

**Αλληλεπίδραση ασθενή-  
αναπνευστήρα στον επεμβατικό  
και μη επεμβατικό μηχανικό  
αερισμό**

ΠΡΙΝΙΑΝΑΚΗΣ ΓΕΩΡΓΙΟΣ

ΕΑ΄ ΜΕΘ

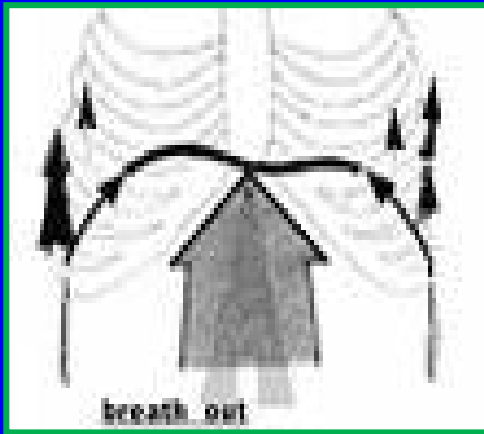
ΠΑΓΝΗ ΗΡΑΚΛΕΙΟΥ

# ΥΠΟΒΟΗΘΟΥΜΕΝΟΣ ΜΗΧΑΝΙΚΟΣ ΑΕΡΙΣΜΟΣ

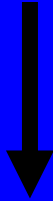
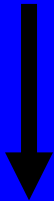
$$P_T = P_{aw} + P_{mus} = V' \times R_{rs} + V \times E_{rs}$$



+

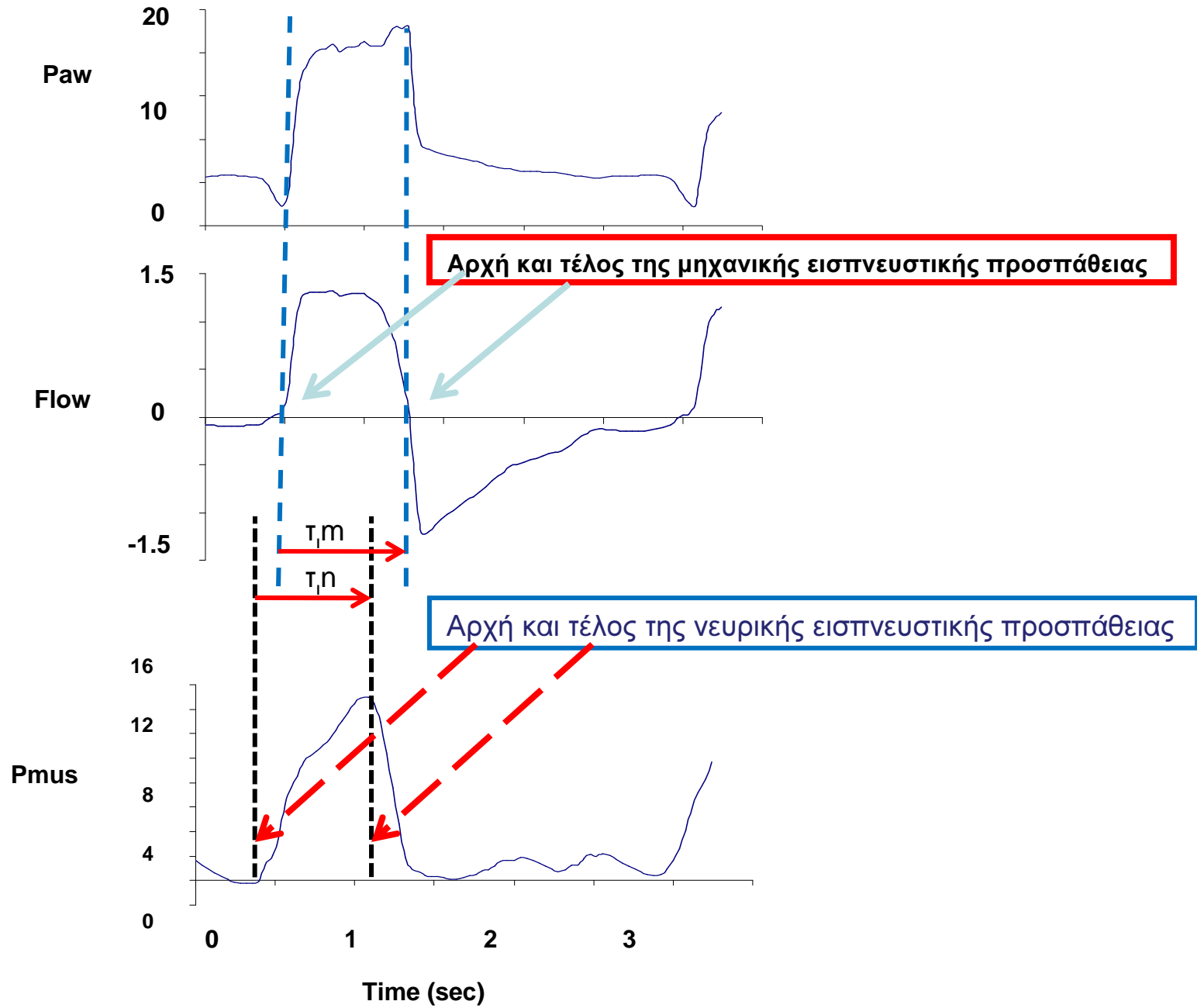


$$= V' \times R_{rs} + V \times E_{rs}$$



$$\text{ΑΝΑΠΝΕΥΣΤΗΡΑΣ} + \text{Ασθενής} = V' \times R_{rs} + V \times E_{rs}$$

# Μηχανικός εισπνευστικός χρόνος και Νευρικός εισπνευστικός χρόνος



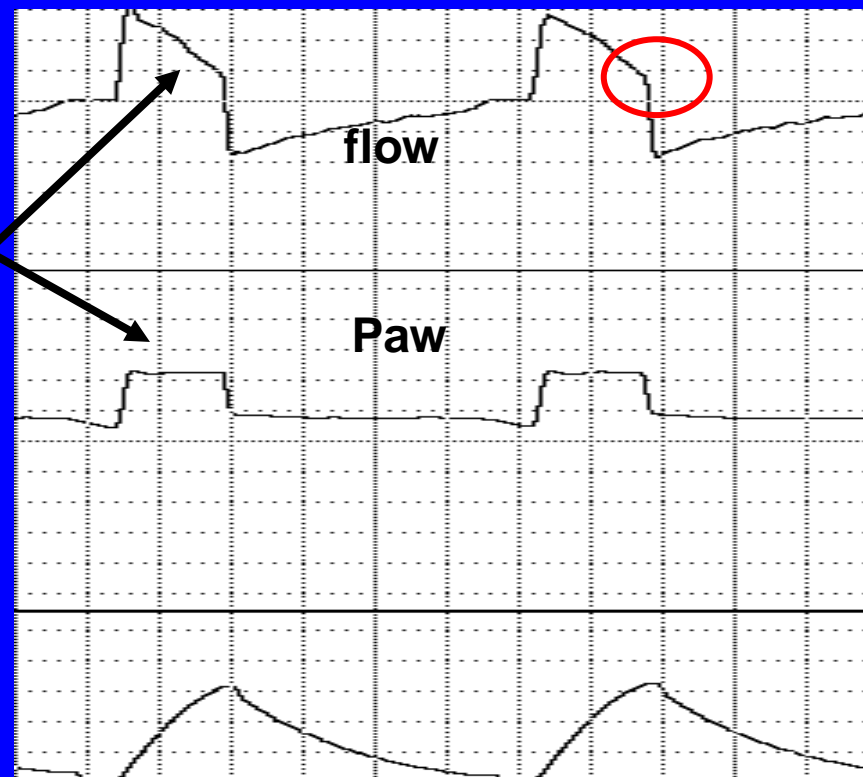
**MONITORING  
ΑΛΛΗΛΕΠΙΔΡΑΣΗΣ  
ΑΣΘΕΝΗ ΑΝΑΠΝΕΥΣΤΗΡΑ**

# PRESSURE SUPPORT VENTILATION

Ο αναπνευστήρας όταν πυροδοτηθεί από τον ασθενή χορηγεί σταθερή πίεση η οποία καθορίζεται από το θεράποντα ιατρό.

Η ροή ελαττώνεται σταδιακά με ρυθμό που εξαρτάται από τις μηχανικές ιδιότητες και από την προσπάθεια του ασθενούς.

Πότε θα σταματήσει η εισπνοή θα εξαρτηθεί από το κριτήριο εκπνοής ( cycling off).

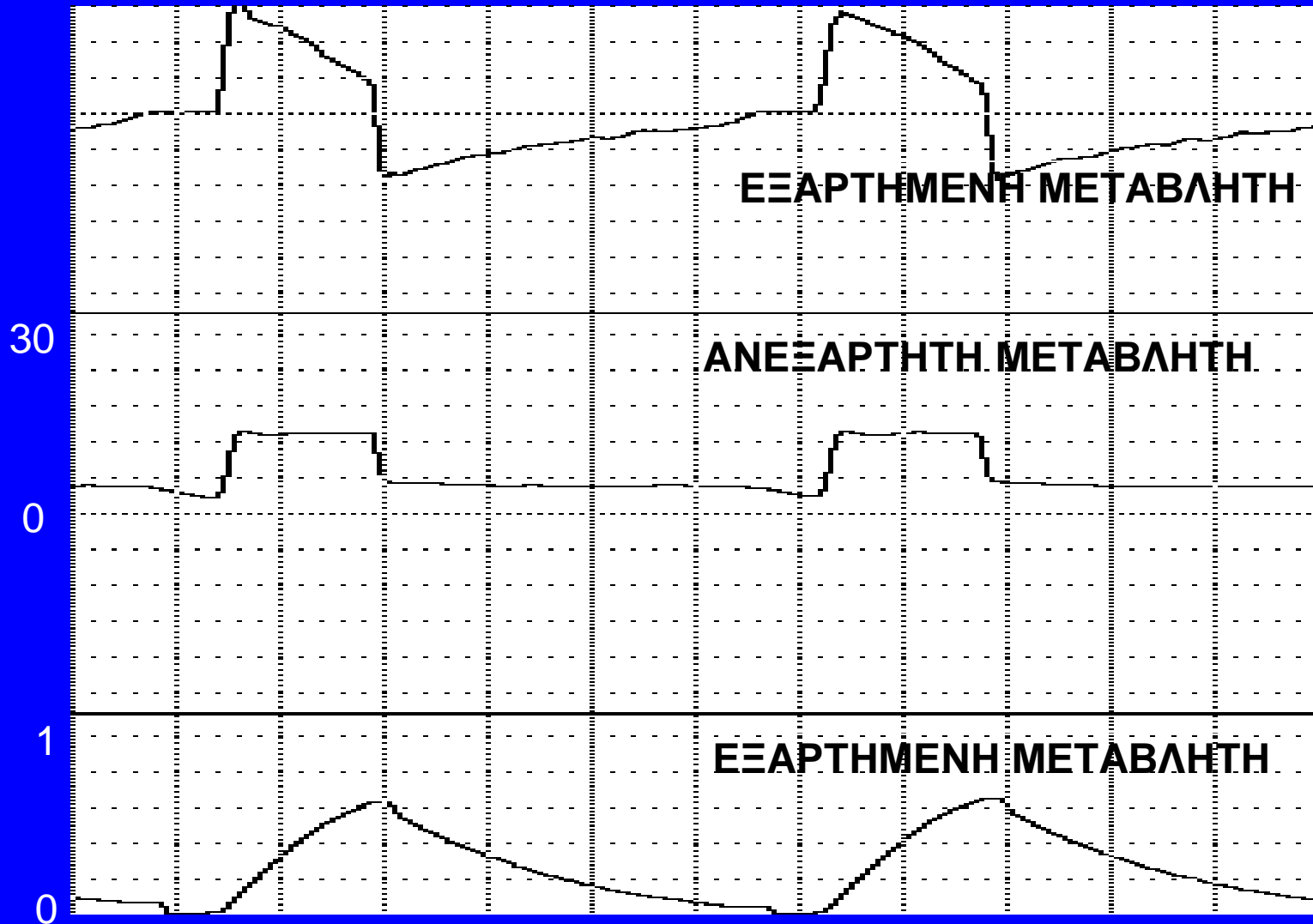


# Waveforms during PSV

Flow

$P_{aw}$

$V_t(t)$



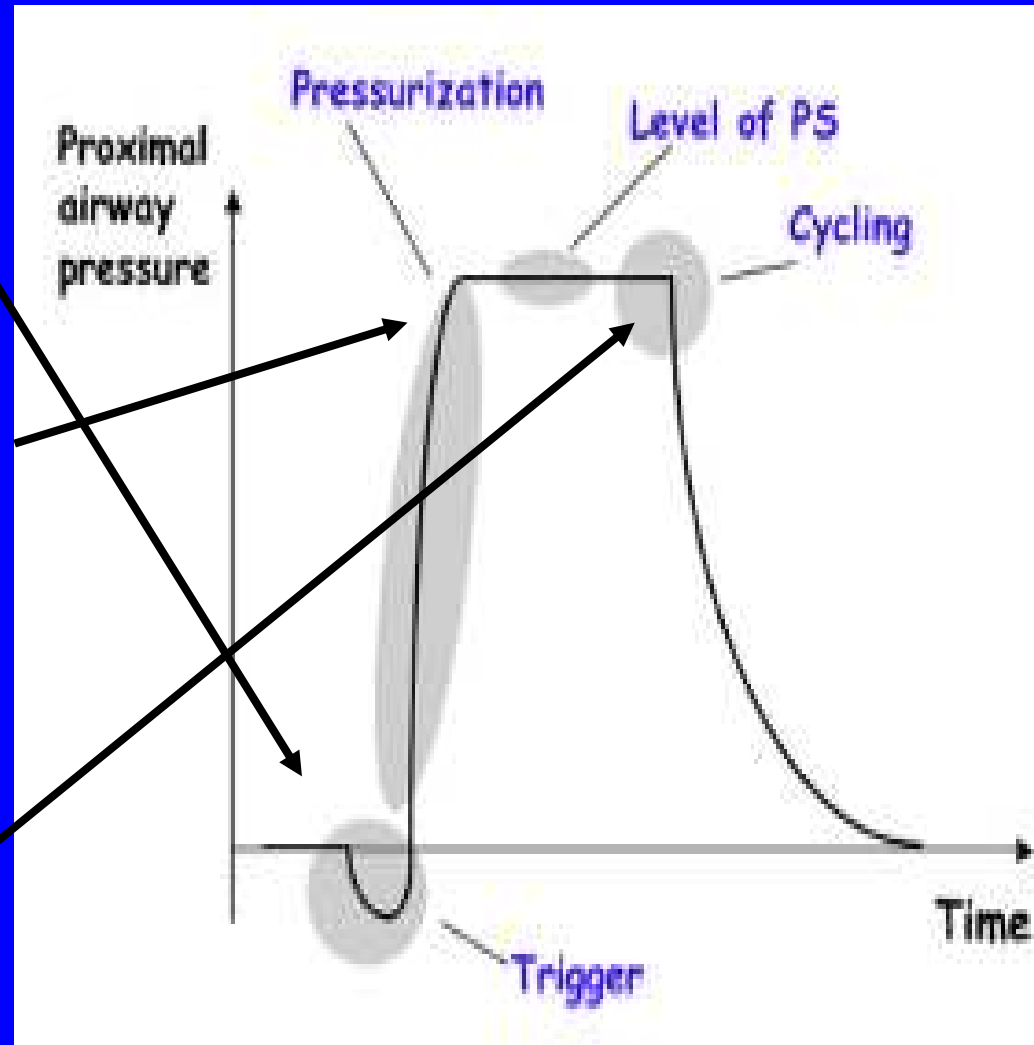
TIME

# Phases of one breath

**Trigger**

**Pressurization**

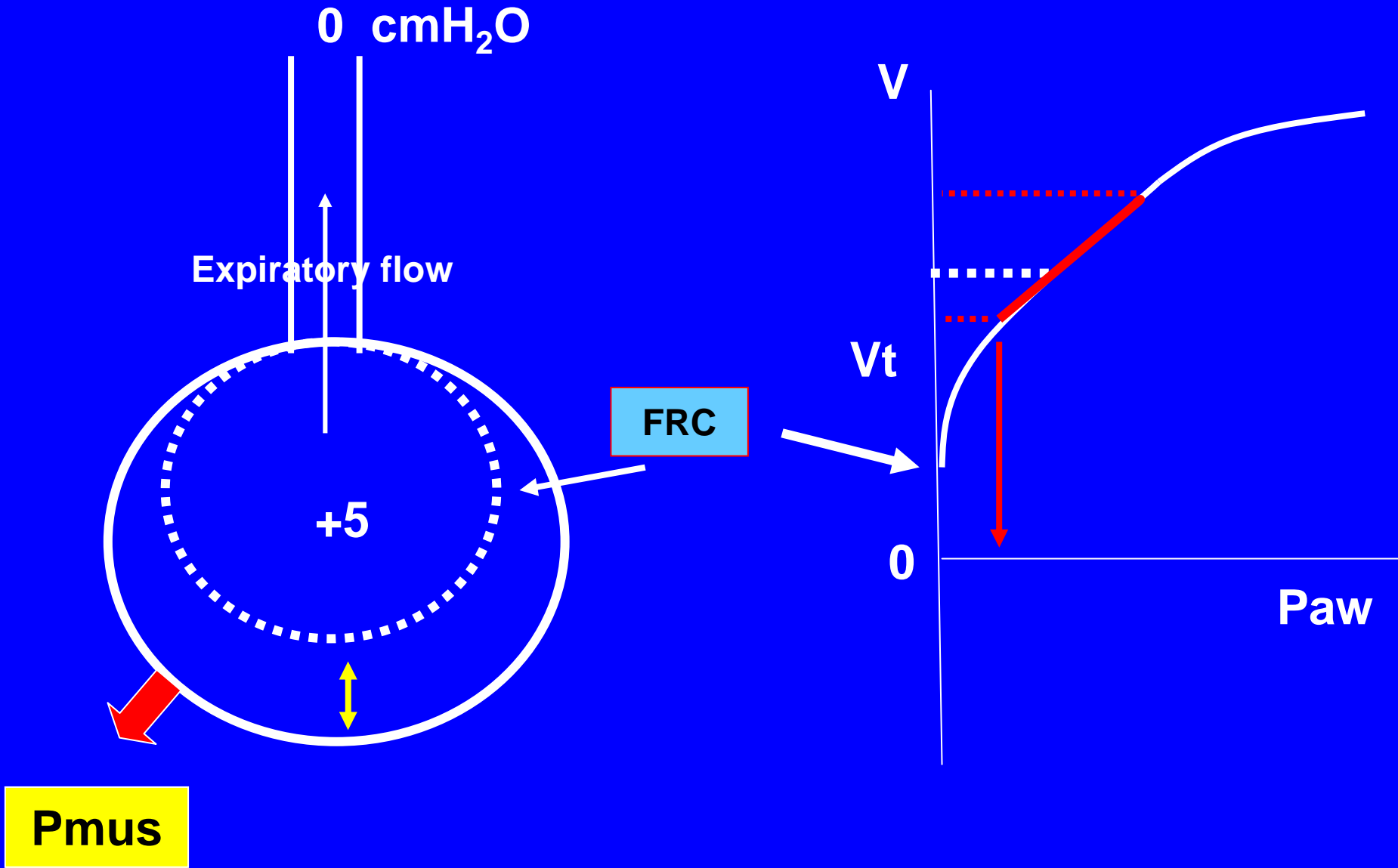
**Cycling off**

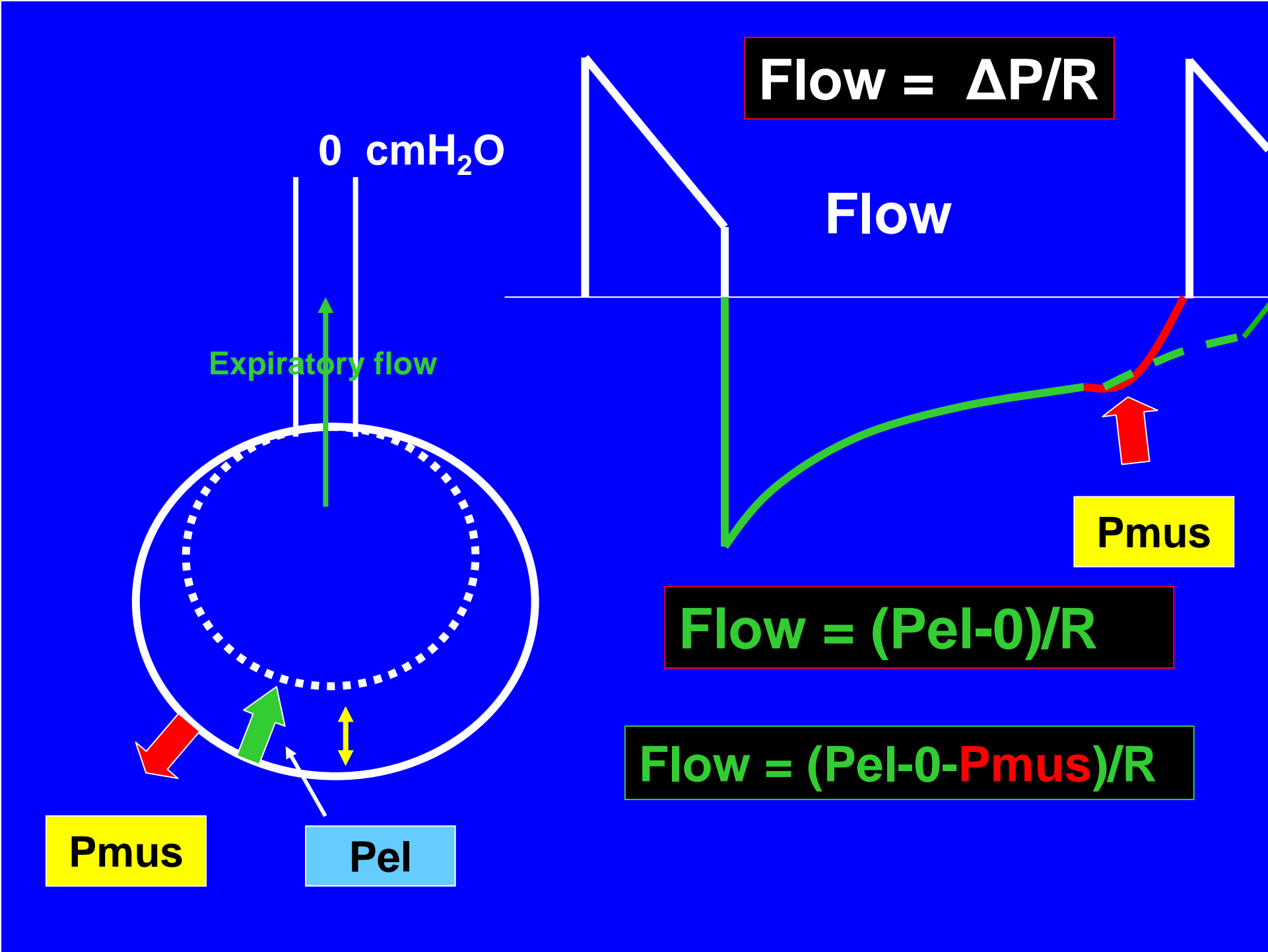


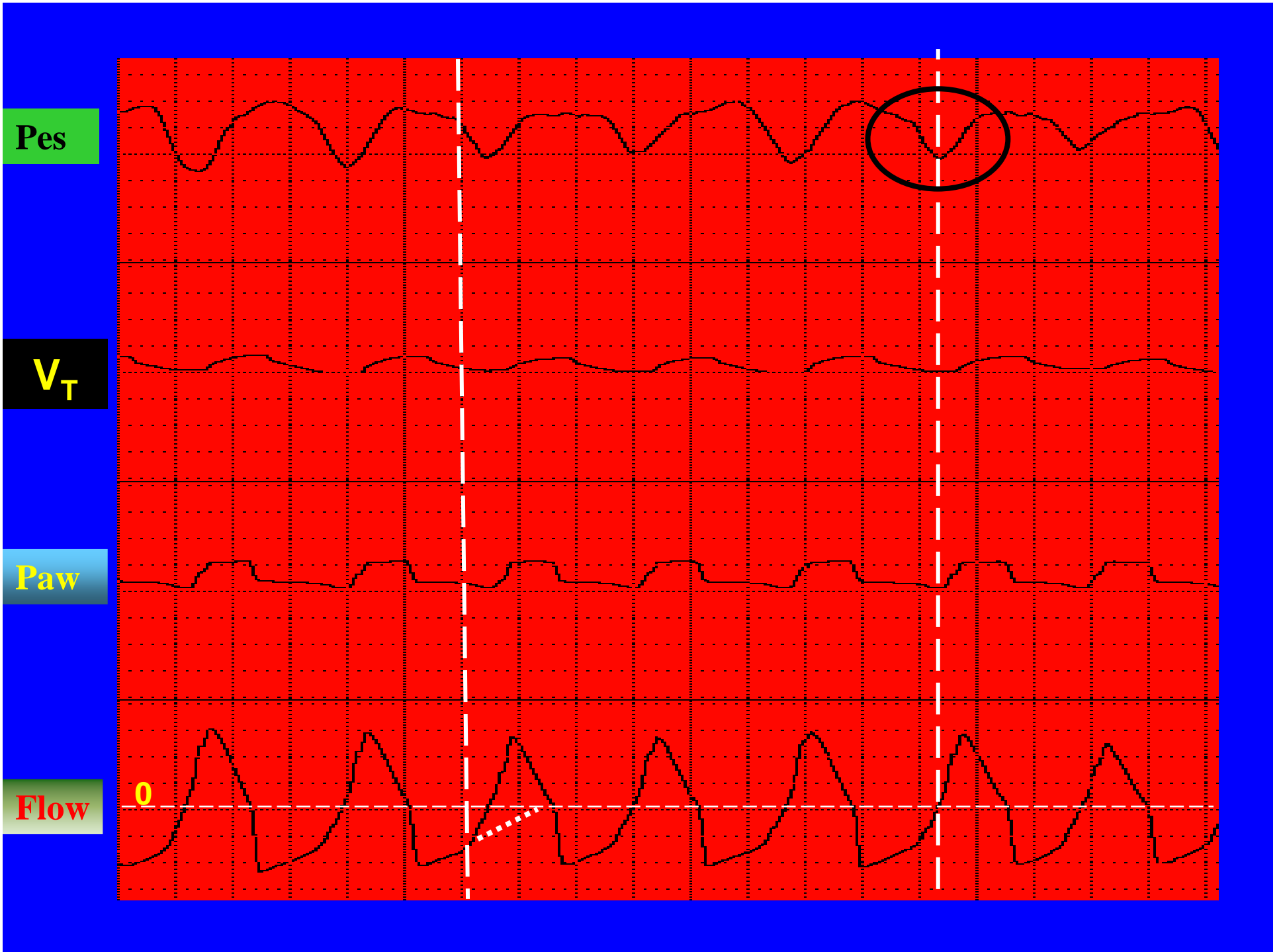
# Dyssynchrony in Triggering

- **DYNAMIC HYPERINFLATION**  
(Δυναμική Υπερδιάταση)
- **MISSING EFFORT**  
(Αναποτελεσματική προσπάθεια)
- **AUTOTRIGGERING**  
(Αυτοδιέγερση)
- **DOUBLE TRIGGERING**  
(Διπλή διέγερση)

# DYNAMIC HYPERINFLATION





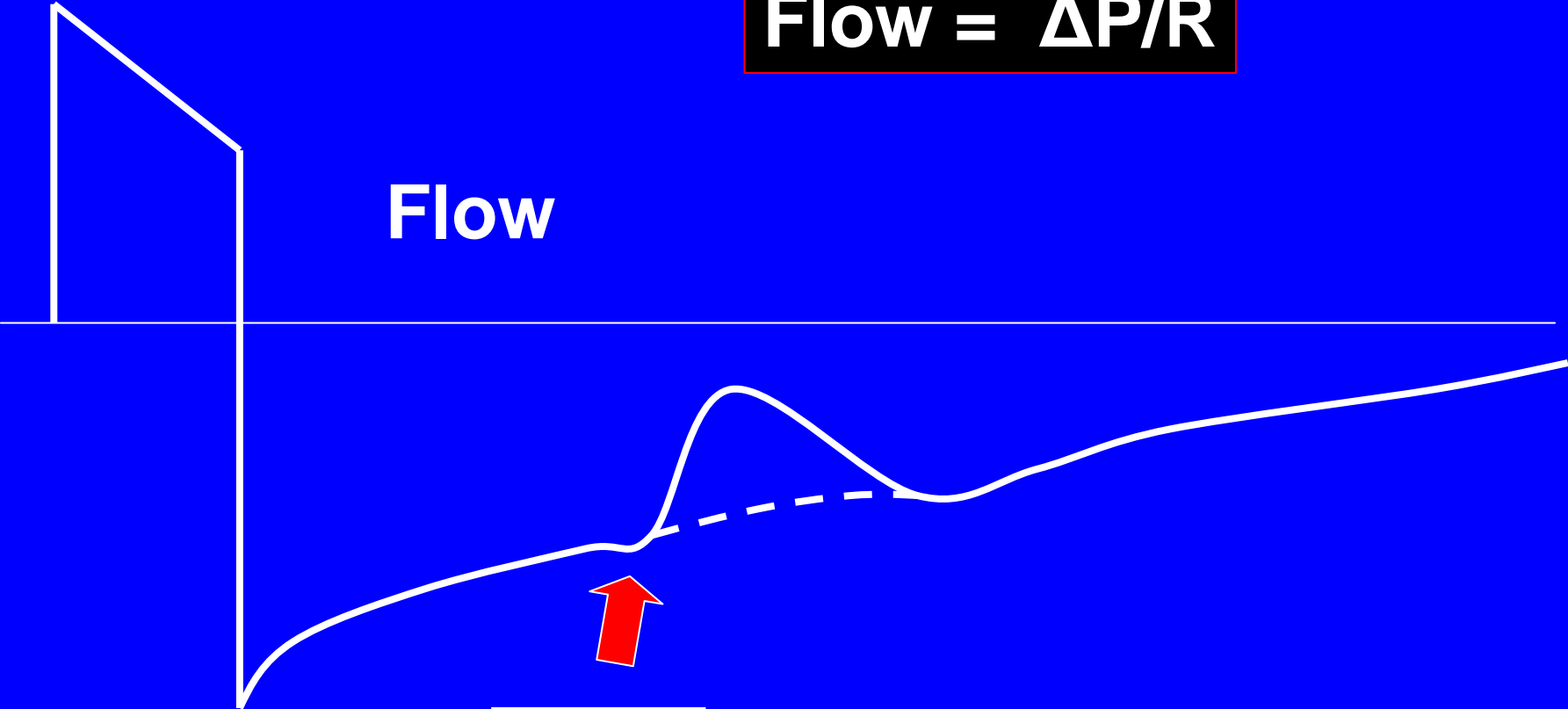


# Missing effort

Frequency Ventilator < Frequency patient

$$\text{Flow} = \Delta P / R$$

Flow



Pmus

$$\text{Flow} = (P_{el-0} - P_{mus}) / R$$

# MISSING EFFORT



Pes

1 2 3 4 5 6 7 8 9 10

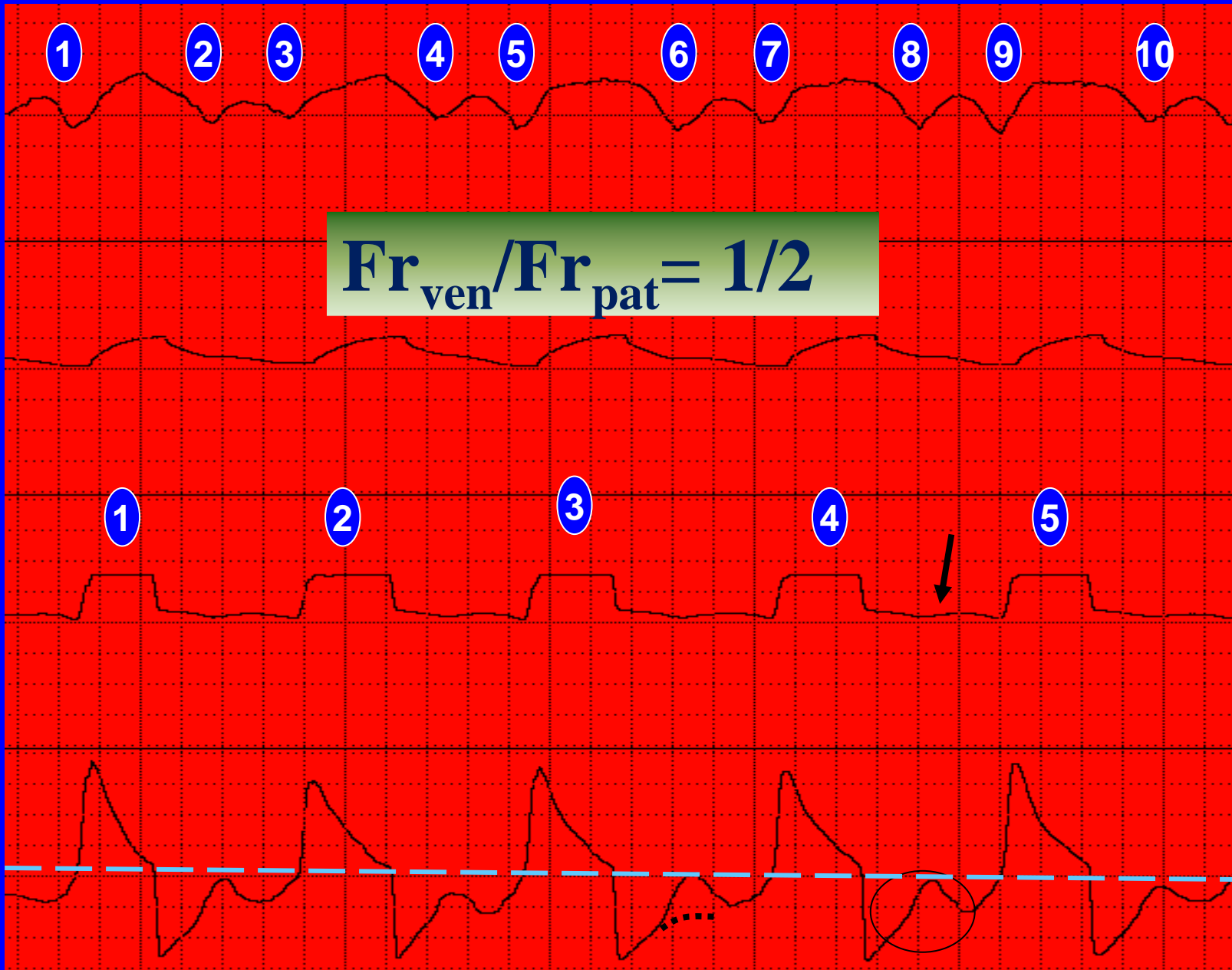
$$Fr_{ven}/Fr_{pat} = 1/2$$

$V_T$

Paw

1 2 3 4 5

Flow

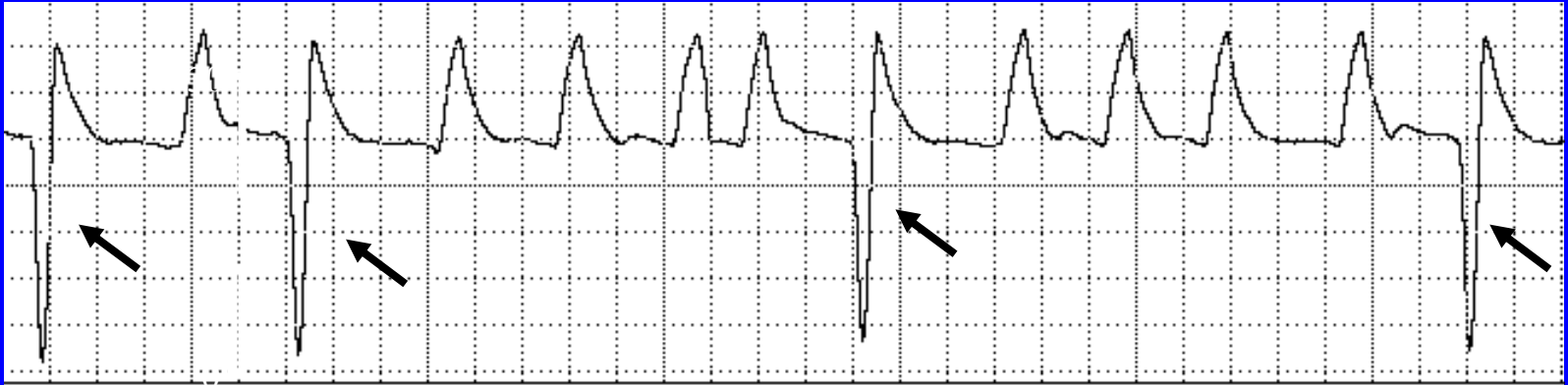


# AUTOTRIGGERING

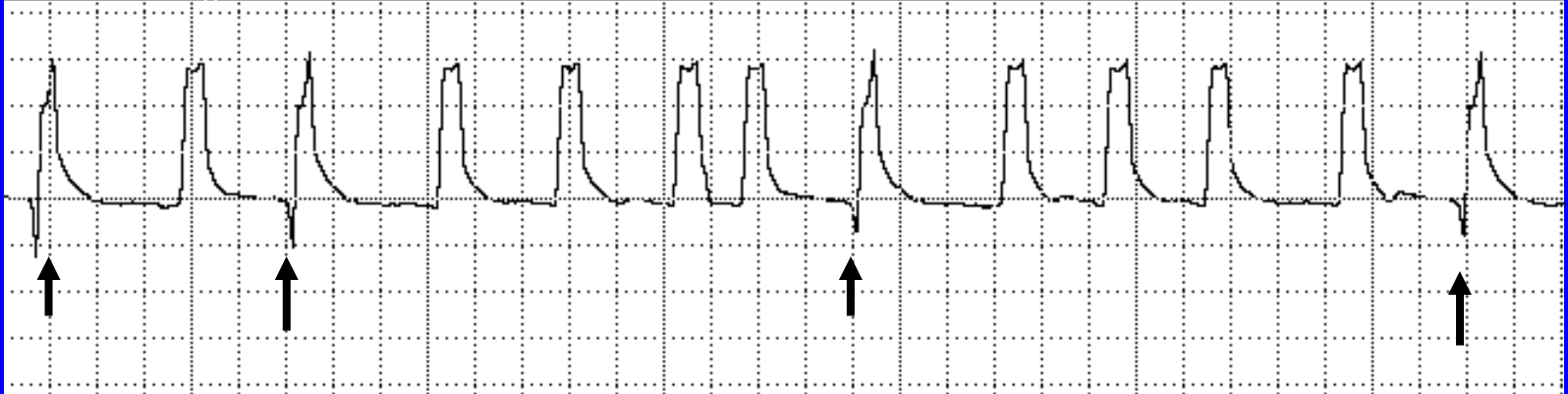
Ο αναπνευστήρας πυροδοτείται  
αυτόματα χωρίς αναπνευστική  
προσπάθεια από τον ασθενή

# AUTOTRIGGERING

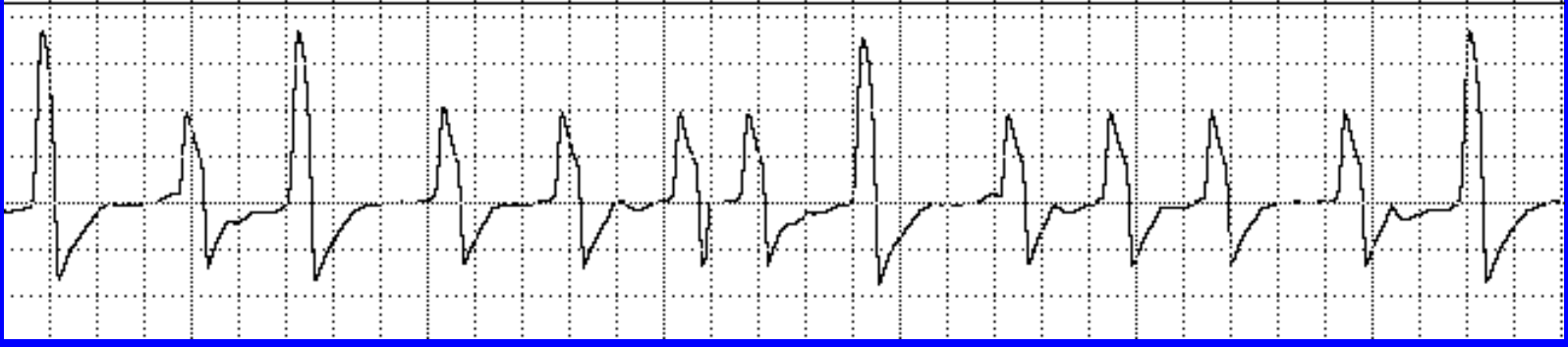
Pes



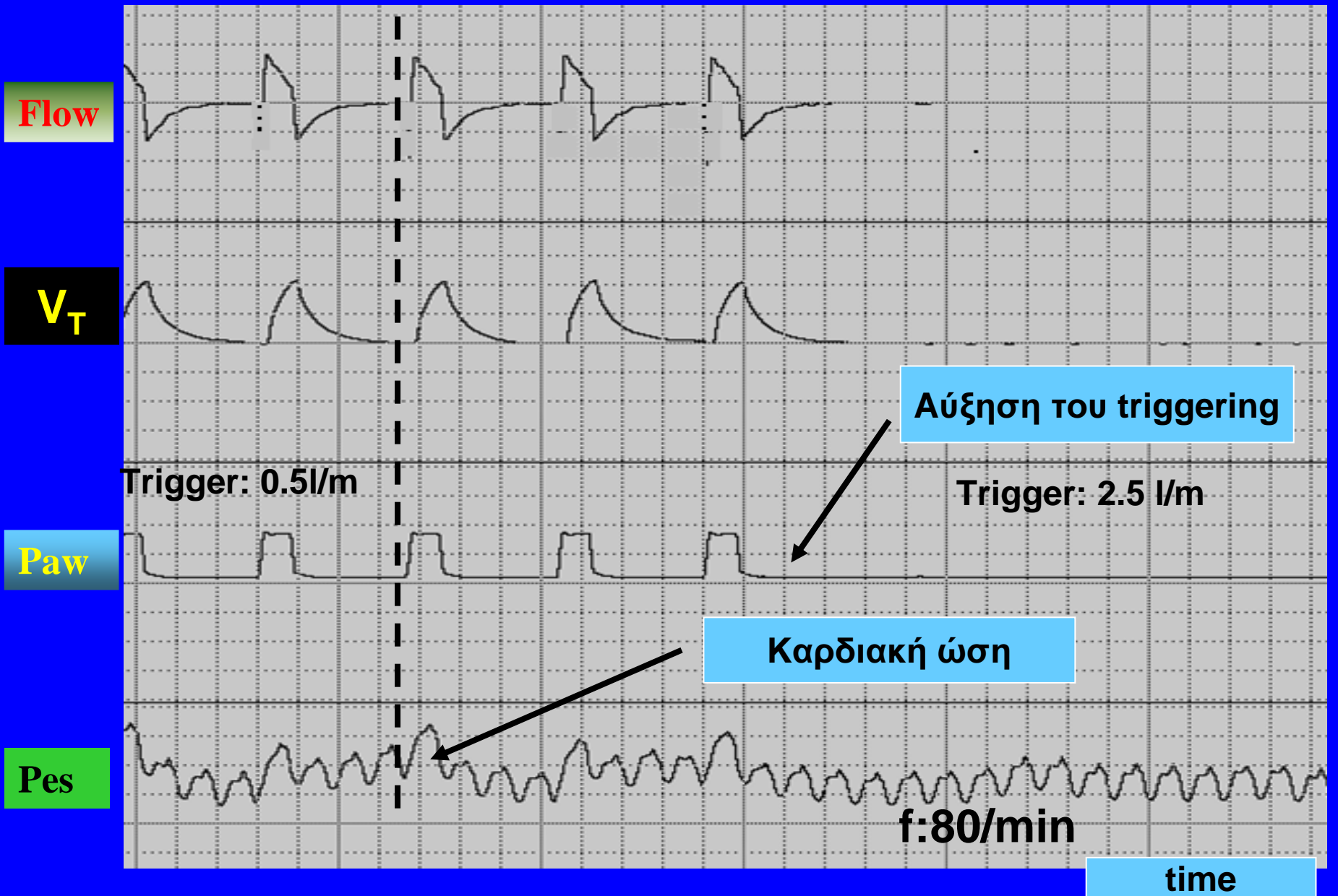
Paw



Flow



# AUTOTRIGGERING



## Cases of Note

*Continued from page 496*

**Table**  
**Potential causes of ventilator autotriggering<sup>a</sup>**

<b>Extrinsic causes</b>	<b>Intrinsic causes</b>
Random artifact in ventilator circuit	Cardiogenic oscillations
Water condensation in ventilator circuit	Bronchopleural fistula
Gas leak in patient/ventilator system (circuit leak)	Chest tube leak
Endotracheal tube cuff leak	
Excessive retraction of an inline suction catheter	

<sup>a</sup> Based on data from Nilsestuen and Hargett,<sup>9</sup> Hess,<sup>10</sup> Kondili et al,<sup>11</sup> Campbell et al,<sup>12</sup> Sager et al,<sup>13</sup> and Al-Khafaji and Manning.<sup>14</sup>

# Double triggering-Διπλή διέγερση

Μιά προσπάθεια του ασθενή πυροδοτεί  
τουλάχιστον δύο προσπάθειες του  
αναπνευστήρα

# DOUBLE AND TRIPLE TRIGGER

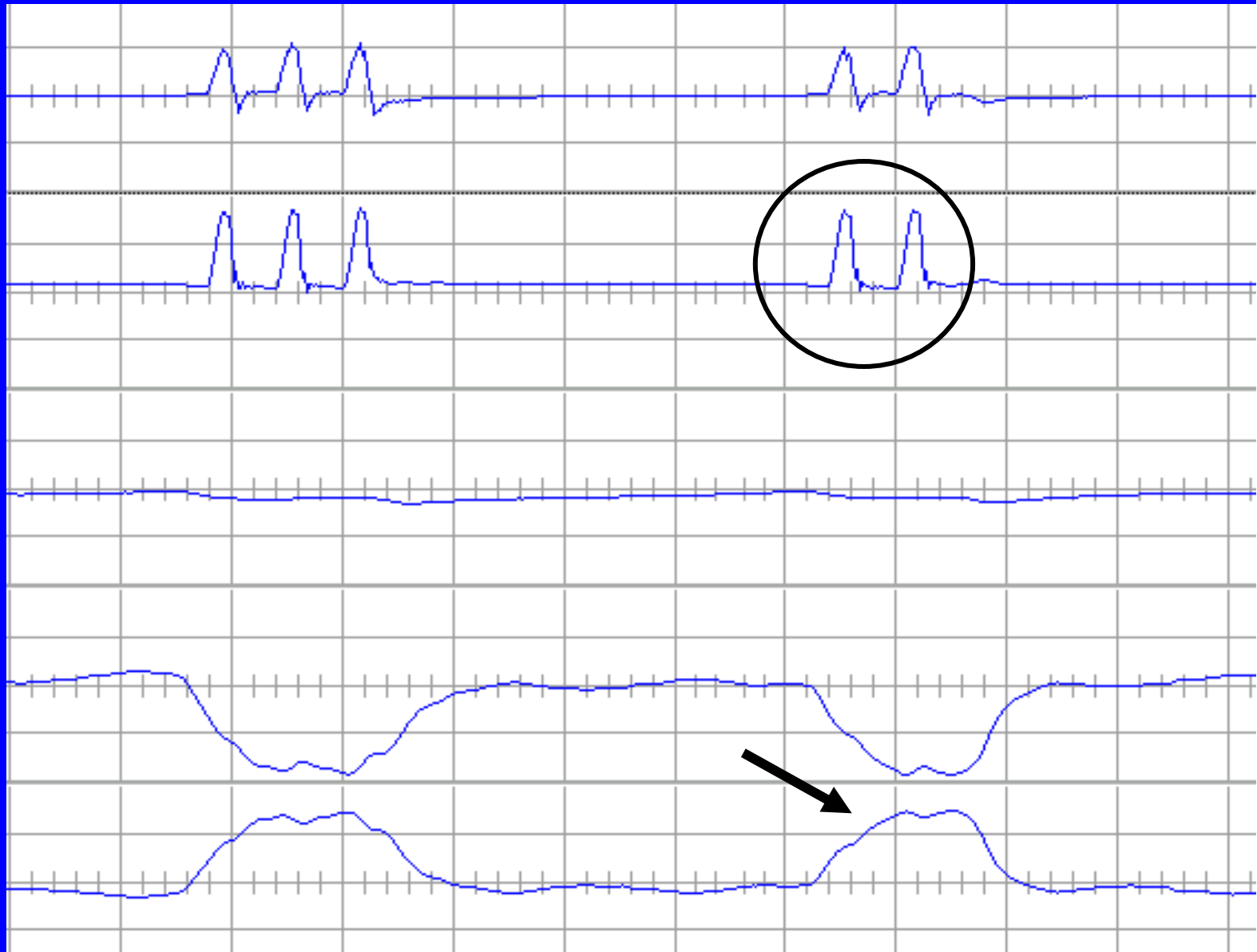
Flow

Paw

Pga

Pes

Pdi

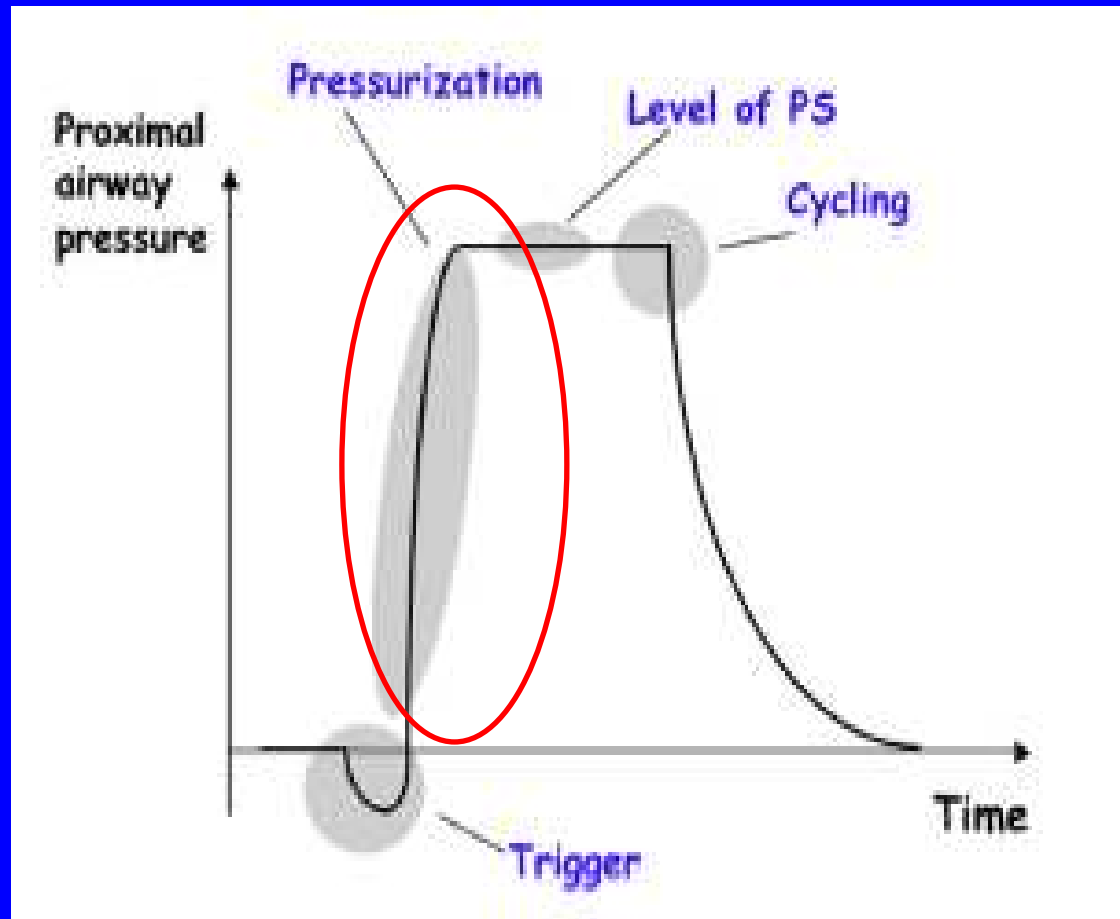


# Causes of double trigger

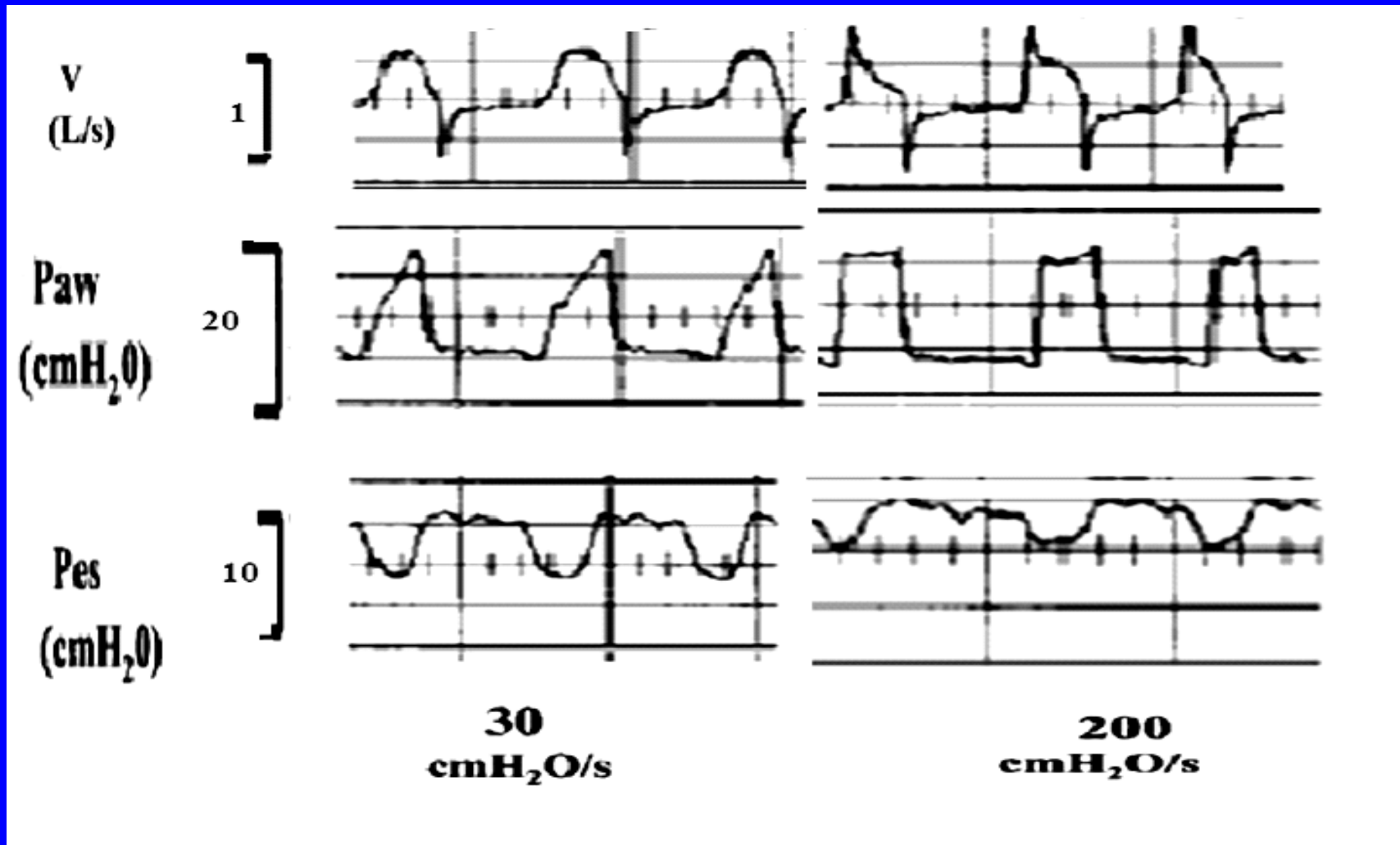
- I. High elastic recoil**
- II. Low expiratory resistance**
- III. Low tidal volume**
- IV. Long neural inspiratory time**
- V. High respiratory drive**
- VI. Low threshold of trigger**

low time  
constant

# Pressurization phase



# Inspiratory rise time



**Fast IRT, less work  
of breathing**

Prinianakis G, Eur Respir J 2004

Bonmarchand G, Intensive Care Med 1996

# **EXPIRATORY DYSSYNCHRONY**

# EXPIRATORY DYSSYNCHRONY

$$T_{\text{Ineural}} > T_{\text{Imechanical}}$$

**Νευρικός εισπνευστικός χρόνος > Μηχανικός εισπνευστικός χρόνος**

**Flo  
W**

Τέλος μηχανικής εισπνευστικής προσπάθειας

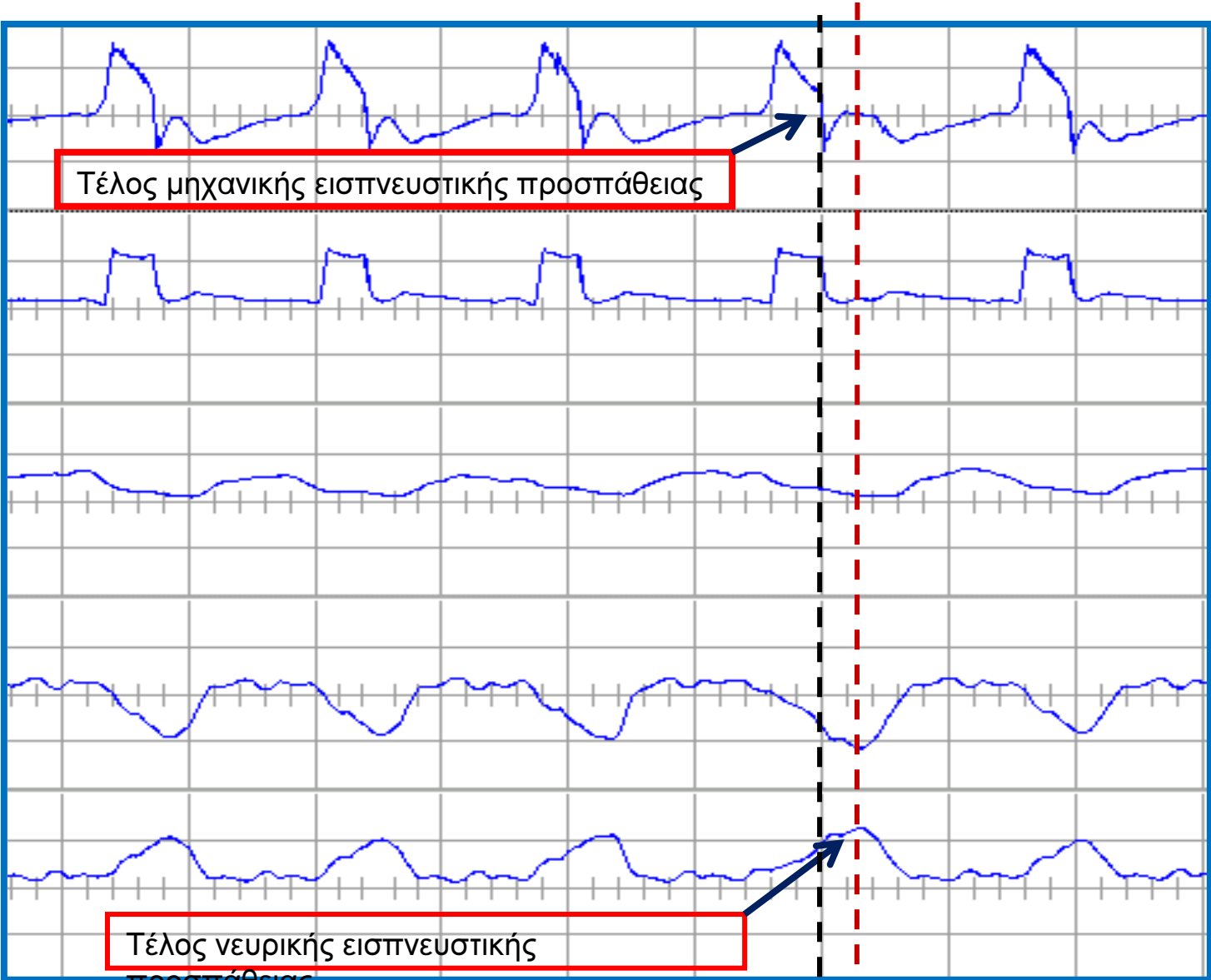
**Paw**

**Pga**

**Pes**

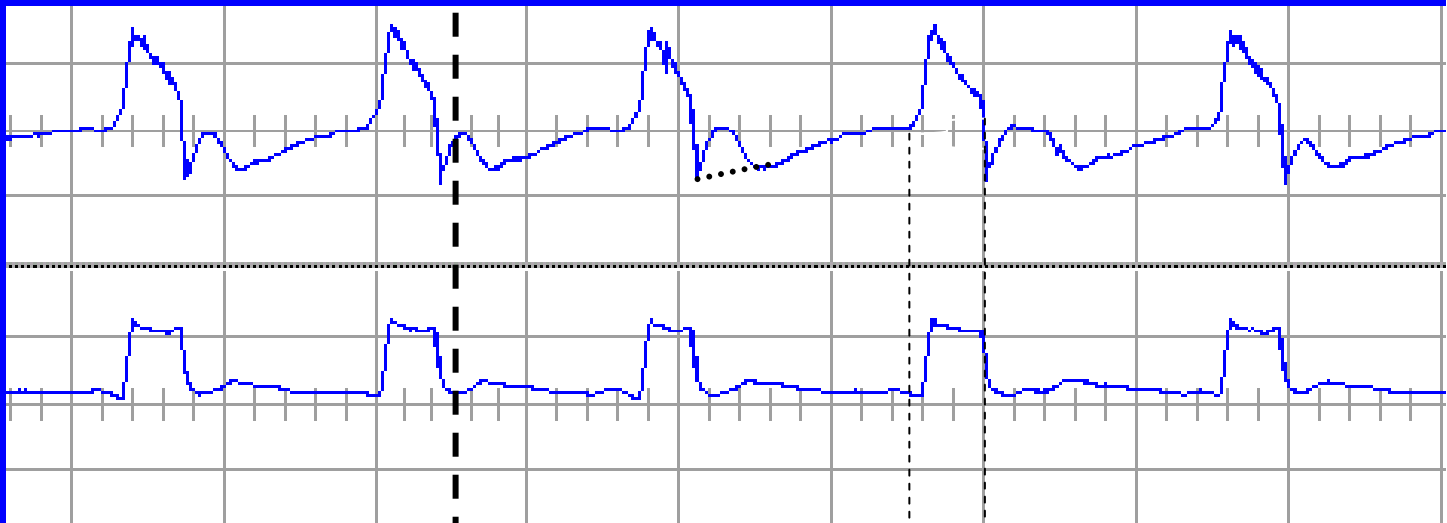
**Pdi**

Τέλος νευρικής εισπνευστικής προσπάθειας

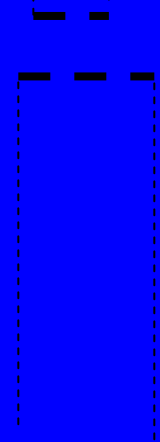


**Flow**

**Paw**



**$T_{In} > T_{Im}$**



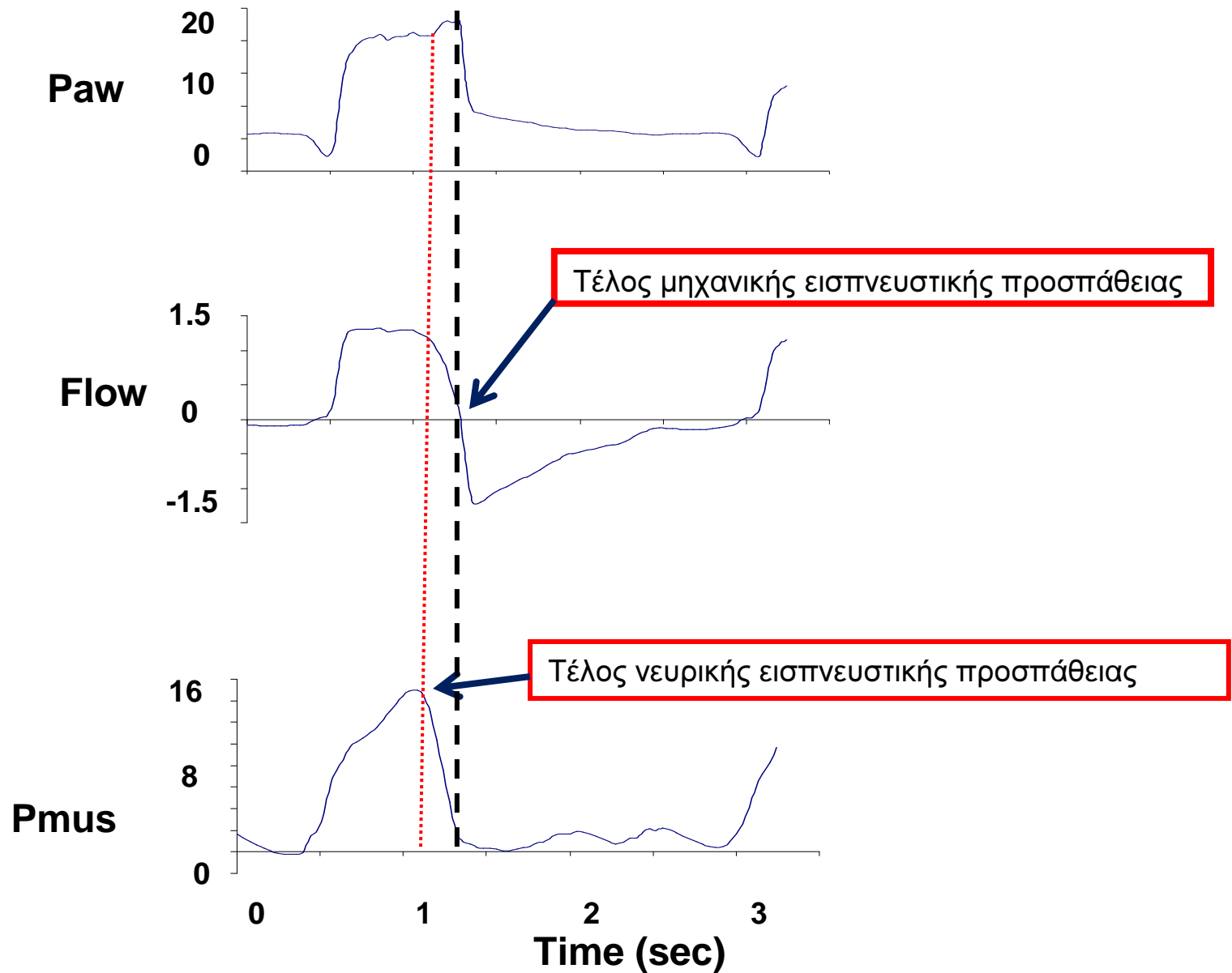
## Εκπνευστική Ασυγχρονία (expiratory dyssynchrony)

Καθυστερημένη μετάβαση στην εκπνοή  
(Delayed Termination).

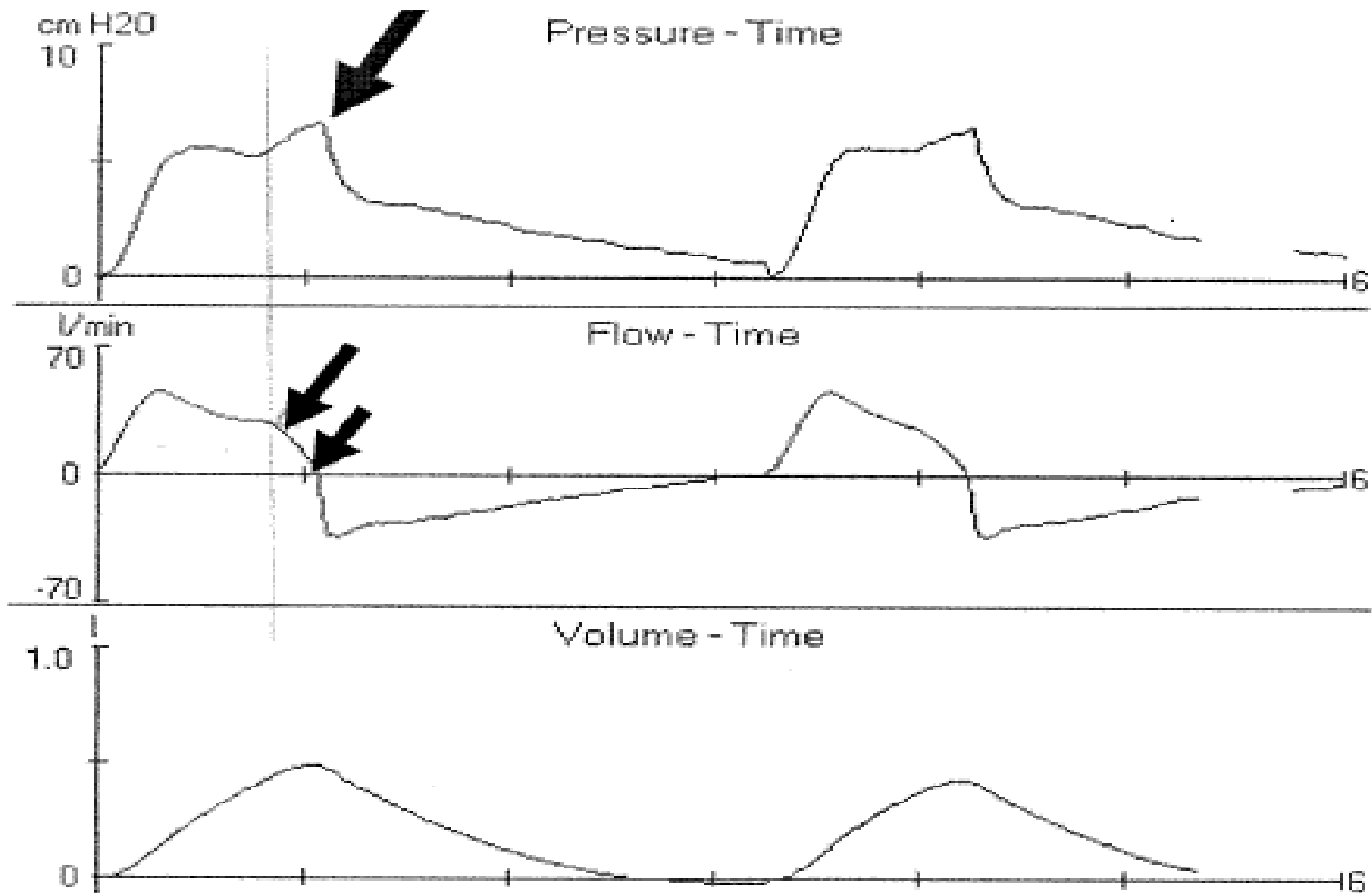
Ο μηχανικός εισπνευστικός είναι μεγαλύτερος  
από τον νευρικό εισπνευστικό χρόνο.

$$T_{I\text{mechanic}} > T_{I\text{neural}}$$

# Νευρικός εισπνευστικός χρόνος < Μηχανικός εισπνευστικός χρόνος



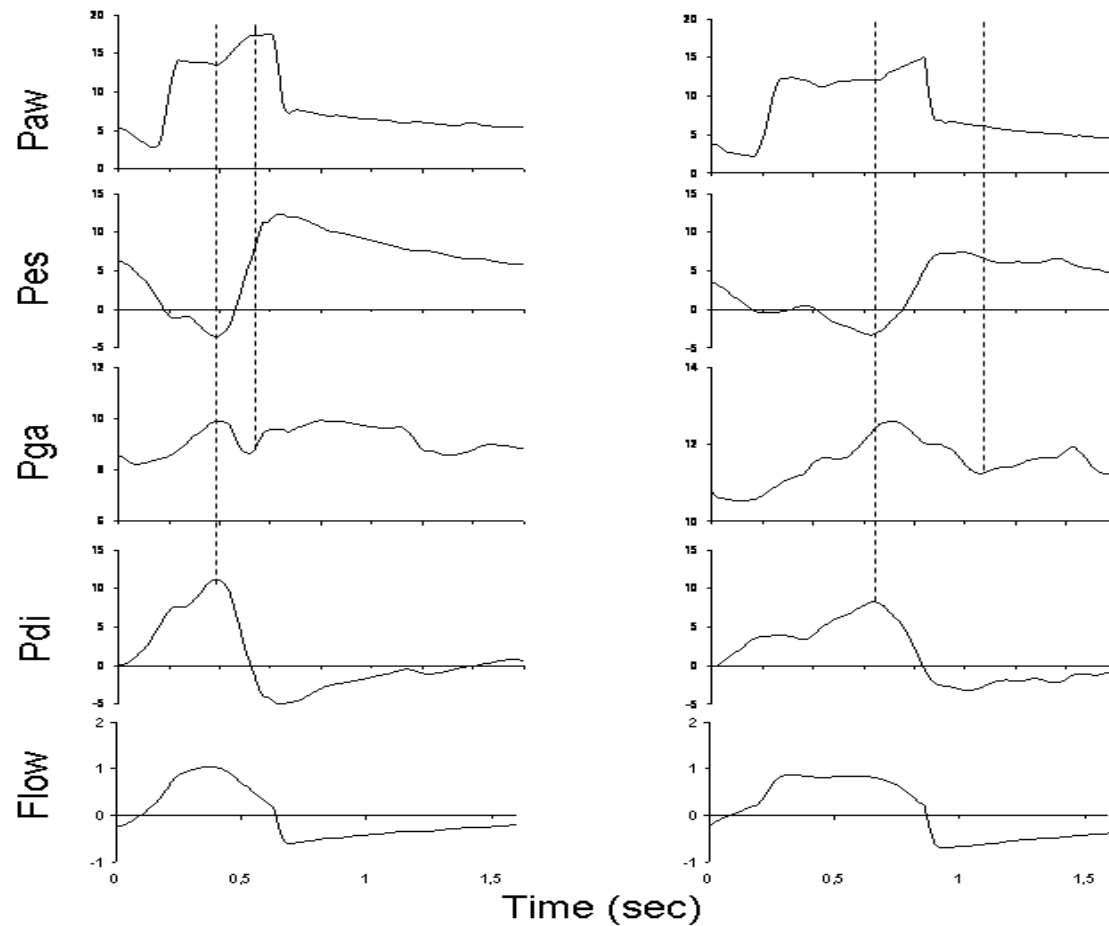
# Τελικοεισπνευστική αύξηση της P<sub>aw</sub> (φαινόμενο εκπνευστικής ασυγχρονίας)



George Prinianakis  
Maria Plataki  
Eumorfia Kondili  
Maria Klimathianaki  
Katerina Vaporidi  
Dimitris Georgopoulos

## Effects of relaxation of inspiratory muscles on ventilator pressure during pressure support

Intensive Care Med 2007



Improvement of patient  
ventilator asynchronies

# ANTIMETΩΠΙΣΗ

- a) decrease the magnitude of dynamic hyperinflation (low tidal volume, long expiratory time, decrease the expiratory resistance),
- b) interventions which increase Pmus during the triggering phase (i.e., decrease in sedation level),
- c) application of external PEEP
- d) decrease the threshold for triggering

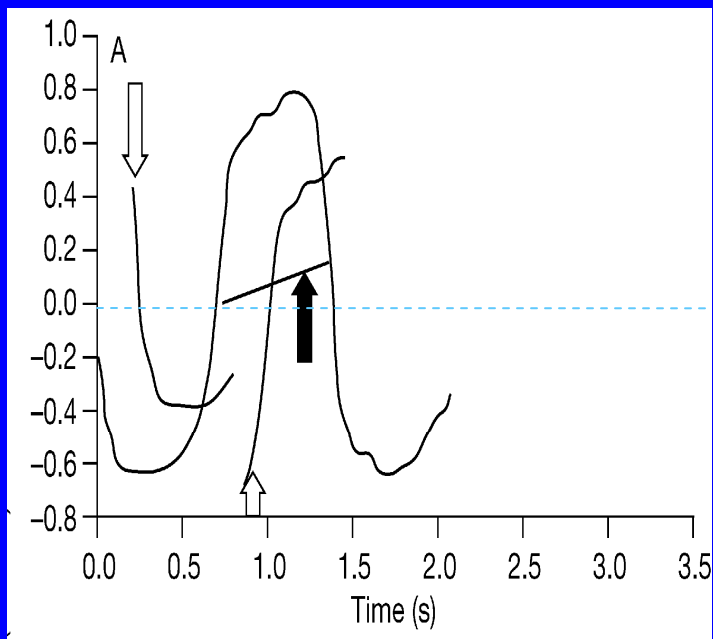
Georgopoulos et al. Intensive Care Med (2006)

# ANTIMETΩΠΙΣΗ

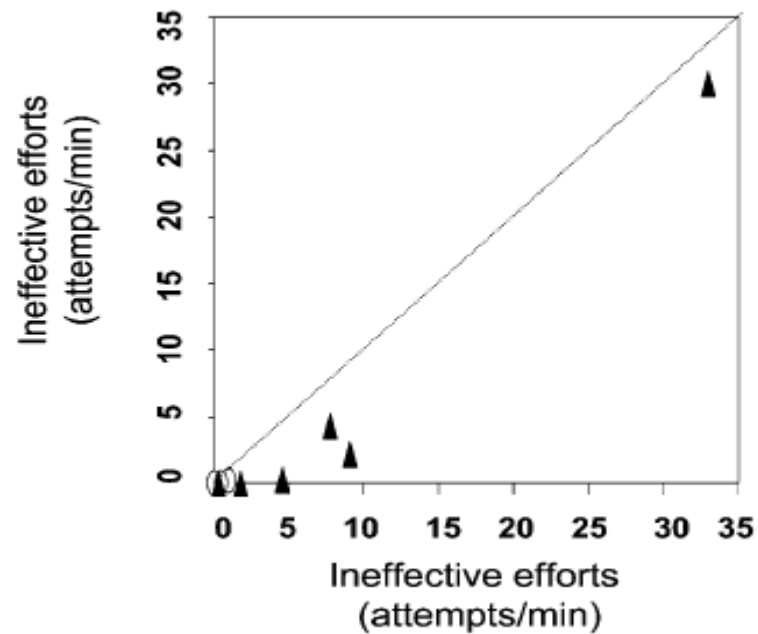
In the presence of dynamic hyperinflation:  
the flow-waveform method of triggering  
(Vision) compared to flow triggering  
decreases

- 1) the triggering delay and
- 2) the number of ineffective efforts

# Flow shape signal and ineffective efforts



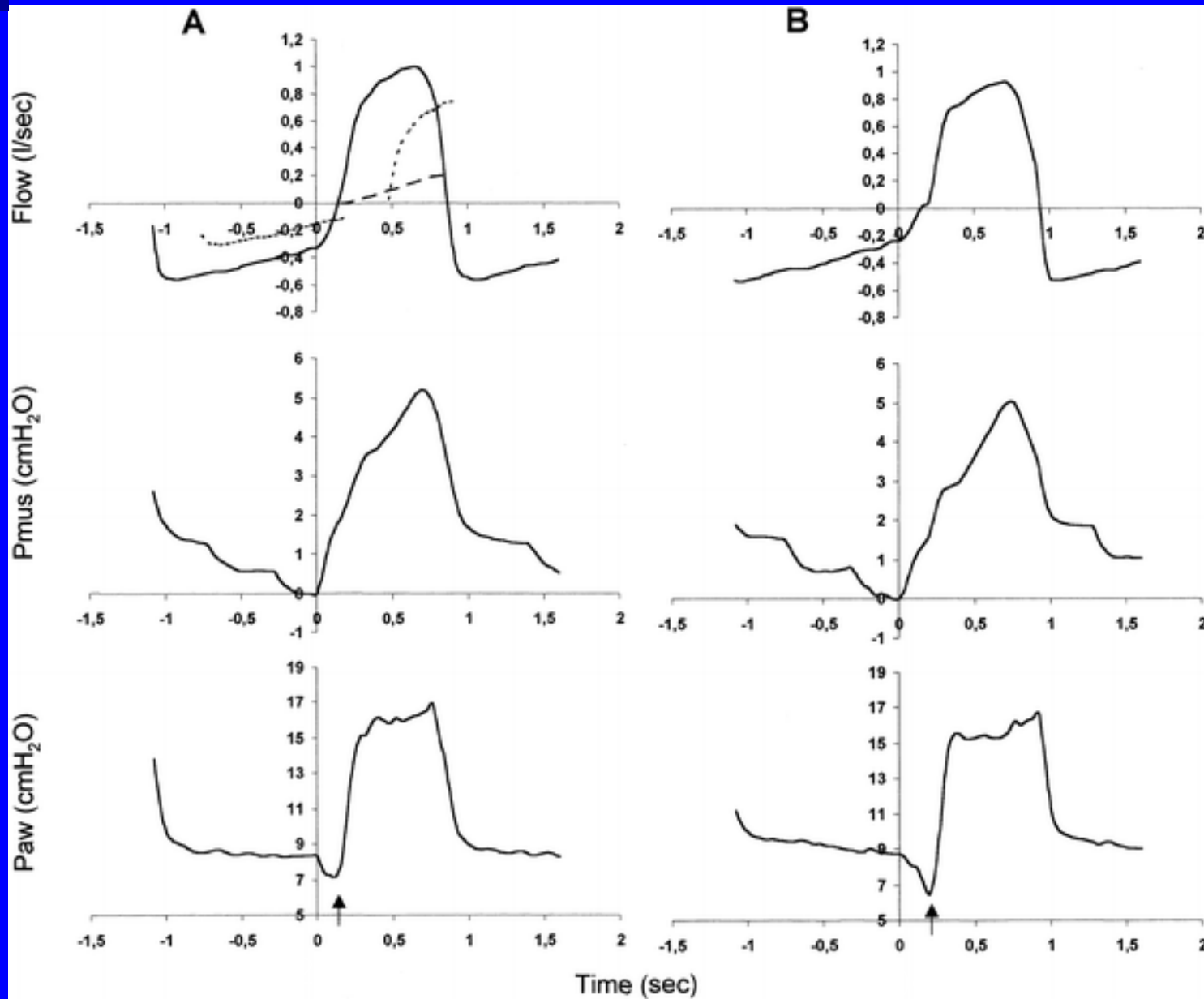
Flow shape signal trigger



Flow trigger

## flow-waveform method

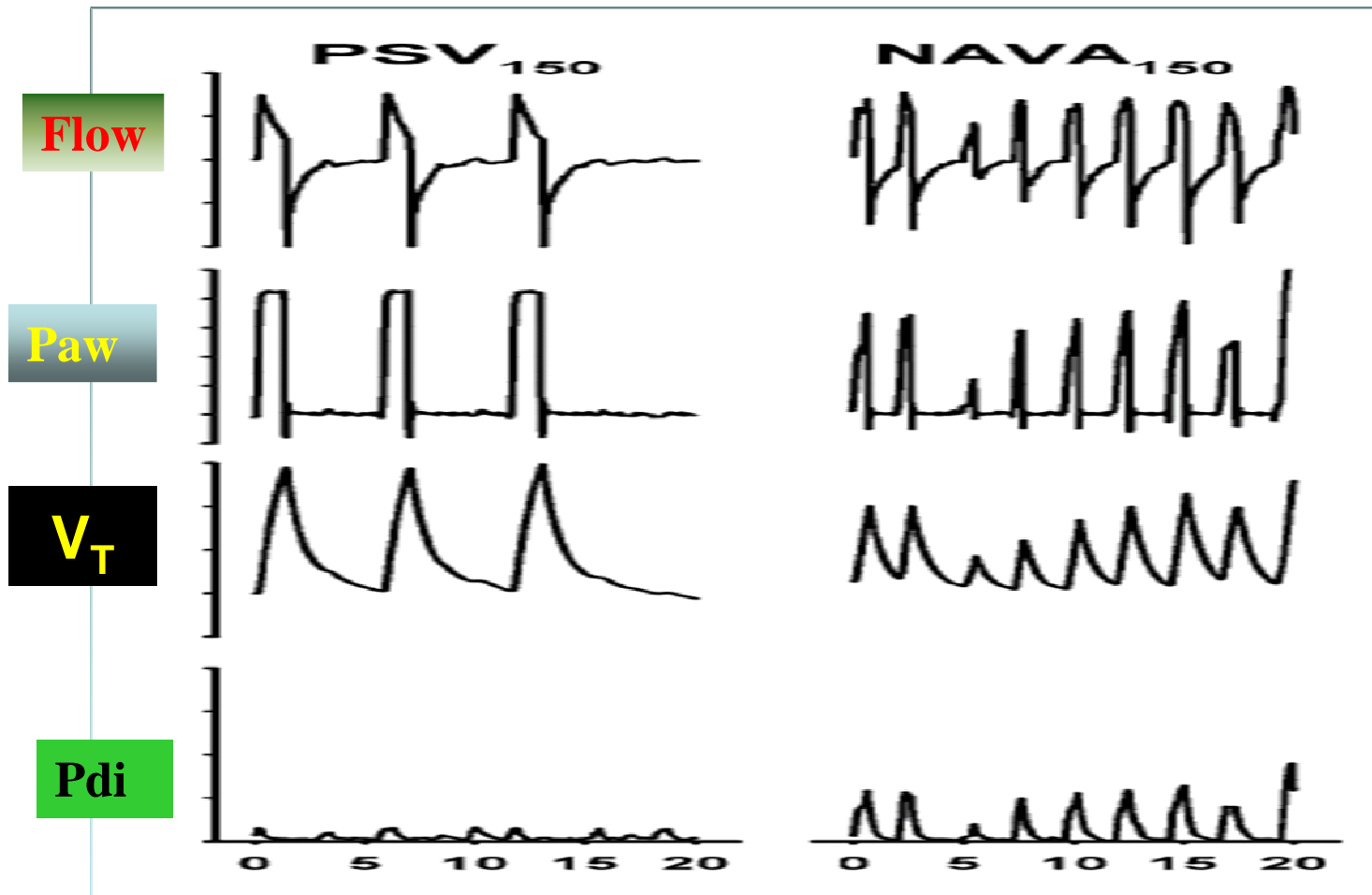
## flow triggering



120ms

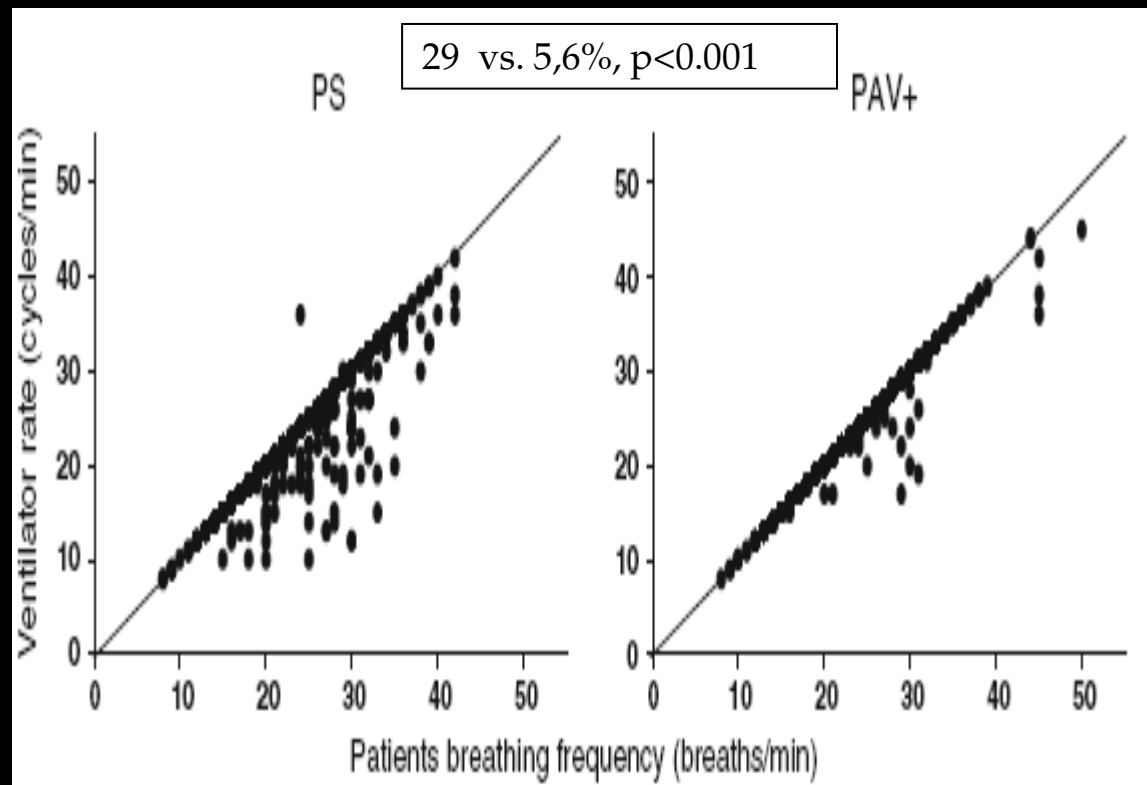
200ms

# Neurally Adjusted Ventilatory Assist



Colombo et al. ICM 2008

# Ineffective efforts and Weaning

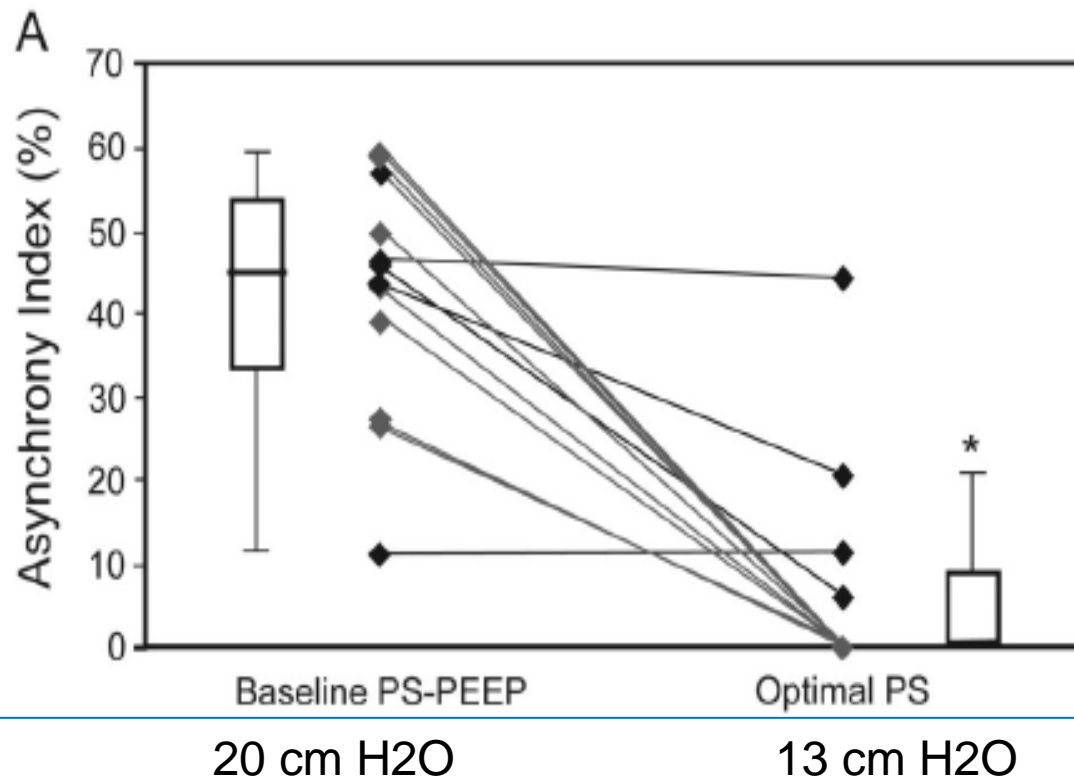


# ASYNCHRONY INDEX

Asynchrony index (%) = number of asynchrony events/total respiratory rate  $\times$  100%

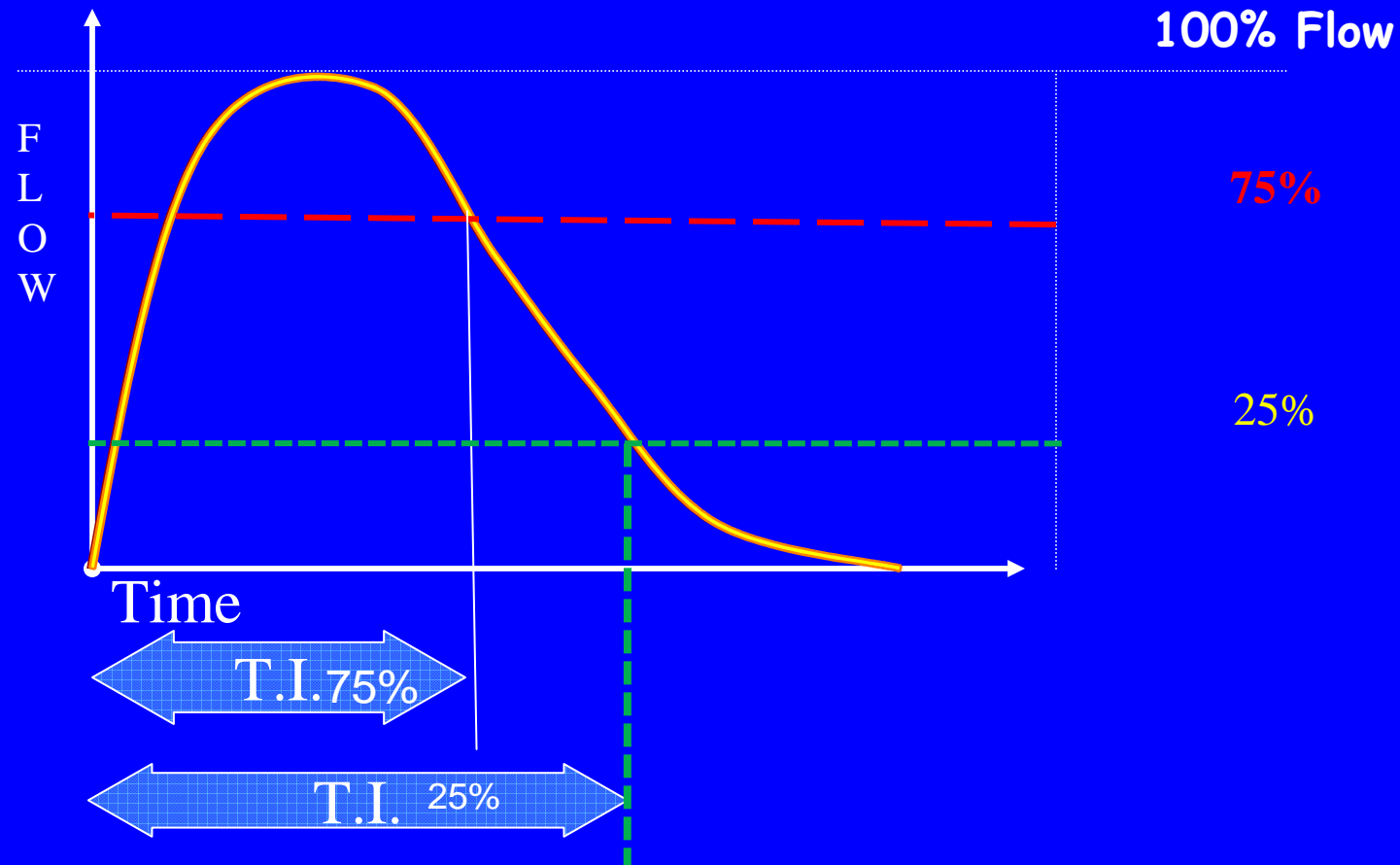
An asynchrony index > 10% was considered severe

# Optimal Pressure Support

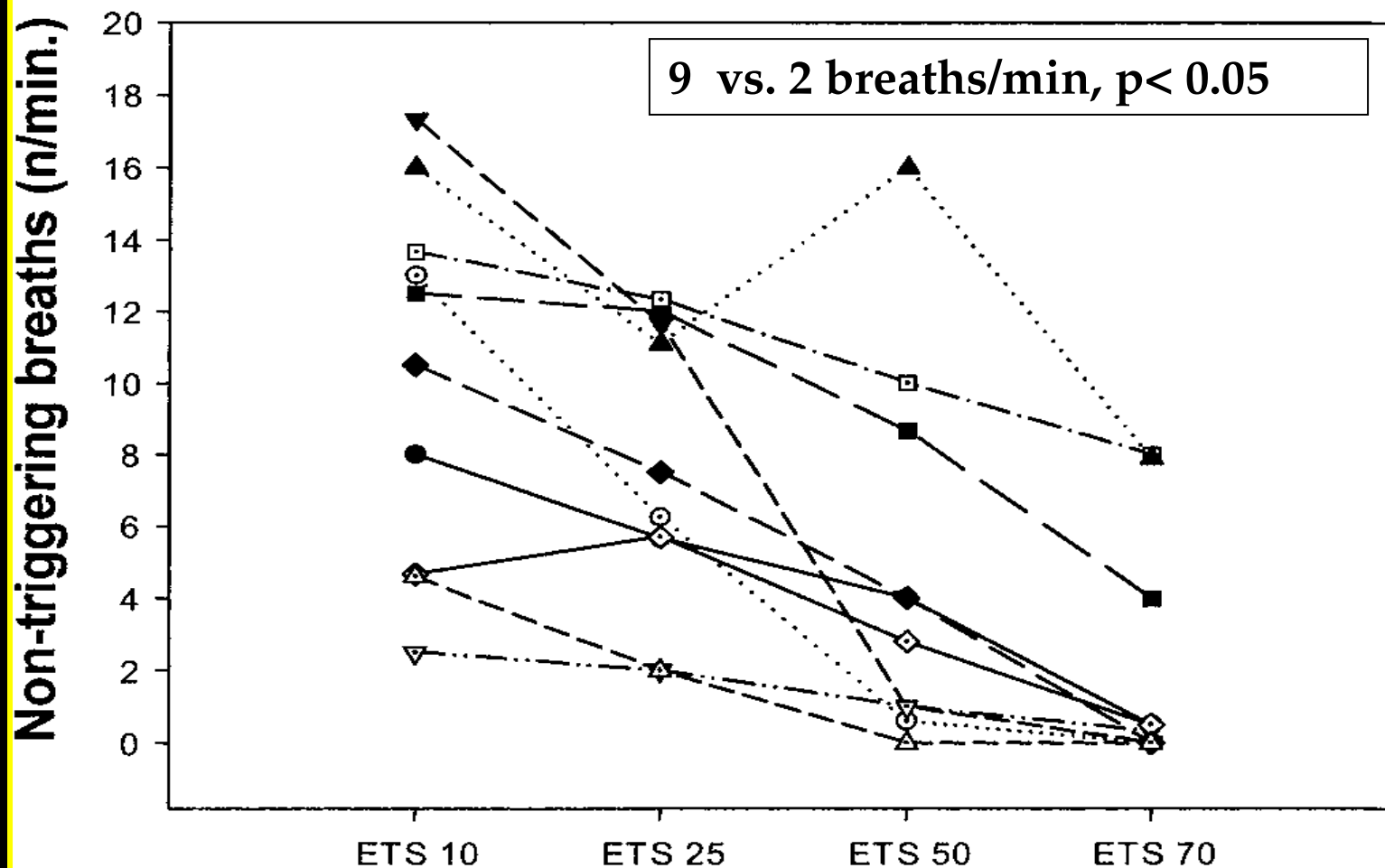


Thille et al. Intensive Care Med 2006.

# Cycling of values



# Effect of cycling of criterion on ineffective efforts in COPD patients



**ΜΗ ΕΠΕΜΒΑΤΙΚΟΣ  
ΜΗΧΑΝΙΚΟΣ  
ΑΕΡΙΣΜΟΣ**

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

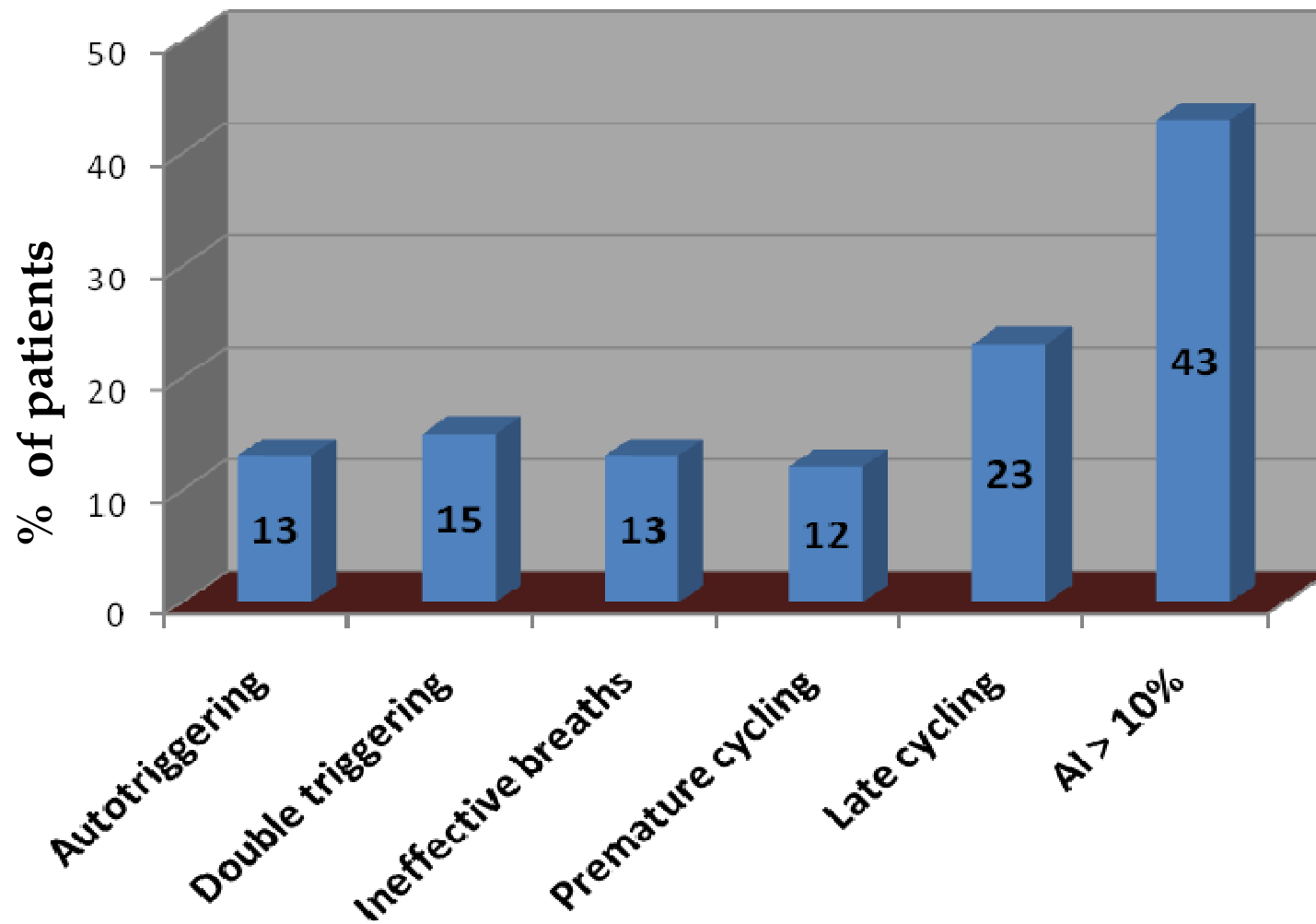
## Patient–ventilator asynchrony during non-invasive ventilation for acute respiratory failure: a multicenter study

55% of patients were hypercapnic

**Table 1** Main clinical characteristics of the patients ( $n = 60$ )

Demographics and initial respiratory parameters mean (SD)	
Age (year)	70 (12)
M:F	41:19
BMI ( $\text{kg}/\text{m}^2$ )	26 (7)
SAPS II	43 (15)
RR ( $n/\text{min}$ )	29 (7)
$\text{PaO}_2/\text{FIO}_2$	186 (83)
$\text{PaCO}_2$ (mmHg)	48 (16)
Cause of acute respiratory failure $n$ (%)	
Acute on chronic respiratory failure	25 (38)
Community-acquired pneumonia	19 (20)
Post-extubation	15 (25)
Cardiogenic pulmonary edema	9 (25)
Post-operative	4 (7)
Thoracic trauma	3 (5)

## Prevalence of patient interaction phenomena during NIMV



# RESULTS

Vignaux et al. ICM 2009

Multivariate analysis showed that:

- 1) **the level of pressure support** (OR: 1.32 per additional cmH<sub>2</sub>O of PS )
  - 2) **the magnitude of leak** (OR: 1.24 per additional l/min of leak)
- were associated with the presence of an AI >10%.

The **comfort VAS** was **higher** in patients with an **AI <10%** (6.5 vs. 5.7,  $p = 0.027$ )

**No difference** was observed in the **intubation rate, length of stay in ICU or mortality** between patients with or without an AI >10%.

## Adverse Effects of Patient-Ventilator Asynchrony on Outcome

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Ultrastructural injury to respiratory muscles

Eccentric or pliometric contraction

Worsens mechanics (  $\uparrow$  intrinsic PEEP)

Alters gas exchange (auto-triggering  $\rightarrow$   $\downarrow$   $P_{aCO_2}$ )

Wastes respiratory work (unnecessary load)

Confounds lung-protective strategy (breath-stacking leads to increased tidal volume)

Noninvasive ventilation =  $\downarrow$  effectiveness and failure to tolerate

May cause periodic breathing, sleep fragmentation

Patient discomfort and dyspnea (  $\uparrow$  sedation)

Can confuse the clinician (weaning decision making)

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Έργο αναπνευστικών  
μυών

δύσπνοια  
ταχύπνοια  
υπερκαπνία

Υπερδιάταση  
ΡΕΕΡi  
Missing effort  
Ασυγχρονία εκπνοής

Ελλιπής  
υποστήριξη

Βέλτιστες ρυθμίσεις  
υποστήριξης

Υπερβολική  
υποστήριξη

Πίεση υποστήριξης