# Interactions cardiopulmonaires : approche physiologique, limites, applications au guidage du remplissage vasculaire

Matthieu Biais, MD, PhD
Service d'Anesthésie et de Réanimation
Hôpital Pellegrin, CHU de Bordeaux

Cours Européens, Lacanau
Samedi 11 juin 2016

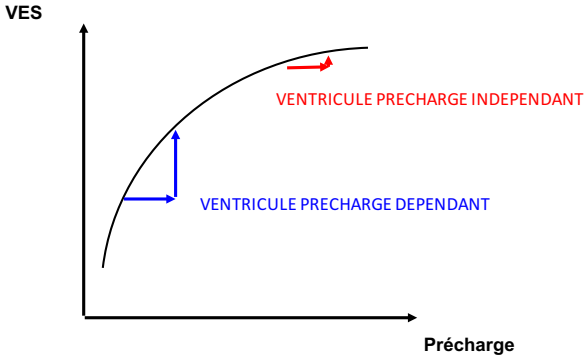
## Interactions Cardiopulmonaires

- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- **Implications Cliniques**
- **Limites**
- **Perspectives**

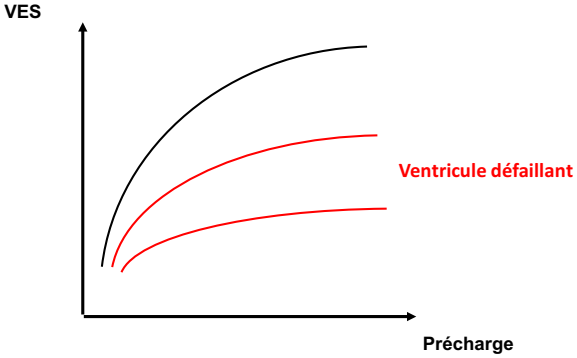
## Interactions Cardiopulmonaires

- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- **Implications Cliniques**
- **Limites**
- **Perspectives**

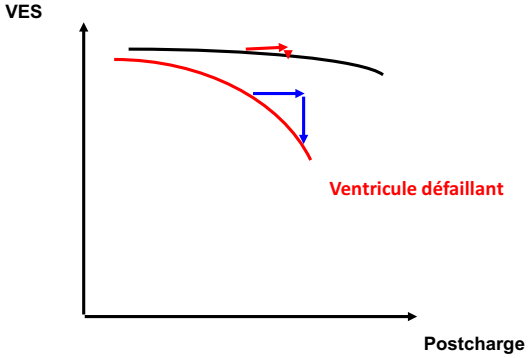
## Relation VES - Précharge



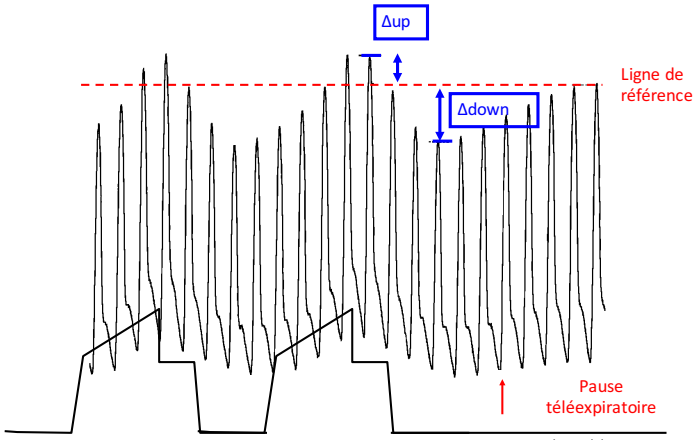

## Relation VES - Précharge




## Relation de VES - Postcharge



# Analyse de la courbe de PA




# Delta-down

Insufflation Mécanique

1. Diminution précharge VD

Augmentation des pressions intrathoraciques

2. Augmentation postcharge VD

Augmentation pressions transpulmonaires

# Delta-down

Insufflation Mécanique

1. Diminution précharge VD

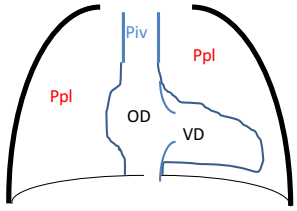
Augmentation des pressions intrathoraciques

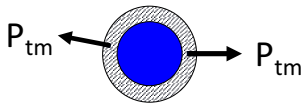
2. Augmentation postcharge VD

Augmentation pressions transpulmonaires

# Pression Transmurale

Pression de distension d'un vaisseau ou d'une cavité cardiaque

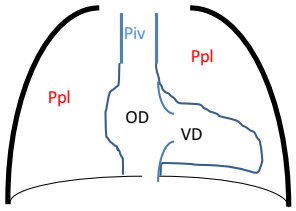



Ptm = Piv – Pev

Pression extravasculaire (Pev)= pression pleurale

# Pression Transmurale




Ptm = Piv – Ppl

Insufflation mécanique

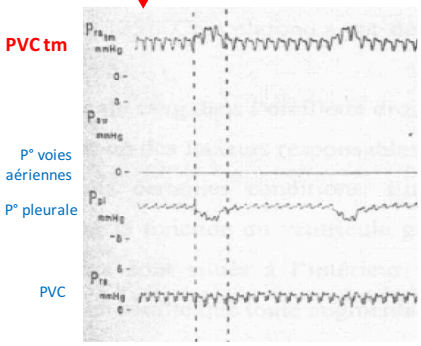
Augmentation de la pression pleurale

Diminution de la Ptm (intrathoracique)

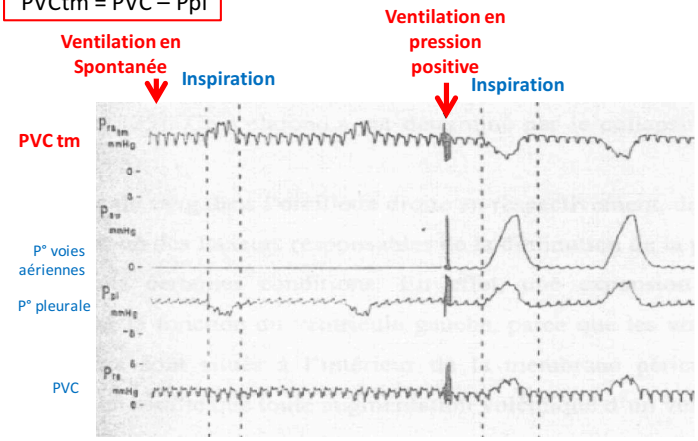
PVCtm = PVC – Ppl

Ventilation en Spontanée

Inspiration

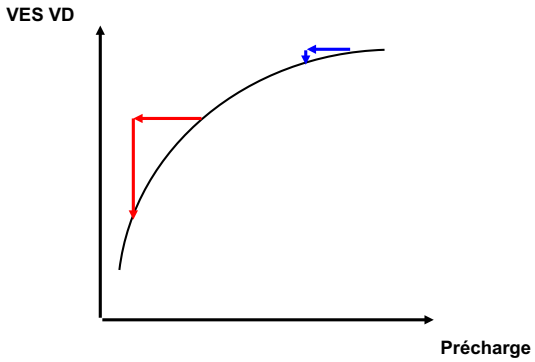


PVCtm = PVC – Ppl




Insufflation : diminution pression transmurale = diminution du retour veineux systémique

## Diminution du VES si VD précharge dépendant



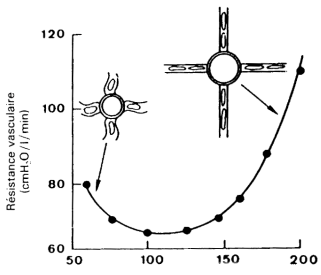

## Delta-down

Insufflation Mécanique

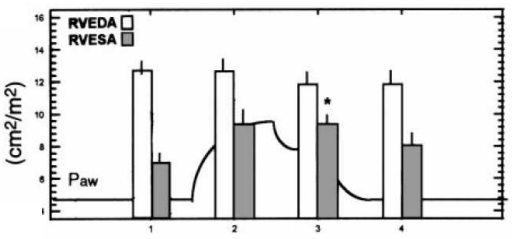
1. Diminution précharge VD
   – Augmentation des pressions intrathoraciques

2. Augmentation postcharge VD
   Augmentation pressions transpulmonaires

## Augmentation Postcharge VD



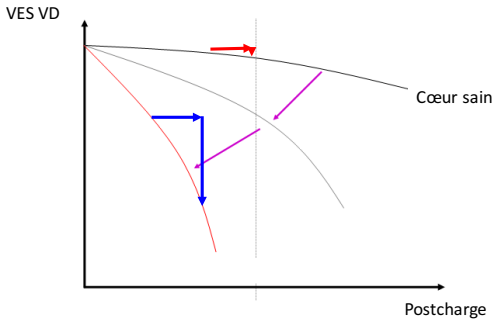

Insufflation mécanique
↓
Distension alvéolaire
↓
↓ Diamètre capillaires pulmonaires
↓
**↑ cyclique des RVP**




Insufflation mécanique:
Augmentation Surface télésystolique VD

*Vieillard-Baron et al. J Appl Physiol 1999*

## Diminution du VES si VD postcharge dépendant



# Delta-down

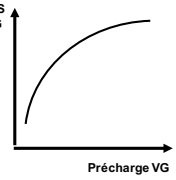
Insufflation Mécanique

↓ Précharge VD
↑ Postcharge VD
→ ↓ Volume éjection VD

*Temps de transit pulmonaire*

↓ Précharge VG

↓ Volume éjection VG




# Delta-up

Insufflation Mécanique

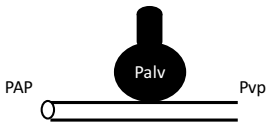
1. Augmentation de la précharge VG
2. Diminution de la contrainte pariétale myocardique

# Delta-up

Insufflation Mécanique

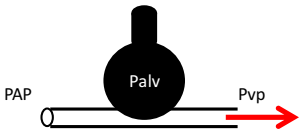
1. Augmentation de la précharge VG
2. Diminution de la contrainte pariétale myocardique

## EXPIRATION




PAP > Pvp > Palv
Zone III de West

## INSUFFLATION MECANIQUE




PAP > Palv > Pvp
Zone II de West

**Effet de chasse du sang veineux pulmonaire vers l'oreillette gauche**

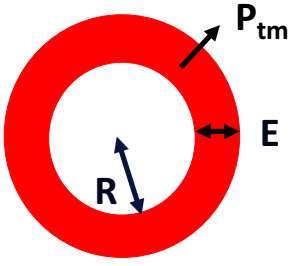
*D'après Vieillard-Baron*

# Delta-up

Insufflation Mécanique

1. Augmentation de la précharge VG
2. Diminution de la contrainte pariétale myocardique

## Contrainte Pariétale Circonférentielle




Loi de Laplace

$$\sigma = (P_{tm} \times R) / E$$

## Contrainte Pariétale Circonférentielle

Insufflation mécanique

↓ Ptm, ↓ R donc ↓ $\sigma$

**Augmentation du VES**

Loi de Laplace

$$\sigma = (P_{tm} \times R) / E$$

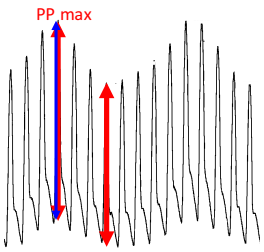
## Delta-up

Insufflation Mécanique

↑ Précharge VG
Diminution Contrainte pariétale VG

**↑ Volume éjection VG**

## Delta-PP




$$\Delta PP = \frac{PPmax - PPmin}{(PPmax + PPmin) / 2} \times 100$$

Pression pulsée = PAS - PAD

$$\text{Pression pulsée} = k. \frac{VES}{\text{Compliance artérielle}}$$

Compliance constante au cours d'un cycle respiratoire

Variations de pression pulsée
=
Variations de VES

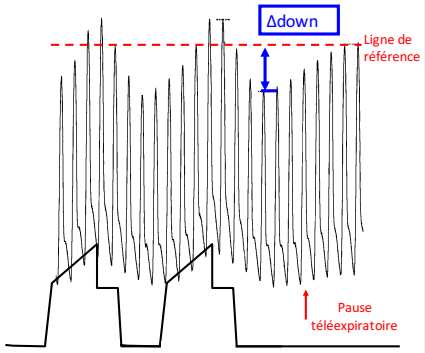
## Insufflation Mécanique

**Diminution VES VD**

- ↓ précharge VD
- ↑ postcharge VD

Temps de transit pulmonaire

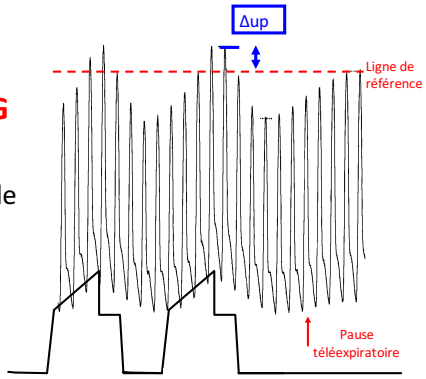
**Diminution VES VG**




## Insufflation Mécanique

**Augmentation VES VG**

- ↑ Précharge VG
- ↓ contrainte pariétale




## Interactions Cardiopulmonaires

- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- Implications Cliniques
- Limites
- Perspectives

# Significativité

## Delta-down

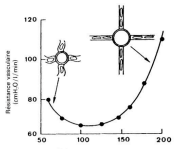
– Effet précharge VD : Hypovolémie

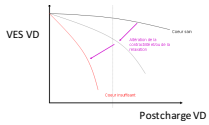
# Significativité

## Delta-down

– Effet précharge VD : Hypovolémie

– Effet postcharge VD : Insuffisance cardiaque droite



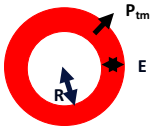




# Significativité

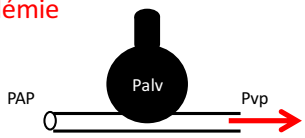
## Delta-up

– Insuffisance cardiaque gauche

$$\sigma = (P_{tm} \times R) / E$$




– Hypervolémie

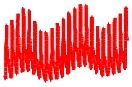



## Interactions Cardiopulmonaires

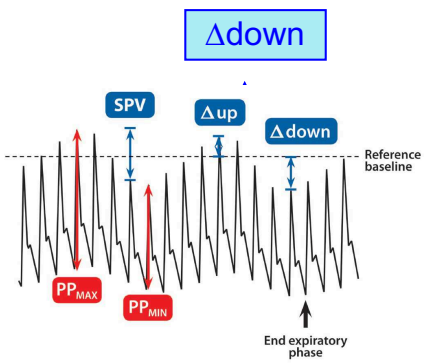
- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- **Implications Cliniques**
- Limites
- Perspectives

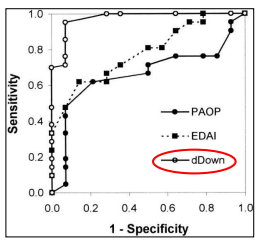
## Indices Dérivés des Interactions Cardio-Respiratoires

Courbe de Pression Artérielle
Deltadown, DPP, VVE



Systolic Pressure Variation as a Guide to Fluid Therapy in Patients with Sepsis-induced Hypotension

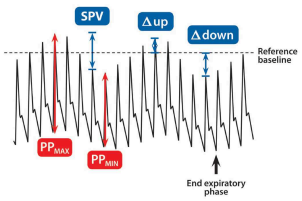


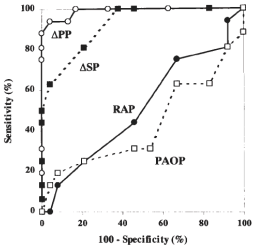




Δdown≥5 mmHg
VPP=95%
VPN=93%

*Tavernier et al. Anesthesiology 1998*

## Relation between Respiratory Changes in Arterial Pulse Pressure and Fluid Responsiveness in Septic Patients with Acute Circulatory Failure



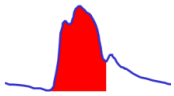

ΔPP ≥ 13%

Se=94%

Sp=96%

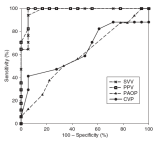
*Michard et al. AJRCCM 2010*

## VVE



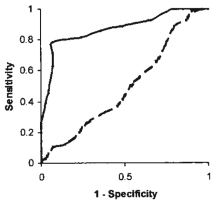
**Uncalibrated pulse contour-derived stroke volume variation predicts fluid responsiveness in mechanically ventilated patients undergoing liver transplantation** *Br J Anaesth* 2008; 101: 761–8

M. Biais, K. Nouette-Gaulain, V. Cottenceau, P. Revel and F. Sztark*



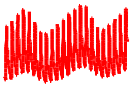
**Stroke Volume Variation as a Predictor of Fluid Responsiveness in Patients Undergoing Brain Surgery**

Haim Berkenstadt, MD*, Nevo Margalit, MD†, Moshe Hadani, MD†, Zeev Friedman, MD*, Eran Segal, MD*, Yael Villa, PhD*, and Azriel Perel, MD*




## Indices Dérivés des Interactions Cardio-Respiratoires

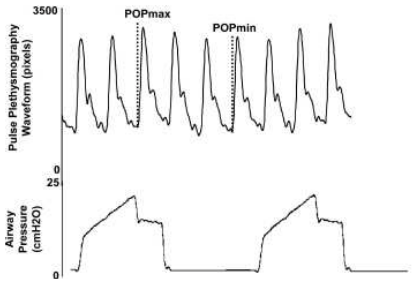
Courbe de Pression Artérielle
Deltadown, DPP, VVE



Courbe de Plethysmographie

## *Respiratory Variations in Pulse Oximetry Plethysmographic Waveform Amplitude to Predict Fluid Responsiveness in the Operating Room*

## ΔPOP




$$\Delta POP = \frac{POPmax - POPmin}{(POPmax + POPmin) / 2} \times 100$$

ΔPOP ≥ 13 %

Sensibilité = 80%

Spécificité = 90%

*Cannesson et al. Anesthesiology 2007*

## Limites

## Réanimation et Noradrénaline

***Poor Agreement between Respiratory Variations in Pulse Oximetry Photoplethysmographic Waveform Amplitude and Pulse Pressure in Intensive Care Unit Patients***

*Svein Aslak Landsverk, M.D.,* Lars O. Hoiseth, M.D.,† Per Kvandal, M.D.,‡ Jonny Hisdal, Ph.D.,§ Oivind Skare, Ph.D.,|| Knut A. Kirkeboen, M.D., Ph.D.#*

Anesthesiology 2008; 109:849–55

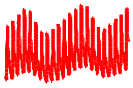
Impact of norepinephrine on the relationship between pleth variability index and pulse pressure variations in ICU adult patients

Matthieu Biais[1,2*], Vincent Cottenceau[3], Laurent Petit[3], Françoise Masson[3], Jean-François Cochard[3] and François Sztark[2,3]

*Critical Care* 2011, **15**:R168

## Indices Dérivés des Interactions Cardio-Respiratoires

Courbe de Pression Artérielle
Deltadown, DPP, VVE



Courbe de Plethysmographie

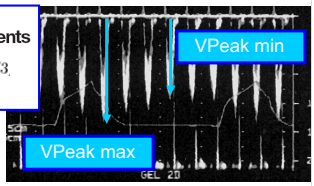
Indices Echographiques

## Echocardiographie doppler

**Respiratory Changes in Aortic Blood Velocity as an Indicator of Fluid Responsiveness in Ventilated Patients With Septic Shock***

*(CHEST 2001; 119:867–873)*

*Marc Feissel, MD; Frédéric Michard, MD; Isabelle Mangin, MD; Olivier Ruyer, MD; Jean-Pierre Faller, MD; and Jean-Louis Teboul, MD, PhD*



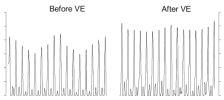

## Doppler œsophagien

Intensive Care Med (2005) 31:1195–1201
DOI 10.1007/s00134-005-2731-0

ORIGINAL

Xavier Monnet
Mario Rienzo
David Osman
Nadia Anguel
Christian Richard
Michael R. Pinsky
Jean-Louis Teboul

**Esophageal Doppler monitoring predicts fluid responsiveness in critically ill ventilated patients**




## Variations Respiratoires des Veines Caves

Veine Cave Inférieure = Extra-thoracique
Sous VM, elle se dilate à l'inspiration

Veine Cave Supérieure = Intra-thoracique
Sous VM, elle se collabe à l'inspiration

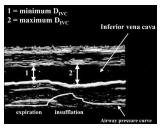
## ΔVCI

Intensive Care Med (2004) 30:1834–1837
DOI 10.1007/s00134-004-2233-5

BRIEF REPORT

Marc Feissel
Frédéric Michard
Jean-Pierre Faller
Jean-Louis Teboul

**The respiratory variation in inferior vena cava diameter as a guide to fluid therapy**



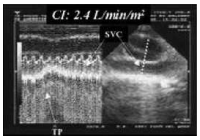

## ΔVCS

Intensive Care Med (2004) 30:1734–1739
DOI 10.1007/s00134-004-2361-y

ORIGINAL

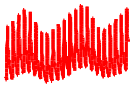
Antoine Vieillard-Baron
Karim Chergui
Anne Rabiller
Olivier Peyrouset
Bernard Page
Alain Beauchet
François Jardin

**Superior vena caval collapsibility as a gauge of volume status in ventilated septic patients**




## Indices Dérivés des Interactions Cardio-Respiratoires

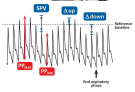
Courbe de Pression Artérielle
Deltadown, DPP, VVE



Courbe de Plethysmographie

Indices Echographiques

Pause Télé-Expiratoire



## Occlusion Télé-Expiratoire

Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients

Xavier Monnet, MD, PhD; David Osman, MD; Christophe Ridel, MD; Bouchra Lamia, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2009; 37:951–956

**Pause télé-expiratoire**

↓

Absence de prochain cycle inspiratoire

↓

Absence de diminution de précharge

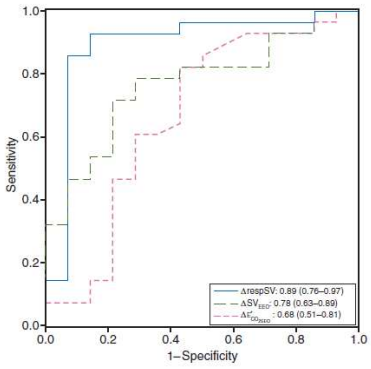
↓

Augmentation du VES

Augmentation
≥ 5% PP
≥ 5% IC
Prédit la réponse au RV

## Occlusion Télé-Expiratoire

**End-expiratory occlusion manoeuvre does not accurately predict fluid responsiveness in the operating theatre**




42 patients, peropératoire

*Guinot et al. Brit J Anaesth 2014*

## Interactions Cardiopulmonaires

- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- **Implications Cliniques**
- **Limites**
- Perspectives

Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: A systematic review of the literature*

Crit Care Med 2009; 37:2642–2647

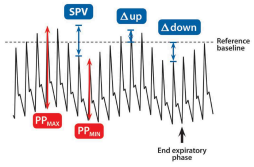
Paul E. Marik, MD, FCCM; Rodrigo Cavallazzi, MD; Tajender Vasu, MD; Amyn Hirani, MD

| Parameter | PPV (n = 14) |
|---|---|
| ROC area | 0.94 (0.92–0.96) |
| Sensitivity | 0.89 (0.82–0.94) |
| Specificity | 0.88 (0.81–0.92) |
| Positive likelihood ratio | 7.26 (4.46–11.80) |
| Negative likelihood ratio | 0.12 (0.07–0.21) |
| Diagnostic odds ratio | 59.86 (23.88–150.05) |

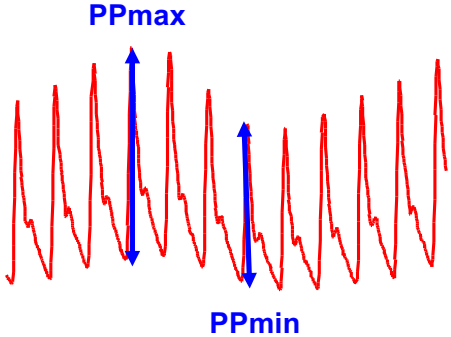
Ça Marche !!!!

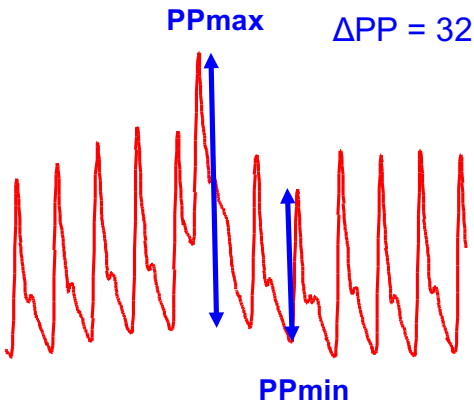
Sauf Quand ça ne Marche Pas …

**Arythmie**




ΔPP = 14%






# C'est Fréquent ?

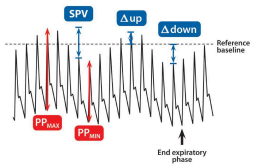
**Incidence and Prognosis of Sustained Arrhythmias in Critically Ill Patients**

*Annane et al. Am J Respir Crit Care Med 2008*

12% des patients de réanimation

Arythmie

**Respiration Spontanée**




Research **Open Access**

**How can the response to volume expansion in patients with spontaneous respiratory movements be predicted?**

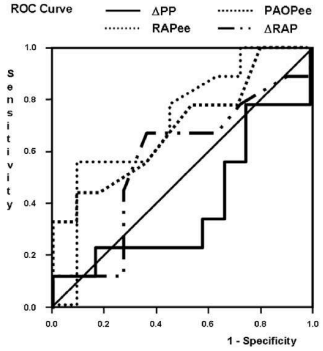
21 patients avec mouvements respiratoires spontanés

*Heenen et al. Crit Care 2006*

Research **Open Access**

**How can the response to volume expansion in patients with spontaneous respiratory movements be predicted?**

21 patients avec mouvements respiratoires spontanés



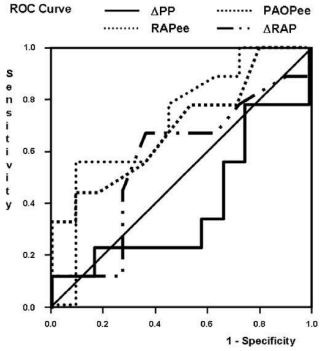

*AUC pour le ΔPP*
*=*
*0,40±0,13*

*Heenen et al. Crit Care 2006*

Research **Open Access**

**How can the response to volume expansion in patients with spontaneous respiratory movements be predicted?**

21 patients avec mouvements respiratoires spontanés




*AUC pour le ΔPP*
*=*
*0,40±0,13*

*Capacité ΔPP à prédire la réponse au remplissage est inférieure à celle de la PVC ou de la PAPO*

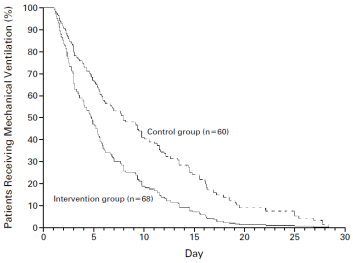
*Heenen et al. Crit Care 2006*

C'est Fréquent les patients en RS ?

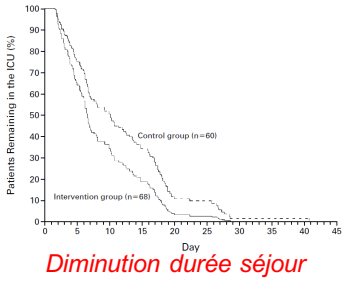
DAILY INTERRUPTION OF SEDATIVE INFUSIONS IN CRITICALLY ILL PATIENTS UNDERGOING MECHANICAL VENTILATION

The NEW ENGLAND JOURNAL of MEDICINE

Interruption quotidienne de la sédation en réanimation




*Diminution durée Ventilation Mécanique*




*Diminution durée séjour ICU*

*Kress et al. N Engl J Med 2000*

Textes des experts

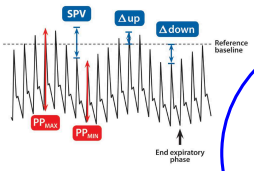
Sevrage de la sédation : modalités et conséquences☆

J. Mantz

Annales Françaises d'Anesthésie et de Réanimation 27 (2008) 611–616

Arythmie

Respiration Spontanée




**Transmission de pression faible**

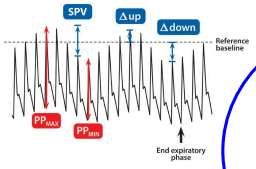
Faible Vt

Driving pressure

Compliance basse

Arythmie

Respiration Spontanée




**Transmission de pression faible**

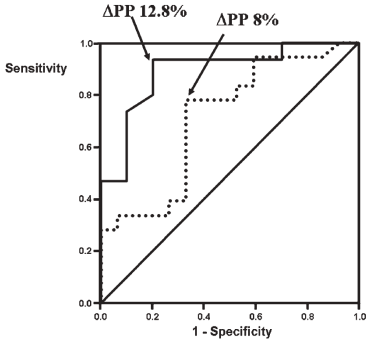
**Faible Vt**

Driving pressure

Compliance basse

ORIGINAL

**Pulse pressure variations to predict fluid responsiveness: influence of tidal volume**




60 patients ventilés

Insuffisance Circulatoire Aigüe

TV > 8 ml/kg

TV < 8 ml/kg

*De Backer et al. Intensive Care 2005*

Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: A systematic review of the literature*

Crit Care Med 2009; 37:2642–2647

Paul E. Marik, MD, FCCM; Rodrigo Cavallazzi, MD; Tajender Vasu, MD; Amyn Hirani, MD

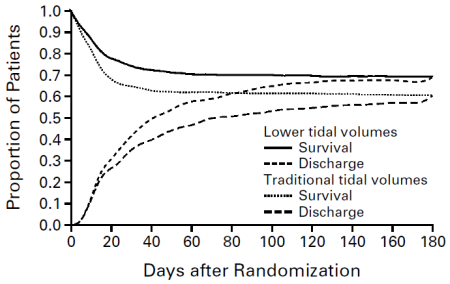
68 citations; of these, 38 citations were excluded due to study design, including studies that investigated the dynamic changes in aortic blood flow, (7, 20–22) studied patients with an open chest during cardiac surgery, (23) used pressure-support ventilation or volume-controlled ventilation with a tidal volume of <7 mL/kg, (24, 25); and five citations were

VENTILATION WITH LOWER TIDAL VOLUMES AS COMPARED WITH TRADITIONAL TIDAL VOLUMES FOR ACUTE LUNG INJURY AND THE ACUTE RESPIRATORY DISTRESS SYNDROME

The NEW ENGLAND JOURNAL of MEDICINE

861 patients SDRA randomisés

12 ml/kg *vs* 6 ml/kg




Contrôle *vs* Ventilation protectrice

*ARDS Network N Engl J Med 2000*

## Association Between Use of Lung-Protective Ventilation With Lower Tidal Volumes and Clinical Outcomes Among Patients Without Acute Respiratory Distress Syndrome

A Meta-analysis

2822 patients SANS SDRA

Ventilation protectrice *vs* Ventilation standard

| | Mean (SD) Protective Ventilation (n = 1416) | Conventional Ventilation (n = 1406) | *P* Value |
|---|---|---|---|
| Age, y | 59.97 (7.92) | 60.22 (7.36) | .93 |
| Weight, kg | 72.71 (12.34) | 72.13 (12.16) | .93 |
| Tidal volume, mL/kg IBW[a] | 6.45 (1.09) | 10.60 (1.14) | <.001 |
| PEEP, cm $H_2O$[a] | 6.40 (2.39) | 3.41 (2.79) | .01 |
| Plateau pressure, cm $H_2O$[a] | 16.63 (2.58) | 21.35 (3.61) | .006 |
| Respiratory rate, breaths/min[a] | 18.02 (4.14) | 13.20 (4.43) | .01 |
| Minute-volume, L/min[a,b] | 8.46 (2.90) | 9.13 (2.70) | .72 |
| $Pao_2/Fio_2$[a] | 304.41 (65.74) | 312.97 (68.13) | .51 |
| $Paco_2$, mm Hg[a] | 41.05 (3.79) | 37.90 (4.19) | .003 |
| pH[a] | 7.37 (0.03) | 7.40 (0.03) | .11 |

*Neto et al. JAMA 2012*

## Association Between Use of Lung-Protective Ventilation With Lower Tidal Volumes and Clinical Outcomes Among Patients Without Acute Respiratory Distress Syndrome

A Meta-analysis

2822 patients SANS SDRA

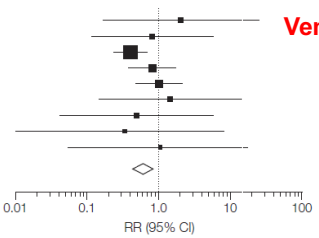
Ventilation protectrice *vs* Ventilation standard

| | Mean (SD) Protective Ventilation (n = 1416) | Conventional Ventilation (n = 1406) | *P* Value |
|---|---|---|---|
| Age, y | 59.97 (7.92) | 60.22 (7.36) | .93 |
| Weight, kg | 72.71 (12.34) | 72.13 (12.16) | .93 |
| Tidal volume, mL/kg IBW[a] | 6.45 (1.09) | 10.60 (1.14) | <.001 |
| PEEP, cm $H_2O$[a] | 6.40 (2.39) | 3.41 (2.79) | .01 |
| Plateau pressure, cm $H_2O$[a] | 16.63 (2.58) | 21.35 (3.61) | .006 |
| Respiratory rate, breaths/min[a] | 18.02 (4.14) | 13.20 (4.43) | .01 |
| Minute-volume, L/min[a,b] | 8.46 (2.90) | 9.13 (2.70) | .72 |
| $Pao_2/Fio_2$[a] | 304.41 (65.74) | 312.97 (68.13) | .51 |
| $Paco_2$, mm Hg[a] | 41.05 (3.79) | 37.90 (4.19) | .003 |
| pH[a] | 7.37 (0.03) | 7.40 (0.03) | .11 |

*Neto et al. JAMA 2012*

## Association Between Use of Lung-Protective Ventilation With Lower Tidal Volumes and Clinical Outcomes Among Patients Without Acute Respiratory Distress Syndrome

A Meta-analysis




**Ventilation protectrice = Diminution**

**MORTALITE**

**INFECTIONS PULMONAIRES**

**ATELECTASIES**

*Neto et al. JAMA 2012*

## A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery

The NEW ENGLAND JOURNAL of MEDICINE

400 patients randomisés

Risque de complications respiratoires

Chirurgie abdominale majeure

**Ventilation protectrice** : Vt=6-8 ml/kg, PEP=6-8 cm$H_2O$, recrutement/30 min

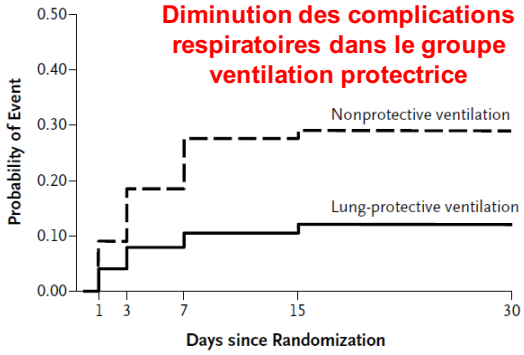
**Ventilation standard** : Vt=10-12 ml/kg, PEP=0, pas de recrutement

*Futier et al. N Engl J Med 2013*

## A Trial of Intraoperative Low-Tidal-Volume Ventilation in Abdominal Surgery

The NEW ENGLAND JOURNAL of MEDICINE

**Diminution des complications respiratoires dans le groupe ventilation protectrice**

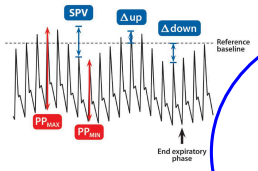



*Futier et al. N Engl J Med 2013*

---

Arythmie

Respiration Spontanée

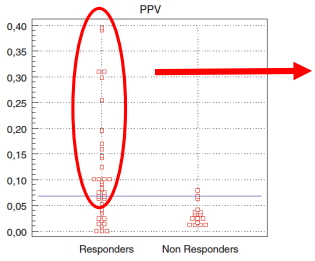



**Transmission de pression faible**
Faible Vt
**Driving pressure**
Compliance basse

---

## The influence of the airway driving pressure on pulsed pressure variation as a predictor of fluid responsiveness

**DRIVING PRESSURE = Pplat – PEP**
57 patients ventilés, insuffisance circulatoire aigüe
Bas Vt : 5,5 ml/kg [3,5-7,7]




**ΔPP élevé** = Répondeurs

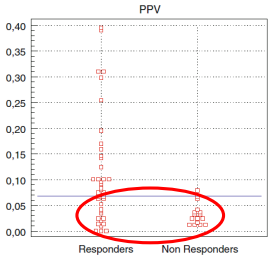
*Muller et al. Intensive Care Med 2010*

---

## The influence of the airway driving pressure on pulsed pressure variation as a predictor of fluid responsiveness

**DRIVING PRESSURE = Pplat – PEP**
57 patients ventilés, insuffisance circulatoire aigüe
Bas Vt : 5,5 ml/kg [3,5-7,7]

**ΔPP bas ??**



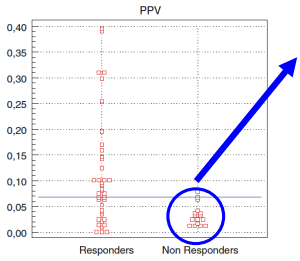

*Muller et al. Intensive Care Med 2010*

---

## The influence of the airway driving pressure on pulsed pressure variation as a predictor of fluid responsiveness

**DRIVING PRESSURE = Pplat – PEP**
57 patients ventilés, insuffisance circulatoire aigüe
Bas Vt : 5,5 ml/kg [3,5-7,7]

**ΔPP bas ??**




Précharge indépendance: NR

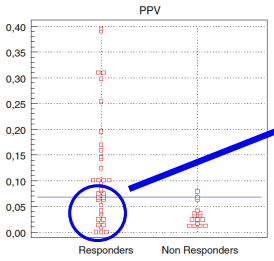
*Muller et al. Intensive Care Med 2010*

---

## The influence of the airway driving pressure on pulsed pressure variation as a predictor of fluid responsiveness

**DRIVING PRESSURE = Pplat – PEP**
57 patients ventilés, insuffisance circulatoire aigüe
Bas Vt : 5,5 ml/kg [3,5-7,7]

**ΔPP bas ??**




Précharge indépendance: NR

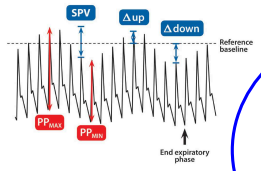
Précharge dépendance : R
**Driving pressure ≤ 20 $cmH_2O$**

**FAUX NEGATIFS +++**

*Muller et al. Intensive Care Med 2010*

Arythmie

Respiration Spontanée




**Transmission de pression faible**

Faible Vt

Driving pressure

**Compliance basse**

---

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance*

54 patients insuffisance circulatoire aigue

Compliance respiratoire = Vt / (Pplat – PEP)

*Monnet et al. Crit Care Med 2012*

---

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance*

54 patients insuffisance circulatoire aigue

Compliance respiratoire = Vt / (Pplat – PEP)

27 SDRA

↓

22 ± 3 ml/cm$H_2O$

*Monnet et al. Crit Care Med 2012*

---

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance*

54 patients insuffisance circulatoire aigue

Compliance respiratoire = Vt / (Pplat – PEP)

27 SDRA

↓

22 ± 3 ml/cm$H_2O$

27 non SDRA

↓

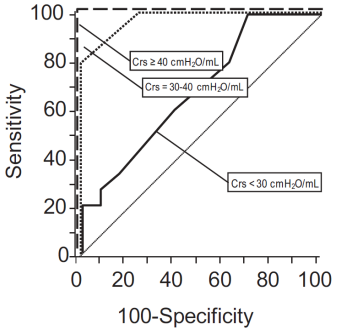
45 ± 9 ml/cm$H_2O$

*Monnet et al. Crit Care Med 2012*

---

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance*

54 patients insuffisance circulatoire aigue




Compliance > 30 ml/cmH2O

AUC = 0,98 ± 0,03

Compliance ≤ 30 ml/cmH2O

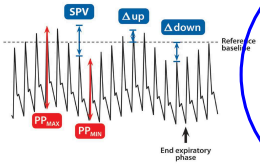
AUC = 0,69 ± 0,10

*Monnet et al. Crit Care Med 2012*

---

Arythmie

Respiration Spontanée




Transmission de pression faible

Faible Vt

Driving pressure

Compliance basse

**Temps de transit pulmonaire trop court**

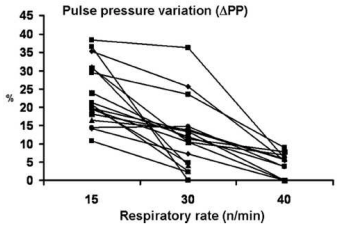
## *Influence of Respiratory Rate on Stroke Volume Variation in Mechanically Ventilated Patients*

17 patients ventilés (Vt=8-10 ml/kg), hypovolémiques
FR : 15, 30 et 40 (Vt et I/E identiques)

*De Backer et al. Anesthesiology 2009*

## *Influence of Respiratory Rate on Stroke Volume Variation in Mechanically Ventilated Patients*

17 patients ventilés (Vt=8-10 ml/kg), hypovolémiques
FR : 15, 30 et 40 (Vt et I/E identiques)

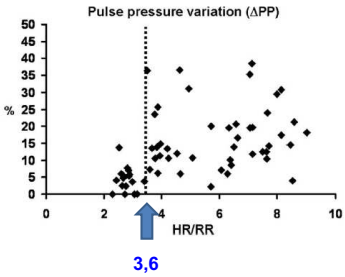



Augmentation FR = diminution du temps de transit pulmonaire
Diminution du ΔPP

*De Backer et al. Anesthesiology 2009*

## *Influence of Respiratory Rate on Stroke Volume Variation in Mechanically Ventilated Patients*

17 patients ventilés (Vt=8-10 ml/kg), hypovolémiques
FR : 15, 30 et 40 (Vt et I/E identiques)




**Ratio FC / FR < 3,6**
**ΔPP inutilisable**

*De Backer et al. Anesthesiology 2009*

## C'est Fréquent ?

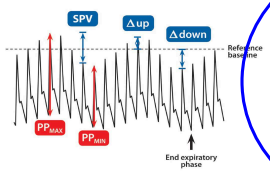
**Ventilation protectrice =**
**bas Vt et haute fréquence**

Exemples
FR = 22, FC<80
FR=25, FC<90

FC/FR < 3,6
ΔPP inutilisable

Arythmie

Respiration Spontanée



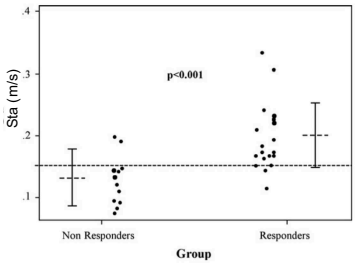

Transmission de pression faible
Faible Vt
Driving pressure
Compliance basse

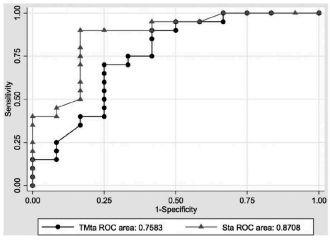
**Insuffisance Cardiaque Droite**

Temps de transit pulmonaire trop court

Assessing fluid responsiveness in critically ill patients: False-positive pulse pressure variation is detected by Doppler echocardiographic evaluation of the right ventricle*

35 patients ventilés ΔPP>12%
23 répondeurs



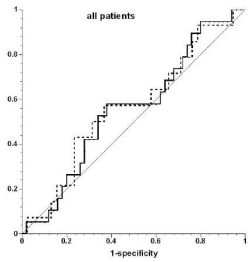




Insuffisance Cardiaque Droite = Faux Positifs

*Mahjoub et al. Crit Care Med 2010*

## Pulse-pressure variation and hemodynamic response in patients with elevated pulmonary artery pressure: a clinical study

69 patients Insuffisance cardiaque droite
Chirurgie Cardiaque ou Choc Septique




**ΔPP: AUC=0,55**

*Wyler von Ballmoos et al. Crit Care 2010*

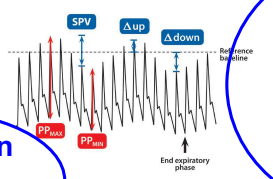
## C'est Fréquent ?

> 1/3 des patients en chocs septique

*Jardin et al. Crit Care Med 1990*
*Vieillard-Baron Anesthesiology 2001*
*Mahjoub et al. Crit Care Med 2009*

Arythmie

Respiration Spontanée




Transmission de pression faible
Faible Vt
Driving pressure
Compliance basse

**Hypertension intra-abdominale**

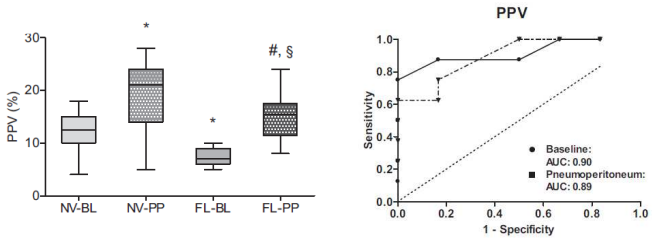
Insuffisance Cardiaque Droite

Temps de transit pulmonaire trop court

## Influence of increased intra-abdominal pressure on fluid responsiveness predicted by pulse pressure variation and stroke volume variation in a porcine model*

14 cochons, augmentation PIA

**Seuil du ΔPP: de 11,5% à 20,5%**




*Renner et al. Crit Care Med 2009*

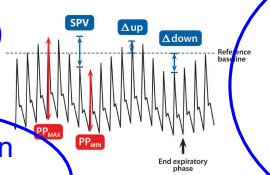
## C'est Fréquent ?

| | |
|---|---|
| Kim et al. Anaesth Intensive Care 2012 | 42 % |
| Vidal et al. Crit Care Med 2008 | 31 % |
| Malbrain et al. Crit Care Med 2005 | 36 % |

Arythmie

Respiration Spontanée

**Décubitus Ventral**



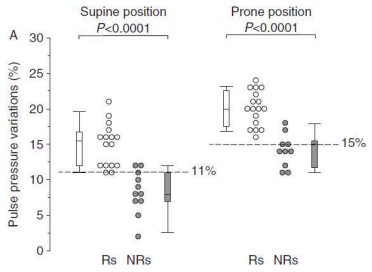

Transmission de pression faible
Faible Vt
Driving pressure
Compliance basse

Hypertension intra-abdominale

Insuffisance Cardiaque Droite

Temps de transit pulmonaire trop court

**Abilities of pulse pressure variations and stroke volume variations to predict fluid responsiveness in prone position during scoliosis surgery**




**Décubitus ventral :**

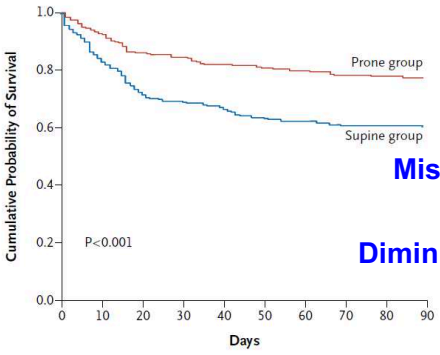
- **Augmentation ΔPP**
- **Augmentation du seuil de 11% à 15%**

*Biais et al. Br J Anaesth 2010*

Prone Positioning in Severe Acute Respiratory Distress Syndrome

The NEW ENGLAND JOURNAL of MEDICINE

466 patients / SDRA randomisés




**Mise en DV prolongé**

**=**

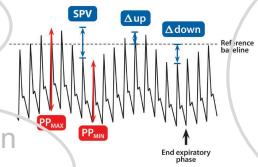
**Diminution de la mortalité**

*Guérin et al. N Engl J Med 2013*

Arythmie

Respiration Spontanée

Décubitus Ventral




Transmission de pression faible

Faible Vt

Driving pressure

Compliance basse

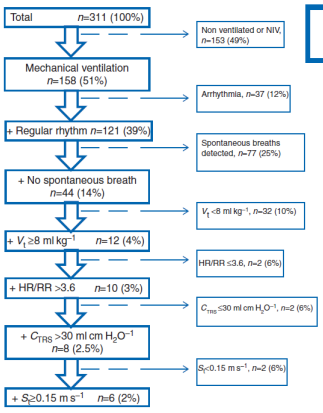
Hypertension intra-

Droite

trop court

# C'est Fréquent ?

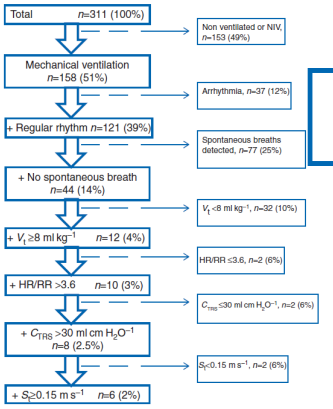
**Evaluation of pulse pressure variation validity criteria in critically ill patients: a prospective observational multicentre point-prevalence study†**




Total *n*=311 (100%)

*Mahjoub et al. Brit J Anaesth 2014*

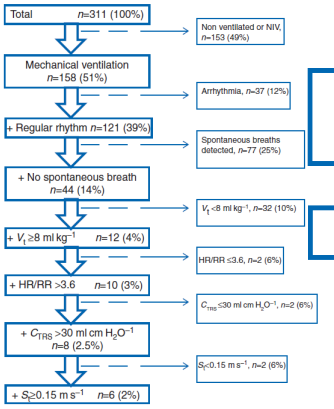
**Evaluation of pulse pressure variation validity criteria in critically ill patients: a prospective observational multicentre point-prevalence study†**




Mechanical ventilation *n*=158 (51%)

*Mahjoub et al. Brit J Anaesth 2014*

**Evaluation of pulse pressure variation validity criteria in critically ill patients: a prospective observational multicentre point-prevalence study†**




Mechanical ventilation *n*=158 (51%)

**n=6 (4%)**

*Mahjoub et al. Brit J Anaesth 2014*

| | | False positive | False negative |
|---|---|---|---|
| L | **Low** HR/RR ratio (Extreme bradycardia or high frequency ventilation) | | ✓ |
| I | **Irregular** heart beats | ✓ | |
| M | **Mechanical** ventilation with low tidal volume | | ✓ |
| I | **Increased** abdominal Pressure (Pneumoperitoneum) | ✓ | |
| T | **Thorax** open | | ✓ |
| S | **Spontaneous** breathing | ✓ | ✓ |

*Michard et al. Crit Care 2015*

## Interactions Cardiopulmonaires

- **Approche Physiologique**
  - Relation VES-Précharge et VES-postcharge
  - Analyse de la courbe de pression artérielle
- **Significativité**
- **Implications Cliniques**
- **Limites**
- **Perspectives**

## L'Epreuve de Remplissage

**Fluid challenge revisited**

- Type de fluide
- Débit de perfusion
- Objectifs du remplissage
- Limites de sécurité

J.L Vincent et al. Crit Care Med 2006

## L'Epreuve de Remplissage

**An Increase in Aortic Blood Flow after an Infusion of 100 ml Colloid over 1 Minute Can Predict Fluid Responsiveness**

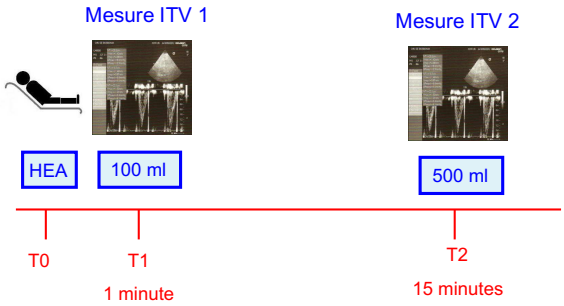
*The Mini-fluid Challenge Study*

- Administration d'une faible quantité de fluide
- Monitorage de la réponse
- Prédiction de la réponse à l'administration d'une plus grande quantité de fluide

Muller et al. Anesthesiology 2011

**An Increase in Aortic Blood Flow after an Infusion of 100 ml Colloid over 1 Minute Can Predict Fluid Responsiveness**

*The Mini-fluid Challenge Study*

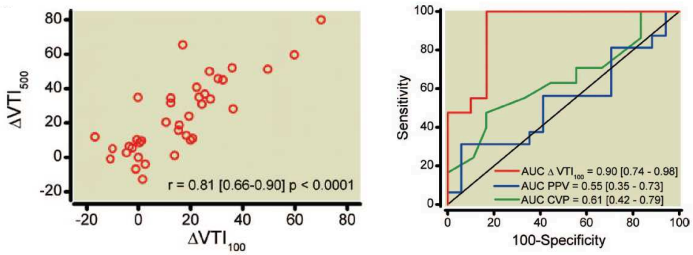



Muller et al. Anesthesiology 2011

**An Increase in Aortic Blood Flow after an Infusion of 100 ml Colloid over 1 Minute Can Predict Fluid Responsiveness**

*The Mini-fluid Challenge Study*

Une augmentation >10% de l'ITVAo après 100ml de colloide sur 1 minute prédit la réponse à un expansion volémique de 500 ml




Muller et al. Anesthesiology 2011

## Conclusion

- La ventilation mécanique
  - Contraint le VD
  - Aide le VG
- Indices dynamiques
  - Prédiction expansion volémique
  - Situations rares
- Place du Mini-Fluid

**Merci**