Part 2

Ultrasound

for

Non-invasive Hemodynamic Monitoring

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Scenario

- 66 y/o man
- Past Hx: heart failure, alcoholic liver cirrhosis, DM, ESRD
- Transfer to ICU: sepsis, suspect SBP
- T/P/R: 39℃, 130 bpm (sinus), 30/min
- BP 95/40 mmHg; GCS E3M5V2; SpO2 95% (mask)
- Positive PE: abd. tender, massive ascites, pitting edema

你敢灌水嗎?

直接用升壓劑and/or強心劑嗎?

佛系重症醫療

不用密集血流動力學監測

不抽血 不照片

不給輸液 不給藥

緣份到了 病患自然會轉出ICU

Rate

Volume

Resistance

Pump

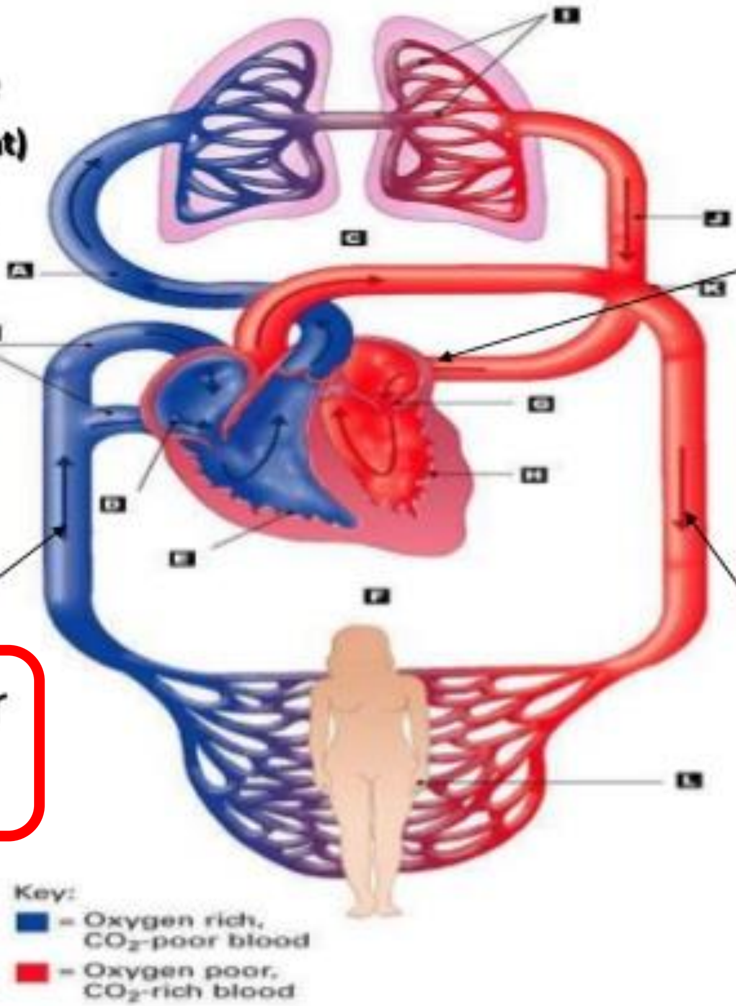
Am J Emerg Med. 2017 Sep;35(9):1335-1347.

4 factors that affecting the hemodynamic conditions

C.O.= HR x **Stroke Volume** **(60-130 Ml/beat)**

Stroke Volume has three components

1. Preload
2. Afterload
3. Contractility



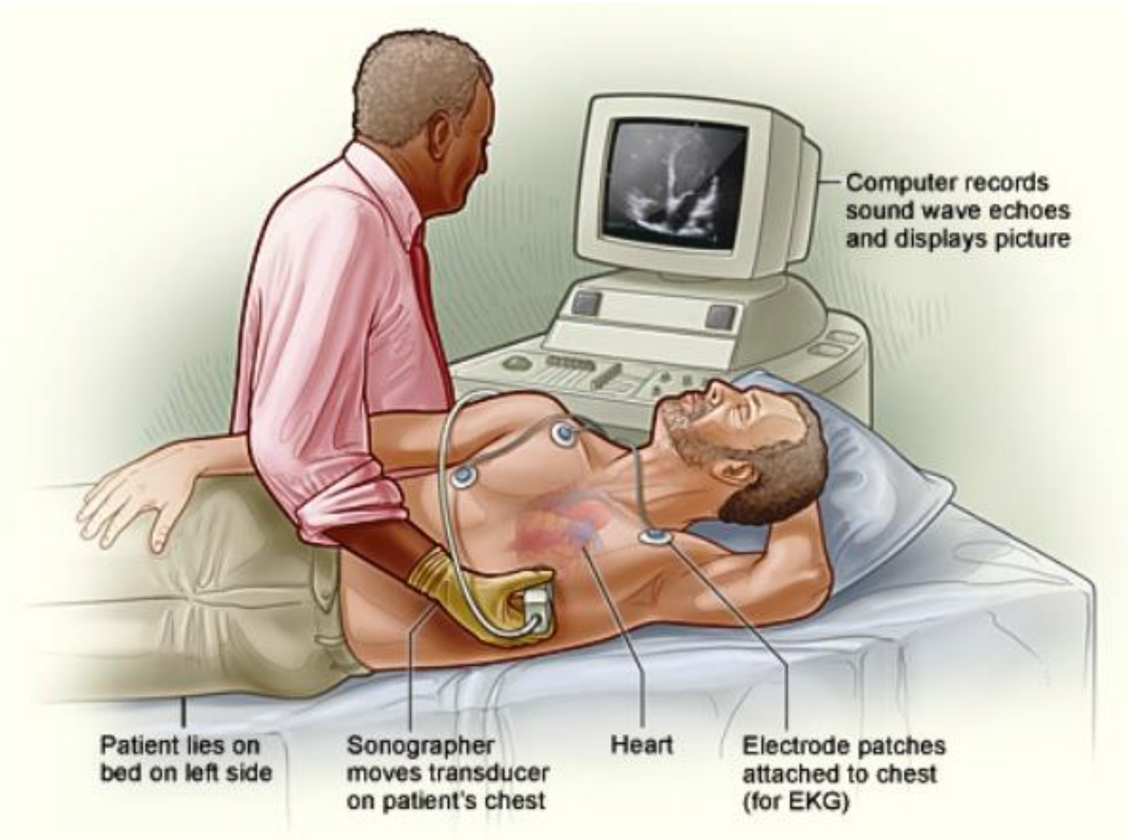
1-Intravascular volume

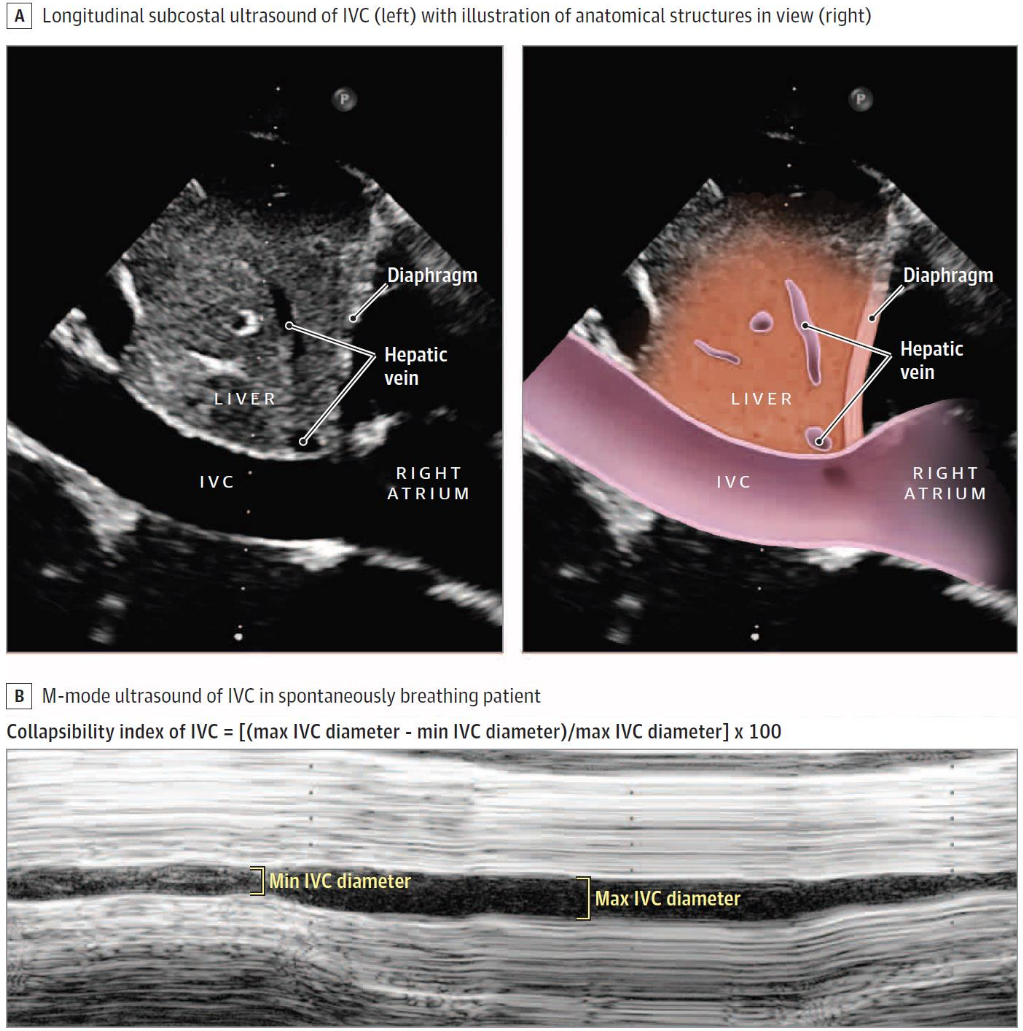
2-Myocardial contraction

3- heart rate

4.Vasoactivity

Ultrasound is a tool





Conflict of Interest: NO

Swan-Ganz catheter

FloTrac® & EV1000®

CO status®

ICON® & AESCULON®

Masimo Root

PiCCO®

LiDCO®

Uscom

CHEETAH NICOM

ClearSight™

中華民國重症醫學專科醫師聯合甄審委員會認證課程

Hemodynamic Monitoring : From Theory to Clinical Application
From Invasive, Minimally-invasive to Non-invasive

聯甄積分 9 分(限額 250 名)

一、課表

■ 時間：2018年3月31日(星期六)08:30-17:20
■ 地點：中國醫藥大學附設醫院I棟癌症大樓1樓階梯教室

時間	題目	講者/座長
08:30 – 09:00	報 到	
09:00 – 09:10	Opening	廖文進 理事長 (中華民國急救加護醫學會)
	座長：廖文進 副院長 (台中童綜合醫院)	
09:10 – 09:50	Evaluation and management of Circulatory Shock : Differential Diagnosis and Treatment	張家昇 醫師 (中國附醫 麻醉部)
09:50 – 10:30	Hemodynamic management in Intensive Care : The State of the Art	黃俊德 醫師 (臺中榮總 重症醫學部)
10:30 – 10:50	***Healthy Break***	
	座長：李博仁 部主任 (臺中榮總 重症醫學部)	
10:50 – 11:30	Evolution of Hemodynamic Monitoring Now : From Tradition to Advanced and Clinical Application of Pulmonary Artery Catheter (Swan Ganz /Thermodilution)	沈靜慧 主任 (臺中榮總 麻醉科)
11:30 – 12:10	Echocardiography application in Intensive Care For Cardiac output and fluid state monitor (Blue/Fall Protocol)	Dr. Gladys Kwan (Tuen Mun Hospital, Hong Kong)
12:10 – 13:30	***Lunch***	
	座長：梁信傑 主任 (TBD 中國附醫 內科加護房)	
13:30 – 14:10	Transpulmonary Thermodilution: Advantage and Disadvantage	袁國慶 主任 (北醫附醫 第二加護病房)
14:10 – 14:50	Non-invasive Hemodynamic Monitoring (ClearSight) current status and future challenge	林怡萱 醫師 (TBD) (臺大醫院 麻醉科)
14:50 – 15:10	***Healthy Break***	
	座長：吳世銓 教授 (中國附醫 麻醉部)	
15:10 – 15:50	Clinical application of Uncalibrated Pulse Contour Waveform Analysis (FloTrac)	劉偉倫 醫師 (輔大附醫 重症醫學部)
15:50 – 16:30	The Future and Benefit of Advanced Hemodynamic Monitoring	*Prof.* Frederic Michard (Lausanne, Switzerland)
16:30 – 17:10	Hemodynamic Monitoring: An Integrative Perspective Pros & Cons	All Speakers
17:10 – 17:20	Closing Remarks 領取學分證明 (現場未領或遺失者不予補發)	吳世銓 教授 (中國附醫 麻醉部)

主辦單位：中華民國重症醫學專科醫師聯合甄審委員會
承辦單位：中華民國急救加護醫學會
協辦單位：台灣愛德華生命科學股份有限公司

其他積分：衛福部醫事人員繼續教育(醫師/專科護理師/護理師)
公務人員終身學習 8 小時

重症醫學專科醫師聯合甄審委員會學分認證課程

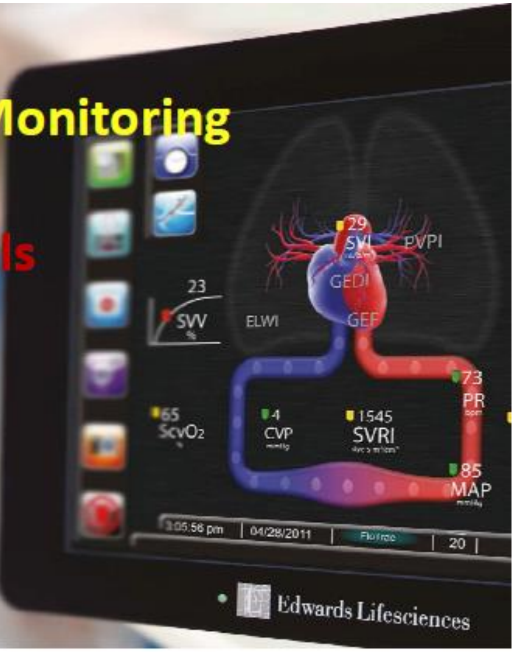
Current Update of Advanced Hemodynamic Monitoring in Critical Care(北區)

主辦單位：重症醫學專科醫師聯合甄審委員會
承辦單位：中華民國重症醫學會
時　　間：2018 年 03 月 31 日 (星期六)
地　　點：台北喜來登飯店 1 樓清翫廳 (台北市中正區忠孝東路一段 12 號)

聯甄 3 分	**臺灣急重症護理學會:** **護理師/士:專業 2.4 分** **專科護理師: 專業 2.4 分**
台灣醫學會 西醫師 : 專業 2.4 分	
台灣內科醫學會: B 類 5 分、台灣麻醉護理學會:2.4 分 **台灣感染症醫學會: B 類 1 分**	

時間	題目	講者/座長
09:30 – 09:40	報 到	
09:40 – 09:50	Opening	周嘉裕 部主任
	座長：周嘉裕 部主任 (台北榮總 重症醫學部)	
09:50 – 10:30	GDT and Hemodynamic Optimization in Critical Care Patient Treatment	哈多吉 部主任 (輔大醫院 急診重症醫學部)
10:30 – 11:10	Hemodynamic Monitoring in Traumatic Patients – What's the Benefits and Needs	韓吟宜 醫師 (臺大醫院 創醫部)
11:10 – 11:30	***Coffee break***	
	座長：周嘉裕 部主任 (台北榮總 重症醫學部)	
11:30 – 12:10	Current Update in Advanced Hemodynamic Monitoring	*Prof.* Frederic Michard (MiCo Founder & Managing Director)
12:10 – 12:30	Q & A	All speakers
12:10 – 12:30	Closing Remarks **簽退領取學分證明 (現場未領或遺失者不予補發)**	周嘉裕 部主任

Haemodynamic Monitoring with Live Porcine Physiologic Models



SG-ANZICS

Pre-Conference Workshop

16th May 2018 (Wed)

Basement 1, NNI Exhibition Hall and
Surgical Sciences Training Centre (SSTC),
Tan Tock Seng Hospital, Singapore

Course Fee: $ 300

Synopsis

The haemodynamic monitoring workshop is designed for doctors working in anaesthesia, emergency medicine and critical care medicine who are taking care of haemodynamically unstable patients. The main objective is to equip participants with the knowledge in interpreting basic and advanced haemodynamic parameters such as $ScvO_2$, stroke volume variation and its limitations. Live animals will be used to demonstrate the changes in haemodynamic parameters for various shock states and response to pharmacological and physiological manoeuvres. Continuous haemodynamic parameters will be correlated with "live" echocardiographic examinations.

Faculty

Tan Tock Seng Hospital, Singapore
- Dr Jonathan TAN, Senior Consultant, AICPM
- Dr FONG Wee Kim, Consultant, AICPM
- Dr CHIA Yew Woon, Consultant, Cardiology
- Dr Paul DRAKEFORD, Registrar, AICPM

Sydney, Australia
- Professor Anthony McLEAN
- Professor Stephen HUANG

Organiser

Tan Tock Seng HOSPITAL

Registration

https://www.ttsh.com.sg/Haemodynamic-Monitoring/

4 CME points (Event ID: SMC20180208-1B-0007)

Sponsor

Edwards

Time	Topic
07:30 – 08:00	**Registration** @ B1 NNI Exhibition Hall
08:00 – 08:05	Welcome and workshop overview
08:05 – 08:50	ESICM concensus on Haemodynamic Monitoring
08:50 – 09:35	Physiology of Fluid Responsiveness and Haemodynamic Optimisation
09:35 – 10:10	Echocardiography in the shock patient
10:10 – 10:25	**MORNING TEA**
10:25 – 11:10	Hands-on station 1: Invasive monitoring [pulmonary thermodilution, transpulmonary thermodilution] and case study
11:10 – 11:55	Handson station 2: Minimally invasive monitoring [Pulse Contour Analysis, Continous venous oximetry] and case study
11:55 – 12:40	Hands-on station 3: Non-invasive monitoring [Photoplethysmography, Bioimpedence/ Bioreactance] and case study
12:40 – 13:20	**LUNCH**
13:20 – 16:15	Simulated Shock Scenarios - Live streaming from Physiology lab
16:15 – 16:25	Evaluation and Feedback
16:25 – 17:00	Summary and Close

2015/10/25聯甄會

	compartment syndrome	
12:10-13:20		***LUNCH***
Mini-invasive hemodynamic monitoring: Why, When and How		
13:20-13:45	Clinical application of **PiCCO** (25 min)	
13:45-14:10	Clinical application of **FloTrac** (25 min)	( )
Non-invasive hemodynamic monitoring: Why, When and How		
14:10-14:35	Clinical application of **ICON**(25 min)	(
14:35-15:00	Clinical application of **USCOM**(25 min)	( )
15:00-15:20		***BREAK***
Traditional hemodynamic monitoring device		
15:20:15:40	Clinical application of **Swan-Ganz** catheters	(
15:40-16:00	Clinical application of bed-side Echocardiography	(

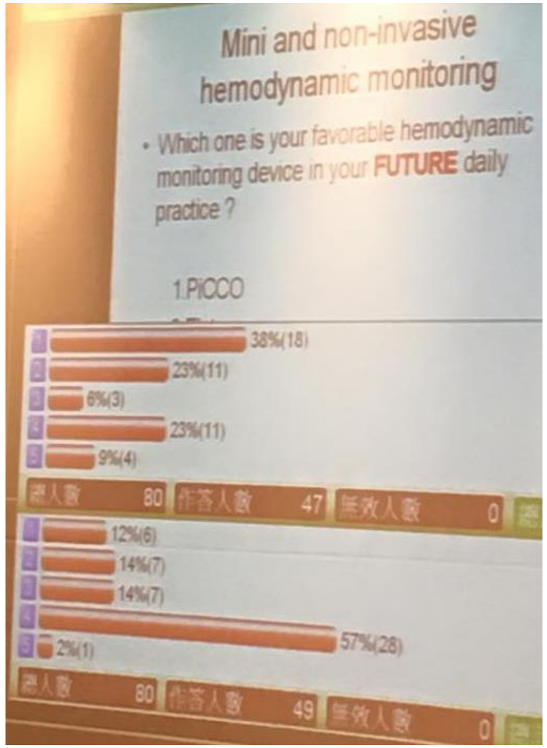
Which one is your favorite hemodynamic monitoring device in your future daily practice ?

2015/10/25

(**Before** introduction)

	PiCCO	Flotrac	ICON	USCOM	No idea
Before introduction	38%	23%	6%	23%	9%
After introduction	12%	14%	14%	57%	2%

(**After** introduction)



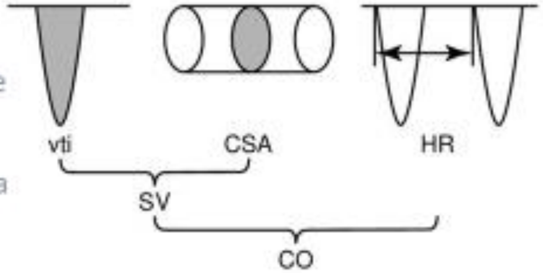
料理東西軍

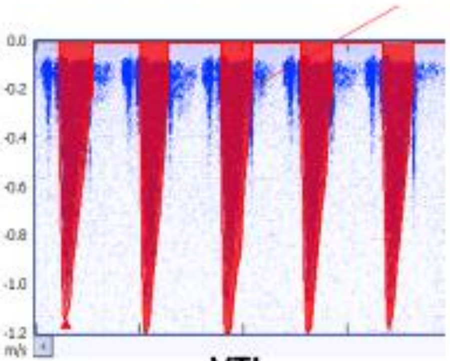
USCOM®

ICON® & AESCULON®

Cardiac Output = Stroke Volume x Heart rate

Stroke Volume = Stroke Distance x Flow Area





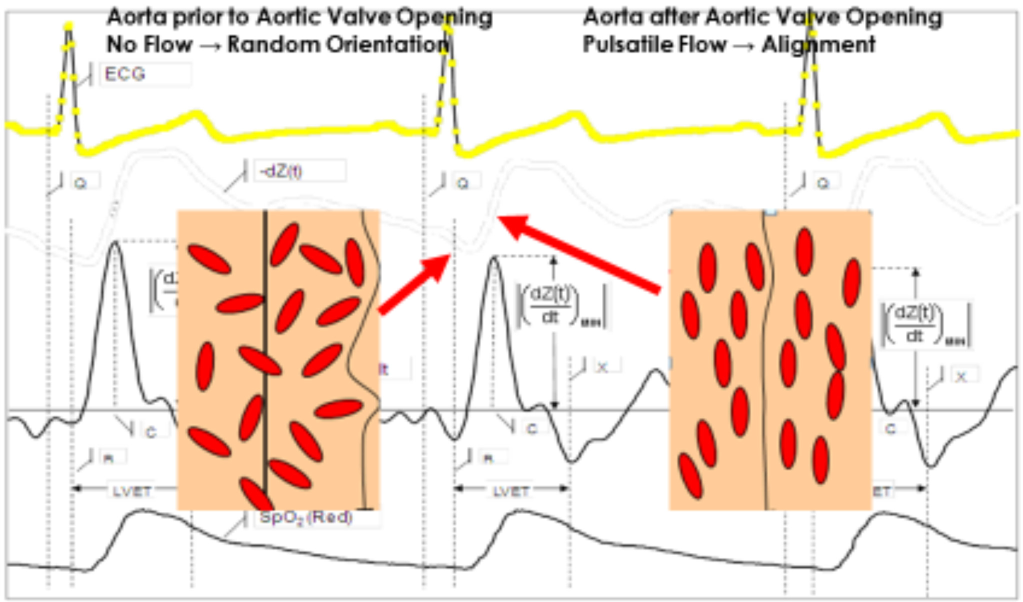
VTI

(Velocity time integral)

X

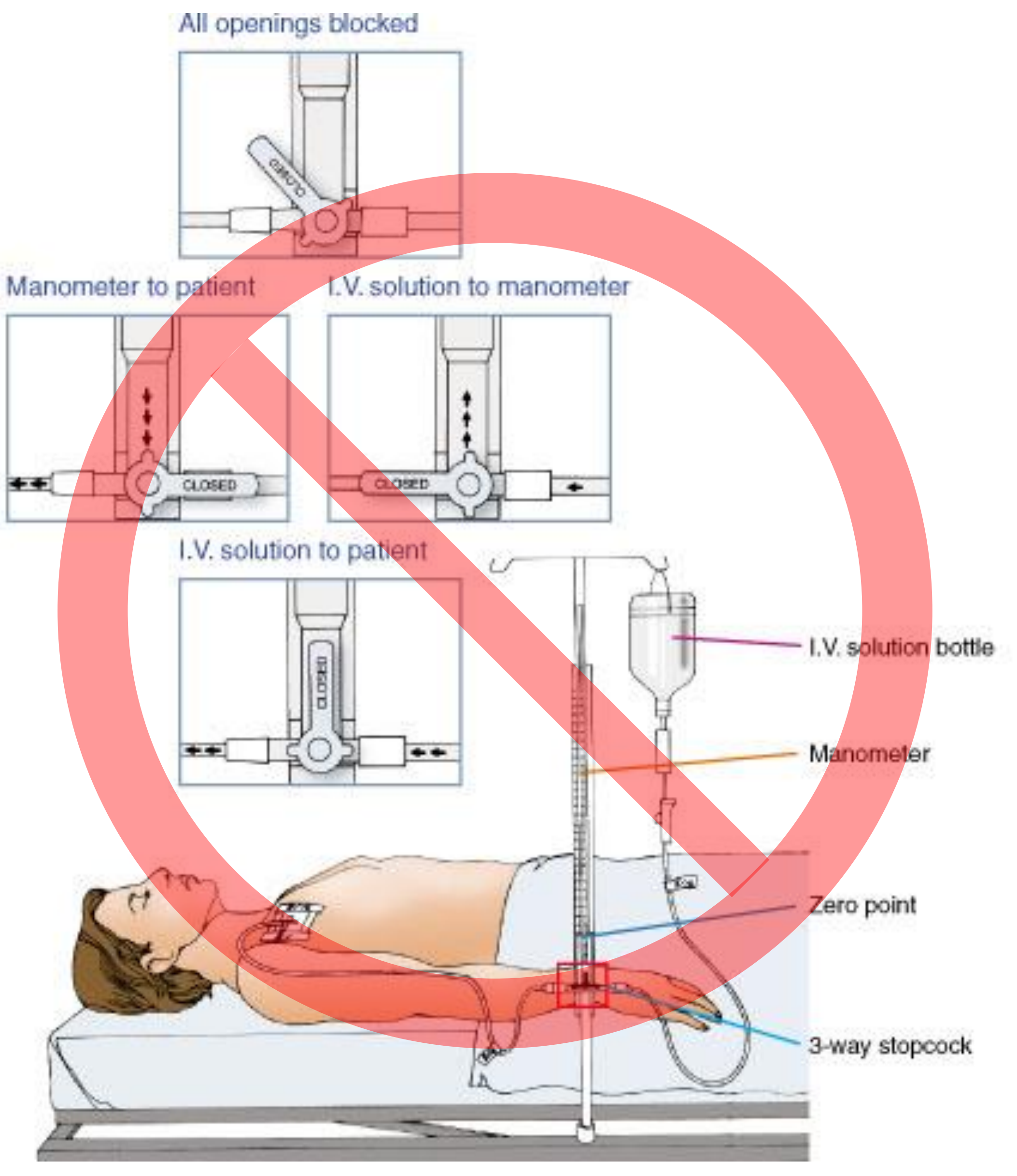
CSA

(Cross-sectional area)




Application of
Hemodynamic Monitoring
for Critically Ill Patients
with Shock
沒有完美的武器
只有適當的選擇


ECMO Free Hb



All openings blocked
CLOSED
Manometer to patient
CLOSED
I.V. solution to manometer
CLOSED
I.V. solution to patient
CLOSED
I.V. solution bottle
Manometer
Zero point
3-way stopcock

TAKE-HOME MESSAGE

Existing evidence suggests that central venous pressure poorly predicts fluid responsiveness in acute and critically ill patients.

Ann Emerg Med. 2016 Jul;68(1):114-6.

Comparison of low, intermediate, and high central venous pressure subgroups.

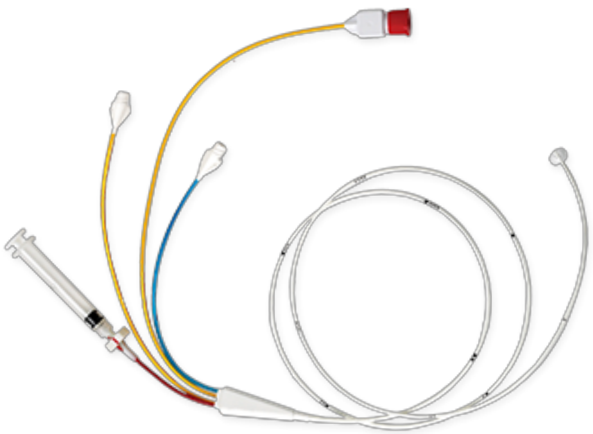
CVP Subgroup (mm Hg)	Number of Patients (%)	Positive Likelihood Ratio (95% CI)	Negative Likelihood Ratio (95% CI)	AUC-ROC (95% CI)
Low (<8)	537 (47)	1.40 (1.24–1.59)	0.74 (0.66–0.83)	0.57 (0.52–0.62)
Intermediate (8–12)	348 (30)	0.78 (0.65–0.94)	1.11 (1.03–1.20)	0.54 (0.48–0.60)
High (>12)	263 (23)	0.69 (0.55–0.85)	1.12 (1.05–1.19)	0.56 (0.48–0.63)

CVP, Central venous pressure; *CI*, confidence interval.

Pulmonary artery catheters for adult patients in intensive care (Review)

Rajaram SS, Desai NK, Kalra A, Gajera M, Cavanaugh SK, Brampton W, Young D, Harvey S, Rowan K

Cochrane Database Syst Rev. 2013 Feb 28;(2):CD003408.



THE COCHRANE COLLABORATION®

Analysis 1.1. Comparison 1 Combined mortality PAC versus no PAC, Outcome 1 Combined mortality of all studies.

Review: Pulmonary artery catheters for adult patients in intensive care

Comparison: 1 Combined mortality: PAC versus no PAC

Outcome: 1 Combined mortality of all studies

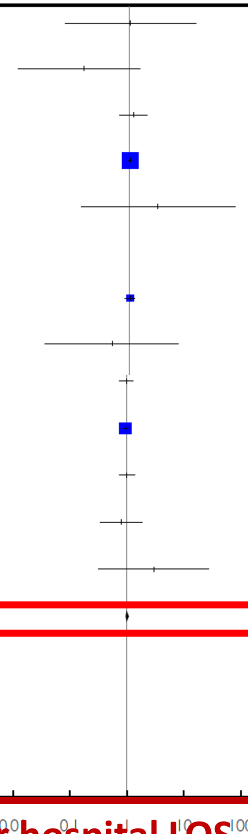
Study or subgroup	PAC n/N	Control n/N	Risk Ratio M-H,Random,95% CI
Bender 1997	1/51	1/53	1.04 [0.07, 16.18]
Berlauk 1991	1/68	2/21	0.15 [0.01, 1.62]
Guyatt 1991	10/16	9/17	1.18 [0.66, 2.12]
Harvey 2005	346/506	337/507	1.03 [0.94, 1.12]
Isaacson 1990	1/49	0/53	3.24 [0.14, 77.71]
Joyce 1990	0/21	0/19	0.0 [0.0, 0.0]
NHLBI 2006	140/513	128/487	1.04 [0.85, 1.27]
Pearson 1989	1/152	1/74	0.49 [0.03, 7.68]
Rhodes 2002	46/96	50/105	1.01 [0.75, 1.34]
Richard 2003	199/335	208/341	0.97 [0.86, 1.10]
Sandham 2003	78/997	77/997	1.01 [0.75, 1.37]
Shoemaker 1988	11/58	7/30	0.81 [0.35, 1.88]
Valentine 1998	3/60	1/60	3.00 [0.32, 28.03]
Total (95% CI)	**2922**	**2764**	**1.01 [0.95, 1.08]**

Total events: 837 (PAC), 821 (Control)

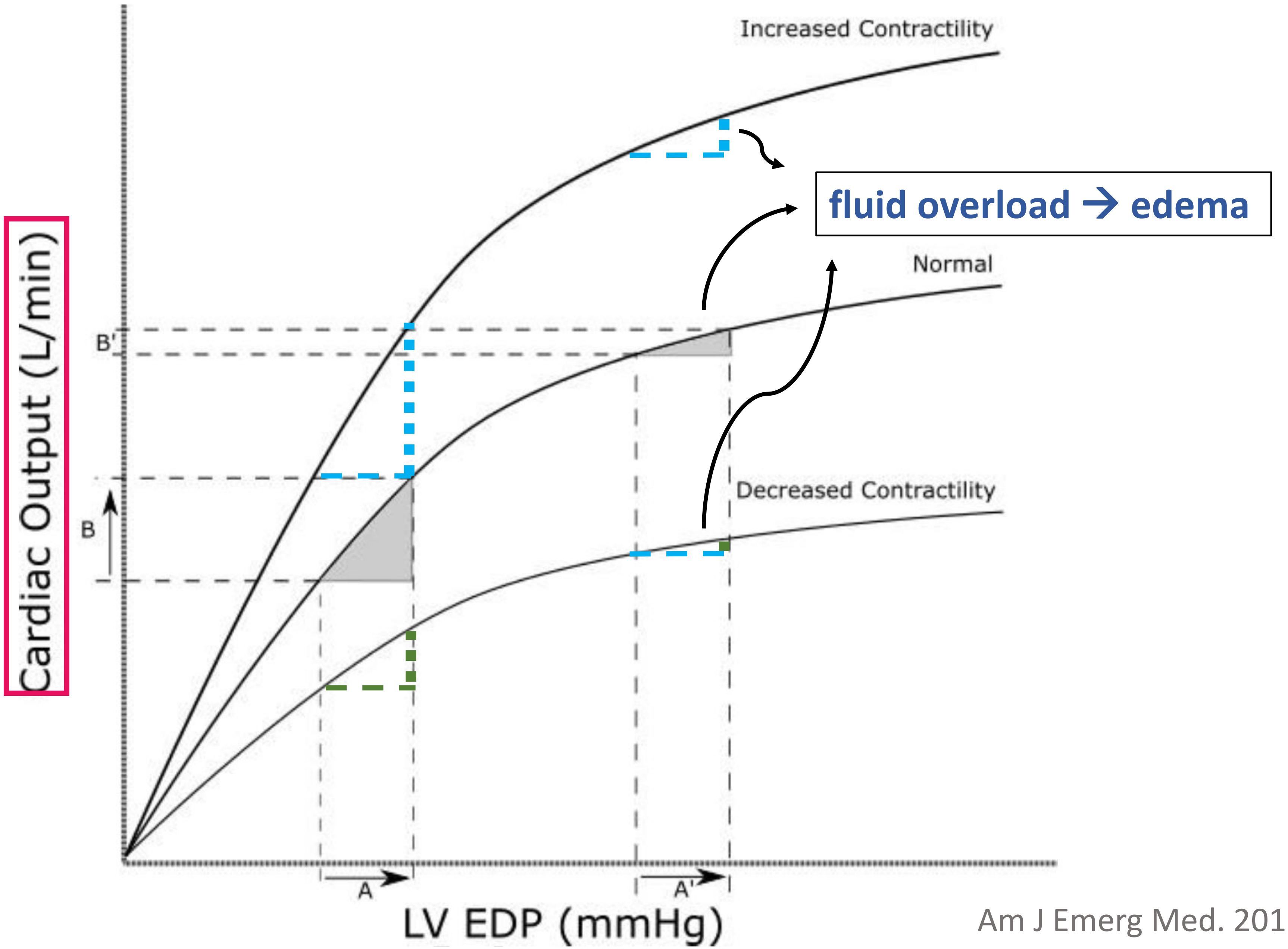
Heterogeneity: Tau² = 0.0; Chi² = 5.26, df = 11 (P = 0.92); I² =0.0%

Test for overall effect: Z = 0.41 (P = 0.68)

Test for subgroup differences: Not applicable



Use of a PAC did not alter the mortality, general ICU or hospital LOS, or cost for adult patients in ICU



你知道眼前的病人
目前處於哪個點嗎

Am J Emerg Med. 2017 Sep;35(9):1335-1347.

Dynamic changes of hemodynamic parameters to predict who is **fluid responsiveness**

是 當 今 王 道

Who is fluid responsiveness? By dynamic evaluation

Methods	Measure/ Cut off value	LR (+)	LR (-)	Reference
Passive leg raising	△CO 10%	**9.4**	**0.16**	Intensive Care Med. 2016 Dec;42(12):1935-1947.
Passive leg raising	△brachial a. peak velocity 10.6%	7	0.2	J Surg Res. 2018 Apr;224:207-214..
Passive leg raising	△corrected flow time 24.6%	7.2	0.4	Am J Med Sci. 2018 Feb;355(2):168-173.
Variation of peak velocity in artery	△ brachial a. 10.95%	8.9	0.23	J Surg Res. 2018 Apr;224:207-214..
Variation of peak velocity in artery	△ carotid a. 13%	7.8	0.24	Am J Emerg Med. 2017 Sep;35(9):1258-1261.
Collapsibility Index in vein	△ IVC, variable cut off value	2.84	0.38	J Intensive Care Med. 2018 Jan 1:885066617752308.
Collapsibility Index in vein	△ internal jugular vein 36%	5.2	0.26	Ulus Travma Acil Cerrahi Derg. 2017 Jul;23(4):294- 300.

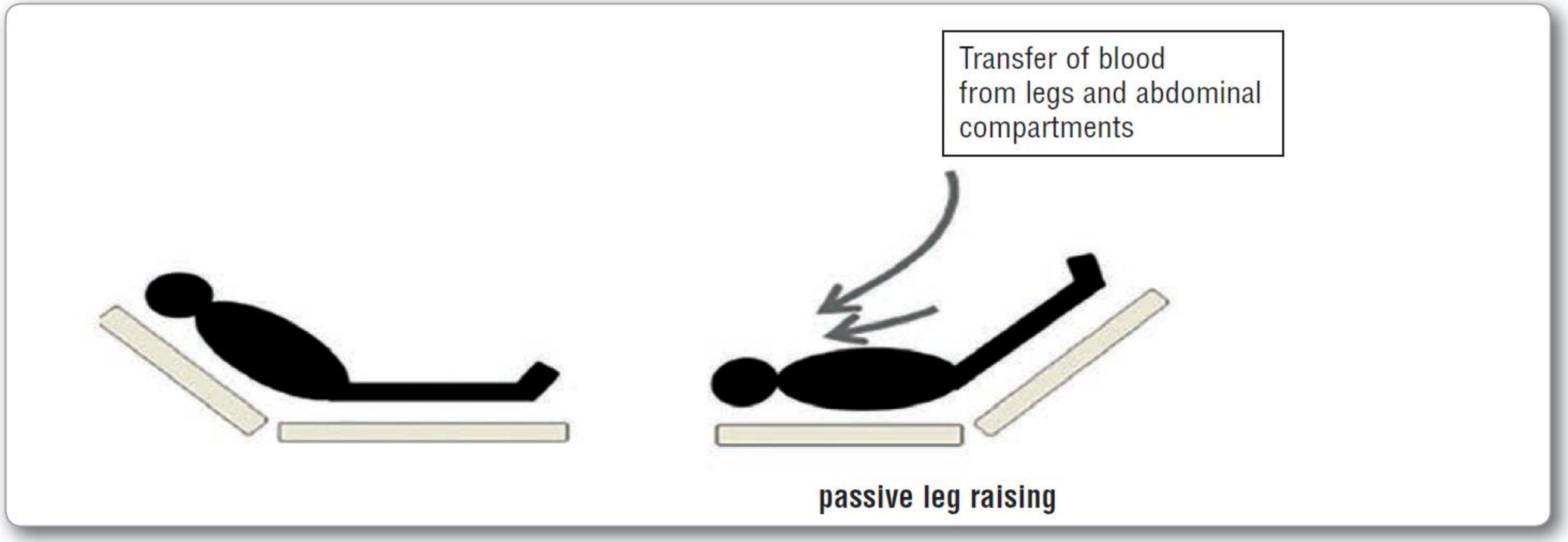
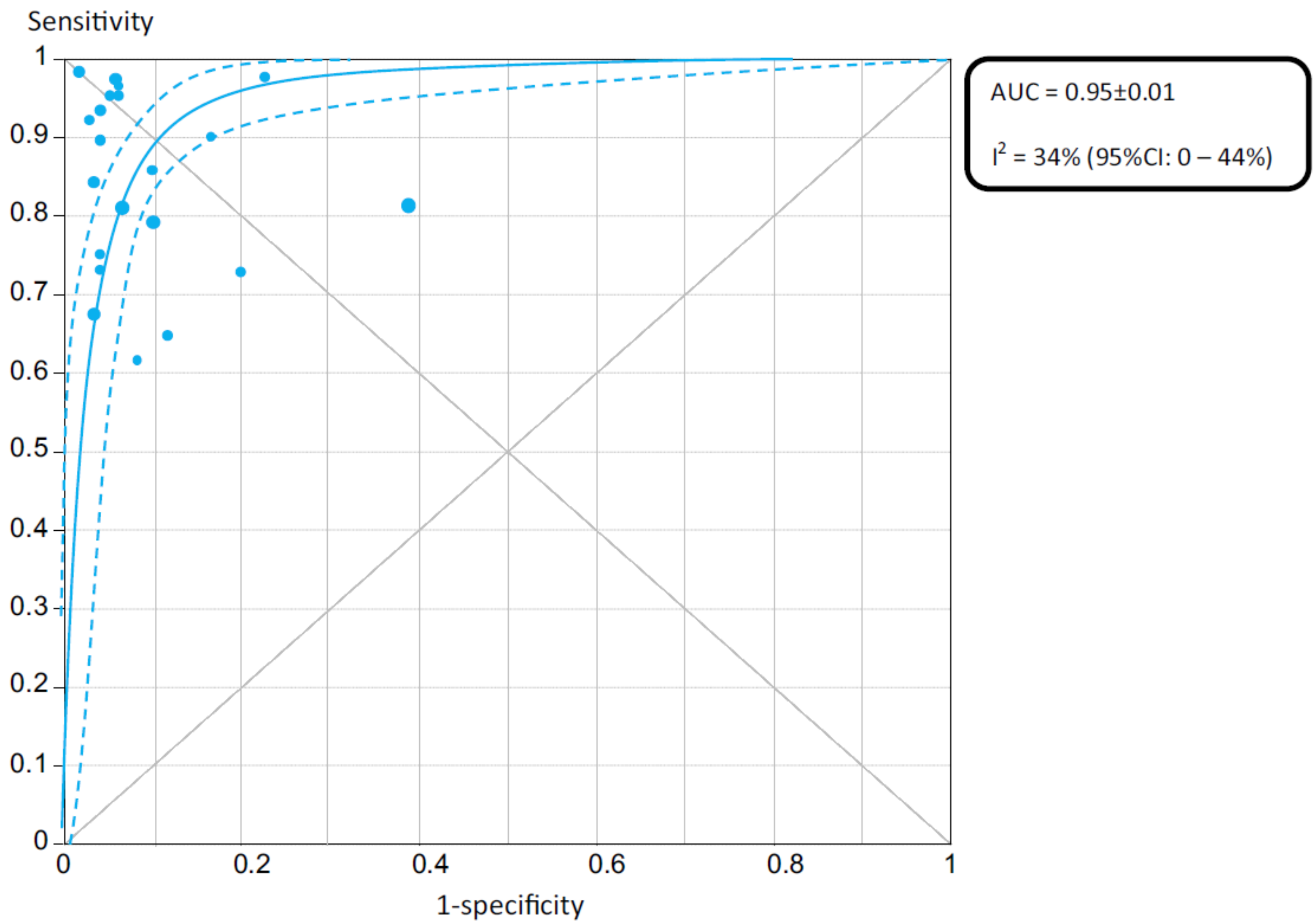


Figure 2 Passive leg-raising is performed by raising the patient's legs to a 45º angle while simultaneously lowering the patient's head and upper torso from a semirecumbent (head of bed elevated 45º) to a supine (flat) position. This maneuver tests for fluid responsiveness.

Adapted with permission from Marik et al.[3]

Intensive Care Med. 2016 Dec;42(12):1935-1947.



LR (+) = 9.4

Table 3 Main results of included studies with pooled and mean values

	Percentage increase in CO (or surrgoate) induced by volume expansion in fluid (%)	Correlation coefficient[a]	PLR-induced changes in cardiac output			
			Sensitivity	Specificity	Area under the ROC curve	Best threshold[b] (%)
Monnet et al. [9]	24	0.83	0.97	0.94	0.96	10
Lafanechère et al. [31]	17	0.71	0.90	0.83	0.95	8
Lamia et al. [32]	19	0.79	0.77	1.00	0.96	13
Maizel et al. [37]	17	0.75	0.63	0.89	0.89	12
Thiel et al. [33]	18	NA	0.81	0.93	0.89	15
Monnet et al. [34]	23	0.6	0.91	1.00	0.94	10
Biais et al. [35]	20	NA	1.00	0.80	0.96	13
Préau et al. [36]	16	0.86	0.86	0.90	0.94	10
Benomar et al. [22]	NA	0.77	0.68	0.95	0.84	9
Lakkhal et al. [21]	NA	NA	0.79	0.90	0.89	7
Guinot et al. [16]	2	0.85	0.62	0.92	0.88	10
Monnet et al. [18]	26	0.7	0.93	0.96	0.93	10
Brun et al. [19]	NA	0.64	0.75	1.00	0.93	12
Kang et al. [23]	9	NA	1.00	1.00	1.00	NA
Dong et al. [12]	14	NA	0.73	0.80	0.88	9
Monge-Garcia et al. [15]	21	0.84	0.95	0.94	0.97	12
Kupersztych-Hagège et al. [13]	14	0.74	0.84	0.97	0.87	9
Silva et al. [14]	38	0.65	1.00	1.00	0.93	10
Monnet et al. [17]	33	0.79	0.95	0.95	0.98	10
Marik et al. [20]	34	NA	0.94	1.00	NA	10
Duus et al. [11]	NA	NA	0.80	0.61	NA	NA
Pooled value/mean	20 ± 9	0.76 (0.73–0.80)	0.85 (0.81–0.88)	0.91 (0.88–0.94)	0.95 ± 0.01	10 ± 2

Results are reported as values, mean ± SD or mean (95% confidence interval)

NA not available

[a] Between PLR-induced and volume expansion-induced changes in cardiac output or surrogates

[b] For the PLR-induced increase in CO or surrogate

Echocardiogram is OK

Crit Care. 2017 Nov 17;21(1):279.

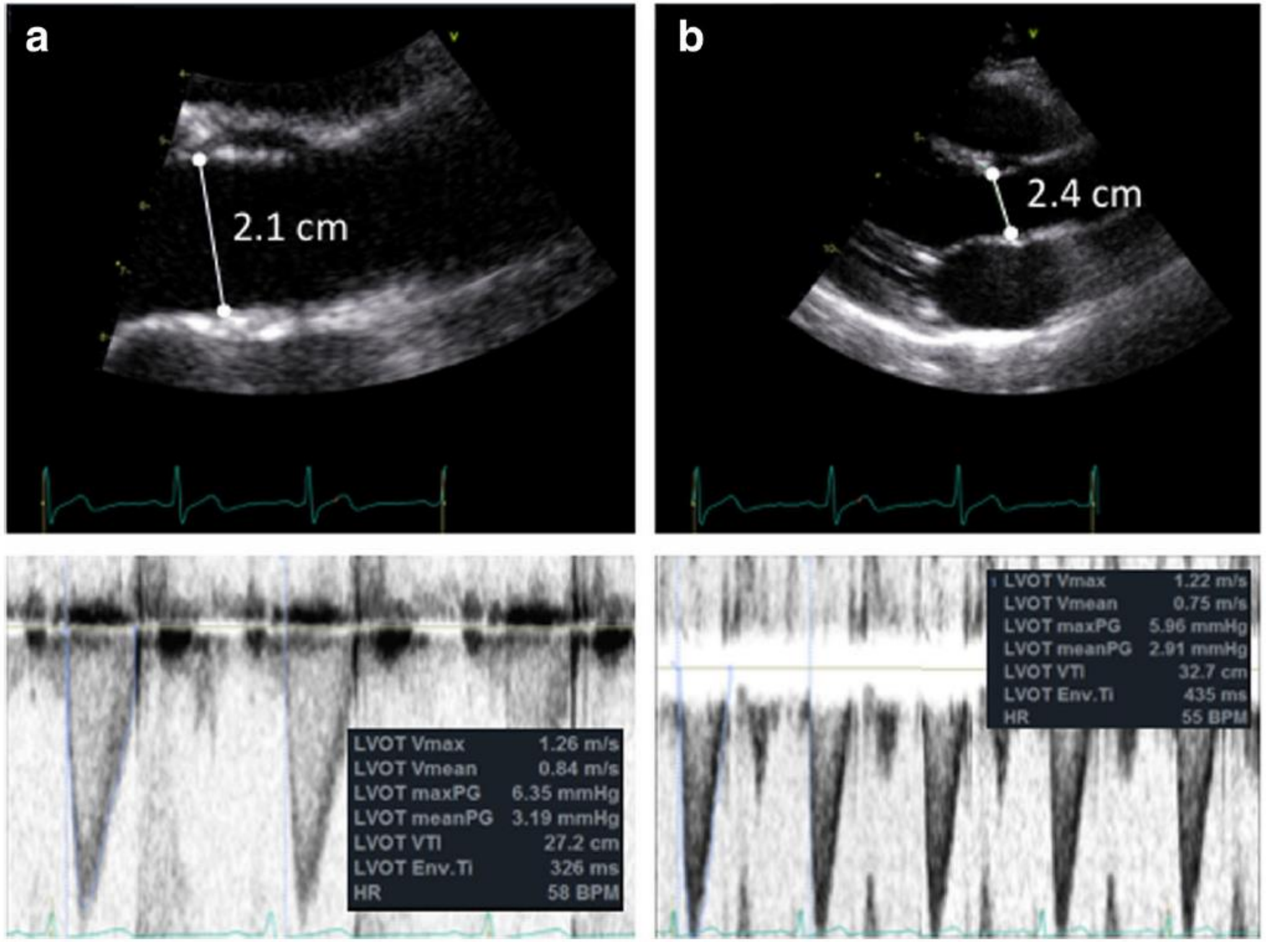


Fig. 1 Accurate stroke volume (SV) estimation: SV = $LVOT_{area} \times LVOT_{VTI}$. **a** *Accurate SV assessment* = [0.785 × 2.1 cm^2] × 27.2 cm = 94 ml. $LVOT_{area}$ estimation: use of zoomed in parasternal long-axis view of the aortic valve with LVOT diameter measured at mid-systole at the site of aortic valve cusp entry along with accurate Doppler settings for LVOT VTI assessment using high sweep speed, low wall filters and reduced gain for modal velocity estimation (brightest portion of spectral tracing) as well as seeing the aortic valve closing click. **b** *Inaccurate SV assessment* = [0.785 × 2.4 cm^2] × 32.7 cm = 148 ml. Potential pitfalls leading to inaccurate SV estimation include mistakes in 2D image acquisition as well as Doppler pitfalls: estimating $LVOT_{area}$ from non-zoomed aortic valve analysis, foreshortened or oblique plane of LVOT interrogation in 2D mode and LVOT spectral Doppler VTI assessment with the sample volume in a wrong position or being too large, with too high gain or too high wall filter settings, low sweep speed and baseline inappropriately low. Note overestimation or underestimation of SV assessment with inappropriate measures


SV
Trend
92

JOURNAL OF SURGICAL RESEARCH • APRIL 2018 (224) 207–214

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Evaluation of the fluid responsiveness in patients with septic shock by ultrasound plus the passive leg raising test

Jingyi Wu, MD,[a,1] *Zhen Wang, MD,*[a,1] *Tao Wang, MS,*[a] *Tao Yu, PhD,*[a] *Jing Yuan, MS,*[a] *Qingling Zhang, MS,*[b] *Weihua Lu, MS,*[a] *and Xia Zhang, MS*[b,*]

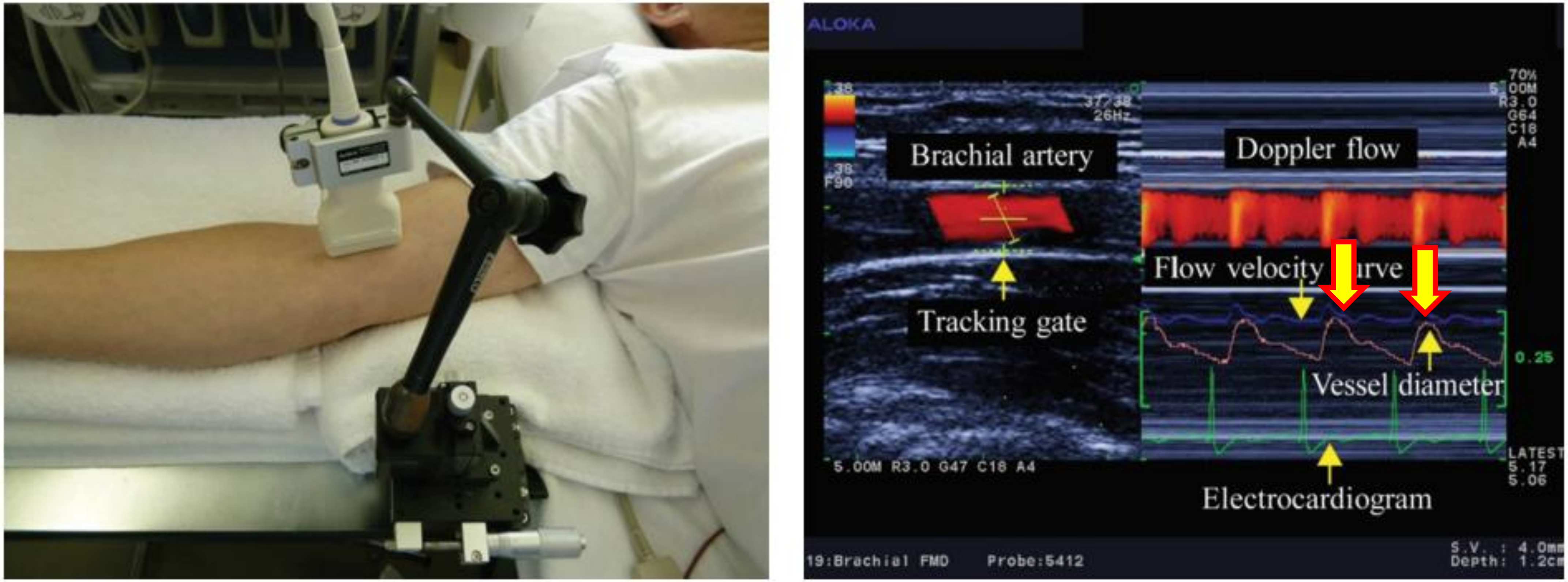
[a] *Department of Intensive Care Unit, The First Affiliated Hospital of Wannan Medical College, Wuhu, Anhui, China*
[b] *Department of Ultrasound, The First Affiliated Hospital of Wannan Medical College, Wuhu, Anhui, China*

J Surg Res. 2018 Apr;224:207-214.

Brachial artery
Peak Velocity

$$VVpeak_{brach}(\%) = 100\% \times (Vpeak_{max} - Vpeak_{min}) / [(Vpeak_{max} + Vpeak_{min})/2]$$

$$\Delta Vpeak_{PLR}(\%) = 100\% \times (Vpeak_{PLR} - Vpeak_1)/Vpeak_1$$



(a) Evid Based Complement Alternat Med. 2012;2012:513638. (b)

AUC:

Δ VpeakPLR 0.898

$VVpeak_{brach}$ 0.891

Δ VpeakPLR :

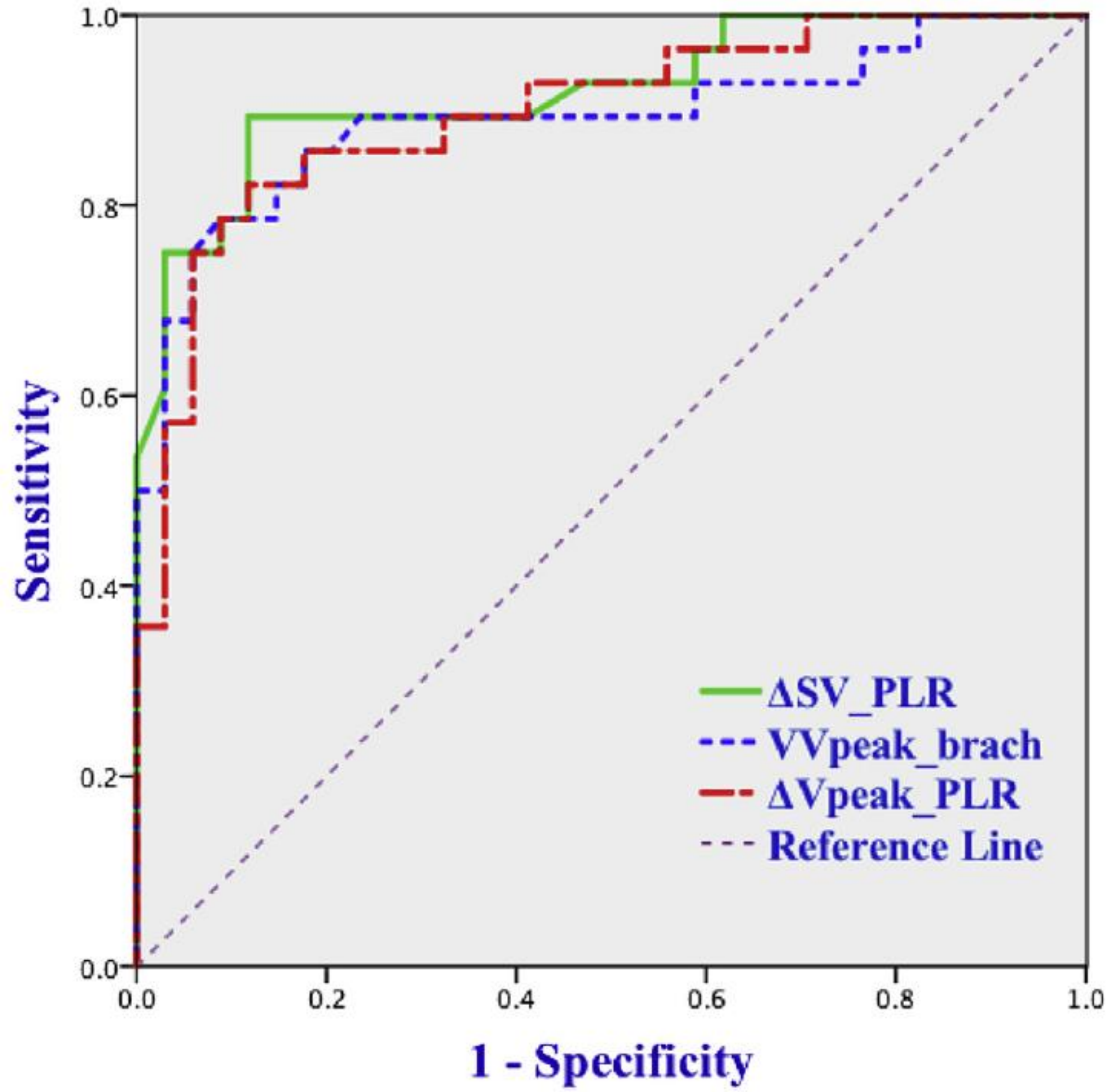
- **>10.6%**
- Sensitivity 82.1%
- Specificity 88.2%.

➔LR (+) 7 ; LR (-) 0.2

$VVpeak_{brach}$:

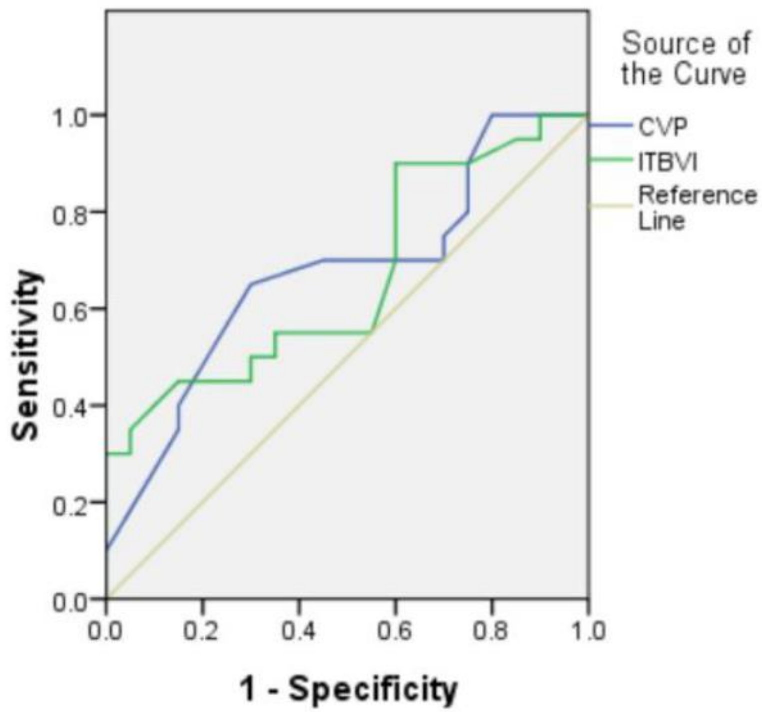
- **> 10.95%**
- Sensitivity 78.6%
- Specificity 91.2%.

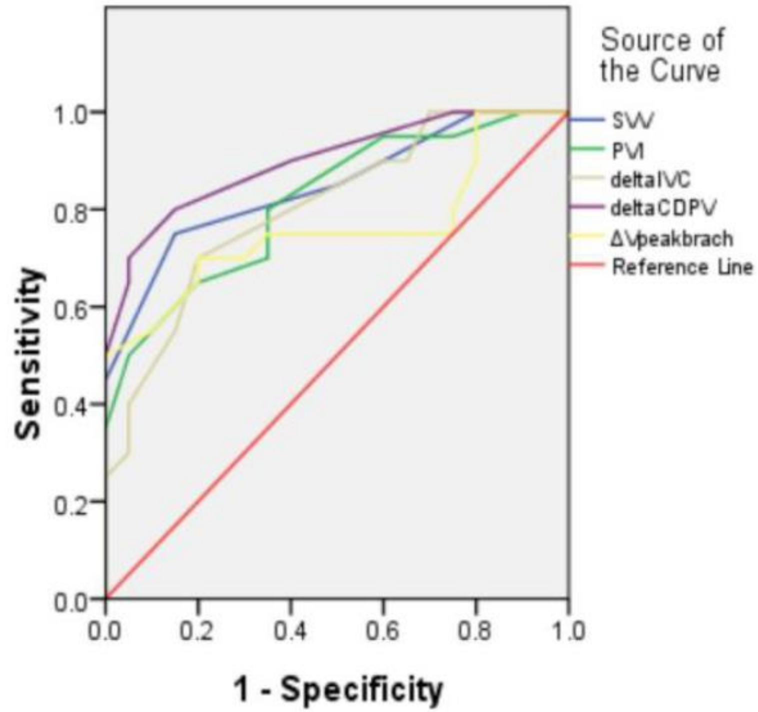
➔LR (+) 8.9 ; LR (-) 0.23



ΔCDPV Carotid Doppler Peak Velocity

Am J Emerg Med. 2017 Sep;35(9):1258-1261.

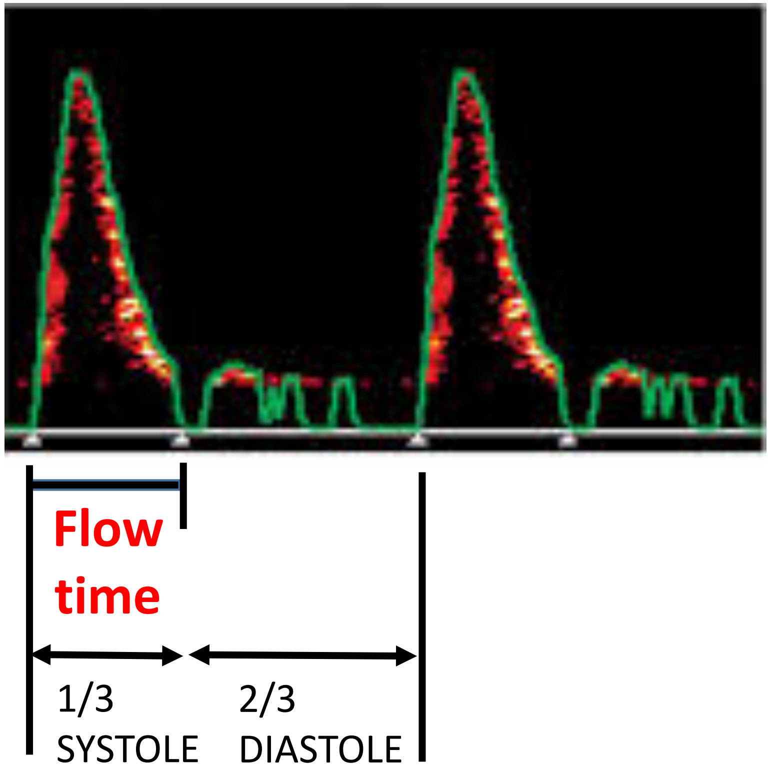




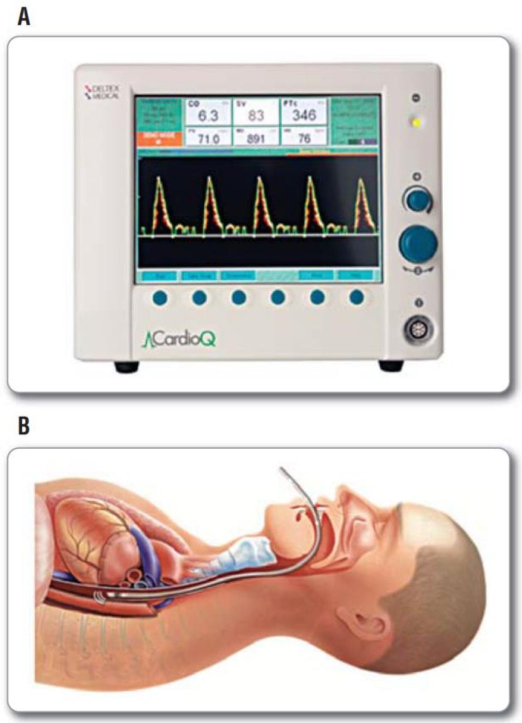
	Threshold	Sensitivity	Specificity	LR(+)	LR(-)
ΔCDPV	**13.0**	78%	90%	**7.8**	**0.24**
SVV	11.5	75%	85%	5	0.29
ΔVpeak brach	11.7	70%	80%	3.5	0.38
ΔIVC	20.5	67%	77%	2.9	0.43

Flow Time Corrected (FTC)

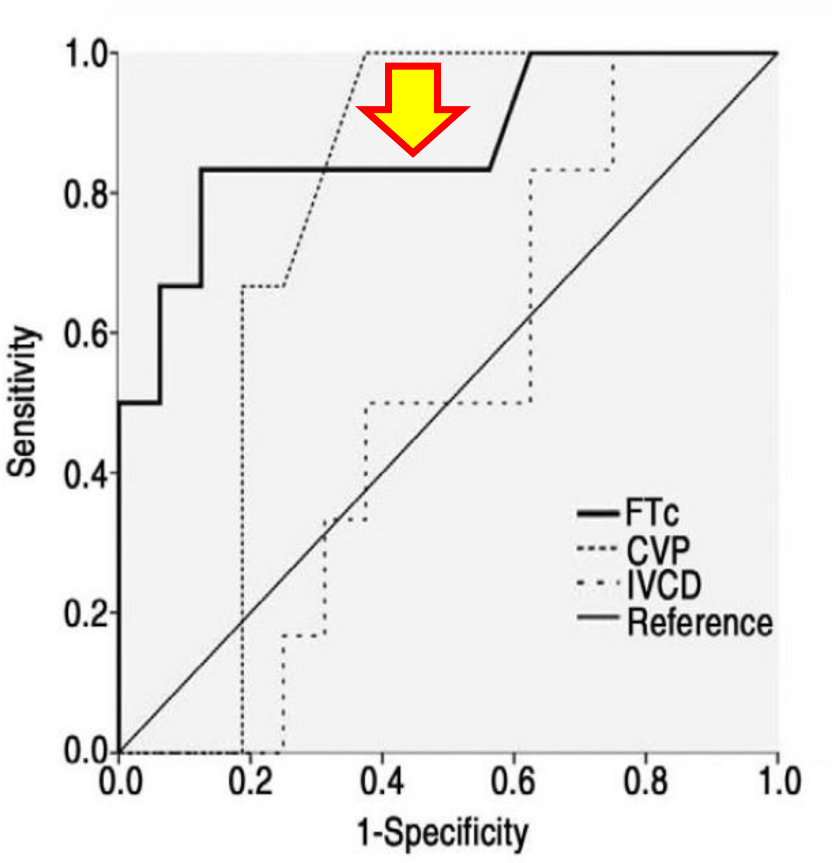
- Corrected to HR of **60 bpm**
- Normal FTC **330-360 ms**
- $FTC = (\text{Flow Time}) / \sqrt{T_{RR}}$



Crit Care Nurse. 2015 Feb;35(1):11-27.



Validity of Corrected Flow Time (FTc) as a Predictor of Fluid Responsiveness in Patients with Sepsis-induced Hypotension



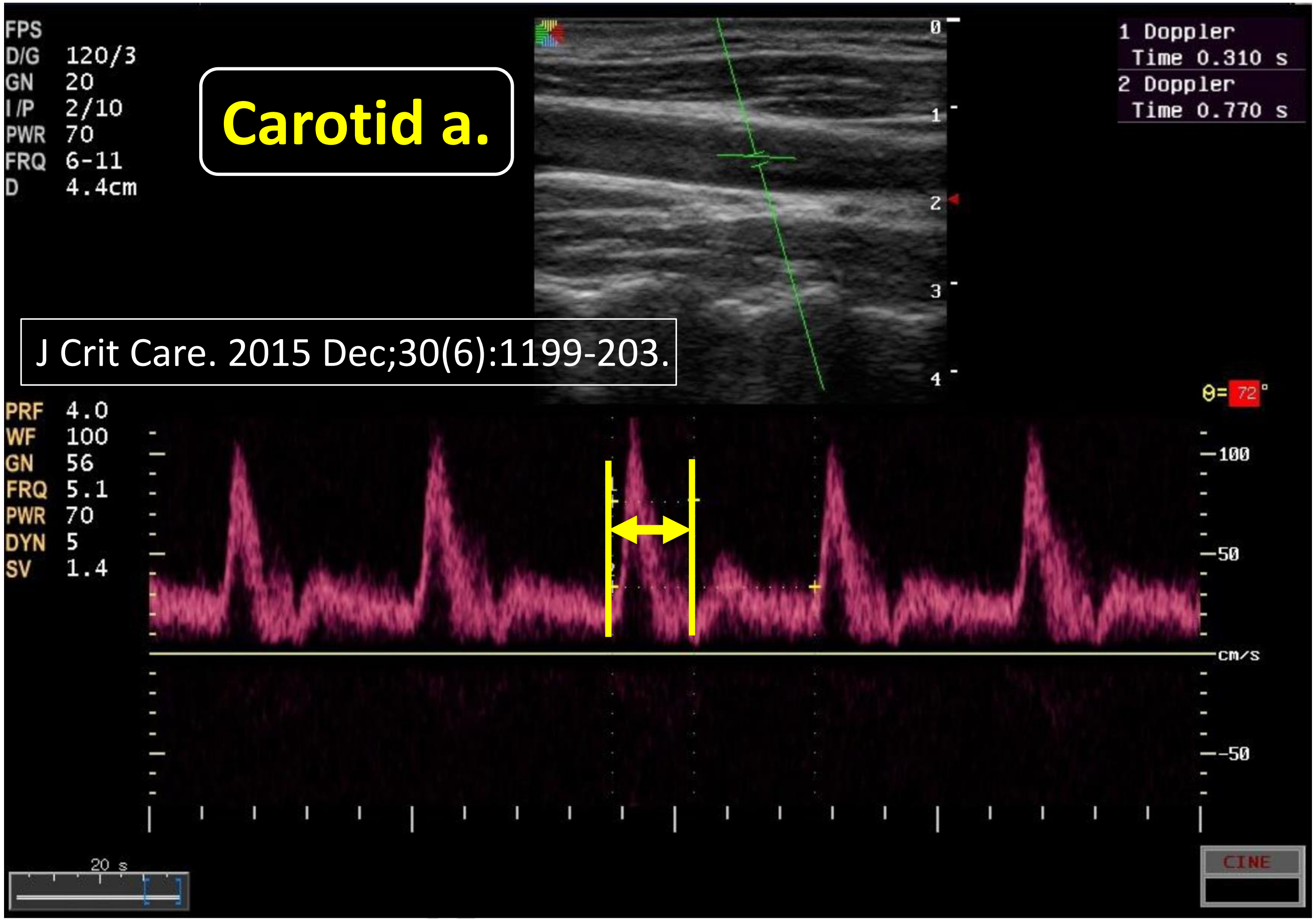
FTc: 0.870 (0.708-0.979;*p*=.009)
CVP 0.771 (0.574-0.968;*p*=0.055)
IVCD: 0.510 (0.265-0.756; *p*=0.941)

✓ The optimal **cut-off value for FTc** was **301 ms**

- sensitivity=88.2%
- specificity=88.8%

⇨ **LR(+) = 7.9**
LR(-) = 0.13

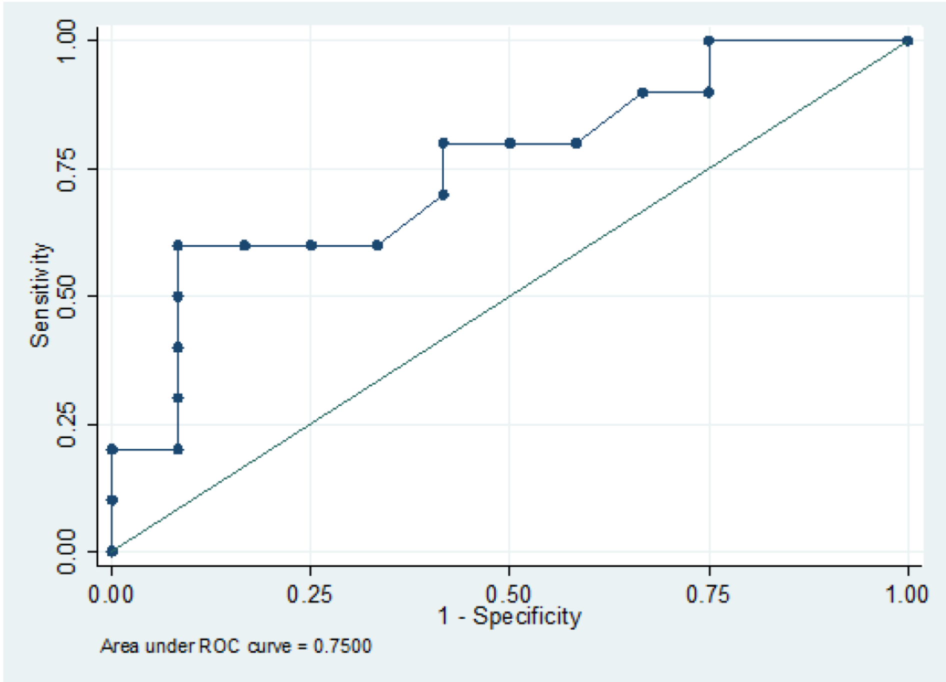
J Korean Soc Emerg Med 2012;23(1): 56-61.



Corrected flow time (FTC) is measured **FROM** **the beginning of systolic upstroke** **TO** **the dicrotic notch**.

Comparing Changes in Carotid Flow Time and Stroke Volume Induced by Passive Leg Raising

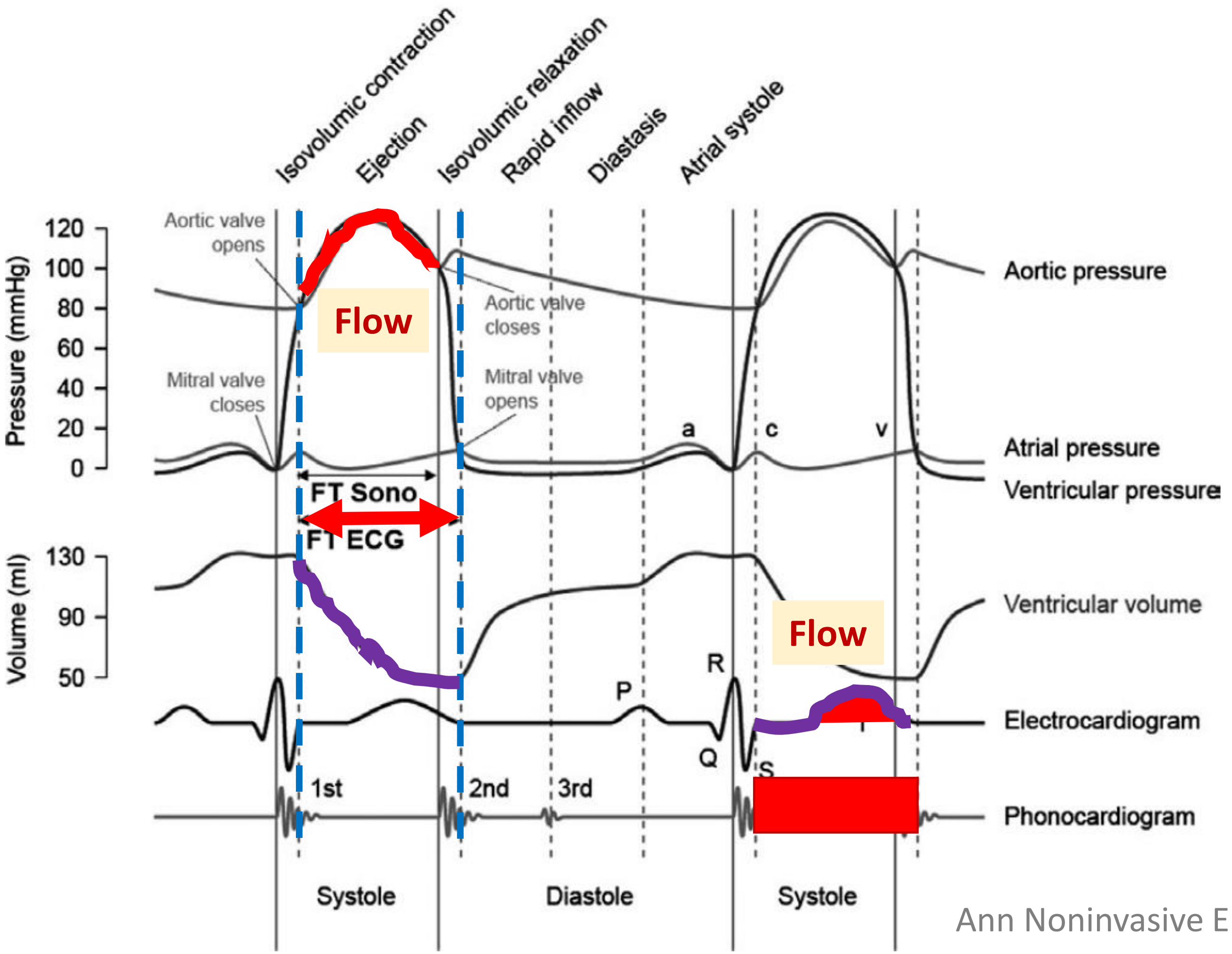
Am J Med Sci. 2018 Feb;355(2):168-173.



Cutoff	TP	FN	FP	TN	Sens.	Spec.	PPV	NPV	+LR	-LR
≥ 9.8%	9	1	9	3	90%	25%	50%	75%	1.2	0.4
≥ 14.8%	8	2	5	7	80%	58%	61%	78%	1.9	0.3
≥ 24.6%	6	4	1	11	60%	92%	86%	73%	7.2	0.4

Flow time in ECG

FTC = (Flow Time)/ √ T_{RR}



Ann Noninvasive Electrocardiol. 2017 Apr 22.

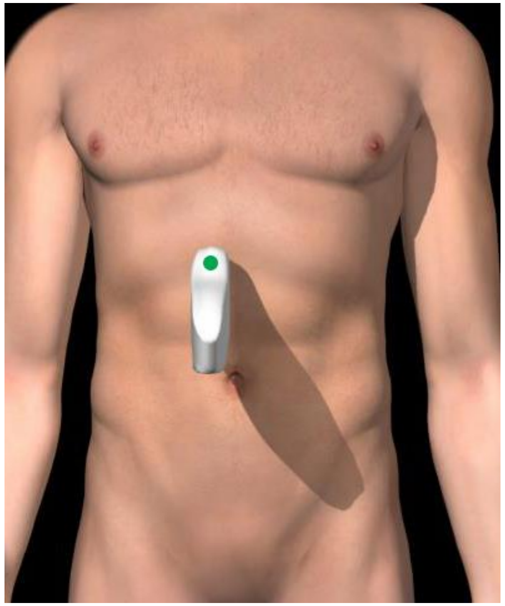
Who is fluid responsiveness? By dynamic evaluation

Methods	Measure/ Cut off value	LR (+)	LR (-)	Reference
Passive leg raising	△CO 10%	**9.4**	**0.16**	Intensive Care Med. 2016 Dec;42(12):1935-1947.
Passive leg raising	△brachial a. peak velocity 10.6%	7	0.2	J Surg Res. 2018 Apr;224:207-214..
Passive leg raising	△corrected flow time 24.6%	7.2	0.4	Am J Med Sci. 2018 Feb;355(2):168-173.
Variation of peak velocity in artery	△ brachial a. 10.95%	8.9	0.23	J Surg Res. 2018 Apr;224:207-214..
Variation of peak velocity in artery	△ carotid a. 13%	7.8	0.24	Am J Emerg Med. 2017 Sep;35(9):1258-1261.
Collapsibility Index in vein	△ IVC, variable cut off value	2.84	0.38	J Intensive Care Med. 2018 Jan 1:885066617752308.
Collapsibility Index in vein	△ internal jugular vein 36%	5.2	0.26	Ulus Travma Acil Cerrahi Derg. 2017 Jul;23(4):294- 300.

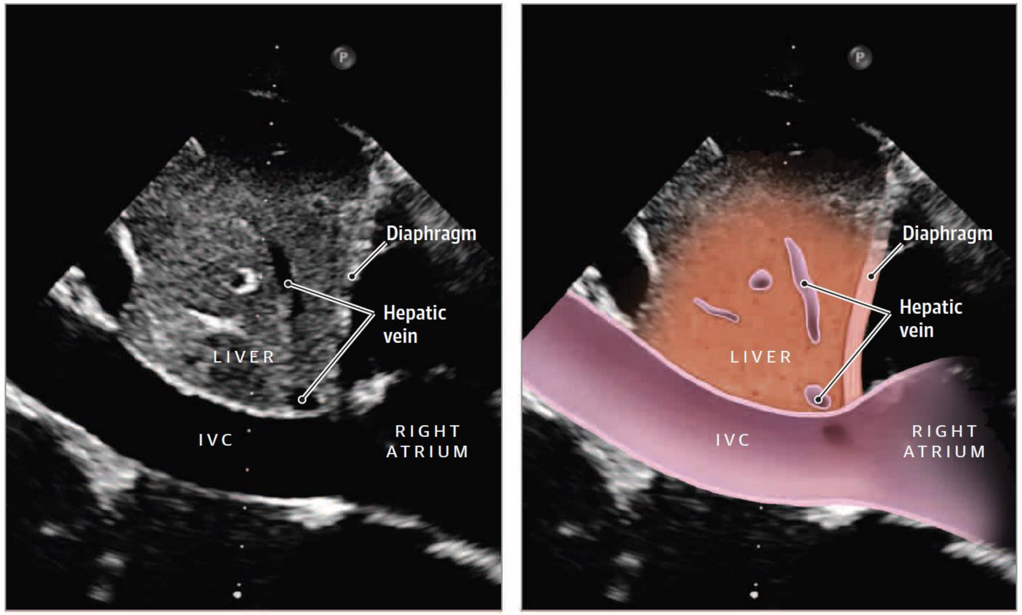
Respiratory Variation

in

Inferior Vena Cava Diameter

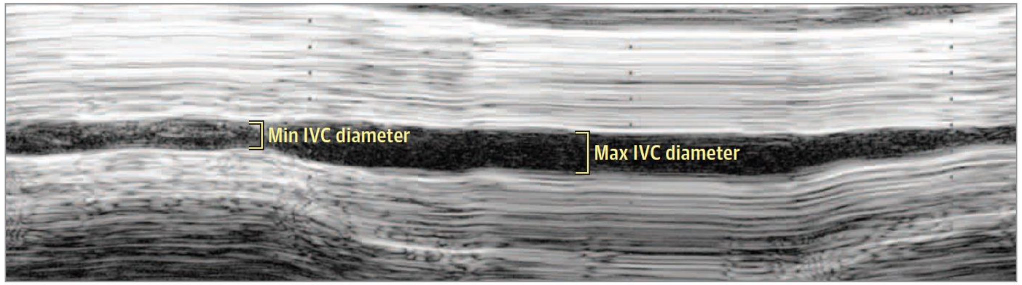


A Longitudinal subcostal ultrasound of IVC (left) with illustration of anatomical structures in view (right)

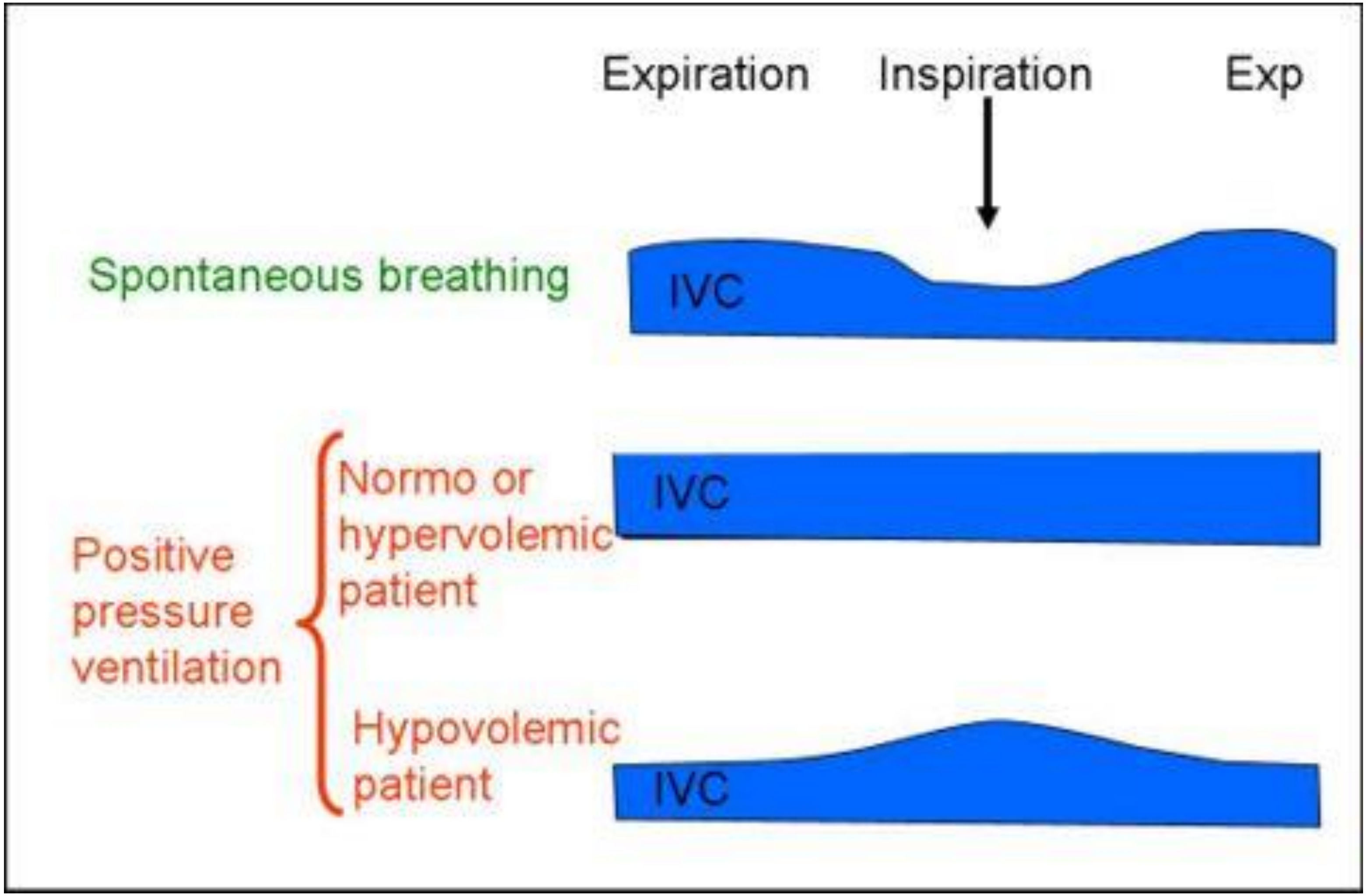


B M-mode ultrasound of IVC in spontaneously breathing patient

Collapsibility index of IVC = [(max IVC diameter - min IVC diameter)/max IVC diameter] x 100



JAMA. 2016 Sep 27;316(12):1298-309.

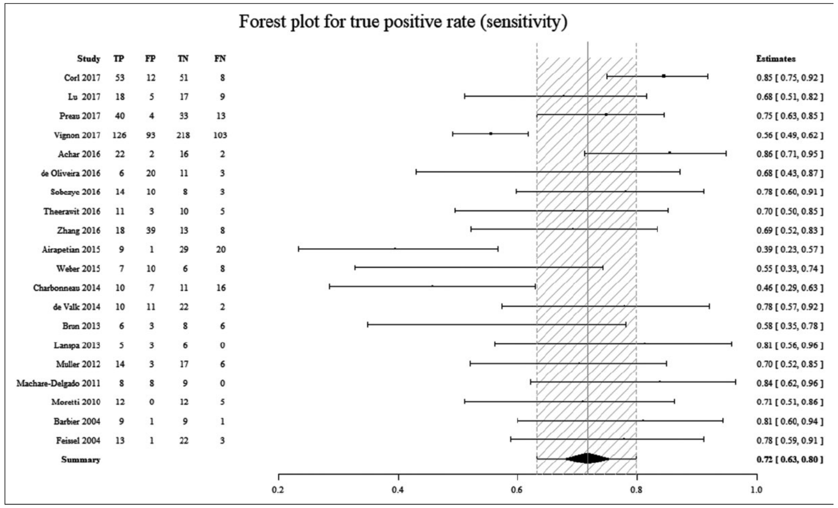


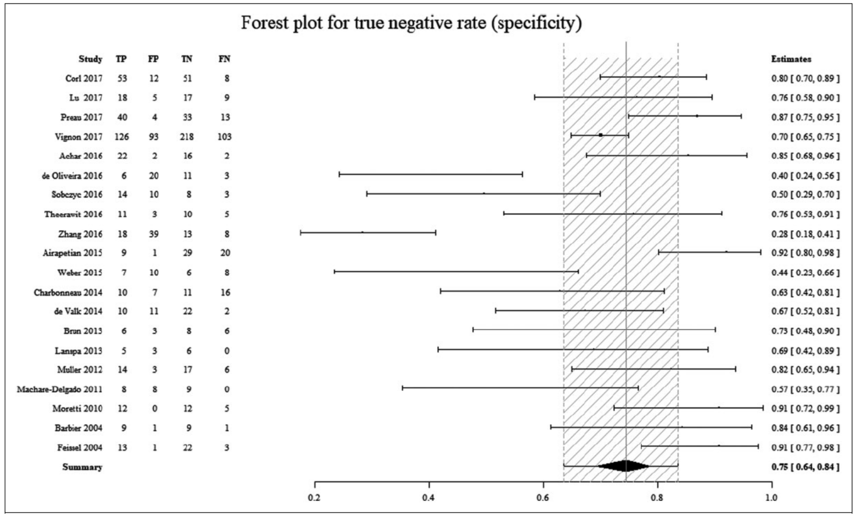
Expiration
Inspiration
Exp
Spontaneous breathing
IVC
Positive pressure ventilation
Normo or hypervolemic patient
IVC
Hypovolemic patient
IVC

Accuracy of **Ultrasonographic Measurements of Inferior Vena Cava** to Determine **Fluid Responsiveness**: A Systematic Review and Meta-Analysis.

- ✓ Sensitivity 0.71 (95% CI: 0.62-0.80)
- ✓ Specificity 0.75 (95% CI: 0.64-0.85)

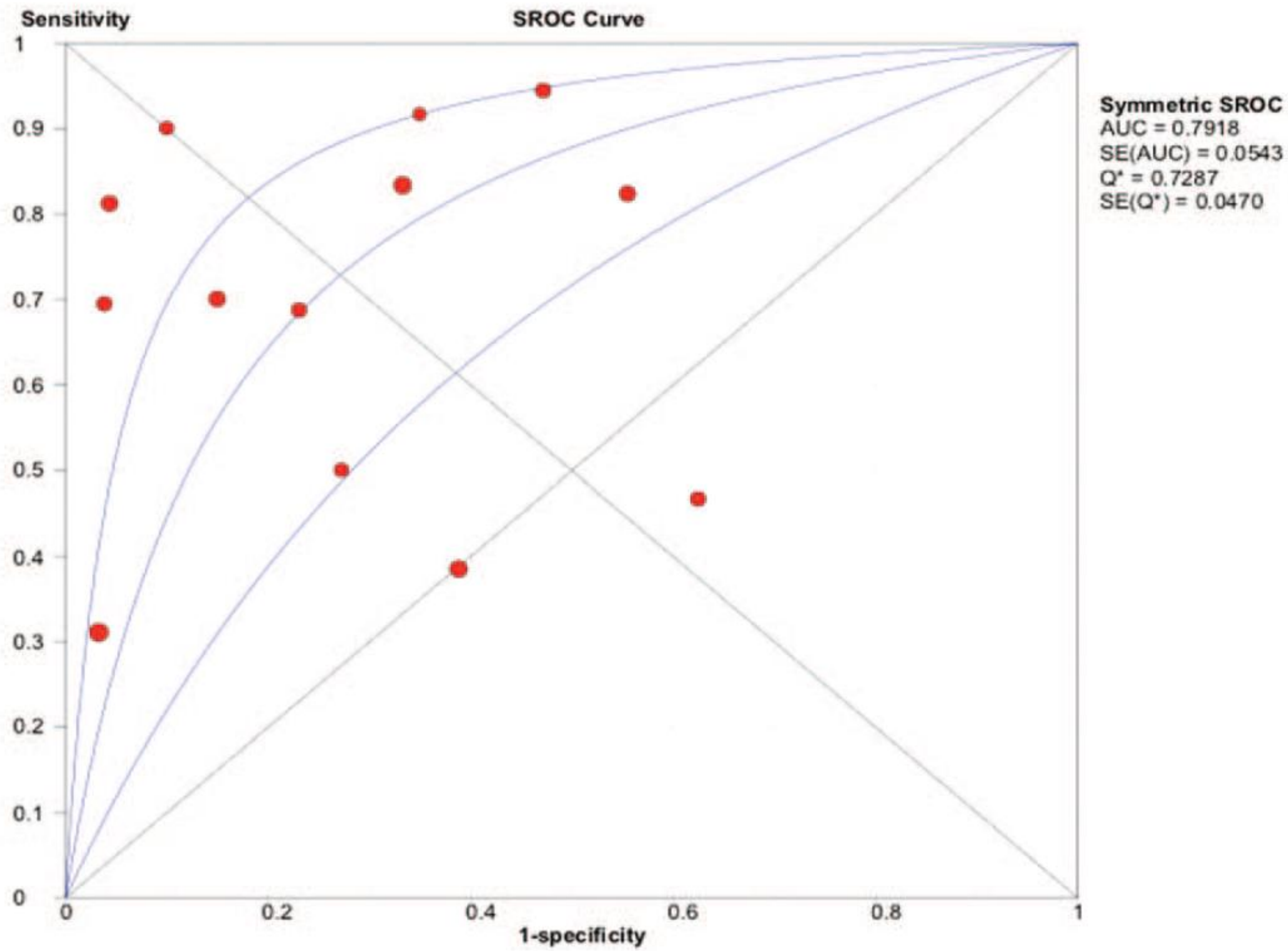
➔ LR(+) : 2.84 (1.72-8.17) ; LR (-) : 0.38 (0.28-0.98)





J Intensive Care Med. 2018 Jan 1:885066617752308.

Shock. 2017 May;47(5):550-559.



Study	Population	Setting	Patient group	Mechanical Ventilation	Tidal Volume (mL/kg)	Fluid challenge content	Fluid challenge volume	Reference standard device	Reference standard measurement	Reference standard threshold	ΔIVC (%) threshold
Airapetian 2015	Adults	ICU	Mixed	No	n/a	0.9% Saline	500 mL	TTE	SV	>10%	42
Barbier 2004	Adults	ICU	Sepsis	Yes	8.5	HES	7 mL/kg	TTE	CI	>15%	18
Brun 2013	Adults	OR	Severe pre-eclampsia	Unclean	n/a	0.9% saline	500 Ml	TTE	SVi	>15%	Not reported
Byon 2013	Children	OR	Neurosurgical	Yes	10	HES	10 mL/kg	TTE	SVi	>10%	Not reported
Charbonneau 2014	Adults	ICU	Sepsis	Yes	8–10	HES	7 mL/kg	TTE	CI	>15%	21
Corl 2012	Adults	ED	Mixed	No	n/a	PLR	PLR	BR	CI	>10%	Not reported
Choi 2010	Children	ICU	Cardiac	Yes	10	HES	10 mL/kg	TTE	SV	>15%	Not reported
de Oliveira 2016	Adults	ICU	Surgical	Yes	8	0.9% saline	500 Ml	TTE	VTI	>15%	16
de Valk 2014	Adults	ED	Mixed	No	n/a	0.9% saline	500 mL	NIV BP	SBP	>10mmHg	36.5
Feissel 2004	Adults	ICU	Sepsis	Yes	8-10	HES	8 mL/kg	TTE	CO	>15%	12
Lanspa 2013	Adults	ICU	Sepsis	No	n/a	Crystalloid	10 mL/kg	TTE	CI	>15%	50
Machare-Delgado 2011	Adults	ICU	Mixed	Yes	8.6	0.9% saline	500 mL	TTE	SVi	>10%	12
Muller 2012	Adults	ICU	Mixed	No	n/a	HES	500 mL	TTE	SV	>15%	40
Moretti 2010	Adults	OR	SAH	Yes	8	HES	7 mL/kg	TPTD	CI	>15%	16
Sobczyc 2016	Adults	ICU	Cardiac	Yes	8	0.9% saline	250 mL	TTE	CO	>15%	18
Theerawit 2016	Adults	ICU	Sepsis	Yes	8	HES	500 mL	PCA	CO	>15%	10
Weber 2015	Children	ICU	Mixed	Yes	7.9	HES	10 mL/kg	TTE	SVi	>10%	Not reported

BR indicates bioreactance; CI, cardiac index; CO, cardiac output; ED, emergency department; HES, hydroxyethyl starch; ICU, intensive care unit; NIV BP, noninvasive blood pressure; OR, operating room; PLR, passive leg raise; SAH, subarachnoid hemorrhage; SBP, systolic blood pressure; SV, stroke volume; SVi, stroke volume index; TPTD, transpulmonary thermodilution; TTE, transthoracic echocardiogram.

Shock. 2017 May;47(5):550-559.

WHAT'S NEW IN INTENSIVE CARE

CrossMark

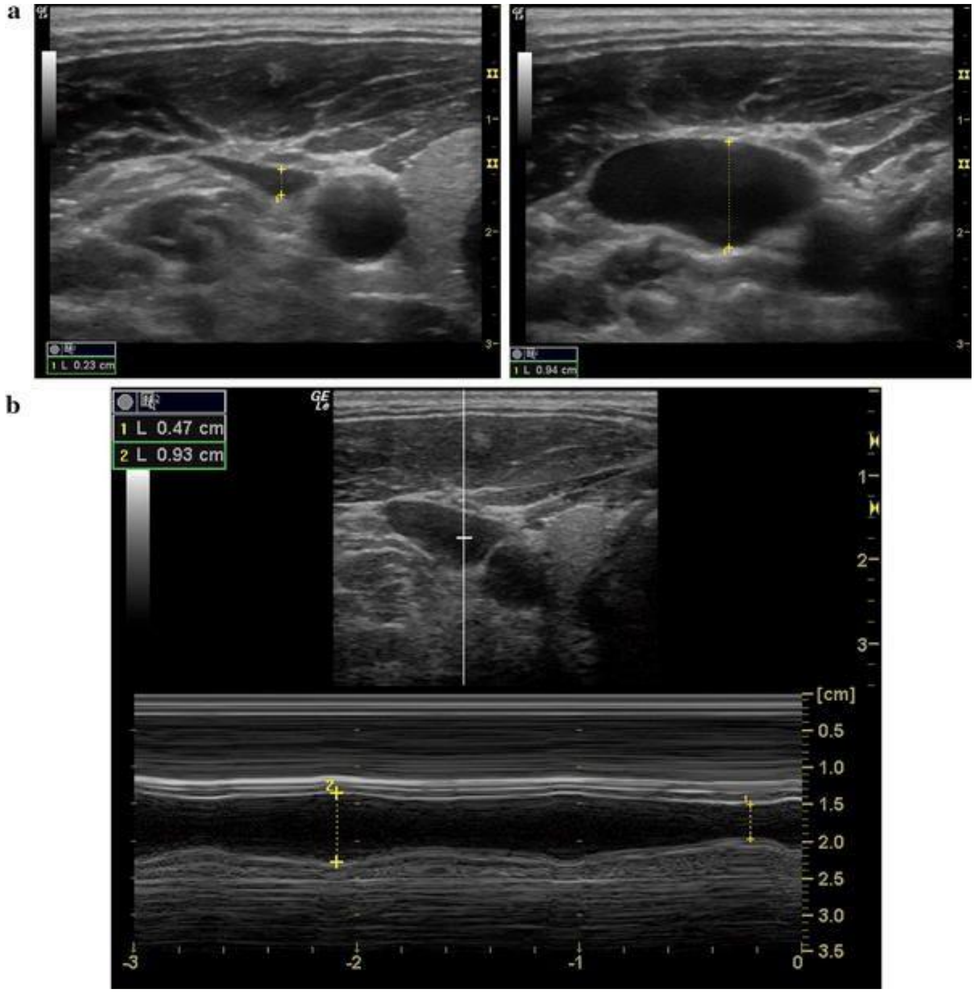
Ten situations where inferior vena cava ultrasound may fail to accurately predict fluid responsiveness: a physiologically based point of view

1. Mechanical ventilation with high PEEP and/or low tidal volumes.
2. Assisted ventilation modalities, NIV, CPAP.
3. Varying respiratory pattern in spontaneous breathing.
4. Asthma/COPD exacerbation.
5. Chronic RV dysfunction, severe TR.
6. RV myocardial infarction.
7. Cardiac tamponade.
8. Intra-abdominal hypertension
9. Local mechanical factors.
10. Patients with pronounced IVC inspiratory lateral displacement.

Intensive Care Med. 2016 Jul;42(7):1164-7.

Internal Jugular Vein Collapsibility Index

IJV-CI



Crit Ultrasound J (2010) 2: 13.

- ✓ **IJV-CI of > 36%** before PLR maneuver had **78% sensitivity and 85% specificity** to predict responder. ➔ **LR (+) 5.2 ; LR (-) 0.26**
- ✓ **Less time** was needed to measure venous diameters for IJV-CI (30 seconds) compared with IVC-CI (77.5 seconds; p<0.001).

The value of internal jugular vein collapsibility index in sepsis

Ulus Travma Acil Cerrahi Derg. 2017 Jul;23(4):294-300.

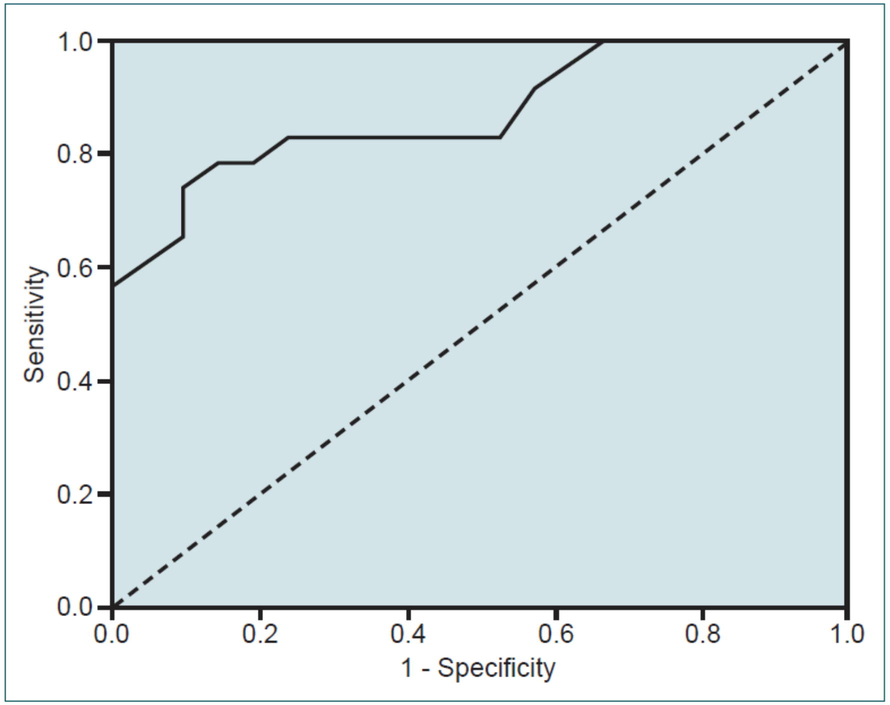


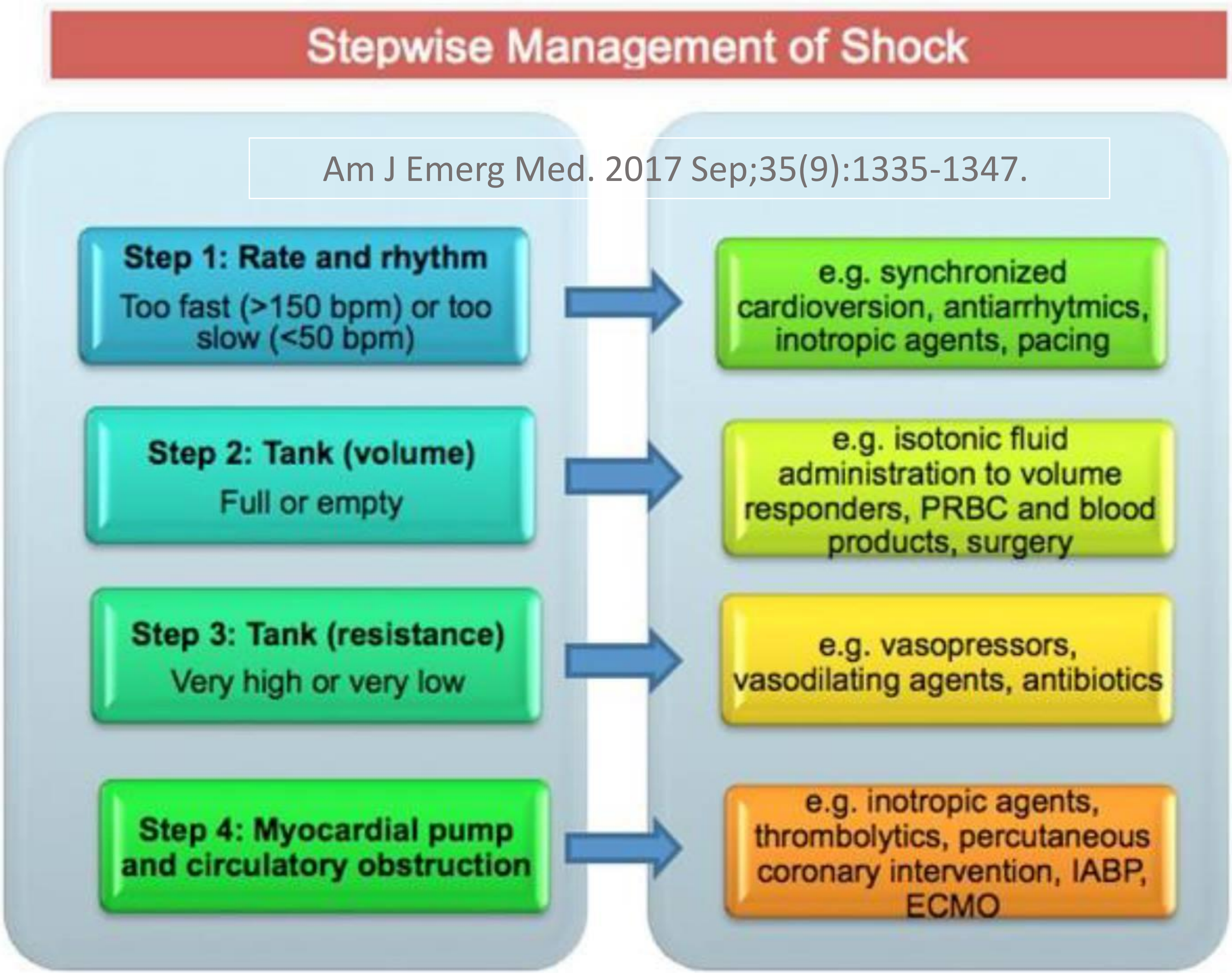
Figure 2. Receiver operating characteristic curve for discriminating responders from non-responders after passive leg raise. The solid line indicates area under curve for internal jugular vein collapsibility index at stage 1 of 0.825; p<0.001.

Rate

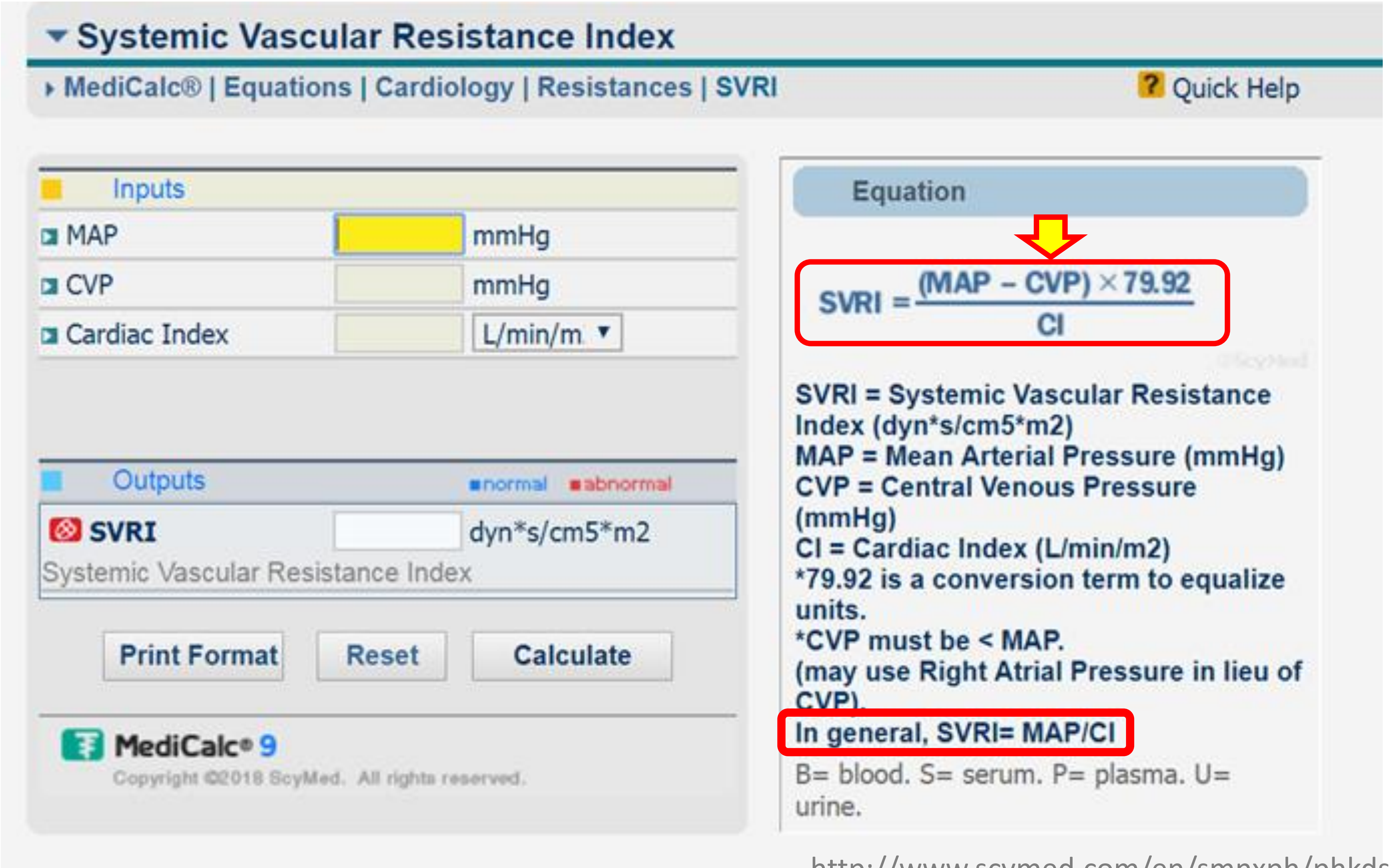
Volume

Resistance

Pump



Am J Emerg Med. 2017 Sep;35(9):1335-1347.



http://www.scymed.com/en/smnxph/phkds224.htm

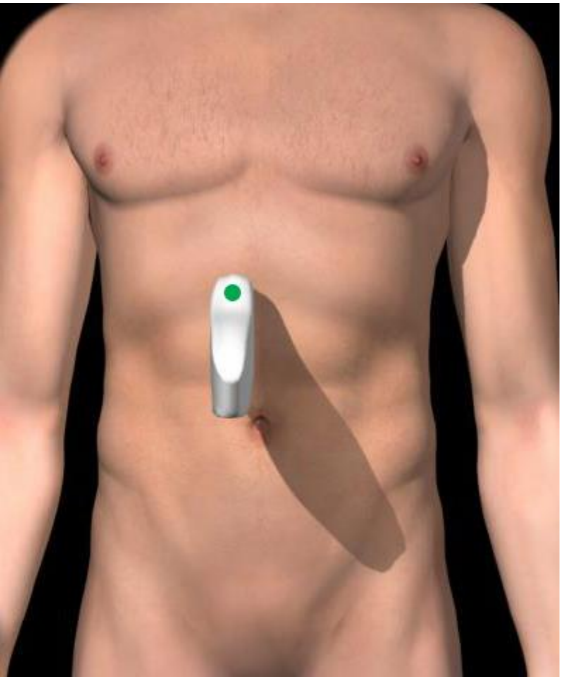
有沒有辦法不打Central Venous Catheter

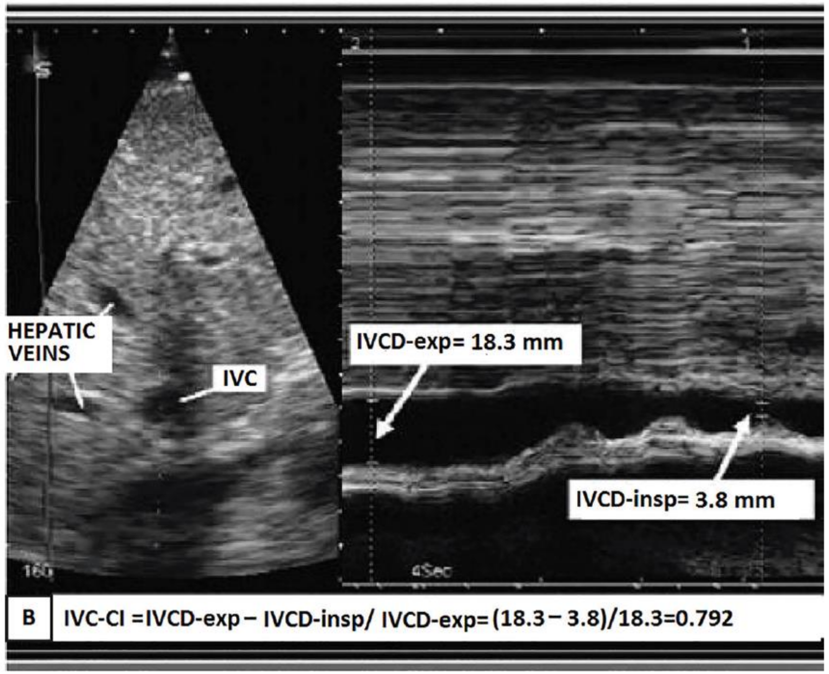
而得到Central Venous Pressure?

Table 2. Estimation of RA Pressure on the Basis of IVC Diameter and Collapse According to Rudski et al [19]

Variables	Normal (0 - 5(3) mm Hg)	Intermediate (5 - 10(8) mm Hg)	High (15 mm Hg)
IVC diameter	≤ 21 mm	≤ 21 mm; > 21 mm	> 21 mm
Collapse with sniff	> 50%	< 50%; > 50%	< 50%
Secondary indices of elevated RAP			Restrictive filling Tricuspid E/e' > 6 Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)

J Am Soc Echocardiogr. 2010 Jul;23(7):685-713



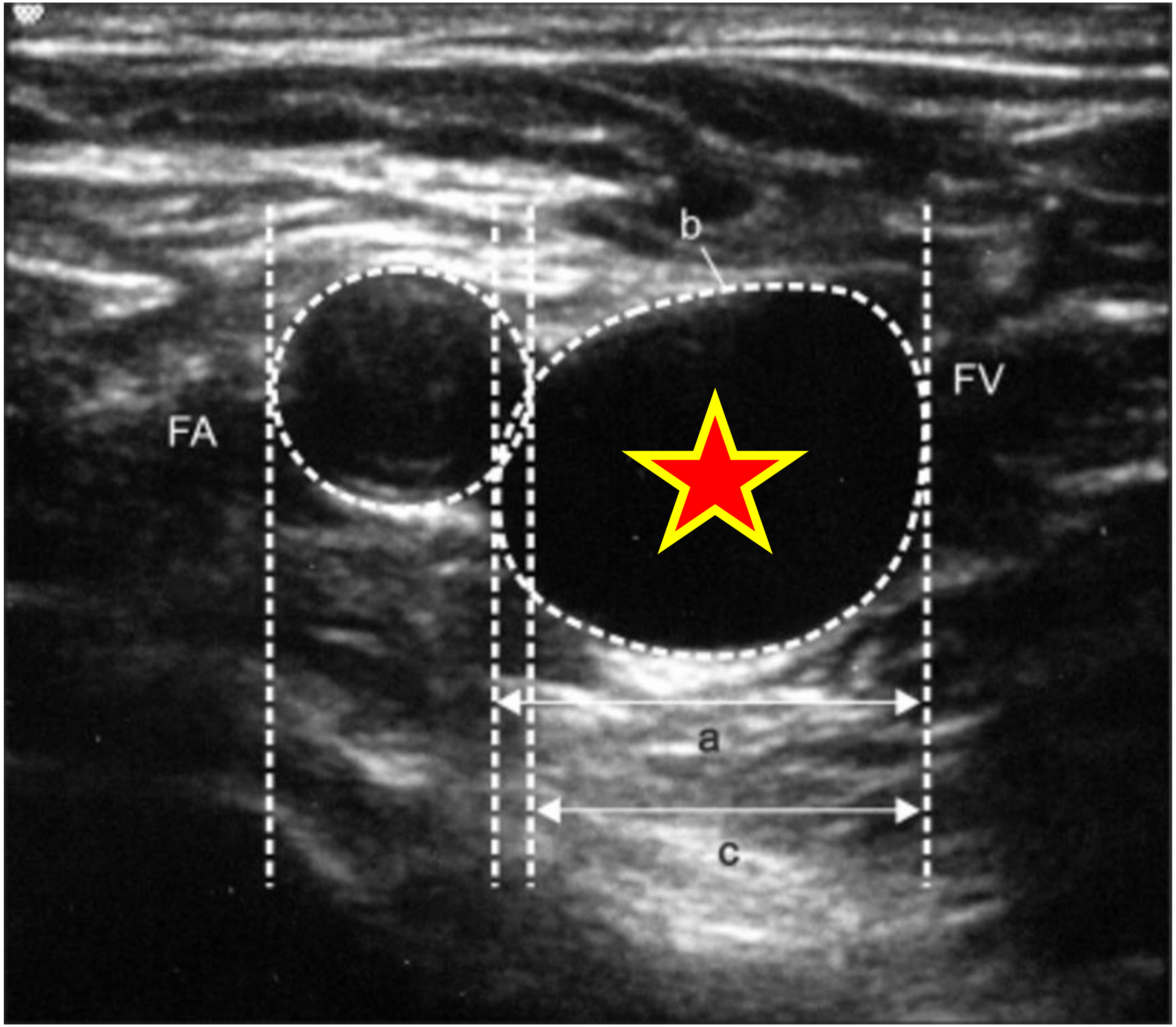


IVC diameter

PLUS

IVC collapsibility index (IVCCI)

= (MAX IVC diameter – min IVC diameter)/ MAX IVC diameter) × 100


b
FA
FV
a
c

Predicting Central Venous Pressure by Measuring Femoral Venous Diameter Using Ultrasonography

Cureus. 2016 Nov; 8(11): e893.

$$CVP\ (cmH_2O) = -0.039 + 10.718 * FVD$$

$$CVP\ (mmHg) = (-0.039 + 10.718 * FVD)/1.36$$

Measurement of Femoral Vein Diameter by Ultrasound to Estimate Central Venous Pressure.

Ann Am Thorac Soc. 2016 Jan;13(1):81-5.

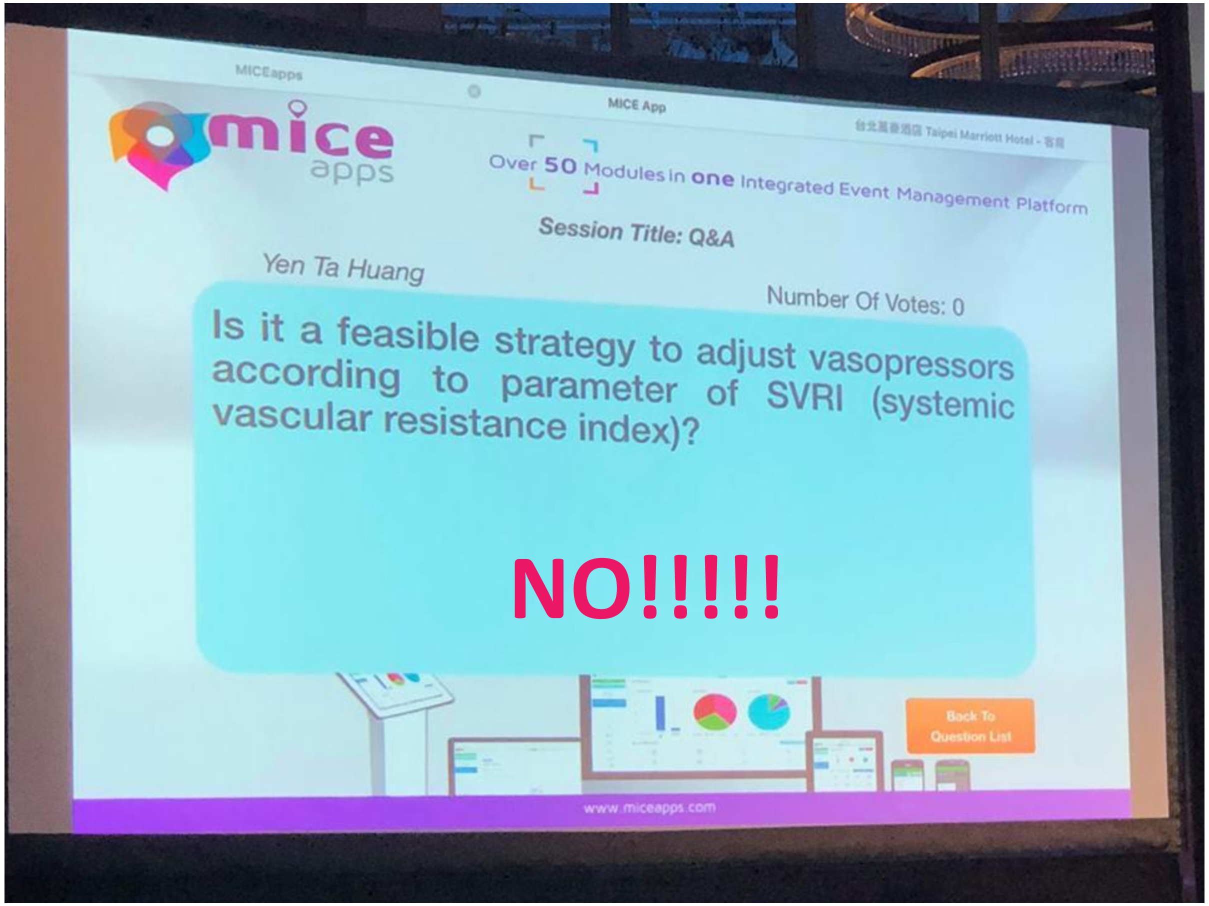
FVD ≤ 0.7 cm ➔CVP < 8 mm Hg [sensitivity 95% ; specificity 89%]

FVD ≥ 1.0 cm ➔CVP > 12 mm Hg [sensitivity 70% ; specificity 70%]

Professor of Critical Care Medicine with secondary appointments in Cardiovascular Diseases, Clinical & Translational Science, Anesthesiology and Bioengineering at the **University of Pittsburgh**

One of **Michael Pinsky**'s **hemodynamic** rule:

Hypotension is medical emergency.



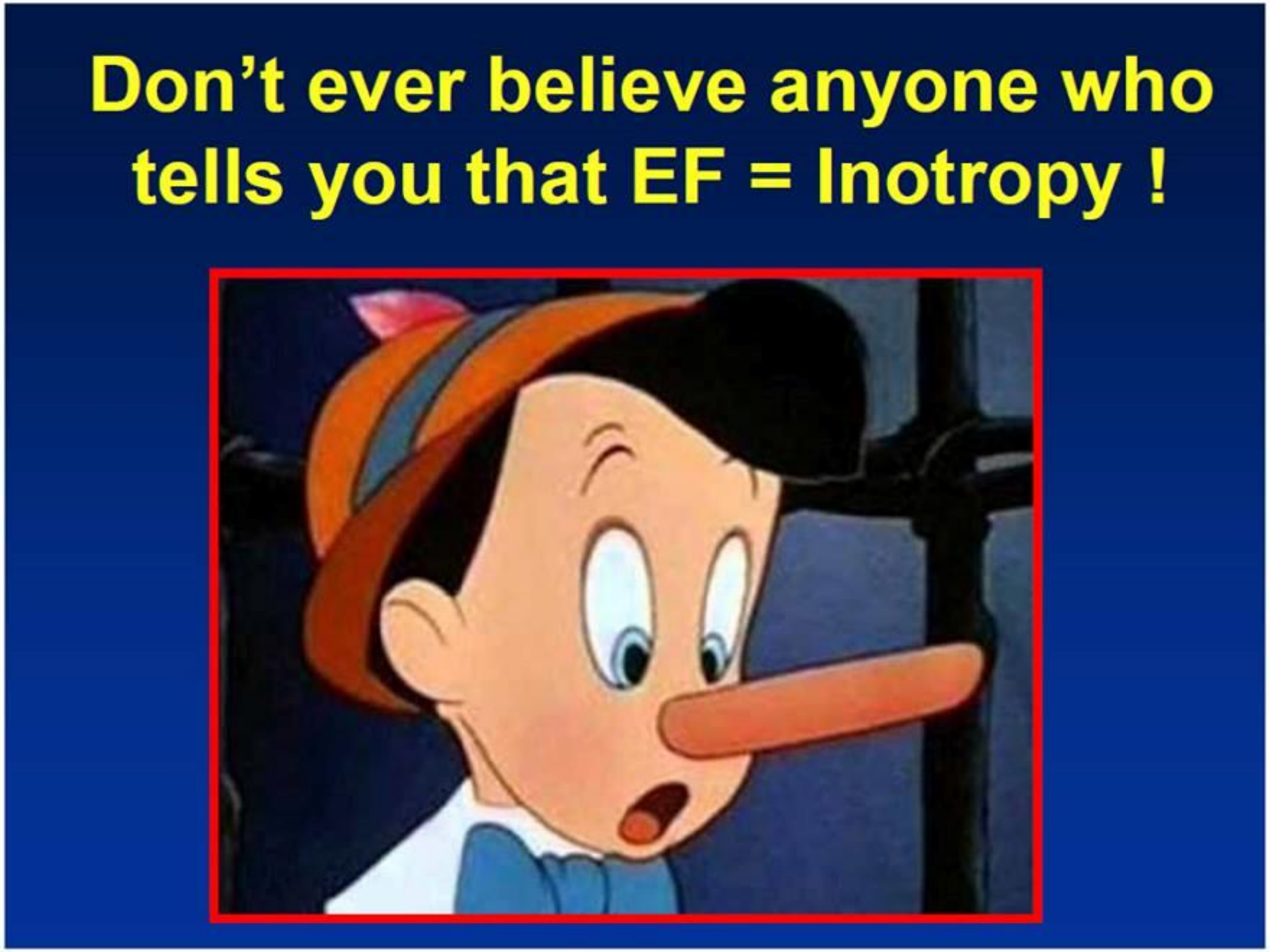
Rate

Volume

Resistance

Pump

Am J Emerg Med. 2017 Sep;35(9):1335-1347.

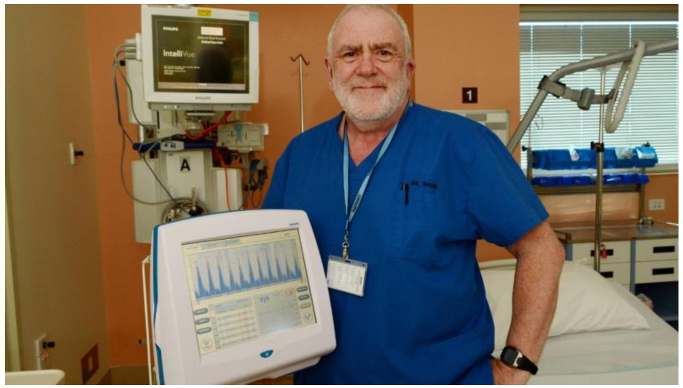


Brendan Smith, MD

Professor at
Notre Dame University

Director of ICU
at Bathurst Base Hospital

Australia



Measurement of Inotropy

Br J Anaesth. 2013 Oct;111(4):580-8.

The Smith-Madigan Index

= potential energy + kinetic energy

= (MAP-CVP)X SV/FT + $1/2mV^2$

$$SMI = \frac{BPmean \times SVol \times 10^{-3}}{7.5 \times FT} + \frac{SVol \times 10^{-6} \times \rho \times Vmean^2}{2 \times FT}$$

where BPmean = (mean arterial pressure–central venous pressure) in mm Hg, SVol=stroke volume in ml, ρ=density in kg m^{-3}, *V*mean=mean velocity in m s^{-1}, FT=systolic flow time in ms. The factors 7.5, 10^{-3} and 10^{-6} are required to convert milliseconds to seconds, millilitres to cubic metres, and millimetres of mercury to kilopascals (kPa) (1 kPa=7.5 mm Hg), to conform to SI values; see text for explanations.

Smith–Madigan inotropy index (SMII) is total inotropy, SMI, divided by body surface area, BSA

$$SMII = \frac{SMI}{BSA}$$

Potential energy to kinetic energy ratio (PKR) is (iv) over (v)

$$PKR = \frac{Power\ (PE)}{Power\ (KE)} = \frac{\Delta P \times \Delta Vol/FT}{½ SVol \rho V^2/FT}$$

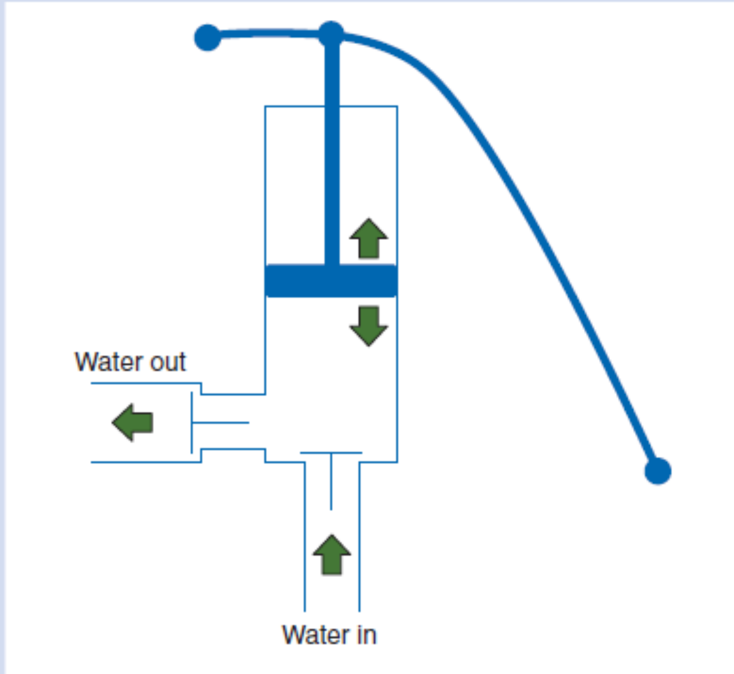


Fig 1 A simple piston water pump. With each sweep of the handle the pump will deliver one stroke volume SVol, at a flow velocity *V*, hydrostatic pressure HP, and in a given flow time (FT) determined by the force exerted on the handle. The parameters of SVol, *V*, HP, and FT can therefore be used to calculate the power transferred to the system.

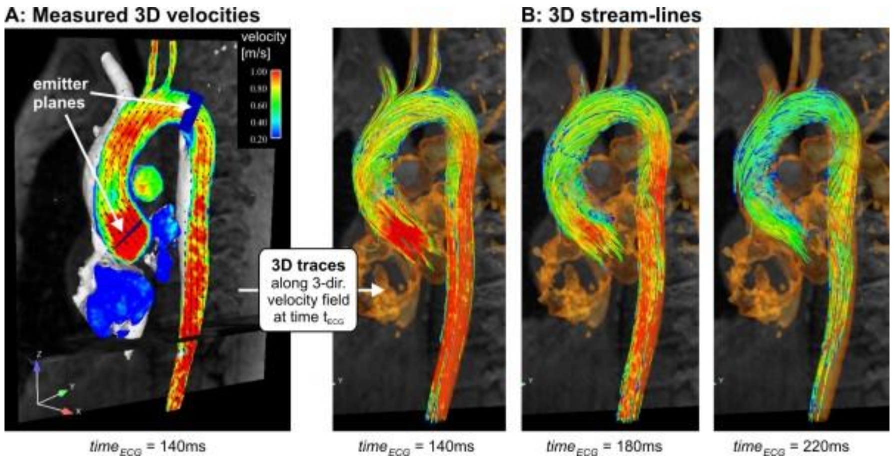
Measurement of Inotropy

Index of Contractility (ICON)

$$ICON^{TM} = \sqrt{\frac{dZ/dt_{Max}}{Z_0}}$$

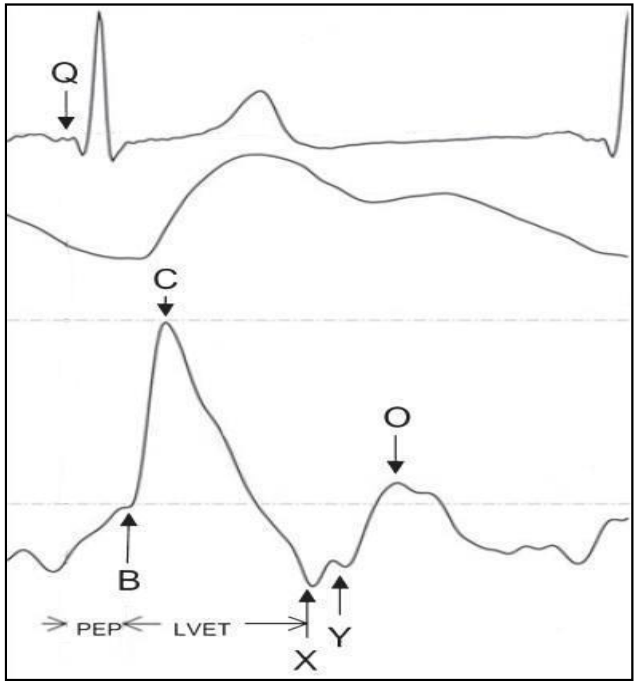
J Cardiovasc Magn Reson. 2011; 13(1): 7.

Peak (first 10-40 ms) acceleration of blood flow in aorta



Systolic Time Ratio (STR)

= PEP/LVET



Clin Hypertens. 2017 Dec 27;23:28.


Thanks for your attention
Be an
INTENSIVIST