Volemización en el Enfermo Crítico

Sebastián Abarca
E.U.UPC 04/2014

Temas

- Introducción
- Conceptos hemodinámicos
- Volemización en enfermos ventilados
  - Mediciones estáticas
  - Mediciones dinámicas
- Conclusión

¿Por que hablar este tema?

¿Por que hablar este tema?

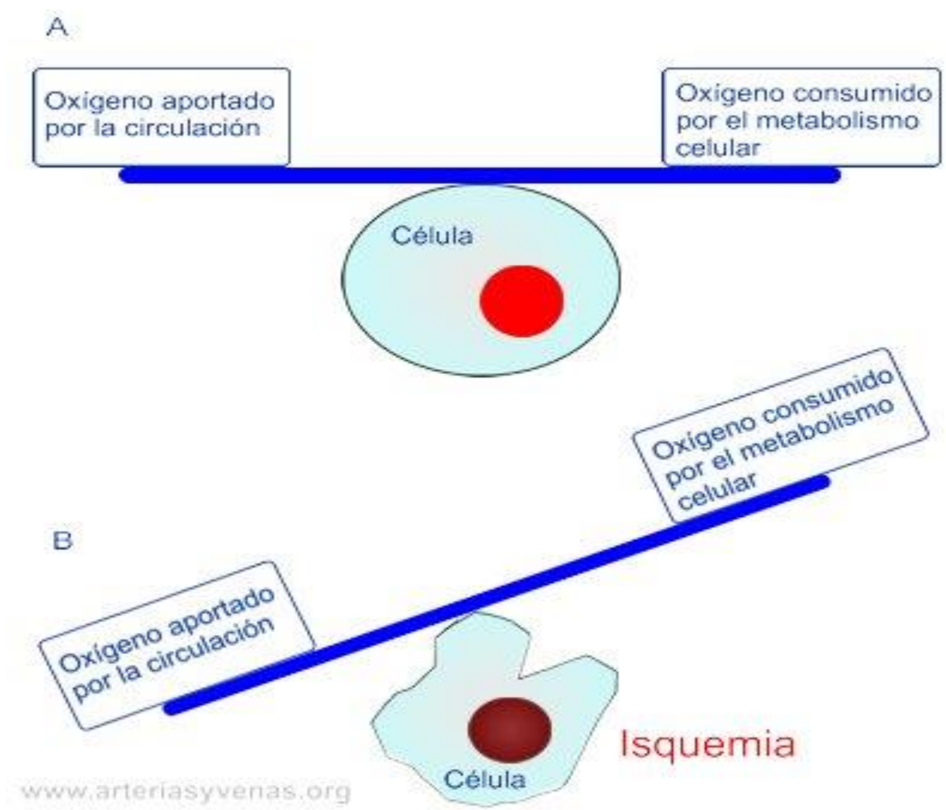
Volumen

↓

Precarga

↓

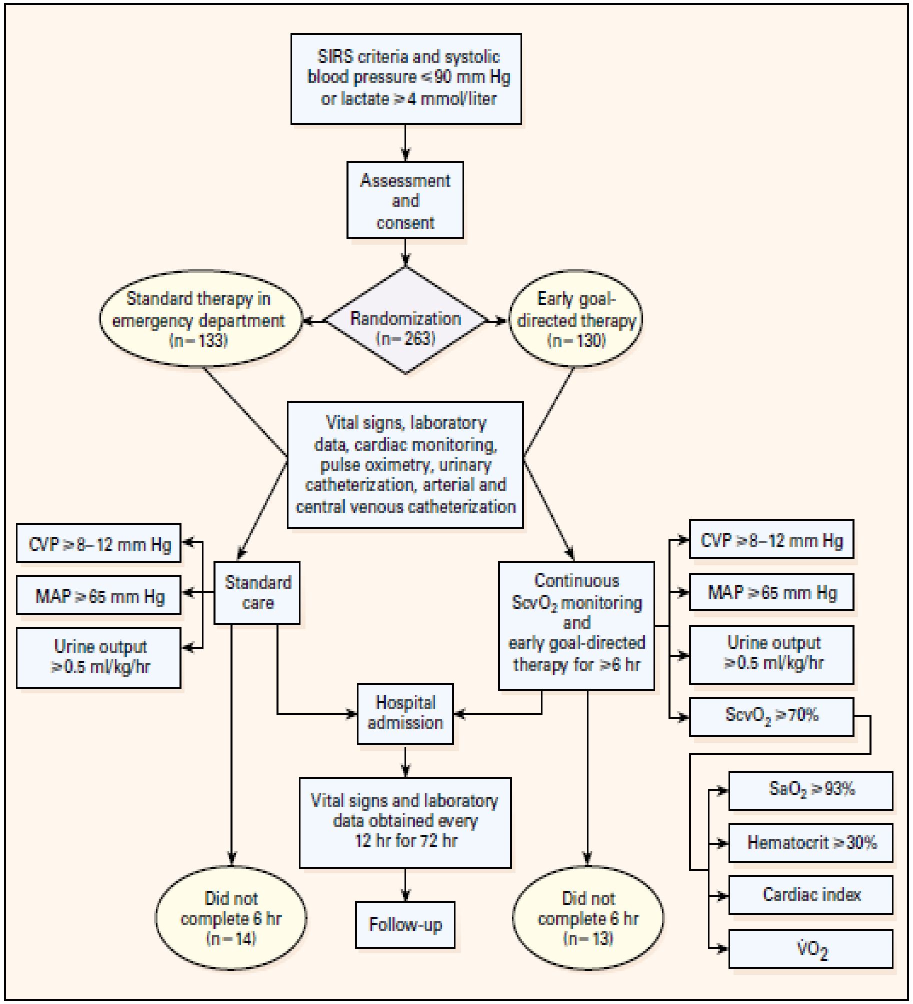
Gasto cardiaco



288 pacientes.
- 25 excluidos (263)
- 236 completaron las 6 hrs.

Tratados en el servicio de urgencia
Se instaló CVC y LA
Tratamiento por 6 hrs

N Engl J Med 2001; 341:1368-77


SIRS criteria and systolic blood pressure ≤90 mm Hg or lactate ≥4 mmol/liter
Assessment and consent
Randomization (n=263)
Standard therapy in emergency department (n=133)
Early goal-directed therapy (n=130)
Vital signs, laboratory data, cardiac monitoring, pulse oximetry, urinary catheterization, arterial and central venous catheterization
Standard care
CVP ≥8–12 mm Hg
MAP ≥65 mm Hg
Urine output ≥0.5 ml/kg/hr
Continuous $ScvO_2$ monitoring and early goal-directed therapy for ≥6 hr
CVP ≥8–12 mm Hg
MAP ≥65 mm Hg
Urine output ≥0.5 ml/kg/hr
$ScvO_2$ ≥70%
SaO_2 ≥93%
Hematocrit ≥30%
Cardiac index
$\dot{V}O_2$
Hospital admission
Vital signs and laboratory data obtained every 12 hr for 72 hr
Follow-up
Did not complete 6 hr (n=14)
Did not complete 6 hr (n=13)

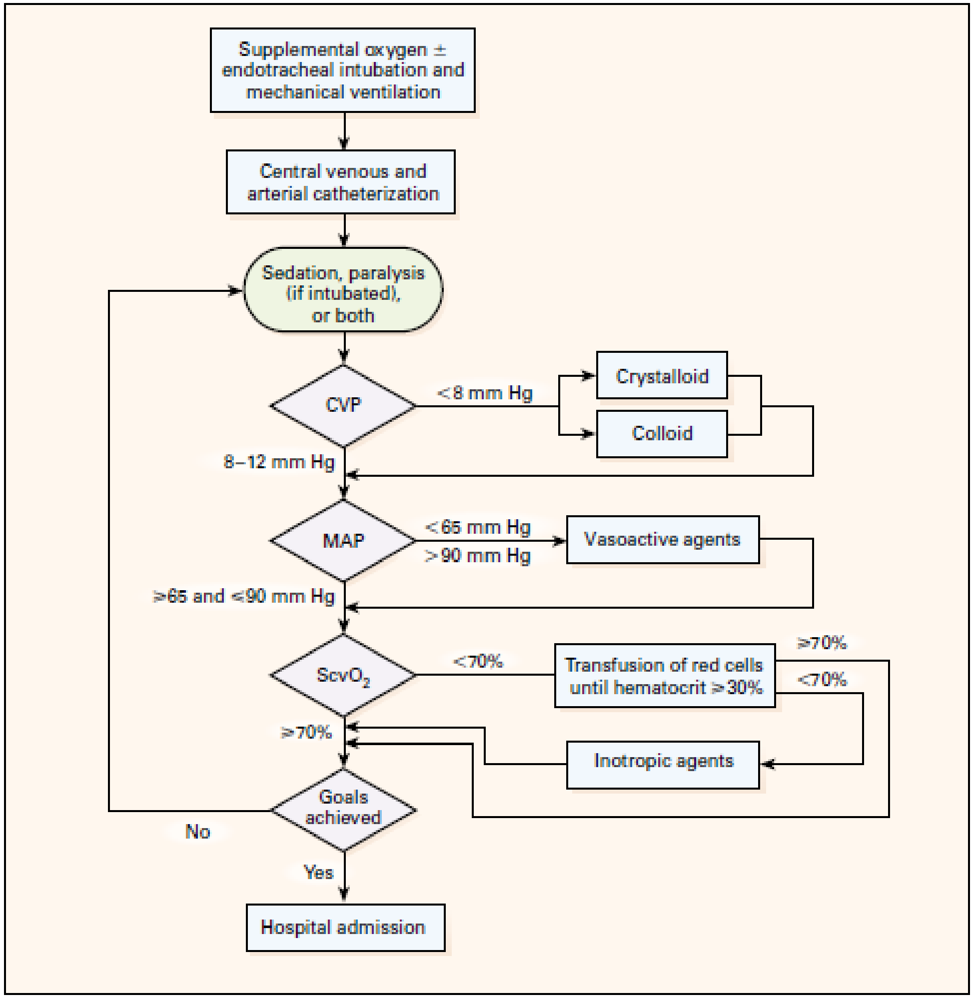

Supplemental oxygen ± endotracheal intubation and mechanical ventilation
Central venous and arterial catheterization
Sedation, paralysis (if intubated), or both
CVP
<8 mm Hg
Crystalloid
Colloid
8–12 mm Hg
MAP
<65 mm Hg
>90 mm Hg
Vasoactive agents
≥65 and ≤90 mm Hg
$ScvO_2$
<70%
Transfusion of red cells until hematocrit ≥30%
≥70%
<70%
≥70%
Inotropic agents
Goals achieved
No
Yes
Hospital admission

TABLE 4. TREATMENTS ADMINISTERED.*

TREATMENT	HOURS AFTER THE START OF THERAPY		
	0–6	7–72	0–72
Total fluids (ml)			
Standard therapy	3499±2438	10,602±6,216	13,358±7,729
EGDT	4981±2984	8,625±5,162	13,443±6,390
P value	<0.001	0.01	0.73
Red-cell transfusion (%)			
Standard therapy	18.5	32.8	44.5
EGDT	64.1	11.1	68.4
P value	<0.001	<0.001	<0.001
Any vasopressor (%)†			
Standard therapy	30.3	42.9	51.3
EGDT	27.4	29.1	36.8
P value	0.62	0.03	0.02
Inotropic agent (dobutamine) (%)			
Standard therapy	0.8	8.4	9.2
EGDT	13.7	14.5	15.4
P value	<0.001	0.14	0.15
Mechanical ventilation (%)			
Standard therapy	53.8	16.8	70.6
EGDT	53.0	2.6	55.6
P value	0.90	<0.001	0.02
Pulmonary-artery catheterization (%)‡			
Standard therapy	3.4	28.6	31.9
EGDT	0	18.0	18.0
P value	0.12	0.04	0.01

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Variable	Standard Therapy (N=133)	Early Goal-Directed Therapy (N=130)	Relative Risk (95% CI)	P Value
	no. (%)			
In-hospital mortality†				
All patients	59 (46.5)	38 (30.5)	0.58 (0.38–0.87)	0.009
Patients with severe sepsis	19 (30.0)	9 (14.9)	0.46 (0.21–1.03)	0.06
Patients with septic shock	40 (56.8)	29 (42.3)	0.60 (0.36–0.98)	0.04
Patients with sepsis syndrome	44 (45.4)	35 (35.1)	0.66 (0.42–1.04)	0.07
28-Day mortality†	61 (49.2)	40 (33.3)	0.58 (0.39–0.87)	0.01
60-Day mortality†	70 (56.9)	50 (44.3)	0.67 (0.46–0.96)	0.03
Causes of in-hospital death‡				
Sudden cardiovascular collapse	25/119 (21.0)	12/117 (10.3)	—	0.02
Multiorgan failure	26/119 (21.8)	19/117 (16.2)	—	0.27

*CI denotes confidence interval. Dashes indicate that the relative risk is not applicable.

†Percentages were calculated by the Kaplan–Meier product-limit method.

‡The denominators indicate the numbers of patients in each group who completed the initial six-hour study period.

clinical investigations in critical care

High Tidal Volume and Positive Fluid Balance Are Associated With Worse Outcome in Acute Lung Injury*

Yasser Sakr, MB BCh, MSc; Jean-Louis Vincent, MD, PhD, FCCP; Konrad Reinhart, MD, PhD; Johan Groeneveld, MD, PhD, FCCP; Argyris Michalopoulos, MD; Charles L. Sprung, MD; Antonio Artigas, MD; and V. Marco Ranieri, MD; on behalf of the Sepsis Occurrence in Acutely Ill Patients Investigators†

Table 3—*Fluid Balance in Liters**

Variables	ALI/ARDS (n = 393)	No ALI/ARDS (n = 2,754)	p Value†
Admission day balance	1.2 ± 2.6	0.6 ± 1.9	< 0.001
Cumulative 48-h balance	2.2 ± 4.3	0.8 ± 3.0	< 0.001
Cumulative 72-h balance	2.5 ± 5.8	0.8 ± 3.8	< 0.001
Cumulative 96-h balance	2.4 ± 7.1	0.7 ± 4.4	< 0.001
Mean daily fluid balance‡	0.2 ± 1.6	0.1 ± 1.2	0.805
Total fluid balance§	0.2 ± 20.5	0.2 ± 9.7	0.077

Chest. 2005 Nov;128(5):3098-108.

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The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

The N... Respiratory Distress ...ork*

Table 3. Main Outcome Variables.*

Outcome	Conservative Strategy	Liberal Strategy	P Value
Death at 60 days (%)	25.5	28.4	0.30
Ventilator-free days from day 1 to day 28†	14.6±0.5	12.1±0.5	<0.001
ICU-free days†			
Days 1 to 7	0.9±0.1	0.6±0.1	<0.001
Days 1 to 28	13.4±0.4	11.2±0.4	<0.001
Organ-failure–free days†‡			
Days 1 to 7			
Cardiovascular failure	3.9±0.1	4.2±0.1	0.04
CNS failure	3.4±0.2	2.9±0.2	0.02
Renal failure	5.5±0.1	5.6±0.1	0.45
Hepatic failure	5.7±0.1	5.5±0.1	0.12
Coagulation abnormalities	5.6±0.1	5.37±0.1	0.23
Days 1 to 28			
Cardiovascular failure	19.0±0.5	19.1±0.4	0.85
CNS failure	18.8±0.5	17.2±0.5	0.03
Renal failure	21.5±0.5	21.2±0.5	0.59
Hepatic failure	22.0±0.4	21.2±0.5	0.18
Coagulation abnormalities	22.0±0.4	21.5±0.4	0.37
Dialysis to day 60			
Patients (%)	10	14	0.06
Days	11.0±1.7	10.9±1.4	0.96

N Engl J Med 2006; 354(24):2564-75

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The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

CRITICAL CARE MEDICINE

Simon R. Finfer, M.D., and Jean-Louis Vincent, M.D., Ph.D., *Editors*

Resuscitation Fluids

John A. Myburgh, M.B., B.Ch., Ph.D., and Michael G. Mythen, M.D., M.B., B.S.

Table 2. Recommendations for Fluid Resuscitation in Acutely Ill Patients.

Fluids should be administered with the same caution that is used with any intravenous drug.

Consider the type, dose, indications, contraindications, potential for toxicity, and cost.

Fluid resuscitation is a component of a complex physiological process.

Identify the fluid that is most likely to be lost and replace the fluid lost in equivalent volumes.

Consider serum sodium, osmolarity, and acid–base status when selecting a resuscitation fluid.

Consider cumulative fluid balance and actual body weight when selecting the dose of resuscitation fluid.

Consider the early use of catecholamines as concomitant treatment of shock.

Fluid requirements change over time in critically ill patients.

The cumulative dose of resuscitation and maintenance fluids is associated with interstitial edema.

Pathological edema is associated with an adverse outcome.

Oliguria is a normal response to hypovolemia and should not be used solely as a trigger or end point for fluid resuscitation, particularly in the post-resuscitation period.

The use of a fluid challenge in the post-resuscitation period (≥24 hours) is questionable.

The use of hypotonic maintenance fluids is questionable once dehydration has been corrected.

Specific considerations apply to different categories of patients.

Bleeding patients require control of hemorrhage and transfusion with red cells and blood components as indicated.

Isotonic, balanced salt solutions are a pragmatic initial resuscitation fluid for the majority of acutely ill patients.

Consider saline in patients with hypovolemia and alkalosis.

Consider albumin during the early resuscitation of patients with severe sepsis.

Saline or isotonic crystalloids are indicated in patients with traumatic brain injury.

Albumin is not indicated in patients with traumatic brain injury.

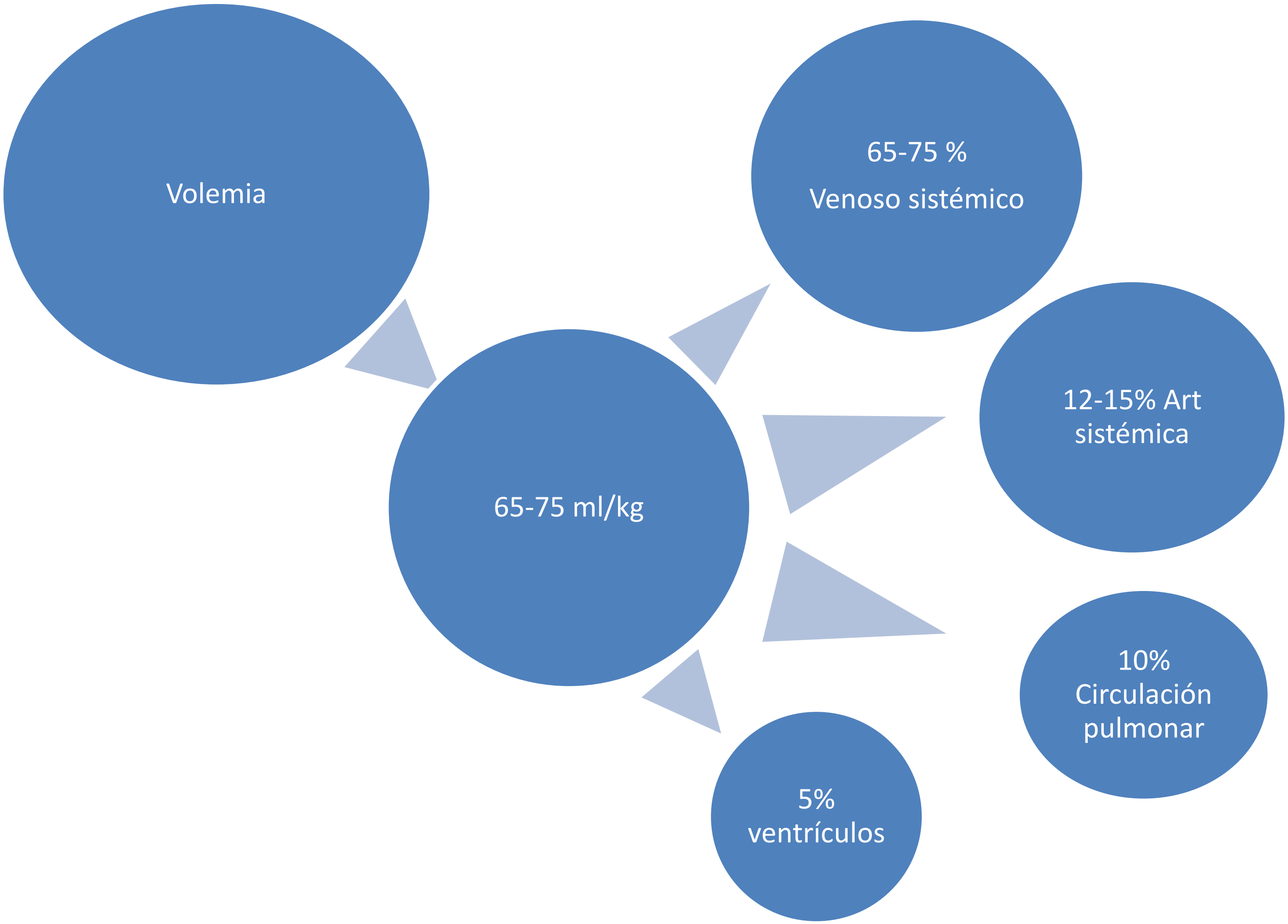
Hydroxyethyl starch is not indicated in patients with sepsis or those at risk for acute kidney injury.

The safety of other semisynthetic colloids has not been established, so the use of these solutions is not recommended.

The safety of hypertonic saline has not been established.

The appropriate type and dose of resuscitation fluid in patients with burns has not been determined.

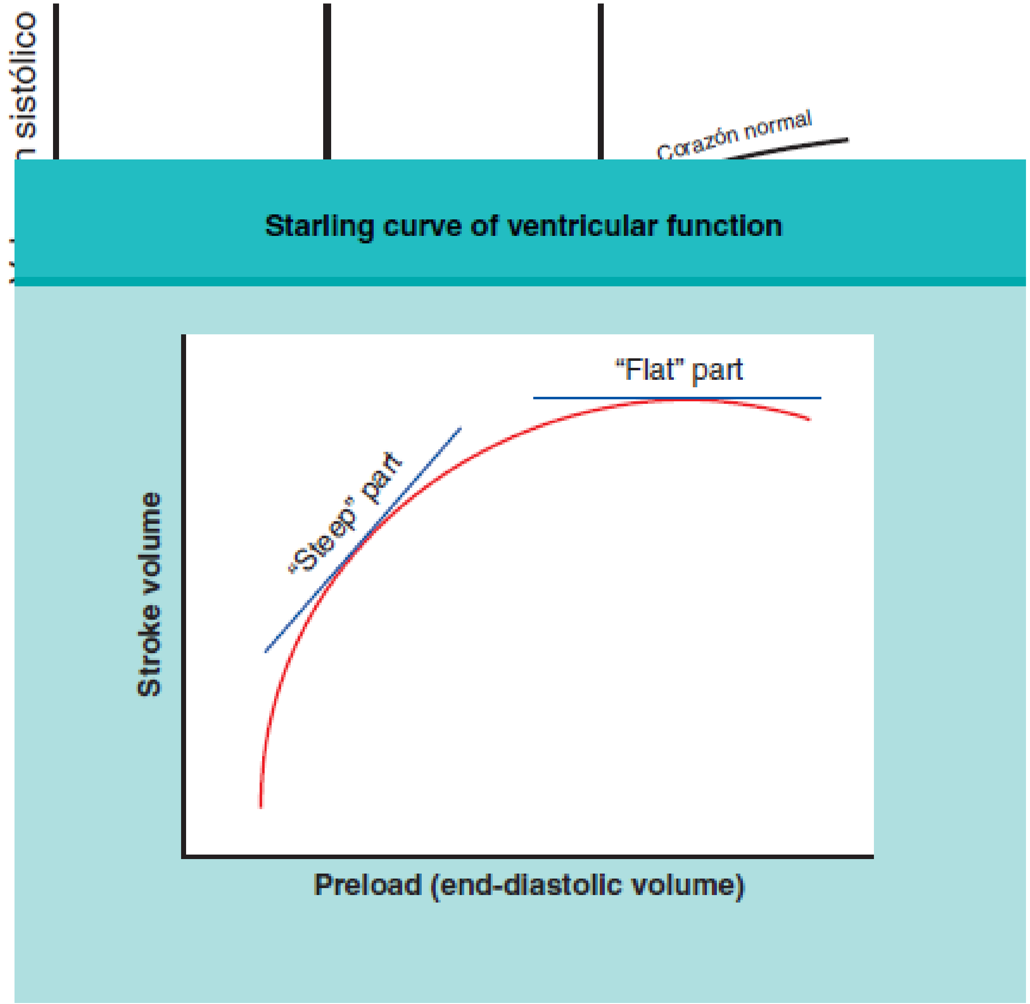
Recuerdo fisiológico

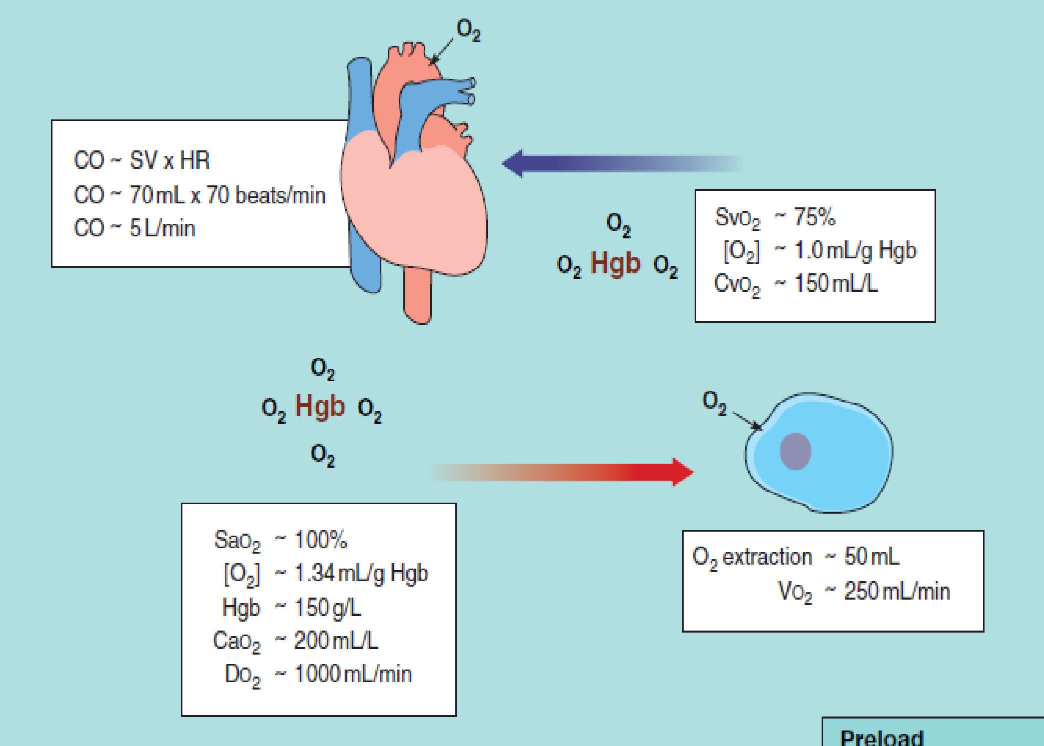


Recuerdo fisiológico

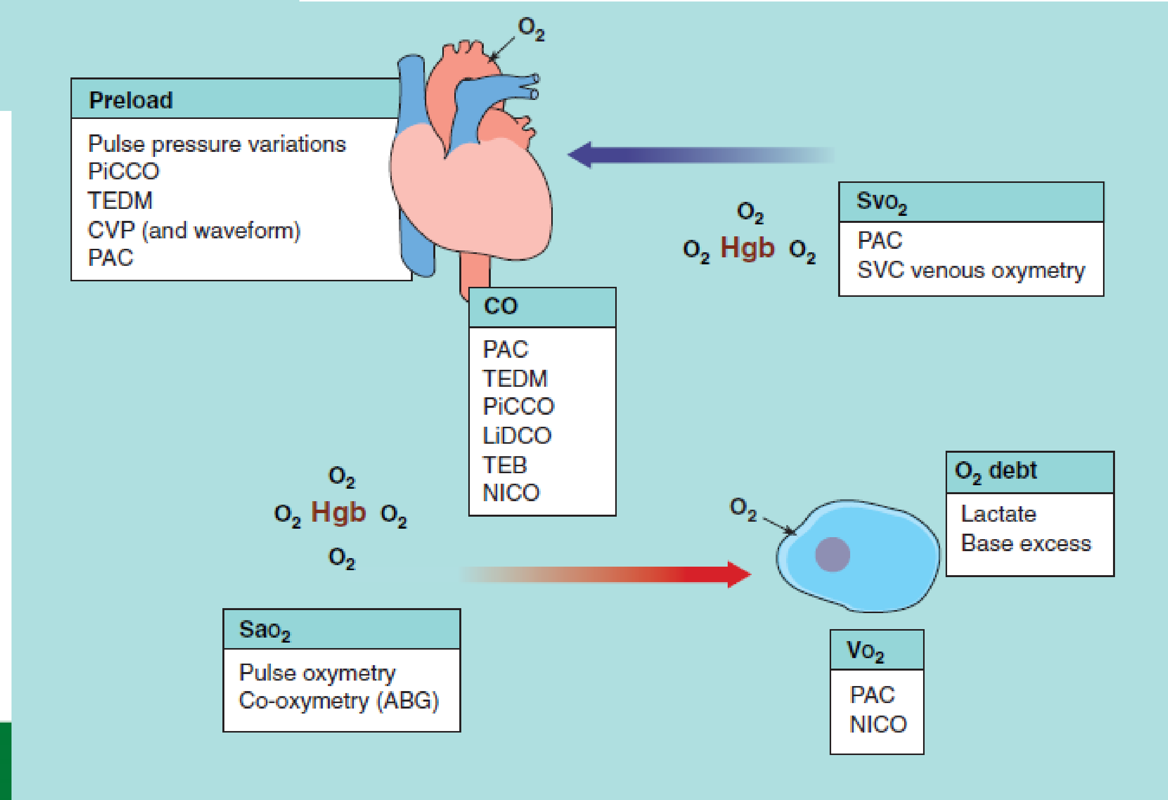
Precarga

- Volumen que distiende al ventrículo izquierdo antes de la contracción
- Determinada por el volumen de sangre al final del periodo de llenado ventricular


n sistólico
Corazón normal
Starling curve of ventricular function
"Flat" part
"Steep" part
Stroke volume
Preload (end-diastolic volume)

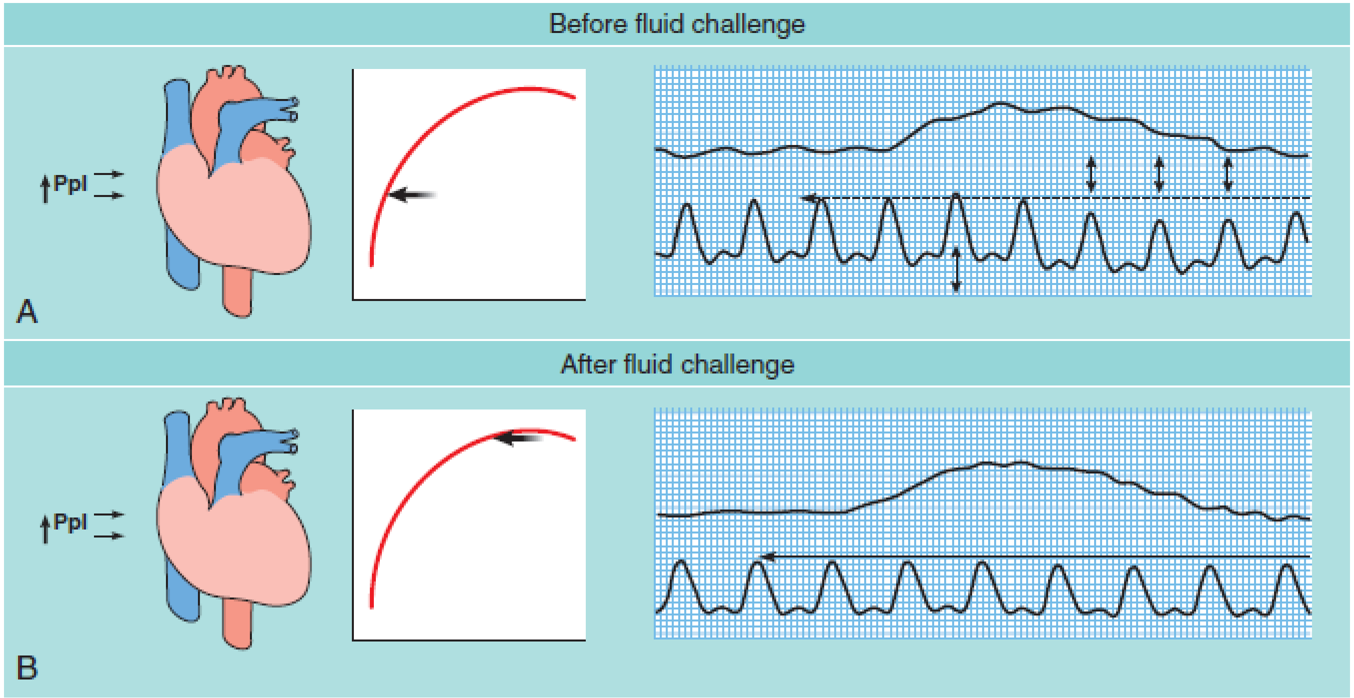


Que monitorear!

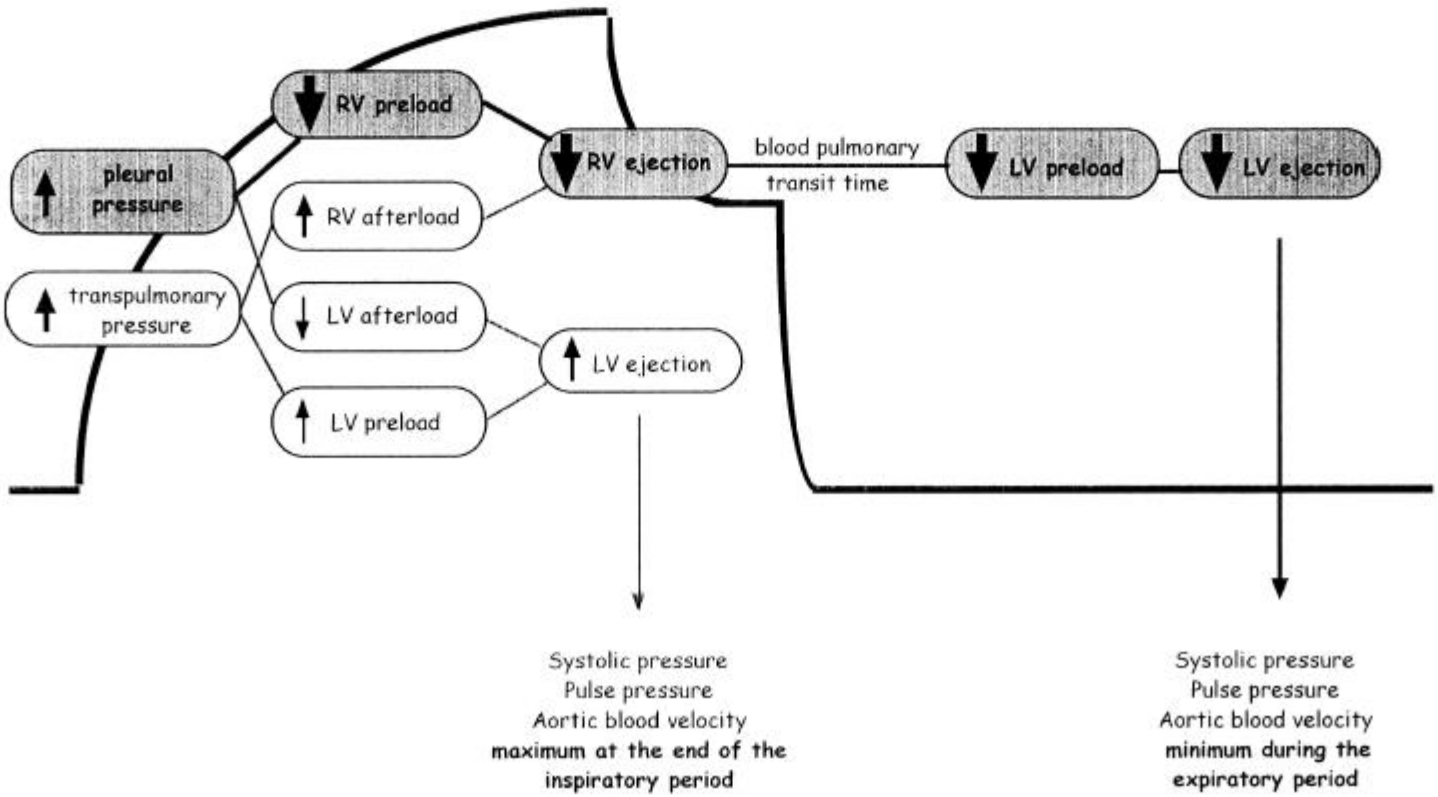


Con que monitorear!

Interacción cardiopulmonar en VMI



Interacción cardiopulmonar



Crit Care 2000; 4:282-289

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¿Quiénes responden a volumen?

Predicting Fluid Responsiveness in ICU Patients*

A Critical Analysis of the Evidence

Frédéric Michard, MD, PhD; and Jean-Louis Teboul, MD, PhD

Table 1—*Main Characteristics of Clinical Studies Investigating the Predictive Factors of Fluid Responsiveness in ICU Patients**

Source	Patients, No.	FC, No.	Fluid Infused	Volume Infused, mL	Speed of FC, min	Definition of Response	Rate of Response, %	Parameters Tested
Calvin et al[2]	28	28	5% Alb	250	20–30	ΔSV > 0%	71	RAP, PAOP, RVEDV
Schneider et al[3]	18	18	FFP	500	30	ΔSV > 0%	72	RAP, PAOP, RVEDV
Reuse et al[4]	41	41	4.5% Alb	300	30	ΔCO > 0%	63	RAP, PAOP, RVEDV
Magder et al[5]	33	33	9% NaCl	100–950		ΔCO > 250 mL/min	52	ΔRAP
Diebel et al[6]	15	22	R. lactate Colloids	300–500 500		ΔCO > 10%	59	PAOP, RVEDV
Diebel et al[7]	32	65	R. lactate	300–500		ΔCO > 20%	40	PAOP, RVEDV
Wagner and Leatherman[8]	25	36	9% NaCl 5% Alb, FFP	938 ± 480 574 ± 187	7–120	ΔSV > 10%	56	RAP, PAOP, RVEDV
Tavernier et al[9]	15	35	HES	500	30	ΔSV > 15%	60	PAOP, LVEDA, Δdown
Magder and Lagonidis[10]	29	29	25% Alb 9% NaCl	100 150–400	15	ΔCO > 250 mL/min	45	ΔRAP
Tousignant et al[11]	40	40	HES	500	15	ΔSV > 20%	40	PAOP, LVEDA
Michard et al[12]	40	40	HES	500	30	ΔCO > 15%	40	RAP, PAOP, ΔPP
Feissel et al[13]	19	19	HES	8 mL/kg	30	ΔCO > 15%	53	LVEDA, ΔVpeak
Total	334	406					52	

*FC = fluid challenge; Alb = serum albumin; FFP = fresh frozen plasma; NaCl = serum saline solution; R. lactate = Ringer's lactate; HES = hydroxyethylstarch; ΔSV = volume expansion-induced changes in stroke volume; ΔCO = volume expansion-induced changes in cardiac output.

Chest 2002 -06-01

¿PVC predice respuesta al volumen?

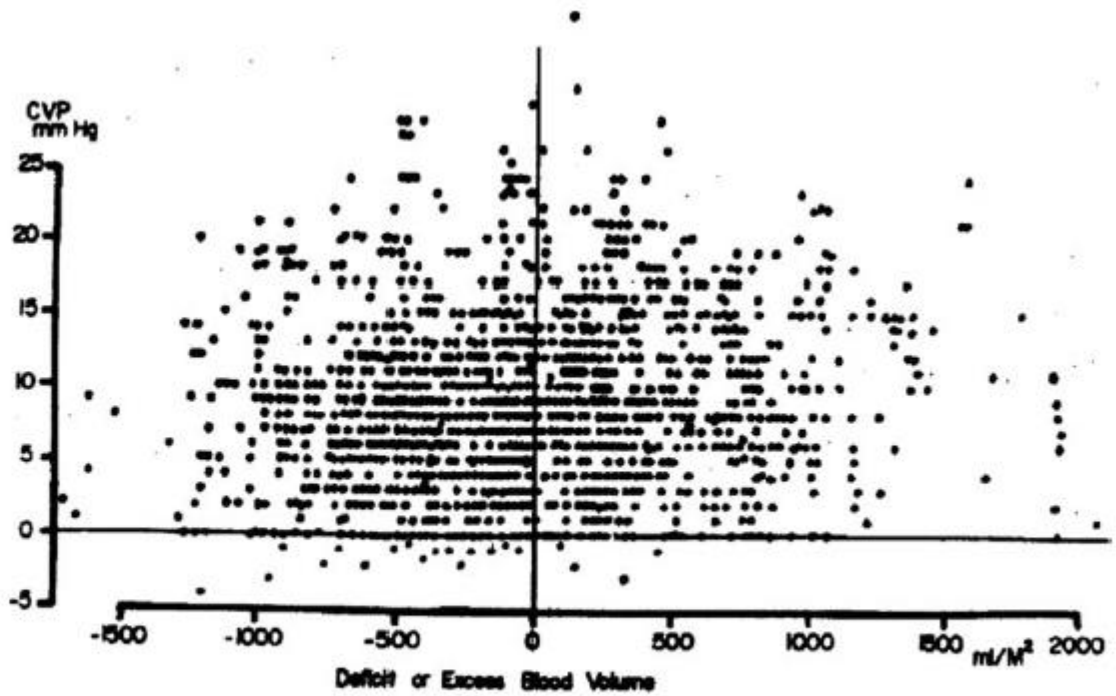


FIGURE 1. Fifteen hundred simultaneous measurements of blood volume and CVP in a heterogenous cohort of 188 ICU patients demonstrating no association between these two variables ($r = 0.27$). The correlation between ΔCVP and change in blood volume was 0.1 ($r^2 = 0.01$). This study demonstrates that patients with a low CVP may have volume overload and likewise patients with a high CVP may be volume depleted. Reproduced with permission from Shippy et al.[11]

Crit Care Med 1984:12:107-112

Constantes dinámicas como respuesta al volumen

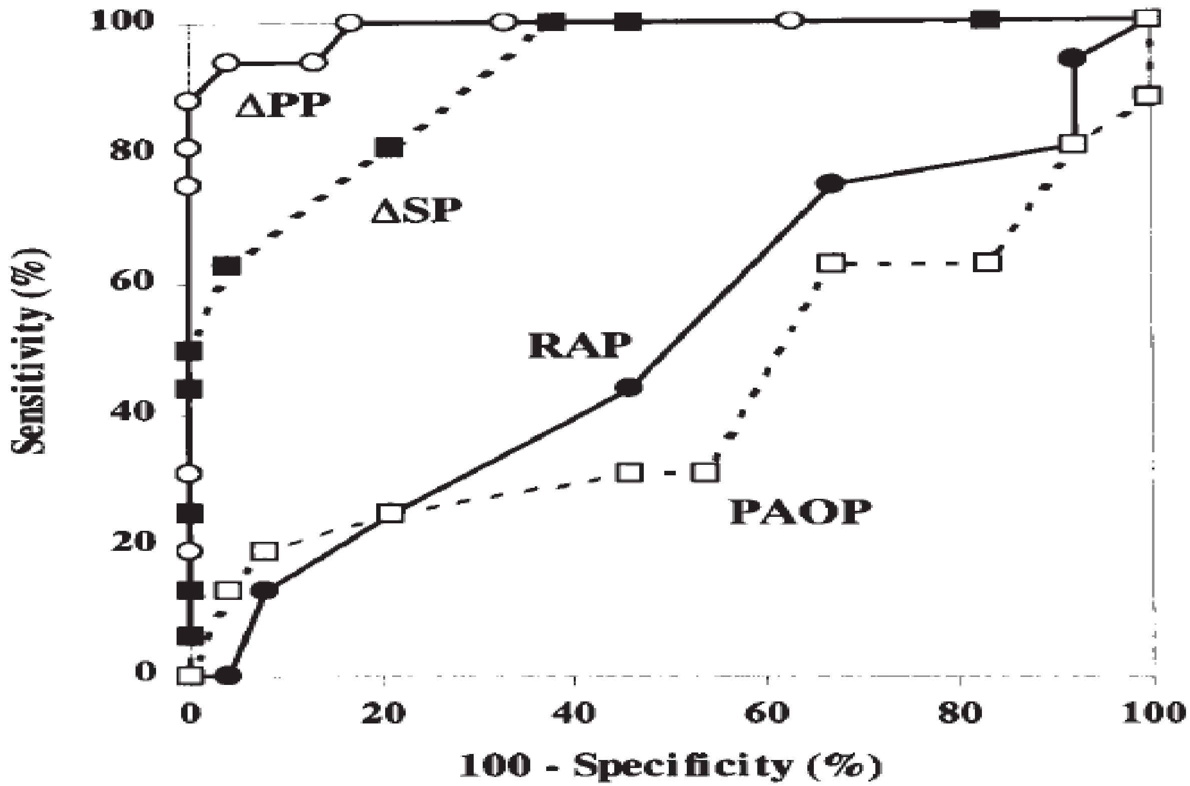


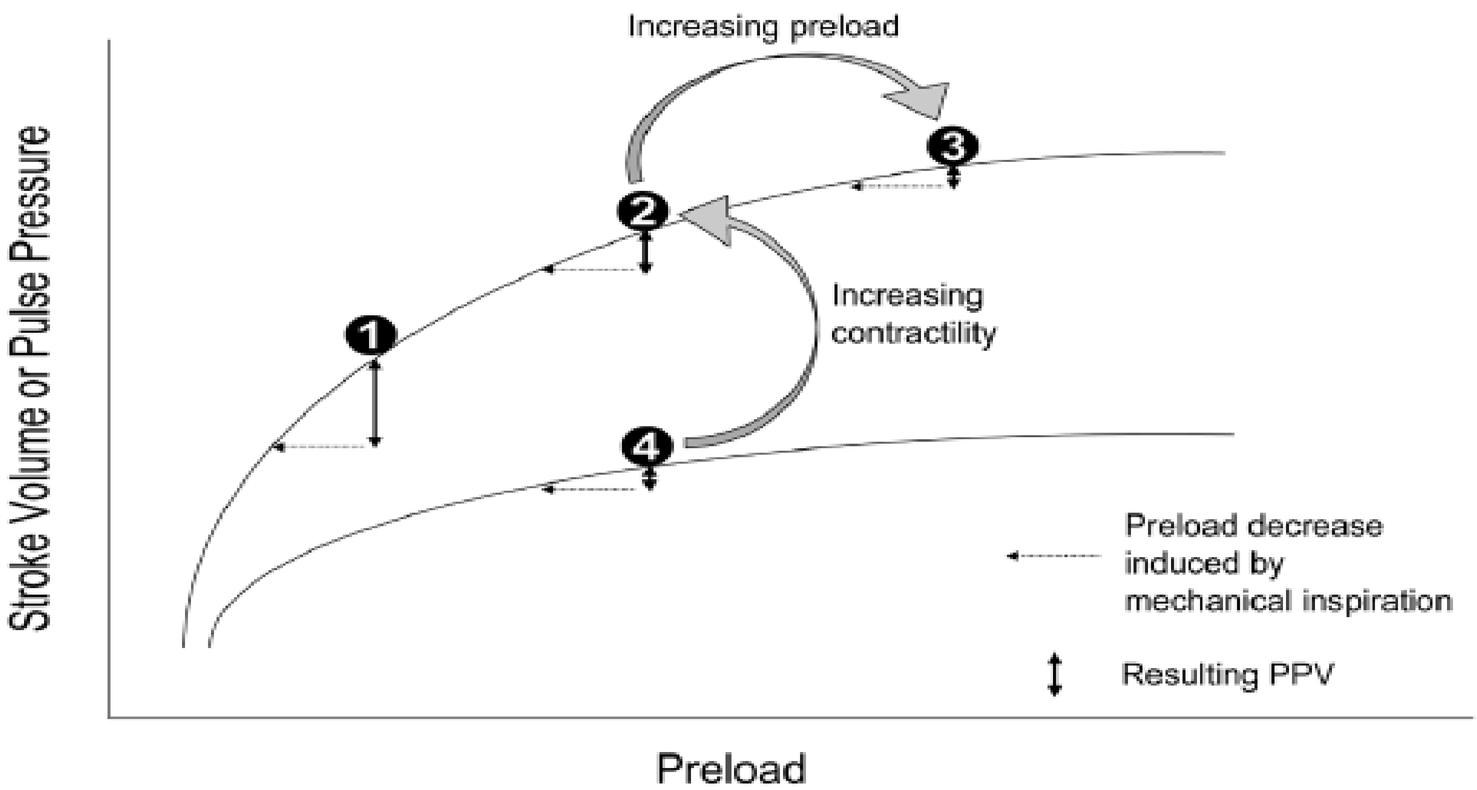
Figure 2. ROC curves comparing the ability of ΔPp, ΔPs, Pra, and Ppao to discriminate responder (CI increase ≥ 15%) and nonresponder patients to VE. The area under the ROC curve for ΔPp was greater than for ΔPs, Pra, and Ppao ($p < 0.01$).

Am J Respir Crit Care Med Vol 162.pp 134-138, 2000

Commentary

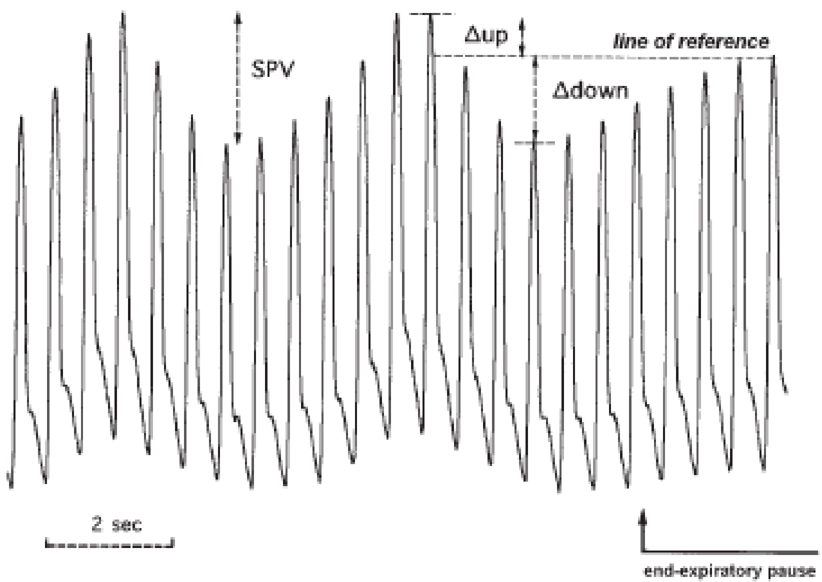
Pulse pressure variation: beyond the fluid management of patients with shock

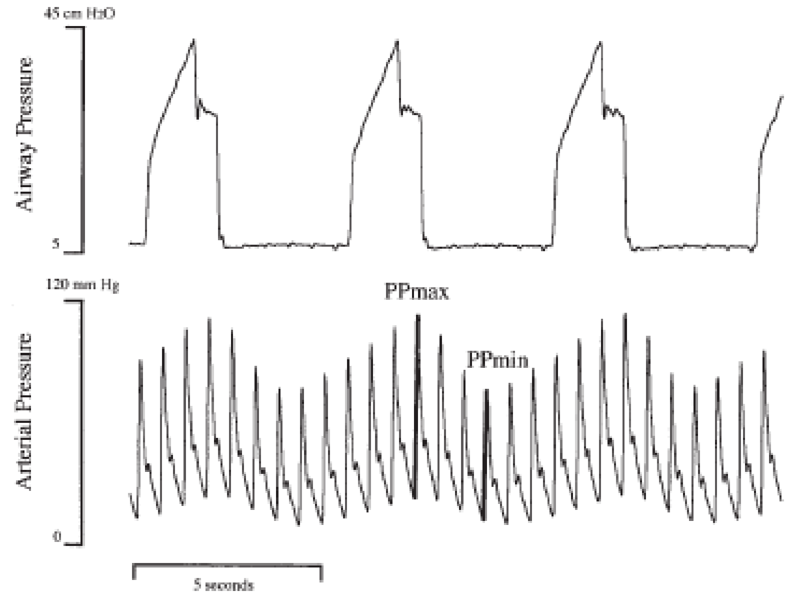
Frédéric Michard[1], Marcel R Lopes[2] and Jose-Otavio C Auler Jr[3]



Crit Care 2007,11:131

Variación de presión de pulso (VPP) y Variación del Volumen sistólico (VVS)





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

Crit Care 2000; 4:282-289

VVS y VPP

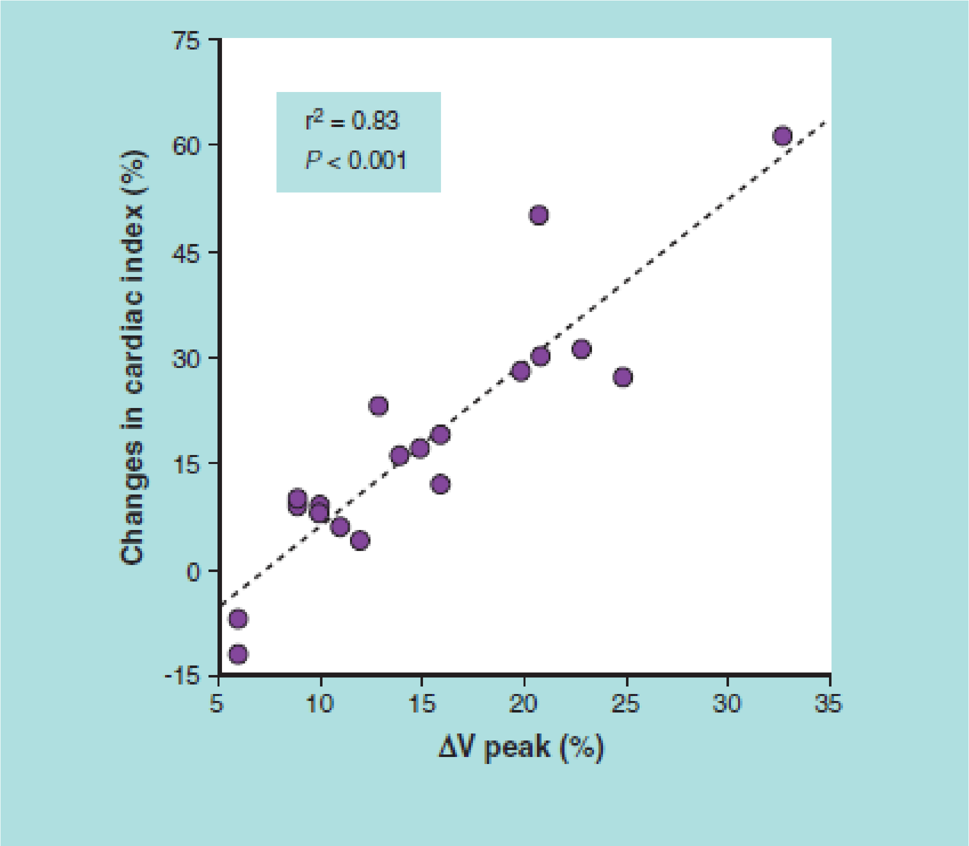
- Para un VT > 7ml/kg una VVS >o= 10% predice aumentos del 15% o mas del volumen sistólico después de un bolo de 500ml
- Para el mismo caso, con una VPP >o= 13%

Consideraciones VPP y VVS

- Ventilación controlada
- VT 7ml/kg o más
- Ritmo sinusal
- Tórax cerrado

Velocidad del flujo aórtico como respuesta al volumen

- ETT o ETE
- Operador dependiente
- Medido en el anillo aórtico
- Diferencia entre flujo máximo y mínimo dividido por el promedio y expresado en porcentaje
- Respondedores >12% de aumento del flujo
- Requiere: RSR, VMI sin esfuerzo inspiratorio y ausencia de HTP



Chest 2009; 119:3: 867-873

Marik et al. Annals of Intensive Care 2011, 1:1
http://www.annalsofintensivecare.com/content/1/1/1

Annals of Intensive Care
a SpringerOpen Journal

REVIEW Open Access

Hemodynamic parameters to guide fluid therapy

Paul E Marik[1*], Xavier Monnet[2], Jean-Louis Teboul[2]

- 300ml aprox
- Aumento 10% GC predice respondedor a volumen
- Guiarse por ecocardiografia, doppler transesofágico, doppler arteria femoral o termodilución.
- Uso en ventilación mecánica con respiración espontánea y arritmias

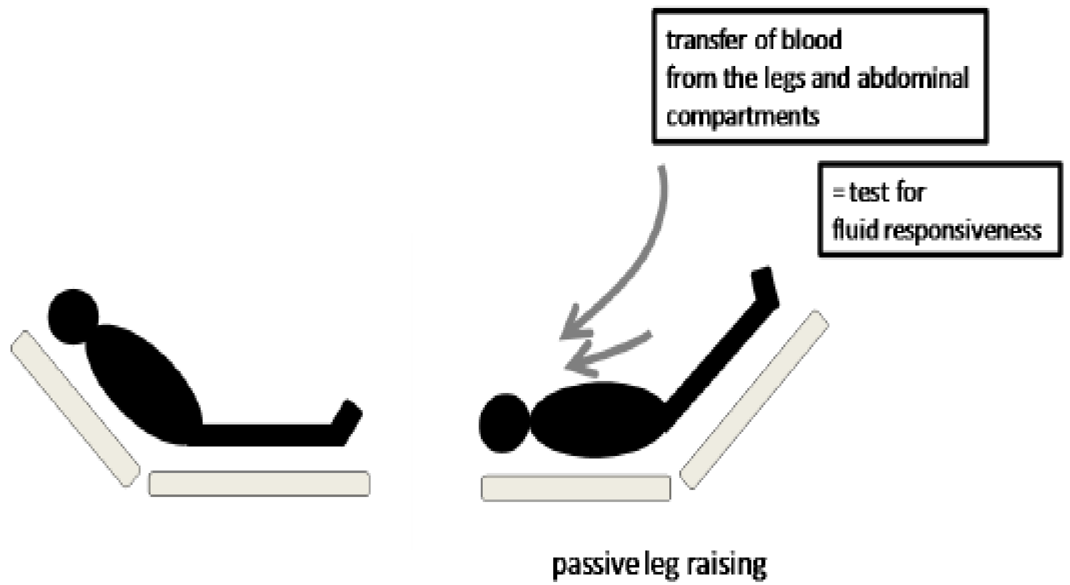
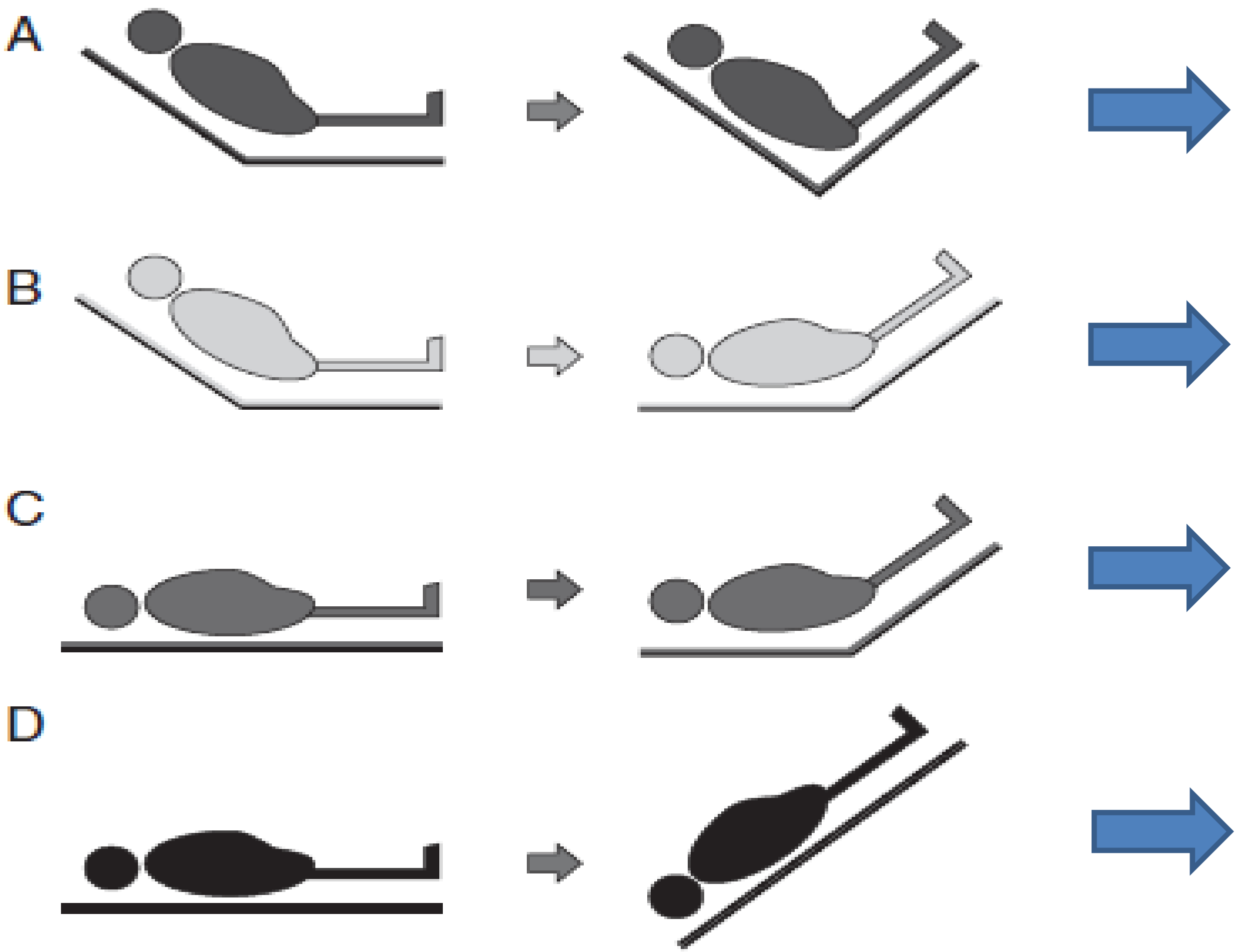


Figure 4 Passive leg raising. The passive leg raising test consists in measuring the hemodynamic effects of a leg elevation up to 45°. A simple way to perform the postural maneuver is to transfer the patient from the semirecumbent posture to the passive leg raising position by using the automatic motion of the bed.



Neurocríticos

Recomendada

Opcional
Mayores complicaciones

Opcional
Mayores complicaciones

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Otros…

- **Variación del diámetro de la vena cava (ETE – ETT)**
  - Índice de colapsabilidad VCI > 18% respondedores
    - *Intensive Care Med. 2004; 30: 1740-6*
  - Índice de colapsabilidad VCS >36% respondedores
    - *Intensive Care Med. 2004; 30: 1734-9*
- **Variables derivadas de la onda pletismográfica:**
  - >20 identifica respondedores a volumen VMI, RSR
    - *Intensive Care Med. 2007; 33:993-9*
- **Test oclusión al final de la espiración:**
  - Bolo de 500ml seguido de 15 seg oclusión. Respondedor si >15% GC
    - *Crit Care Med. 2009; 37: 951-6*
- **Volumen telediastólico global (termodilución):**
  - < 600ml/m2 predice >80% respuesta a volumen
  - 600 – 850ml/m2 predice un 50%
  - > 850 ml/m2 predice un 20%
- **Velocidad flujo sanguíneo en arteria braquial**
  - > 16% predice respondedores
    - *Chest. 2007; 24: 324-337*
- **Volumen ventricular derecho al final de la diástole (Catéter arteria pulmonar)**
  - <90 ml/m2 respondedor a volumen
  - >140 ml/m2 no respondedor a volumen
    - *Reanimation. 2004; 13: 255-66*
- **Etc…**

Table 4: Advantages and disadvantages of the various dynamic parameters used to predict preload responsiveness.

Method	Advantages	Disadvantages
Respiratory changes in CVP	Most critically ill septic patients have an IJ or SC CVL	It requires that the inspiratory effort be significant—a fall in PAWP of ≥2 mmHg was used in the original study by Magder et al. [11]
	It can be used in spontaneously breathing patients	
Respiratory changes in IVC diameter	It is non-invasive and requires an ultrasound with M-mode which is now becoming widely available	It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
	It is easy to learn and teach	It may not be reliable in conditions associated with IAH, for example, obesity, massive ascites, abdominal compartment syndrome
	It can be easily repeated as often as necessary	
Respiratory changes in SVC diameter	It is more accurate than respiratory change in IVC diameter	It is semi-invasive and requires TEE and expertise in using it
		It is not continuous
		It too is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
PPV	PPV can be calculated manually from a 30 sec printout of the arterial blood pressure waveform	It is invasive and requires an arterial line
		It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
SVV-FloTrac Vigileo	It does not require frequent recalibration	It is invasive and requires an arterial line
	It provides additional data: SV, CO	It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR

Crit Care Res Pract. 2012;2012:761051

SVV-PiCCO Plus	It provides additional data: SV, CO, TBV, and EVLW	It is invasive and requires an IJ or SC CVL and a femoral arterial line with a thermistor It requires frequent recalibration It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
PVI	It is noninvasive	It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
	It is easy to use	It is not reliable if peripheral perfusion is severely compromised
	It does not require calibration	
Respiratory changes in aortic blood flow velocity	Esophageal Doppler US monitoring uses a smaller esophageal probe than TEE and therefore is less invasive; it can also be left in place for continuous monitoring; it also requires less training to use and is less expensive	Semi-invasive and requires TEE or esophageal Doppler US and expertise in using it It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR It suffers from additional limitations: Long learning curve with a lack of reproducibility

Crit Care Res Pract. 2012;2012:761051

Method	Advantages	Disadvantages
		Inability to obtain continuous reliable measurements Requirement for 24-hour availability Practical problems related to the presence of the probe in the patient's esophagus As esophageal Doppler probes are inserted blindly, the resulting waveform is highly dependent on correct positioning
Respiratory changes in brachial artery blood flow velocity	It is non-invasive and requires only a US with Doppler which is now becoming widely available in ICUs It is easy to learn and teach as demonstrated by a study where residents used it after learning the technique	It is only reliable in mechanically ventilated patients who are receiving ≥8 mL/kg PBW tidal volume, are not making any significant respiratory efforts, and are in NSR
PLR maneuver	It can be used in spontaneously breathing patients It can be used in patients with arrhythmias It can be completely noninvasive if CO is measured by a noninvasive method, for example, USCOM or NICOM	It requires continuous CO monitoring by a technology with a rapid response time, for example, USCOM, NICOM, FloTrac Vigileo, PiCCO, or PAC with such capability

CVP: central venous pressure, IJ: internal jugular, SC: subclavian, CVL: central venous line, PAWP: pulmonary artery wedge pressure, IVC: inferior vena cava, PBW: predicted body weight, NSR: normal sinus rhythm, IAH: intra-abdominal hypertension, SVC: superior vena cava, TEE: transesophageal echocardiography, PPV: pulse pressure variation, SVV: stroke volume variation, SV: stroke volume, CO: cardiac output, TBV: thoracic blood volume, EVLW: extravascular lung water, US: ultrasound, USCOM: ultrasonic cardiac output monitor, NICOM: noninvasive cardiac output monitor.

Crit Care Res Pract. 2012;2012:761051

Resumen

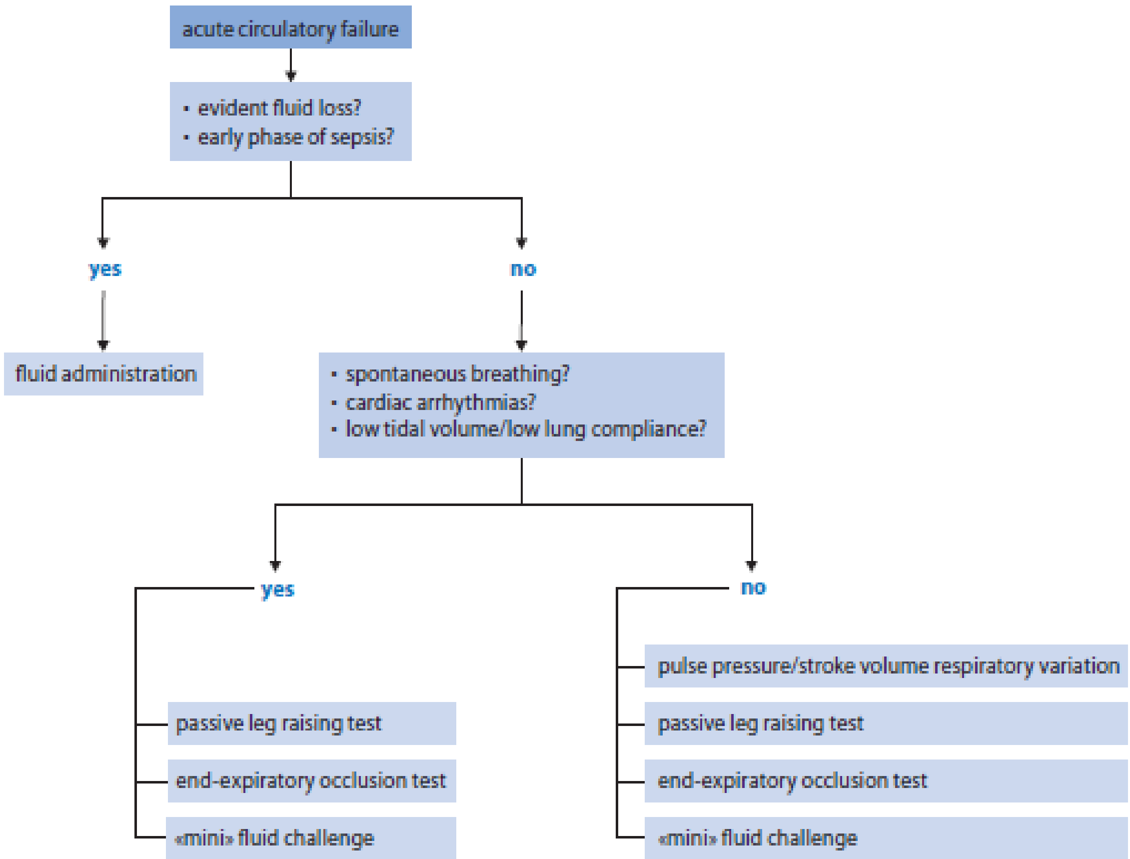

Figure 2. Decision-making process of fluid administration.

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Resumen

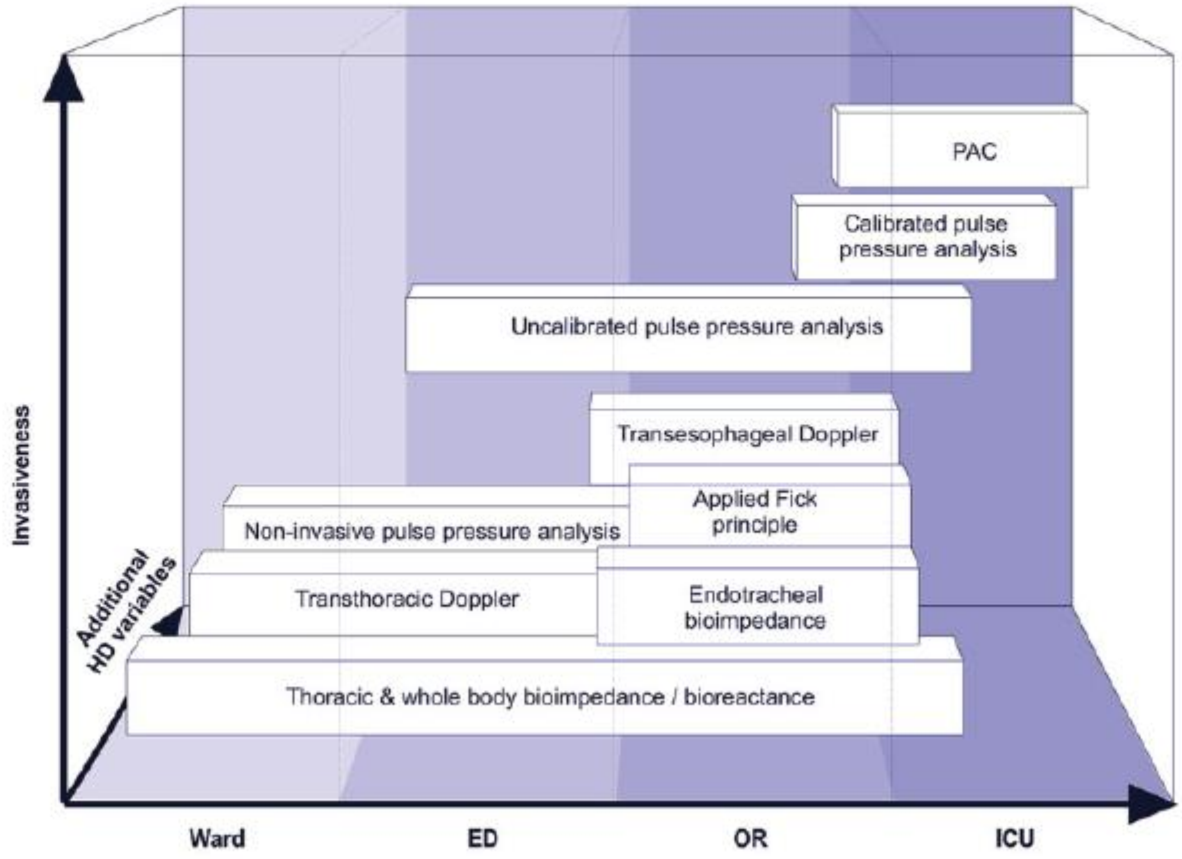

Figure 3. Integrative hemodynamic monitoring approach. ED, emergency department; HD, hemodynamic; OR, operating room; PAC, pulmonary artery catheter. Reproduced with permission from Alhashemi and colleagues [3].

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Conclusiones

- Reanimación precoz!
- Utilizar clínica y parámetros dinámicos!
- Monitoreo indicado para el enfermo indicado!
- Guiarse por metas!

GRACIAS

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