Fluid administration and the **right ventricle**

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Major causes of acute RV dysfunction in critically ill patients

- **Sepsis**-induced myocardial dysfunction
- Acute **pulmonary embolism**
- RV dysfunction due to **ARDS**

ARDS-related Pulmonary Hypertension

- hypoxic vasoconstriction
- mediators-related vasoconstriction
- perivascular edema
- microthrombi in pulmonary vessels
- microvascular remodeling

Major causes of acute RV dysfunction in critically ill patients

- **Sepsis**-induced myocardial dysfunction — Acute **decrease** in **contractility**
- Acute **pulmonary embolism**
- RV dysfunction due to **ARDS**
- **Deleterious** effects of **MV**

Acute **increase** in **PVR**

Major causes of acute RV dysfunction in critically ill patients

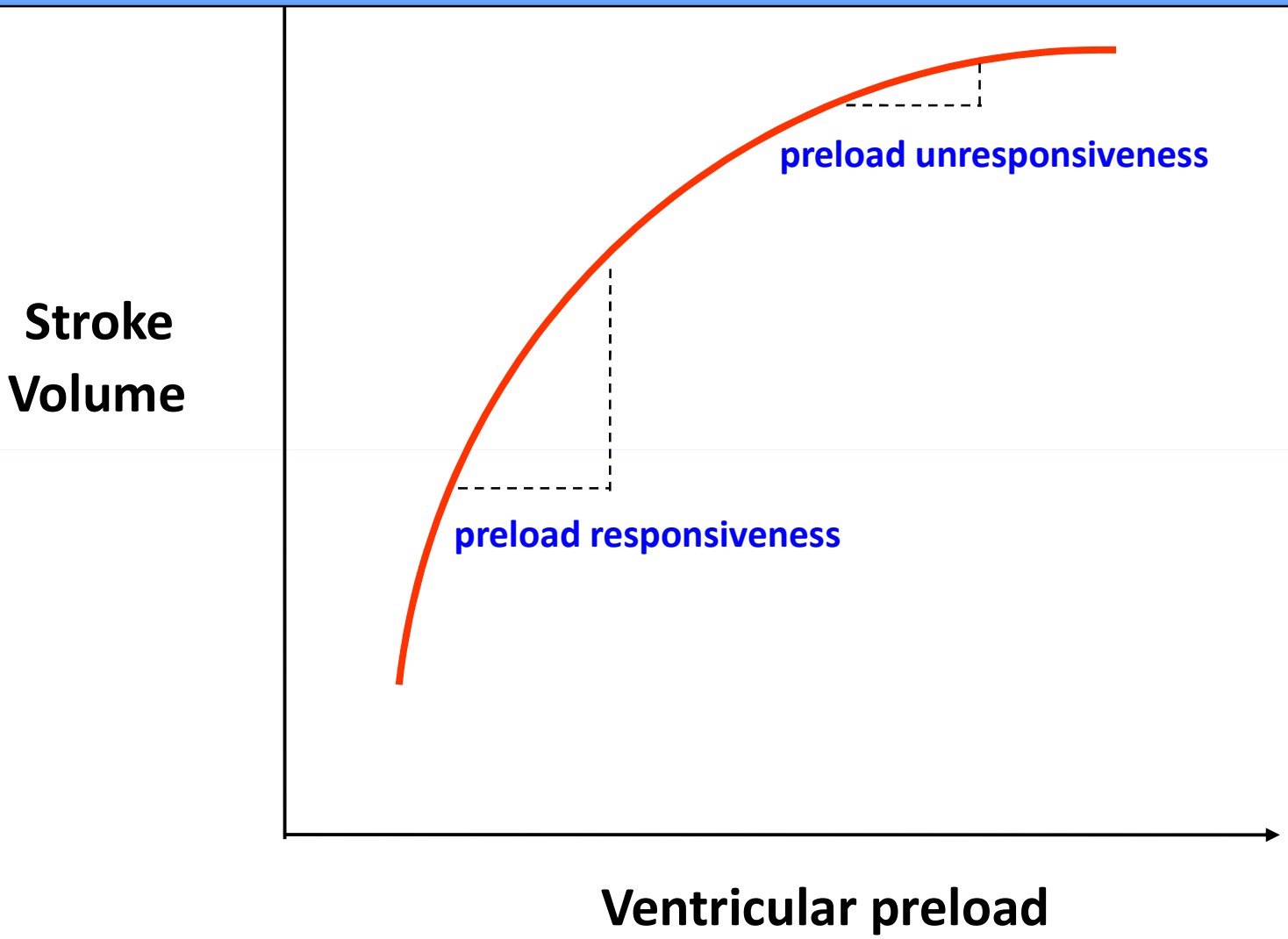
- **Sepsis**-induced myocardial dysfunction
- Acute **pulmonary embolism**
- RV dysfunction due to **ARDS**

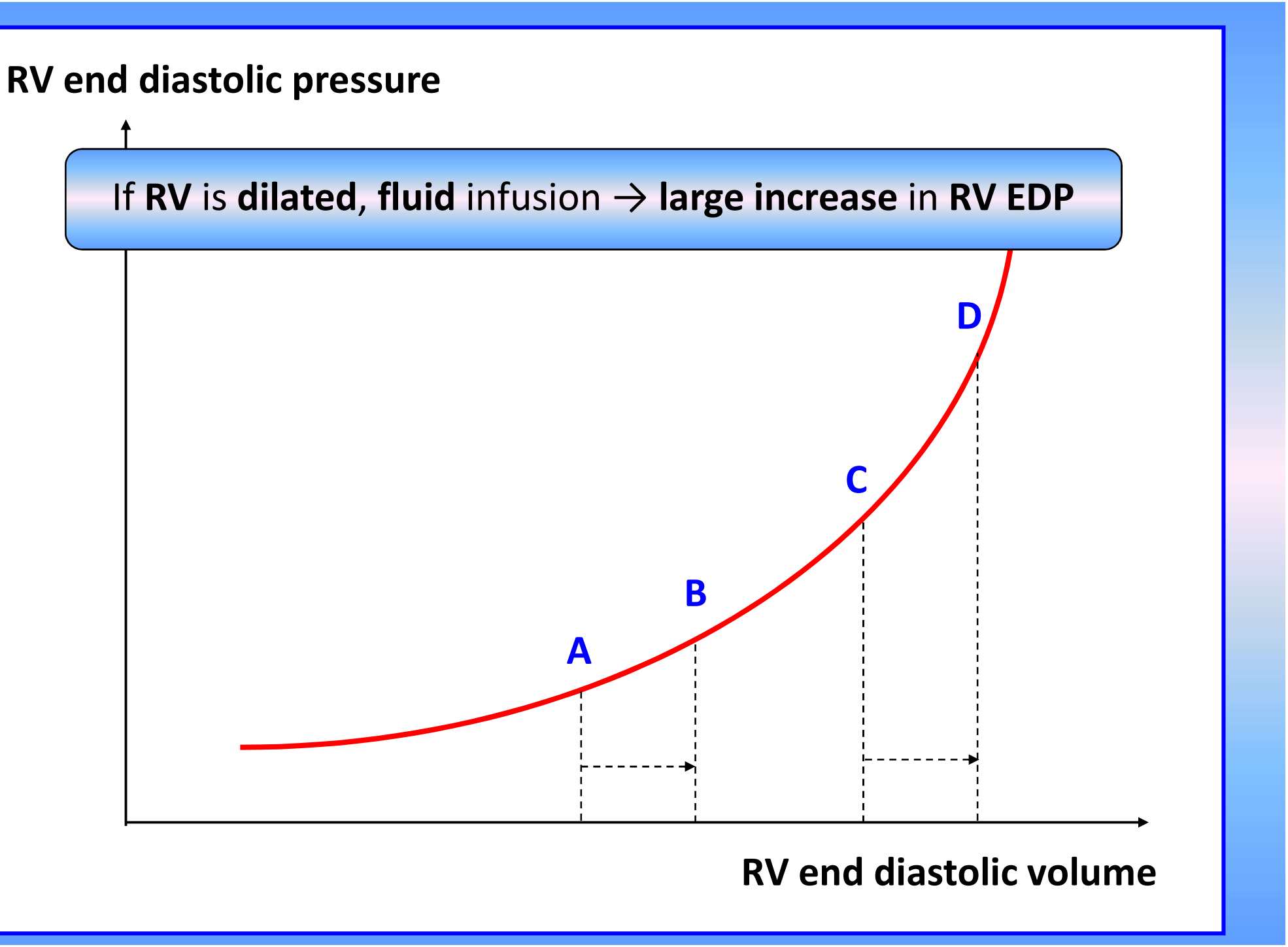
} « **Structura**l » causes of RV dysfunction

- **Deleterious** effects of **MV** → « **Functional** » cause of RV dysfunction

What about **fluid** administration in such cases?

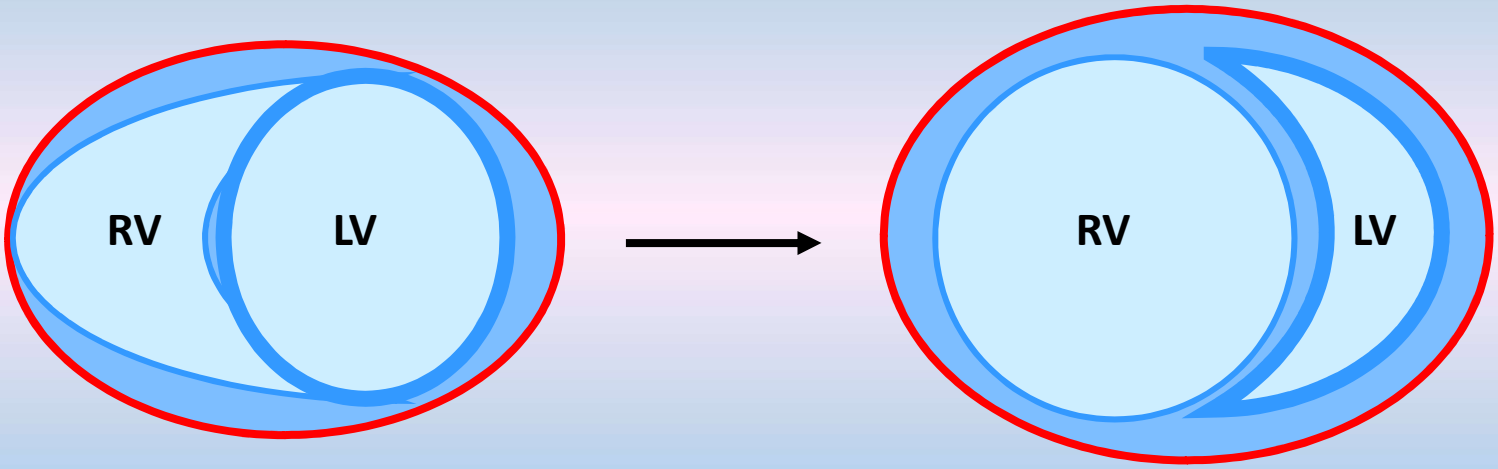
If **RV** is **dilated, fluid** infusion → **no increase** in **RV stroke volume**




RV end diastolic pressure
If RV is dilated, fluid infusion → large increase in RV EDP
D
C
B
A
RV end diastolic volume

If **RV** is **dilated, fluid** infusion → **no increase** in **RV stroke volume**

If **RV** is **dilated, fluid** infusion → **large increase** in **RV EDP**



Ventricular interdependence → **decrease** in **LV stroke volume**

Fluid infusion not only does **not increase** but can even **decrease CO**

Major causes of acute RV dysfunction in critically ill patients

- **Sepsis**-induced myocardial dysfunction
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- RV dysfunction due to **ARDS**

} « **Structura**l » causes of RV dysfunction

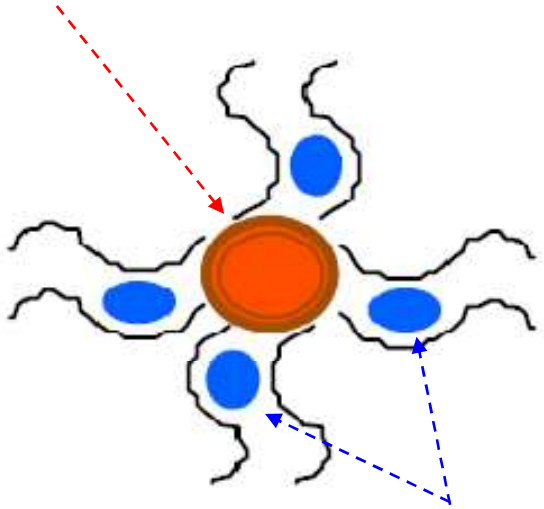
- **Deleterious** effects of **MV** → « **Functional** » cause of RV dysfunction

What about **fluid** administration in such cases?

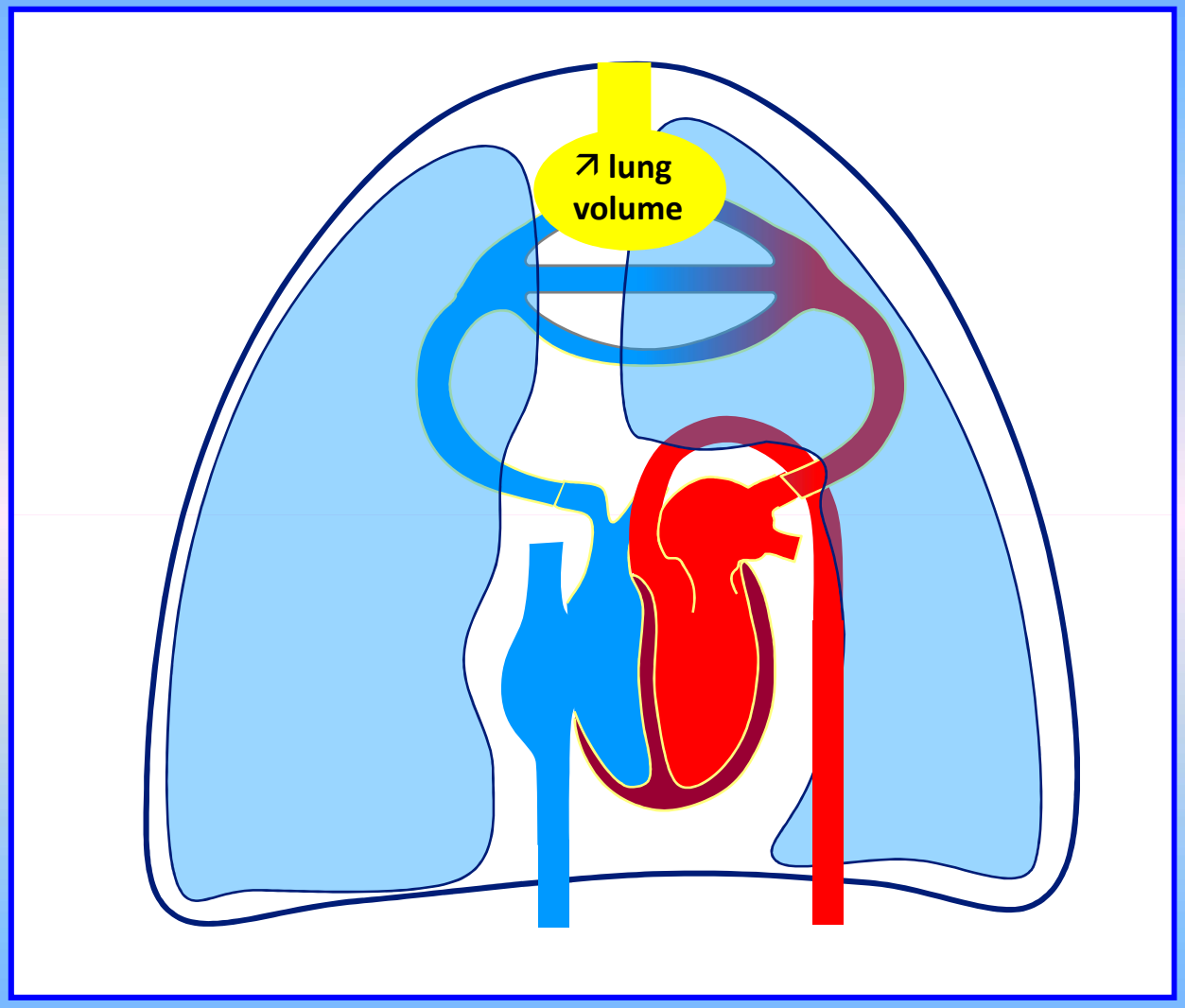
Mechanical insufflation and RV afterload

- **Pulmonary vascular resistance** and **lung volume**

extra-alveolar vessels



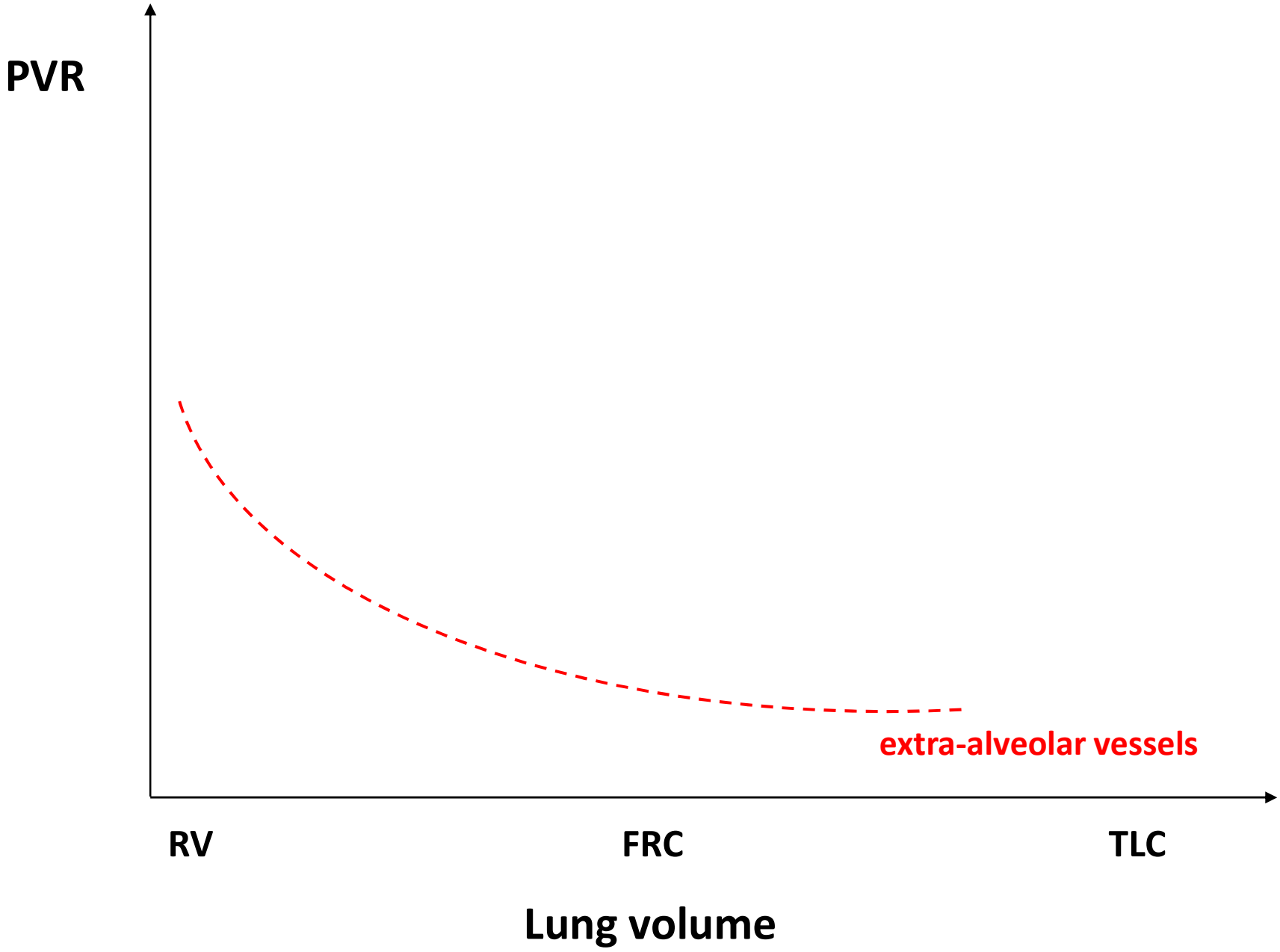
intra-alveolar vessels

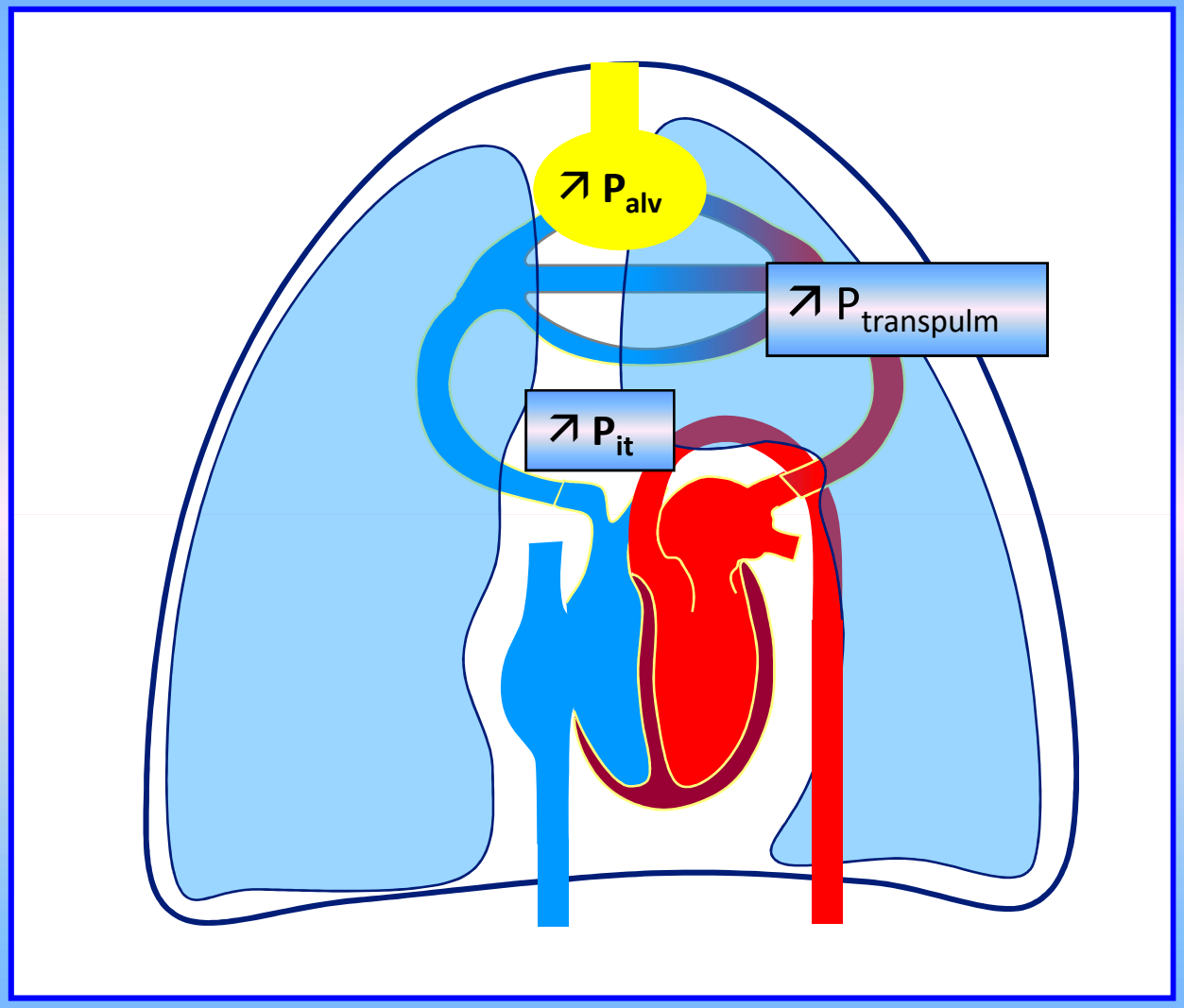


↗ **Lung volume**

decreases the **resistance**

of the **extra-alveolar vessels**


PVR
extra-alveolar vessels
RV
FRC
TLC
Lung volume



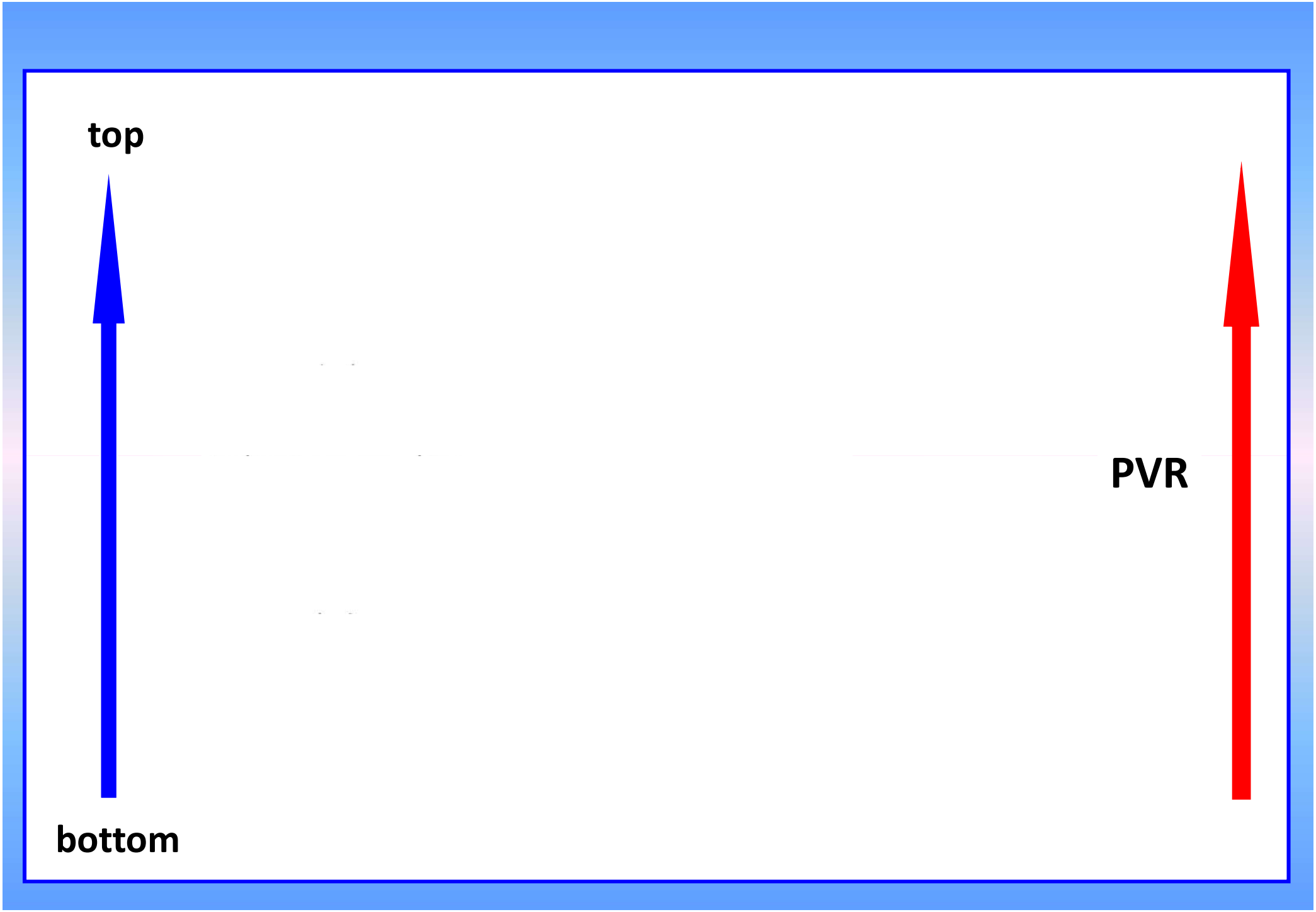
↗ **Lung volume**

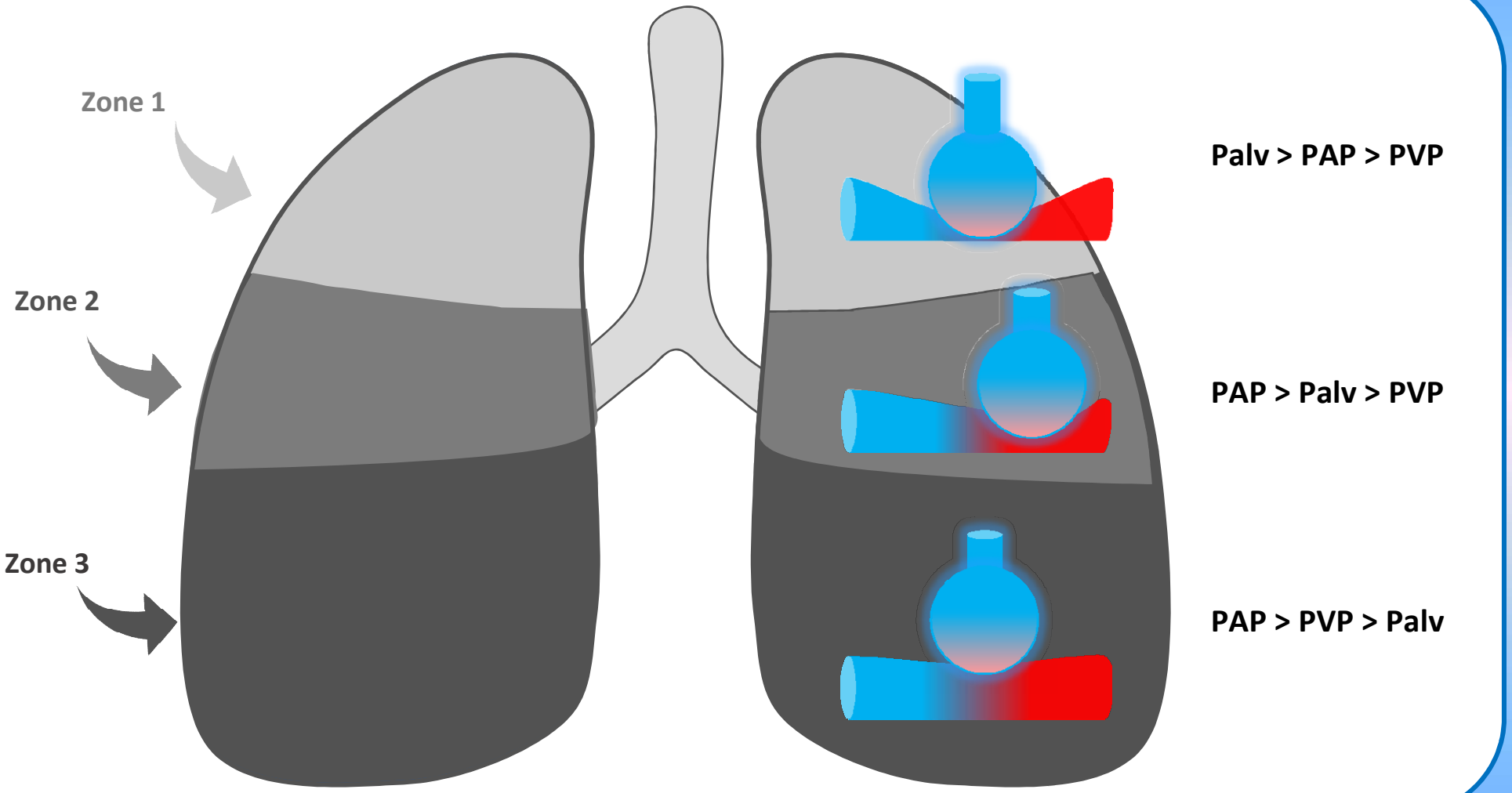
decreases **the** resistance of **the extra-alveolar vessels**

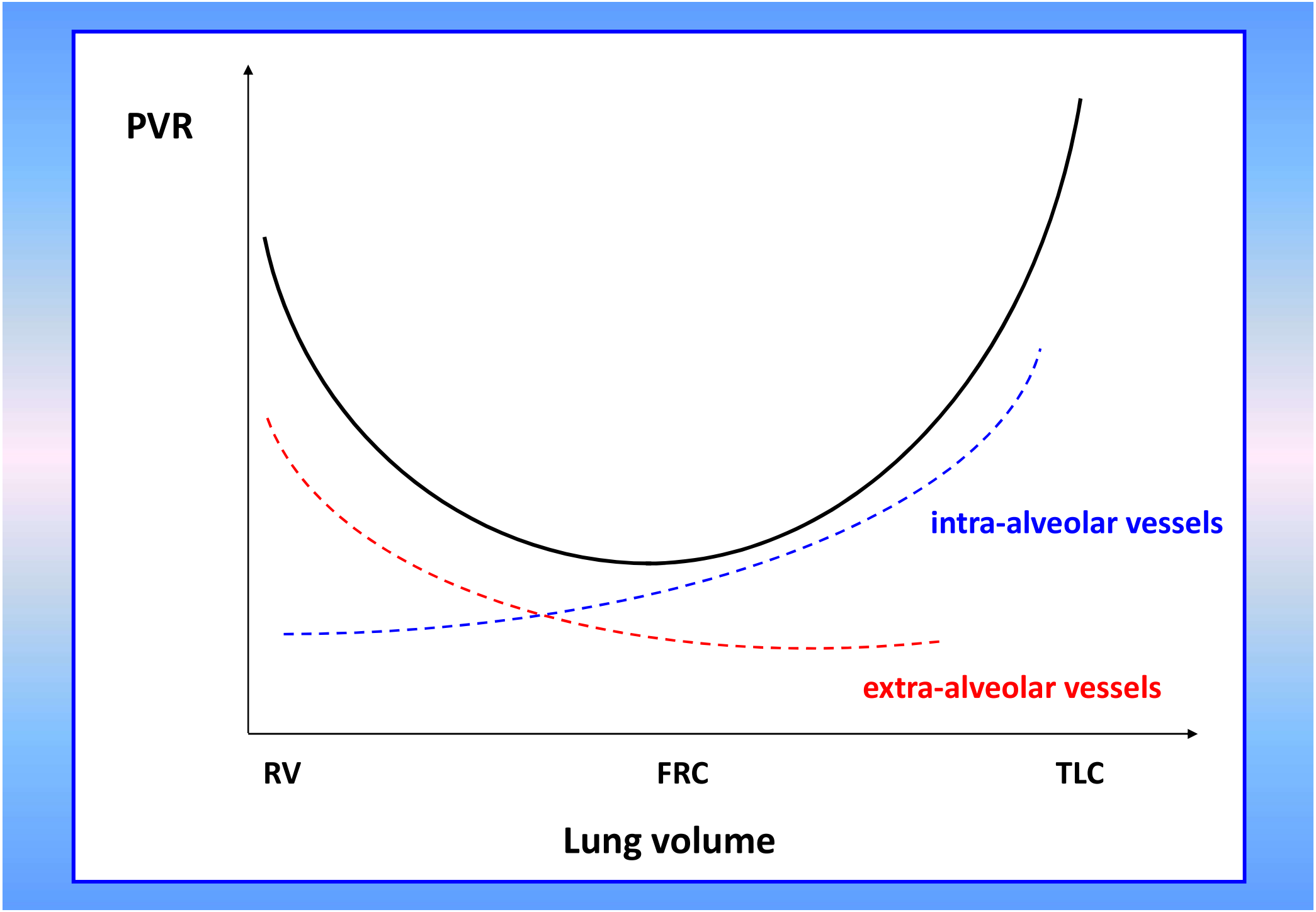
↗ **Transpulmonary pressure**

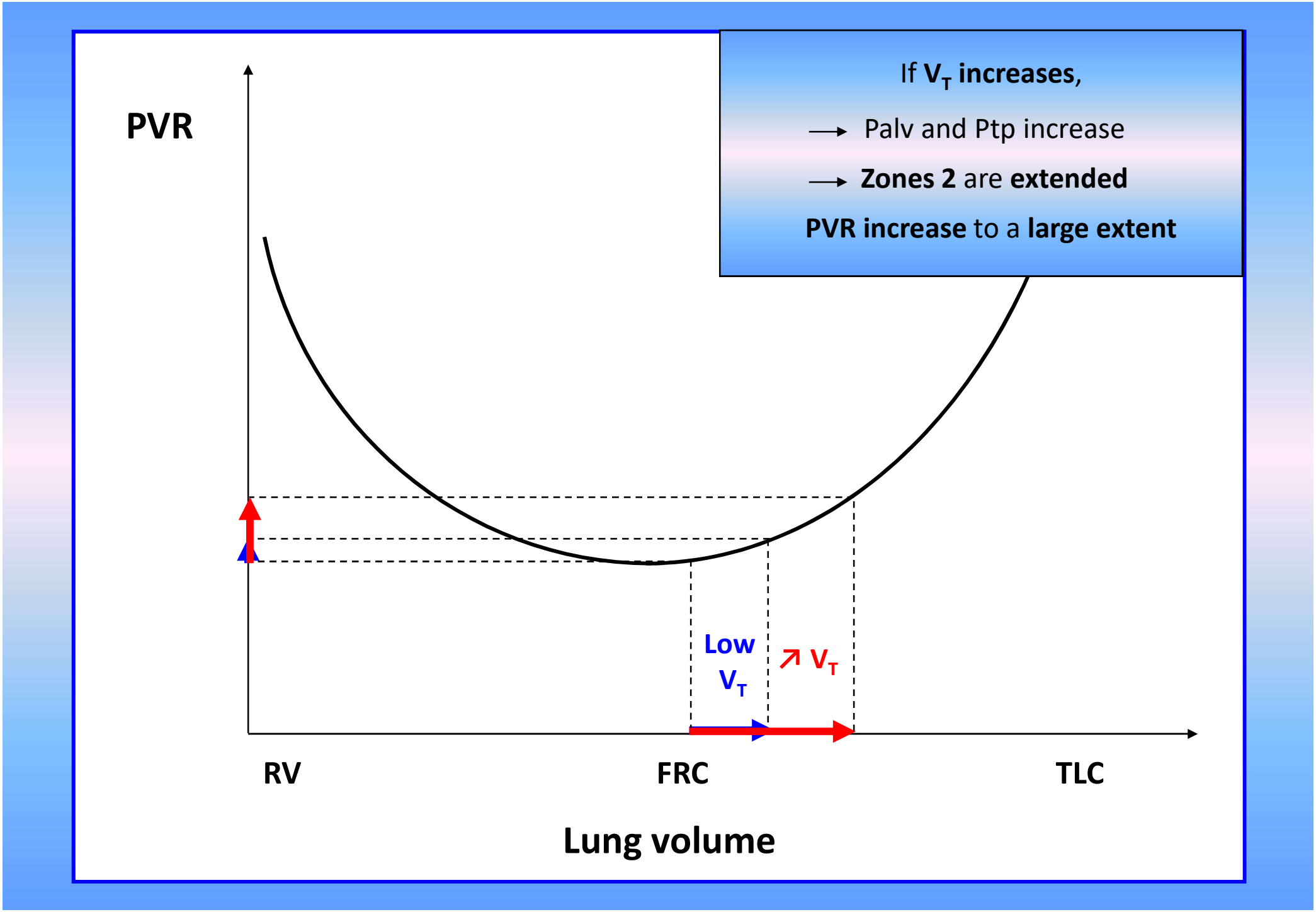
= P_{alv} - P_{it}

Increases the **resistance** of the **intra-alveolar vessels**


top
PVR
bottom

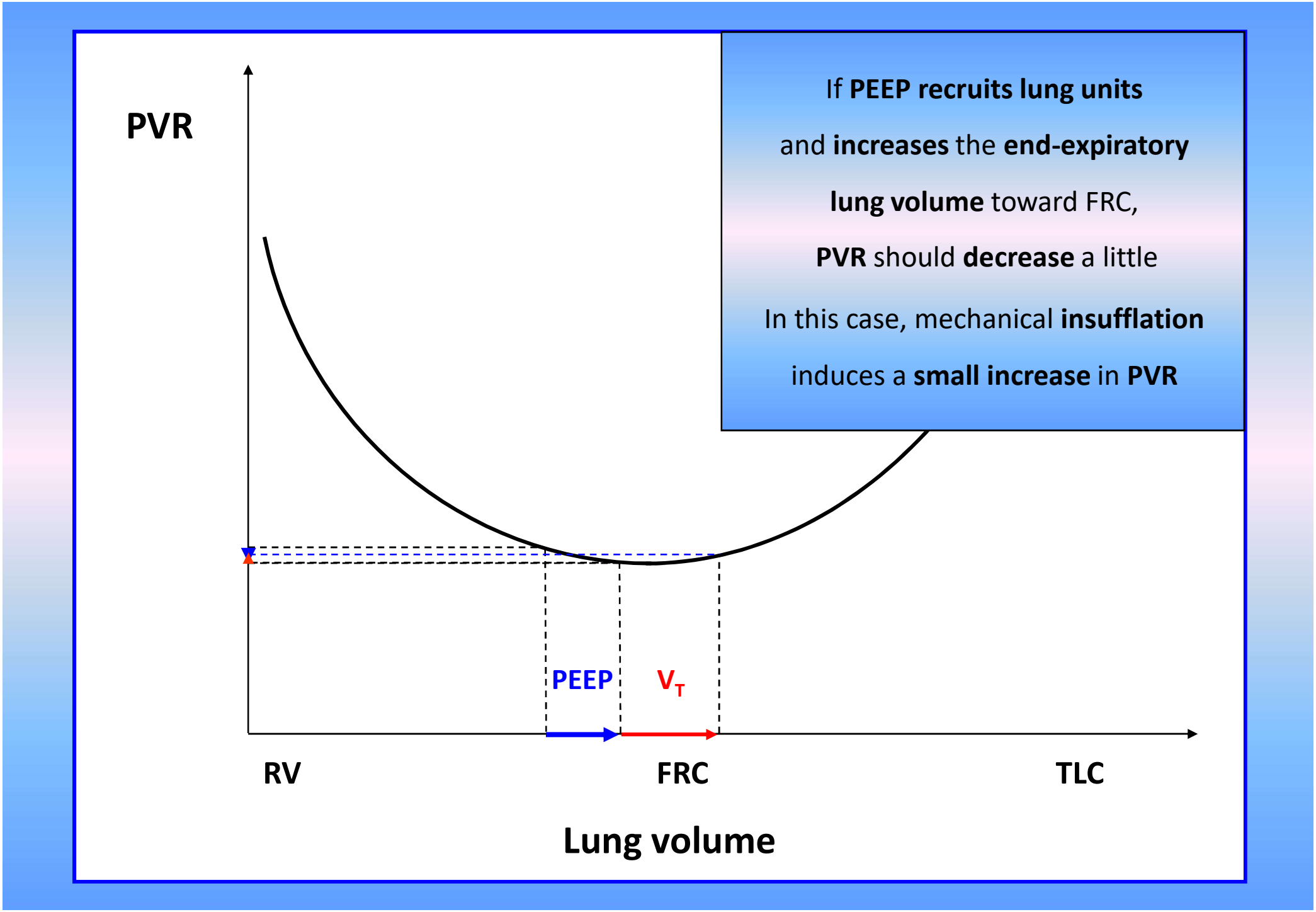

Zone 1
Zone 2
Zone 3
Palv > PAP > PVP
PAP > Palv > PVP
PAP > PVP > Palv

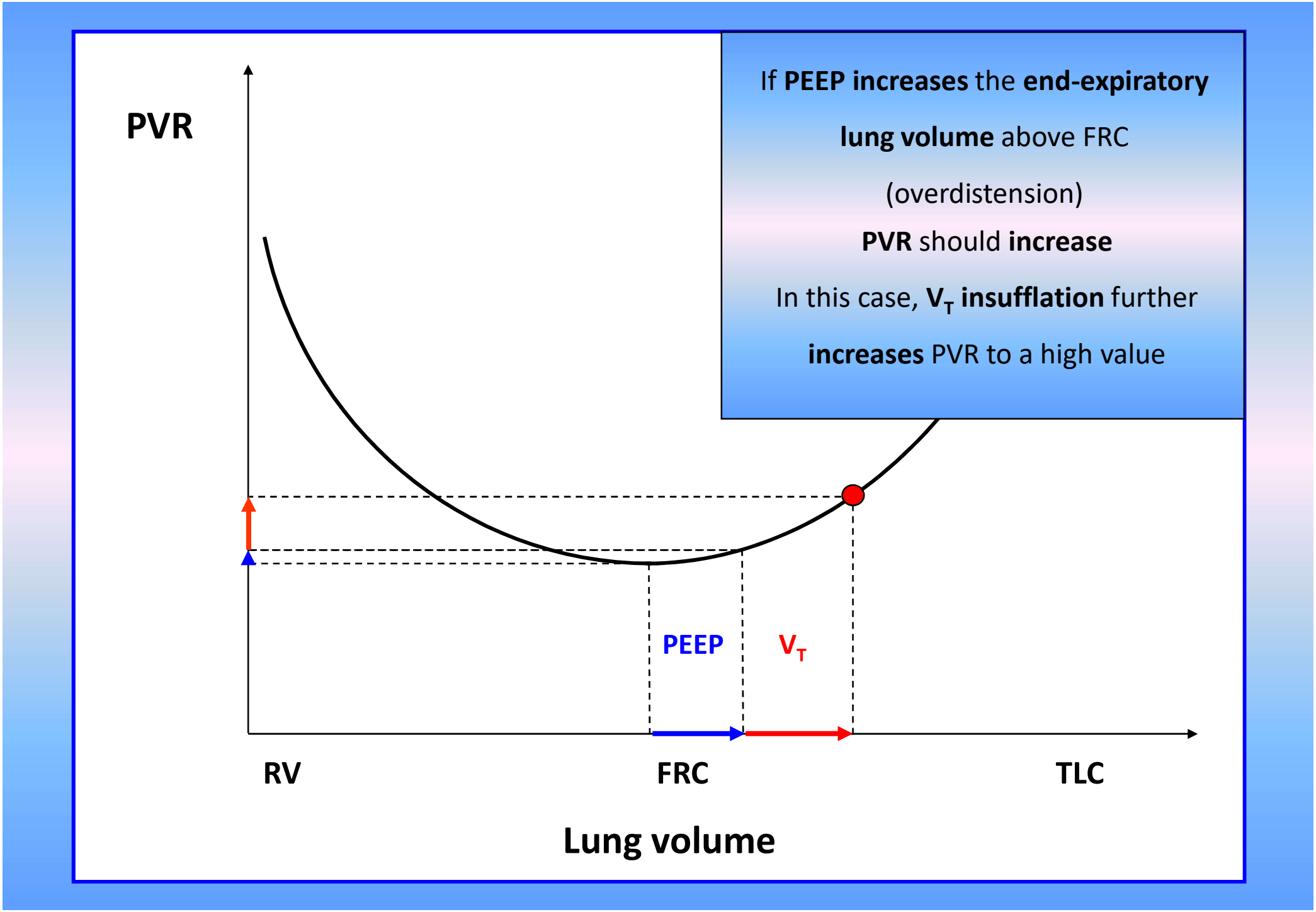

PVR
intra-alveolar vessels
extra-alveolar vessels
RV
FRC
TLC
Lung volume

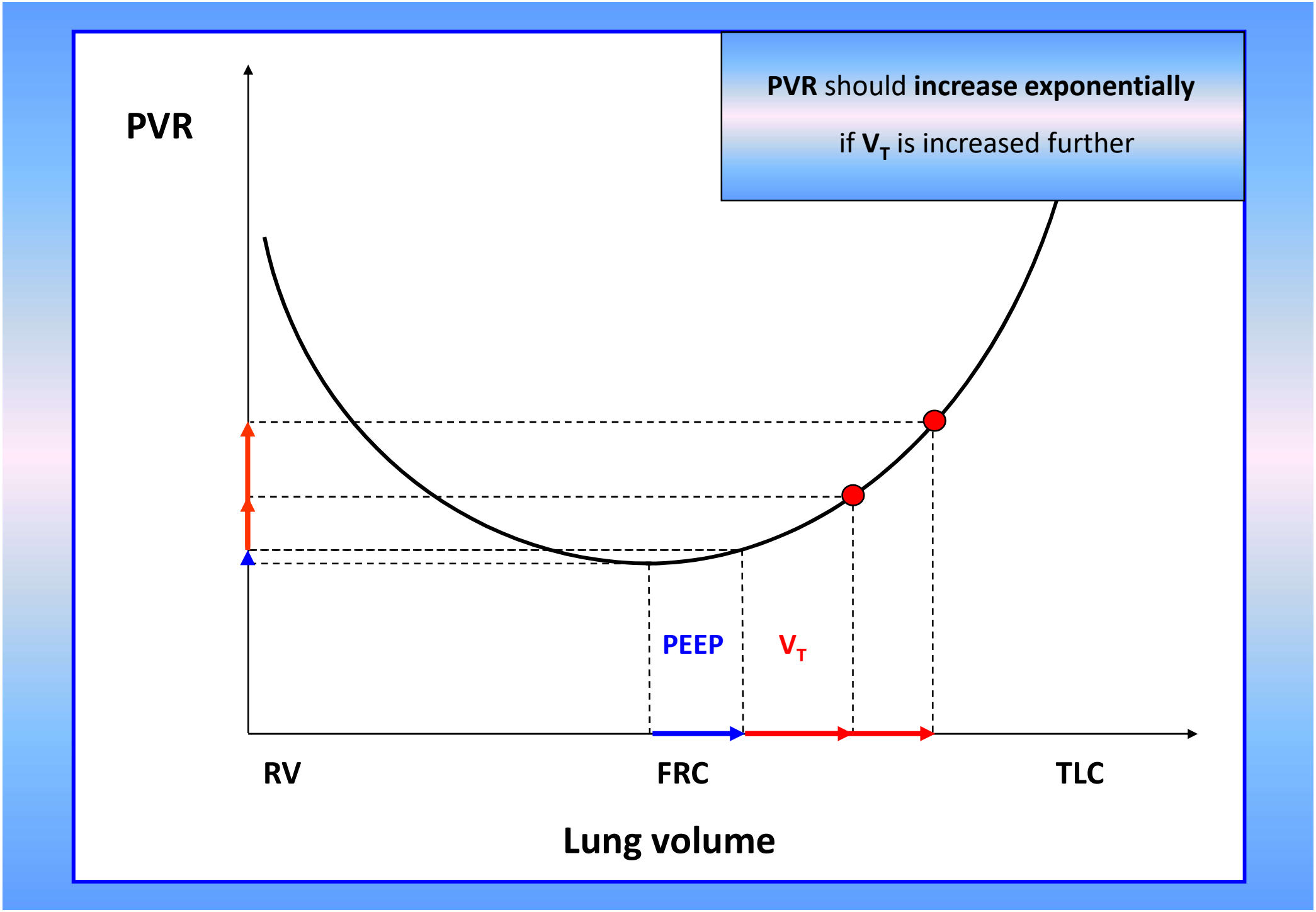

If V_T increases,
→ Palv and Ptp increase
→ Zones 2 are extended
PVR increase to a large extent
PVR
Low V_T
↗ V_T
RV
FRC
TLC
Lung volume

What about **PEEP** application?

- **Physiological aspects**
- **Clinical application**


If PEEP recruits lung units
and increases the end-expiratory
lung volume toward FRC,
PVR should decrease a little
In this case, mechanical insufflation
induces a small increase in PVR
PVR
PEEP
V_T
RV
FRC
TLC
Lung volume


If **PEEP increases** the **end-expiratory lung volume** above FRC (overdistension)
PVR should **increase**
In this case, **V_T insufflation** further **increases** PVR to a high value
PVR
PEEP
V_T
RV
FRC
TLC
Lung volume


PVR should increase exponentially
if V_T is increased further
PVR
PEEP
V_T
RV
FRC
TLC
Lung volume

What about **PEEP** application?

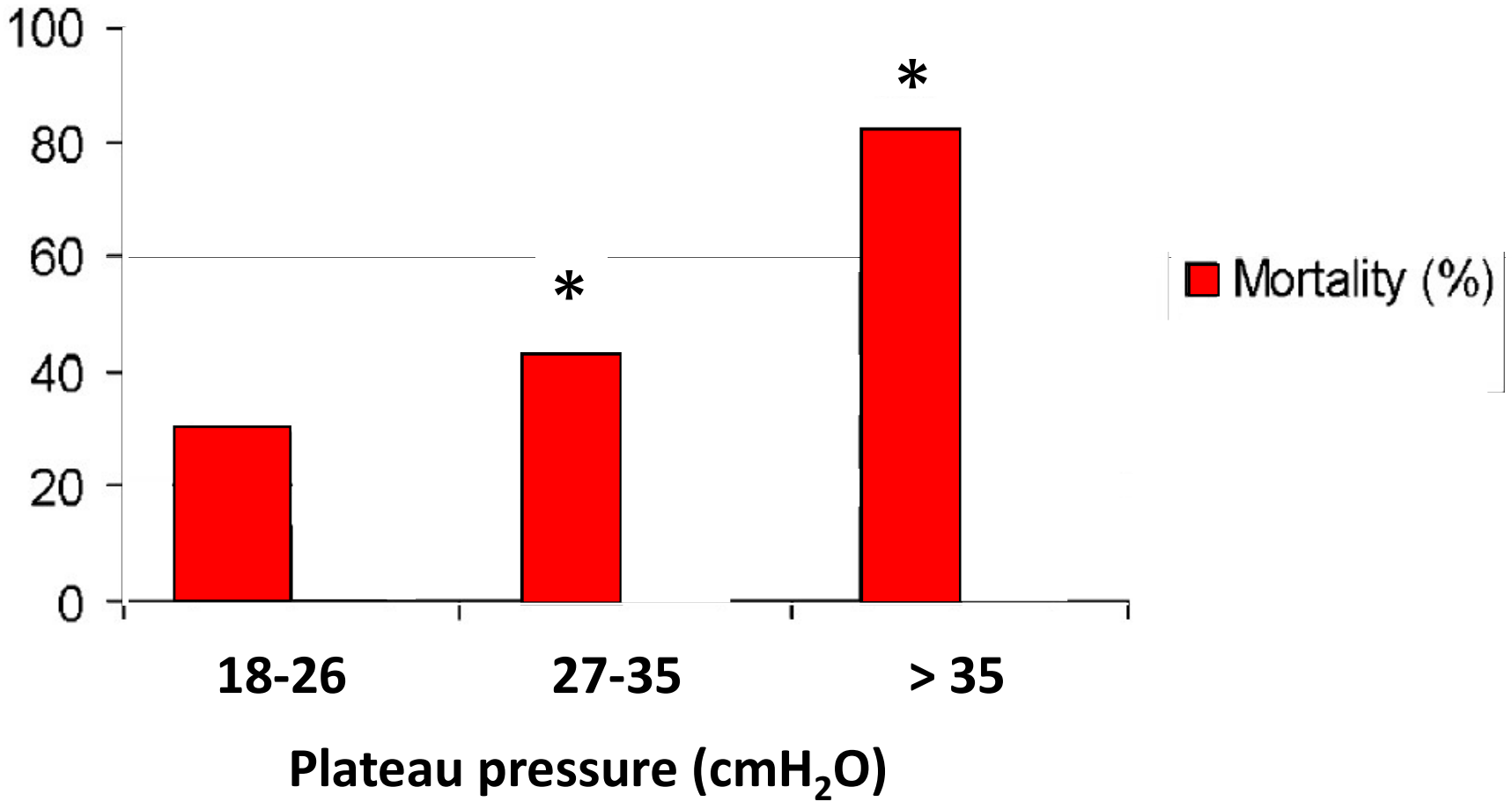
- Physiological aspects
- **Clinical application**

Intensive Care Med (2007) 33:444–447

ORIGINAL

François Jardin
Antoine Vieillard-Baron

Is there a safe plateau pressure in ARDS? The right heart only knows



Intensive Care Med **2016**

SEVEN-DAY PROFILE PUBLICATION

Armand Mekontso Dessap
Florence Boissier
Cyril Charron
Emmanuelle Bégot
Xavier Repessé
Annick Legras
Christian Brun-Buisson
Philippe Vignon
Antoine Vieillard-Baron

Acute cor pulmonale during protective ventilation for acute respiratory distress syndrome: prevalence, predictors, and clinical impact

752 pts

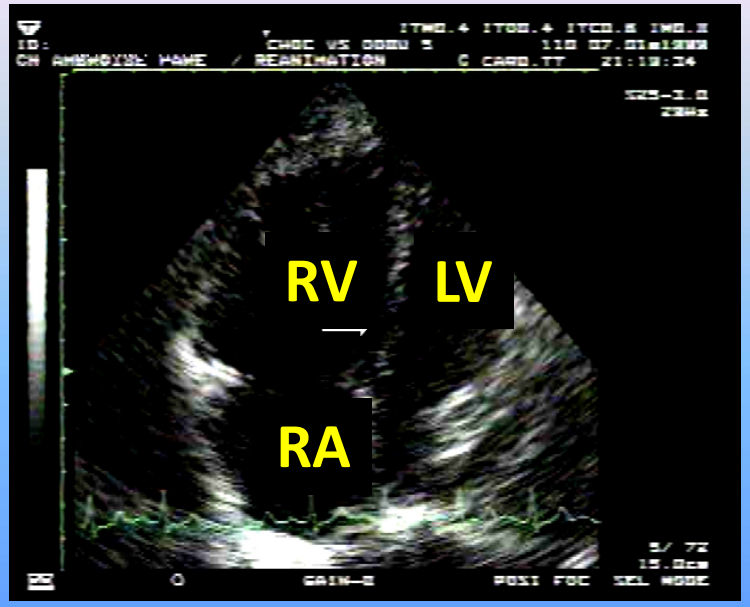
prevalence **ACP : 22%**

11 centres

ACP defined

as **RVEDA/LVEDA > 0.6**

and **septal dyskinesia**



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Acute cor pulmonale during protective ventilation for acute respiratory distress syndrome: prevalence, predictors, and clinical impact

752 pts

11 centres

Table 3 The acute cor pulmonale risk score

Parameter
Pneumonia as cause of ARDS
Driving pressure $\geq$18 cmH_2O[a]

Intensive Care Med (2009) 35:69–76

ORIGINAL

David Osman
Xavier Monnet
Vincent Castelain
Nadia Anguel
Josiane Warszawski
Jean-Louis Teboul
Christian Richard

Incidence and prognostic value of right ventricular failure in acute respiratory distress syndrome

145 ARDS patients

with **lung protectiv**

prevalence **ACP : 10%**

Definition of **ACP**

- **mean PAP > 25 mmHg**
- **RAP > PAOP**
- **Stroke Index < 30 mL/m²**

Reduction of transpulmonary pressure

using ventilatory strategies

aimed at limiting plateau pressure,

is associated with

high reduction of incidence and severity

of acute cor pulmonale during ARDS

CONFERENCE REPORTS AND EXPERT PANEL

Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016

Andrew Rhodes[1*], Laura E. Evans[2], Waleed Alhazzani[3], Mitchell M. Levy[4], Massimo Antonelli[5], Ricard Ferrer[6],

Intensive Care Med (2017) 43:304–377

M. MECHANICAL VENTILATION

1. We recommend using a target tidal volume of 6 mL/kg predicted body weight compared with 12 mL/kg in adult patients with sepsis-induced acute respiratory distress syndrome (ARDS) (strong recommendation, high quality of evidence).
2. We recommend using an upper limit goal for plateau pressures of 30 cm H_2O over higher plateau pressures in adult patients with sepsis-induced severe ARDS (strong recommendation, moderate quality of evidence).

Hemodynamic effects of **PEEP** application

In ARDS pts, PEEP generally:

1. **Increases cardiac output**
2. **Decreases cardiac output**
3. **Exerts no effect**
4. **It depends on volemic status**

single choice

Hemodynamic effects of **PEEP** application

In ARDS pts, PEEP generally:

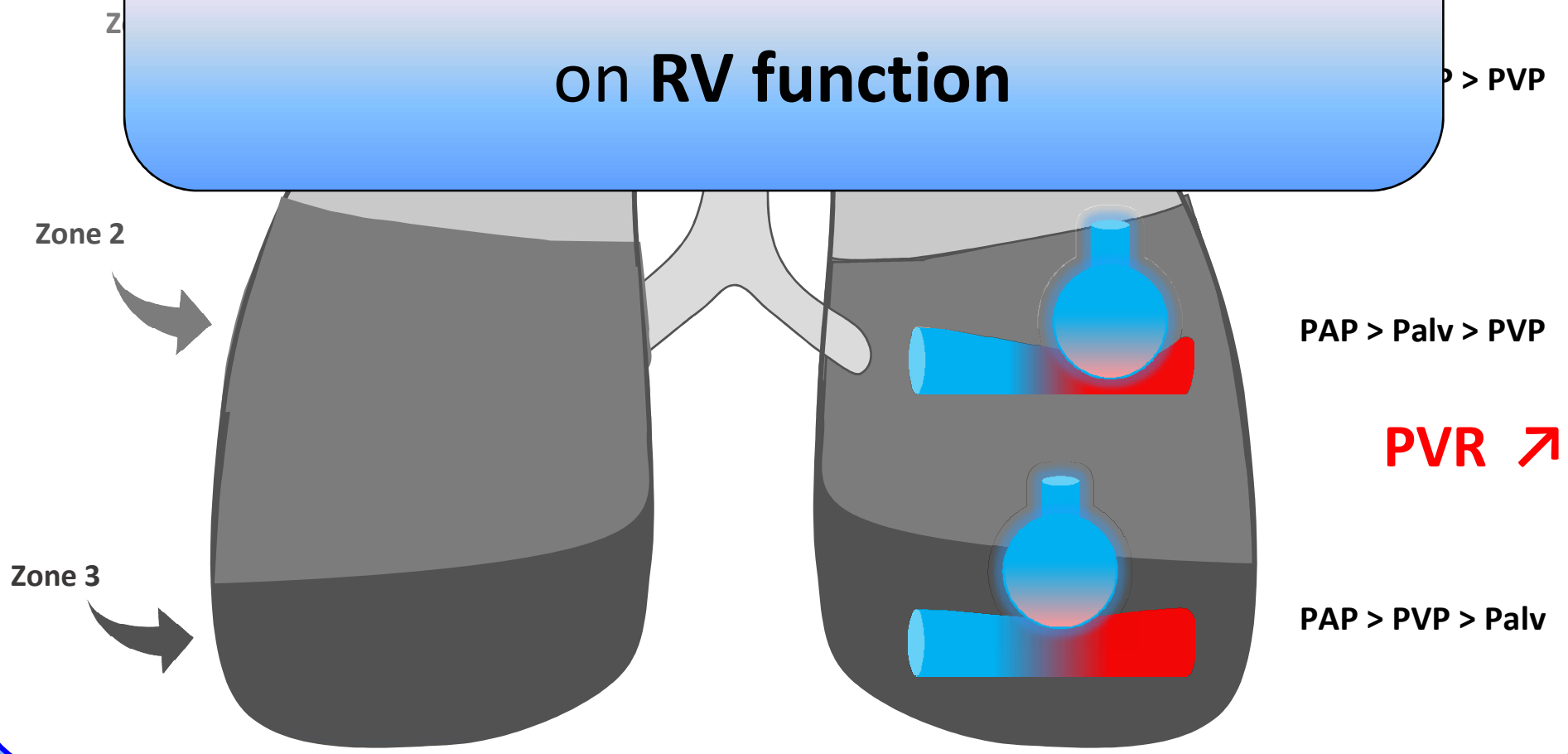
1. Increases cardiac output
2. Decreases cardiac output
3. Exerts no effect
4. **It depends on volemic status**

single choice

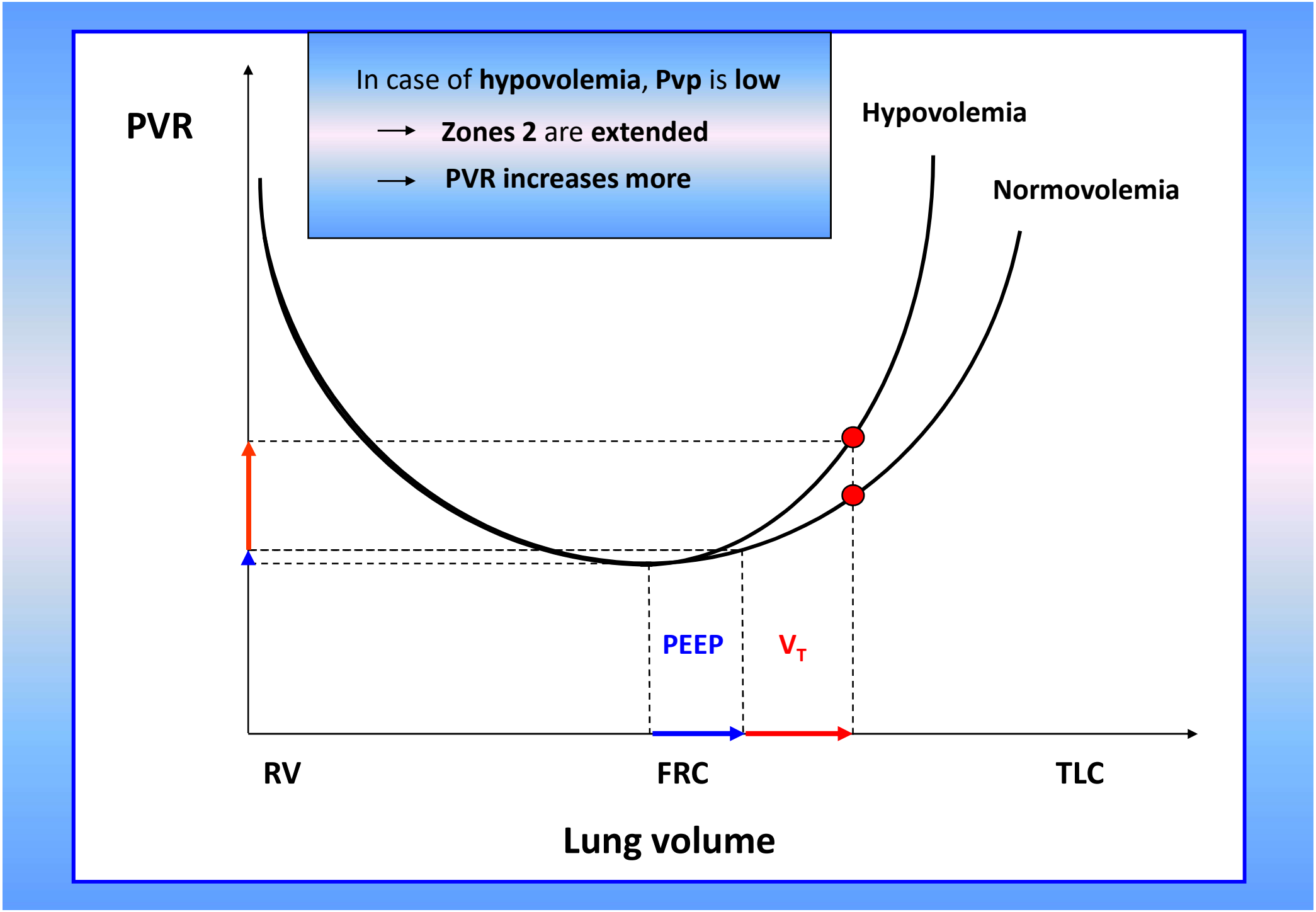
Hypovolemia amplifies

the **deleterious** impact of MV + PEEP

on **RV function**



Hypovolemia favors the extent of zones 2 by reducing intravascular pressures


In case of **hypovolemia**, **Pvp** is **low**
→ **Zones 2** are **extended**
→ **PVR increases more**
PVR
Hypovolemia
Normovolemia
PEEP
V_T
RV
FRC
TLC
Lung volume

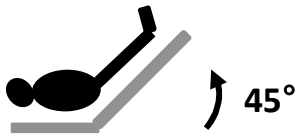
Hemodynamic impact of a positive end-expiratory pressure setting in acute respiratory distress syndrome: Importance of the volume status*

Emilie Fougères, MD; Jean-Louis Teboul, MD, PhD; Christian Richard, MD; David Osman, MD; Denis Chemla, MD, PhD; Xavier Monnet, MD, PhD

Crit Care Med 2010; 38:802–807

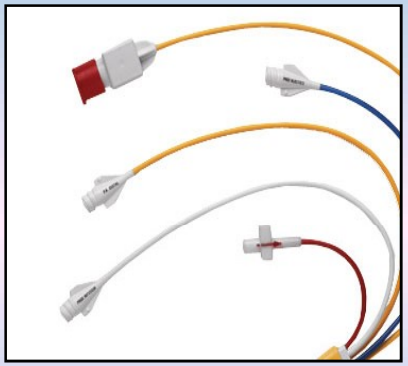
Pplat : 30 cmH_2O →

TV 6 mL/kg	TV 6 mL/kg
Low PEEP 5 cmH_2O	High PEEP 13 cmH_2O



Passive Leg Raising

Simulating a volume challenge



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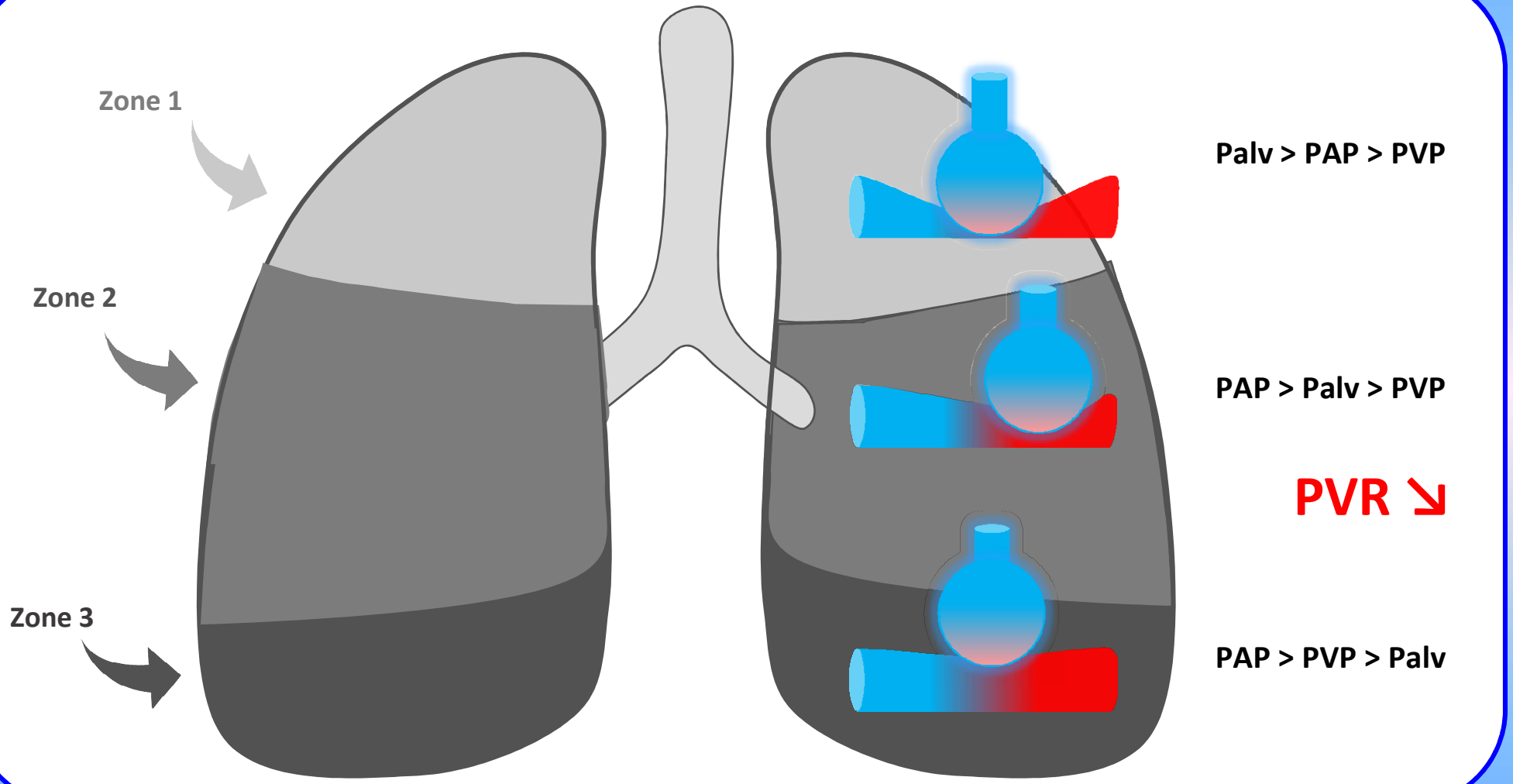
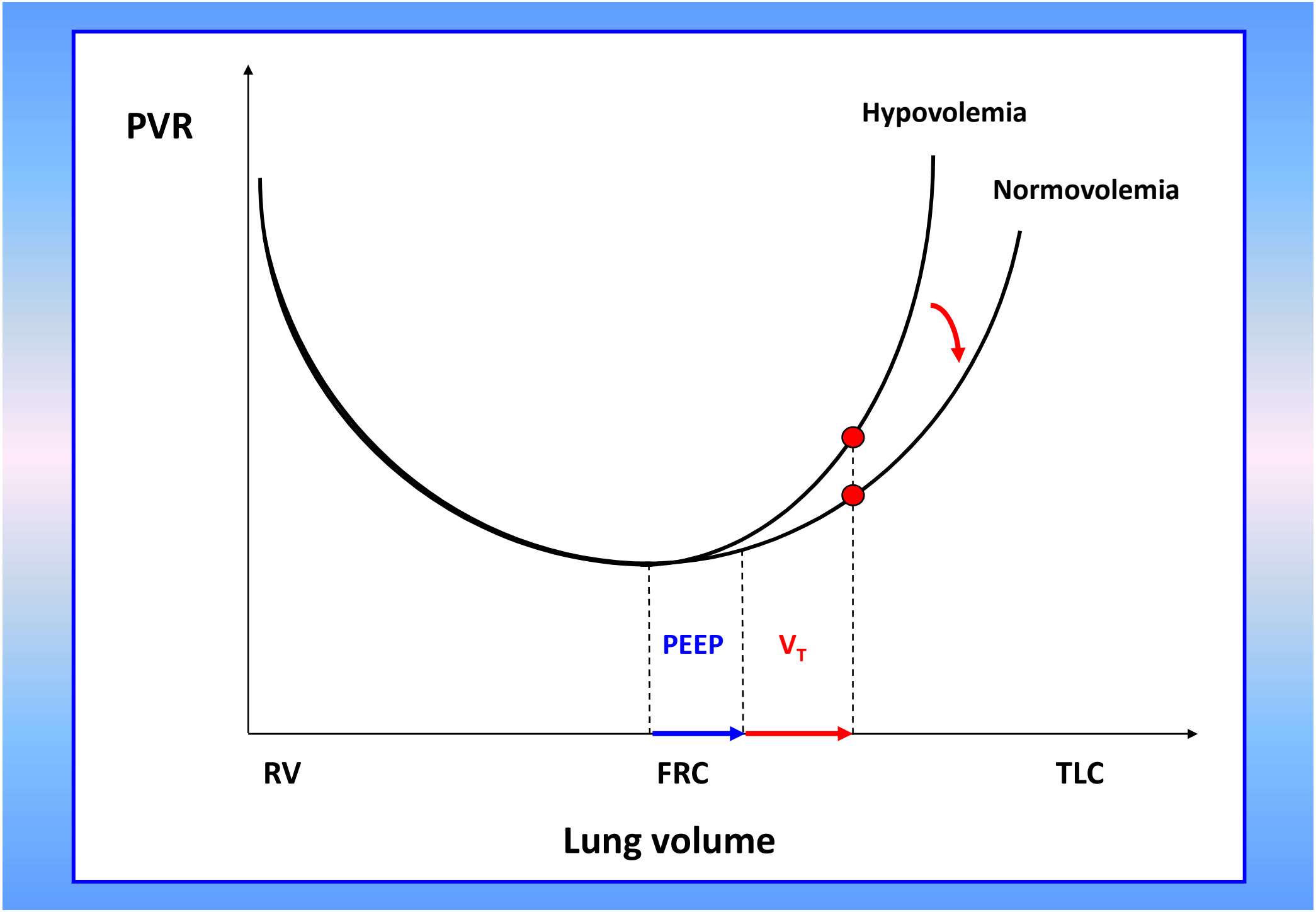
	Minimal PEEP	
Cardiac index, mean ± SD, L/min/m^2	4.1 ± 1.4	↘
Pulmonary artery occlusion pressure, mean ± SD, mm Hg	10.5 ± 4.3	↗
Pulmonary artery mean − occlusion pressure gradient, mean ± SD, mm Hg	14.5 ± 8.6	↗
Right ventricle end diastolic area, mean ± SD, cm^2	[illegible]	↗
Left ventricle end diastolic [illegible]	[illegible]	

Increased RV afterload with PEEP

Decreased RV afterload with volume


Zone 1
Zone 2
Zone 3
Palv > PAP > PVP
PAP > Palv > PVP
PVR ↘
PAP > PVP > Palv


PVR
Hypovolemia
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Conclusion -1-

In critically ill pts, **RV dilation** may occur due to **"structural" causes**

(PE, ARDS-related PH, septic myocardial dysfunction)

Fluid infusion cannot **increase CO** and can even **decrease CO**

In patients receiving MV, **RV dilation** may also occur due to **MV itself**

(high P_{TP} increasing PVR due to extension of zone 2 conditions)

By increasing Pvp, **fluid** infusion can restore zone 3 conditions,

thus decreasing PVR and RV size, and can **increase CO**

Conclusion -2-

In cases of any **doubt**, a **PLR** test can be **helpful**

*essentially in **ARDS**, where « **structural** »*

*and « **functional** » causes may both exist*

In any case, the **benefit/risk** ratio of **fluid** infusion

must be carefully **assessed**

*essentially in **ARDS**, where capillary permeability is altered*

شكرا

Thank you

Merci