Detection of weaning failure from cardiac origin

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Invasive or non invasive positive pressure ventilation is an established treatment of severe cardiogenic pulmonary edema.

Weaning-induced pulmonary edema may develop and may be a cause of weaning failure in predisposed patients.
Weaning-induced increase in PAOP

Acute myocardial infarction complicated by respiratory failure. The effects of mechanical ventilation

Rasanen et al. Chest 1984

Acute left ventricular dysfunction during unsuccessful weaning from MV

Lemaire et al. Anesthesiology 1988

Enoximone and acute left ventricular failure during weaning from mechanical ventilation after cardiac surgery


Continuous recordings of mixed venous oxygen saturation during weaning from mechanical ventilation and the ramifications thereof

Jubran et al. AJRCCM 1998
Acute Left Ventricular Dysfunction during Unsuccessful Weaning from Mechanical Ventilation

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Weaning-induced pulmonary edema / mechanisms

- LV preload augmentation
- LV afterload augmentation
- LV compliance reduction
Most often, **hyperdynamic state** (increased $O_2$ demand)

$\rightarrow$ **Increase in venous return, central blood volume**

and **LV preload**

**Weaning-induced pulmonary edema / mechanisms**

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Mechanisms:

- Catecholamine discharge: arterial vasoconstriction
- Intrathoracic pressure reduction
The decrease in intrathoracic pressure results in an increased end-diastolic and end-systolic volume consistent with increased afterload.
Radionuclide angiocardiography during weaning in COPD patients without CAD

Richard C, Teboul JL, Archambaud F et al.
Left ventricular function during weaning of patients with COPD
Intensive Care Med 1994; 20: 181-6

LVEF (%)

MV_1  SV  MV_2
Weaning-induced pulmonary edema / mechanisms

- LV preload augmentation
- LV afterload augmentation
- LV compliance reduction
Acute Left Ventricular Dysfunction during Unsuccessful Weaning from Mechanical Ventilation

PAOP subscript tm (mmHg)

MV
SV

LV EDVI (mL/m²)
Weaning-induced pulmonary edema / mechanisms

- LV preload augmentation
- LV afterload augmentation
- LV compliance reduction

Mechanisms:
- Myocardial ischemia
- Interdependence RV/LV: RV dilation
Weaning-induced pulmonary edema / mechanisms

LV preload augmentation
LV afterload augmentation
LV compliance reduction

Mechanisms:
• Myocardial ischemia
• Interdependence RV/LV: RV dilation
Myocardial ischemia and weaning from mechanical ventilation

**Reduction in myocardial O₂ supply**
- hypoxemia
- reduction in diastolic perfusion time (tachycardia)
- reduction in subendocardial perfusion

**Augmentation in myocardial O₂ demand**
- LV afterload augmentation
- increased cardiac work secondary to increased WOB

**Myocardial O₂ supply/demand unbalance**
Mechanical Ventilation

Lemaire F, Teboul JL, Cinotti L et al. Acute LV dysfunction during unsuccessful weaning from MV. *Anesthesiology 1988; 69: 171-9*
Weaning-induced pulmonary edema / mechanisms

Mechanisms:

- Myocardial ischemia
- **Interdependence RV/LV**: RV dilation
  - Increase in systemic venous return
  - Increase in pulmonary vascular resistance
Which categories of patients at risk of weaning failure from cardiac origin?

Patients with **LV disease** (CAD) and **associated COPD**

- **airway obstruction**
  - Deep inspiratory fall in intrathoracic pressure and elevated WOB

- **biventricular interdependence**

  Decreased LV compliance

- Increased RV and LV preload and increased LV afterload

  Increased cardiac work and thus increased risk of myocardial ischemia
When should cardiac-related weaning failure be suspected?

- when CHF and COPD coexist
- when other obvious causes of weaning failure have been discarded
How to diagnose a weaning-induced pulmonary edema?

Weaning trial: **T-piece or low level of Pressure support**

- PA catheter?
  - increase in PAOP
How to diagnose a weaning-induced pulmonary edema?

Weaning trial: **T-piece or low level of Pressure support**

- PA catheter?
  - increase in PAOP
  - decrease in $\text{SvO}_2$
Jubran A, Mathru M, Dries D, Tobin MJ.
Continuous recordings of mixed venous oxygen saturation during weaning from MV
Am J Respir Crit Care Med 1998; 158: 1763-9
How to diagnose a weaning-induced pulmonary edema?

Weaning trial: **T-piece or low level of Pressure support**

- PA catheter?

- Doppler-echo?

  E/A and E/Ea

assumed to reflect PAOP
Pulsed Doppler
transmitral flow

Estimate of LVEDP
Pulsed Doppler

Estimate of LVEDP

Tissue Doppler Imaging

transmitral flow

velocity of the mitral annulus

$\frac{E}{Ea}$
Can E/A and E/Ea at the end of a Spontaneous Breathing Trial identify weaning failure from cardiac origin defined as a weaning-induced increase in PAOP > 18 mmHg?
The predictive value of each of this variable was not sufficiently acceptable to diagnose weaning-induced pulmonary edema.
The combination of E/A > 0.95 and E/Ea > 8.5 at the end of a SBT predicted weaning-induced pulmonary edema with a high accuracy.

**E/A** at the end of the SBT

**PE +** defined as a PAOP > 18 mmHg at the end of a SBT

- Se = 82%
- Sp = 91%
- PPV = 88%
- NPV = 87%
How to diagnose a weaning-induced pulmonary edema?

Weaning trial: **T-piece or low level of Pressure support**

- PA catheter?
- Doppler-echo?
- BNP?
Use of N-terminal pro-brain natriuretic peptide to detect acute cardiac dysfunction during weaning failure in difficult-to-wean patients with chronic obstructive pulmonary disease*

Salvatore Grasso, MD; Antonio Leone, MD; Michele De Michele, MD; Roberto Anaciero, MD; Aldo Cafarelli, MD; Giovanni Ancona, MD; Tania Strippoli, MD; Francesco Bruno, MD; Paolo Pugliese, MD; Michele Dambrosio, MD; Lidia Delfino, MD; Francesco Di Serio, MD; Tommaso Fiore, MD

Crit Care Med 2007; 35:96-105
BNP higher than 275 pg/mL predicted weaning failure...... but not weaning failure from cardiac origin
The changes in BNP during the WT did not differ between patients who failed and patients who succeeded the WT.
How to diagnose a weaning-induced pulmonary edema?

Weaning trial: **T-piece** or **low level of Pressure support**

- PA catheter?
- Doppler-echo?
- BNP?
- Hemoconcentration?
Hydrostatic pulmonary edema

Increase in plasma protein concentration during weaning could detect weaning-induced pulmonary edema.

Hemoconcentration
Weaning-induced PO defined as intolerance to SB and a PAOP > 18 mmHg.
Weaning-induced PO

No weaning-induced PO

Se = 85 %
Sp = 100 %

Anguel et al Intensive Care Med 2008
Which therapy? *Pharmacological agents*

- **Diuretics** if pulmonary edema is assumed to be related to increased preload secondary to increased venous return.
• 9/15 patients who initially failed to wean because of pulmonary edema were successfully weaned after 8 days furosemide treatment (5 L losses)

• After treatment, PAOP was lower during spontaneous breathing than before (9 ± 3 vs 25 ± 15 mmHg)
Which therapy? Pharmacological agents

- **Diuretics** if pulmonary edema is assumed to be related to *increased preload*
  secondary to *increased venous return*

- **Nitrates** if suspected myocardial ischemia
Which therapy? Pharmacological agents

- **Diuretics** if pulmonary edema is assumed to be related to **increased preload** secondary to increased venous return

- **Nitrates** if suspected myocardial ischemia

- **Vasodilators** if increase in **LV afterload** is suspected
Diuretics if pulmonary edema is assumed to be related to increased preload secondary to increased venous return.

Nitrates if suspected myocardial ischemia.

Vasodilators if increase in LV afterload is suspected.

Inotropes: not logical!

Bonchodilating drugs why not, if marked airway obstruction assumed to be the precipitating factor.

No proof of efficacy, no definitive recommendation.
PS + PEEP

- Decremental levels of PS and keeping 5 to 8 cmH$_2$O of PEEP
- Continue after extubation (facial mask)

No proof of efficacy of such procedures
In case of preexisting cardiac disease, weaning failure from cardiac origin is not uncommon. Its recognition is important since a specific therapy (after individualized evaluation) can result in successful weaning.

Complex and intricate mechanisms (vicious circle) generated by marked increased respiratory muscles activity.

Thank you