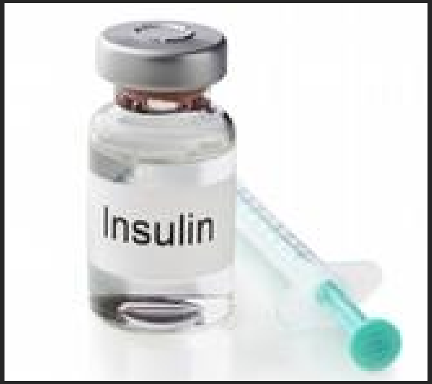
Fluid responsiveness

Beneš Jan

Klinika anesteziologie, resuscitace a intenzivní medicíny,
Fakultní nemocnice a Lékařská Fakulta v Plzni Univerzity Karlovy v Praze

Jak se rozhodujete „podat tekutinu“ Vašemu pacientovi?



? mmol/l GLY

? mmHg

Jak se rozhodujete „podat tekutinu“ Vašemu pacientovi?

1. Příliš to neřeším
    - Za předpokladu, že NĚCO kape
    - A že toho není PŘÍLIŠ

ANESTEZIA / URGENTNÍ PÉČE
… FIELD OF HEADLES REFLEXES

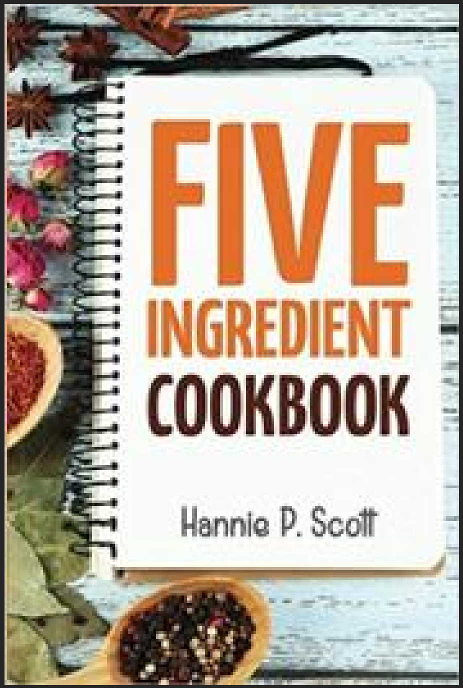


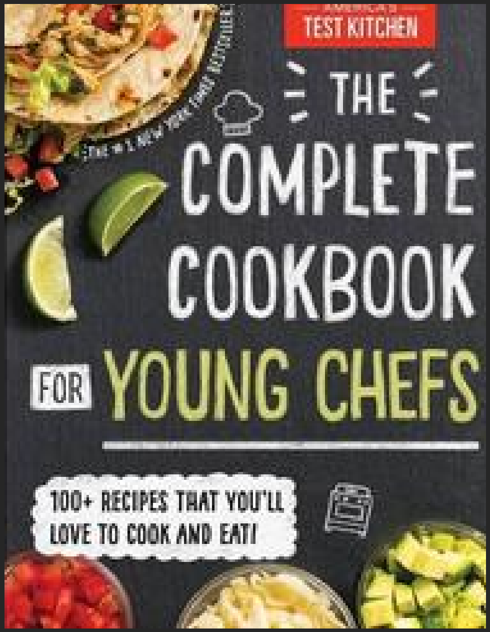

Jak se rozhodujete „podat tekutinu“ Vašemu pacientovi?

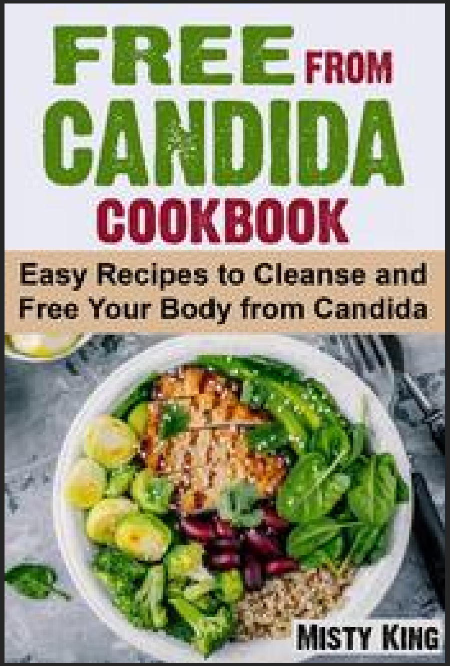
1. Příliš to neřeším
   - Za předpokladu, že NĚCO kape
   - A že toho není PŘÍLIŠ

2. Larsen říká 8-10 [ml/kg/hr]

ANESTEZIA / URGENTNÍ PÉČE
… ANO ŠÉFE !!!





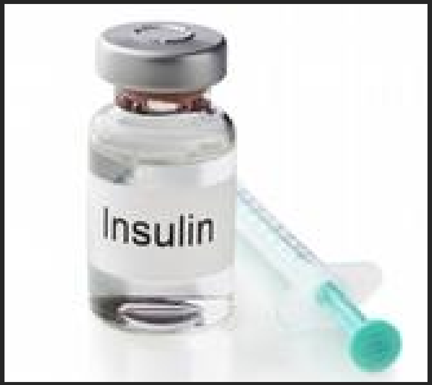


Jak se rozhodujete „podat tekutinu“ Vašemu pacientovi?

1. Příliš to neřeším
   - Za předpokladu, že NĚCO kape
   - A že toho není PŘÍLIŠ

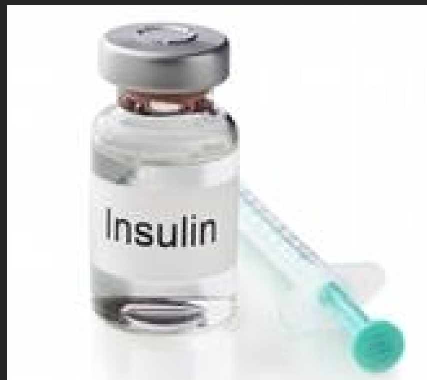
2. Larsen říká 8-10 [ml/kg/hr]

3. Něco měřím
   - MAP
   - DIURÉZA
   - CVP



? mmol/l
GLYcidemie

? mmHg
ICP


Insulin


25mg
Only
Captopril-Tablet
Each tablet contians:Captopril 25mg
ACE inhibitor
DMS PHARMA

British Journal of Anaesthesia 97 (6): 755–7 (2006)
doi:10.1093/bja/ael290

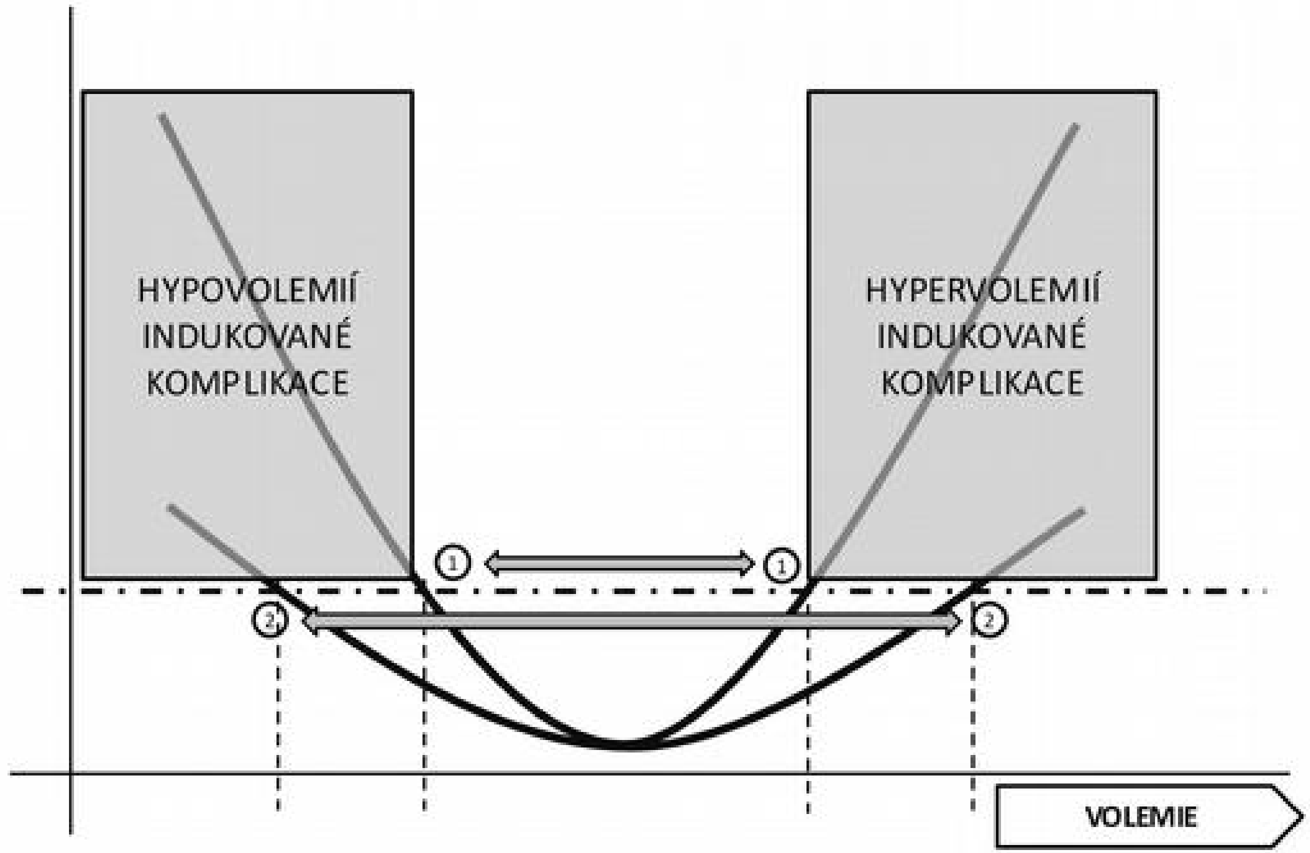
Editorial

REGI
HYPO

POF
DODA

PORUCI

PORU
(GIT, LE

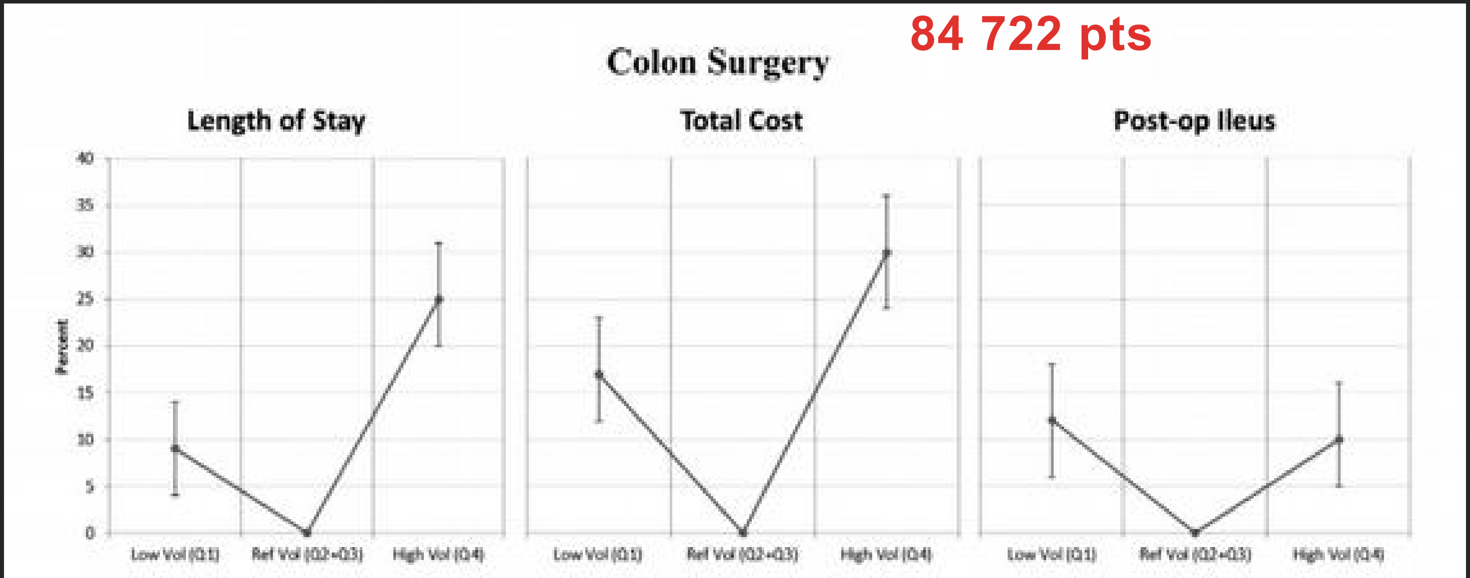


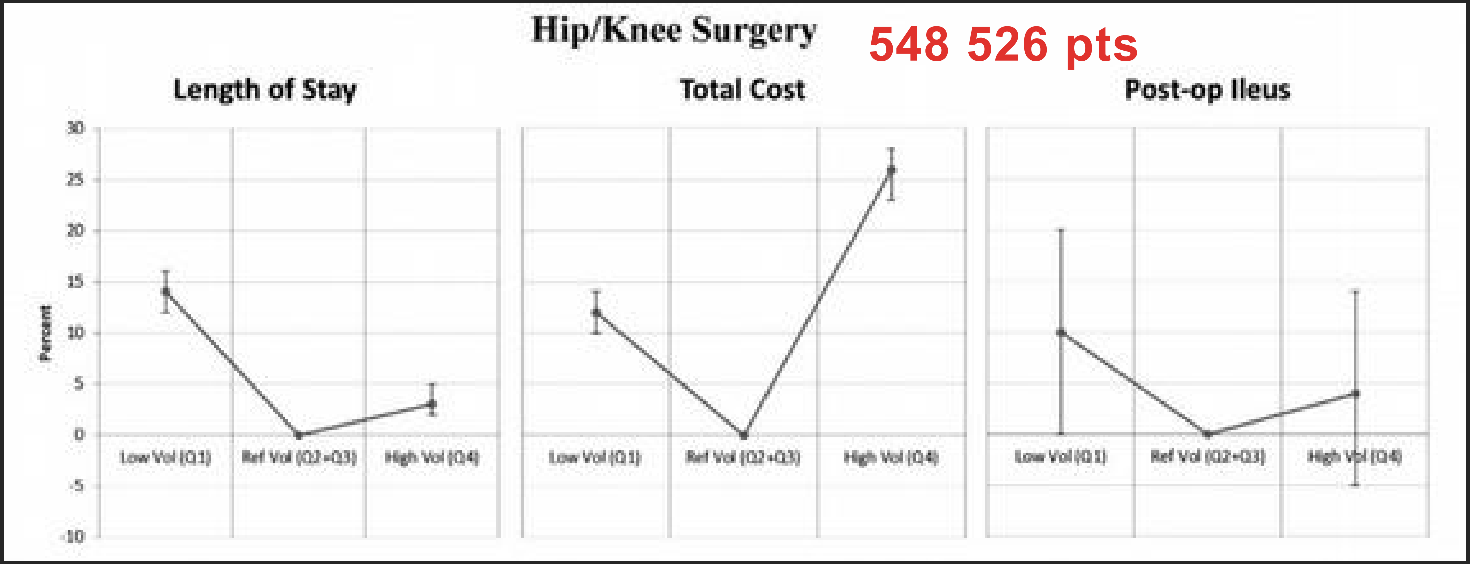
ORIGINAL ARTICLE

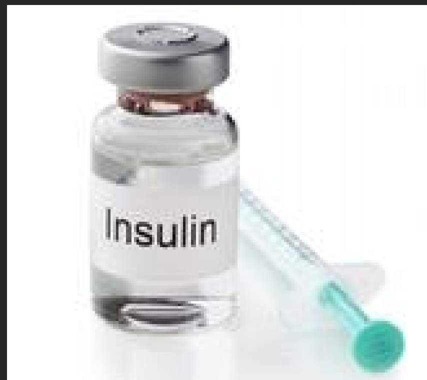
Perioperative Fluid Utilization Variability and Association With Outcomes

Considerations for Enhanced Recovery Efforts in Sample US Surgical Populations

Julie K. M. Thacker, MD, William K. Mountford, PhD,† Frank R. Ernst, PharmD, MS,‡ Michelle R. Krukas, MA,‡ and Michael (Monty) G. Mythen, MBBS, MD, FRCA, FFICM, FCAI (Hon)§*



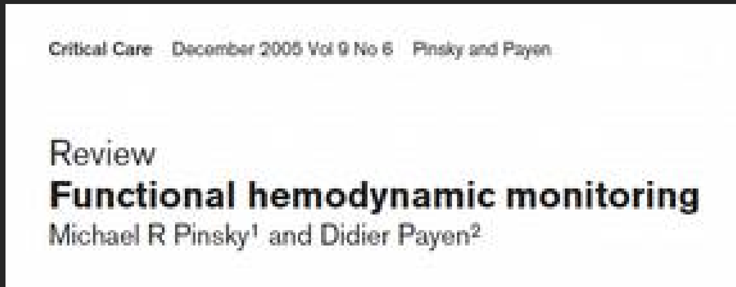




mmol/l GLY

mmHg

?



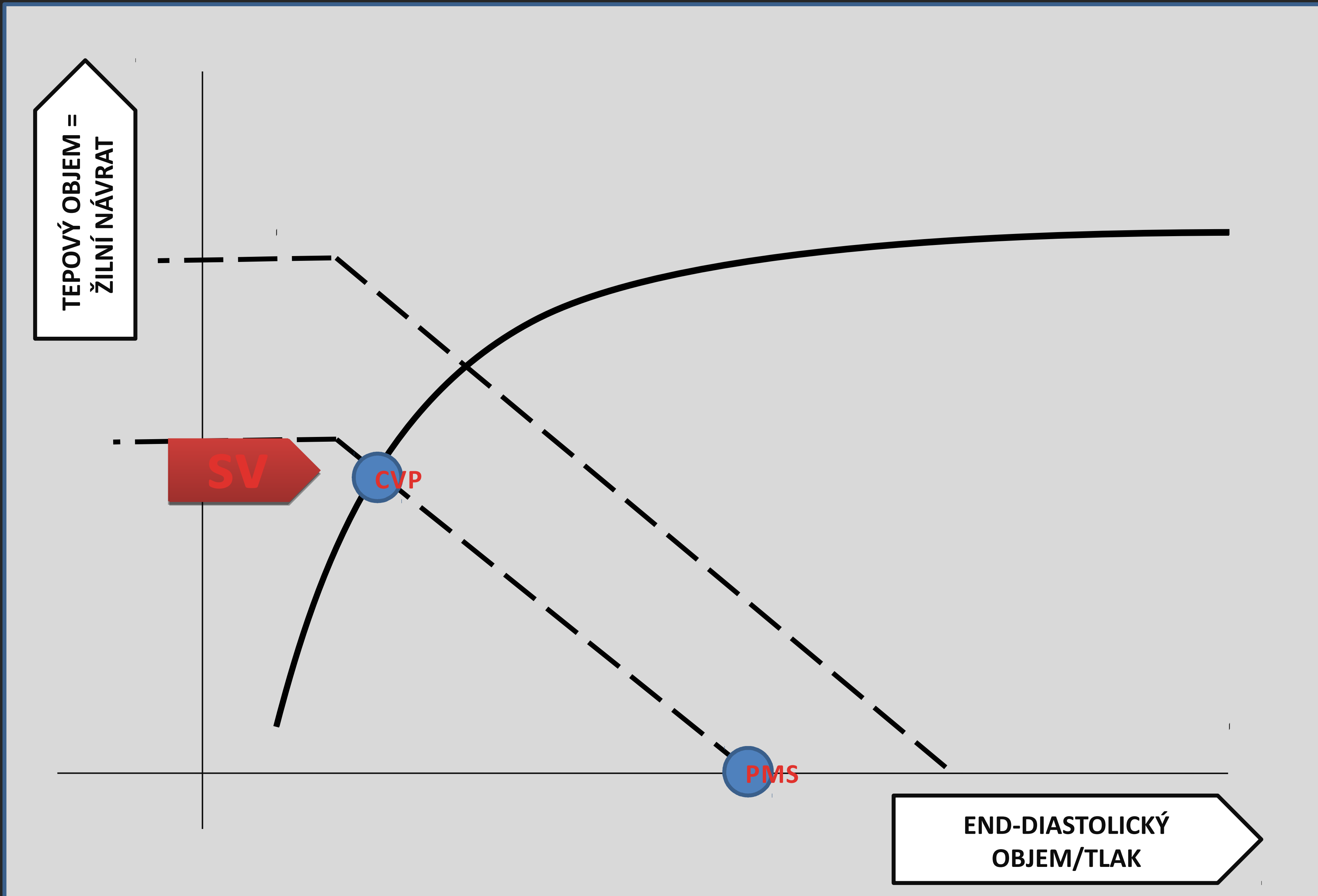
Critical Care December 2005 Vol 9 No 6 Pinsky and Payen

Review

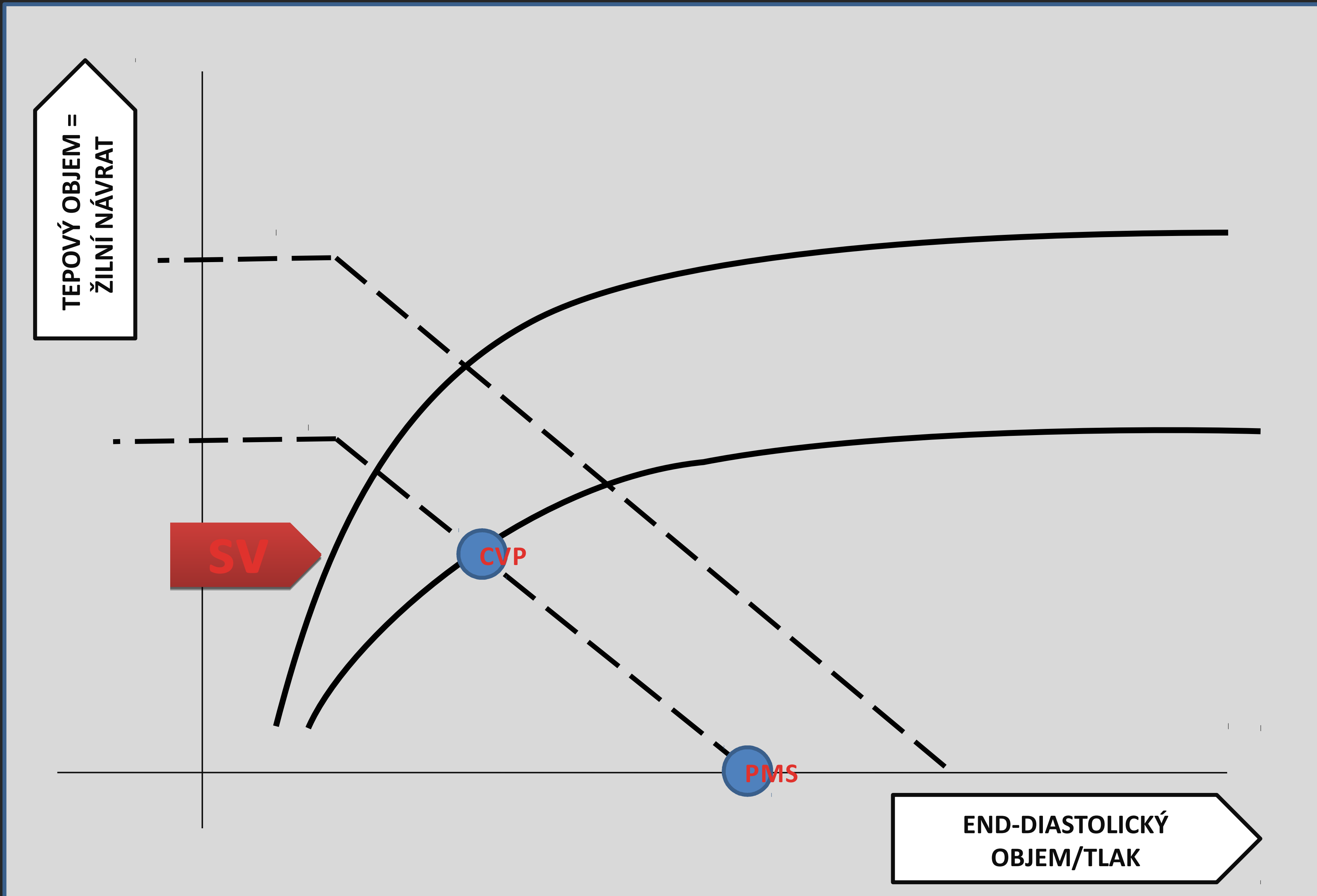
Functional hemodynamic monitoring

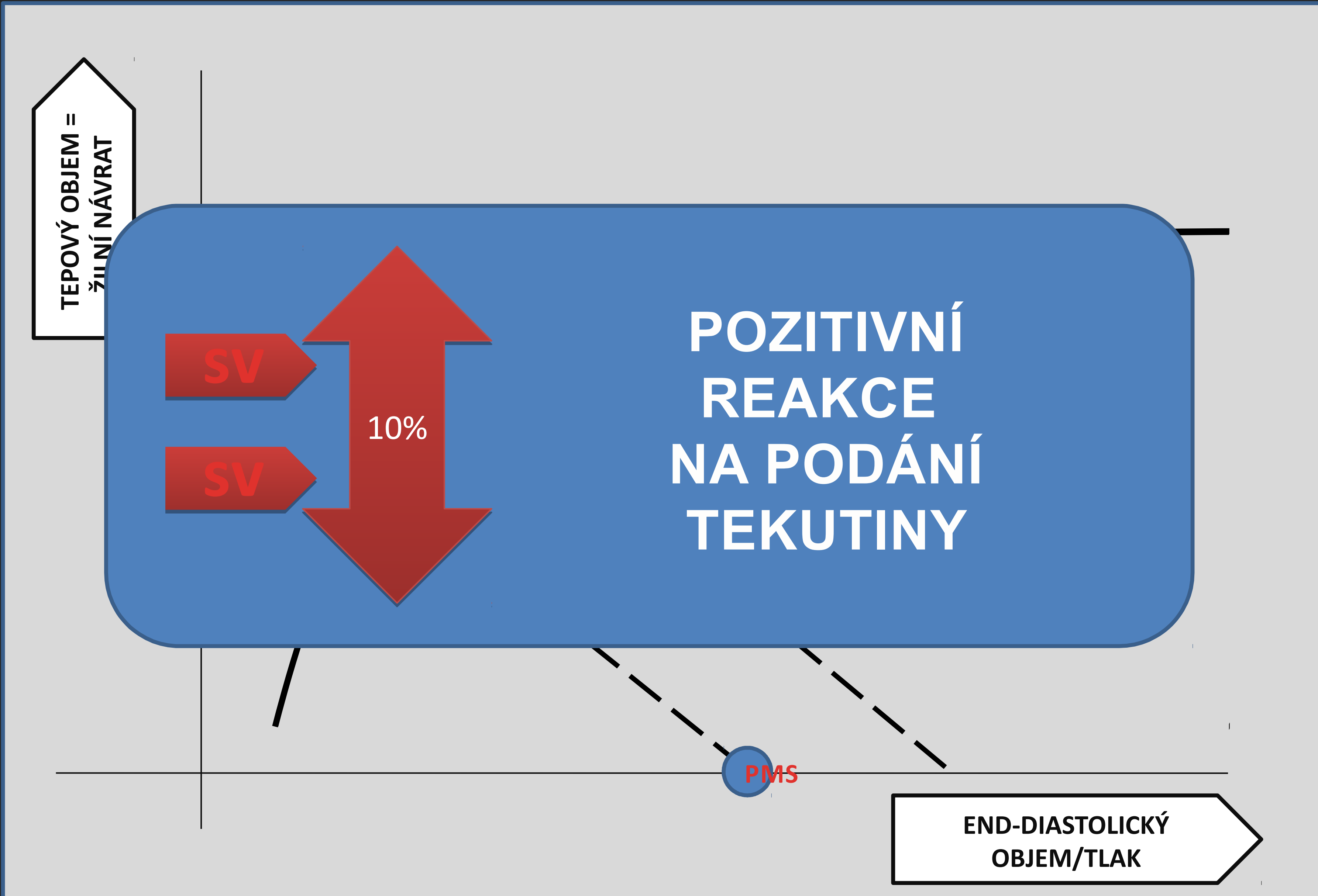
Michael R Pinsky[1] and Didier Payen[2]

$$DO_2 = 1{,}34 \times Hb \times SaO_2 \times CO$$



TEPOVÝ OBJEM =
ŽILNÍ NÁVRAT
SV
CVP
PMS
END-DIASTOLICKÝ
OBJEM/TLAK


TEPOVÝ OBJEM =
ŽILNÍ NÁVRAT
SV
CVP
PMS
END-DIASTOLICKÝ
OBJEM/TLAK

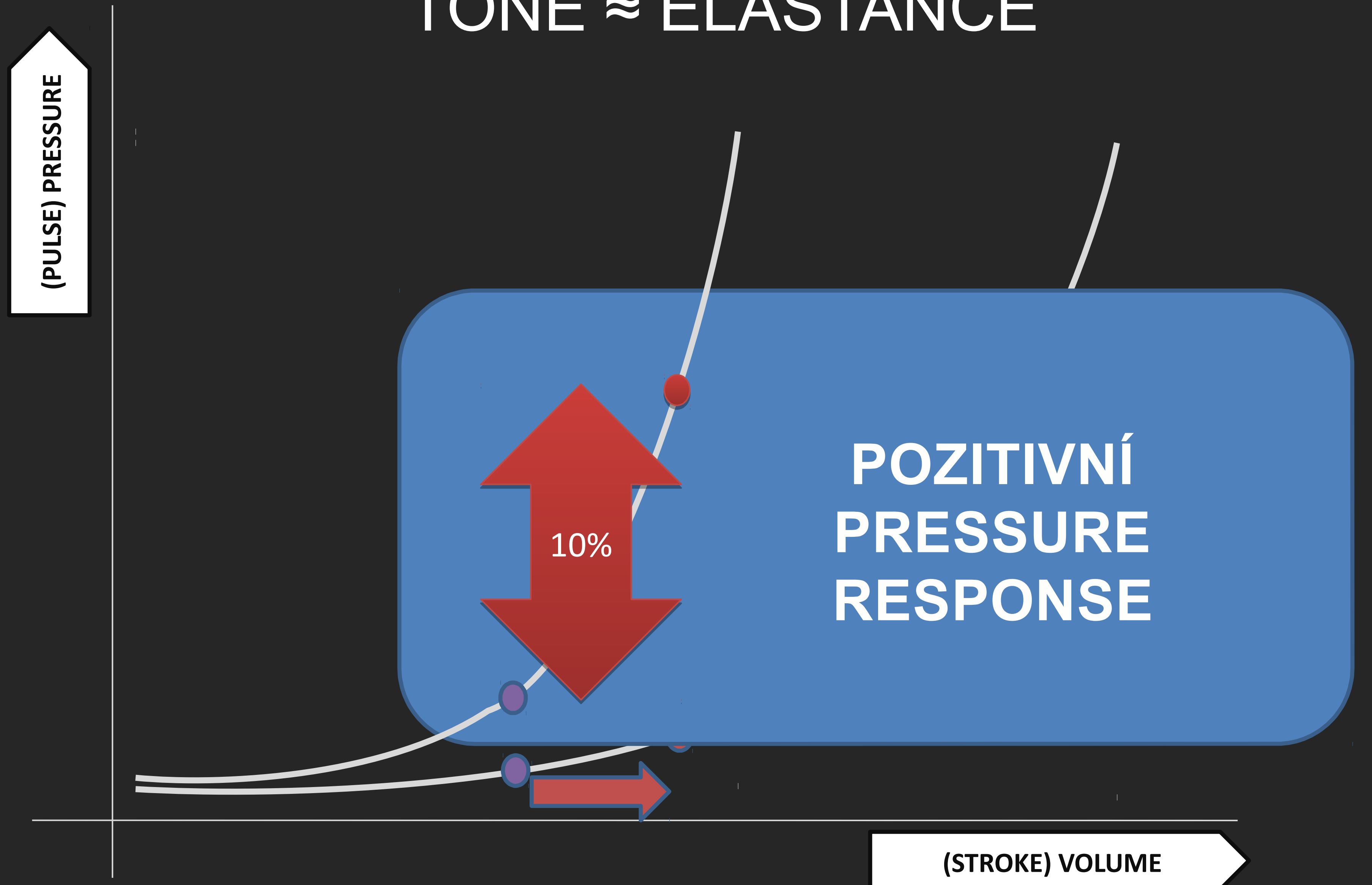

TEPOVÝ OBJEM = ŽILNÍ NÁVRAT
SV
SV
10%
POZITIVNÍ REAKCE NA PODÁNÍ TEKUTINY
PMS
END-DIASTOLICKÝ OBJEM/TLAK

CO

SVRI x CO ≈ MAP – CVP

TONE ≈ ELASTANCE

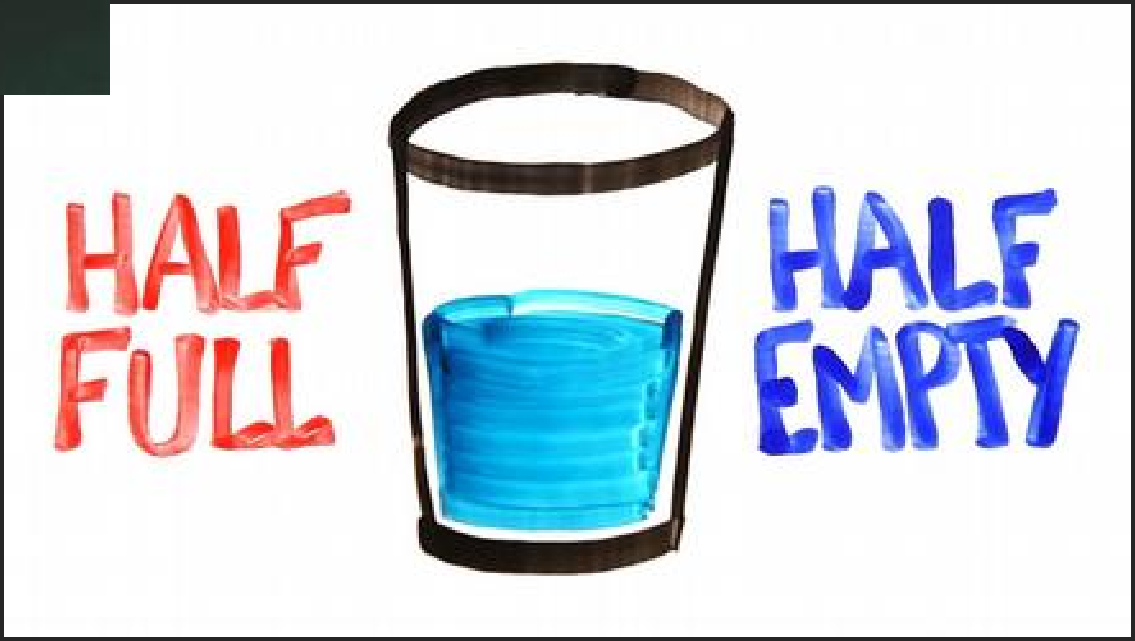


POMINEME-LI LÉČBU DEHYDRATACE
A VYUŽITÍ JAKO VEHIKULUM
JE HLAVNÍ INDIKACÍ PODÁNÍ
I.V. TEKUTIN SNAHA O ZLEPŠENÍ
OBĚHOVÝCH PARAMETRŮ
(FLUID / PRESSURE RESPONSE)

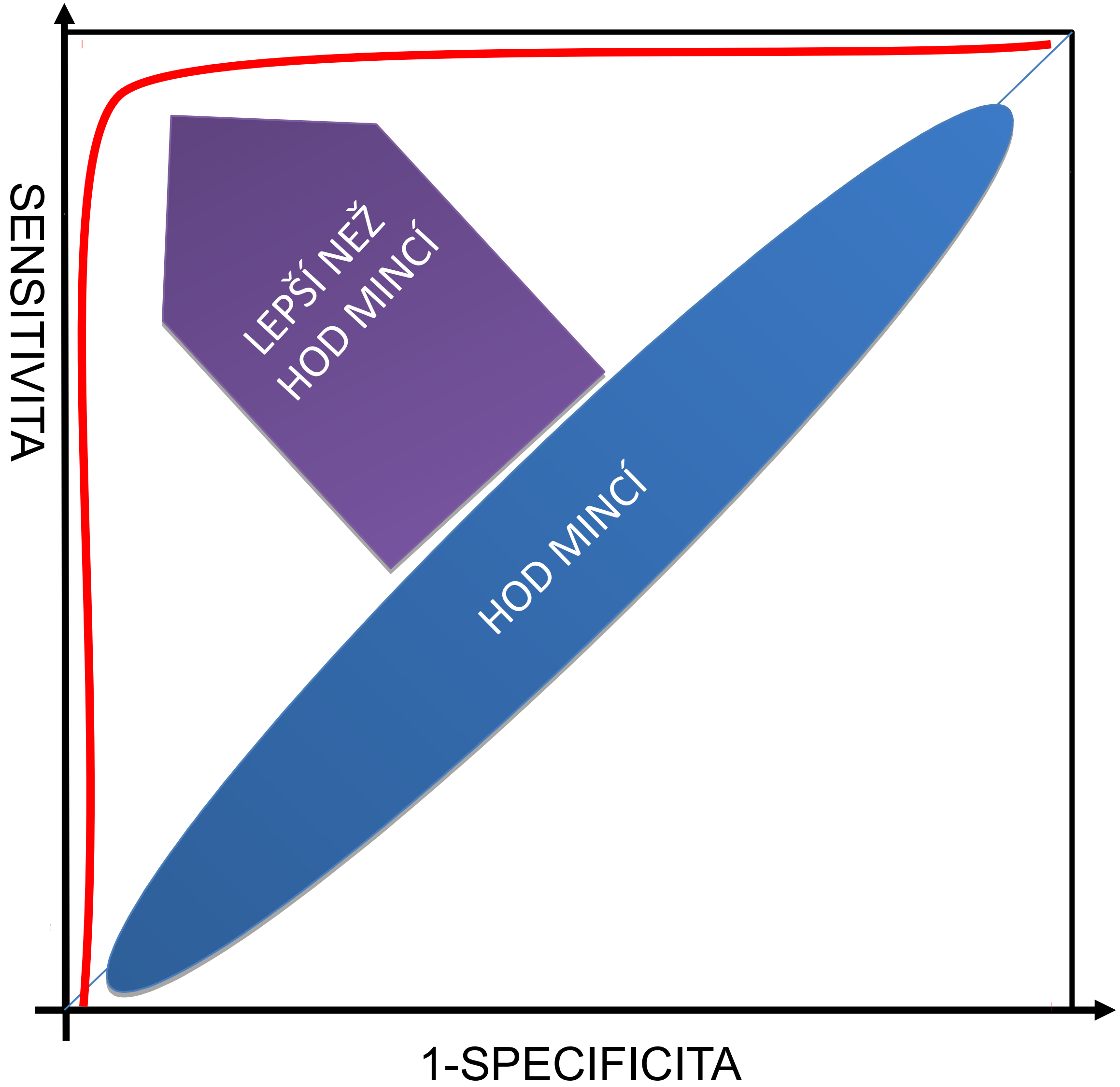
PRINCIP TEKUTINOVÉ VÝZVY

POROVNAT

PREDIKCE FLUID RESPONSIVITY


HALF
FULL
HALF
EMPTY

ROC
ANALÝZA



PRELOAD

STATICKÉ PARAMETRY

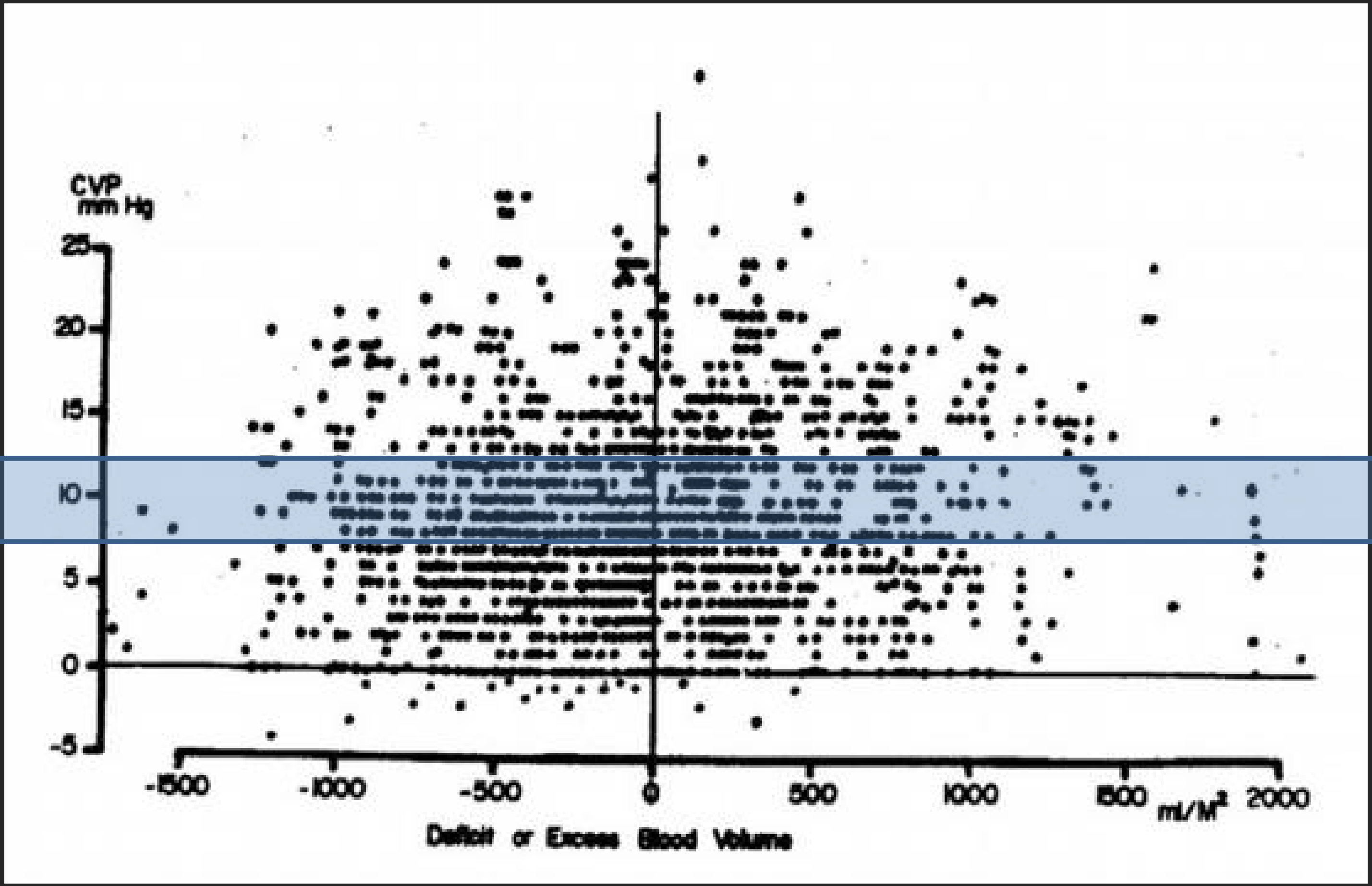
(CVP, PAOP, GEDV …)

Does Central Venous Pressure Predict Fluid Responsiveness?*

A Systematic Review of the Literature and the Tale of Seven Mares

(CHEST 2008; 134:172–178)

Paul E. Marik, MD, FCCP; Michael Baram, MD, FCCP; and Bobbak Vahid, MD



PRELOAD

ST CKÉ RAM RY

CVP, PAO DV ..

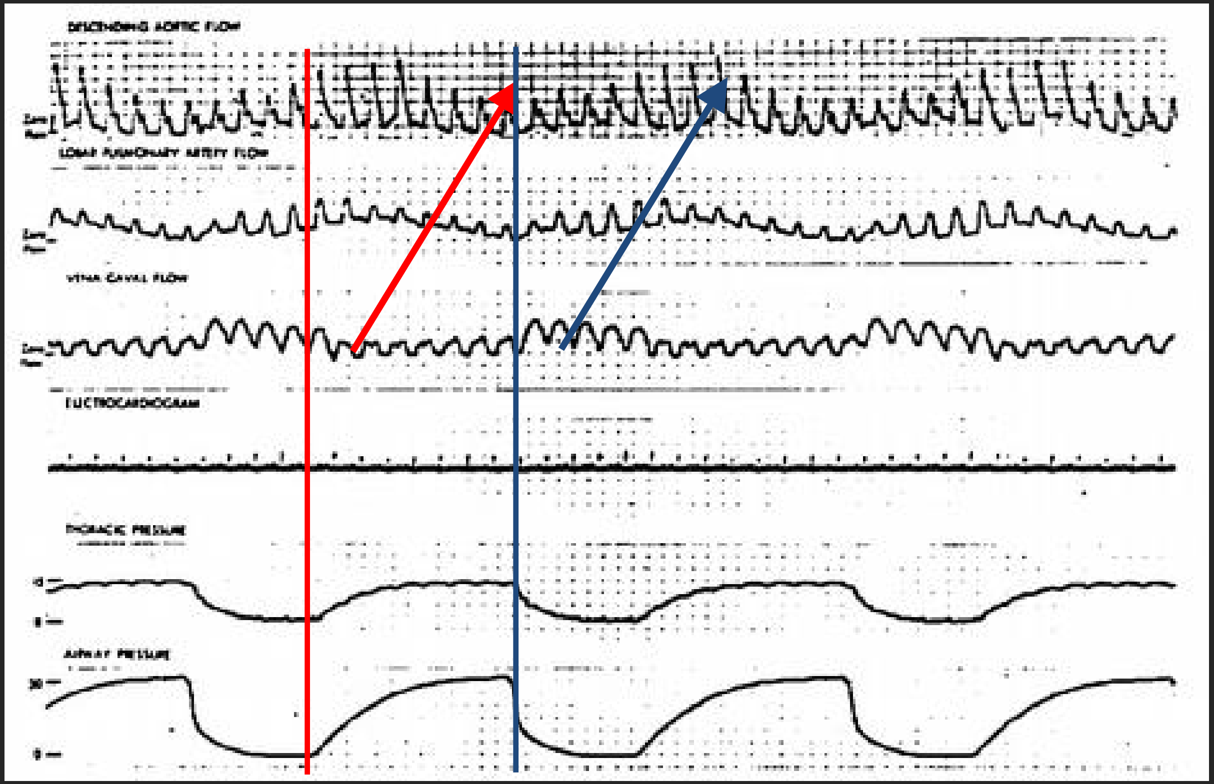
DYNAMICKÉ PARAMETRY

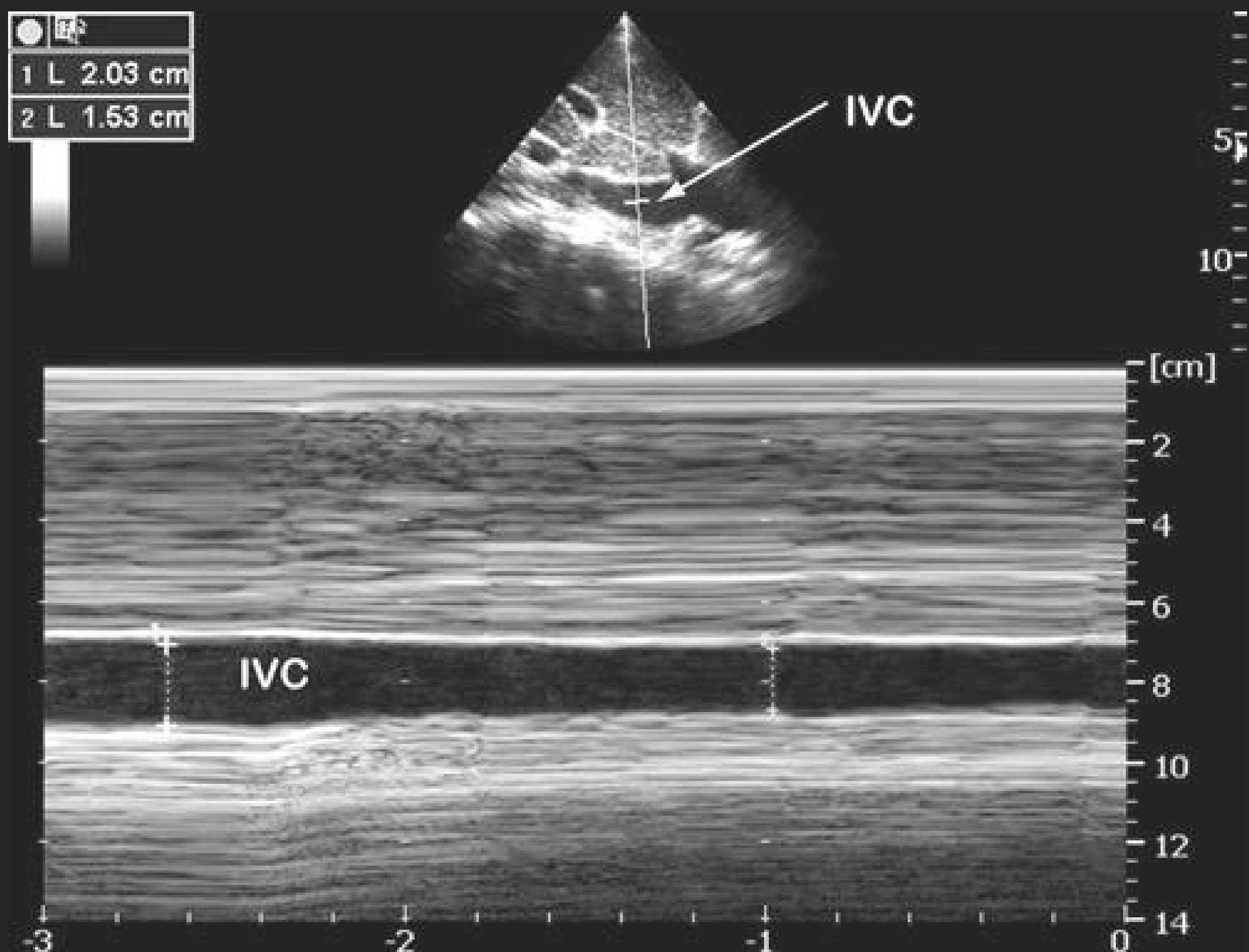
(FTc, SPV, PPV, SVV, PVI…)

Hemodynamic Effects of Intermittent Positive Pressure Respiration

Anesthesiology 1966

Beverly C. Morgan, M.D.,* Wayne E. Martin, M.D.,† Thomas F. Hornbein, M.D.,‡
Edward W. Crawford, M.D.,§ Warren G. Guntheroth, M.D.¶




1 L 2.03 cm
2 L 1.53 cm
IVC
IVC
[cm]
2
4
6
8
10
12
14
-3
-2
-1
0
5
10

SPONTÁNNÍ VENTILACE

VCI KOLAPS

VCI KOLAPS

$$\frac{\text{IVC exp} - \text{IVC insp}}{\text{IVC exp}} * 100$$

> 50% REPONSIVITA

> 50% REPONSIVITA

UMĚLÁ PLICNÍ VENTILACE

VCI DISTENZE

VCI DISTENZE

$$\frac{\text{IVC max} - \text{IVC } min}{\text{IVC min}} * 100$$

> 18/20% REPONSIVITA

> 18/20% REPONSIVITA

Ten situations where inferior vena cava ultrasound may fail to accurately pre[...] responsiveness: a physiologically bas[...] of view

G. Via[1*], G. Tavazzi[1,2,3] and S. Price[3]

Condition affecting IVC ultrasound reliability for FR	Cause of inaccuracy for FR	Type of inaccuracy for FR
1. Mechanical ventilation with high PEEP and/or low tidal volumes	Larger IVC size, potentially with systemic venous congestion and low respiratory variations, but coexisting with FR	FN
2. Assisted ventilation modalities, NIV, CPAP	Spontaneous breathing activity makes IVC variation unpredictable	FP and FN
3. Varying respiratory pattern in spontaneous breathing	Significant inspiratory effort, producing markedly negative intrathoracic pressures may induce IVCc in absence of FR	FP
	Shallow breathing, with small intrathoracic pressure changes, may induce absence of IVCc in presence of FR	FN
4. Asthma/COPD exacerbation	Lung hyperinflation and auto-PEEP simultaneously reduce venous return and induce IVC distension: this may mimic absence of FR	FN
	Forced expiration ("abdominal breathing" causing expiratory collapse) may mimic IVCc	FP
5. Chronic RV dysfunction, severe TR	Chronic enlargement of IVC and reduced IVCc may erroneously rule out FR	FN
6. RV myocardial infarction	RV dilatation and systemic venous congestion (large IVC) may be associated with FR	FN
7. Cardiac tamponade	Marked venous return hindrance: fluid challenge may be a beneficial haemodynamic intervention despite IVC plethora	FN
8. Intra-abdominal hypertension	Smaller IVC size, IVCd or IVCc abolition (depending on type respiration/ventilation mode)	FP and FN
9. Local mechanical factors	Venous return hindrance, IVC dilatation (stenosis, thrombosis)	FN
	IVC compression (masses)	FP
	Hindrance to IVC size change (ECMO cannulae, cava filters)	FN
10. Patients with pronounced IVC inspiratory lateral displacement	Migration of IVC imaging plane, false inspiratory size reduction	FP

EJA

Eur J Anaesthesiol 2018; 35:1–9

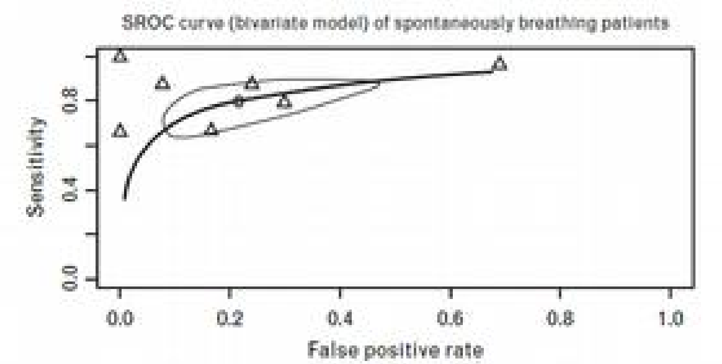
ORIGINAL ARTICLE

Diagnostic accuracy of inferior vena caval respiratory variation in detecting fluid unresponsiveness

A systematic review and meta-analysis

Saurabh K. Das, Nang S. Choupoo, Debasis Pradhan, Priyam Saikia and Xavier Monnet

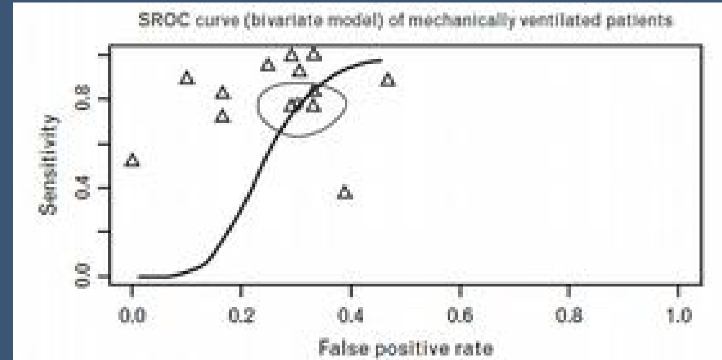
23 studií
1574 pts



SROC curve of spontaneously breathing patients using bivariate model. Ellipse denotes confidence region, Δ denotes data, ○ denotes summary estimate. SROC, summary receiver operating characteristics.

SPONTÁNNÍ VENTILACE

AUC 0,857
SENSITIVITA 80%
SPECIFICITA 79%

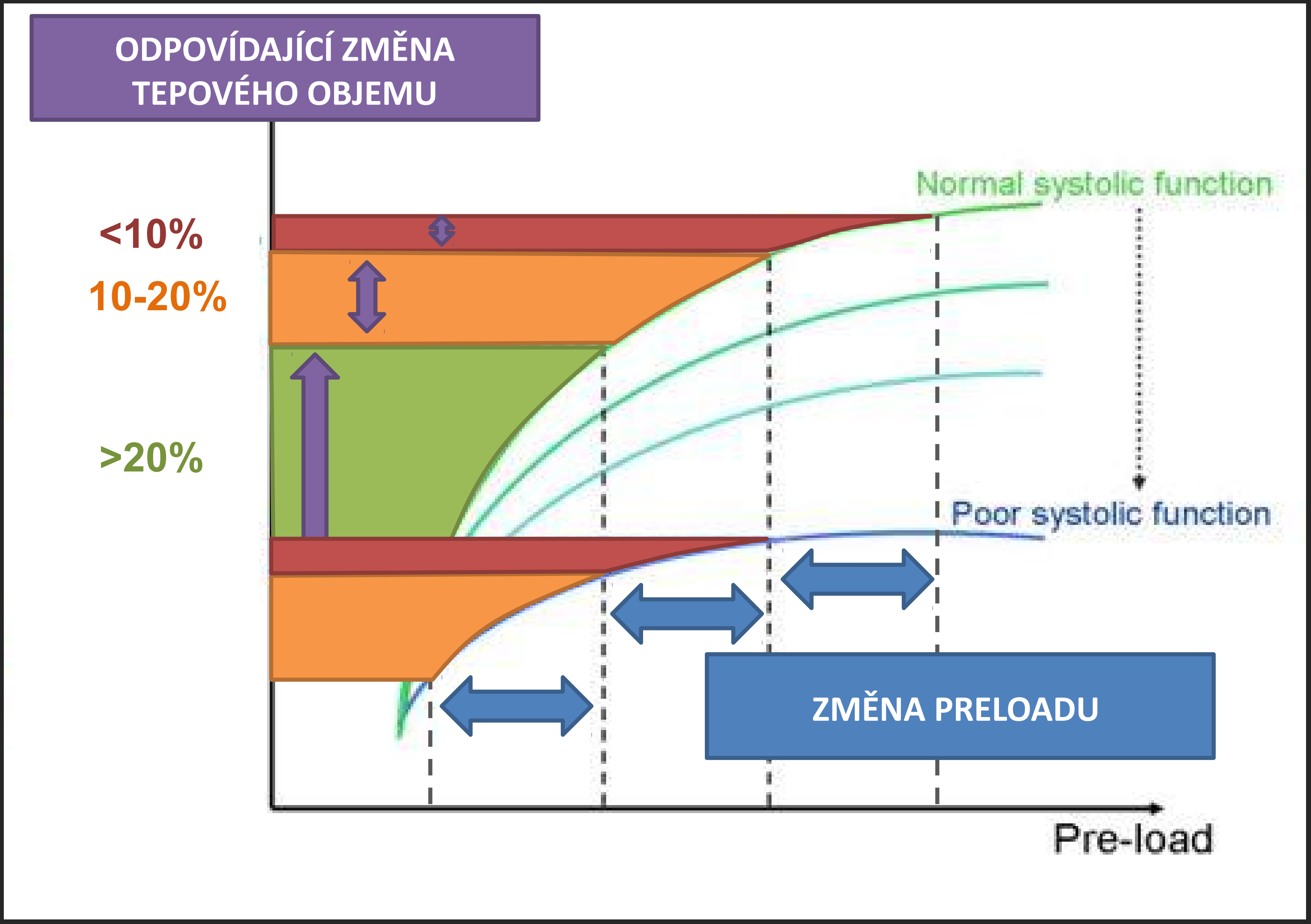


SROC curve of mechanically ventilated patients using bivariate model. Ellipse denotes confidence region, Δ denotes data, ○ denotes summary estimate. SROC, summary receiver operating characteristics.

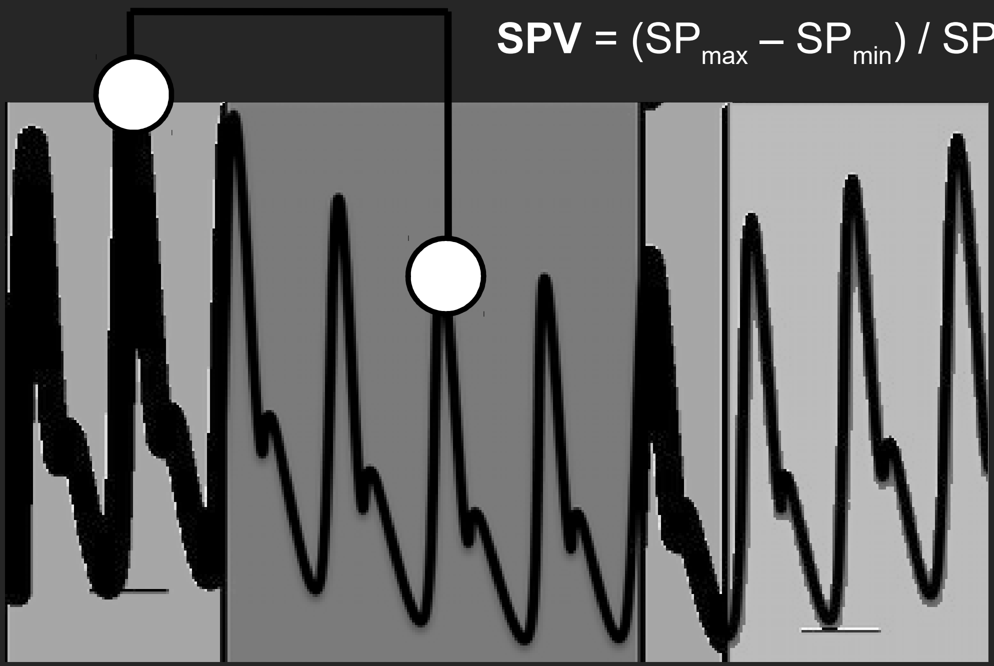
UMĚLÁ PLICNÍ VENTILACE

AUC ROC 0,75
SENSITIVITA 79%
SPECIFICITA 70%

DYNAMICKÉ PARAMETRY
= FRANK STARLINGOVA KŘIVKA



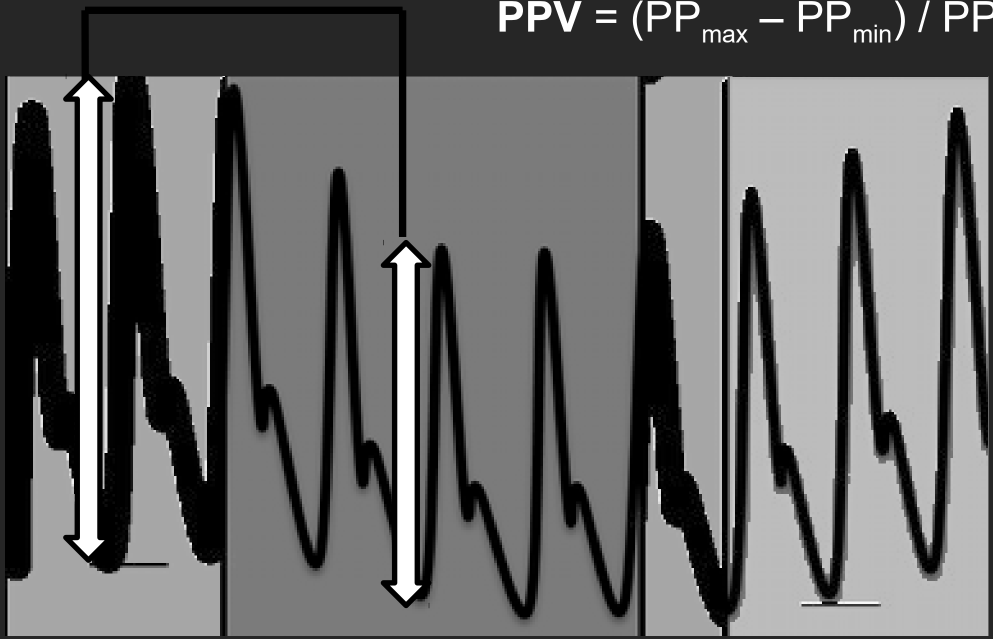
Zkratka	Název	Zóna cut off	Automatické hodnocení
SVV	Variace tepového objemu	9-12%	Nutné
PPV	Variace pulzního tlaku	9-13%	Možné
SPV	Variace systolického tlaku	10-13%	Ne
ΔDown	Pokles STK oproti end-exspiriu	5 mmHg	Ne
PVI	Variace pletysmografického signálu	9,5-15%	Možné
----	variace VTI/ABF		Ne



SPV = $(SP_{max} - SP_{min}) / SP_{mean}$

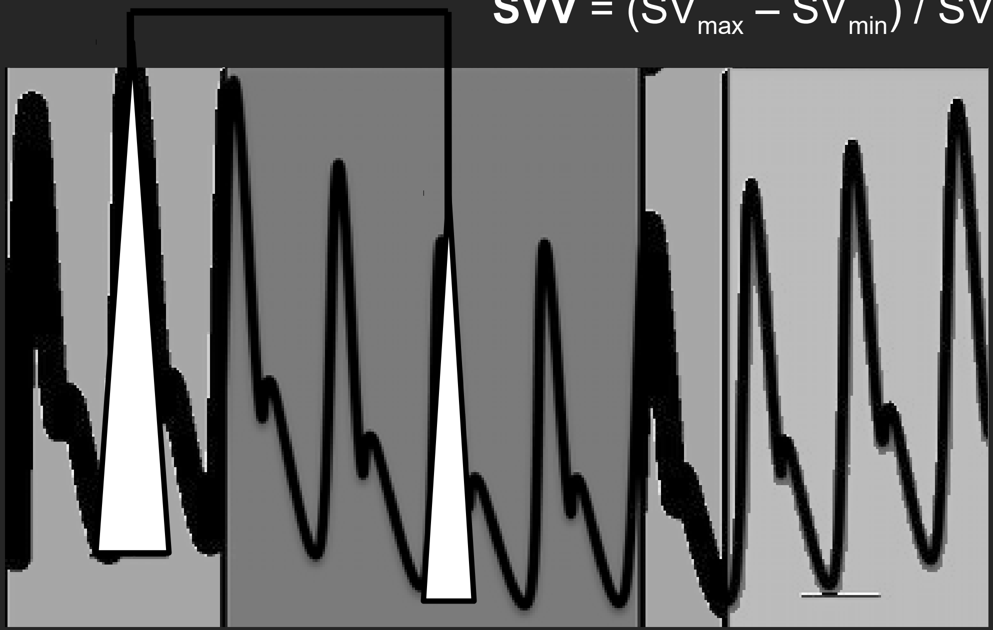
Zkratka	Název	Zóna cut off	Automatické hodnocení
SPV	Variace systolického tlaku	10-13%	Ne
----	variace Vmax (Doppler)		Ne

$\textbf{PPV} = (PP_{max} - PP_{min}) / PP_{mean}$



Zkratka	Název	Zóna cut off	Automatické hodnocení
PPV	Variace pulzního tlaku	9-13%	Možné
PVI	Variace pletysmografického signálu	9,5-15%	Možné

$$SVV = (SV_{max} - SV_{min}) / SV_{mean}$$

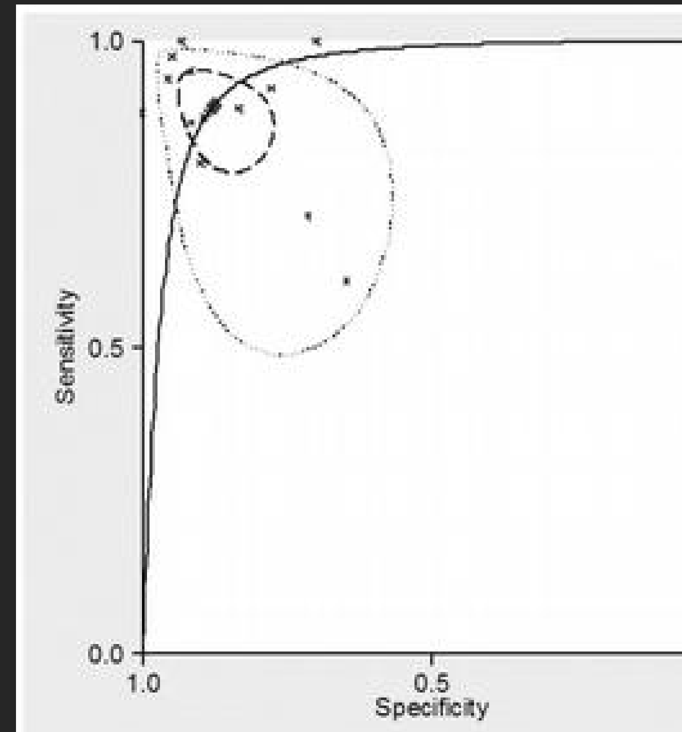


Zkratka	Název	Zóna cut off	Automatické hodnocení
SVV	Variace tepového objemu	9-12%	Nutné
----	variace VTI/ABF		Ne

Review Article
Crit Care Med 2009 Vol. 37, No. 9

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

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



29 studies = 685 patients
AUC (PPV) = 0,94 (0,92-0,96) …12,5%
AUC (SVV) = 0,84 (0,81-0,87) … 11,6%

J Anesth (2011) 25:904–916
DOI 10.1007/s00540-011-1217-1

REVIEW ARTICLE

Accuracy of stroke volume variation in predicting fluid responsiveness: a systematic review and meta-analysis

Zhongheng Zhang · Baolong Lu · Xiaoyan Sheng · Ni Jin

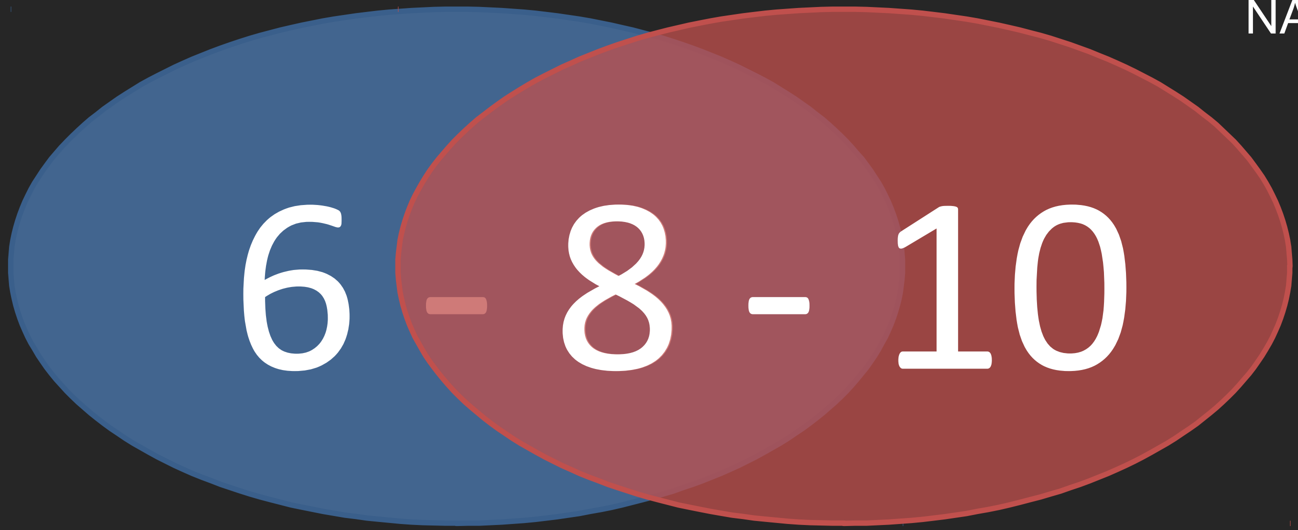
23 studies – 568 patients
AUC (all) = 0,93 (0,91-0,95)

Setting [no. of studies (data sets)]	Sensitivity (95% CI)	Specificity (95% CI)	DOR (95% CI)	AUC-ROC (95% CI)[a]
Across all settings (12 [15])	0.81 (0.77–0.85)	0.80 (0.70–0.88)	18.4 (9.52–35.5)	0.93 (0.907–0.945)
In OR under general anesthesia (8 [10])	0.80 (0.75–0.84)	0.78 (0.61–0.89)	14.1 (5.84–34.3)	0.94 (0.92–0.96)
In ICU (4 [5])	0.86 (0.78–0.92)	0.84 (0.74–0.91)	28.3 (12.3–65.1)	0.85 (0.79–0.91)
Patients ventilated with TV > 8 ml/kg (10 [13])	0.81 (0.77–0.85)	0.80 (0.68–0.89)	17.5 (8.44–36.5)	0.85 (0.82–0.88)
Hemodynamic monitoring with PiCCO system (6 [6])	0.80 (0.72–0.85)	0.84 (0.75–0.91)	21.0 (10.7–41.5)	0.85 (0.81–0.89)
Hemodynamic monitoring with Vigileo system (7 [9])	0.85 (0.78–0.90)	0.78 (0.58–0.91)	20.8 (6.09–71.2)	0.96 (0.94–0.98)

		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	✔	✔

PROTEKTIVNÍ VENTILACE

PREDIKCE ODPOVĚDI NA TEKUTINU



VENTILACE S UŽITÍM

8 ml/kg IDEÁLNÍ HMOTNOSTI

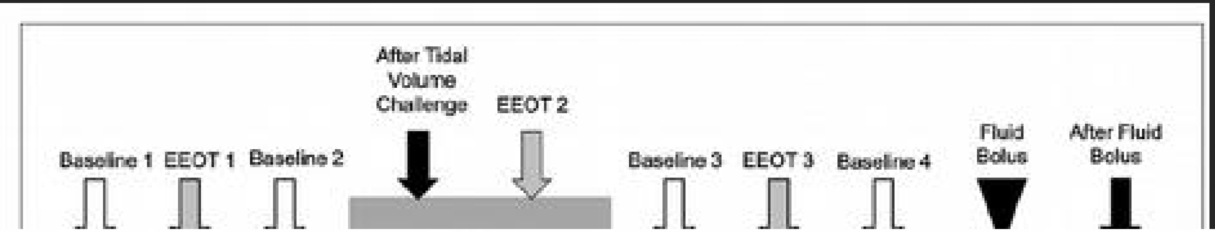
UMOŽNÍ JAK **PROTEKTIVNÍ VENTILACI** TAK

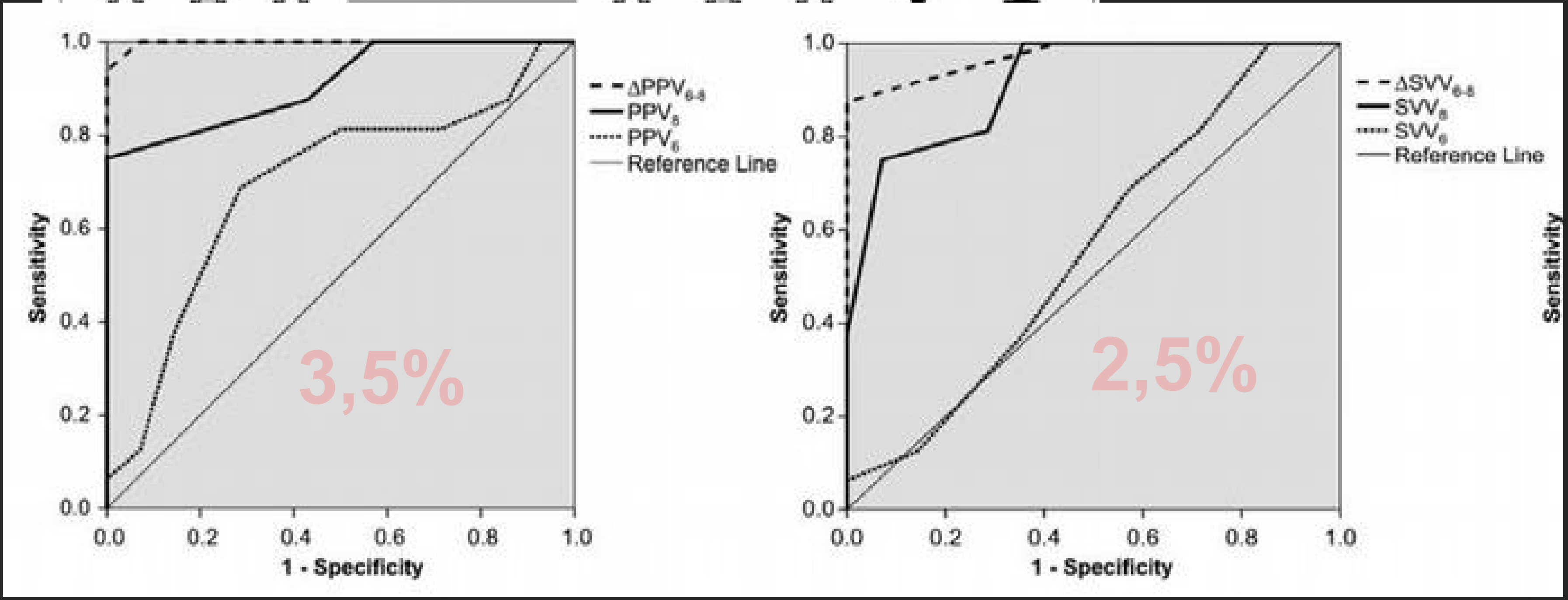
PŘEDPOVĚĎ **FLUID RESPONSIVENESS**

TIDAL VOLUME CHALLENGE

The Changes in Pulse Pressure Variation or Stroke Volume Variation After a "Tidal Volume Challenge" Reliably Predict Fluid Responsiveness During Low Tidal Volume Ventilation* (*Crit Care Med* 2017; 45:415–421)

Sheila Nainan Myatra, MD, FCCM[1]; Natesh R Prabu, MD, DM[1]; Jigeeshu Vasishtha Divatia, MD, FCCM[1]; Xavier Monnet, MD, PhD[2]; Atul Prabhakar Kulkarni, MD, FICCM[1]; Jean-Louis Teboul, MD, PhD[2]





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]

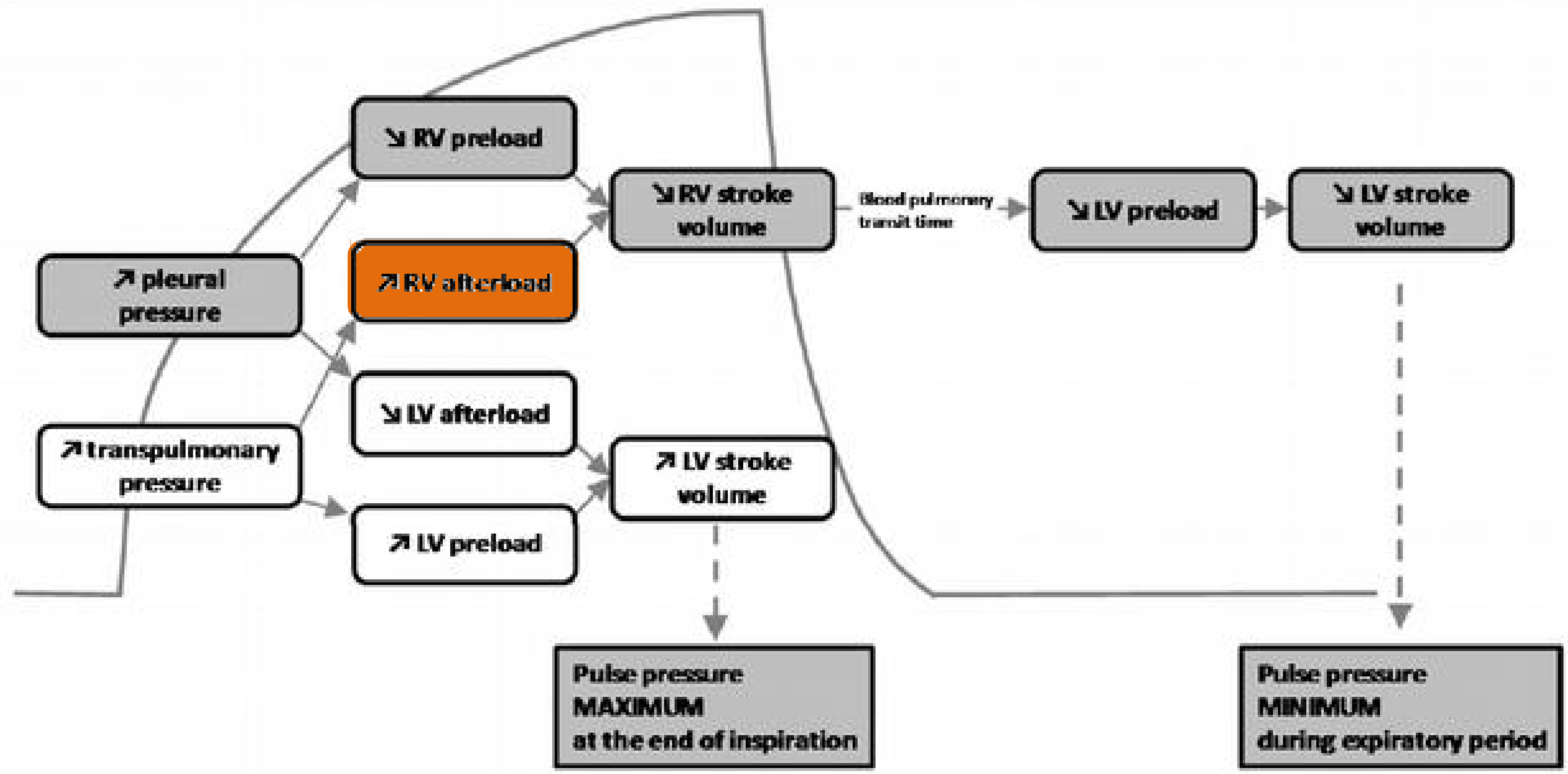


Figure 2 Heart-lung interactions. Hemodynamic effects of mechanical ventilation. The cyclic changes in left ventricular (LV) stroke volume are mainly related to the expiratory decrease in LV preload due to the inspiratory decrease in right ventricular (RV) filling. Reproduced with permission from Critical Care/Current Science Ltd [24].

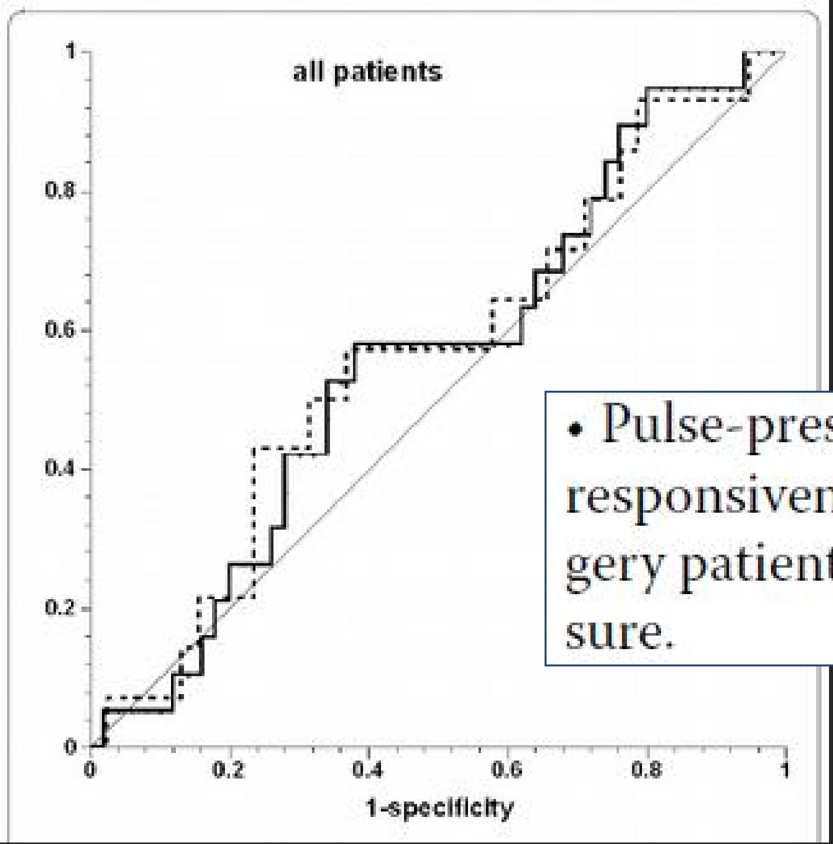
Wyler von Ballmoos et al. Critical Care 2010, 14:R111
http://ccforum.com/content/14/3/R111

CRITICAL CARE

RESEARCH Open Access

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

Moritz Wyler von Ballmoos[1], Jukka Takala[1], Margareta Roeck[1], Francesca Porta[1], David Tueller[1], Christoph C Ganter[1], Ralph Schröder[1], Hendrik Bracht[1], Bertram Baenziger[2] and Stephan M Jakob*[1]



- Pulse-pressure variation does not predict fluid responsiveness in septic shock and post-cardiac surgery patients with increased pulmonary artery pressure.

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]

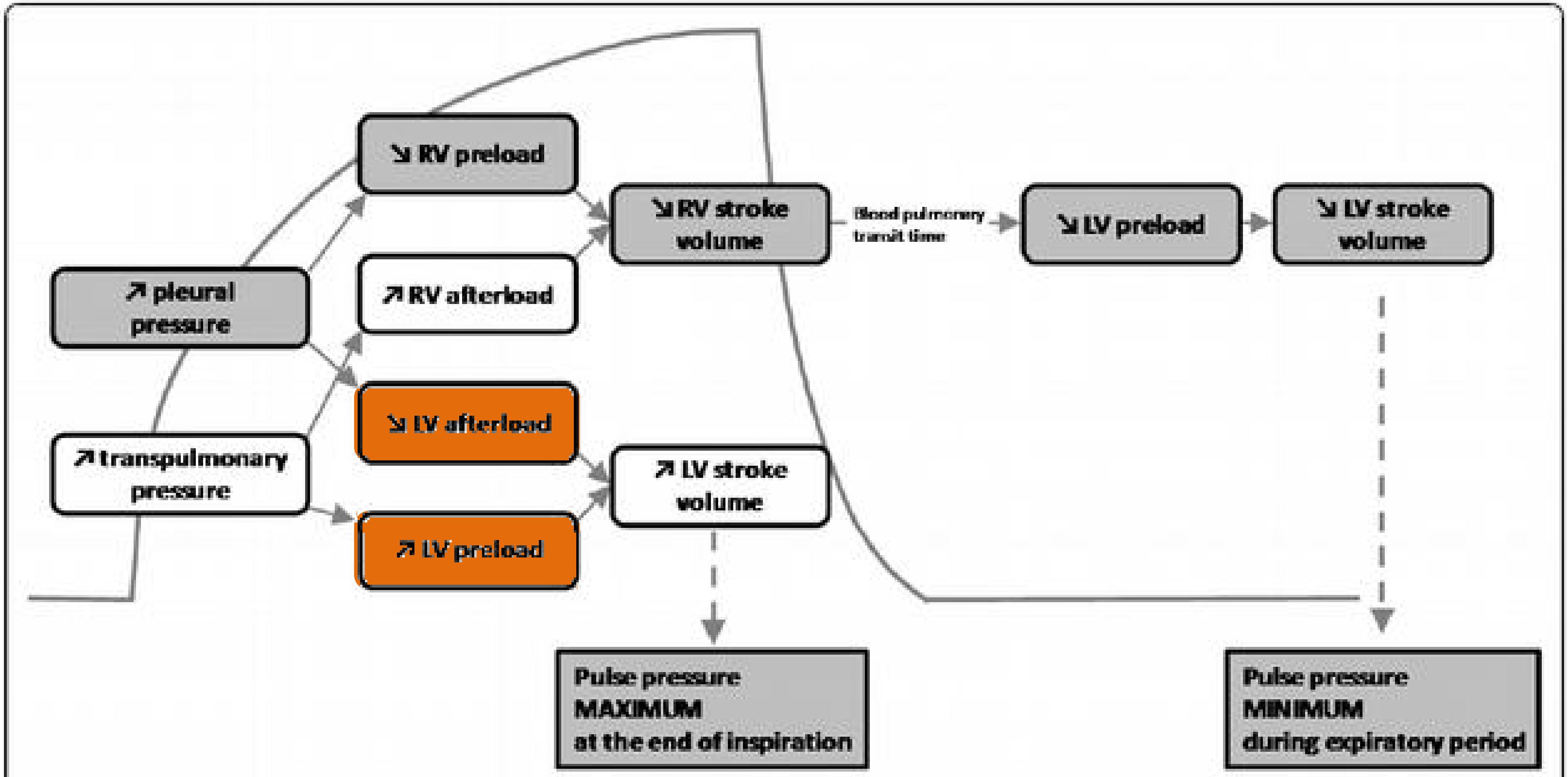


Figure 2 Heart-lung interactions. Hemodynamic effects of mechanical ventilation. The cyclic changes in left ventricular (LV) stroke volume are mainly related to the expiratory decrease in LV preload due to the inspiratory decrease in right ventricular (RV) filling. Reproduced with permission from Critical Care/Current Science Ltd [24].

PRELOAD

ST CK RAM RY
CVP, PAO DV ..

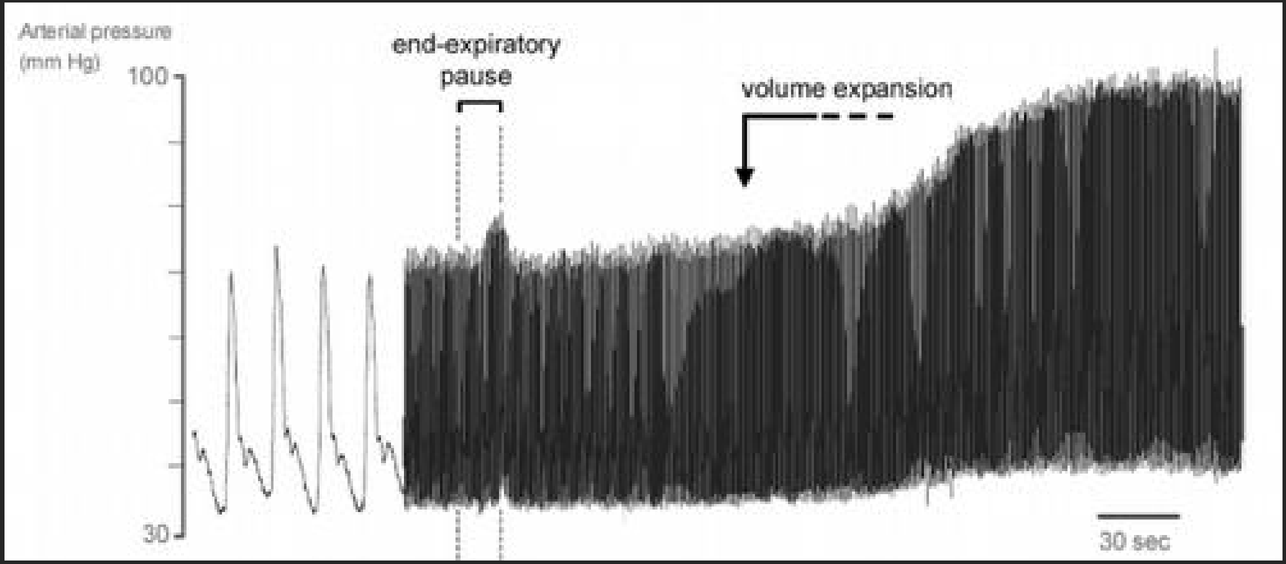
DYNAMICKÉ PARAMETRY
(FTc, SPV, PPV, SVV, PVI...)

DYNAMICKÉ MANÉVRY
(FCH, MFCH, PLR, EEO, EIO, PEEP-CH ...)

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

END.EXPIRATORY OCCLUSION

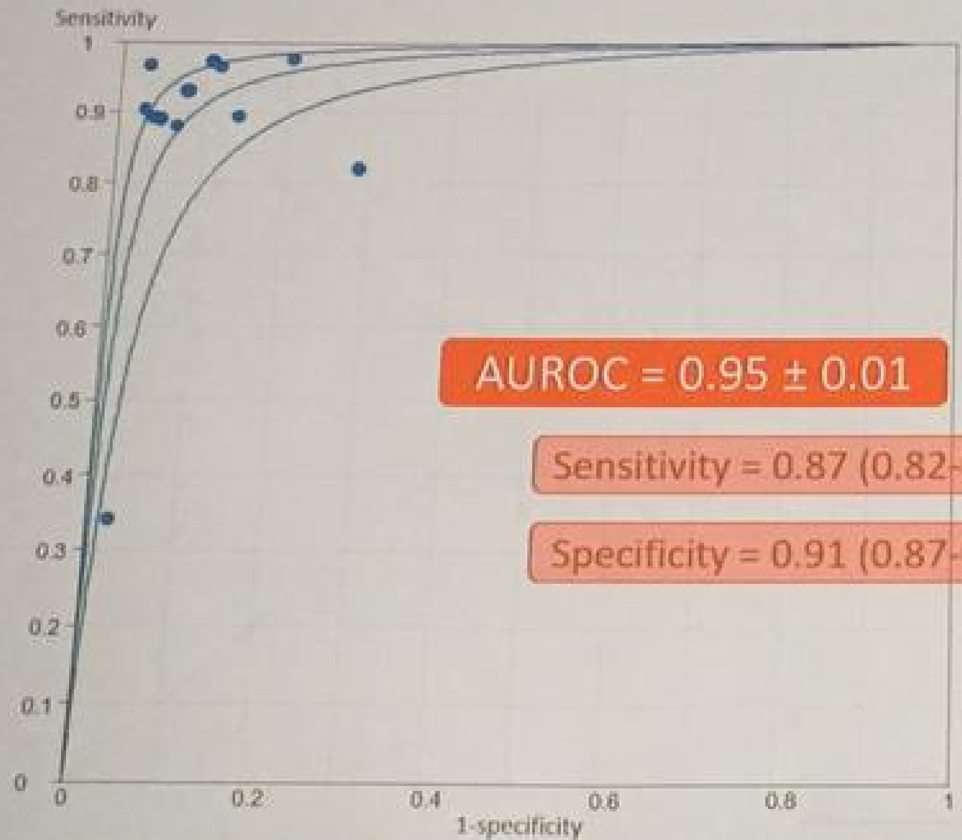


	ROC Area	95% CI	Threshold Value	Sensitivity (%)	Specificity (%)	p^a
Effects of the end-expiratory pause on arterial pulse pressure	0.957	0.825–0.994	5%	87	100	—
Effects of the end-expiratory pause on pulse contour-derived cardiac index	0.972	0.849–0.995	5%	91	100	0.587
Effects of the end-expiratory pause on arterial systolic pressure	0.714	0.528–0.859	4%	67	82	0.001

End-expiratory occlusion test to predict fluid responsiveness: a systematic review and meta-analysis

GAVELLI Francesco, SHI Rui, TEBOUL Jean-Louis, MONNET Xavier *In preparation*

13 studies
530 patients



AUROC = 0.95 ± 0.01

Sensitivity = 0.87 (0.82-0.91)

Specificity = 0.91 (0.87-0.94)

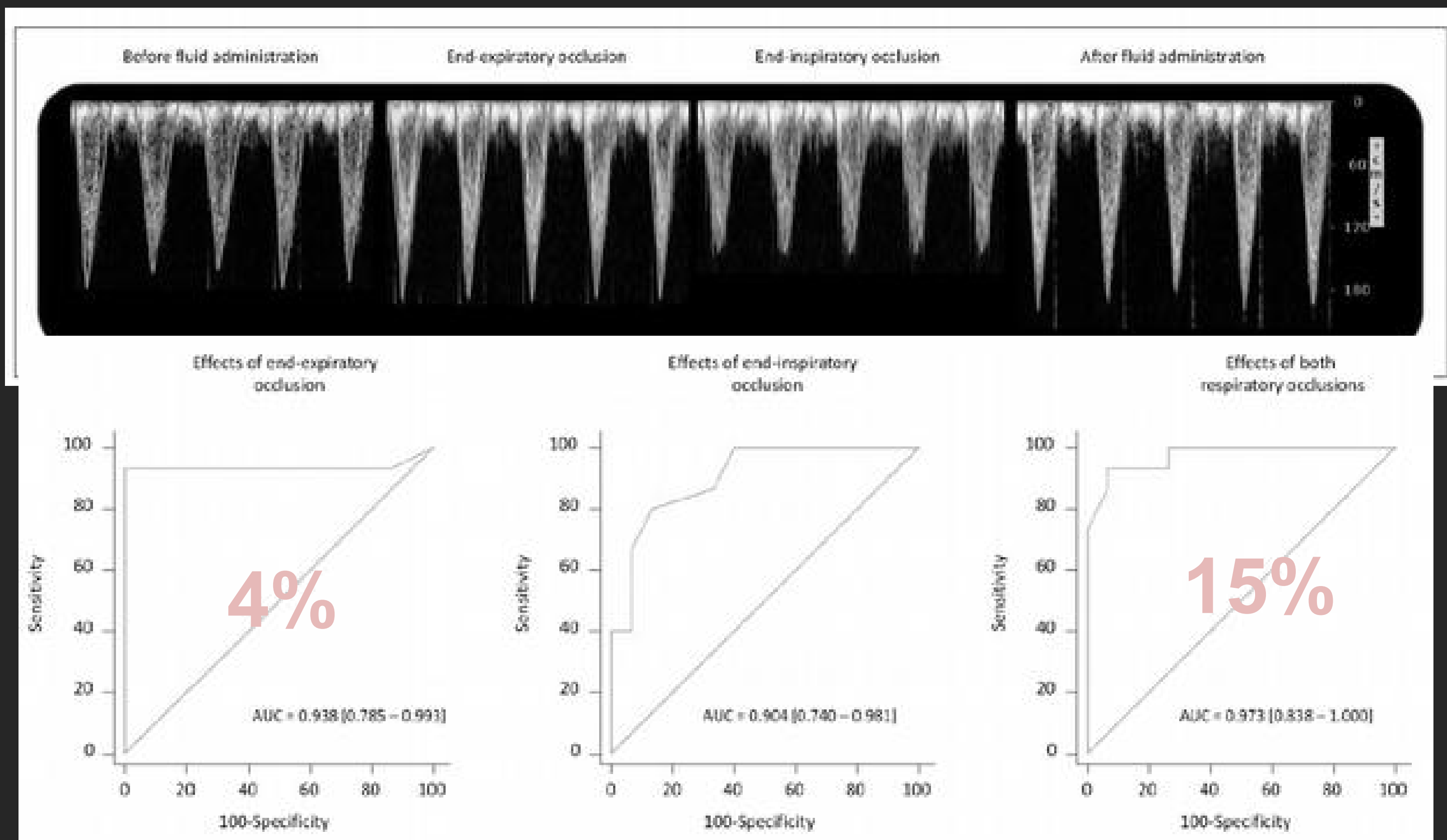
? With echocardiography ?

courtesy to Xavier Monnet

Predicting Fluid Responsiveness in Critically Ill Patients by Using Combined End-Expiratory and End-Inspiratory Occlusions With Echocardiography

Mathieu Jozwiak, MD[1,2]; François Depret, MD[1,2]; Jean-Louis Teboul, MD, PhD[1,2]; Jean-Emmanuel Alphonsine, MD[1,2]; Christopher Lai, MD[1,2]; Christian Richard, MD[1,2]; Xavier Monnet, MD, PhD[1,2]

END.INSPIRATORY OCCLUSION

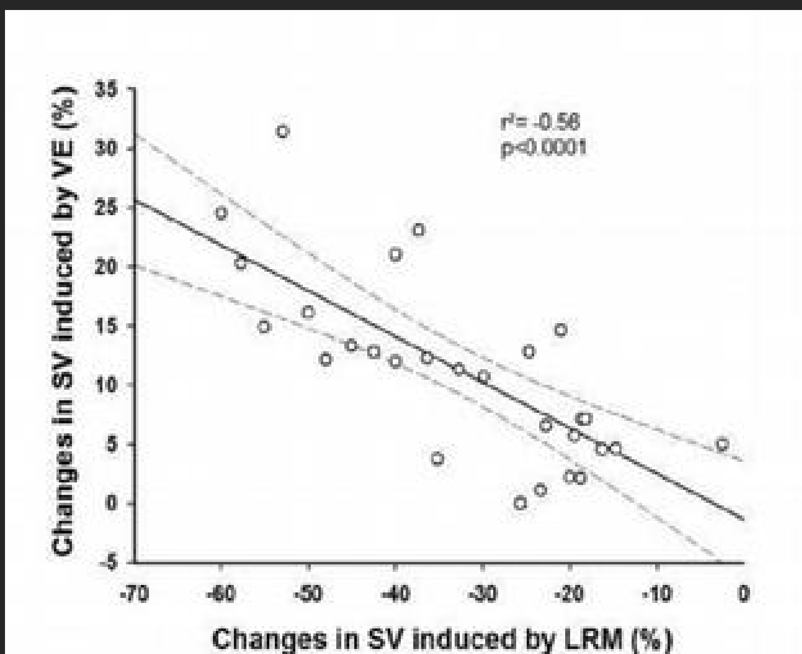


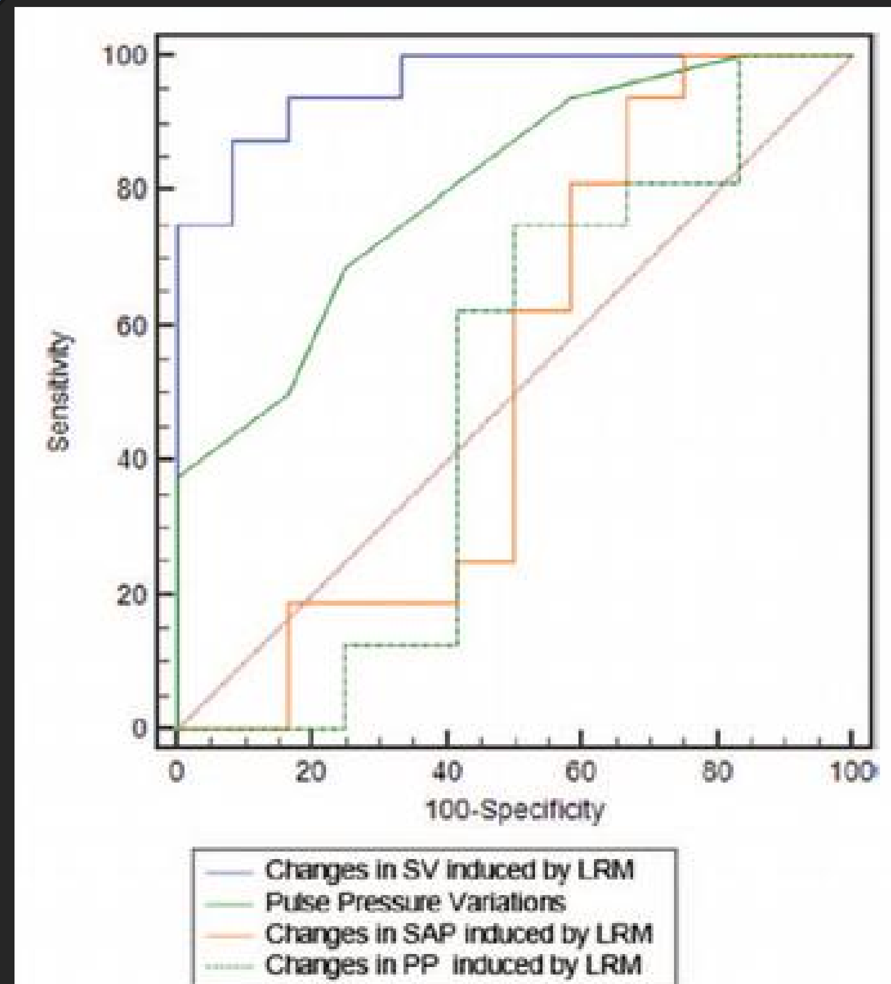
RECRUITMENT

Changes in Stroke Volume Induced by Lung Recruitment Maneuver Predict Fluid Responsiveness in Mechanically Ventilated Patients in the Operating Room

Matthieu Biais, M.D., Ph.D., Romain Lanchon, M.D., Musa Sesay, M.D., Lisa Le Gall, M.D., Bruno Pereira, Ph.D., Emmanuel Futier, M.D., Ph.D., Karine Nouette-Gaulain, M.D., Ph.D.

30 (cm H2O) na 30 (s)





PEEP CHALLENGE

Minerva Anestesiologica 2019 Jun 17

DOI: 10.23736/S0375-9393.19.13721-2

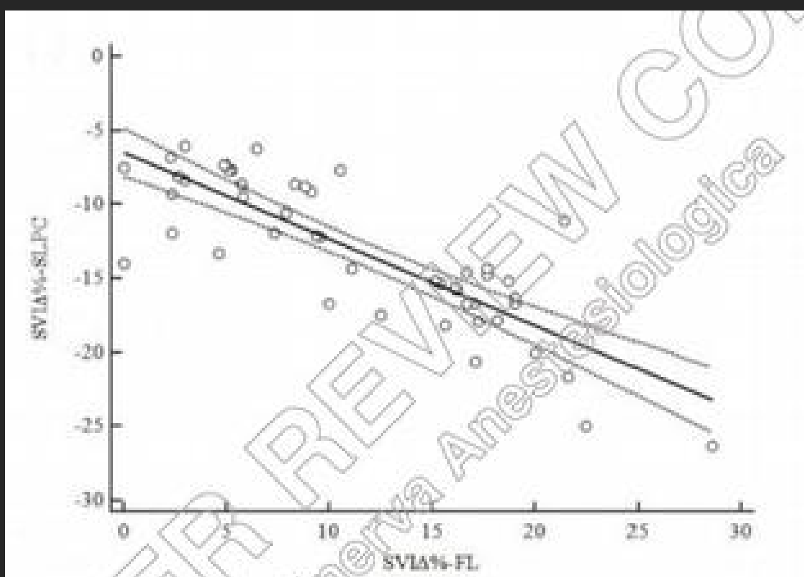
language: English

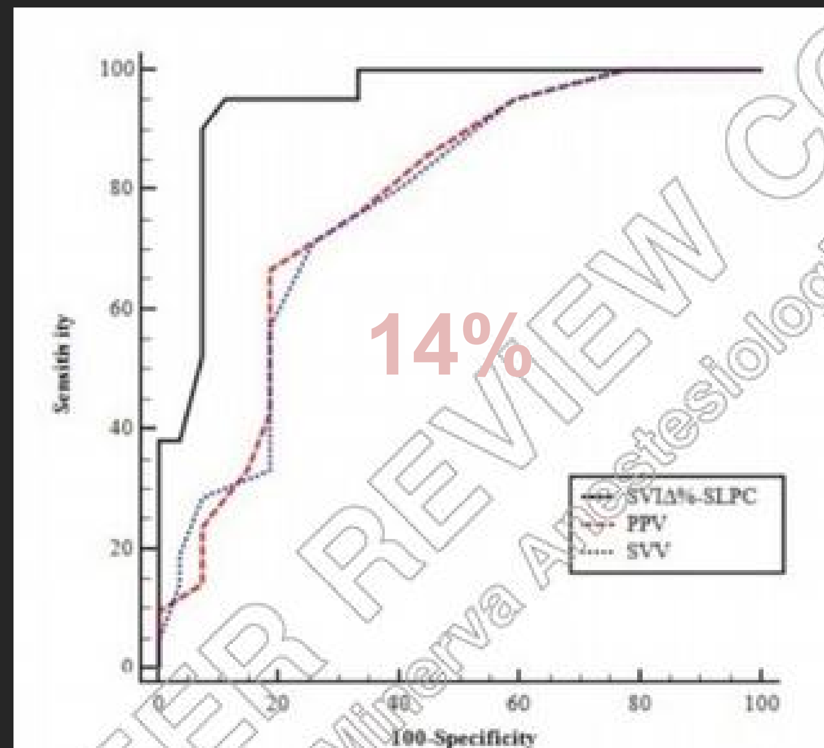
A challenge with 5 cmH2O of positive end-expiratory pressure predicts fluid responsiveness in neurosurgery patients with protective ventilation: an observational study

Achmet ALI [1], Evren AYGUN [1], Taner ABDULLAH [1], Sahika BOLSOY-DEVECI [2], Mukadder ORHAN-SUNGUR [1], Mert CANBAZ [1], Ibrahim O. AKINCI [1]

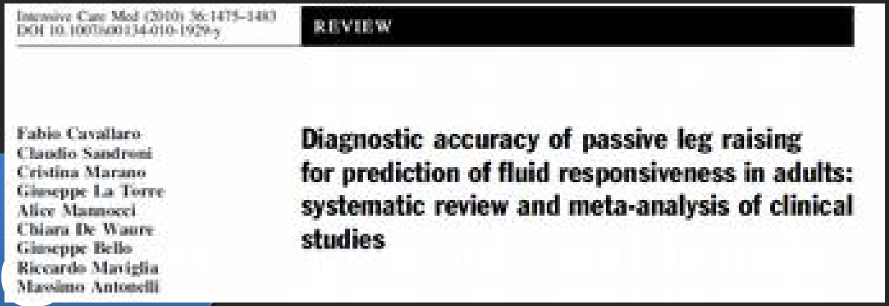
[1] *Department of Anesthesiology and Reanimation, Istanbul Medical Faculty, Istanbul University, Istanbul, Turkey;* [2] *Department of Anesthesiology and Reanimation, Besni State Hospital, Adiyaman, Turkey*

ΔPEEP 5 cmH2O





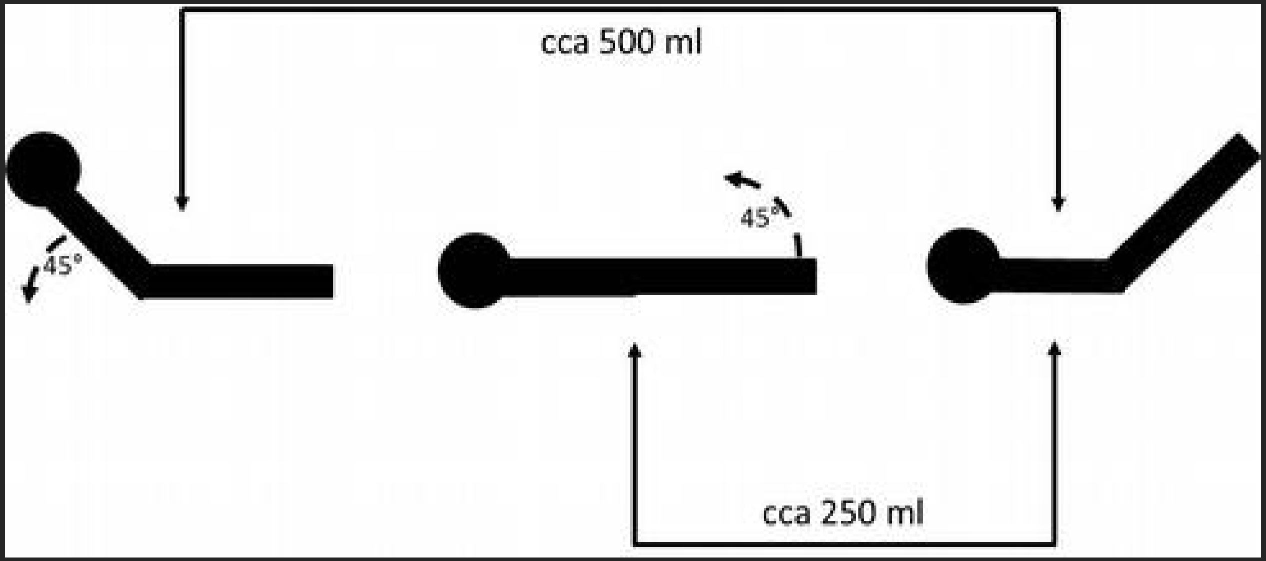
PASSIVE LEG RAISING


Intensive Care Med (2010) 36:1475–1483
DOI 10.1007/s00134-010-1929-y

REVIEW

Fabio Cavallaro
Claudio Sandroni
Cristina Marano
Giuseppe La Torre
Alice Mannocci
Chiara De Waure
Giuseppe Bello
Riccardo Maviglia
Massimo Antonelli

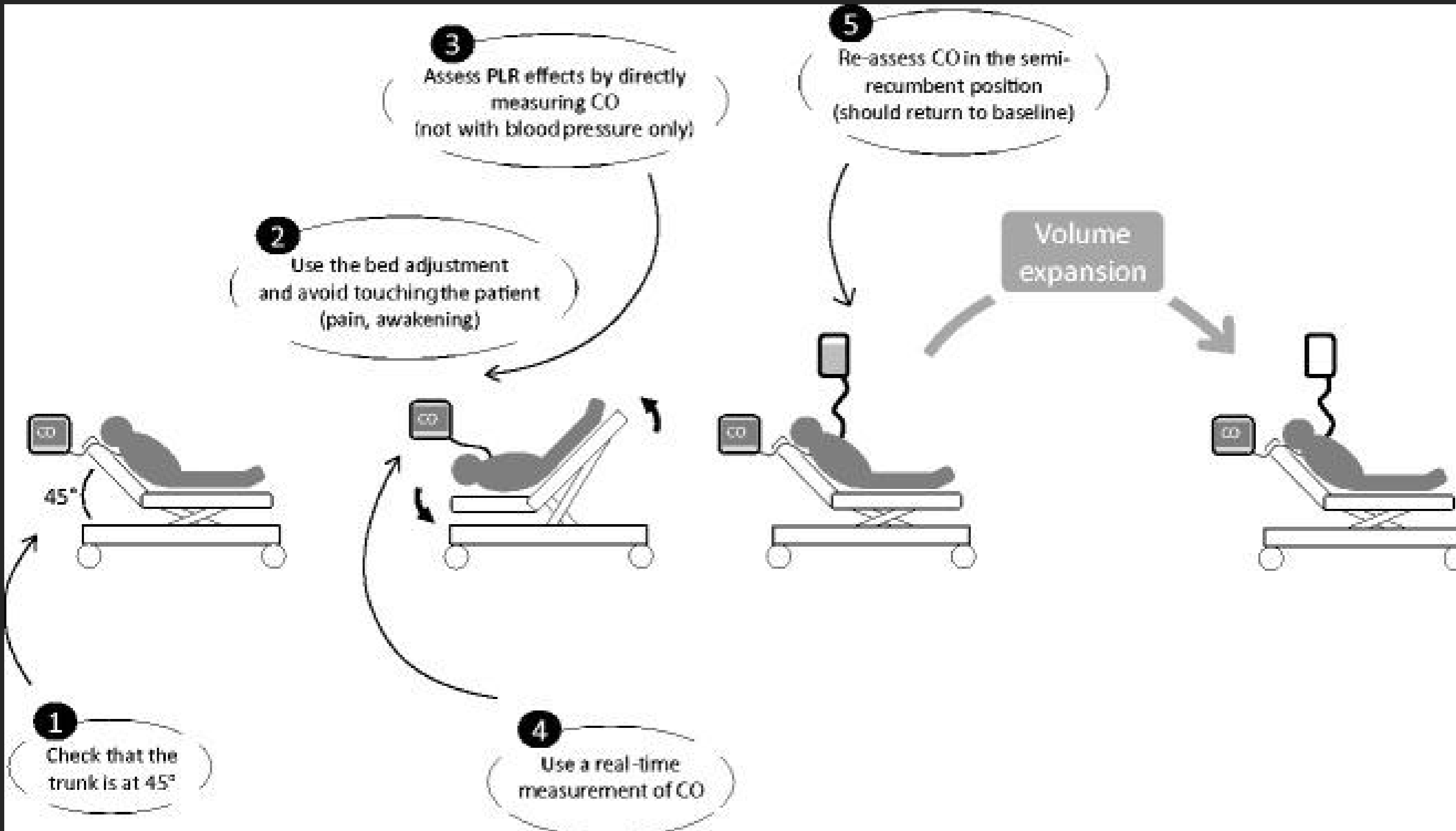
Diagnostic accuracy of passive leg raising for prediction of fluid responsiveness in adults: systematic review and meta-analysis of clinical studies



ΔSV/CO 10% ... AUC 0,95

Δ ABF/VTI 8-12% … AUC 0,96

ΔPP 9-12% … AUC 0,76

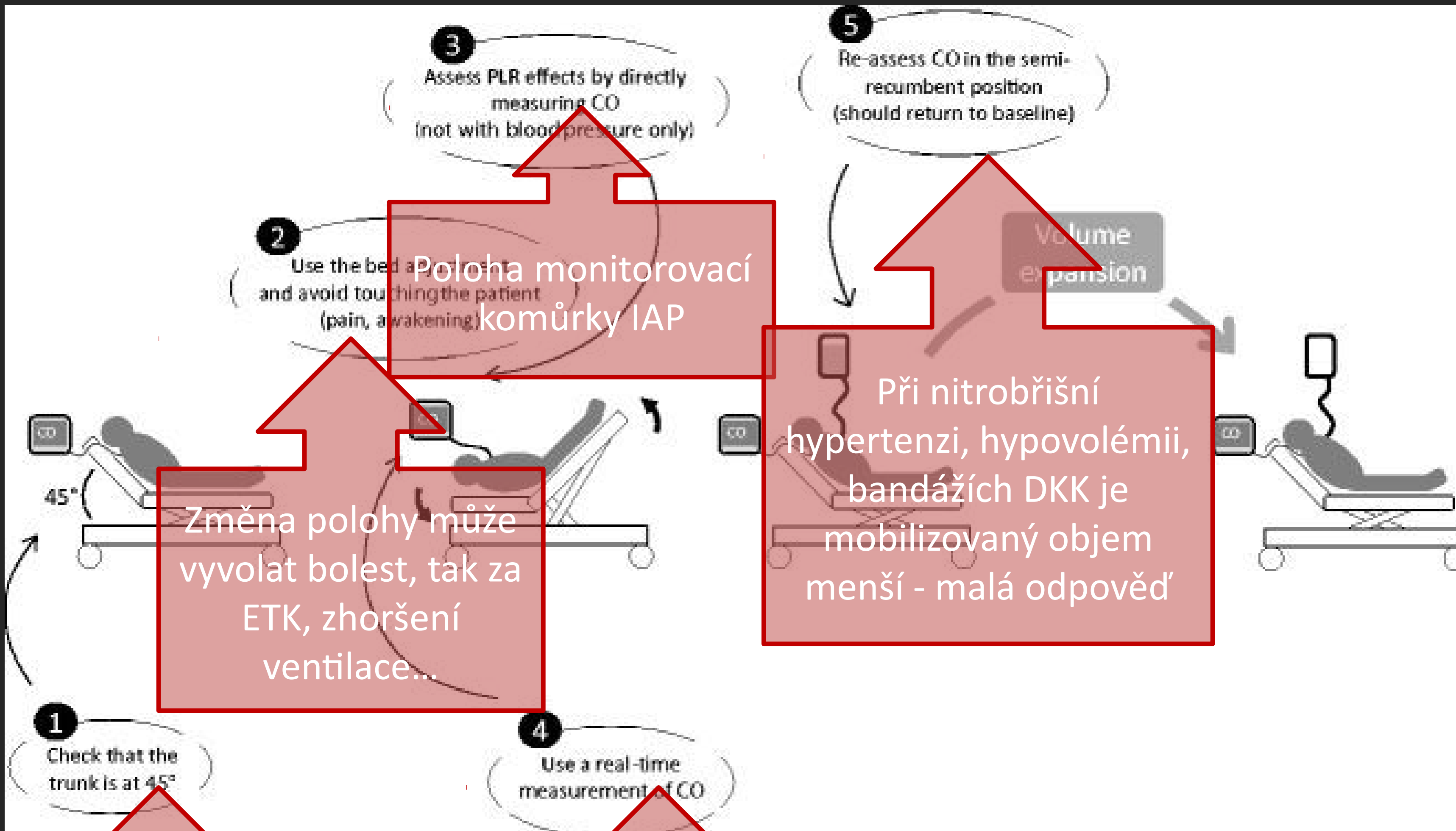


CRITICAL CARE

EDITORIAL

Passive leg raising: five rules, not a drop of fluid!

Xavier Monnet[1,2*] and Jean-Louis Teboul[1,2]



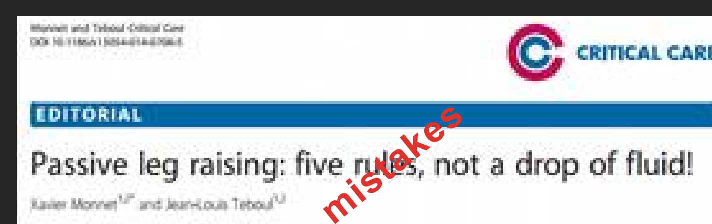
Poloha monitorovací komůrky IAP

Při nitrobřišní hypertenzi, hypovolémii, bandážích DKK je mobilizovaný objem menší - malá odpověď

Změna polohy může vyvolat bolest, tak za ETK, zhoršení ventilace...

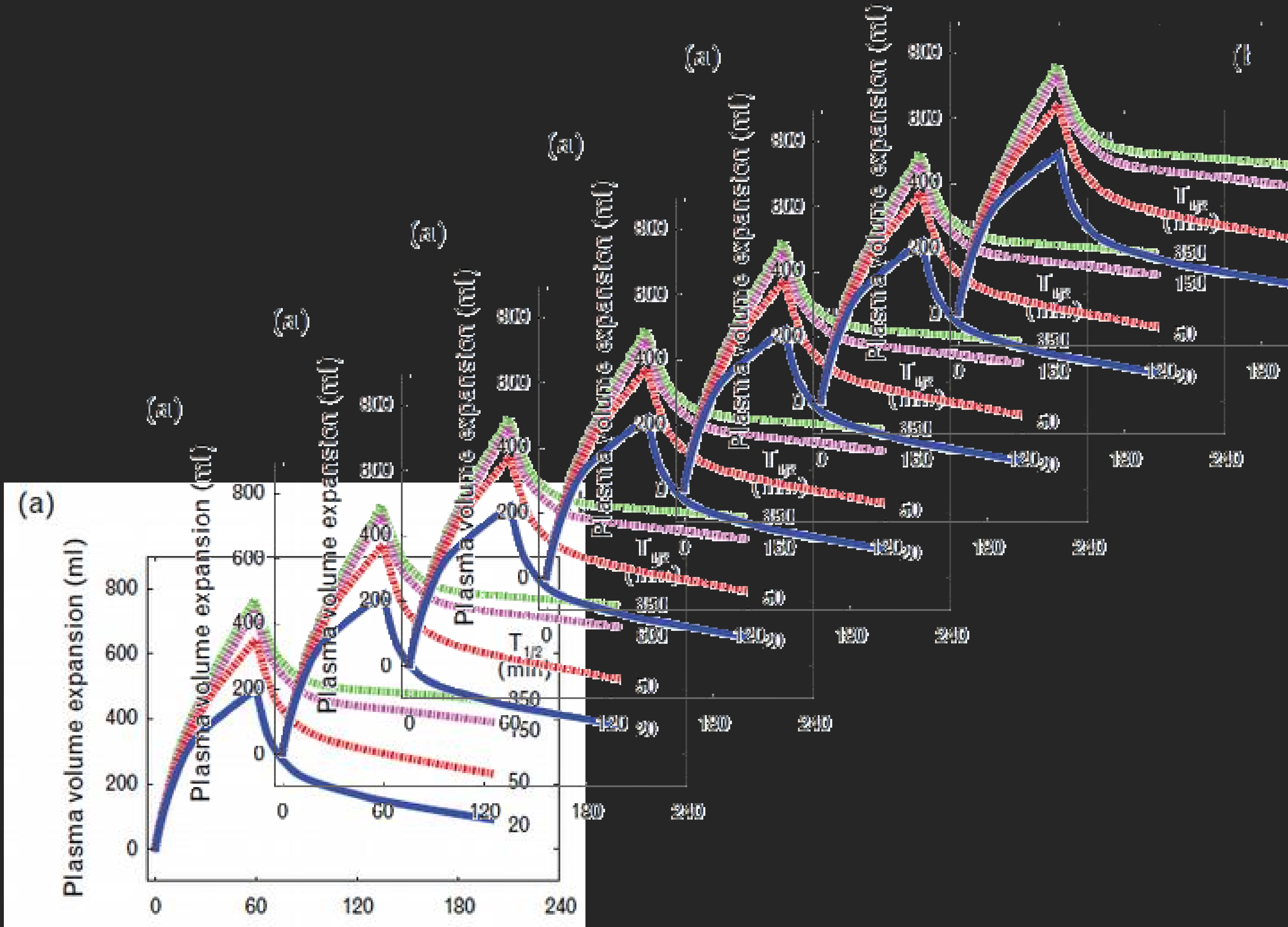
Kontraindikace změny polohy (ICP)

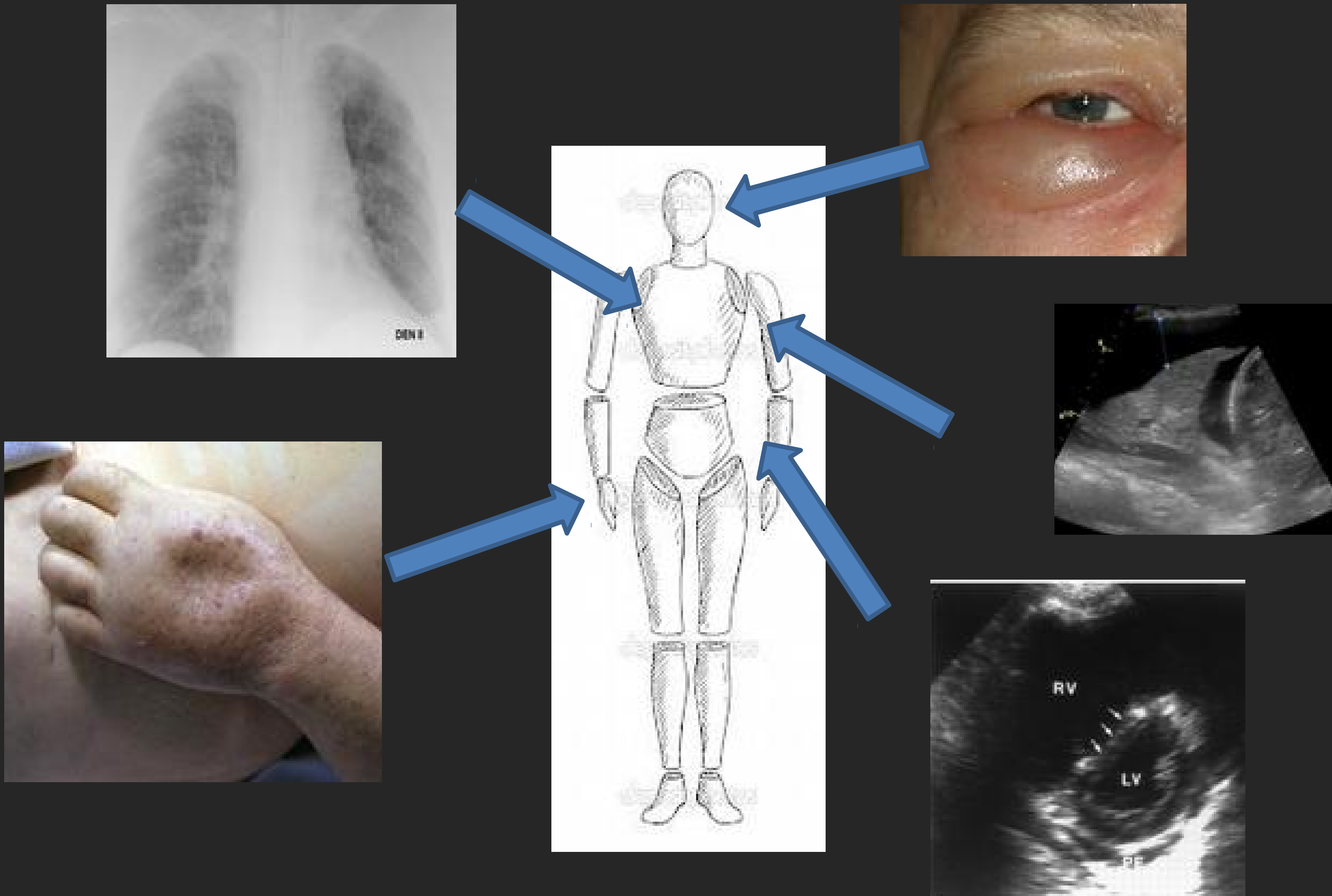
Nestejné místo zhodnocení (ECHO), faktor času



I WANT YOU TO

GIVE FLUIDS


(a)
Plasma volume expansion (ml)
800
600
400
200
0
0
60
120
180
240
$T_{1/2}$ (min)
350
150
50
20


RV
LV
PE

JE-LI FR A
POTŘEBUJE JI -
ZVAŽ TEKUTINU

NENÍ-LI FR
NEDÁVEJ
TEKUTINU

EJ TEKUTINU
DOKUD
JE FR

Díky za pozornost

benesj@fnplzen.cz