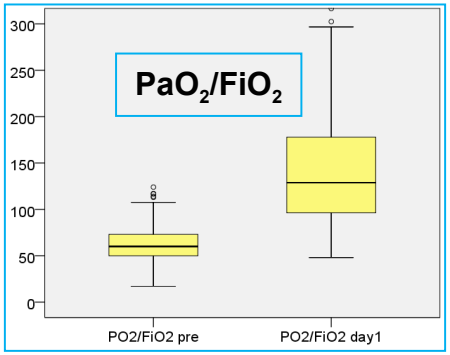
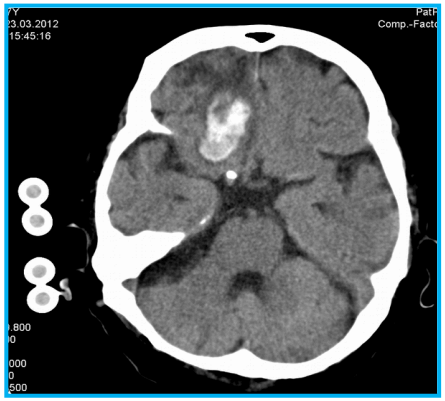
ECMO: a breakthrough in care for respiratory failure ?

PD Dr. Thomas Müller
Regensburg
no conflict of interest

Overview

- Mortality of severe ARDS
- Indication for ECMO
- Efficiency of ECMO:
  gas transfer, ventilation, outcome
- Problems of ECMO
- Conclusion



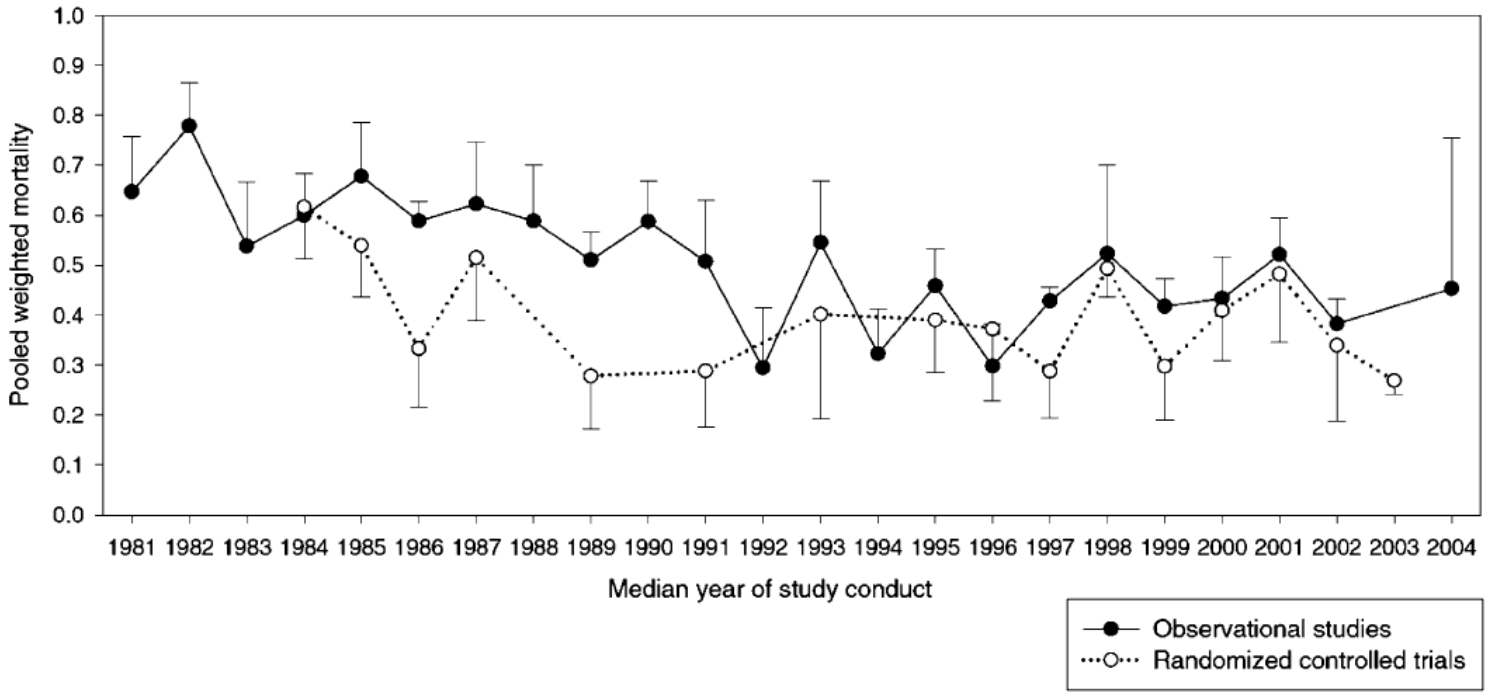


ARDS - Mortality

Legionellosis

Phua et al, Am J RespirCrit Care Med 2009;179:220-27

ARDS - Mortality



„These results highlight the need for future effective therapeutic interventions in this highly lethal syndrome“

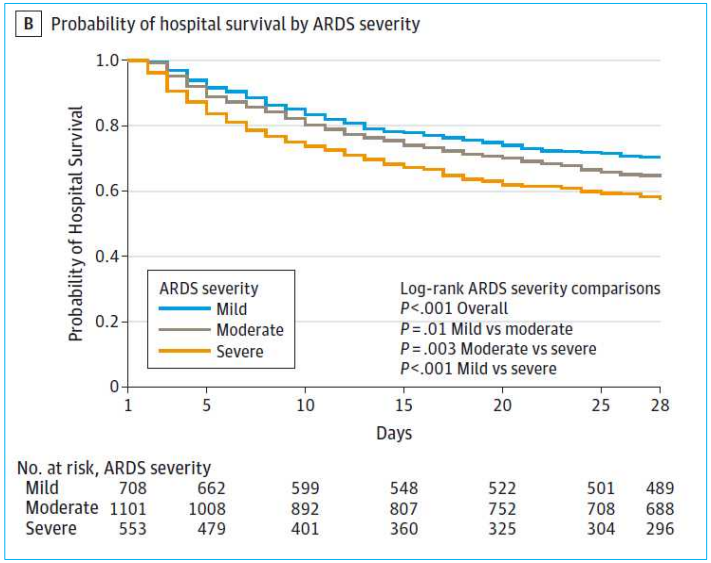
Phua et al, Am J RespirCrit Care Med 2009;179:220-27

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries

Giacomo Bellani, MD, PhD; John G. Laffey, MD, MA; Tài Pham, MD; Eddy Fan, MD, PhD; Laurent Brochard, MD, HDR; Andres Esteban, MD, PhD; Luciano Gattinoni, MD, FRCP; Frank van Haren, MD, PhD; Anders Larsson, MD, PhD; Daniel F. McAuley, MD, PhD; Marco Ranieri, MD; Gordon Rubenfeld, MD, MSc; B. Taylor Thompson, MD, PhD; Hermann Wrigge, MD, PhD; Arthur S. Slutsky, MD, MASc; Antonio Pesenti, MD; for the LUNG SAFE Investigators and the ESICM Trials Group

- 459 ICUs from 50 countries
- 3022 patients (10.4 %) with ARDS



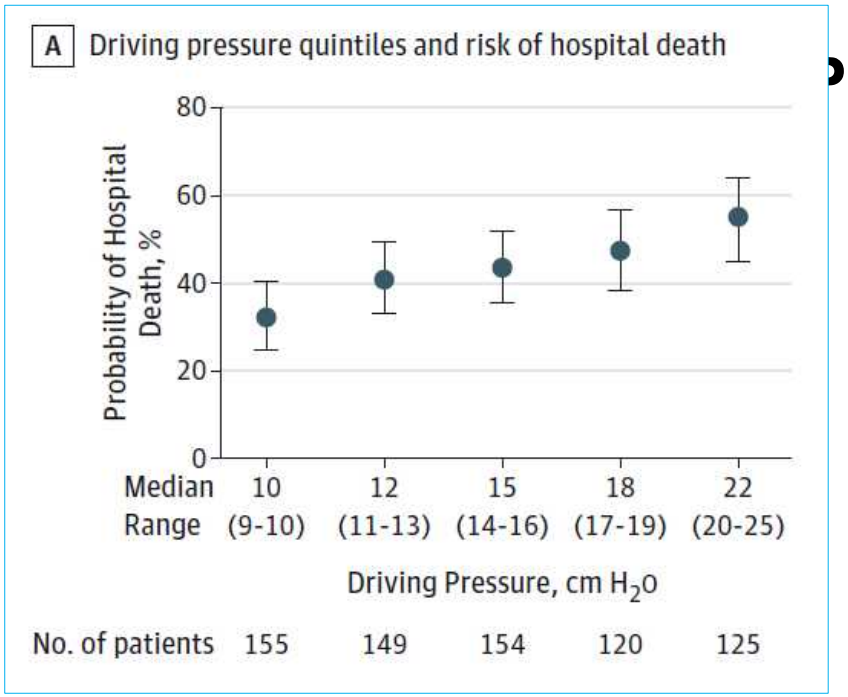
- hospital mortality 40 %: 34.9 % - 40.3 % - 46.1 %

  mild – moderate - severe

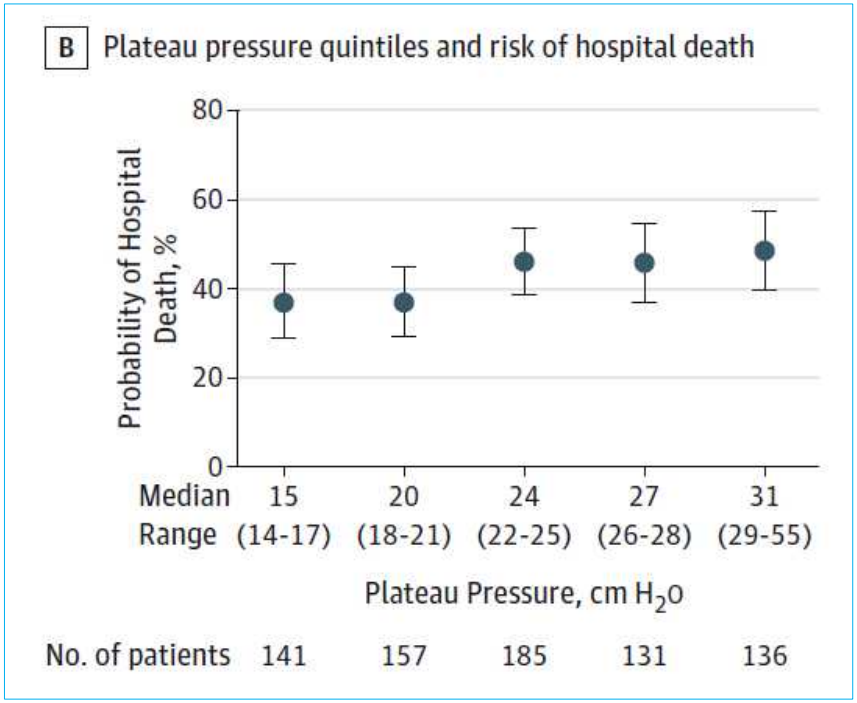
JAMA 2016;315:788-800

LUNG SAFE:
Mortality and Driving/Plateau Pressure

Driving Pressure



Pressure



JAMA 2016;315:788-800

Case Presentation

- 49 yr, female, past history empty
- 30.01: dry cough, fatigue, flu-like symptoms, diarrhoea, temp 38.5°C
- 01.02.: admission to external hospital,
  - progressive dyspnoe
  - PCT 20 µg/l, CRP 177 mg/l, lactate 113 mg/l,
    WBC 2.2/µl, Platelets 78/nl, INR 1.63, aPTT 54 sec
  - Ampicillin, Sulbactam, Clarithromycin
  - CT-Scan:
  - intubation
  - referral
- broad spectrum antibiotic coverage

expected mortality?

Case Presentation

- 02.02: septic shock and MOF:
  - + 11 liters volume
  - PCT 177 ng/ml, CK 3475 U/l, troponin I 22.6 ng/ml, platelets 77/nl, INR 1.84, aPTT 87 sec, AT-III 19 %, D-Dimers > 35 mg/l
  - PaO_2/FiO_2 98 mmHg, $PaCO_2$ 40 mmHg
  - PEEP/PIP 14/27 → 17/31 cm H_2O
  - noradrenaline 6 mg/h, epinephrine 0.5 mg/h
  - lactate 90 mg/dl
  - ECHO: septic cardiomyopathy

- 12:00 o´clock decision for ECMO:

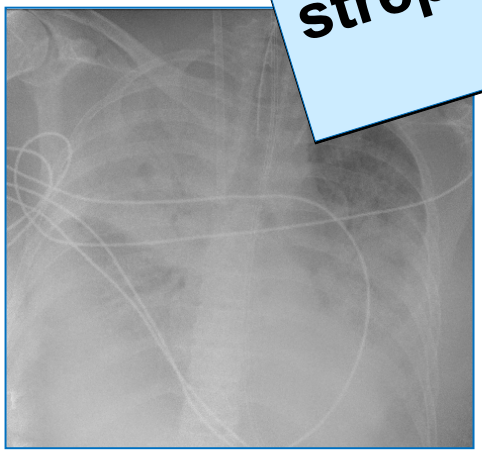
  veno-arterial cannulation, blood flow 3.8 l/min
- plasma exchange

expected mortality?

Case Presentation

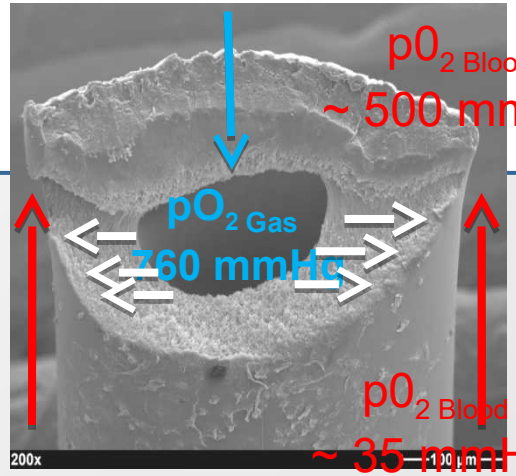
- 18:00 o´clock:
  - noradrenaline 1.8 mg/h, epinephrine 0.3 mg/h
  - lactate 110 mg/dl
  - PaO_2/FiO_2 50 mmHg, $PaCO_2$ 45 mmHg
  - PEEP/PIP 17/31 → 24/38 cm H_2O
- decision for additional ven
  VAV ECMO; h
- chest X-ray

diagnosis:
streptococcal toxic shock syndrome
group A streptococci



expected mortality?

Extracorporeal Gas Transfer

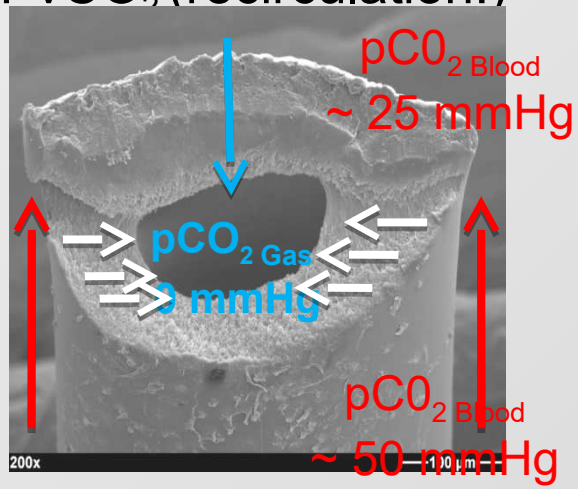


1. O_2 Transfer

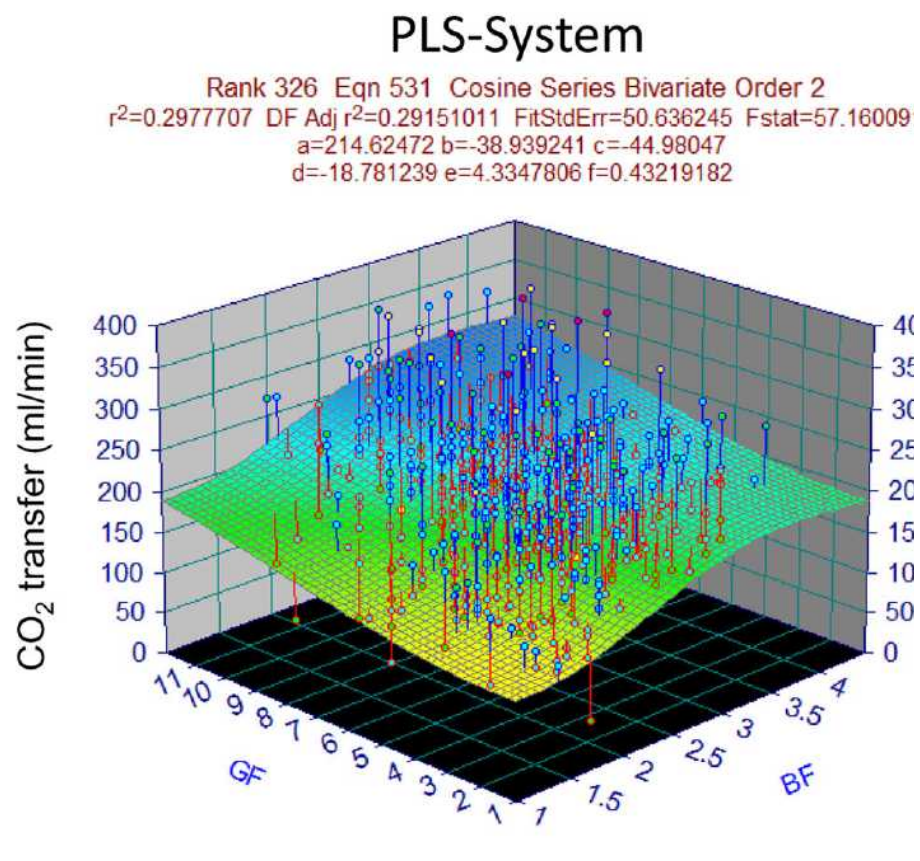
- efficiency depends on blood flow and blood sat
- effects:
  - avoid hxpoxemia
  - protective ventilation: VILI ↓, right heart strain ↓
  - gain of time

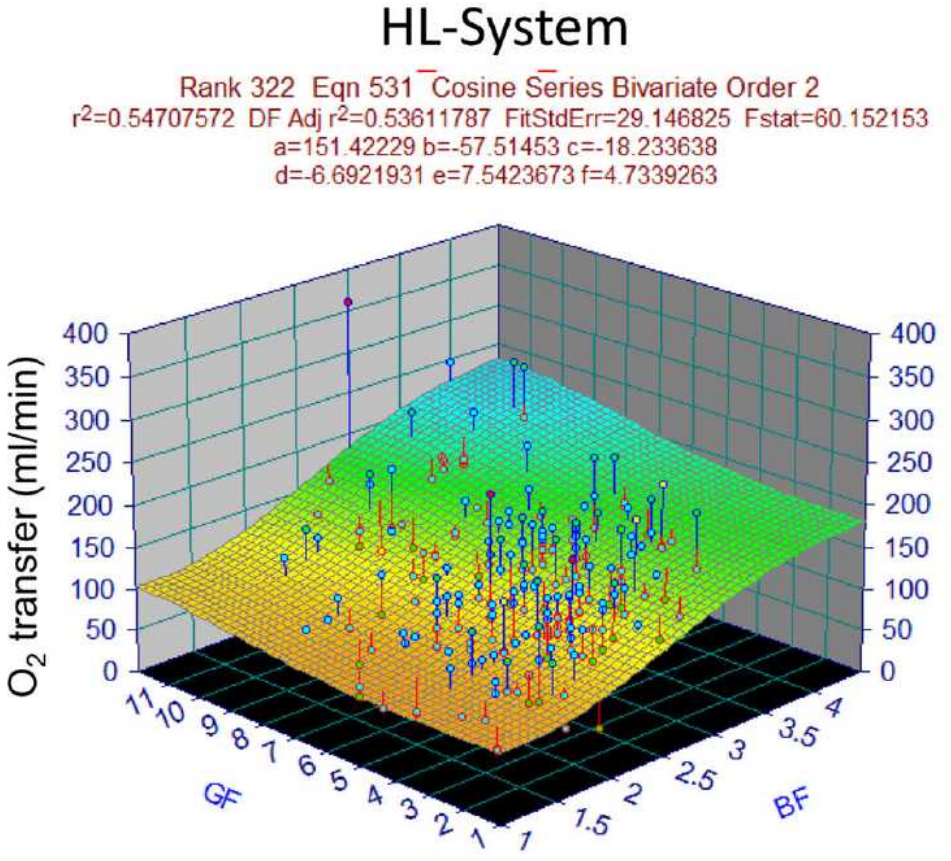
2. CO_2 Elimination

- efficiency depends on blood flow, gas flow and $PvCO_2$ (recirculation!)
- effects:
  - protective ventilation ↑
  - over-inflation ↓
  - work of breathing ↓
  - facilitation of extubation ?
  - avoidance of intubation?



Gas-transfer Capacity of MOs





Lehle K et al, ICM 2014;40:1870-77

Indication: ELSO

1. In hypoxic respiratory failure due to any cause (primary or secondary) ECLS should be considered when the risk of mortality is 50% or greater, and is indicated when the risk of mortality is 80% or greater.
    a. 50% mortality risk is associated with a $PaO_2/FiO_2 < 150$ on $FiO_2 > 90\%$ and/or Murray score 2-3.
    b. 80% mortality risk is associated with a $PaO_2/FiO_2 < 100$ on $FiO_2 > 90\%$ and/or Murray score 3-4 despite optimal care for 6 hours or more.

2. CO_2 retention on mechanical ventilation despite high Pplat (>30 cm H_2O)

3. Severe air leak syndromes

4. Need for intubation in a patient on lung transplant list

5. Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care)

www.ELSO.org/resources/guidelines

Indication for VV ECMO

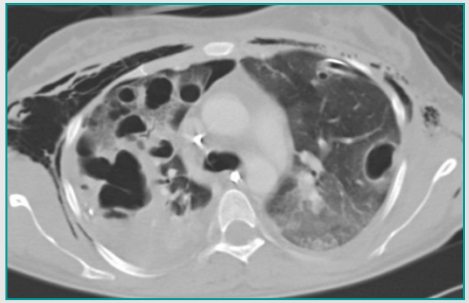
1. <u>rescue</u>

   vital gas exchange can not be secured by conventional means,
   and rapidly progressive hemodynamic instability
   (P/F < 60 mm Hg, and pH < 7.2, and PIP > 35 cm H_2O, and Nor > 1.5 mg/h)

2. <u>semielektive</u>

   lung protective ventilation not possible
   to secure vital gas exchange;
   no improvement after 12 – 24 hours

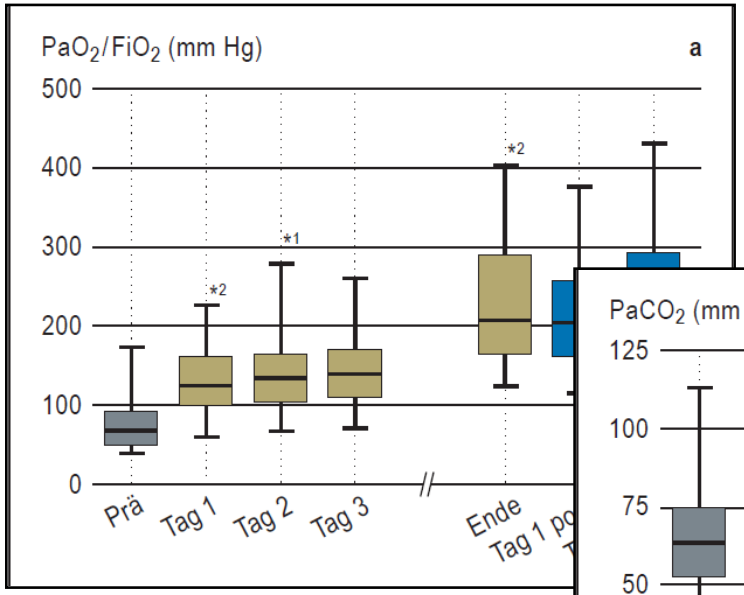
3. <u>given that:</u>
   - treatable cause
   - all conventional therapeutic methods optimized
   - no contraindication

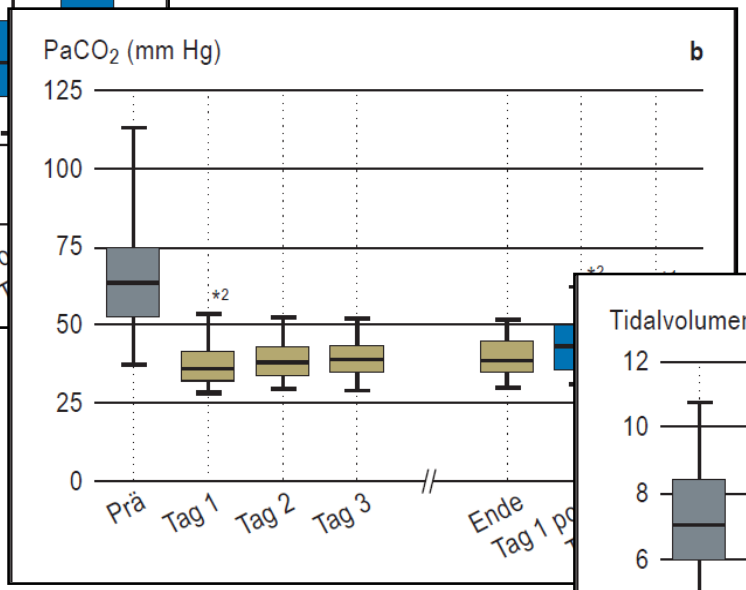


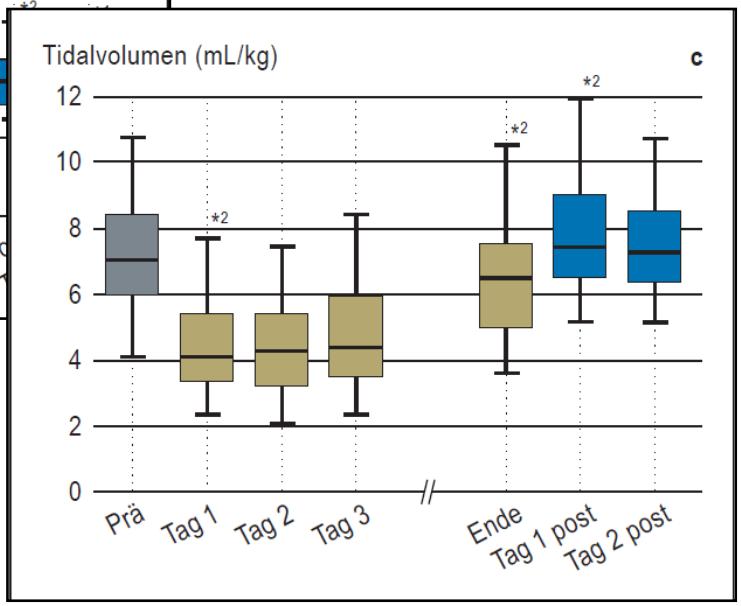
- PaO_2/FiO_2 < 80 mm Hg with PEEP > 15 cm H_2O
- uncompensated respiratory acidosis: pH < 7,15

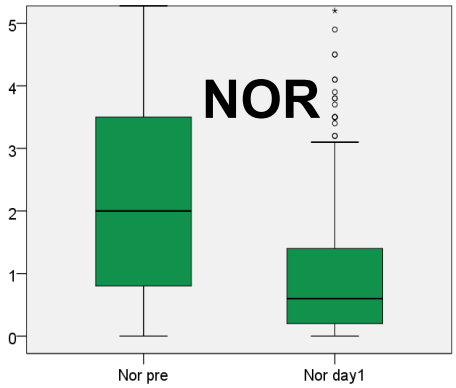
Brodie D, Bacchetta M, New Engl J Med 2011; 365:1905-14

Vv-ECMO: PaO_2/FiO_2 ,$PaCO_2$ and TV



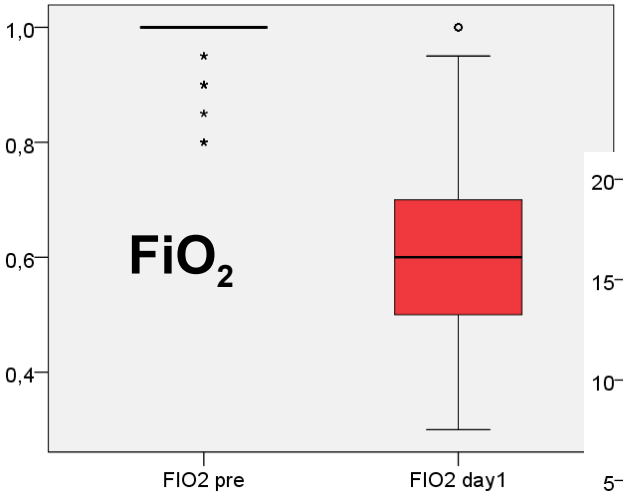


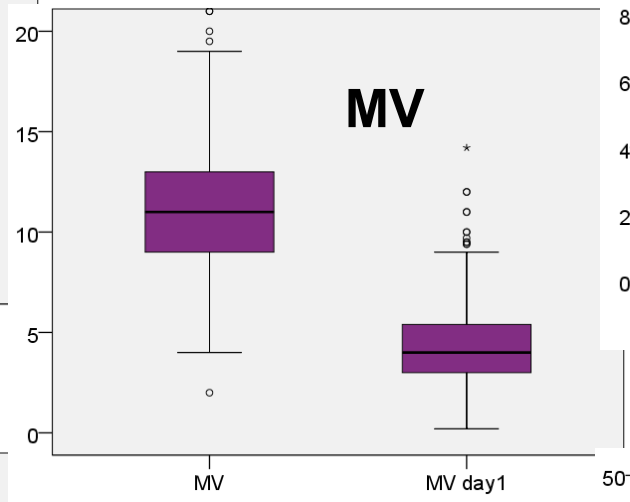


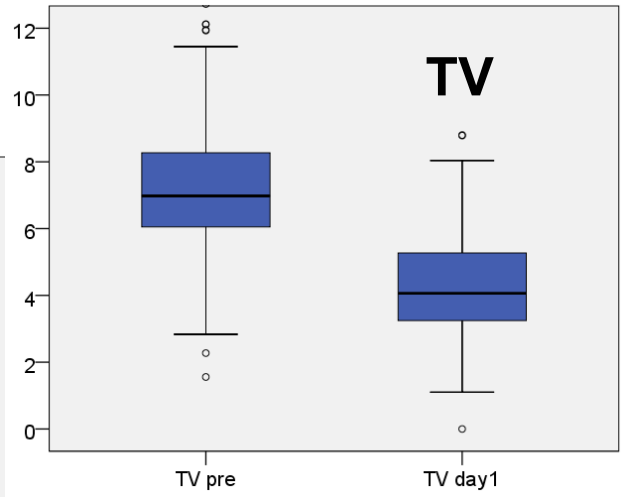


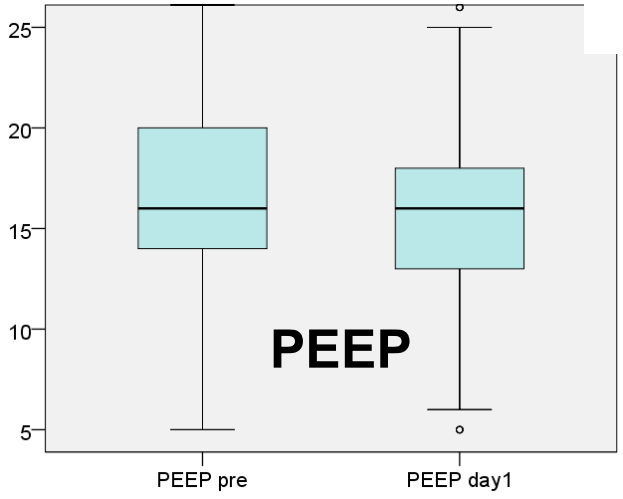
Müller et al, Dtsch Arztebl Int 2013;110:159-66

Ventilation on ECMO

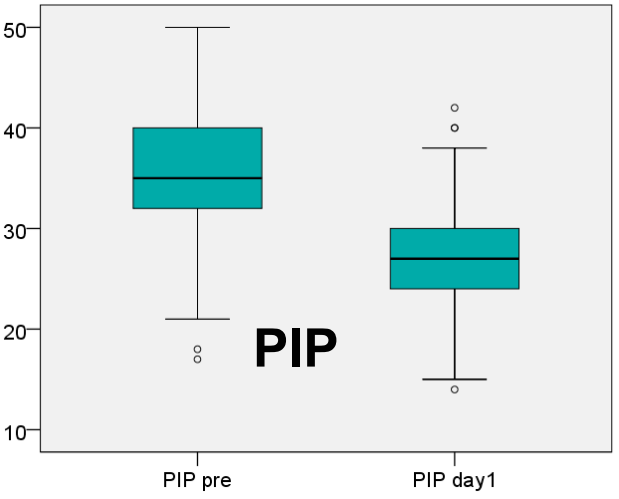








n = 375



Survival with modern ECMO

Study	Literature	Number	Age	Survival
ANZ ECMO	JAMA 2009;302:online Oct 12	68	34.4	75 %
Italian ECMOnet	Intensive Care Med 2011;37:1447	60	40	68 %
ELSO H1N1 registry (adults > 20 yrs)	www.elso.med.umich.edu/ April 13, 2011	218	?	70 %
CESAR	Lancet 2009;374:1351-63	68	39.9	63 %
UK ECMO for H1N1	JAMA 2011;306:online Oct 5	69	36.5	71 %
REVA Research Network	Am J Respir Crit Care Med 2013;187:276-85	123	42	64 %

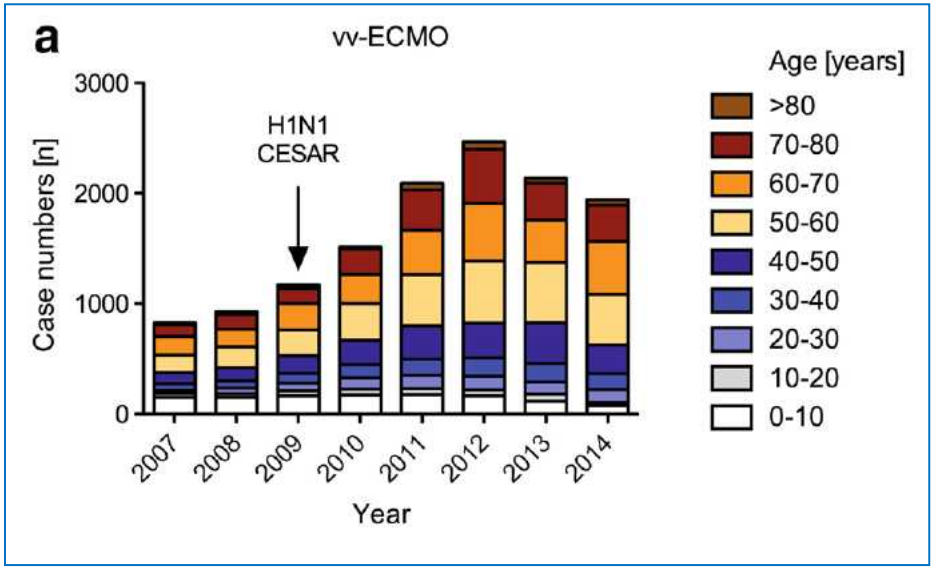
ORIGINAL

Extracorporeal membrane oxygenation: evolving epidemiology and mortality

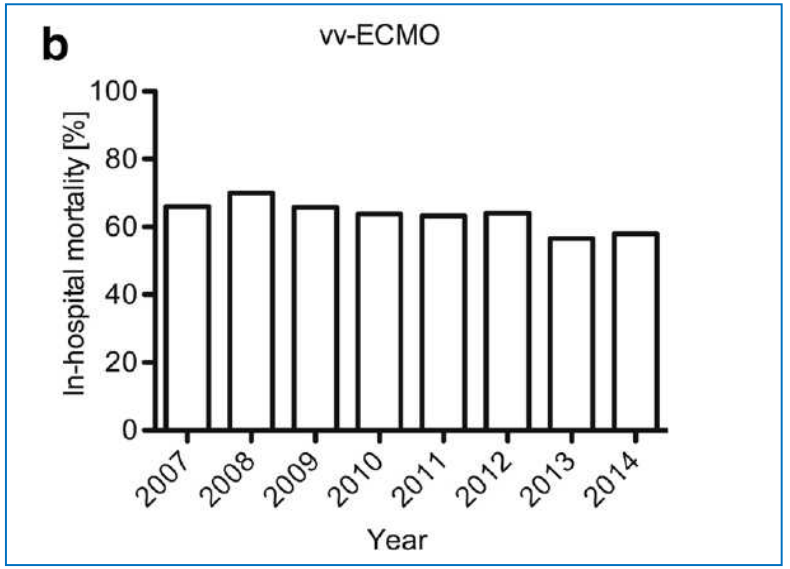
Christian Karagiannidis[1*], Daniel Brodie[2], Stephan Strassmann[1], Erich Stoelben[3], Alois Philipp[4], Thomas Bein[5], Thomas Müller[6] and Wolfram Windisch[1]

- incidence **VV-ECMO** 2014: 2.4/100 000 (n = 1944)
- in-hospital mortality 2014: 58 %

case numbers

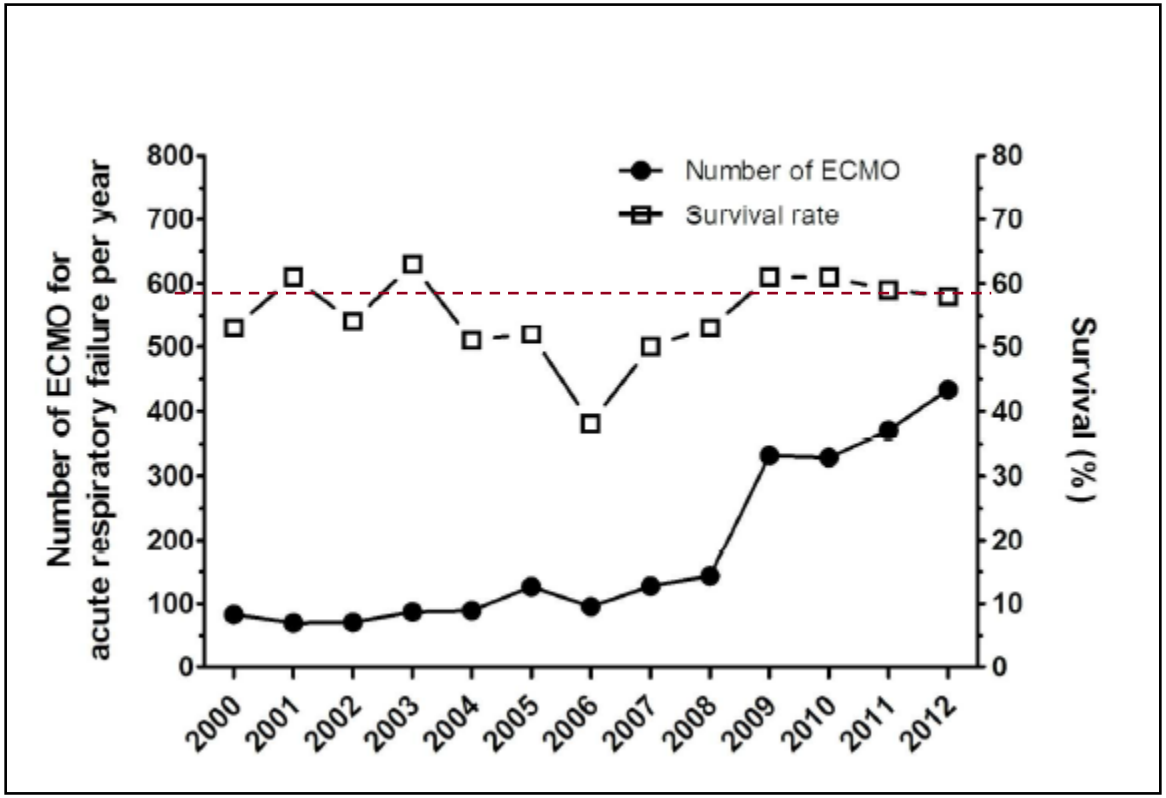


mortality



Intensive Care Med 2016, March 4 epub ahead of print

Survival RESP-Score Population



N = 2355

Age (years) 41 (28-54)

Schmidt M et al, AJRCCM in press 02.April 2014

Prediction of mortality in adult patients with severe acute lung failure receiving veno-venous extracorporeal membrane oxygenation: a prospective observational study

Critical Care 2014, **18**:R67 doi:10.1186/cc13824

CRITICAL CARE

Table 4 Novel mortality prediction models for ALF-patients receiving ECMO support

	Coefficient	OR	95% CI
Model 1 (pre-ECMO)			
Age (per 5 years)	0.176	1.193	(1.148-1.239)
Immunocompromised state	0.958	2.605	(1.316-5.158)
Minute ventilation (L/min)	0.098	1.103	(1.014-1.199)
Pre-ECMO haemoglobin (g/dL)	−0.182	0.834	(0.728-0.954)
Pre-ECMO lactate (mmol/L)	0.013	1.013	(1.004-1.023)
Intercept	−2.083		

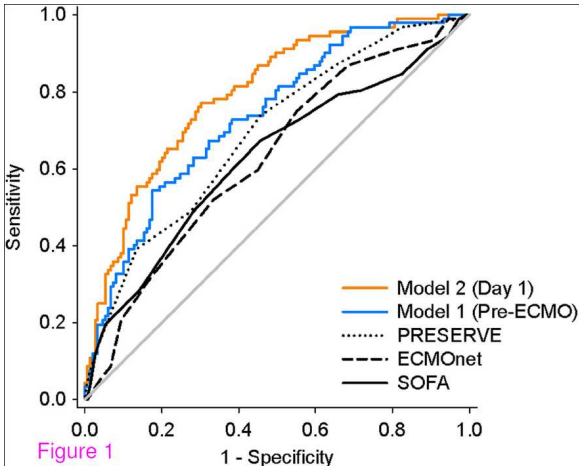


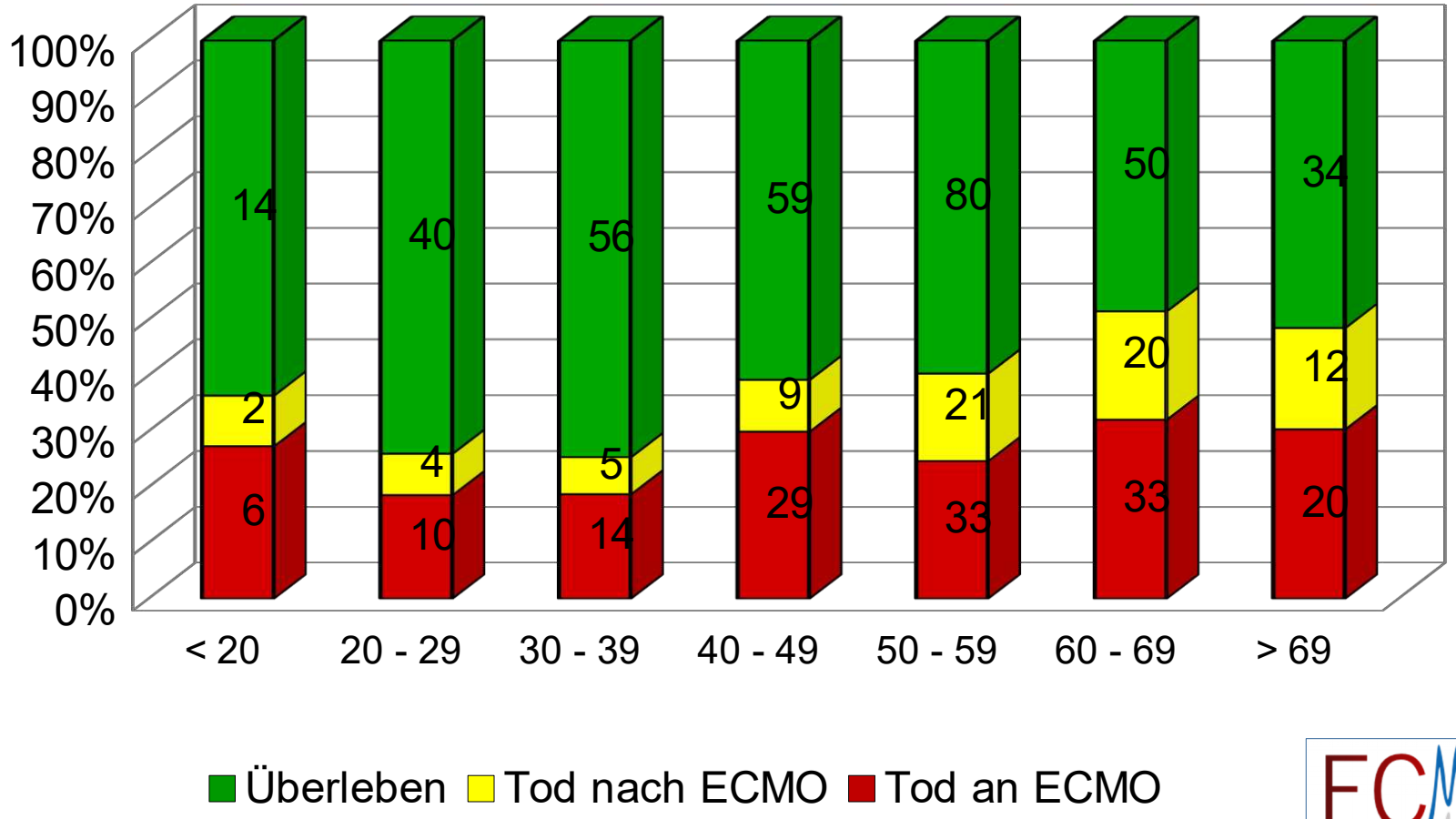
Figure 1

Model 2 (day 1):

age	day 1 FiO_2
immunocompromised state	day 1 fibrinogen
minute ventilation	day 1 norepi.
pre ECMO Hb	day 1 CRP

TB Enger...T Müller, Crit Care 2014;18:R67

Outcome according to age (n = 551)



Long-Term Survival in Adults Treated With Extracorporeal Membrane Oxygenation for Respiratory Failure and Sepsis*

Viktor von Bahr, MD[1]; Jan Hultman, MD, PhD[1,2]; Staffan Eksborg, PhD[3]; Björn Frenckner MD, PhD[2,4]; Håkan Kalzén MD[1,2]

Variable	Total	Pneumonia, Bacterial	Pneumonia, Viral	Pneumonia, Aspiration	Nonpulmonary Infection	Severe Inflammatory Response[a]	Traumatic Chest/ Lung Contusion	Other Respiratory Etiology[b]
N	255[c]	134	31	19	24	23	9	15
Age at treatment (yr)	46 (33–58)	49 (37–59)	44 (29–53)	46 (32–57)	55 (23–66)	34 (24–46)	38 (23–51)	44 (33–63)
Sex, male, *n* (%)	166 (65)	83 (62)	19 (61)	11 (58)	18 (75)	16 (70)	9 (100)	10 (67)
Time on extracorporeal membrane oxygenation ICU[d] (d)	8 (4–17)	9 (4–17)	15 (7–34)	5 (3–15)	4 (3–8)	6 (2–19)	7 (4–10)	7 (4–12)
Cannulation, VV,[e] *n* (%)	135 (53)	78 (58)	14 (45)	10 (53)	9 (38)	9 (39)	5 (56)	10 (67)
Cannulation, VA, *n* (%)	70 (27)	29 (22)	10 (32)	5 (26)	12 (50)	6 (26)	3 (33)	5 (33)
Converted to VV,[f] *n* (%)	13 (5)	7 (5)	3 (10)	0 (0)	0 (0)	3 (13)	0 (0)	0 (0)
Converted to VA, *n* (%)	37 (15)	20 (15)	4 (13)	4 (21)	3 (13)	5 (22)	1 (11)	0 (0)
Pao_2:Fio_2 ratio[g] at referral (mmHg)	54 (47–60)	54 (47–60)	51 (44–58)	56 (48–62)	52 (49–56)	52 (38–59)	56 (34–66)	61 (51–67)
Follow-up time in survivors (yr)	4.4 (2.1–9.3)	5.2 (2.2–10.7)	4.2 (1.4–4.4)	5.4 (4.4–6.8)	2.0 (1.3–6.2)	10.4 (1.3–10.6)	10.3 (6.8–12.8)	6.1 (3.6–11.9)
Follow-up time in diseased[h] (d)	48 (14–427)	56 (33–544)	*4/502* (*n* = 2)	*21/157/ 334/727* (*n* = 4)	*5/14/15/60* (*n* = 4)	*1/3/15/870* (*n* = 4)	*173/427* (*n* = 2)	12 (11–55)

Crit Care Med. 2017 Feb;45(2):164-170

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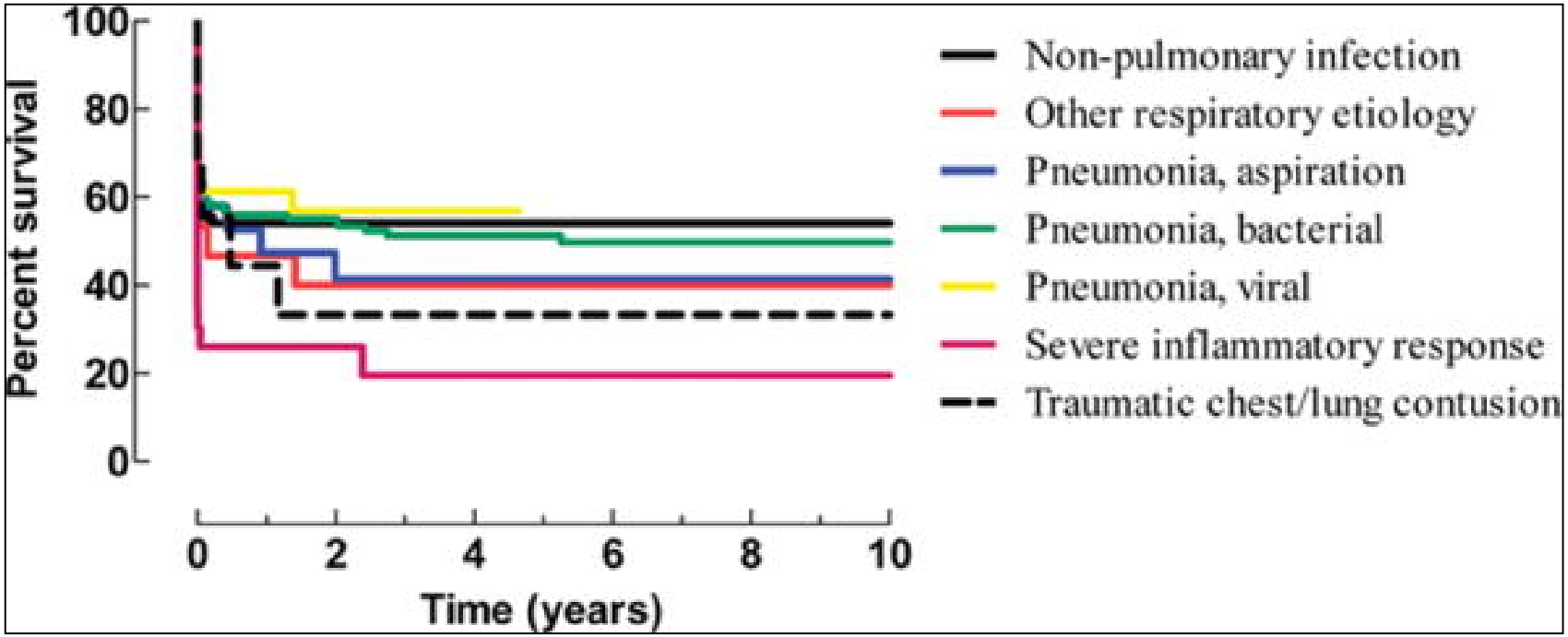
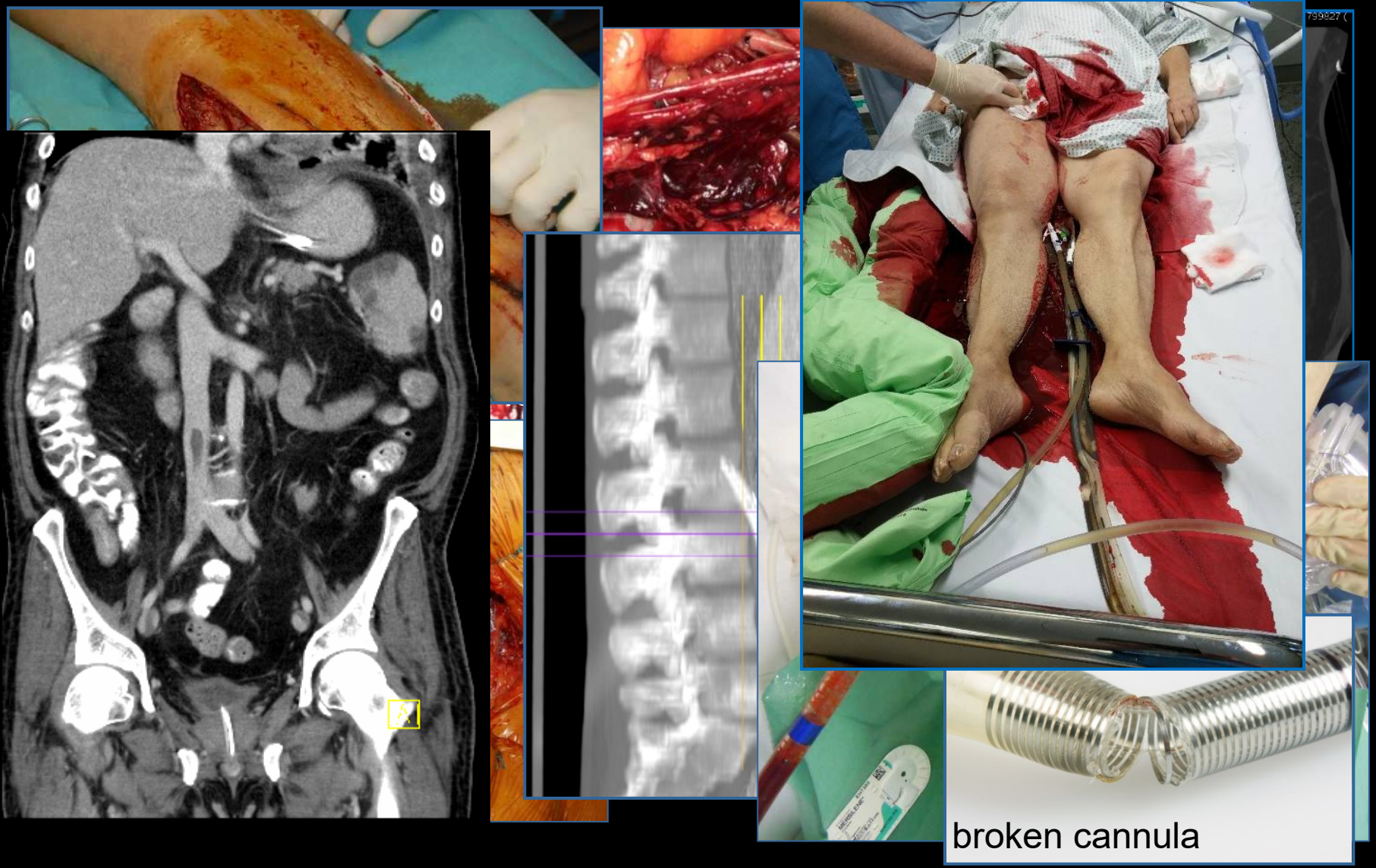
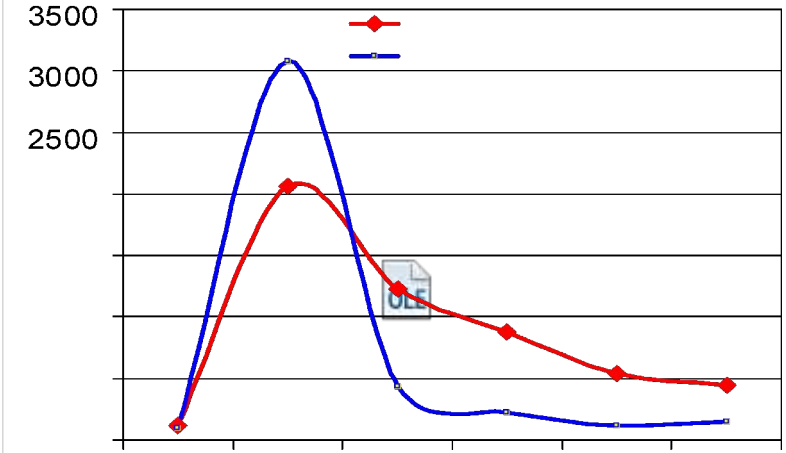


Crit Care Med. 2017 Feb;45(2):164-170

Risks of ECMO

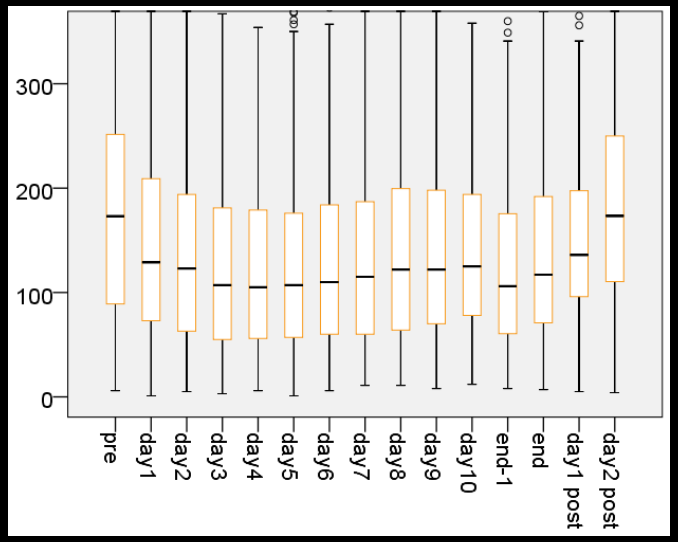


Risk of Technical Failure

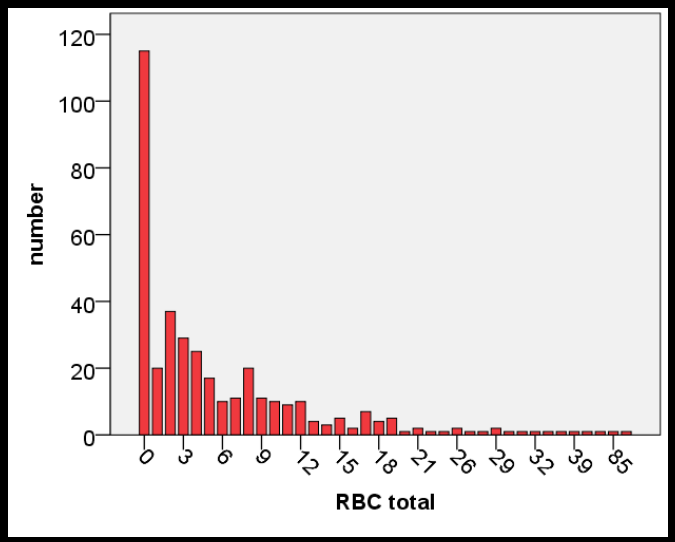


Avoid unnecessary interventions

- risk of bleeding:
  platelets 173 000 → 105 000 day 4 (61%)
  (n = 440)



- no unnecessary blood transfusions
  - ✓ Hb transfusion threshold 8.0 g/dL
  - ✓ RBCs/day on ECMO:
    0.31 (0.00;0.78)



VV-ECMO and Cerebral Complications: preliminary results

- 04/2006 – 10/2015

495 vv ECMO runs

CCT n=290

no pathology	ICB	ischemia
n = 226 (78 %)	n = 53 (18 %)	n = 11 (4 %)
survival	survival	survival
n = 142 (63%)	n = 27 (51%)	n = 8 (73%)

Requirements for an ECMO Center

Position Paper for the Organization of Extracorporeal Membrane Oxygenation Programs for Acute Respiratory Failure in Adult Patients

1. experience in the treatment of severe ARDS: tertiary care ICU
2. transport possible with ECMO: mobile team
3. experience with ECMO:
   - > 10 (20) cases per year
   - 24/7 trained personel: intensivists, nurses, (perfusionists)
4. management of complications:
   - blood bank, lab, CT 24/7
   - ECMO replacement equipment
   - vascular surgery, (abdominal-, thoracic surgery)
5. quality managment:
   - regular training
   - data base
   - M + M conference
   - participation in national or international registry

Am J Respir Crit Care Med. 2014 Sep 1;190(5):488-96.

Conclusion: ECMO: a breakthrough in care for respiratory failure ?

1. ECMO safes lifes.

2. indications:
   - relatively sure: severe refractory ARDS
   - uncertain: CO_2 elimination (avoidance of intubation? facilitated weaning?)
3. balance benefits versus risks
4. costs !
5. experience necessary: ECMO Center


EuroELSO 2017
6th EuroElso Congress on ECMO-ECLS
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ELSO
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4 - 7 MAY 2017
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