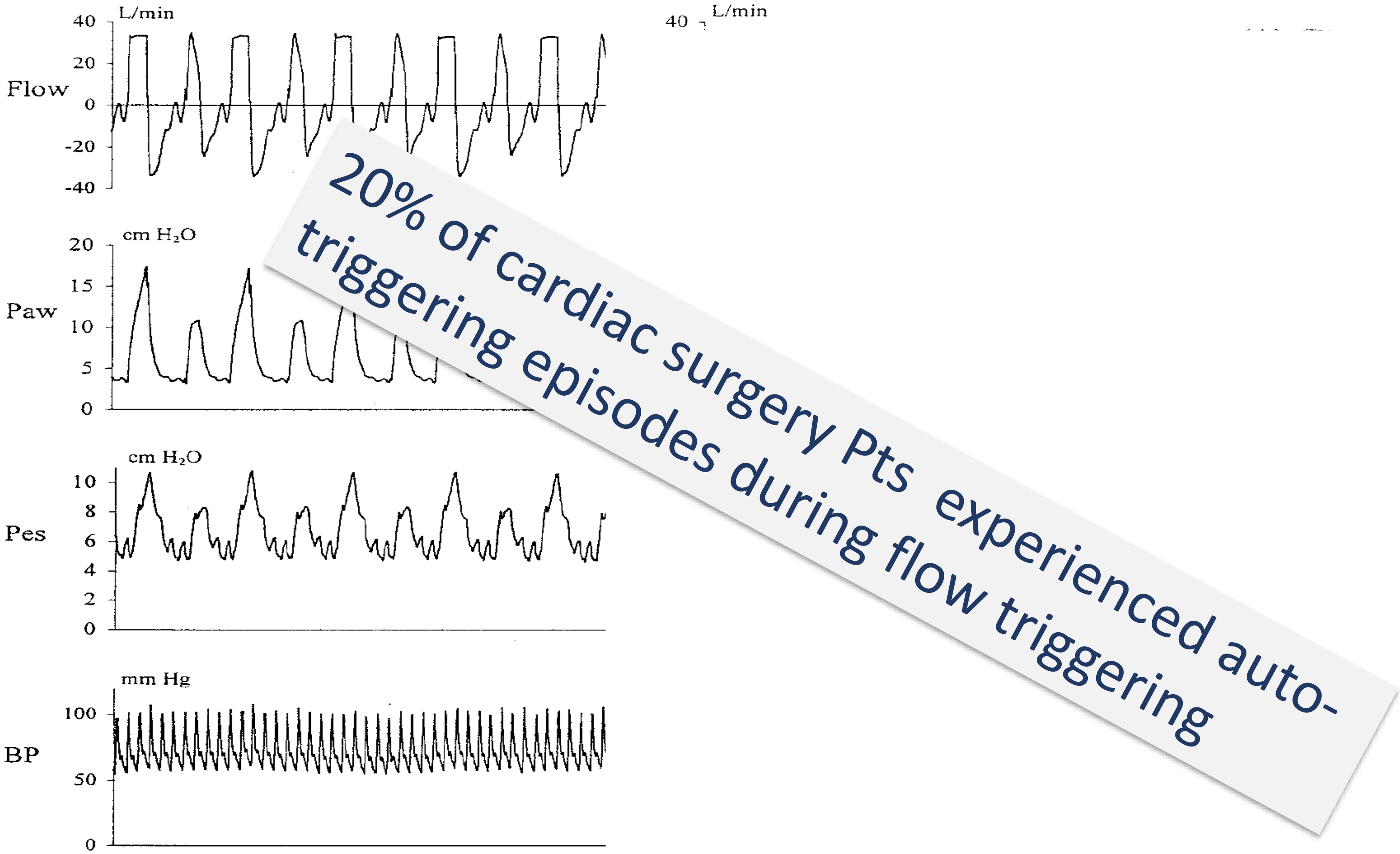


Diagnosi: atto inspiratorio meccanico erogato senza essere preceduto da deflessione negativa Paw

Cause: oscillazioni cardiache, condensa, perdite, ↑↑ sensibilità del trigger inspiratorio

Soluzioni: rimuovere condensa dai tubi (modificare sistema di umidificazione?), correggere le perdite, ↓ sensibilità del trigger inspiratorio

Patient who underwent mitral valve replacement and tricuspid annuloplasty



Trigger sensitivity 1 L/min

Imanaka H. Critical Care Medicine: 28 :2 402-407 2000

Asincronie di trigger espiratorio

Diagnosi:

Ciclaggio espiratorio precoce: distorsione delle tracce di flusso e Paw, Tinsp < ½ Tinsp medio (Tinsp medio = tempo durante il quale il flusso è positivo, calcolaro su 30 atti)
Doppi cicli: due atti meccanico separati da un Texp < ½ Tinsp medio

Cause: ↑↑ drive/sforzo inspiratorio, ↓↓ Psupp, ↑↑ % trigger exp. (inspirazione meccanica troppo corta), ciclaggio a tempo con un tempo inspiratorio massimo troppo basso, ↓↓ costante di tempo del sistema respiratorio, cause cliniche neurologiche (encefalopatia/respiro di Kussmaul)

Soluzioni: esclusione cause neurologiche, ↑ Psupp se sospetta sotto-assistenza (↓Vt), ↑ % trigger exp. (allungamento inspirazione meccanica), ↑ tempo inspiratorio massimo (0.8 - 1 sec)

NB: se segni di ↑↑ drive/sforzo nel setting acuto, ventilazione protettiva controllata vs. controllo del drive respiratorio?

Asincronie di trigger Espiratorio

Ciclaggio espiratorio tardivo e ciclaggio a tempo (*hang-up*)

Diagnosi:

Ciclaggio espiratorio tardivo: *Tinsp > 2*Tinsp medio*

Ciclaggio a tempo: segnalato dal ventilatore

Cause: perdite!!, ↓↓ % trigger exp. (inspirazione meccanica troppo lunga), ↑↑ costante di tempo del sistema respiratorio

Soluzioni: correggere le perdite, ↑ % trigger exp. (idealmente sopra il flusso delle perdite; accorciamento inspirazione meccanica), settare un tempo inspiratorio massimo di 0.8-1 sec, passare a una modalità ciclata a tempo (++ PACV)

Altre asincronie

Flow starvation

Pham et al – Crit Care Clin 2018

PSV/PACV: ↑ Psupp / Pinsp

VACV: ↑ Flusso o Vt vs. passare a modalità pressometrica assistita, dove lo sforzo muscolare del paziente concorre a determinare il picco di flusso inspiratorio

Cause: insufficiente flusso inspiratorio (i centri bulbari sono soddisfatti dal flusso; ++ se ↓ Vt), ↑↑ drive/sforzo inspiratorio (++ se ↑ Vt)

Soluzioni: ↑ flusso inspiratorio vs. ↓ drive respiratorio / ventilazione meccanica protettiva controllata?

Altre asincronie

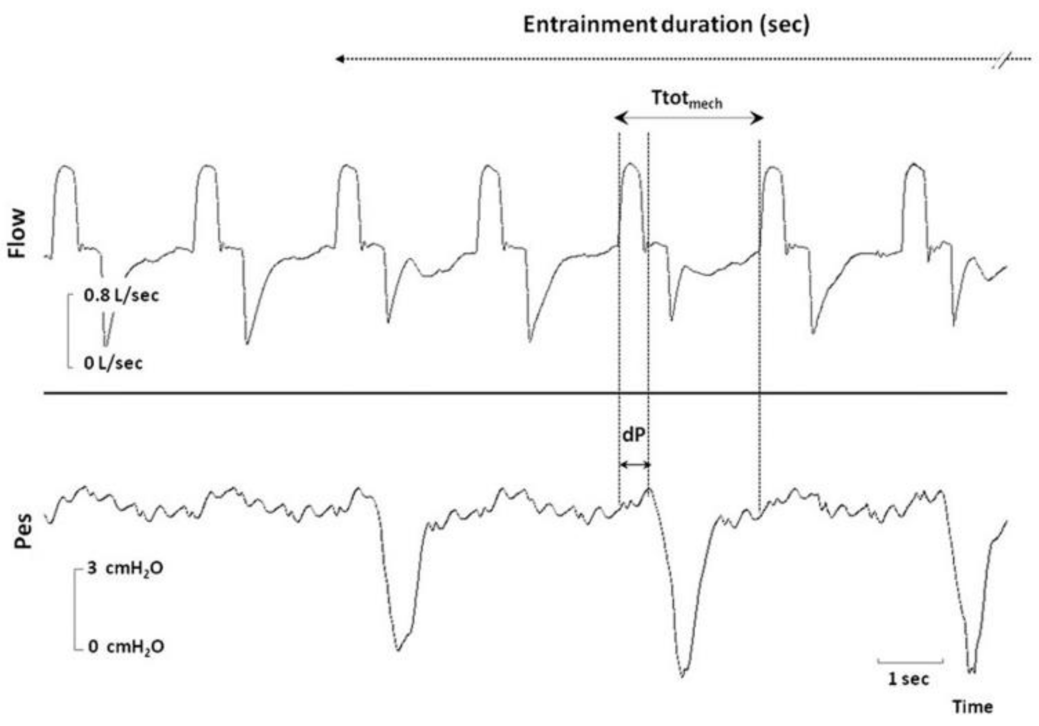
Reverse triggering non armonico

CHEST Original Research
CRITICAL CARE

Mechanical Ventilation-Induced Reverse-Triggered Breaths

A Frequently Unrecognized Form of Neuromechanical Coupling

Evangelia Akoumianaki, MD; Aissam Lyazidi, PhD; Nathalie Rey, MD; Dimitrios Matamis, MD; Nelly Perez-Martinez, MD; Raphael Giraud, MD; Jordi Mancebo, MD; Laurent Brochard, MD; and Jean-Christophe Marie Richard, MD, PhD



Θ = dP / Ttot * 360°
Entrainment ratio = 1:2

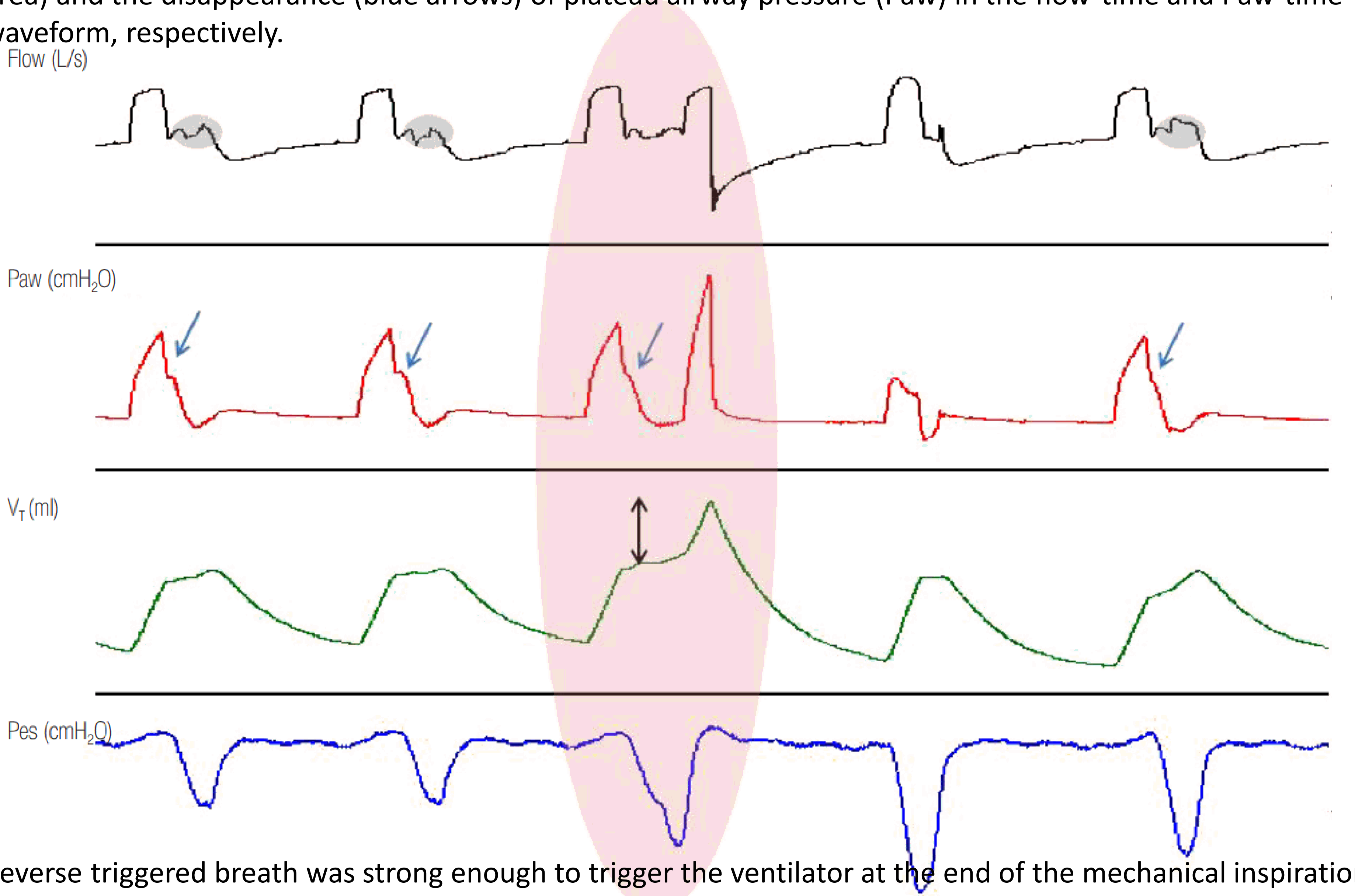
Cause: ++ sedazione profonda, ↓ FR impostata

Conseguenze: ventilazione non-protettiva (↑↑ Vt!), variabilità Pplat (monitoraggio), attività muscolare respiratoria non controllata (consumo di O2, citochine, effetti emodinamici)

Soluzioni: ↑ FR impostata, ↓ sedazione e passaggio a modalità assistita se possibile, paralisi neuromuscolare se modalità assistita non sicura, ↓ sensibilità del trigger inspiratorio (non risolve le conseguenze dell'attività muscolare respiratoria incontrollata!)

Reverse triggering in ACV.

Indirect evidence of patient inspiratory activity during mechanical inflation is the flow distortion (grey shaded area) and the disappearance (blue arrows) of plateau airway pressure (Paw) in the flow-time and Paw-time waveform, respectively.

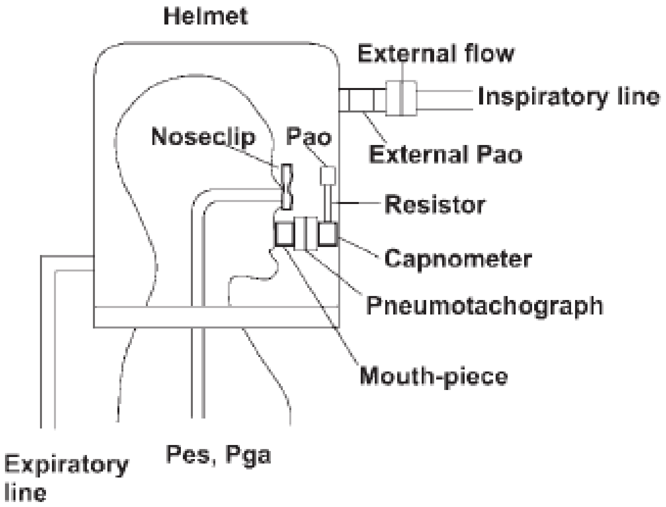


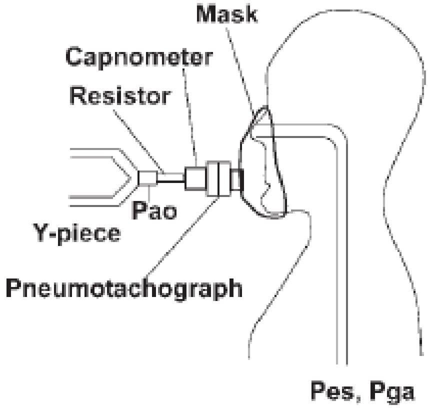
Reverse triggered breath was strong enough to trigger the ventilator at the end of the mechanical inspiration, causing breath stacking (red shaded area). V) during breath stacking increased from 444 ml to 800 ml

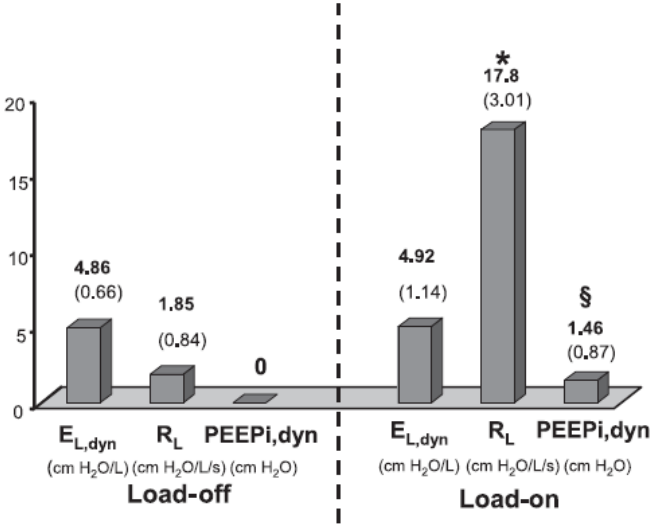
Effectiveness of mask and helmet interfaces to deliver noninvasive ventilation in a human model of resistive breathing

Fabrizio Racca,[1] Lorenzo Appendini,[2] Cesare Gregoretti,[3] Elisa Stra,[1] Antonio Patessio,[2] Claudio F. Donner,[2] and V. Marco Ranieri[1]

[1]*Dipartimento di Anestesia e Rianimazione, Università di Torino, Ospedale S. Giovanni Battista-Molinette, Torino;* [2]*Divisione di Pneumologia, Fondazione Salvatore Maugeri, IRCCS, Istituto Scientifico di Veruno, Veruno (NO);* *and* [3]*Servizio di Anestesia e Rianimazione, Azienda Ospedaliera CTO-CRF-Maria-Adelaide, Torino, Italy*

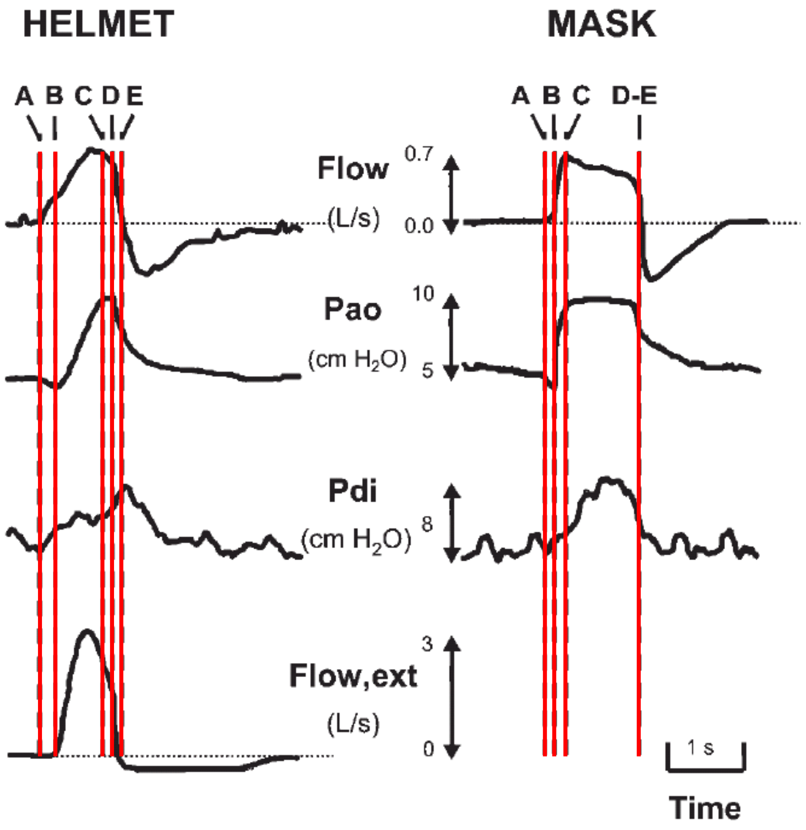


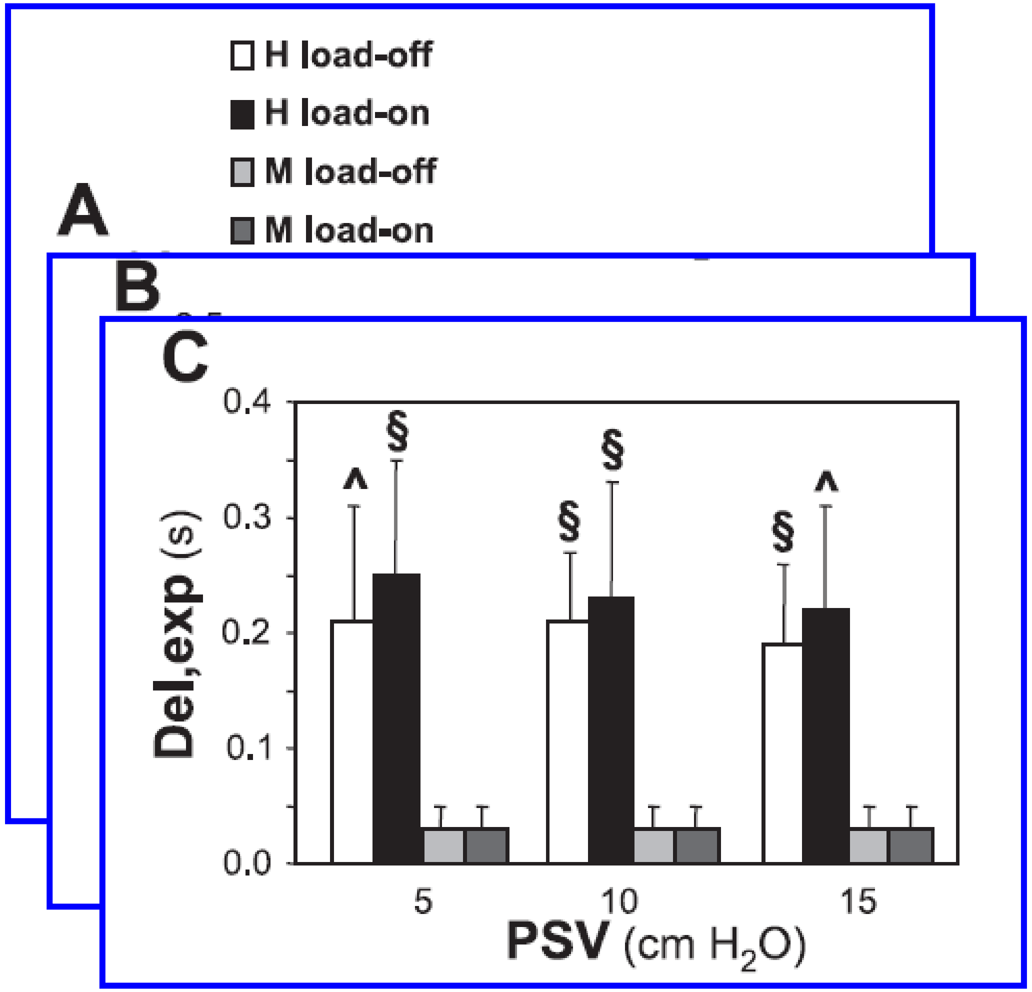




Racca F et al. J Appl Physiol 2005;99:1262-71

Patient-ventilator interaction with helmet PSV is poor





Racca F et al. J Appl Physiol 2005;99:1262-71

Helmet to deliver noninvasive ventilation: "Handle with care"*

only significant difference in synchrony induced by the higher helmet settings in the study by Vargas et al (9) was an improvement in the inspiratory trigger delay, an effect that the authors properly attribute to an improved better pressure and flow transmission, consequent to the lower helmet compliance with higher positive end-expiratory pressure. Cycling off the ventilator is also an important component of the synchrony between the patient and the ventilator. Vargas et al (9) fail to improve the expiratory trigger delay when applying the specific helmet settings.

Because the longer expiratory trigger delay is primarily consequent to a longer expiratory time constant, increasing the threshold of the cycling-off criteria up to 75% should decrease the magnitude of the time lag between the end of neural and mechanical inspiration