NIH | COVID-19 Treatment Guidelines

Hemodynamics

Last Updated: October 9, 2020

Most of the hemodynamic recommendations below are similar to those previously published in the *Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016*. Ultimately, patients with COVID-19 who require fluid resuscitation or hemodynamic management of shock should be treated and managed identically to patients with septic shock.[1]

COVID-19 patients who require fluid resuscitation or hemodynamic management of shock should be treated and managed for septic shock in accordance with other published guidelines, with the following exceptions.

Recommendation

- For adults with COVID-19 and shock, the COVID-19 Treatment Guidelines Panel (the Panel) recommends using dynamic parameters, skin temperature, capillary refilling time, and/or lactate levels over static parameters to assess fluid responsiveness **(BIIa)**.

GUIDELINES

Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19)

Waleed Alhazzani[1,2], Morten Hylander Møller[3,4], Yaseen M. Arabi[5], Mark Loeb[1,2], Michelle Ng Gong[6], Eddy Fan[7], Simon Oczkowski[1,2], Mitchell M. Levy[8,9], Lennie Derde[10,11], Amy Dzierba[12], Bin Du[13], Michael Aboodi[6], Hannah Wunsch[14,15], Maurizio Cecconi[16,17], Younsuck Koh[18], Daniel S. Chertow[19], Kathryn Maitland[20], Fayez Alshamsi[21], Emilie Belley-Cote[1,22], Massimiliano Greco[16,17], Matthew Laundy[23], Jill S. Morgan[24], Jozef Kesecioglu[10], Allison McGeer[25], Leonard Mermel[8], Manoj J. Mammen[26], Paul E. Alexander[2,27], Amy Arrington[28], John E. Centofanti[29], Giuseppe Citerio[30,31], Bandar Baw[1,32], Ziad A. Memish[33], Naomi Hammond[34,35], Frederick G. Hayden[36], Laura Evans[37] and Andrew Rhodes[38*]

HEMODYNAMICS

8 In adults with **COVID-19 and shock**, we ***suggest*** using dynamic parameters skin temperature, capillary refilling time, and/or serum lactate measurement over static parameters in order to assess fluid responsiveness

Clinical management of COVID-19

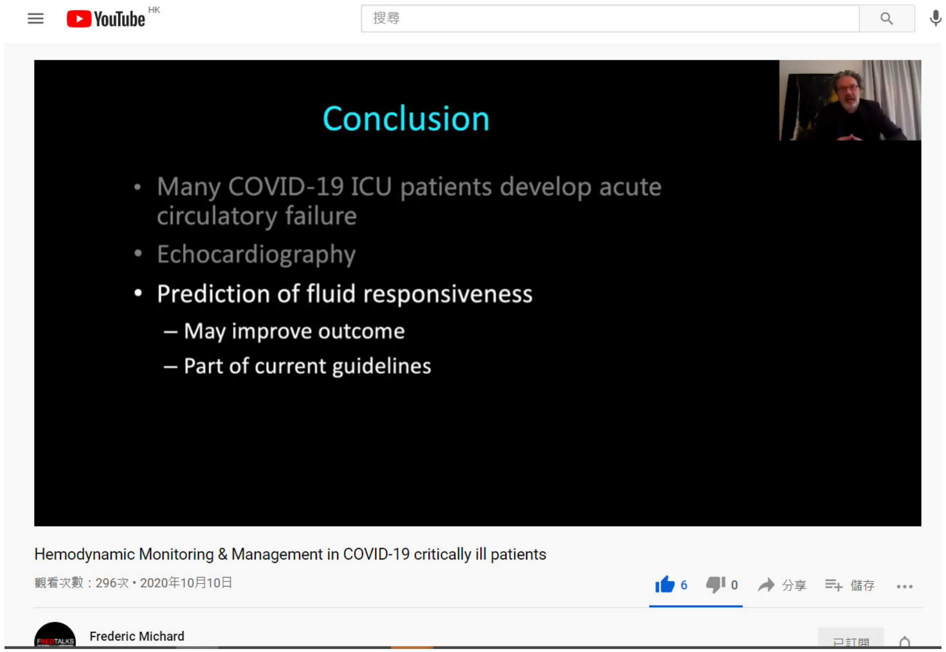
Interim guidance
27 May 2020

World Health Organization

Consider dynamic indices of volume responsiveness to guide volume administration beyond initial resuscitation based on local resources and experience *(3)*. These indices include passive leg raises, fluid challenges with serial stroke volume measurements, or variations in systolic pressure, pulse pressure, inferior vena cava size, or stroke volume in response to changes in intrathoracic pressure during mechanical ventilation.

Organ Failure in COVID-19

- Pneumonia & ARDS
- Acute circulatory failure
- AKI



https://www.youtube.com/watch?v=tl5pTqBizPU

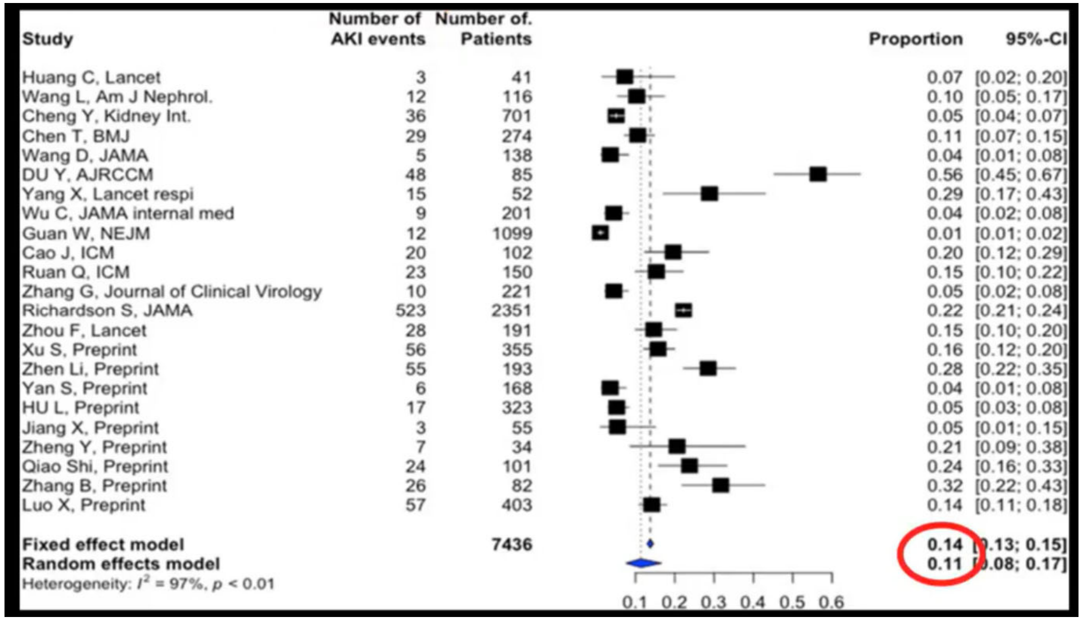
Intensive Care Med
https://doi.org/10.1007/s00134-020-06153-9

NARRATIVE REVIEW

Acute kidney injury in critically ill patients with COVID-19

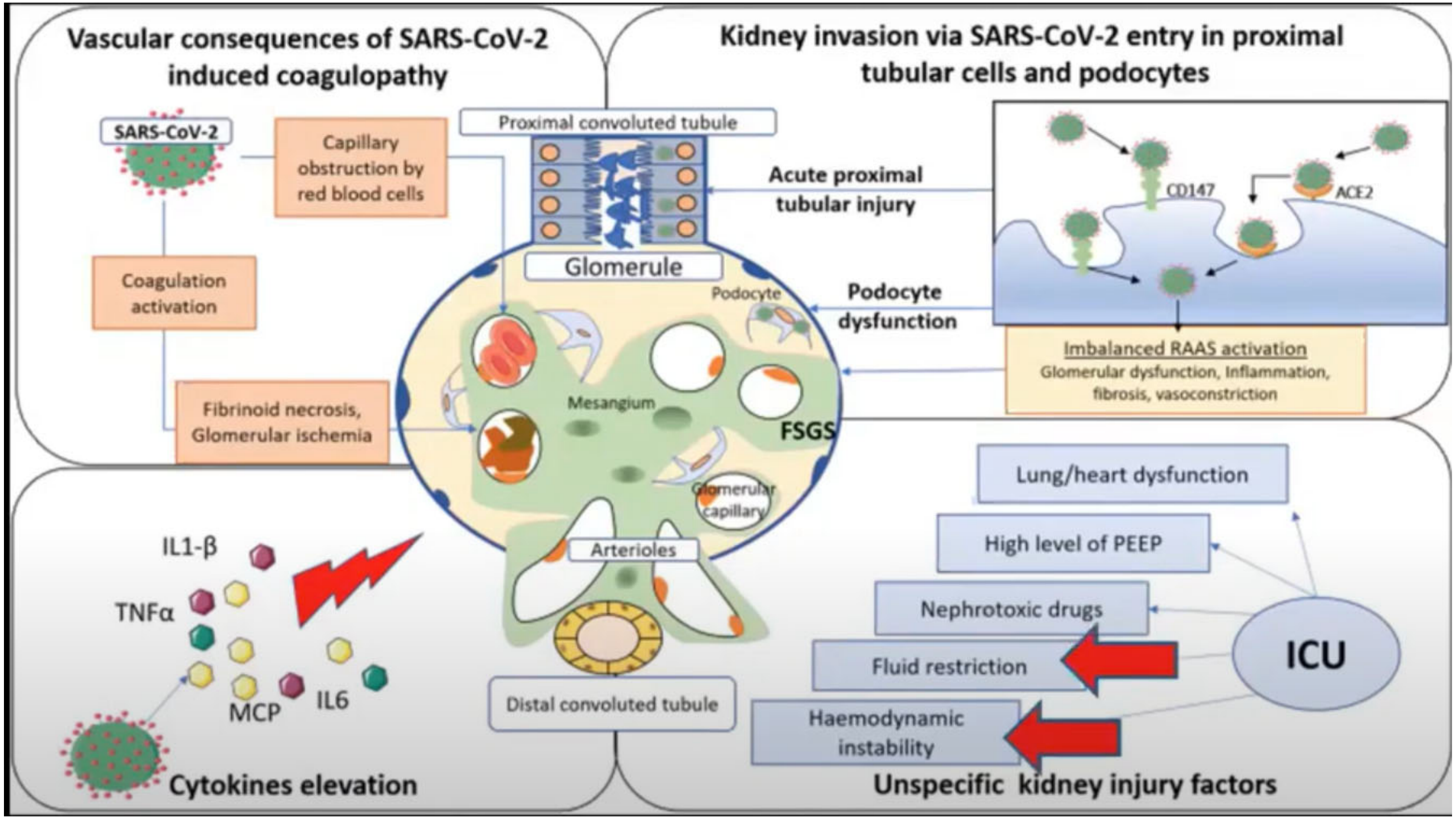
Paul Gabarre[1], Guillaume Dumas[1], Thibault Dupont[1], Michael Darmon[1], Elie Azoulay[1] and Lara Zafrani[1,2*]

11~14% developed AKI



Study	Number of AKI events	Number of. Patients	Proportion	95%-CI
Huang C, Lancet	3	41	0.07	[0.02; 0.20]
Wang L, Am J Nephrol.	12	116	0.10	[0.05; 0.17]
Cheng Y, Kidney Int.	36	701	0.05	[0.04; 0.07]
Chen T, BMJ	29	274	0.11	[0.07; 0.15]
Wang D, JAMA	5	138	0.04	[0.01; 0.08]
DU Y, AJRCCM	48	85	0.56	[0.45; 0.67]
Yang X, Lancet respi	15	52	0.29	[0.17; 0.43]
Wu C, JAMA internal med	9	201	0.04	[0.02; 0.08]
Guan W, NEJM	12	1099	0.01	[0.01; 0.02]
Cao J, ICM	20	102	0.20	[0.12; 0.29]
Ruan Q, ICM	23	150	0.15	[0.10; 0.22]
Zhang G, Journal of Clinical Virology	10	221	0.05	[0.02; 0.08]
Richardson S, JAMA	523	2351	0.22	[0.21; 0.24]
Zhou F, Lancet	28	191	0.15	[0.10; 0.20]
Xu S, Preprint	56	355	0.16	[0.12; 0.20]
Zhen Li, Preprint	55	193	0.28	[0.22; 0.35]
Yan S, Preprint	6	168	0.04	[0.01; 0.08]
HU L, Preprint	17	323	0.05	[0.03; 0.08]
Jiang X, Preprint	3	55	0.05	[0.01; 0.15]
Zheng Y, Preprint	7	34	0.21	[0.09; 0.38]
Qiao Shi, Preprint	24	101	0.24	[0.16; 0.33]
Zhang B, Preprint	26	82	0.32	[0.22; 0.43]
Luo X, Preprint	57	403	0.14	[0.11; 0.18]
Fixed effect model		**7436**	**0.14**	**[0.13; 0.15]**
Random effects model			**0.11**	**[0.08; 0.17]**

Heterogeneity: $I^2 = 97\%$, $p < 0.01$



Vascular consequences of SARS-CoV-2 induced coagulopathy
SARS-CoV-2
Capillary obstruction by red blood cells
Coagulation activation
Fibrinoid necrosis, Glomerular ischemia
Proximal convoluted tubule
Glomerule
Podocyte
Mesangium
FSGS
Glomerular capillary
Arterioles
Distal convoluted tubule
Kidney invasion via SARS-CoV-2 entry in proximal tubular cells and podocytes
Acute proximal tubular injury
Podocyte dysfunction
CD147
ACE2
Imbalanced RAAS activation
Glomerular dysfunction, Inflammation, fibrosis, vasoconstriction
IL1-β
TNFα
MCP
IL6
Cytokines elevation
Lung/heart dysfunction
High level of PEEP
Nephrotoxic drugs
Fluid restriction
Haemodynamic instability
ICU
Unspecific kidney injury factors

thebmj

BMJ 2020;369:m1963 doi: 10.1136/bmj.m1963 (Published 26 May 2020)

PRACTICE

Check for updates

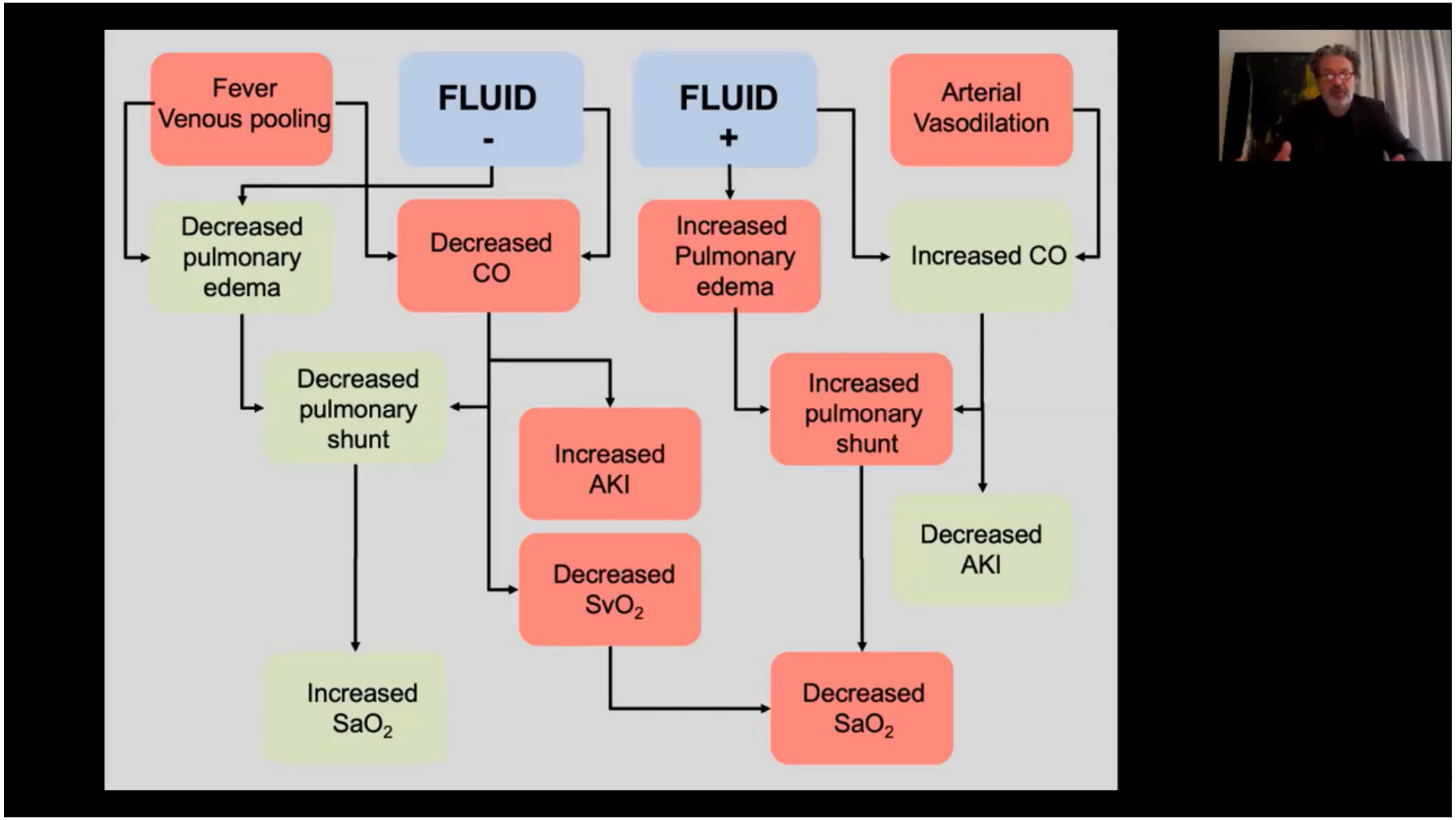
GUIDELINES

Covid-19 and acute kidney injury in hospital: summary of NICE guidelines

What you need to know

- Acute kidney injury (AKI) may be common in patients with covid-19 and is associated with an increased risk of dying
- AKI associated with covid-19 may be caused by volume depletion, multi-organ failure, viral infection leading directly to kidney tubular injury, thrombotic vascular processes, glomerulonephritis, or rhabdomyolysis
- Maintaining optimal fluid status (euvolaemia) is critical in reducing the incidence of AKI

Importance in Fluid Responsiveness Prediction



Dubin *et al. Ann. Intensive Care* (2020) 10:40
https://doi.org/10.1186/s13613-020-00659-7

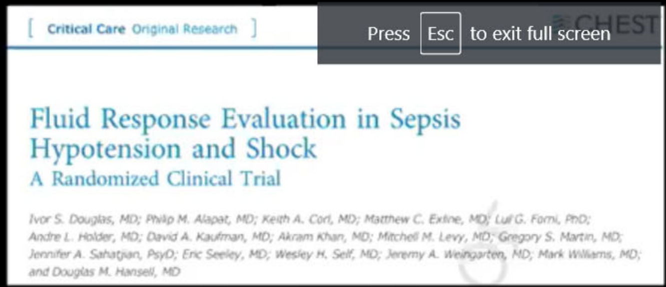
Annals of Intensive Care

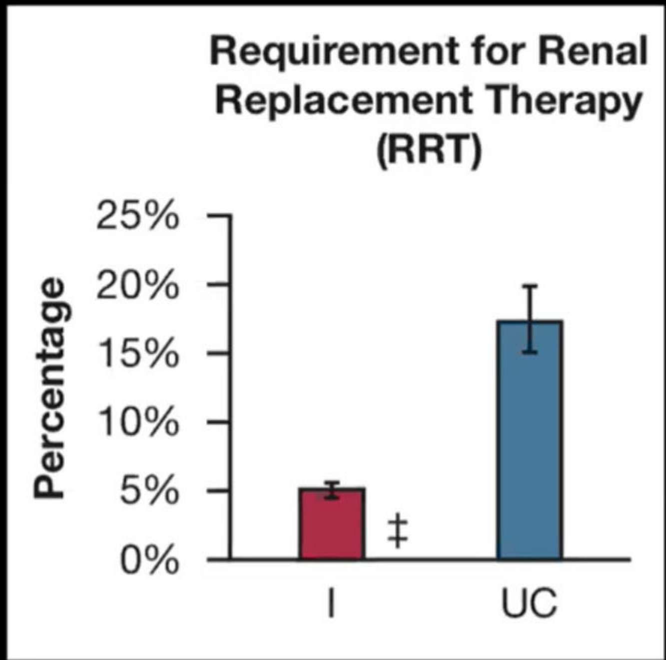
RESEARCH **Open Access**

Characteristics of resuscitation, and association between use of dynamic tests of fluid responsiveness and outcomes in septic patients: results of a multicenter prospective cohort study in Argentina

Arnaldo Dubin[1*], Cecilia Loudet[2], Vanina S. Kanoore Edul[3], Javier Osatnik[4], Fernando Ríos[5], Daniela Vásquez[6], Mario Pozo[7], Bernardo Lattanzio[8], Fernando Pálizas[7], Francisco Klein[9], Damián Piezny[5], Paolo N. Rubatto Birri[1], Graciela Tuhay[9], Analía García[10], Analía Santamaría[11], Graciela Zakalik[12], Cecilia González[13] and Elisa Estenssoro[2] on behalf of the investigators of the SATISEPSIS group

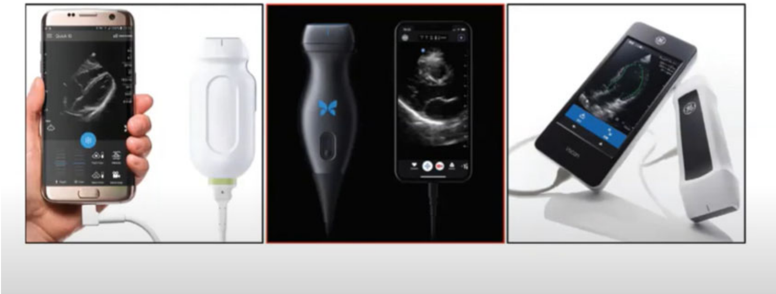
Favorable for Survival in Fluid Responsiveness Group


[Critical Care Original Research]
Press Esc to exit full screen
Fluid Response Evaluation in Sepsis Hypotension and Shock
A Randomized Clinical Trial
Ivor S. Douglas, MD; Philip M. Alapat, MD; Keith A. Corl, MD; Matthew C. Exline, MD; Luis G. Forni, PhD; Andre L. Holder, MD; David A. Kaufman, MD; Akram Khan, MD; Mitchell M. Levy, MD; Gregory S. Martin, MD; Jennifer A. Sahatjian, PsyD; Eric Seeley, MD; Wesley H. Self, MD; Jeremy A. Weingarten, MD; Mark Williams, MD; and Douglas M. Hansell, MD


Requirement for Renal Replacement Therapy (RRT)
Percentage
25%
20%
15%
10%
5%
0%
‡
I
UC

Practical Aspects to optimize Fluid Status

- Echocardiography (TTE, TEE



- Fluid Responsiveness
- ScvO2
- TPTD

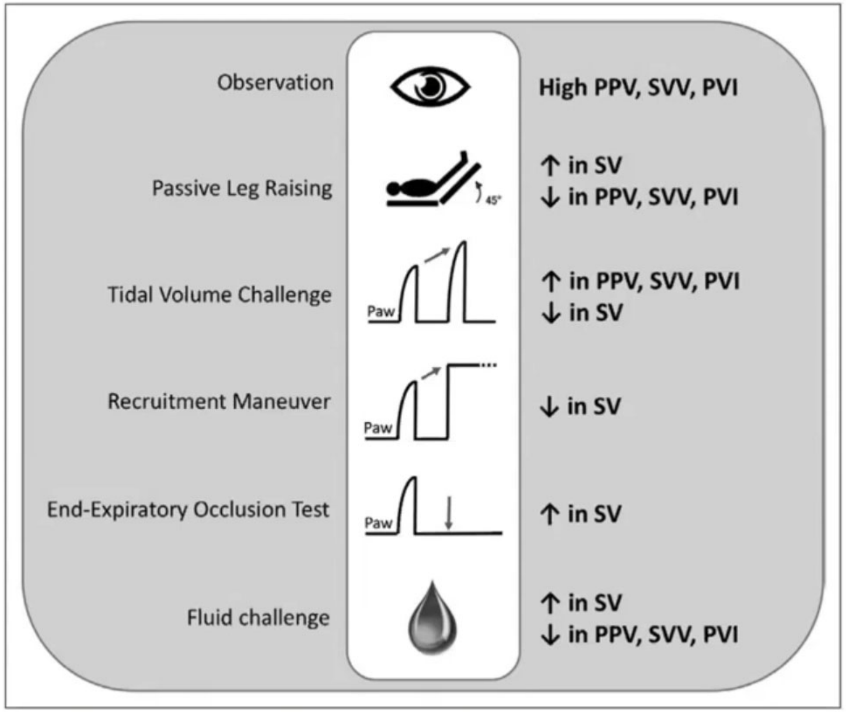


Figure 1. Methods currently available to detect, or unmask, a fluid responsive state. Paw = airway pressure, PPV = pulse pressure variation, PVI = plethysmographic variation index, SV = stroke volume, SVV = stroke volume variation, *down arrowhead* = significant decrease, *up arrowhead* = significant increase.

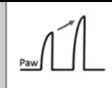
Michard F. Toward Precision Hemodynamic Management. Crit Care Med 2017

The Changes in Pulse Pressure Variation or Stroke Volume Variation After a "Tidal Volume Challenge" Reliably Predict Fluid Responsiveness During Low Tidal Volume Ventilation

CCM 2016

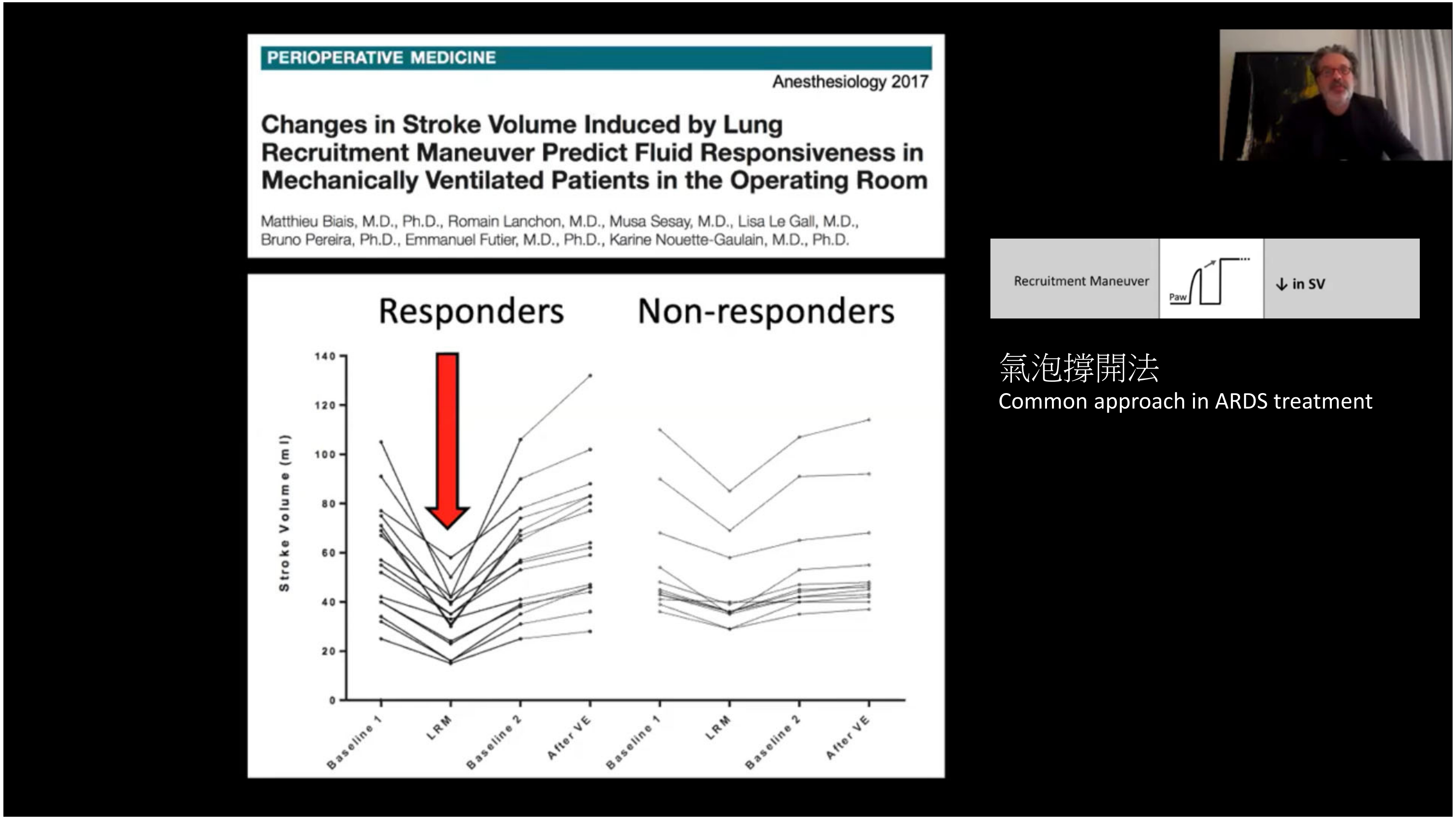
Sheila Nainan Myatra, MD, FCCM[1]; Natesh R Prabu, MD, DM[1]; Jigeeshu Vasishtha Divatia, MD, FCCM[1]; Xavier Monnet, MD, PhD[2]; Atul Prabhakar Kulkarni, MD, FICCM[1]; Jean-Louis Teboul, MD, PhD[2]

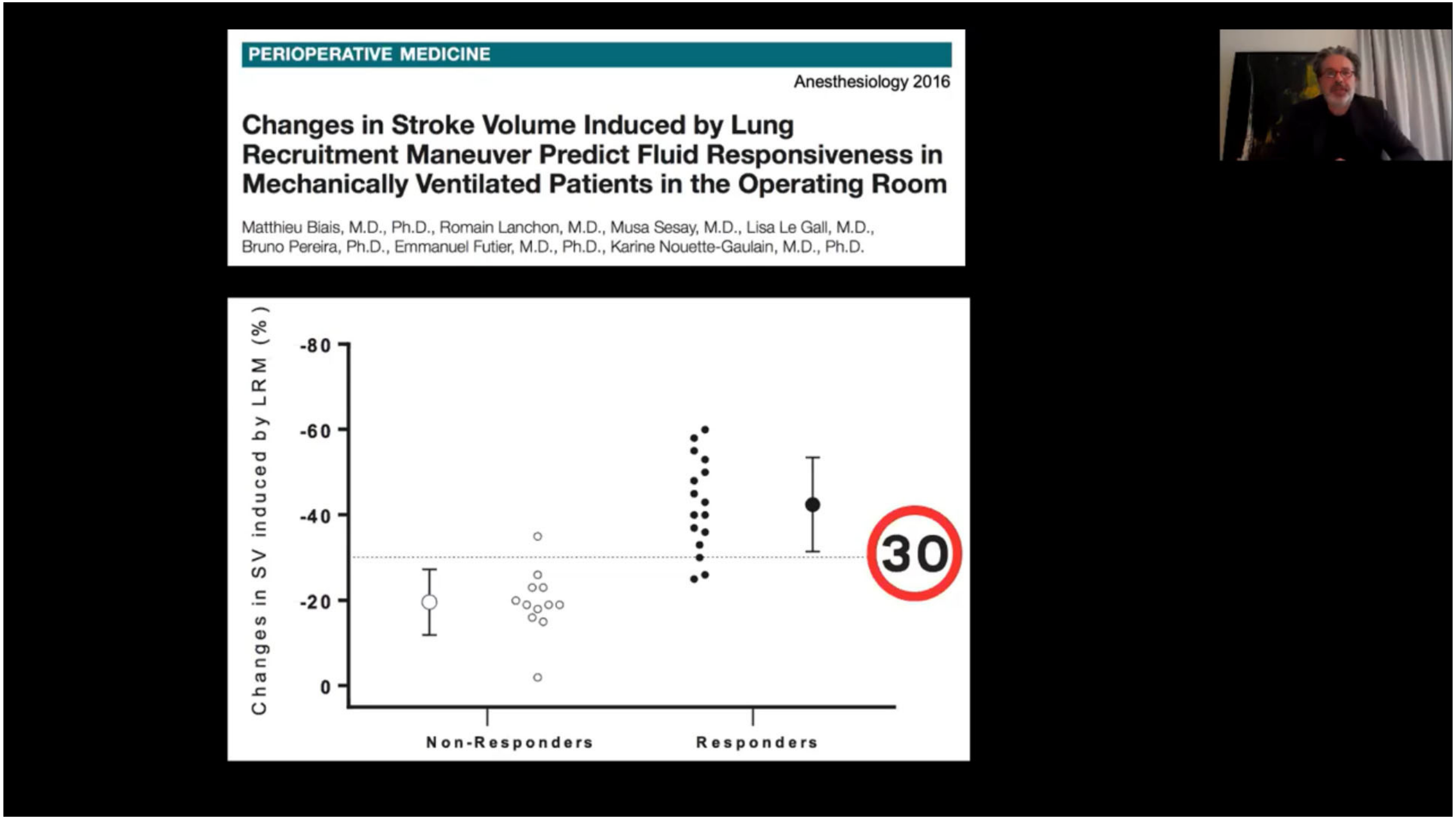
Tidal Volume Challenge



↑ in PPV, SVV, PVI
↓ in SV

Variables	Area Under the Receiver-Operating Characteristic Curve (95% CI)	p	Best Cutoff Value (%)	Sensitivity (%)	Specificity (%)
PPV at V_t 6 mL/kg PBW	0.69 (0.49–0.89)	0.071	–	–	–
SVV at V_t 6 mL/kg PBW	0.56 (0.35–0.77)	0.575	–	–	–
PPV at V_t 8 mL/kg PBW	0.91 (0.81–1.00)	< 0.001	11.5	75	100
SVV at V_t 8 mL/kg PBW	0.92 (0.82–1.00)	< 0.001	10.5	75	93
Change in PPV from V_t 6 to 8 mL/kg PBW	0.99 (0.98–1.00)	< 0.001	3.5	94	100
Change in SVV from V_t 6 to 8 mL/kg PBW	0.97 (0.92–1.00)	< 0.001	2.5	88	100


PERIOPERATIVE MEDICINE
Anesthesiology 2017
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.
Responders
Non-responders
Stroke Volume (ml)
140
120
100
80
60
40
20
0
Baseline 1
LRM
Baseline 2
After VE
Baseline 1
LRM
Baseline 2
After VE
Recruitment Maneuver
Paw
↓ in SV
氣泡撐開法
Common approach in ARDS treatment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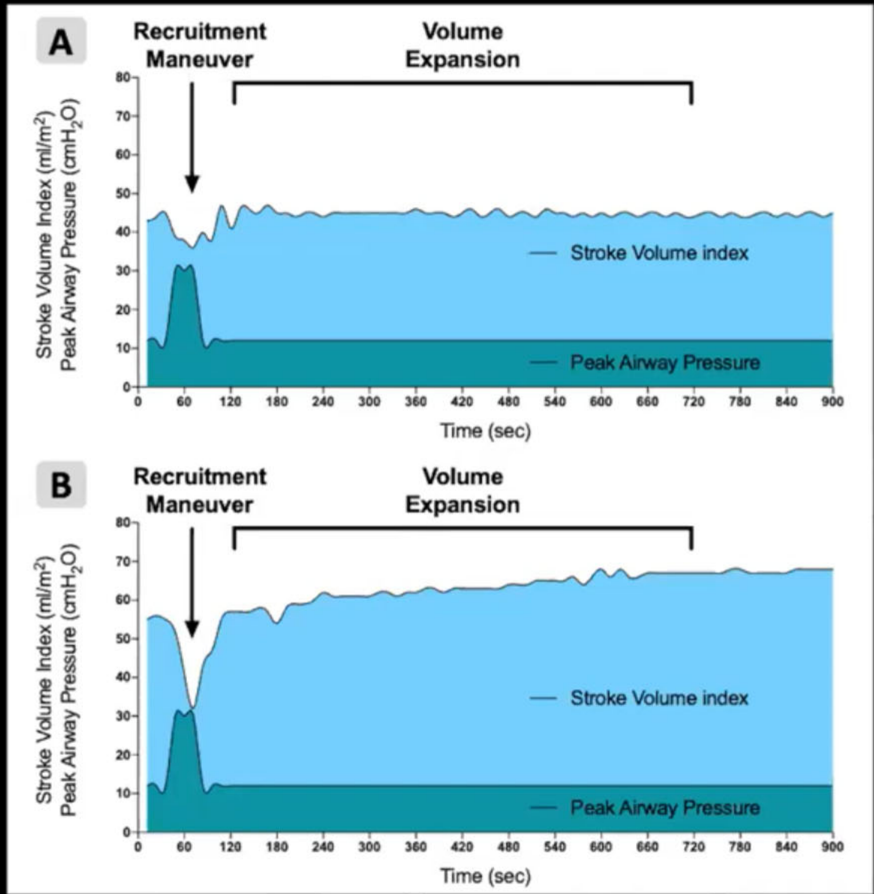
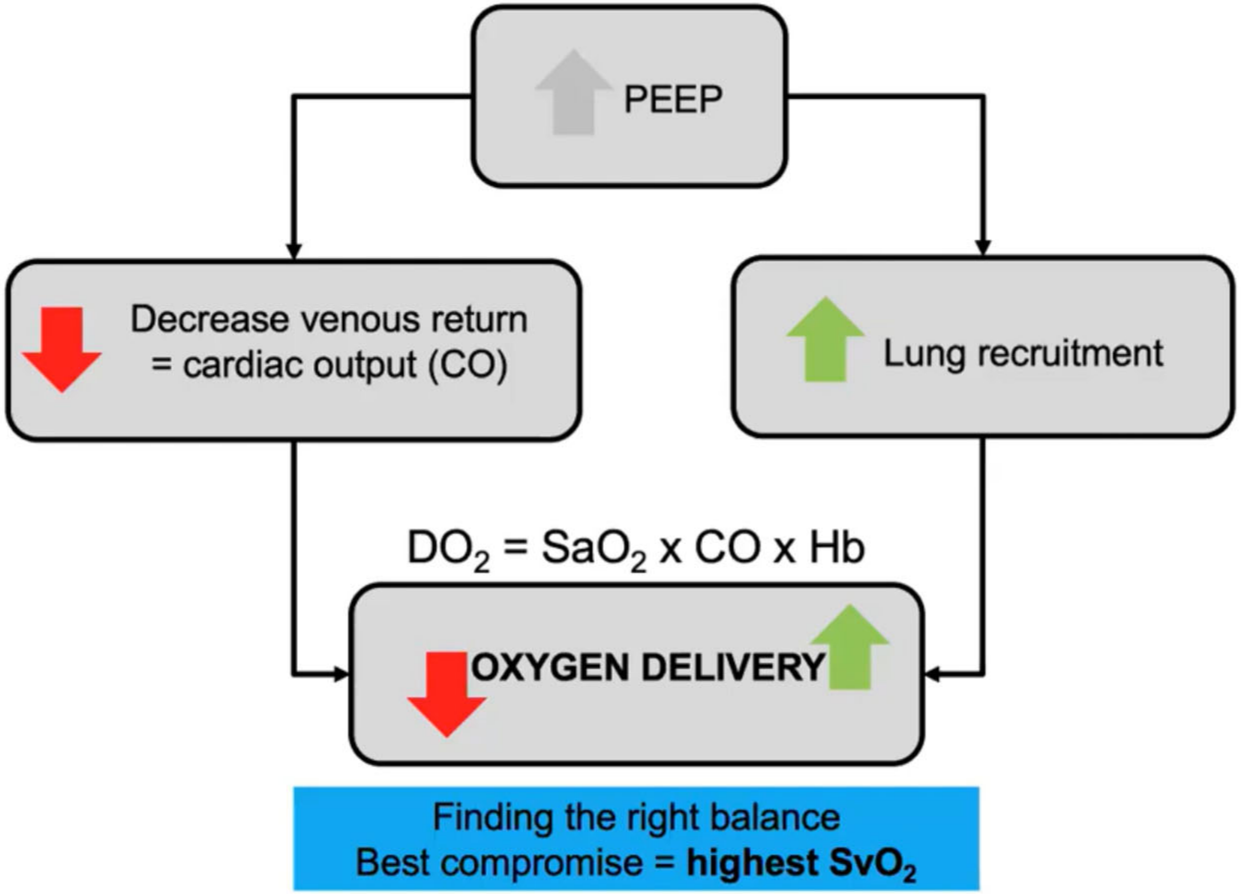
Changes in SV induced by LRM (%)
-80
-60
-40
-20
0
Non-Responders
Responders
30

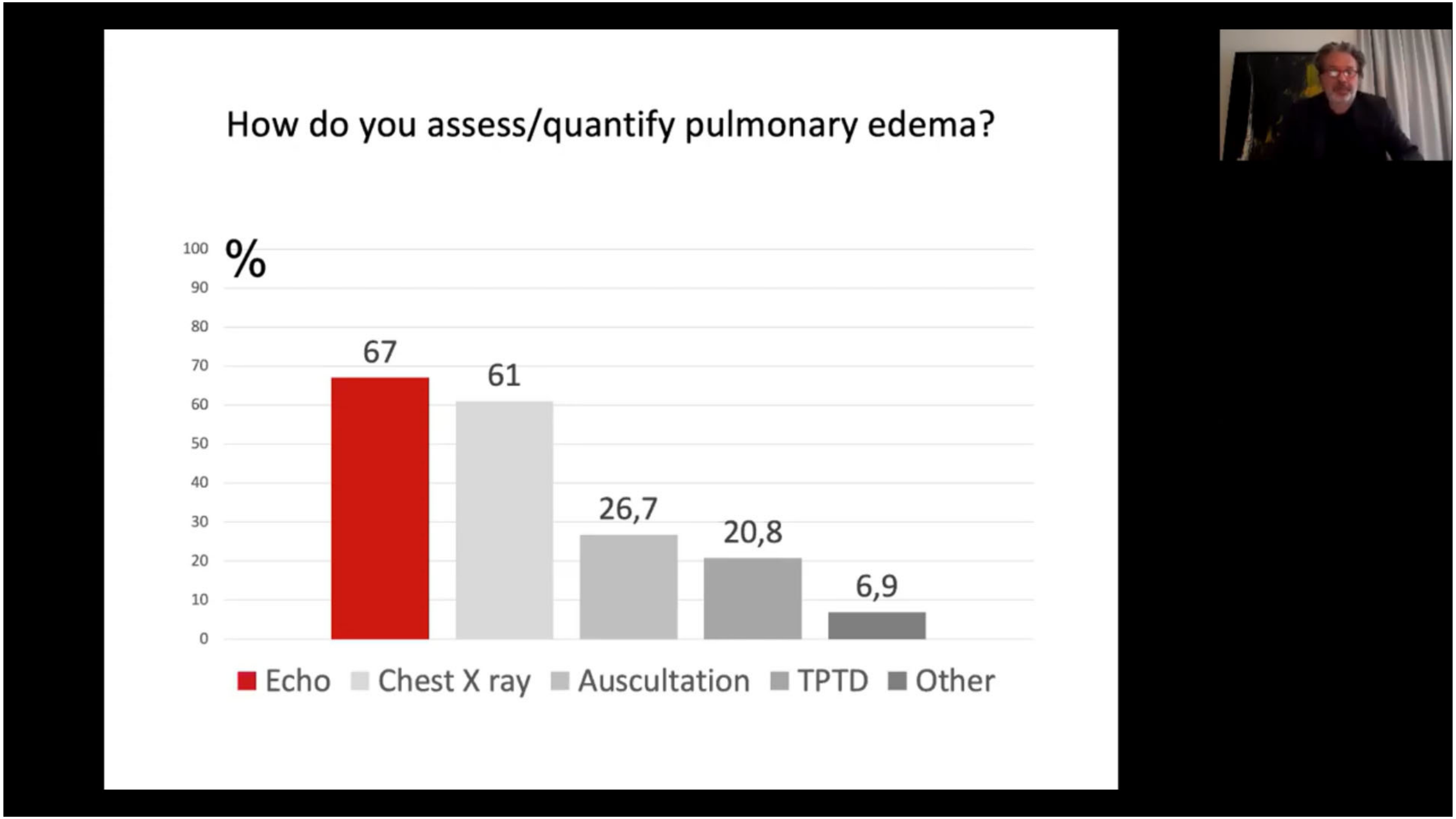
30 cmH_2O
30 sec
< 30 %

30 cmH_2O
30 sec
> 30 %

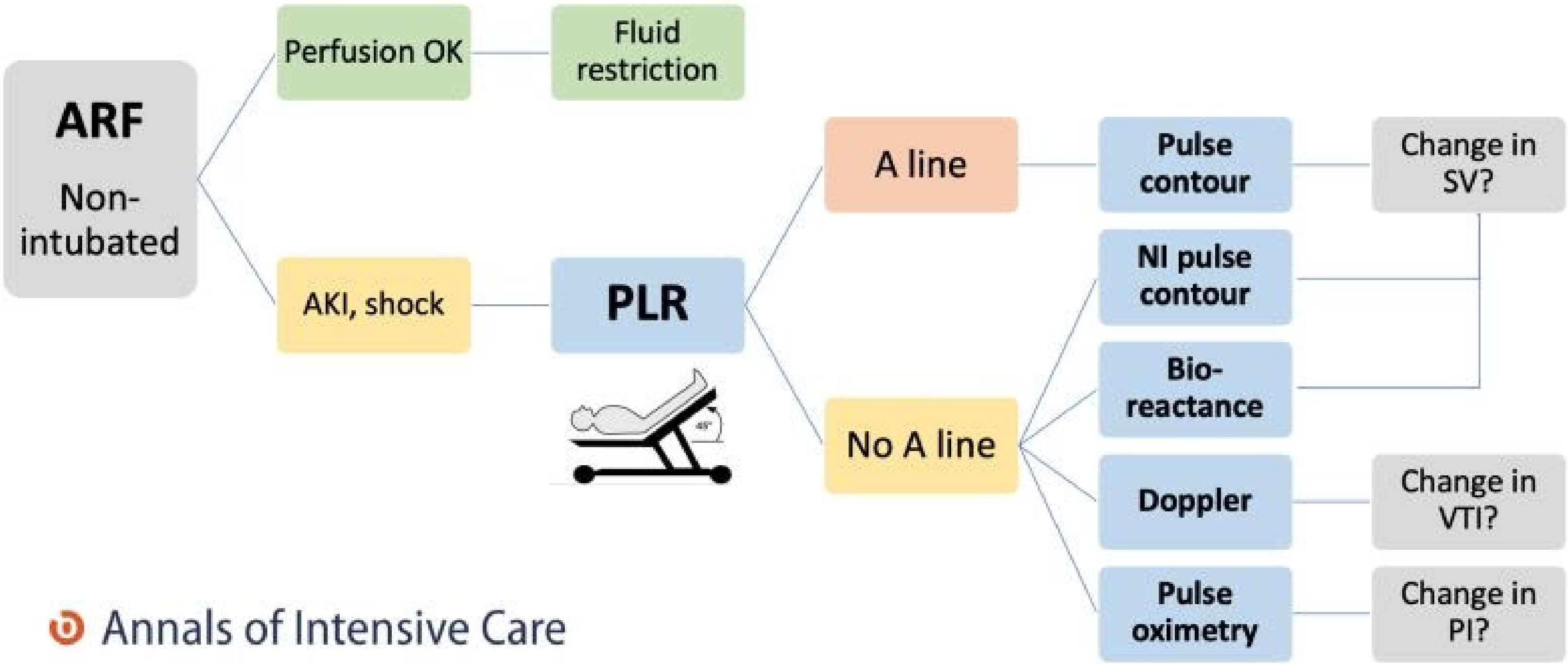


Predicting fluid responsiveness: Time for automation
Michard F & Biais M. Crit Care Med 2019


PEEP
Decrease venous return
= cardiac output (CO)
Lung recruitment
$DO_2 = SaO_2 \times CO \times Hb$
OXYGEN DELIVERY
Finding the right balance
Best compromise = **highest SvO_2**

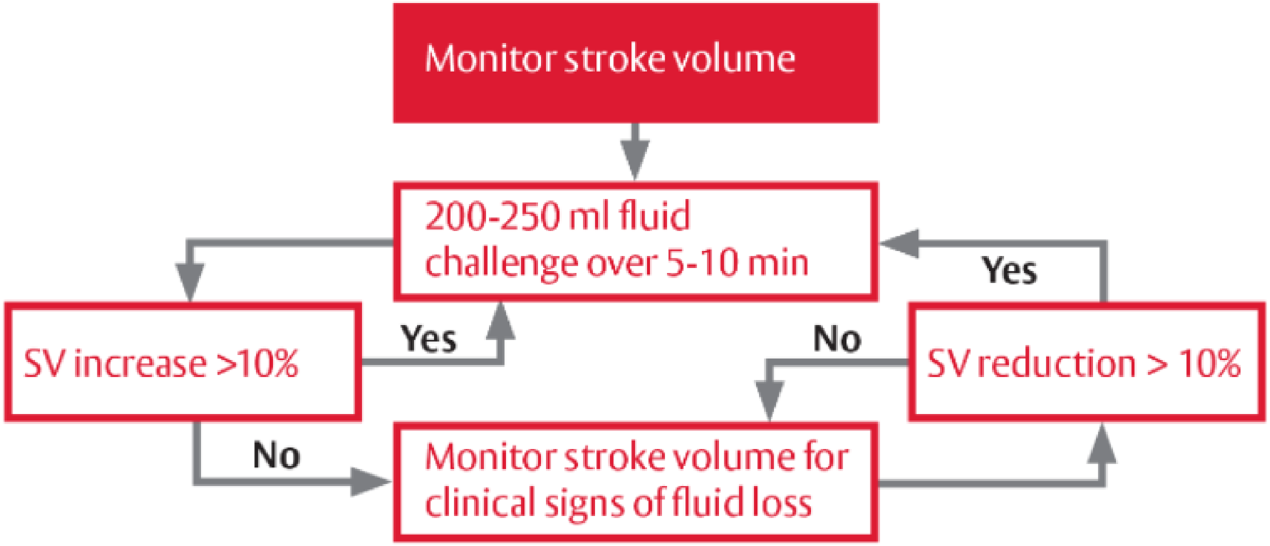

How do you assess/quantify pulmonary edema?
%
100
90
80
70
60
50
40
30
20
10
0
67
61
26,7
20,8
6,9
Echo
Chest X ray
Auscultation
TPTD
Other

Importance in assess fluid responsiveness in Acute Renal Failure



Annals of Intensive Care

Stroke volume optimization % change in stroke volume (ΔSV) is a sensitive method for assessing preload responsiveness in all patients.



Managing shock in COVID-19 patients

Type of shock	MAP	CO/SV	DO_2	CVP	MPAP	PCWP	SVR	HPI	dP/dt	Ea_{dyn}
Hypovolemic	↓→	↓	↓	↓	↓	↓	↑	↑	↑↓	↑
Obstructive	↓	↓	↓	↑	↑	↑→	↑→	↑	↑	↑↓
Cardiogenic	↓→	↓	↓	↑	↑	↑	↑	↑	↓	↑↓
Distributive	↓	↑	↑	↓	↓	↓	↓	↑	↑	↓

↑ Increased ↓ Decreased → No change

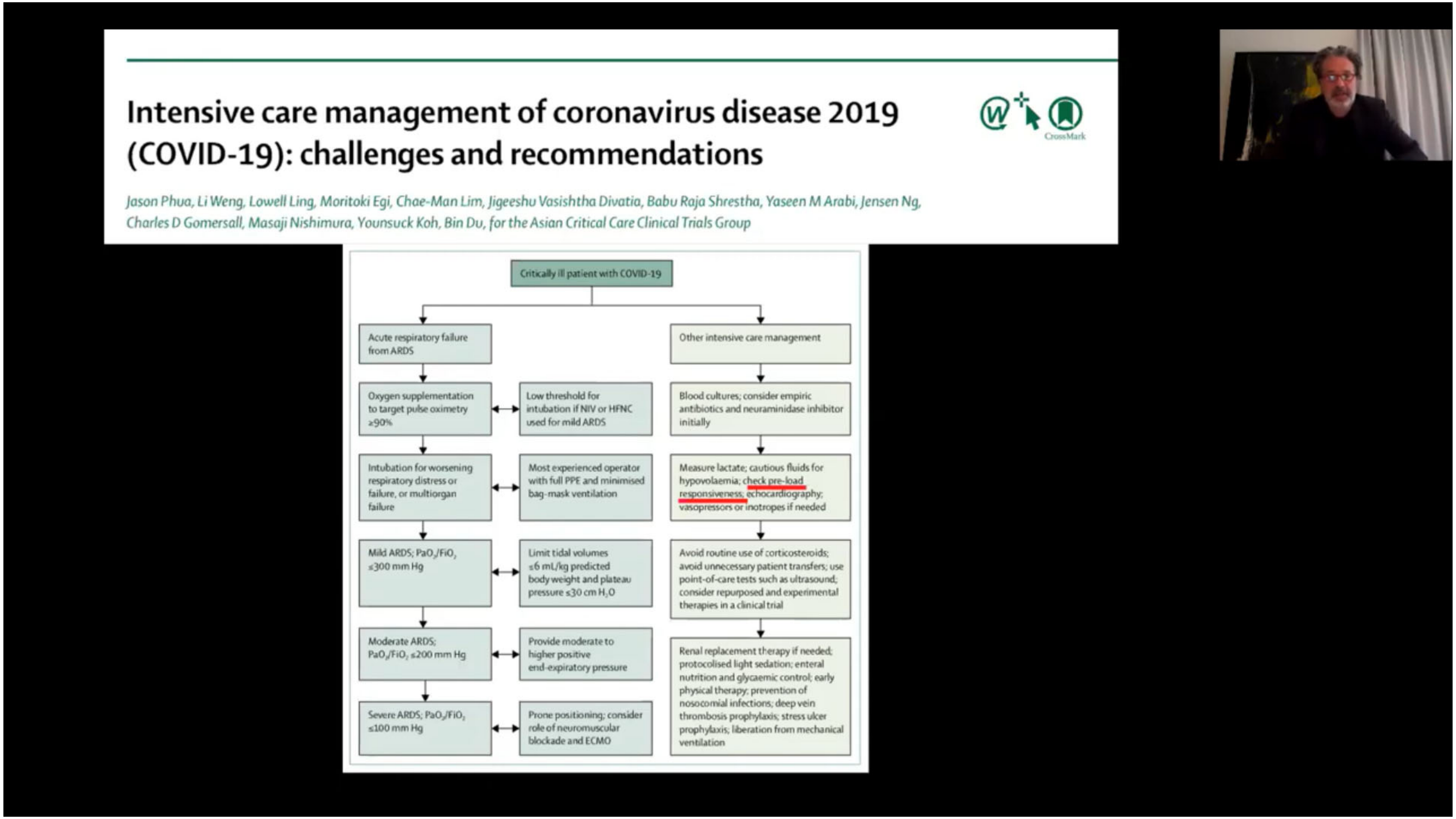
Edwards Lifesciences: COVID-19 support

As understanding of the novel SARS-CoV-2 virus and resulting COVID-19 disease evolves almost daily, clinicians around the world are in constant discussions on how best to care for, treat, and manage patients with COVID-19 and resulting sepsis, septic shock, and/or acute respiratory distress syndrome (ARDS). Their focus is on supporting ideal oxygenation and maintaining appropriate fluid balance to minimize severe life-threatening complications. Included within this newsletter are resources that can help clinicians minimize the complexity of managing fluids in patients hospitalized with COVID-19.

"No monitoring device, no matter how simple or complex, invasive or noninvasive, inaccurate or precise will improve outcomes unless coupled to a treatment, which itself improves outcome."[1]

Pinsky and Payen

https://www.edwards.com/pages/COVID19-hemodynamics-in-ICU


Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations
Jason Phua, Li Weng, Lowell Ling, Moritoki Egi, Chae-Man Lim, Jigeeshu Vasishtha Divatia, Babu Raja Shrestha, Yaseen M Arabi, Jensen Ng, Charles D Gomersall, Masaji Nishimura, Younsuck Koh, Bin Du, for the Asian Critical Care Clinical Trials Group
CrossMark
Critically ill patient with COVID-19
Acute respiratory failure from ARDS
Other intensive care management
Oxygen supplementation to target pulse oximetry ≥90%
Low threshold for intubation if NIV or HFNC used for mild ARDS
Blood cultures; consider empiric antibiotics and neuraminidase inhibitor initially
Intubation for worsening respiratory distress or failure, or multiorgan failure
Most experienced operator with full PPE and minimised bag-mask ventilation
Measure lactate; cautious fluids for hypovolaemia; check pre-load responsiveness; echocardiography; vasopressors or inotropes if needed
Mild ARDS; PaO_2/FiO_2 ≤300 mm Hg
Limit tidal volumes ≤6 mL/kg predicted body weight and plateau pressure ≤30 cm H_2O
Avoid routine use of corticosteroids; avoid unnecessary patient transfers; use point-of-care tests such as ultrasound; consider repurposed and experimental therapies in a clinical trial
Moderate ARDS; PaO_2/FiO_2 ≤200 mm Hg
Provide moderate to higher positive end-expiratory pressure
Renal replacement therapy if needed; protocolised light sedation; enteral nutrition and glycaemic control; early physical therapy; prevention of nosocomial infections; deep vein thrombosis prophylaxis; stress ulcer prophylaxis; liberation from mechanical ventilation
Severe ARDS; PaO_2/FiO_2 ≤100 mm Hg
Prone positioning; consider role of neuromuscular blockade and ECMO

Applicability of pulse pressure variation: how many shades of grey?

Frederic Michard[1*], Denis Chemla[2] and Jean-Louis Teboul[3]

CRITICAL CARE

		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	✔	✔