VV ECMO

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KOMPLEXNÍ KARDIO VASKULÁRNÍ CENTRUM VFN Praha

Indications to ECMO „bridge“

- 1.) Cardiogenic shock, CPR
  - Reversible LV or RV failure
- 2.) Critical oxygenation failure:
  - ARDS
- 3.) Hypercapnic respiratory failure
  - Reversible retention of CO_2 , lung protection
- 4.) Barotrauma, bronchopleural communication
  - Lowering of Paw, Ptp
- 5.) Airway obstruction
  - Time to dg. and treatment
- 6.) On waiting list for lung Tx
  - Avoiding intubation and complications, bridge to Tx

Indications to VV-ECMO – ELSO guidelines

Hypoxic respiratory failu

- Estimated mortali

PaO_2/FiO_2 <150, Murray

- Estimated mortali

PaO_2/FiO_2 <80, Murray 3

Retention CO_2, $PaCO_2$ >

Air-leak (barotrauma)

Age < 65 years

IPPV up to 7 days

Blocked airway

Cardiorespiratory collaps

Reparable lung disease

Contraindications to VV ECMO:

Absolute:

- IC bleeding, stroke
- hypoxic cardiac arrest
- irreversible lung damage, incurable disease
- **severe heart failure, cardiogenic shock**
- **severe pulmonary hypertension (PAPm > 50 mmHg)**

Relative:

- age > 75 years
- obesity with a BMI over 40
- aggressive IPPV ≥ 7 days
- advanced liver disease
- trauma with extensive bleeding
- hemorrhagic diathesis and severe thrombocytopenia IDEA study, AJRCCM 2018
- imunocompromise IDEA, AJRCCM 2018, Intens Care Med 2013

ECMO….in/on time !

Supady *et al. Crit Care* (2021) 25:90
https://doi.org/10.1186/s13054-021-03486-9

Critical Care

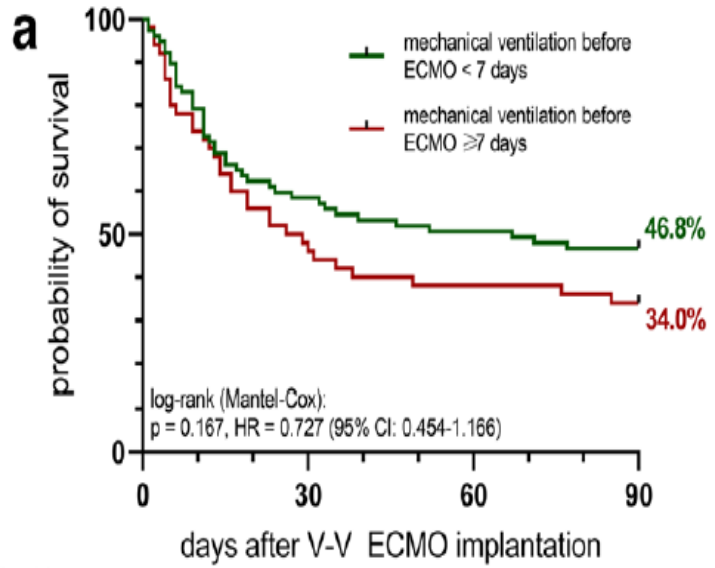
RESEARCH LETTER **Open Access**

Survival after extracorporeal membrane oxygenation in severe COVID-19 ARDS: results from an international multicenter registry

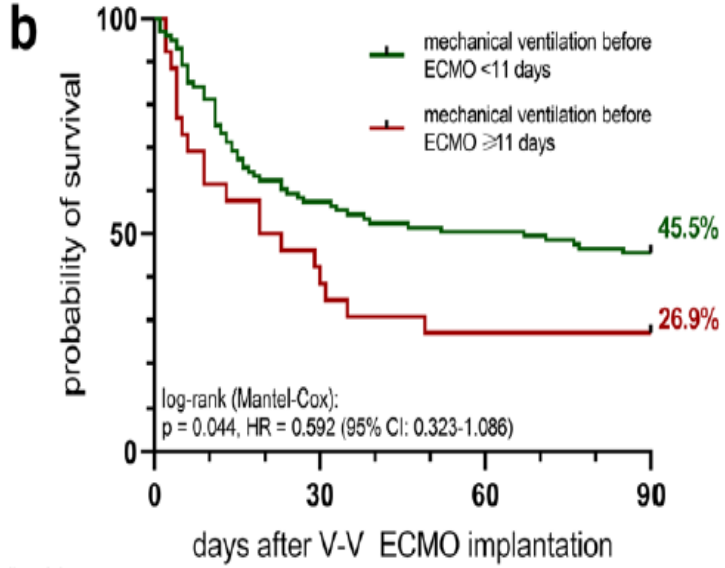
Extracorporeal Life Support Organization (ELSO)

Patient Specific Supplements to the ELSO General Guidelines

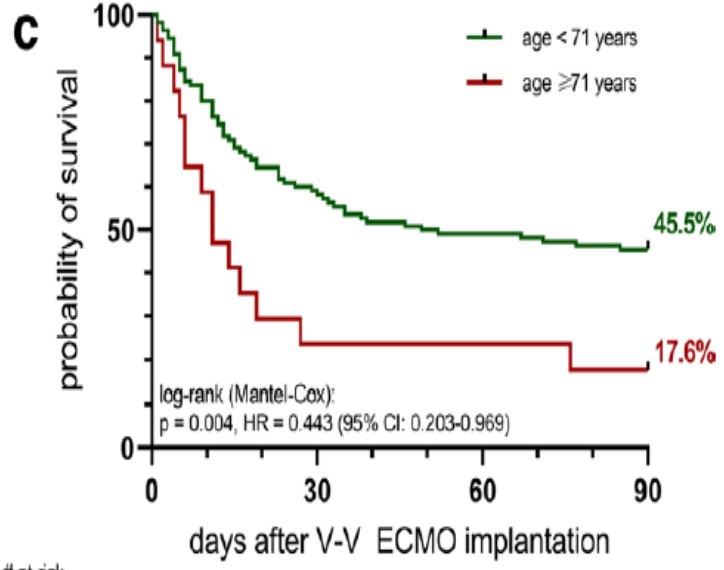
127 patients, 15 ECMO centers



# at risk				
ventilation < 7d	77	46	40	36
ventilation ⩾7d	50	24	20	17

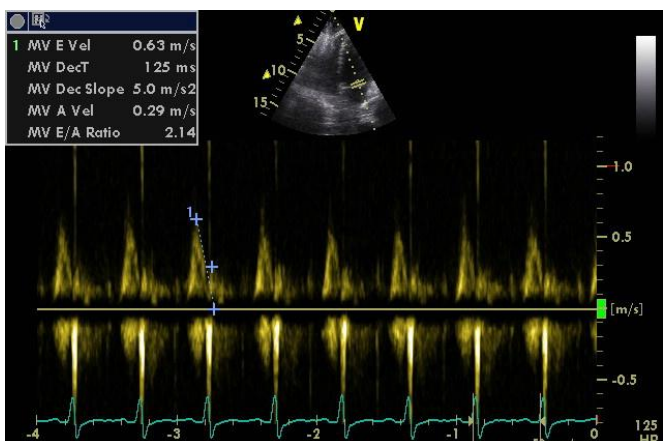


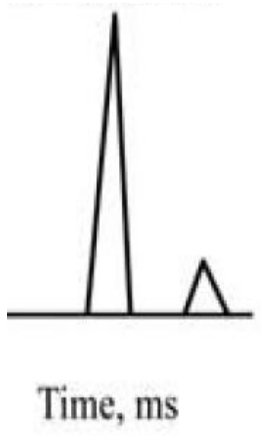
# at risk				
ventilation < 11d	101	59	52	46
ventilation ⩾11d	26	11	8	7



# at risk				
age < 71 years	110	65	55	50
age ⩾71 years	17	5	5	3

VV-ECMO: Is this ARDS ? What is LVEDP ? Is ECMO indicated ?





Transmitral doppler and 100 % PPV for **PAWP >18 mmHg**
(Boussugues A, et al: Crit Care Med 2002, Giannuzzi P, J Am Coll Cardiol 1994)

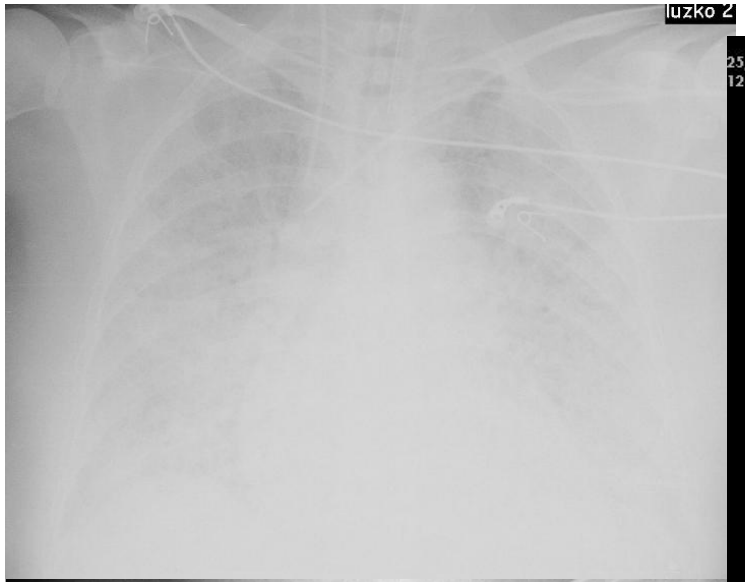
Echocardiography in extracorporeal life support: A key player in procedural guidance, tailoring and monitoring

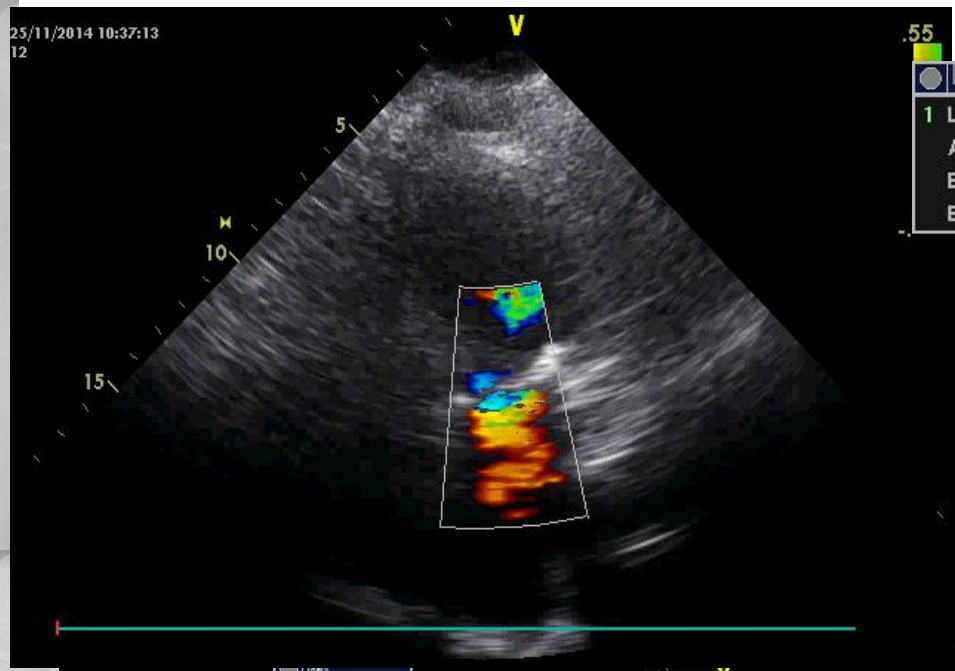
Perfusion
1–11

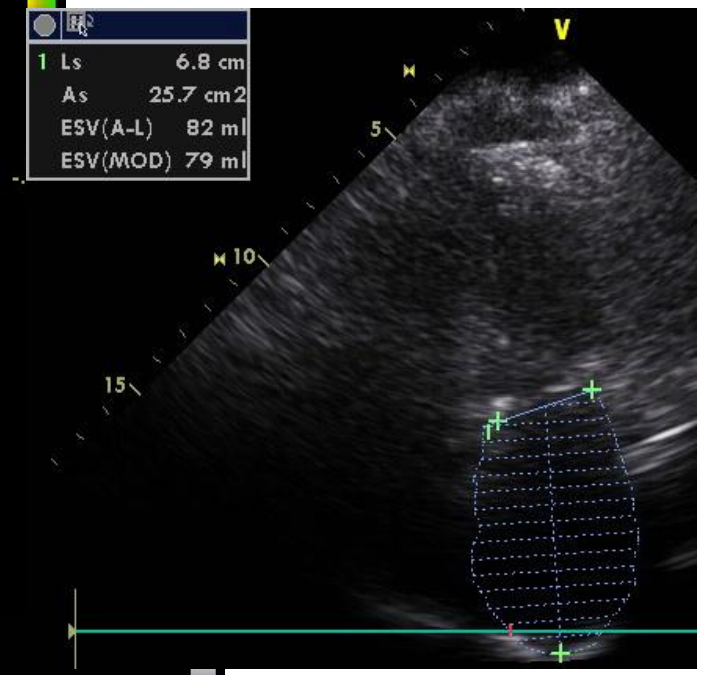
DOI: 10.1177/0267659118766438
journals.sagepub.com/home/prf
SAGE

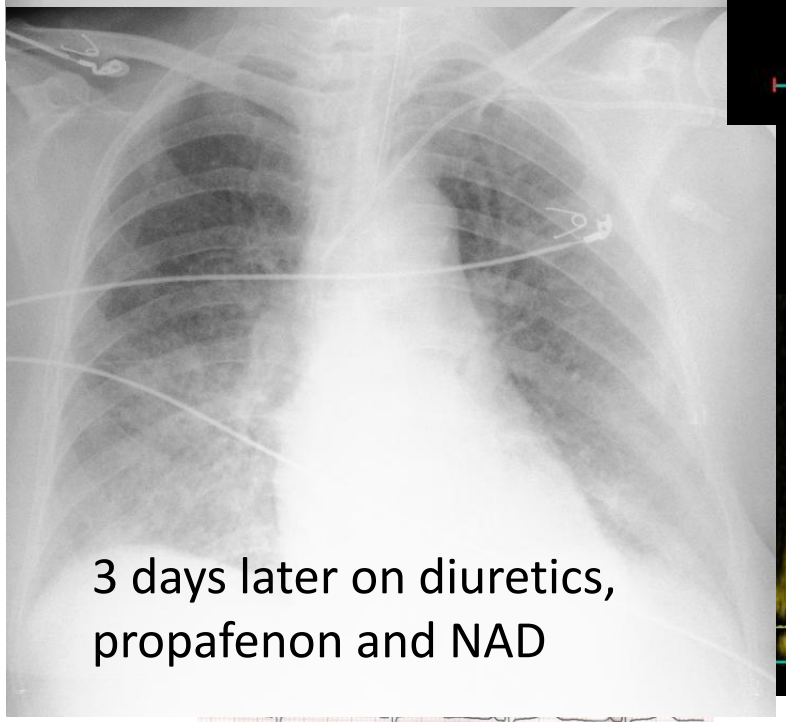
Dirk W. Donker,[1] Christiaan L. Meuwese,[2] Sue A. Braithwaite,[3]
Michael Broomé,[4,5,6] Joris J. van der Heijden,[1]
Jeannine A. Hermens,[1] Marc Platenkamp,[1] Michel de Jong,[7]
Jacqueline G.D. Janssen,[1] Martin Balík[8] and Jan Bělohlávek[9]

LV dysfunction (HFpEF) referred as „ARDS“ to ECMO

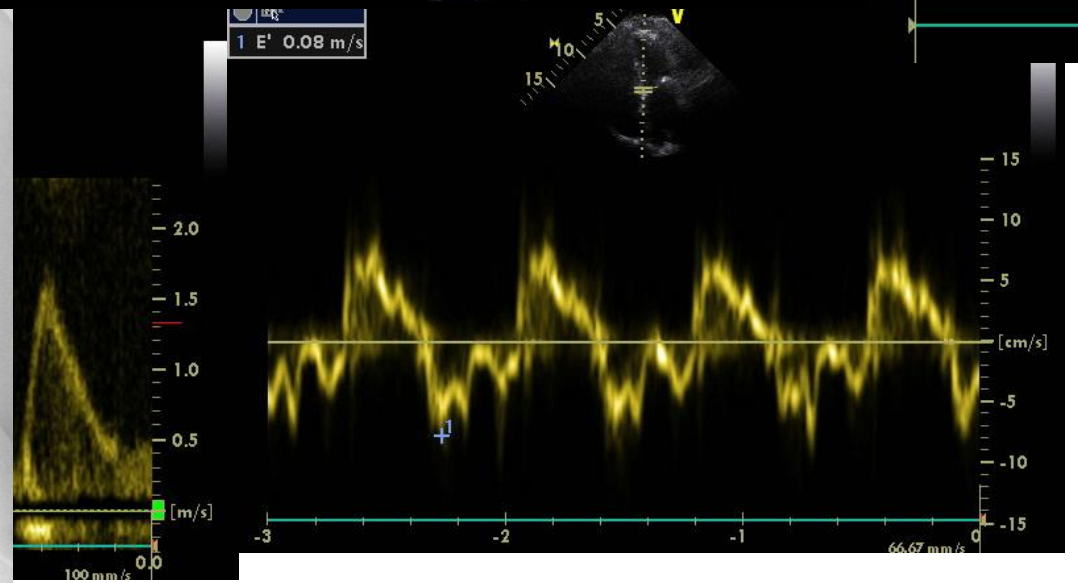








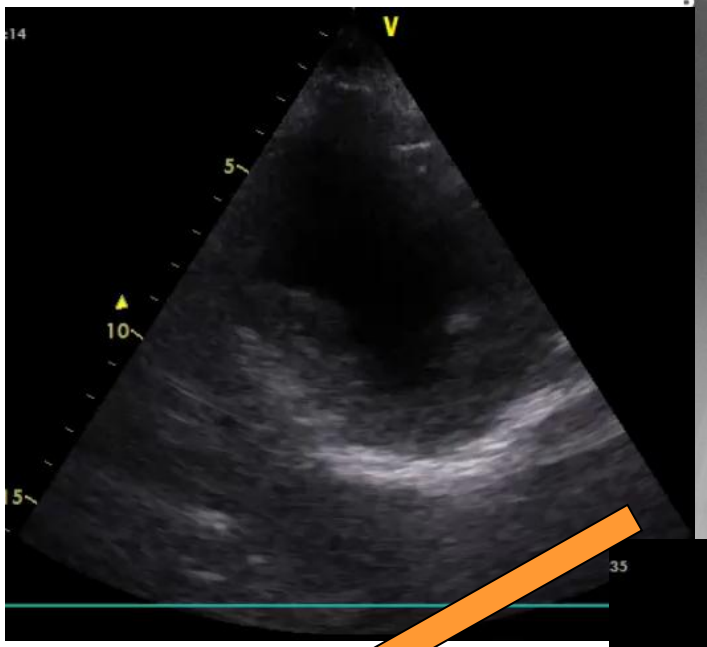
3 days later on diuretics, propafenon and NAD

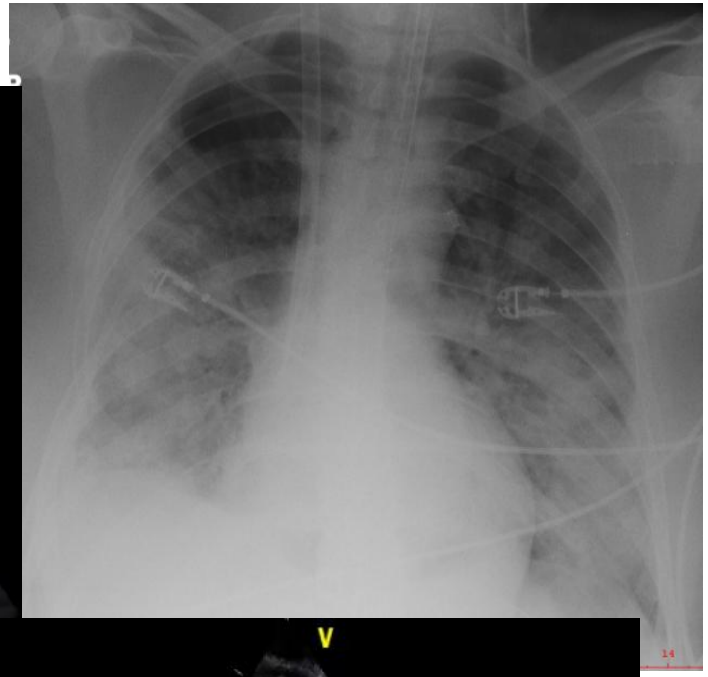


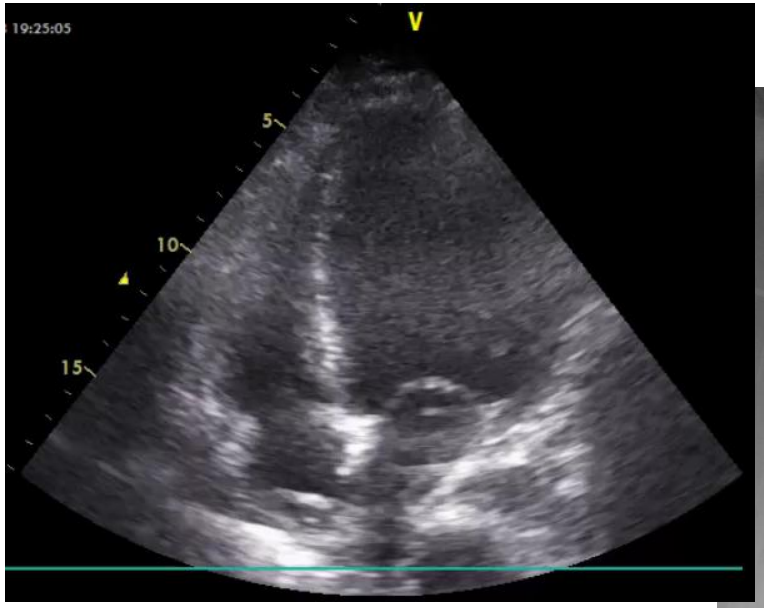
- LA ESV 50 ml/m²
- E/E´ 21

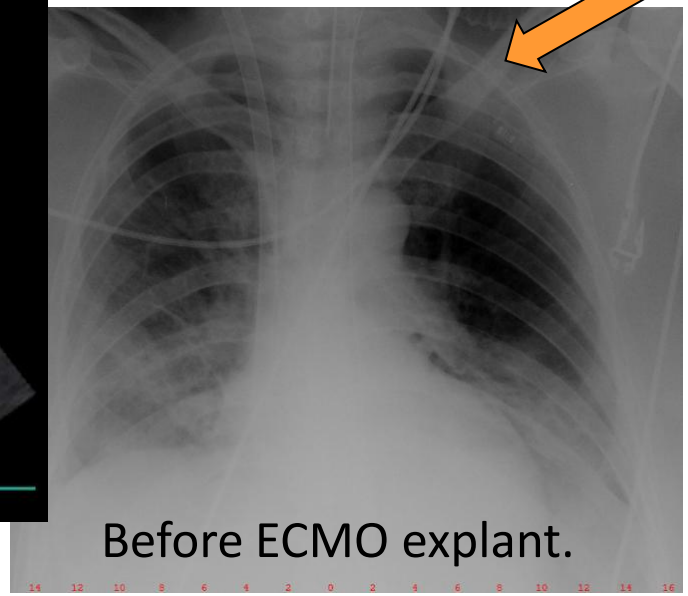
Respiratory failure in a 47y female manager – VA or VV ECMO ?

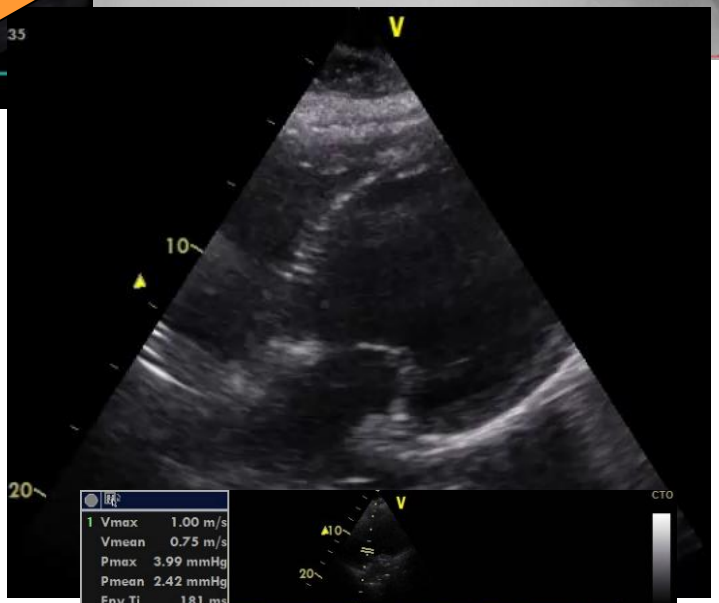
- Known “heart problem“ with HF medications
- Influenza B - ARDS
- Rescued hypoxic paO_2/FiO_2 82
- VV-ECMO 7 days

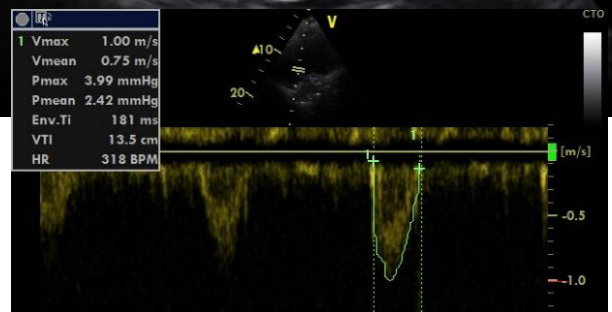






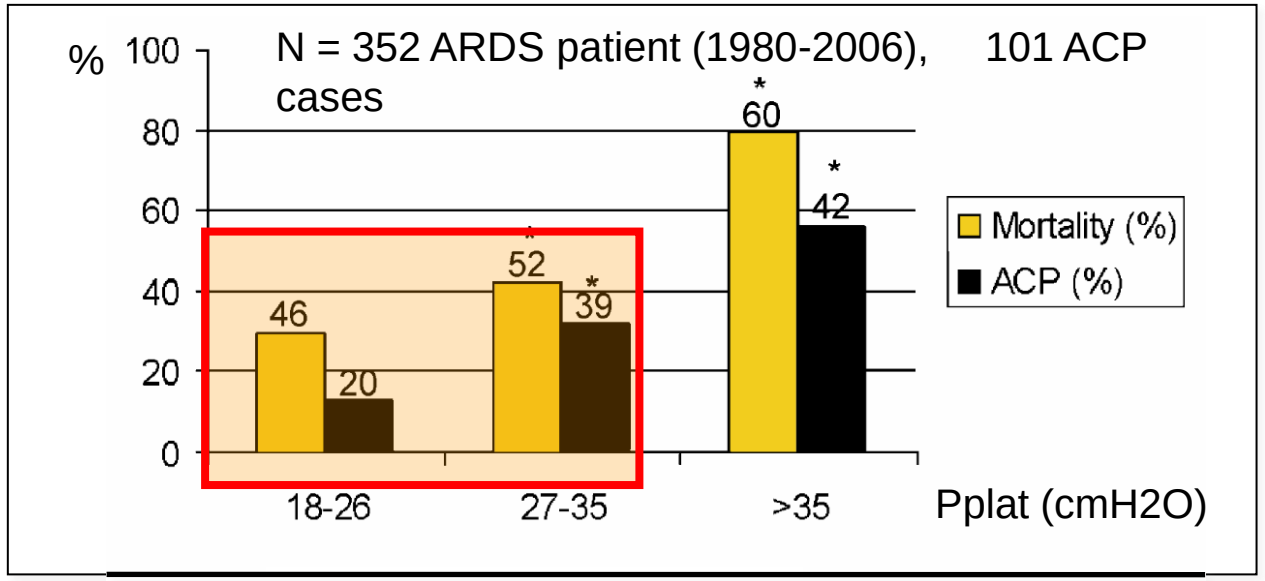




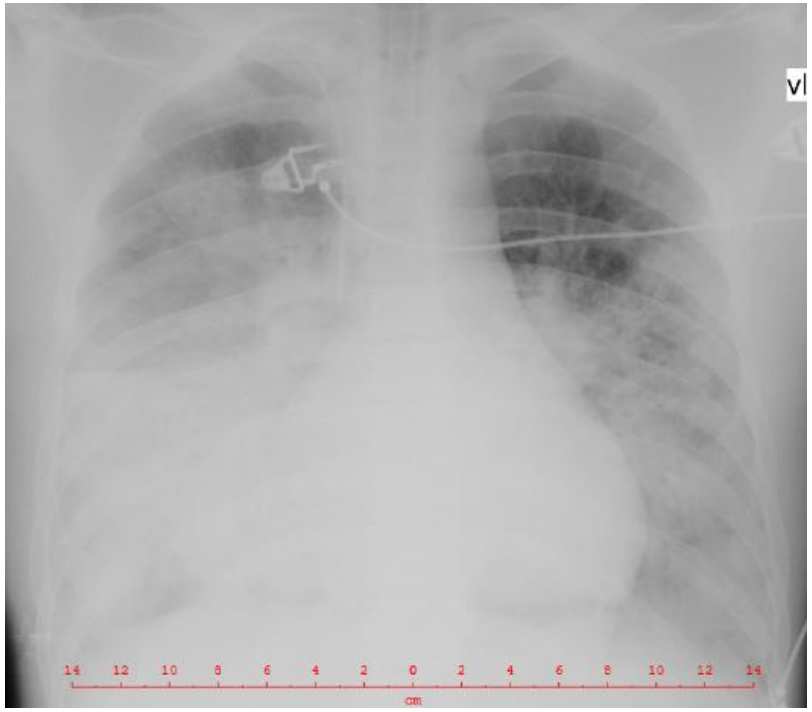


Right ventricular failure: Primary or obstructive, secondary to severe respiratory failure

- ARDS: ACP up to 33% (Jardin F, Intensive Care Med 2007)
- Pplat < 27 mbar only 13%
- Survival on IPPV linearly related to EF_RV (Steltzer H: Anaesthesia 1994)
- ACP and RVF as an indication to VA-ECMO….



Jardin F, Vieillard-Baron A. INT CARE MED 2007

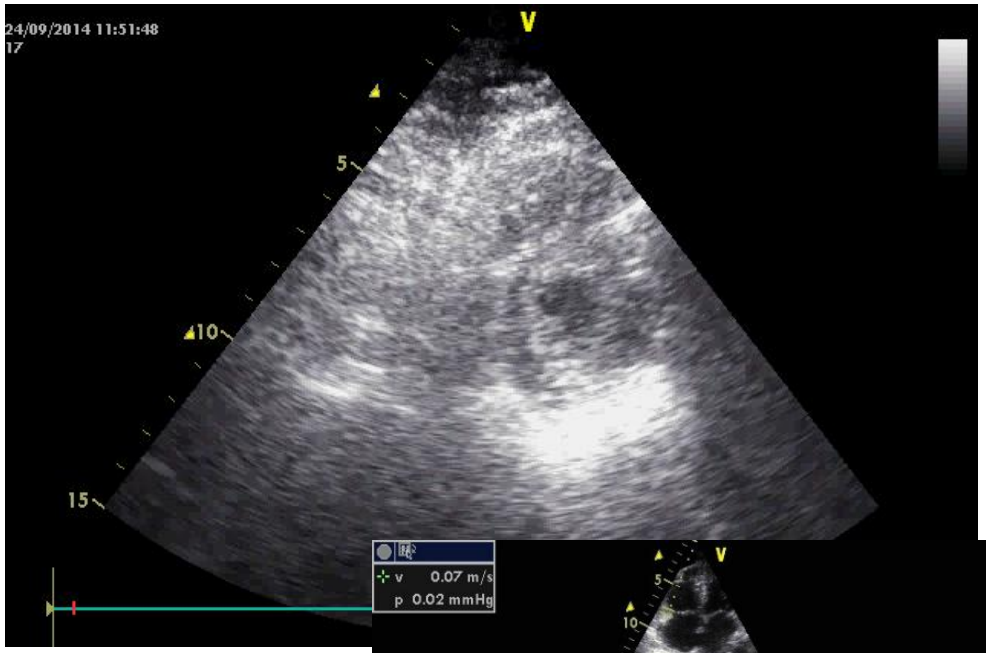


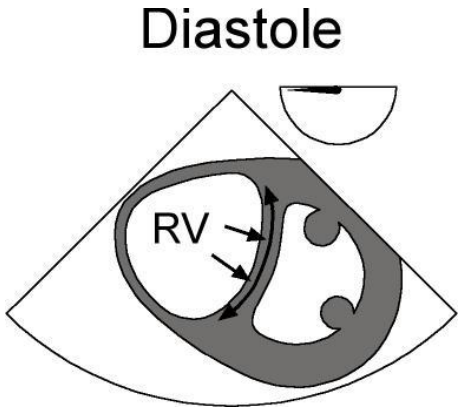
N = 352 ARDS patients (1980-2006)

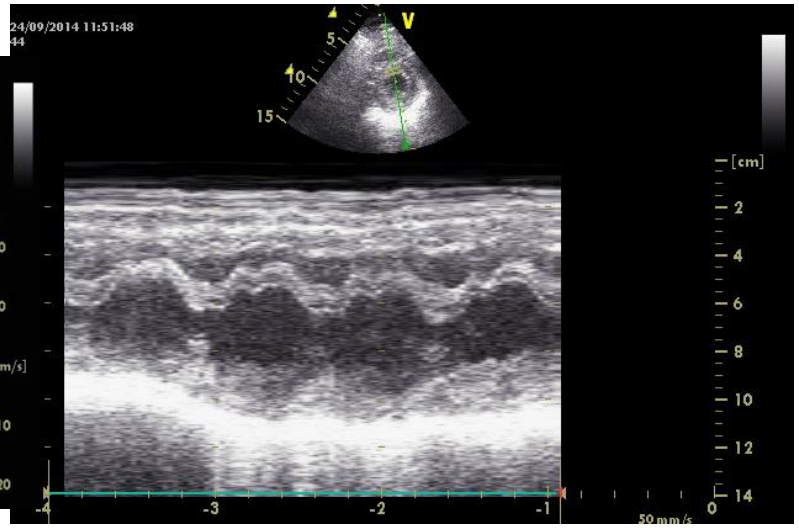
101 ACP cases

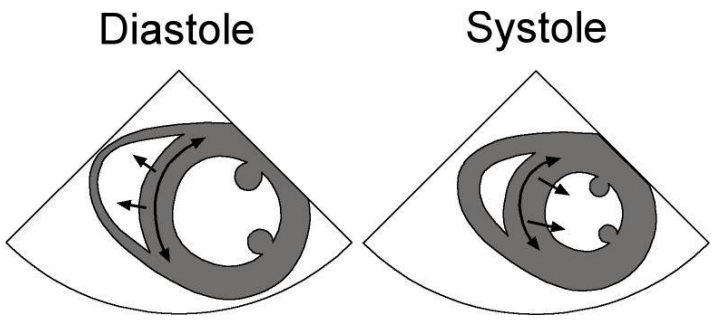
ACP 13% for Pplat < 27 cmH2O

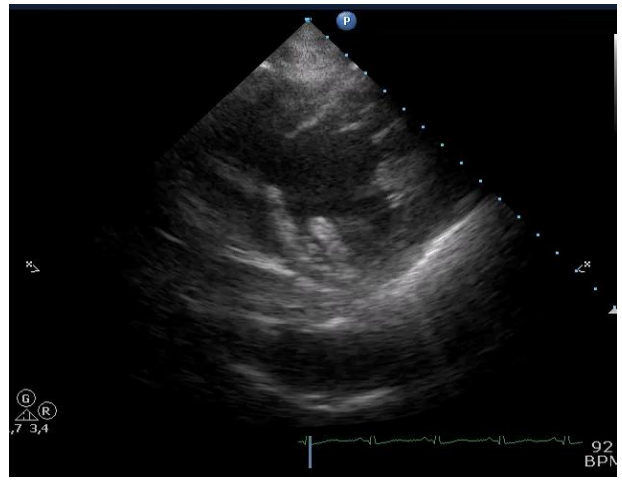
RV dysfunction and ECMO



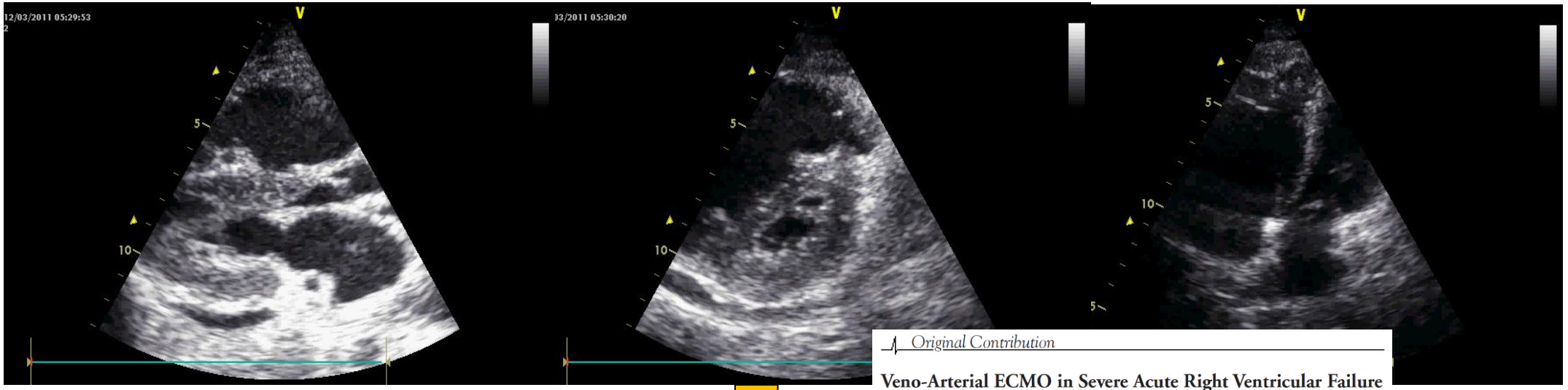


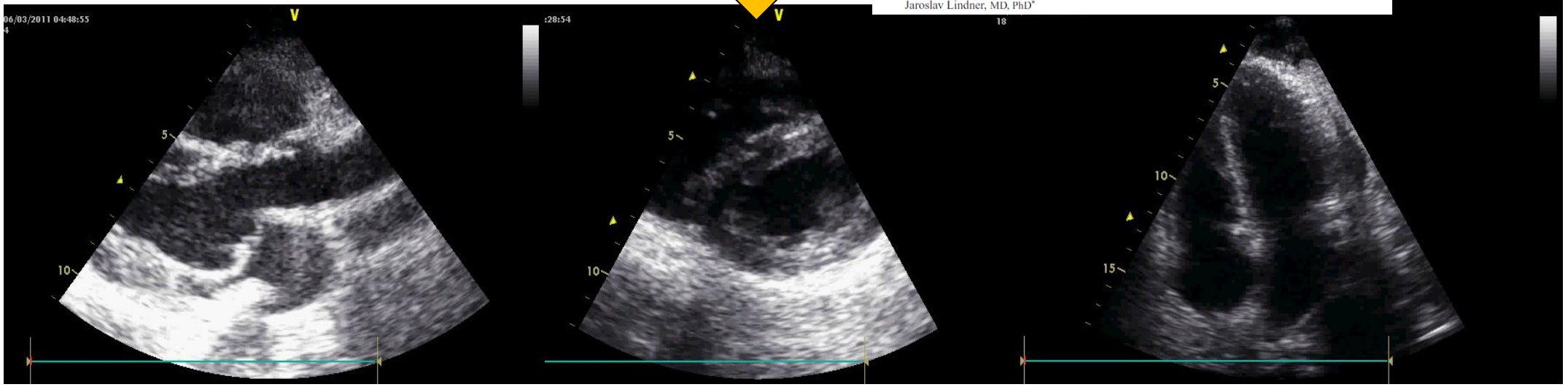






ACP during conventional therapy of ARDS+PE – from VA-ECMO to VAV-ECMO



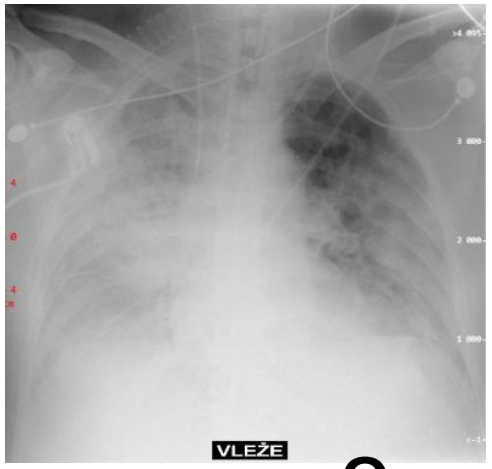


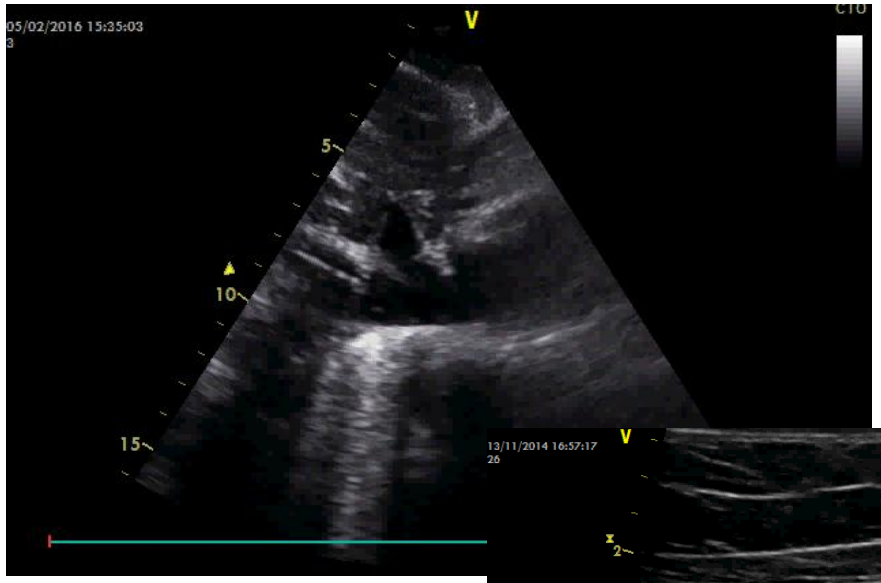
Original Contribution

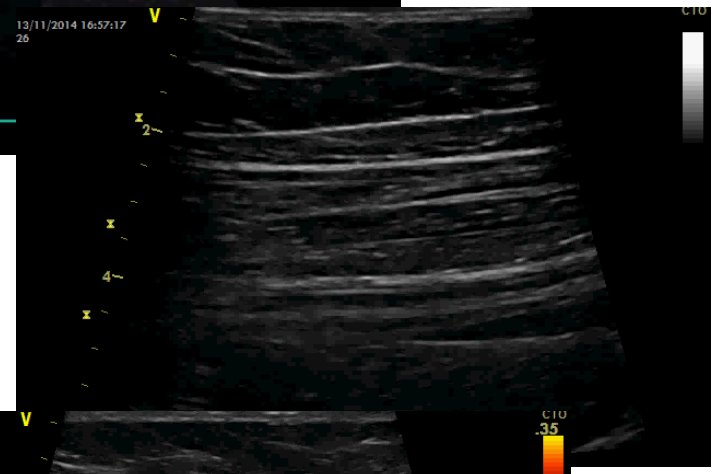
Veno-Arterial ECMO in Severe Acute Right Ventricular Failure with Pulmonary Obstructive Hemodynamic Pattern

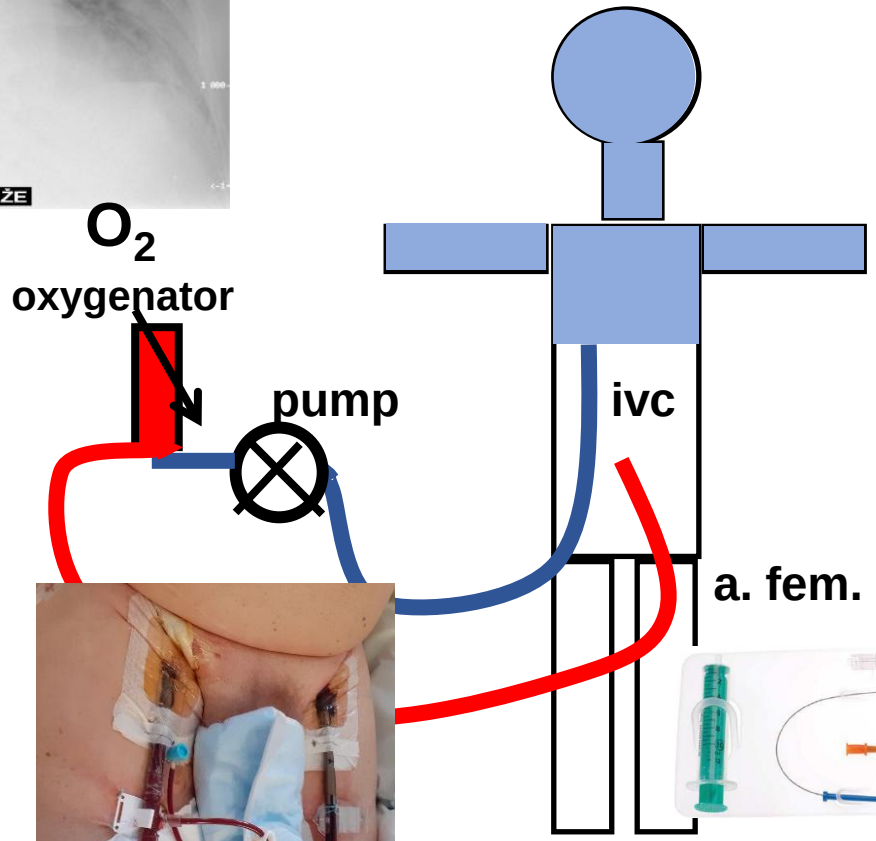
Jan Belohlavek, MD, PhD§, Vilem Rohn, MD, PhD*, Pavel Jansa, MD§, Jan Tosovsky, MD, PhD*, Jan Kunstyr, MD, PhD†, Michal Semrad, MD, PhD‡, Jan Horak, MD, PhD§, Michal Lips, MD†, Frantisek Mlejnsky, Mgr*, Martin Balik, MD, PhD†, Andrew Klein, MD**, Ales Linhart, MD, PhD§, Jaroslav Lindner, MD, PhD*

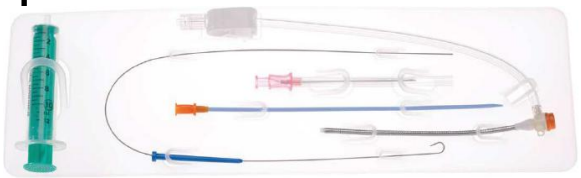
cardiorespiratory failure and CS: FF_V-A ECMO



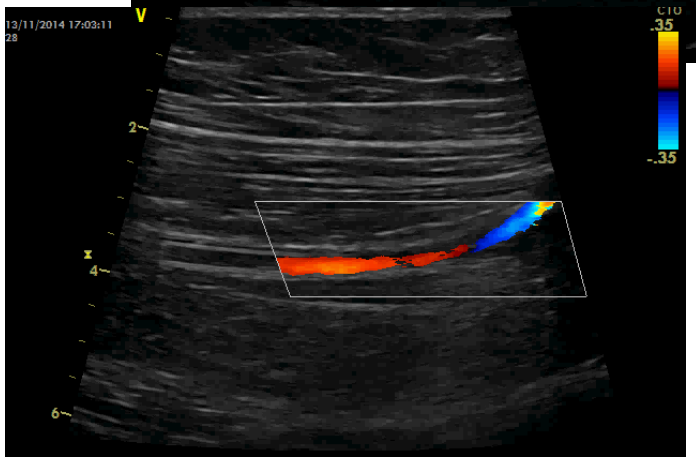






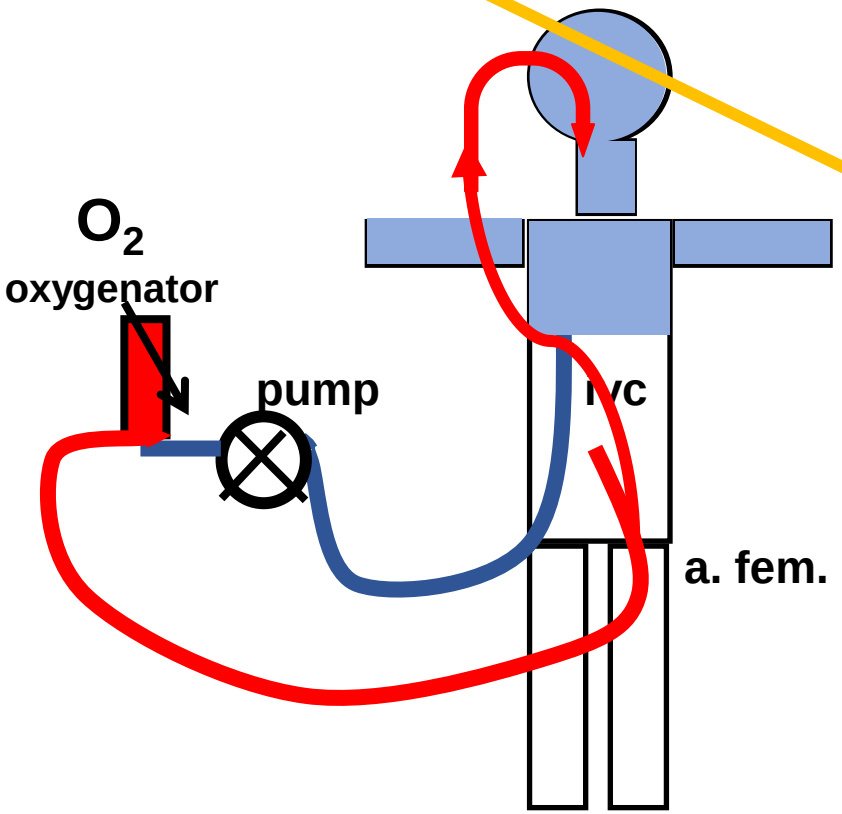


Harlequin syndrome



Primary respiratory failure on VA-ECMO…….

….CO increases to 6.4 l/min….develops Harlequin syndrome with 6.3 l/min ECMO flow (<u>total CO 12.7 l/min</u>)



Harlequin syndrome

What would you do now ?

- Switch from VA to VA-V ECMO
- CO 6.2 l/min
- ECMO 6.3 l/min 2 of these return to VJIdx
- <u>total CO 10.5 l/min</u>

Qb in hypoxic respiratory failure: ECMO / CO (target > 60%)

- impact on peripheral DO_2
- hybrid VA-V or VV-A modalities –

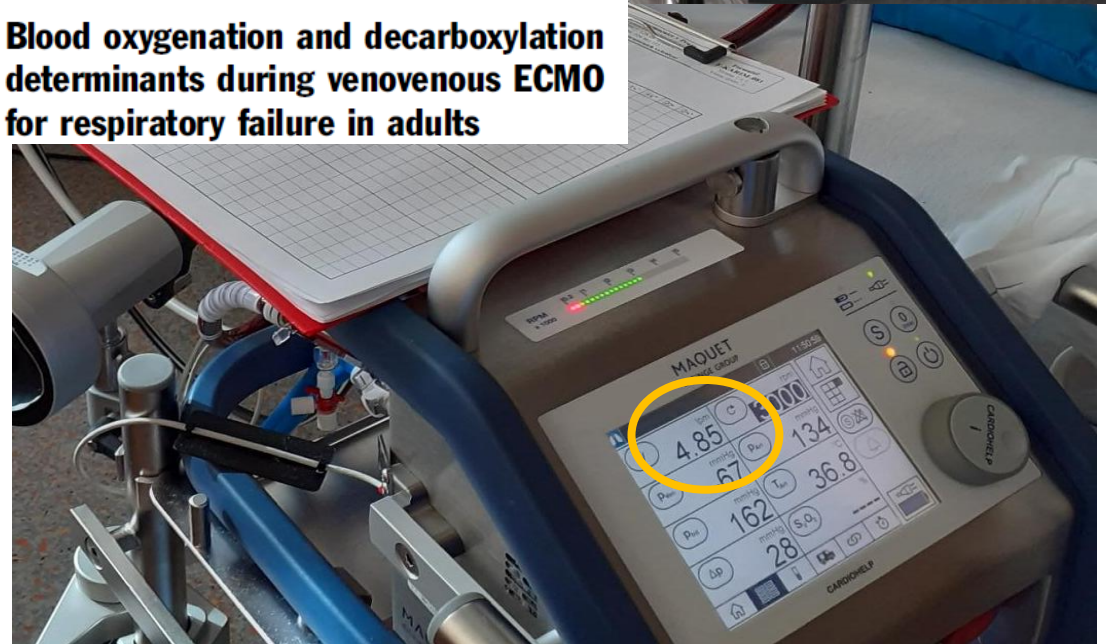
Qb split between oxygenation and circulatory support

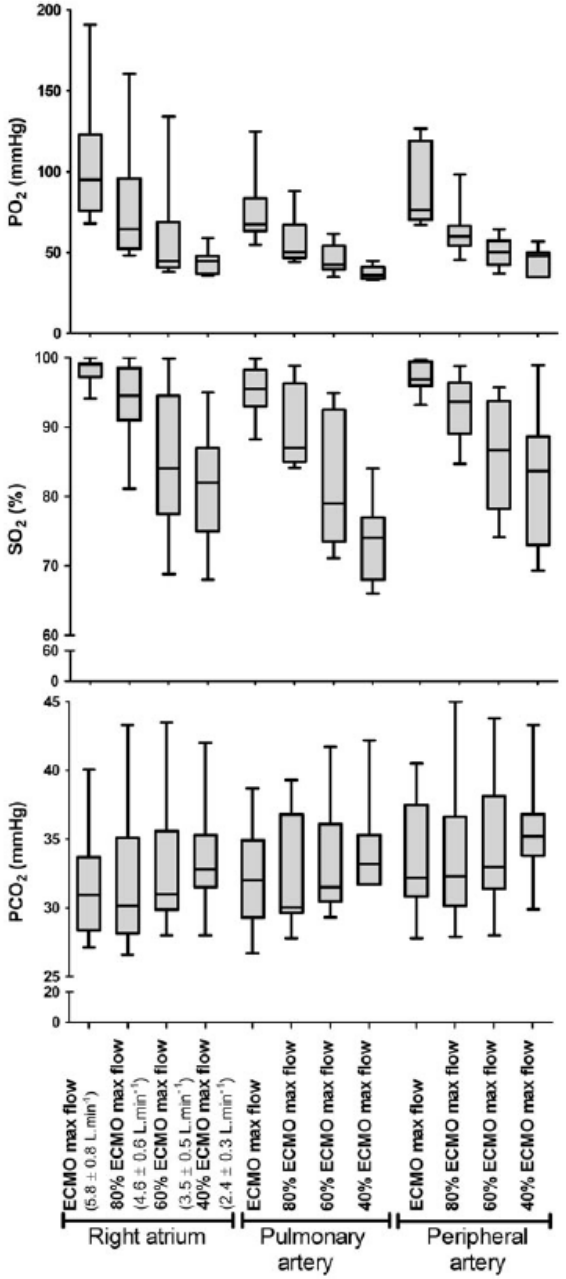
Intensive Care Med (2013) 39:838–846
DOI 10.1007/s00134-012-2785-8

ORIGINAL

Matthieu Schmidt
Guillaume Tachon
Christine Devilliers
Grégoire Muller
Guillaume Hekimian

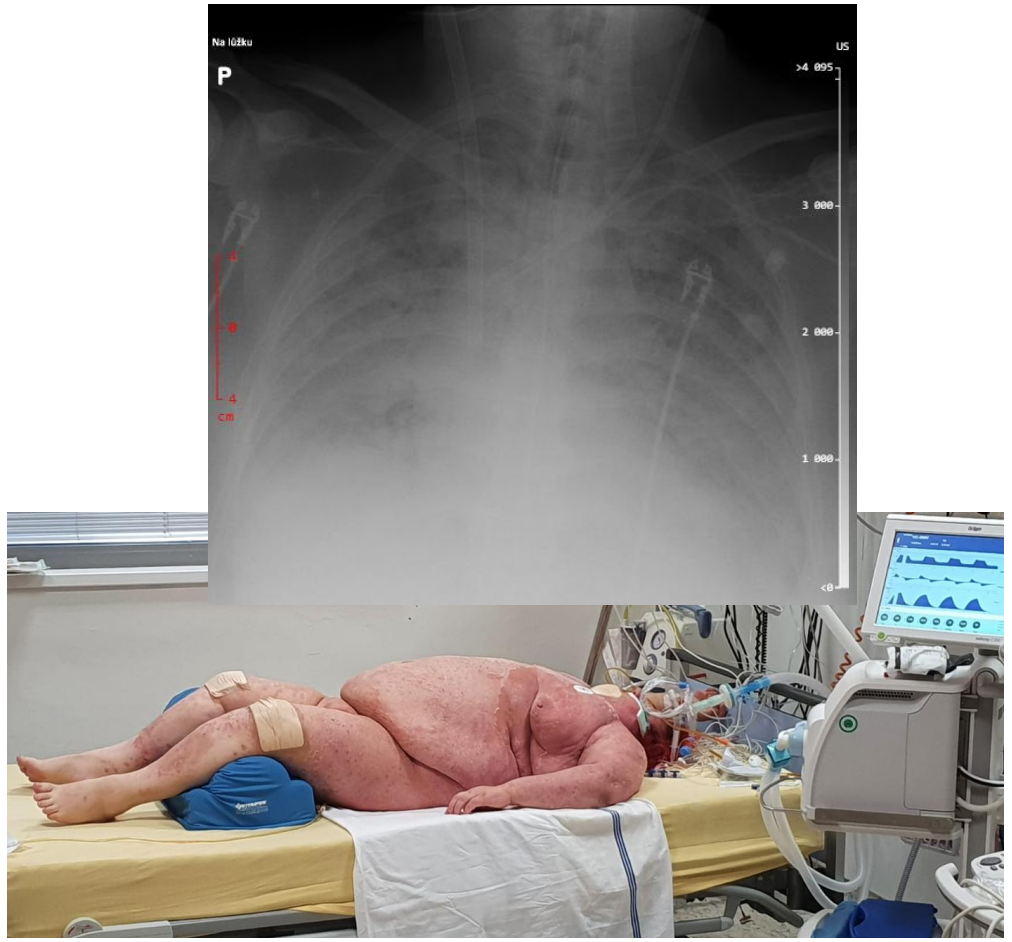
Blood oxygenation and decarboxylation determinants during venovenous ECMO for respiratory failure in adults





Why to prevent HF related VA in severe hypoxia….

- Qb setting influenced
  - BMI (cardiac output) - VV
  - severity of hypoxia - VV
  - severity of shock (SVR) - VA
- Obesity is not a contraindication to ECMO….unless small caliber vessels in severe hypoxia
- Limitations of single site cannulation (< 4 l/min)



Patient's treatment.

Journal of Critical Care 72 (2022) 154162

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journal homepage: www.journals.elsevier.com/journal-of-critical-care

The impact of obesity on the outcome of severe SARS-CoV-2 ARDS in a high volume ECMO centre: ECMO and corticosteroids support the obesity paradox

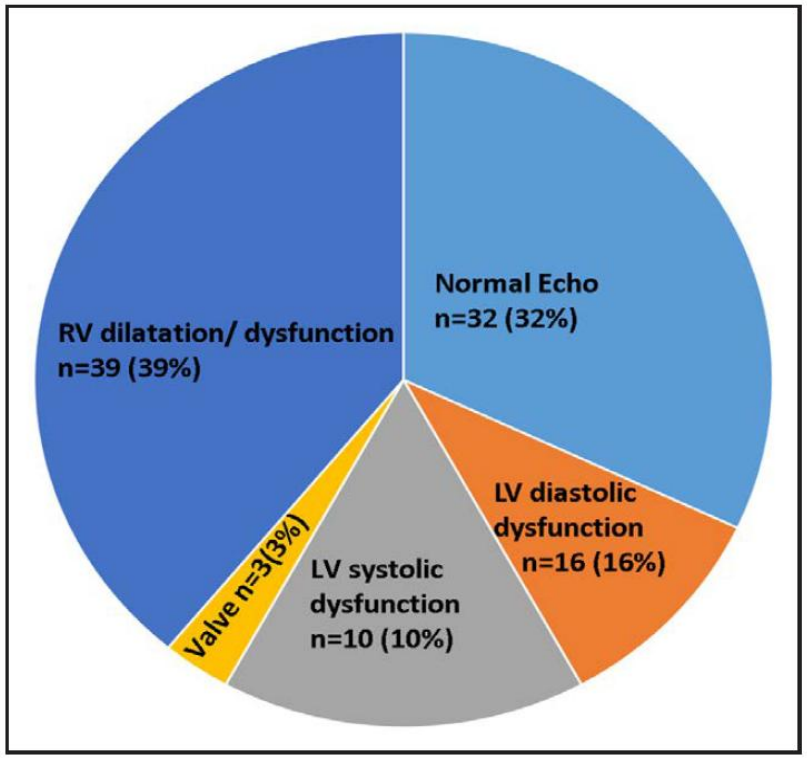
M. Balik [a,*], E. Svobodova [a], M. Porizka [a], M. Maly [a], P. Brestovansky [a], L. Volny [a], T. Brozek [a], T. Bartosova [a], I. Jurisinova [a], Z. Mevaldova [a], O. Misovic [a], A. Novotny [a], J. Horejsek [a], M. Otahal [a], M. Flaksa [a], Z. Stach [a], J. Rulisek [a], P. Trachta [a], J. Kolman [a], R. Sachl [a], J. Kunstyr [a], P. Kopecky [a], S. Romaniv [a], M. Huptych [b], M. Svarc [c], G. Hodkova [c], J. Fichtl [c], F. Mlejnsky [c], T. Grus [d], J. Belohlavek [e], M. Lips [a], J. Blaha [a]

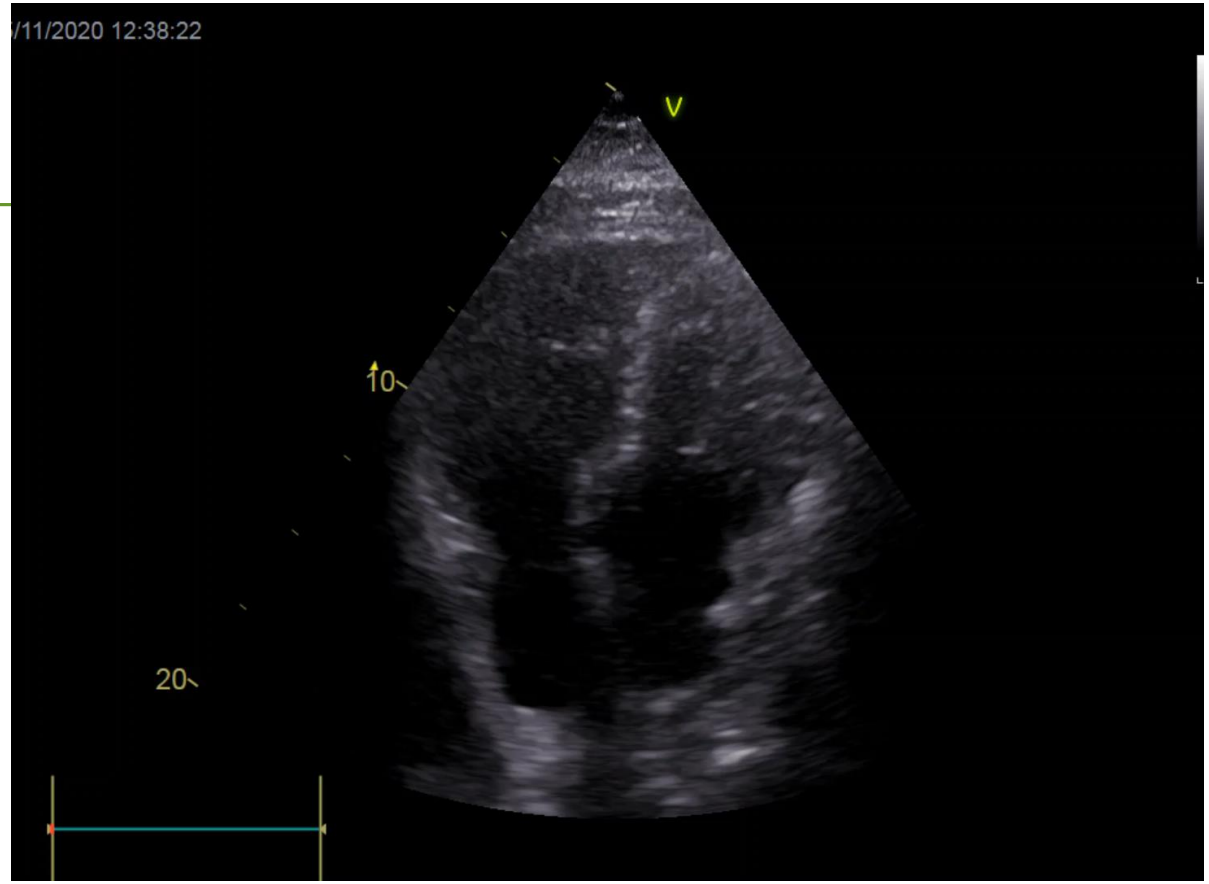
	BMI > 30 (n = 171)	BMI ≤ 30 (n = 121)	P-value
VV ECMO	45% (77)	34.7% (42)	0.087
- ECMO drainage cannula (F)	29 (25–29)	27 (25–29)	0.503
- ECMO return cannula (F)	23 (21—23)	23 (21–23)	0.726
- Initial blood flow (l/min)	4.7 (4.2–5.2)	4.6 (4.2–5)	0.631
- Initial sweep gas flow (l/min)	3 (2.5–4)	3 (2.5–3.5)	0.459

ORIGINAL RESEARCH ARTICLE

Spectrum of Cardiac Manifestations in COVID-19

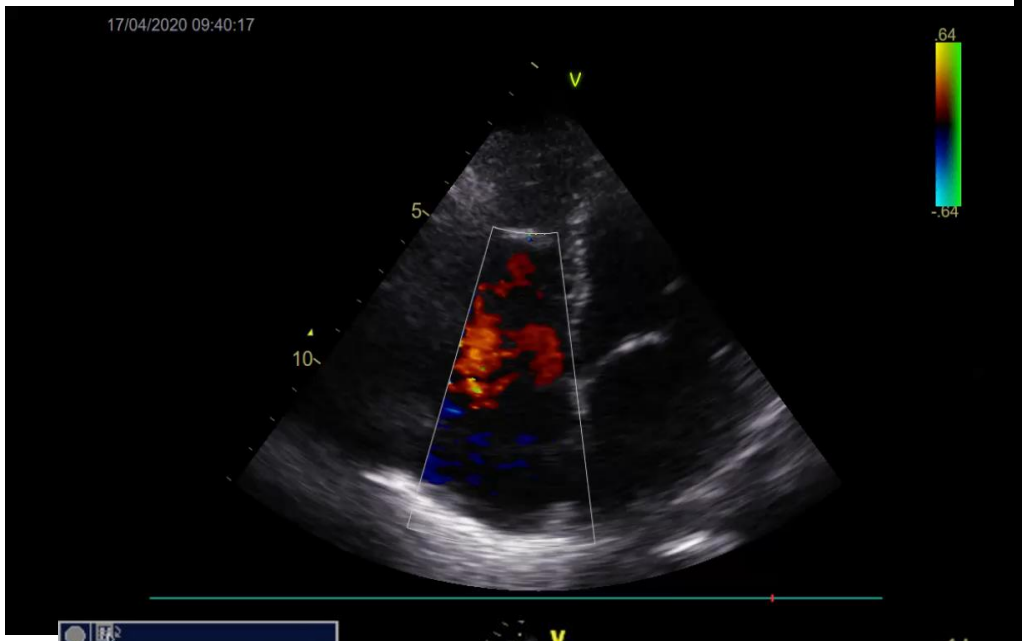
A Systematic Echocardiographic Study

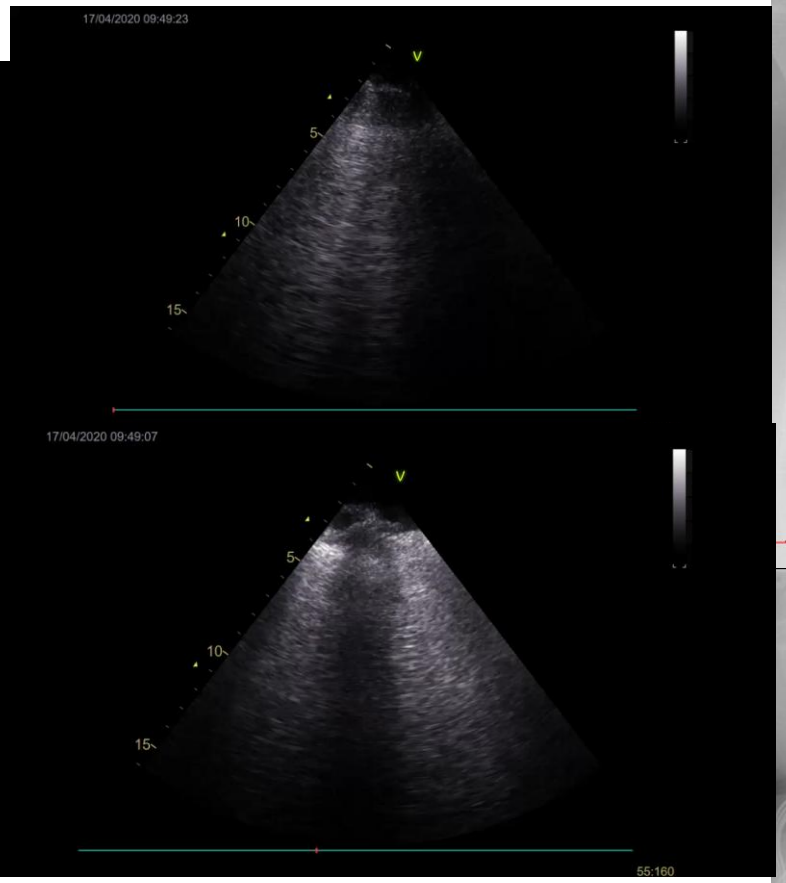


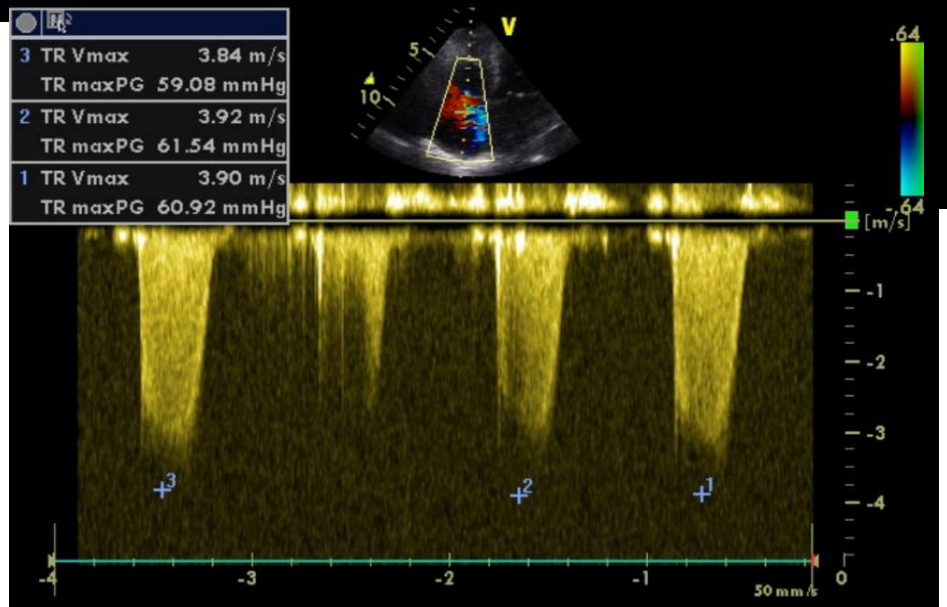


- Dilated RV and PH in 31-39%
- Related to mortality, OR 4.5, p=0.005
  (Argulian E, JACC 2020, 13:2459-60)
- SV arrhythmias in 44% ICU patients

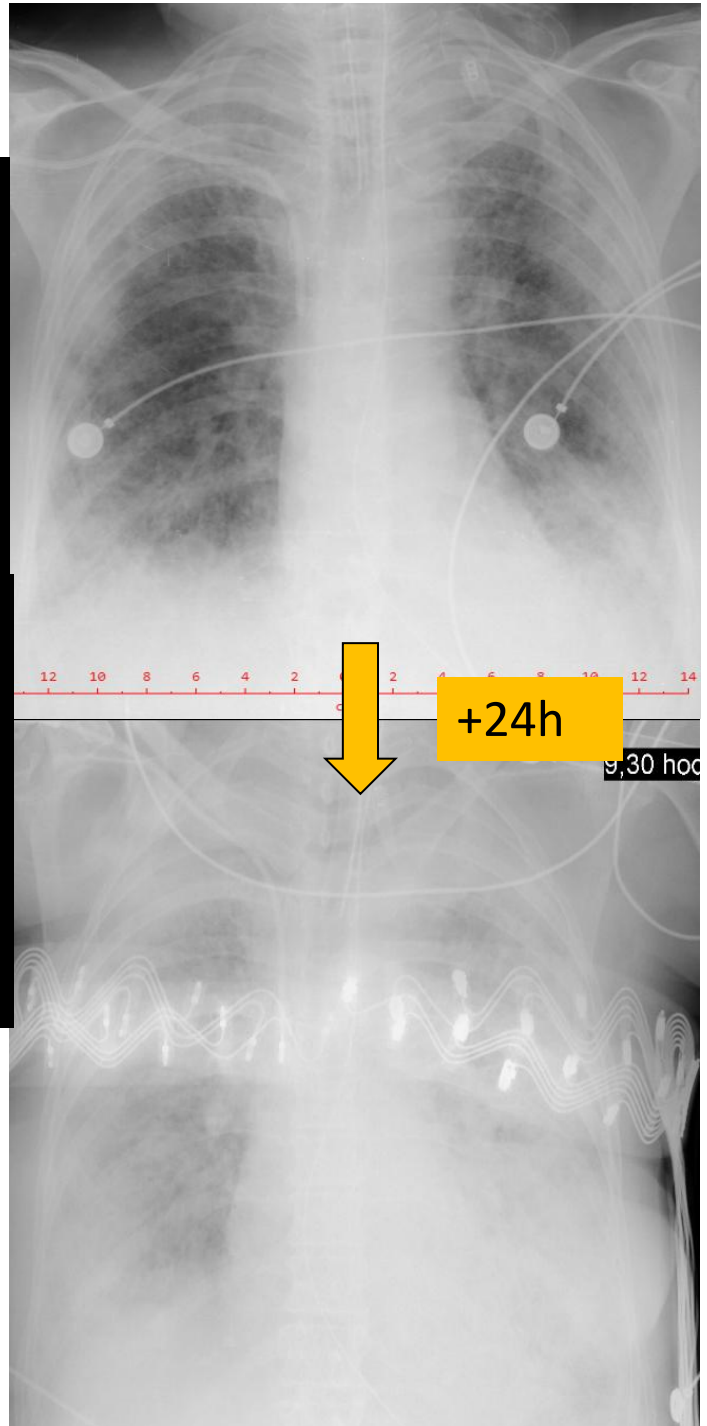
RV dysfunction and PH in Covid-19







- AVP 1-4 IU/h
- NAD<0.5 ug/kg.min



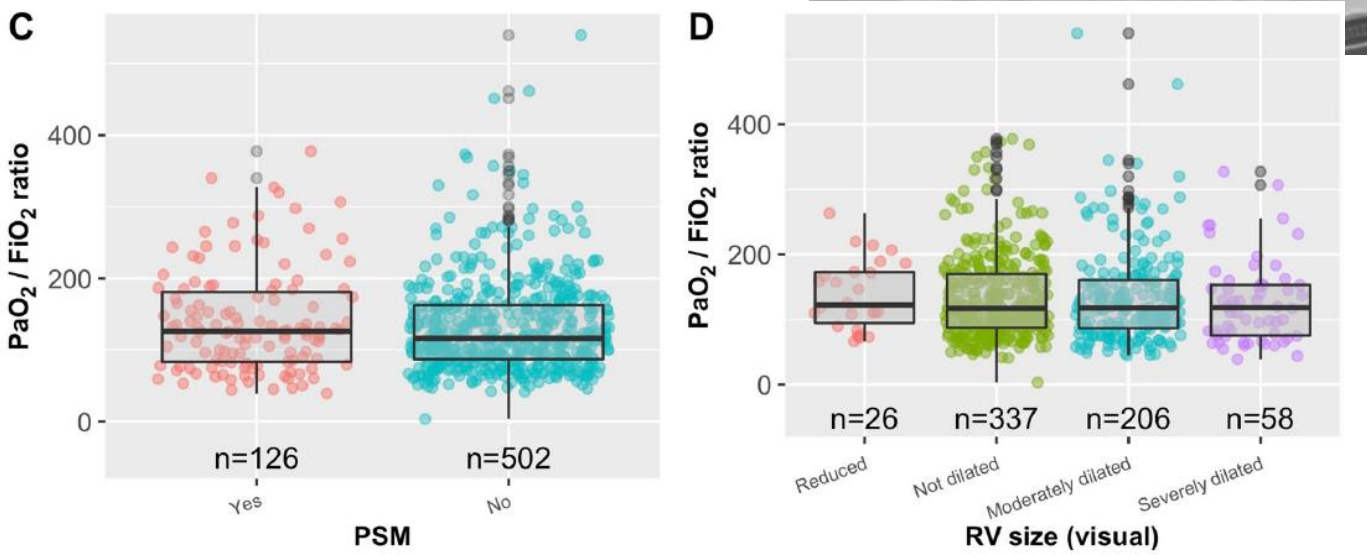
RV echocardiography parameters as an indication to earlier VV-ECMO instead of later VA ?

ORIGINAL

Echocardiography findings in COVID-19 patients admitted to intensive care units: a multi-national observational study (the ECHO-COVID study)

Stephen Huang[1], Philippe Vignon[2], Armand Mekontso-Dessap[3], Ségolène Tran[4], Gwenael Prat[5], Michelle Chew[6], Martin Balik[7], Filippo Sanfilippo[8], Gisele Banauch[9], Fernando Clau-Terre[10], Andrea Morelli[11], Daniel De Backer[12], Bernard Cholley[13], Michel Slama[14], Cyril Charron[4], Marine Goudelin[2], Francois Bagate[3], Pierre Bailly[5], Patrick-Johansson Blixt[6], Paul Masi[3], Bruno Evrard[2], Sam Orde[1], Paul Mayo[15], Anthony S. McLean[1] and Antoine Vieillard-Baron[4,16*] on behalf of the ECHO-COVID research group

- No relation between right heart echoparameters and ELSO oxygenation/ ventilation criteria for VV-ECMO
- Progression of ACP towards a need for VA-ECMO not desirable in ARDS with higher BMI



Petit *et al. Crit Care* (2021) 25:220
https://doi.org/10.1186/s13054-021-03646-x

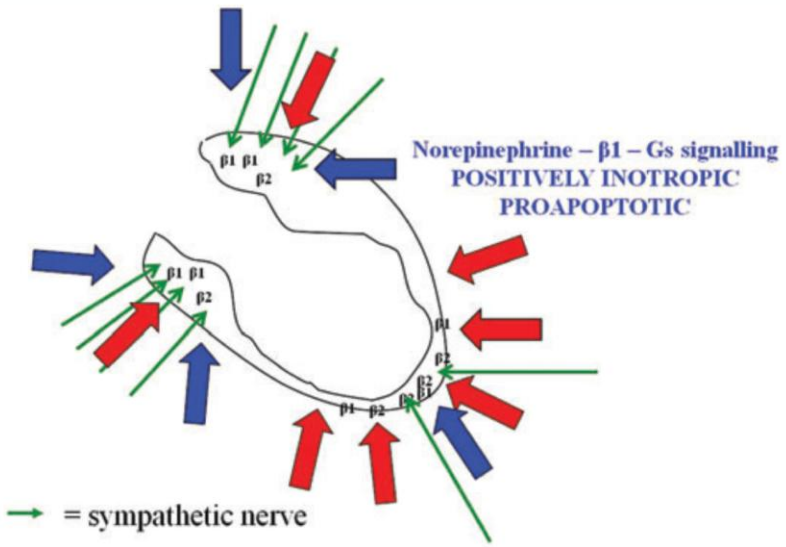
Critical Care

RESEARCH LETTER Open Access

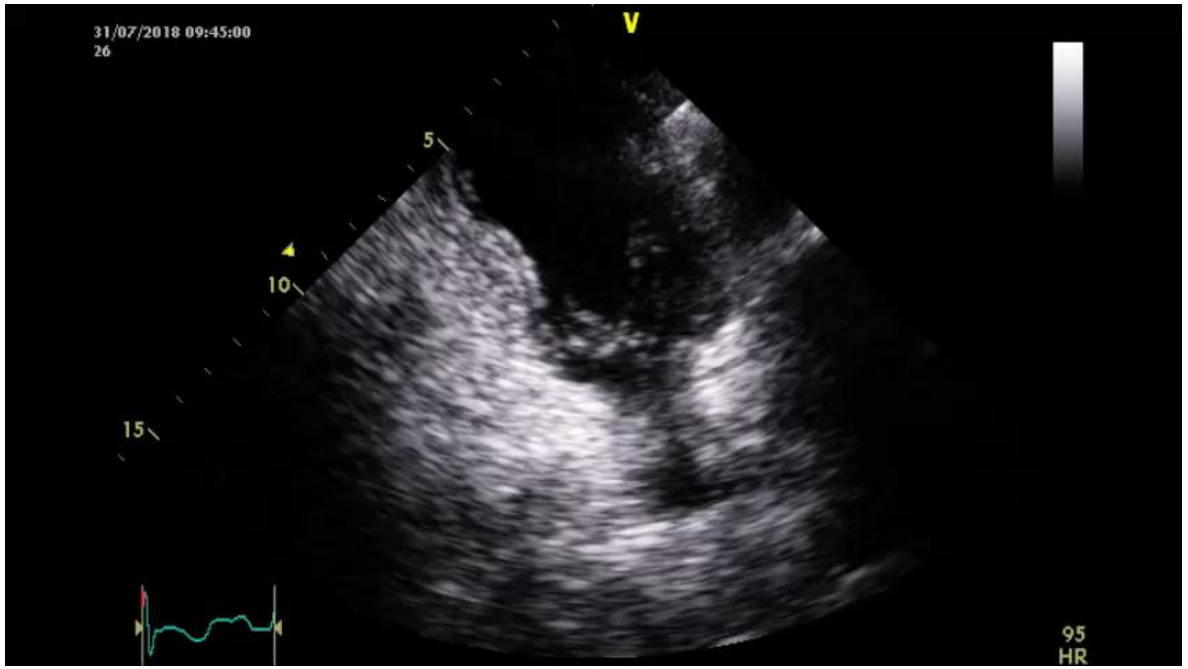
Evaluation of right ventricular function and driving pressure with blood gas analysis could better select patients eligible for VV ECMO in severe ARDS

Matthieu Petit[1,2*], Armand Mekontso-Dessap[3,4,5], Paul Masi[3,4], Annick Legras[7], Philippe Vignon[6] and Antoine Vieillard-Baron[1,2]

Hypoxia, catecholamines, inflammation…..stress related cardiac dysfunction - Tako-Tsubo Syndrome (TTS)



Lyon et al. Nat Clin Prac Cardiovasc Med 2008;5:22-9



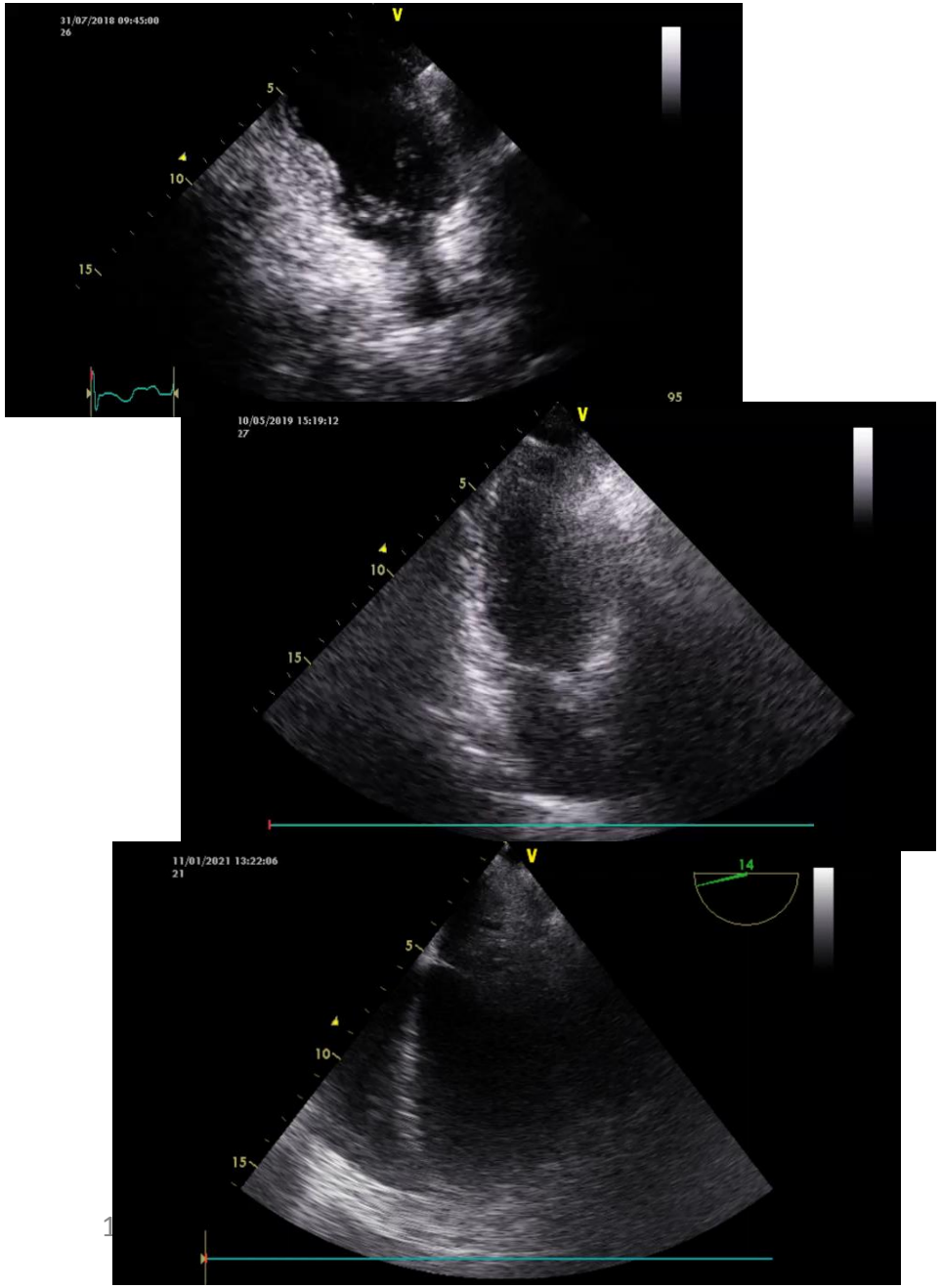
- Signal membrane G-proteins – distribution of heart adrenergic receptors
- Triggers
  - emotional: primary TTS
  - physical: secondary TTS (sepsis, surgery, SAH, stroke, pheochromocytoma, ARDS, trauma)
- ECG ST-elevation, echo, TnI/CKMBmass, neg. SKG, absence of myocarditis

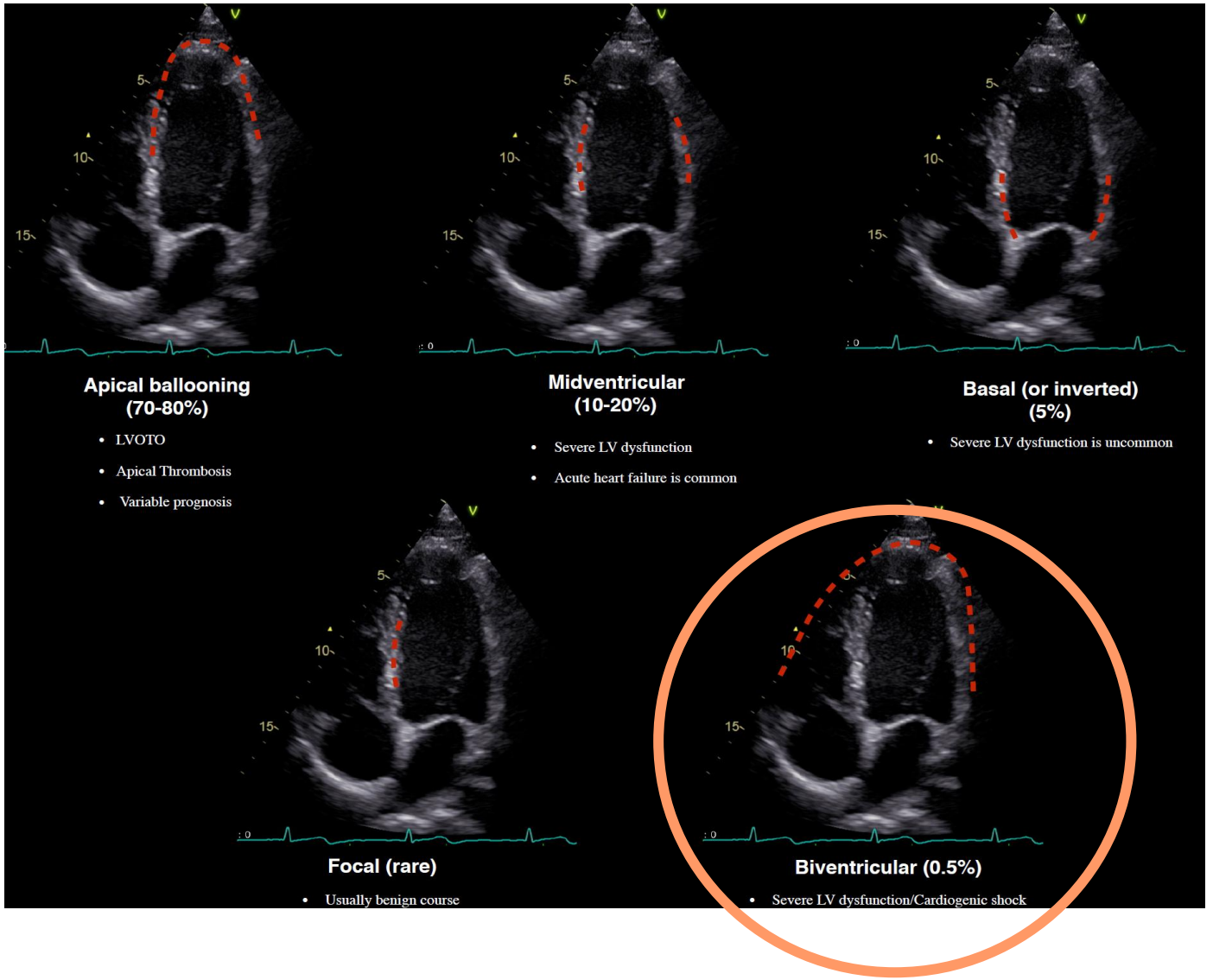
JACC: HEART FAILURE VOL ■, NO ■, 2022

Structural and Functional Brain Changes in Acute Takotsubo Syndrome

Hilal Khan, MB BCh, BAO,[a] David T. Gamble, MBChB,[a] Amelia Rudd, RDCS, BSE,[a] Alice M. Mezincescu, MD, PhD,[a]

RV triggered or primary LV form of TTS





Tavazzi G, Balik M, Chew M, Vieillard-Baron A, McLean T: Stress related cardiomyopathies in the critically ill – a narrative review of pathophysiology and current management

Risk of stress cardiomyopathy on VV ECMO

- RV on IPPV / ARDS / PE
- stress cardiomyopathy (…hypoxia, arrythmias, catecholamines)
- septic cardiomyopathy in superinfections
- coronary endothelium, microembolisations

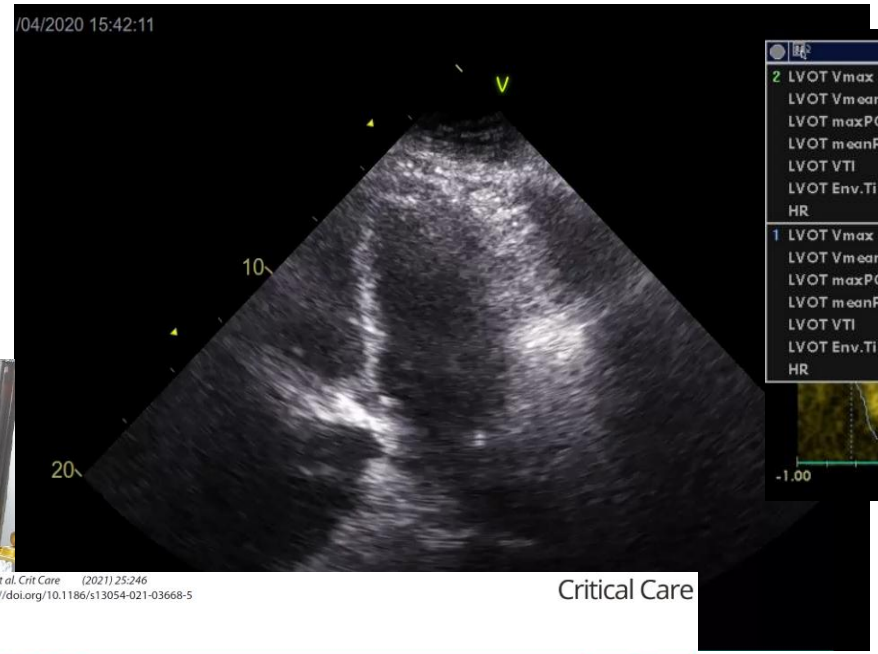
JACC REVIEW TOPIC OF THE WEEK

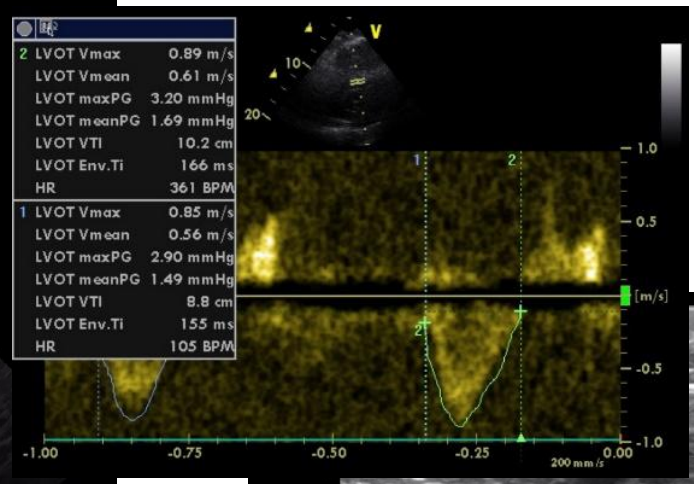
Pathological Evidence for SARS-CoV-2 as a Cause of Myocarditis

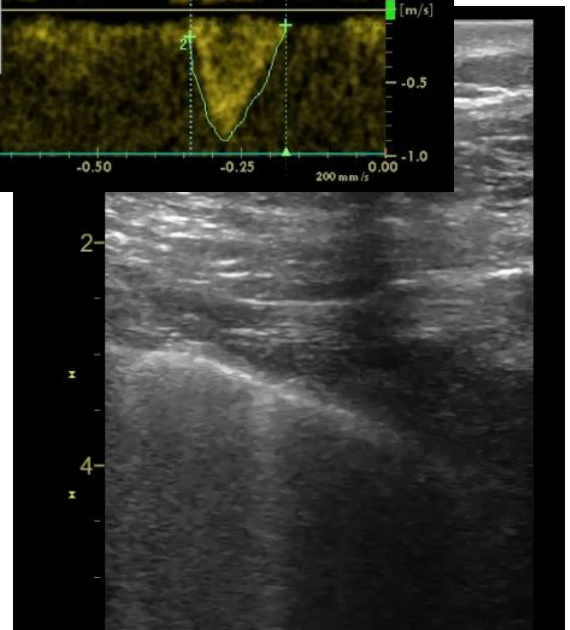
JACC Review Topic of the Week

Rika Kawakami, MD,[a,*] Atsushi Sakamoto, MD,[a,*] Kenji Kawai, MD,[a] Andrea Gianatti, MD,[b] Dario Pellegrini, MD,[b]

myocarditis only 4.5% of heart failures







Ling et al. Crit Care (2021) 25:246
https://doi.org/10.1186/s13054-021-03668-5

Critical Care

RESEARCH Open Access

Venoarterial extracorporeal membrane oxygenation as mechanical circulatory support in adult septic shock: a systematic review and meta-analysis with individual participant data meta-regression analysis

Ryan Ruiyang Ling[1†], Kollengode Ramanathan[1,2*†], Wynne Hsing Poon[1], Chuen Seng Tan[3], Nicolas Brechot[4,5], Daniel Brodie[6], Alain Combes[4,7] and Graeme MacLaren[1,2]

Ventilator induced lung/cardiac injury – are we calculating all factors at the bedside ?

IPPV: dynamic and static power delivered to the cardiorespiratory system

….times respiratory rate

A concept of dynamic interaction of IPPV with lung, pulmonary circulation and the heart

$$\text{Power}_{rs} = RR \cdot \left\{ \Delta V^2 \cdot \left[\frac{1}{2} \cdot EL_{rs} + RR \cdot \frac{(1 + I:E)}{60 \cdot I:E} \cdot R_{aw} \right] + \Delta V \cdot PEEP \right\},$$

IPPV = mechanical power

- Vt (exponential^2)
- ΔPaw (Pplat-PEEP) (exponential^2)
- Flow (exponential^2)
- PEEP (exponential$^{1.4}$)
- RR (linear)

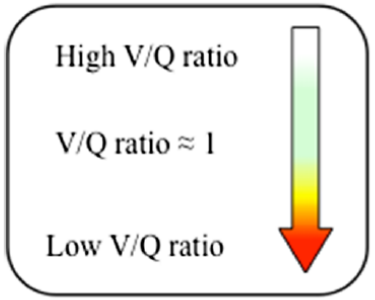
….mechanical damage

- Lung size (small with lower threshold..)
- Edema, inflammation
- Inhomogenity (main factor for VILI !)
- **<u>Perfusion, RV</u>**
- pH, pCO_2, pO_2

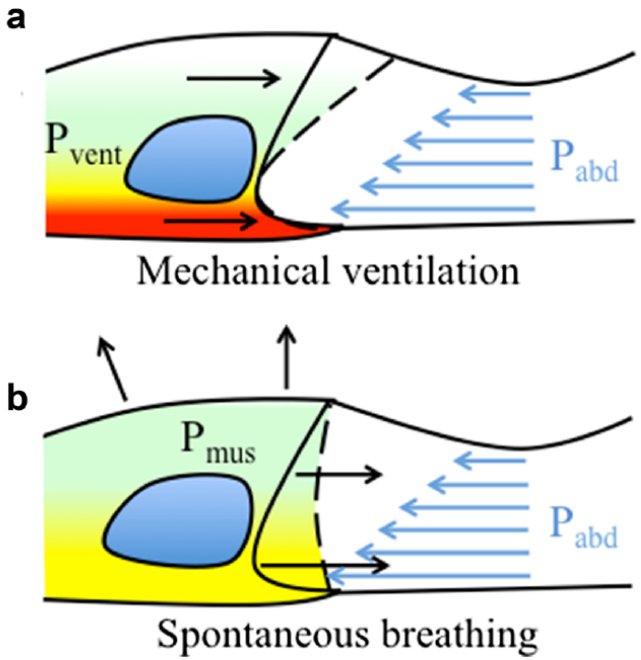
Awake ECMO vs intubated ECMO

•PROS

- Better V/Q matching in Covid19
- Tone of respiratory muscles and thoracic elastance
- Prevention of CIP and diaphragmatic dysfunction
- Better venous return
- Better pulmonary lymphatic drainage
- Less VAP (primary barriers)
- Less delirium
- Rehabilitation
- Peroral feeding



Langer *et al. Critical Care* (2016) 20:150
DOI 10.1186/s13054-016-1329-y



•CONS

- TPP and spont. hyperventilation
- Higher resp. muscles VO_2
- Risk of displacement of cannulas
- Pain, anxiety
- Limits of double site cannulation (venous return)

IPPV related stress - awake ECMO as a prevention of ACP ?

- endothelial inflammation/damage
- loss of pulmonary vasoregulation, V/Q mismatch
- thrombogenesis, AFOP
- PH, RV dilatation
- Intolerance of IPPV:
  cough, barotrauma (26%)

Ann Am Thorac Soc Vol 11, No 6, pp 956–961, Jul 2014

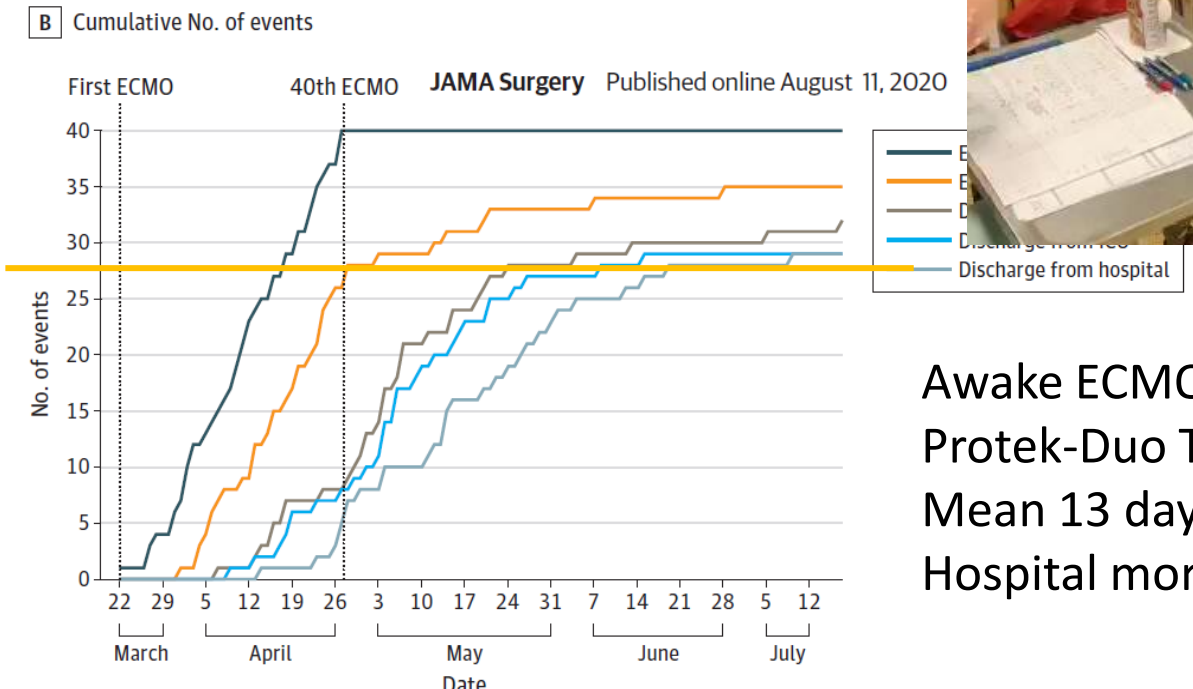
Mechanical Ventilation during Extracorporeal Membrane Oxygenation

An International Survey

Only 27% spont triggered modes

Jonathan D. Marhong*, Teagan Telesnicki*, Laveena Munshi, Lorenzo Del Sorbo, Michael Detsky, and Eddy Fan

Interdepartmental Division of Critical Care Medicine, and Department of Medicine, University of Toronto, University Health Network and Mount Sinai Hospital, Toronto, Ontario, Canada



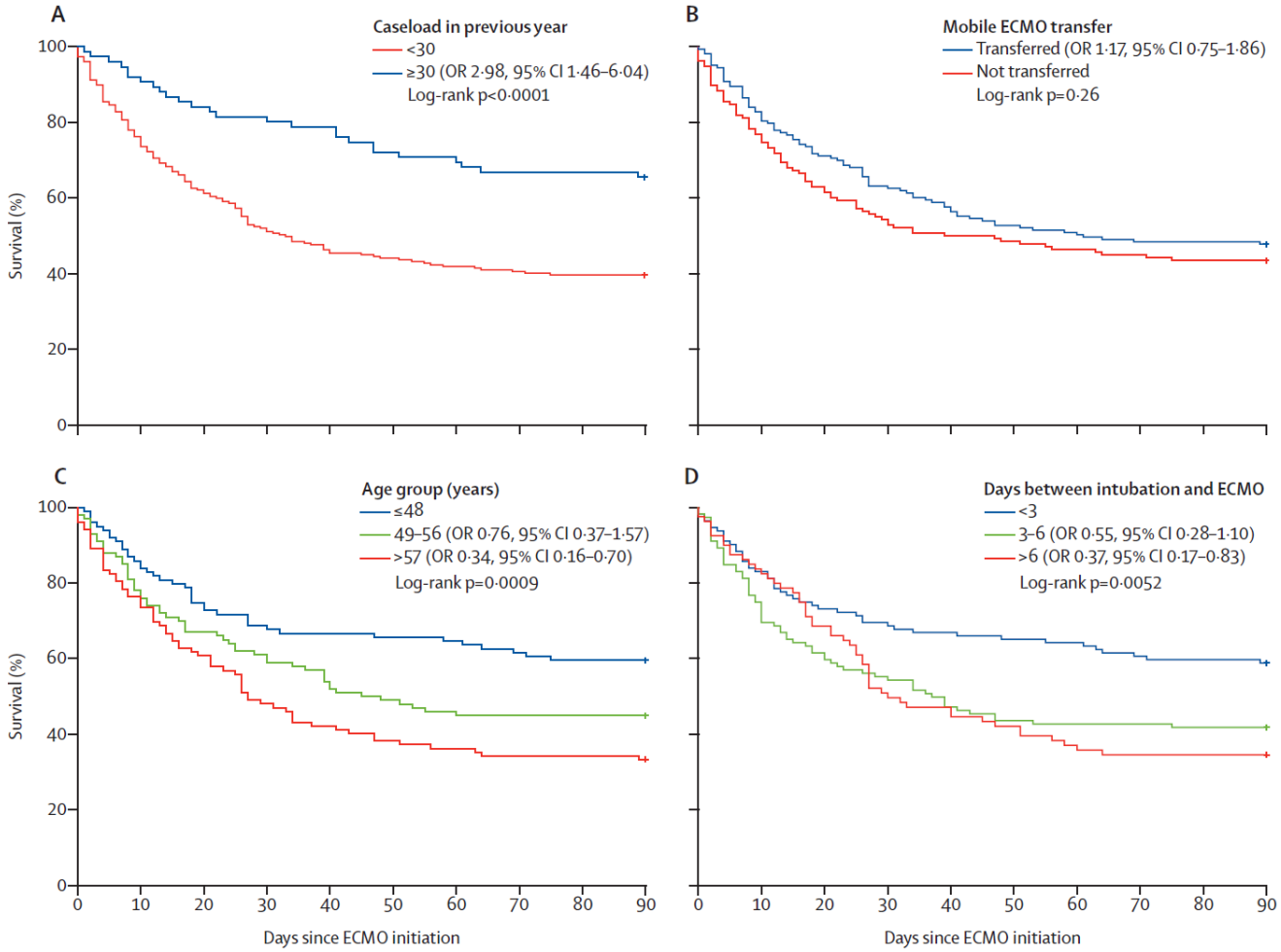
Awake ECMO:
Protek-Duo Tandem Heart
Mean 13 days to spont. ventilation
Hospital mortality 27%

ECMO caseload and outcome

Extracorporeal membrane oxygenation network organisation and clinical outcomes during the COVID-19 pandemic in Greater Paris, France: a multicentre cohort study

*Guillaume Lebreton, Matthieu Schmidt, Maharajah Ponnaiah, Thierry Folliguet, Marylou Para, Julien Guihaire, Emmanuel Lansac, Edouard Sage, Bernard Cholley, Bruno Mégarbane, Pierrick Cronier, Jonathan Zarka, Daniel Da Silva, Sebastien Besset, Igor Lacombat, Nicolas Mongardon, Christian Richard, Jacques Duranteau, Charles Cerf, Gabriel Saiydoun, Romain Sonneville, Jean-Daniel Chiche, Patrick Nataf, Dan Longrois, Alain Combes, Pascal Leprince, and the Paris ECMO-COVID-19 investigators**

- Age
- Experience > 30 cases/year (HR 2.98)
- Time-to-ECMO
- Renal insufficiency (HR 0.67)



A minimum requirement for 20 ECMO patients/year moved to 30/year after pandemic of Covid-19….

Herrmann *et al. Critical Care* (2022) 26:190
https://doi.org/10.1186/s13054-022-04053-6

Critical Care

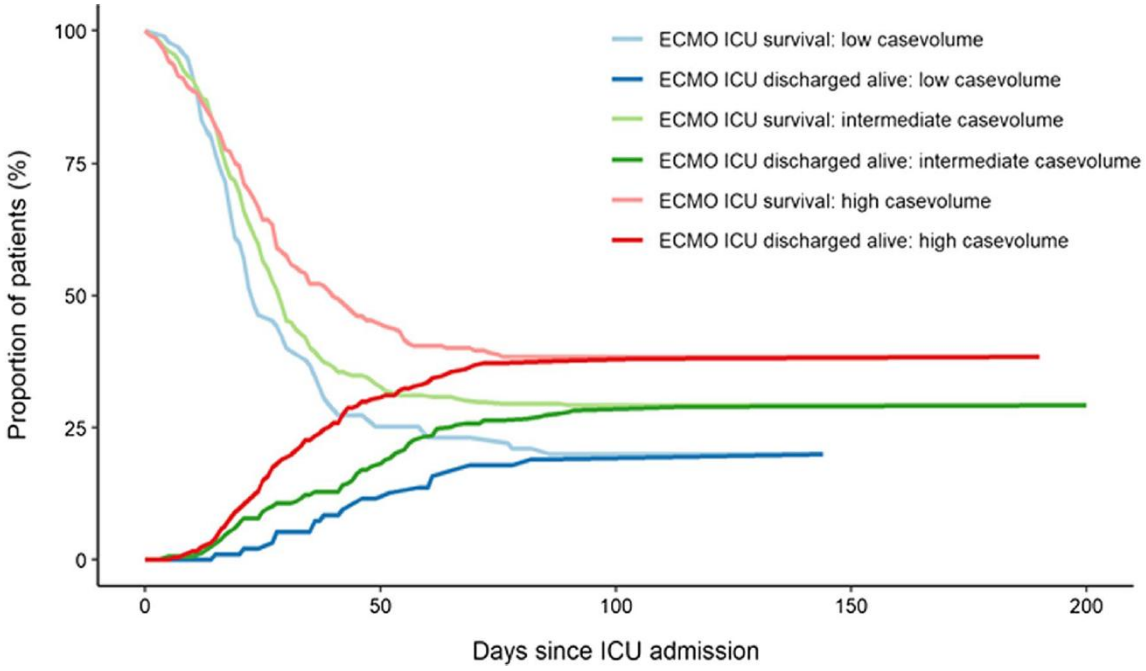
Karagiannidis *et al. Critical Care* (2021) 25:413
https://doi.org/10.1186/s13054-021-03831-y

Critical Care

RESEARCH Open Access

Key characteristics impacting survival of COVID-19 extracorporeal membrane oxygenation

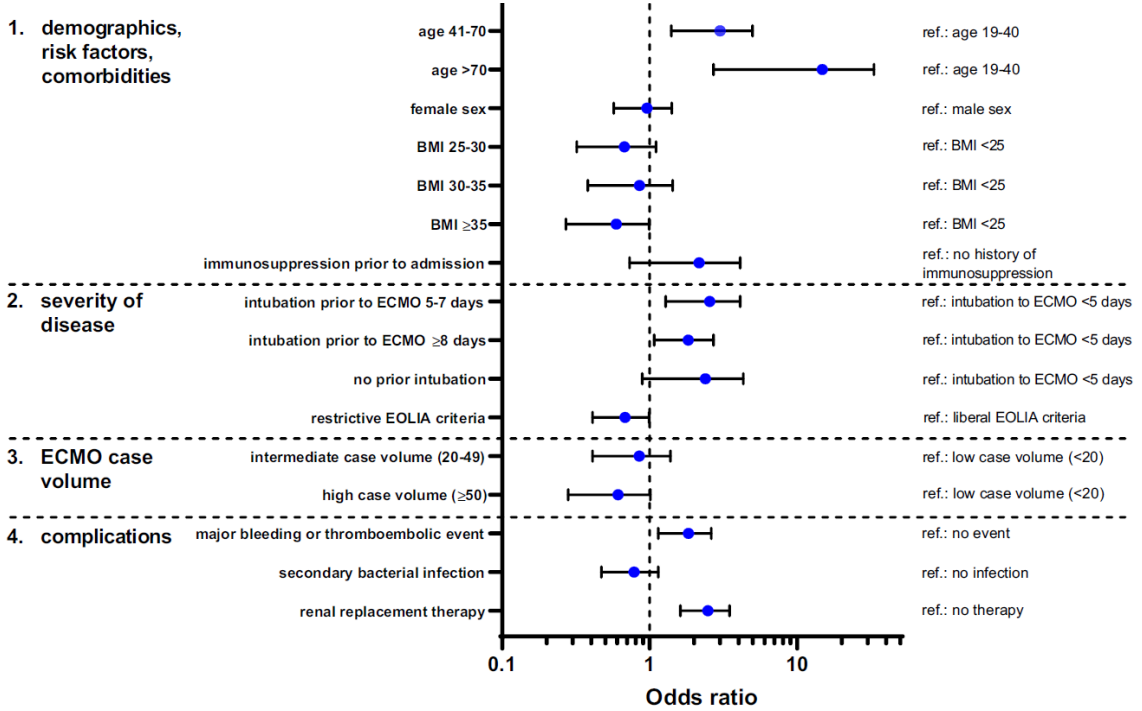
Johannes Herrmann[1], Christopher Lotz[1], Christian Karagiannidis[2], Steffen Weber-Carstens[3], Stefan Kluge[4], Christian Putensen[5], Andreas Wehrfritz[6], Karsten Schmidt[7], Richard K. Ellerkmann[8], Daniel Oswald[9], Gösta Lotz[10], Viviane Zotzmann[11,12], Onnen Moerer[13], Christian Kühn[14], Matthias Kochanek[15], Ralf Muellenbach[16], Matthias Gaertner[17], Falk Fichtner[18], Florian Brettner[19], Michael Findeisen[20], Marku



RESEARCH LETTER Open Access

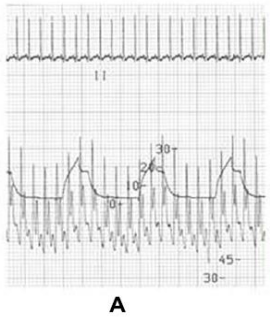
Complete countrywide mortality in COVID patients receiving ECMO in Germany throughout the first three waves of the pandemic

Christian Karagiannidis[1*], Arthur S. Slutsky[2], Thomas Bein[3], Wolfram Windisch[1], Steffen Weber-Carstens[4] and Daniel Brodie[5]



Take home message

- Key: Echo + CUS + vessels
- Avoid ACP on IPPV
  - ACP triggered CRS
  - ACP triggered CS
- Avoid TTS and HF
  - Decatecholaminisation
  - Cardiac protection
- Echoparameters as indicators to VV-ECMO
- VV-ECMO in borderline cases
  - Allow for spontaneous IPPV or awake ECMO
  - Hybrid modalities as a back up 24/7: VV-A or VA-V



frontiers in Physiology

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