V-V ECMO indications and management

Universitätsklinikum Regensburg

ELSO Center of Excellence 2014

The Extracorporeal Life Support Organiziation

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V-V ECMO indications and management

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Intensive Care Med (2016) 42:889–896
DOI 10.1007/s00134-016-4273-z

patients receiving ECMO is steadily increasing. In-hospital mortality decreased over time and reached 58 and 66 % for vv-ECMO and va-ECMO in 2014, respectively. In addition, mortality steadily increased with age and was especially

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]

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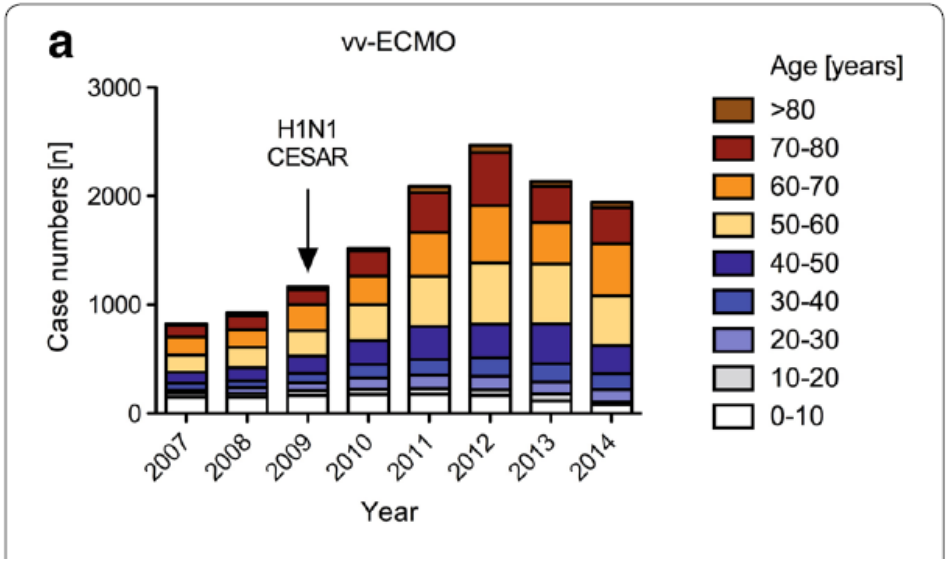
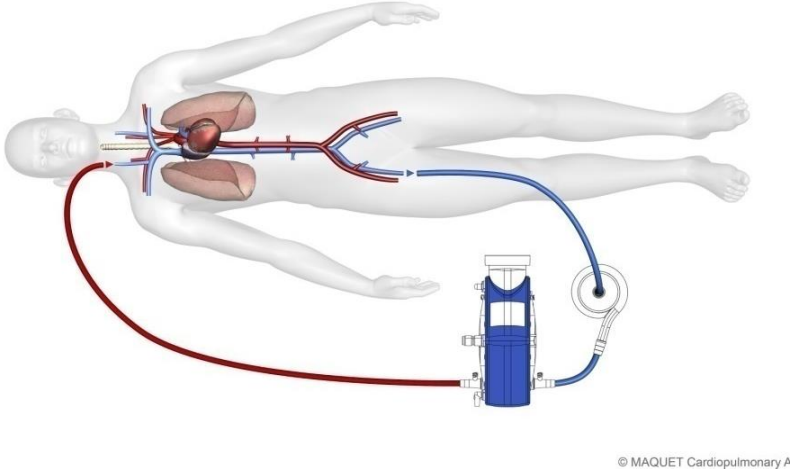
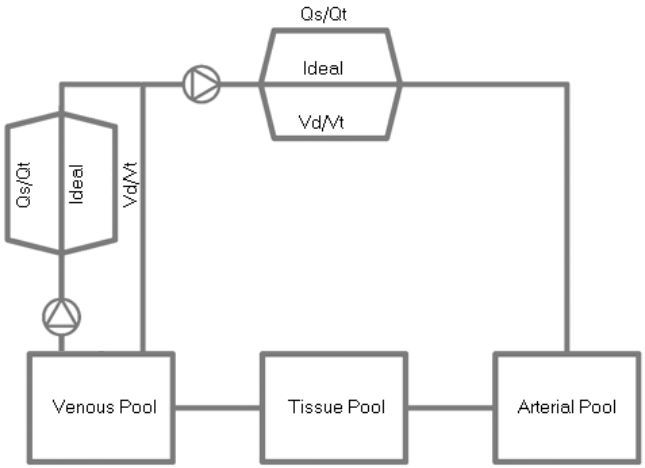


Basics

V-V ECMO concept





Two cannulaes

Femoral ven	>	Jugular ven
Jugular ven	>	Femoral ven
Femoral ven	>	Subclavia ven
Femoral ven	><	Femoral vein

Bi-caval-dual lumen Catheter

Jugular ven	(AVALON, Maquet)
Femoral ven	(Twinport, Novalung)
Jug ven	(Twinport, Novalung)

Pulmonary vascular restistance (PVR)

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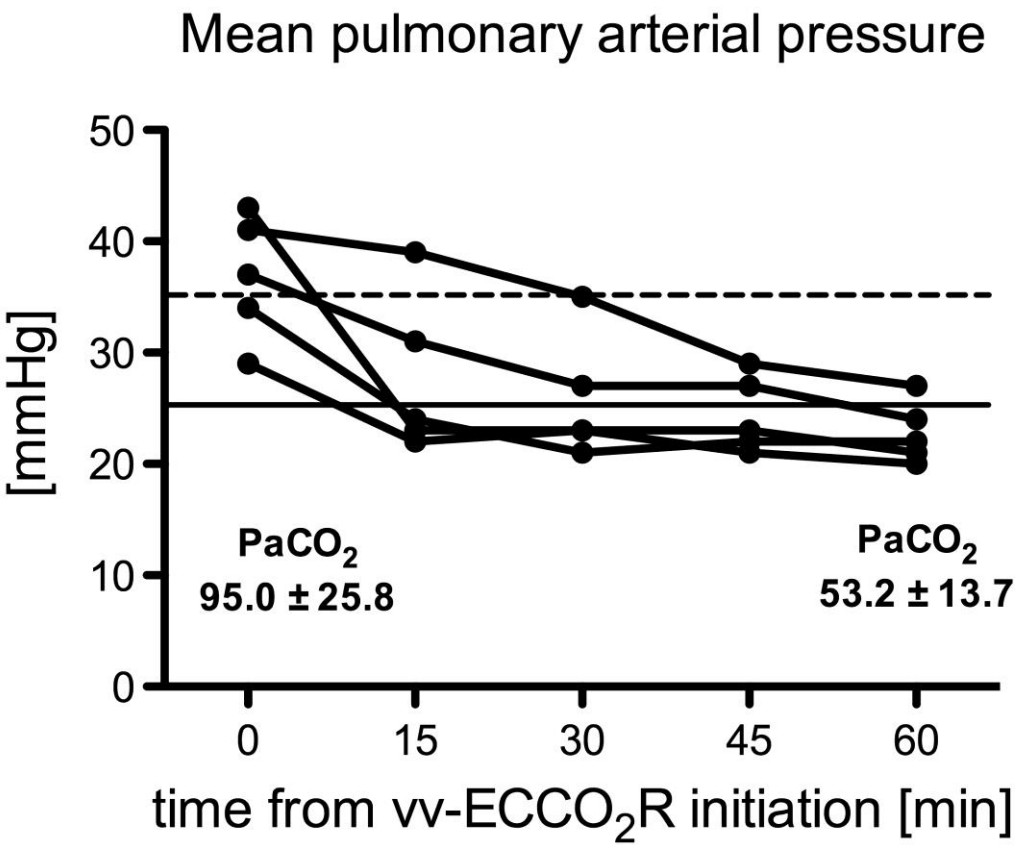

Extracorporeal CO_2 Removal improves pulmonary hypertension in acute exacerbation of severe COPD

Christian Karagiannidis[1*#], Stephan Strassmann[1#], Alois Philipp[2], Thomas Müller[2] and Wolfram Windisch[1]

Intensive Care Med DOI 10.1007/s00134-015-3917-8; Jul. 2015

Structur of a ECMO program

http://www.uniklinikum-regensburg.de/zentren/ECMO_Zentrum/index.php

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Home > Zentren > ECMO > Informationen für Ärzte > **Zuweisung Kontakte**

Informationen für Ärzte
Kontakt

Die zentralen Ansprechpartner für einen ECMO-Transport finden Sie unter:

Klinik und Poliklinik für Innere Medizin II

Schwerpunkte: Internistisches Lungenversagen
Pneumonie, Sepsis etc. , Zustand nach Reanimation

Tel.: 0941 944-7351 Fax.: 0941 944-7365

Klinik für Anästhesiologie

Schwerpunkte: Lungenversagen nach Polytrauma, peri- und postoperatives Lungenversagen

Tel.: 0941 944-7920 Fax.: 0941 944-7924

Klinik und Poliklinik für Herz-, Thorax- und herznahe Gefäßchirurgie

Schwerpunkte: Kardiogener Schock mit kardialen Unterstützungssystemen

Tel.: 0941 944-9834 Fax.: 0941 944-9832

Klinik und Poliklinik für Kinder und Jugendmedizin

Schwerpunkte: Lungenversagen, Sepsis

Tel.: 0941 944-2081 Fax.: 0941 944-2111

Zentrale Telefonnummer für Transportanfragen:

0941 9939-90

- Patienten / Besucher
- Einweiser
- Studierende
- Wissenschaftler
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ECMO

- Allgemeine Informationen
- Behandlungspartner
- **Informationen für Ärzte**
- **Zuweisung Kontakte**
- Publikationen
- Medizinische Leistungen
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The Extracorporeal Life Support Organiziation

Indications

ECMO in acute lung failure

Indication:

Acute reversible lung failure
refractory to conventional therapy

Definitinion:

PaO_2/FiO_2 **<** 80 mm Hg
under FiO2 = 1.0 +
PEEP = 20 cm H2O,
refractory resp. azidosis:
pH < **7,15**, **pCO_2 ++**

Contraindication:

Hard criteria
age > 75 years
poor life expectancy due to comorbidities

Weak criteria:
sepsis
ARDS > 10 days

ECMO in acute lung failure

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Enger *et al. Critical Care* 2014, **18**:R67
http://ccforum.com/content/18/2/R67

CRITICAL CARE

RESEARCH Open Access

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

Tone Bull Enger[4], Alois Philipp[1], Vibeke Videm[4,7], Matthias Lubnow[2], Alexander Wahba[5,6], Marcus Fischer[2], Christof Schmid[1], Thomas Bein[3] and Thomas Müller[2*]

Model 1	OR	(95% CI)
Age (per 5 years)	1.193	(1.148-1.239)
Immunocompromised state	2.605	(1.316-5.158)
Pre-ECMO hemoglobin (g/dL)	0.834	(0.728-0.954)
Pre-ECMO lactate (mmol/L)	1.013	(1.004-1.023)
Minute ventilation (mL/min)	1.103	(1.014-1.199)

Management

ECMO in acute lung failure

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Cannulation for V-v ECMO

klinikum-regensburg.de/zentren/ECMO_Zentrum/index.php

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Schwerpunkte: Kardiogener Schock mit kardialen Unterstützungssystemen

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Klinik und Poliklinik für Kinder und Jugendmedizin

Schwerpunkte: Lungenversagen, Sepsis

Tel.: 0941 944-2001 Fax.: 0941 944-2111

Zentrale Telefonnummer für Transportanfragen:
0941 9939-00

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ECMO in acute lung failure – canulation risk

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single dual lumen: Avalon
N: 108
Sever complications: 6 (2†)

both femoral venes
N: 13
Sever complications: none

seperate cannulation

N 407	V.femoral
N 351	V.jugularis
N 56	V. subclavia

Sever complications: four

single dual lumen: TwinPort
N: 31 Size: 24FR
Sever complications: two

Regensburg experiences (n= 557)
ECMO Database UKR (2007– 8/2016)

ECMO Management

Optimize cannula position (X-ray, avoid recirculation)

Optimize extracorporeal bloodflow

Optimize heamoglobin (consider transfusion)

Optimize ventilator settings

Diagnose Oxygenator dysfunction and consider replacement

ECMO Management - cannula position

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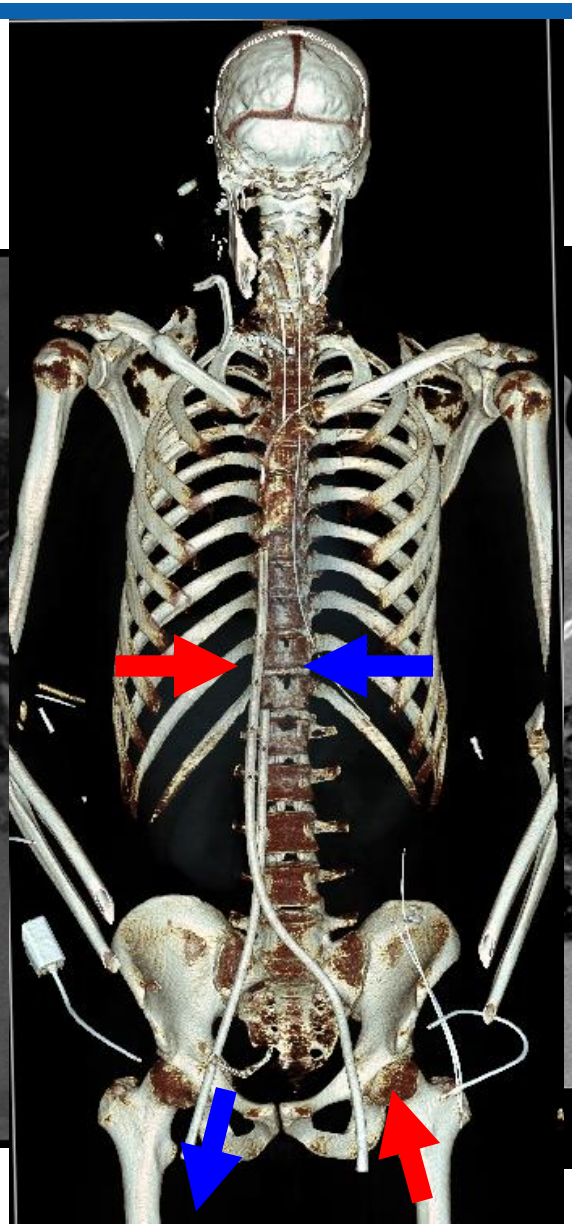


ECMO Management - ventilation

Common approach to mech. Ventilation in „Regensburg“

Bloodflow < 3.5 l/min, Gasflow > 4.0 l/min

two cannulas or singel access (Avalon or Novaport))

FiO_2 < 0.6

PEEP idem, PIP < 28 cmH_2O

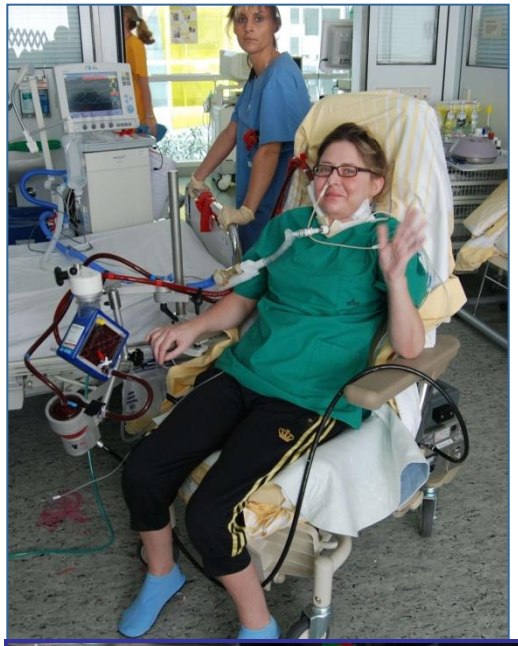
TV < 4 ml/kg pred. BW, MV < 5 L/min

I:E 1:1 – 4:1

SaO_2 ≥ 90%

$PaCO_2$ according to pH, usually 40 mmHg

ECMO Management: run-up



insertion of cannula:

US control of vessels

Seldinger - technique:

1000 - 5000 IU heparin

femoral vein: **38 cm long; 21 or 23 Fr**

internal jugular: **15 cm long; 17 or 19 Fr**

alt.: double-lumen catheter

blood flow:

start with 2.0 l/min bloodflow

increase (depending on PaO_2, saO_2

gas flow:

start with 2.0 l/min

increase (depending on $PaCO_2$)

anticoagulation:

heparin i.v.: aPTT ~ 1,5 normal

add Aspirin, if no CI

adapt ventilation !

chest – X-ray, (abdominal US)

ECMO Management: run-up

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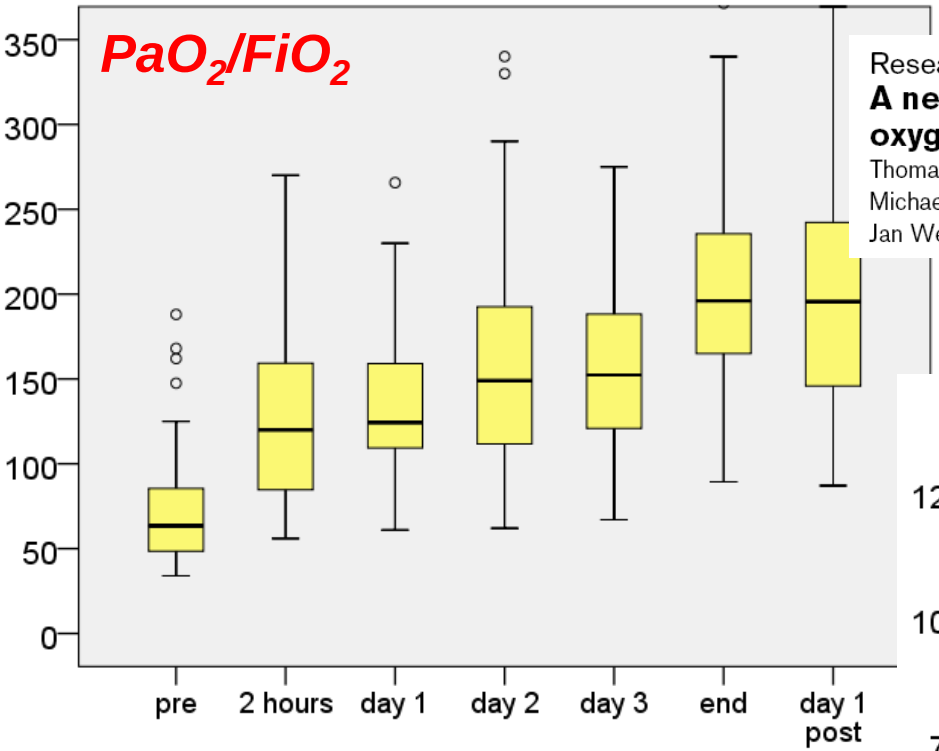


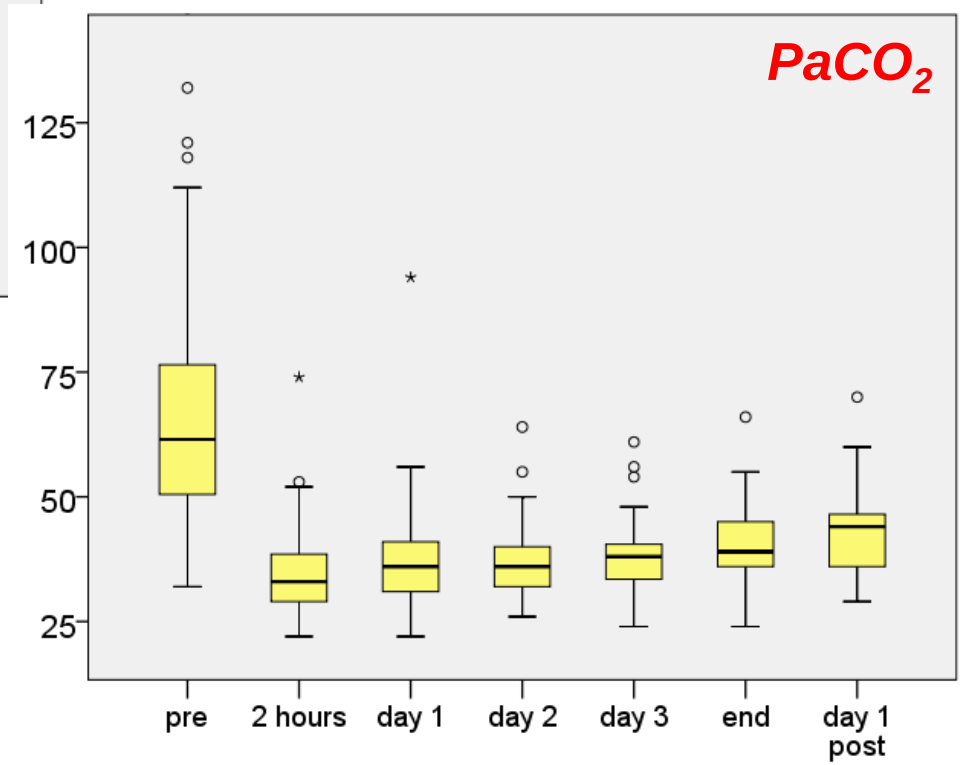
Research

Open Access

A new miniaturized system for extracorporeal membrane oxygenation in adult respiratory failure

Thomas Müller[1], Alois Philipp[2], Andreas Luchner[1], Christian Karagiannidis[1], Thomas Bein[3], Michael Hilker[2], Leopold Rupprecht[2], Julia Langgartner[4], Markus Zimmermann[3], Matthias Arlt[3], Jan Wenger[1], Christof Schmid[2], Günter AJ Riegger[1], Michael Pfeifer[1] and Matthias Lubnow[1]

Critical Care 2009,13:R205



Bloodflow: 2,7 +/- 0,6 l/min
Gasflow: 6,0 +/- 2,3 l/min
O_2 Transfer: 154 +/- 47 ml/min
CO_2 Transfer: 201 +/- 58 ml/min
(n = 160)

ECMO Management - recirculation

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Cannulation:
Jugular vene 21Fr 15 cm long
Femoral vene 23Fr 38 cm long

0 vs 19 %

3.0 vs 4.5 l/min bloodflow

ECMO Management - weaning

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ECMO + protective ventilation treatment of ARDS

↓

improved gas exchange: for 24 hrs
FiO_2 < 0,40
PaO_2 ~ 80 mm Hg
$PaCO_2$ ~ 35 mm Hg

→ **yes** →

ECMO - Weaning
reduce blood flow ~ 1,5 l/min (24 hrs)
reduce gas flow ~ 1,0 l/min (24 hrs)

↓

blood gases and ventilation stable

↓

stop gas flow ~ 120 min
stop heparin

↓

blood gases, ventilation stable

↓

yes

↓

remove ECMO

no ←

↓

no

↓

reevaluate in 24 hours

CO_2 removal to facilitate extubation

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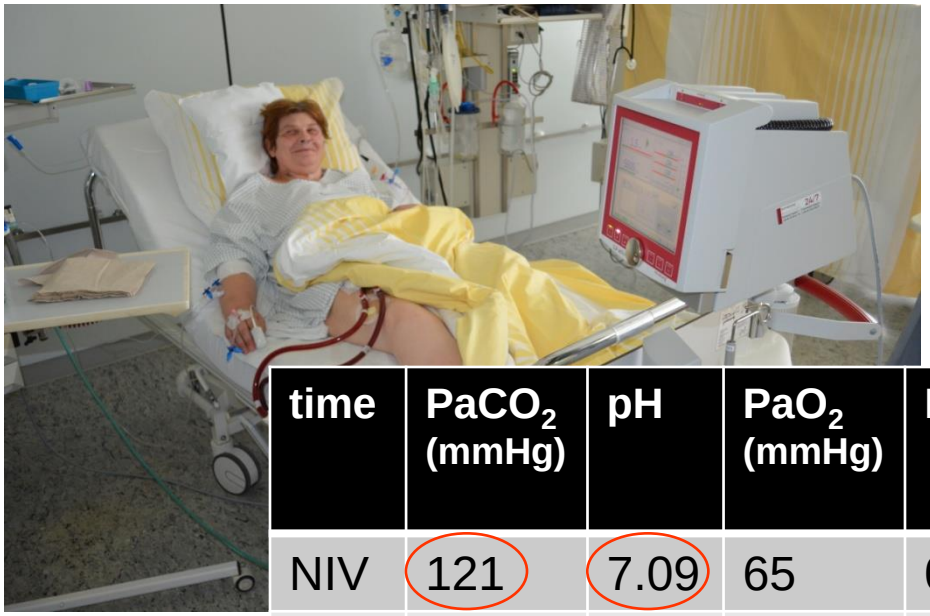

56 yrs,
exacerbated COPD
NIV failure
referral intubated:
24 Fr double-lumen cannula femoral

time	$PaCO_2$ (mmHg)	pH	PaO_2 (mmHg)	FiO_2	blood flow (L/min)	gasflow (L/min)	CO_2 transfer (mL/min)	O_2 transfer (mL/min)
NIV	121	7.09	65	0.5				
MV	81	7.29	63	0.5				
2 hs	53	7.45	55	0.4	1.9	4	177	113
d1	49	7.46	54	4l	1.8	8	236	124
d2	45	7.42	60	4l	1.7	5	150	136
d3	50	7.40	68	4l	1.6	3	91	72
d4	49	7.39	66	4l	1.4	1	40	58
d5	44	7.43	60	3l	1.4	2	104	76

Anticoagulation managment on ECMO - How we do it

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Name	substance	measured	range
Heparin	unfraktioniertes Heparin	aPTT, ACT	50 – 60; 130 - 160
Argatroban	Antithrombin Inhibitor	aPTT	~ 50
Clexane	low-moleculare Heparin	anti-Xa-Activität	?

Datum: 26.08.2016 Verlaufstag im KH

Laborwerte

Klinische Chemie

Kreatinin [mg/dl]:	1,3	Bilirubin ges.:	1,5
Harnstoff [mg/dl]:	59	Bilrubin direkt:	0,9
CK [U/l]:	774	Eiweiss:	
MB [U/l]:	4	Albumin:	26
GOT [U/l]:	3609	CRP:	120
GPT [U/l]:	3205	PCT:	23
Alk Phosphase:	124	S100:	
LDH [U/l]:	982	NSE:	80
Lipase [U/l]:		Troponin:	
CHE:			

Gerinnung

Quick:	67
INR:	1,3
PTT:	47
Fibriogen:	394
D-Dimer:	7
ATIII:	40
freiesHb:	84
Fa_VIII:	
vWF_Ag:	
vWF_Aktiv:	
Fa_XIII:	

Hämatologie

Leukozyten:	9,0
Hb:	9,4
HK:	28
Thrombozyten:	96

Multiplate

ASP:	
ADP:	
Trap:	

Rotem

EXT_A10:	
EXT_CT:	
EXT_CFT:	0
EXT_MCF:	
INT_A10:	
INT_CT:	
INT_CFT:	
INT_MCF:	
Fib_A10:	
Fib_MCF:	

Anticoagulation managment on ECMO - How we do it

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Hemostatic Changes During Extracorporeal Membrane Oxygenation: A Prospective Randomized Clinical Trial Comparing Three Different Extracorporeal Membrane Oxygenation Systems

Maximilian V. Malfertheiner, MD[1]; Alois Philipp, ECCP[2]; Matthias Lubnow, MD[1]; Florian Zeman, MD[3]; Tone Bull Enger, MD[4]; Thomas Bein, MD[5]; Dirk Lunz, MD[5]; Christof Schmid, MD[2]; Thomas Müller, MD[1]; Karla Lehle, PhD[2]

Conclusions: Over time, miniaturized veno-venous extracorporeal membrane oxygenation therapy increasingly activates coagulation. The different types of membrane oxygenators and pumps did not significantly alter hemostasis. (*Crit Care Med* 2016; XX:00–00)

Throubelshooting

Technical complications of ECMO

Primary complications:

those that occur during the process of initiating ECMO

Secondary complications:

those that develop in response to the pathophysiology of extracorporeal circulation.

Technical-induced hemolysis in patients with respiratory failure supported with veno-venous ECMO – Prevalence and Risk Factors

Karla Lehle[1*], Alois Philipp[1], Florian Zeman[4], Dirk Lunz[3], Matthias Lubnow[2], Hans-Peter Wendel[5], Laszlo Göbölös[6], Christof Schmid[1], Thomas Müller[2]; PLOS ONE Dec 2015

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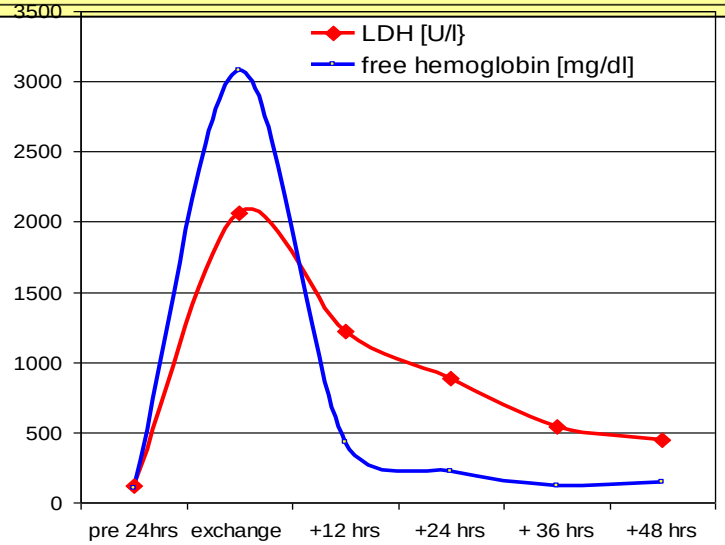
Zeit	FiO2	aPaO2	aSätt	aPaCO2	a PH	Hb	MAP	Noradrenalin	MV	TV	Lac.	sO2 v. MO	Gasf.	O2-Trans. MO	Flow	CO2_Trans. MO	AST	LDH	PTT	D-Dimer	Fib.	Thr	fr. Hb
prä Impl.	1,00	98	89	45	6,99	13,0	69	8,00	45,6	7	55						132	1063	52	35	348	80	
1.Tag	0,80	76	95	40	7,37	12,0	67	2,40	4,0	345	61	54	6	255	3,8	243	10605	10506	120	35	252	40	
2. Tag	0,80							3,00			161				3,8		20099	14630					
3. Tag	0,80					10,0		2,50			159				3,5							45	
4. Tag	0,50	71	91	37	7,34	9,7	71	2,20	3,0	263	62	54	6	204	3,0	189	1525	2556	61	22	129	46	
5. Tag	0,60	82	95	30	7,41	8,6	66	1,80	3,5	290	23	64	3	147	3,0	165	1083	1860	54	29	109	27	
6. Tag	0,45	85	95	37	7,37	8,0	75	1,30	5,0	506	17	60	5	159	3,0	132	451	1121	54	35	214	14	90
7. Tag	0,40	95	98	33	7,4	8,9	74	1,20	3,6	363	11	68	5	143	3,1	127	252	927	42	32	159	28	121
8. Tag	0,40	72	94	34	7,39	8,3	73	0,50	4,0	318	12	76	4	115	2,5	120	169	702	38	14	179	18	72
9. Tag	0,45	69	93	40	7,4	8,6	50	0,10	4,0	334	12	69	4	110	2,3	159	121	557	37	20	140	26	79
10. Tag	0,45	95	98	47	7,35	10,2	60	0,30	3,5	376	12	80	3	65	1,5	176	110	510	36	18	206	36	72
ECMO Ende	0,35	62	90	42	7,38	8,9	83	0,80	4,2	376	16	53	3	114	1,7	127	194	1271	42	11	249	54	2117
2Std.n. ECMO	0,40	72	93	50	7,32	8,5	91	6,00	8,0	567	13	53						1228	34	8	264	91	680
1.Tag.n. ECMO	0,50	80	96	44	7,32	7,4	75	1,30	12,0	492	12						126	725	38	7	274	71	222
2.Tag.n. ECMO	0,40	75	94	44	7,29	9,3	71	1,40	11,0	616	16						112	587	43	8	307	55	127



Efficiency in Extracorporeal Membrane Oxygenation — Cellular Deposits on Polymethypentene Membranes Increase Resistance to Blood Flow and Reduce Gas Exchange Capacity; *Karla Lehle, Alois Philipp, et. al., ASAIO J 2008 Nov-*

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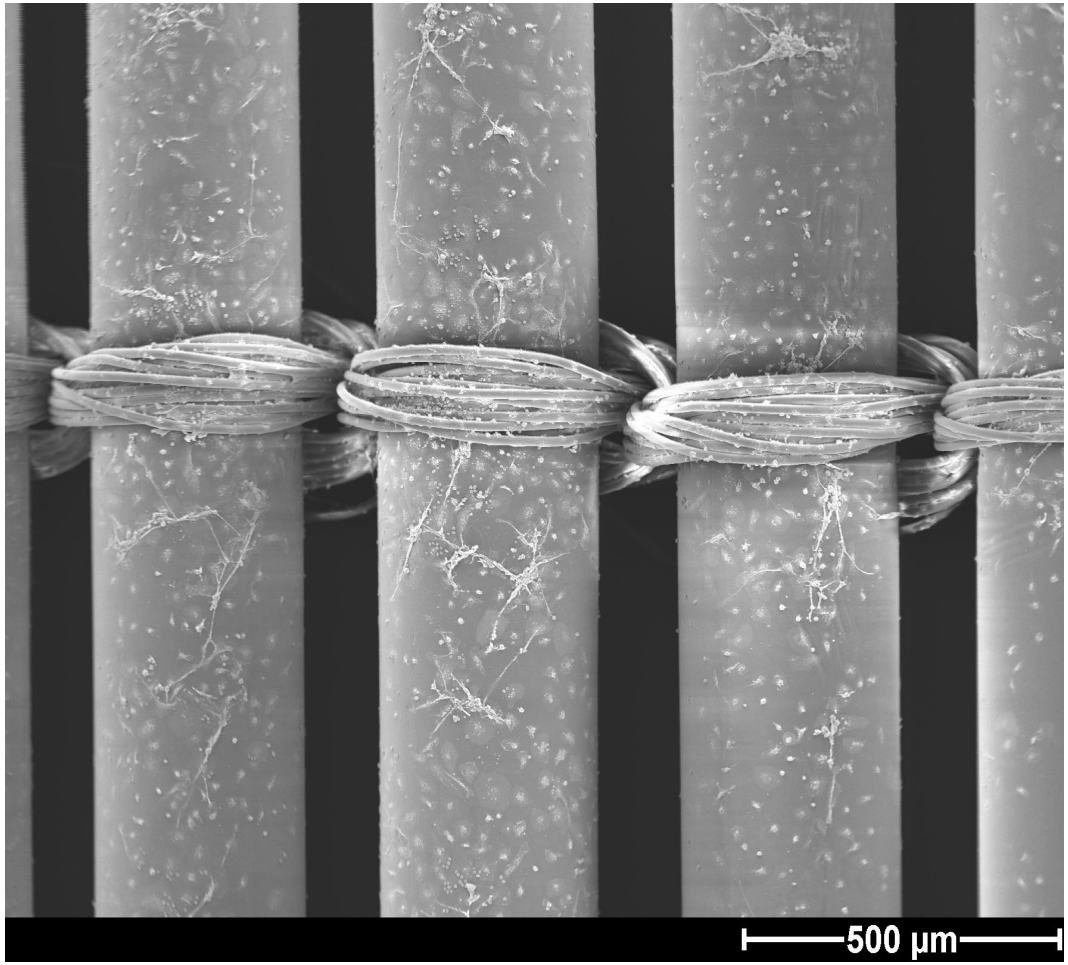
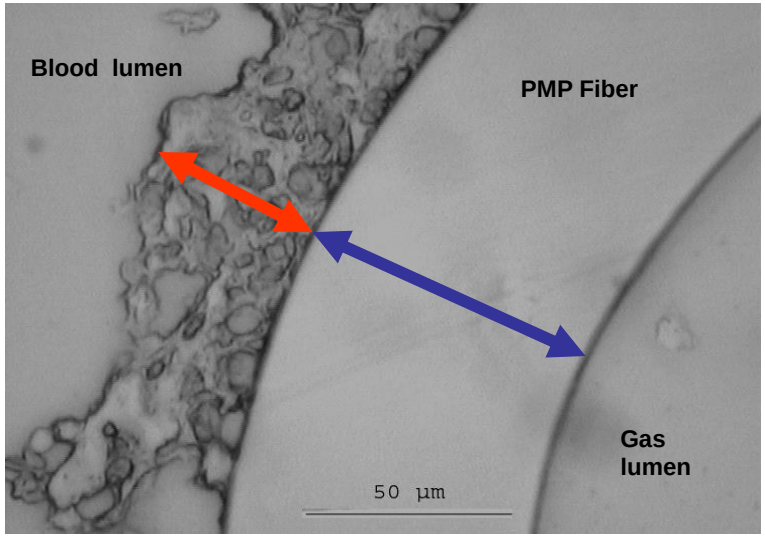
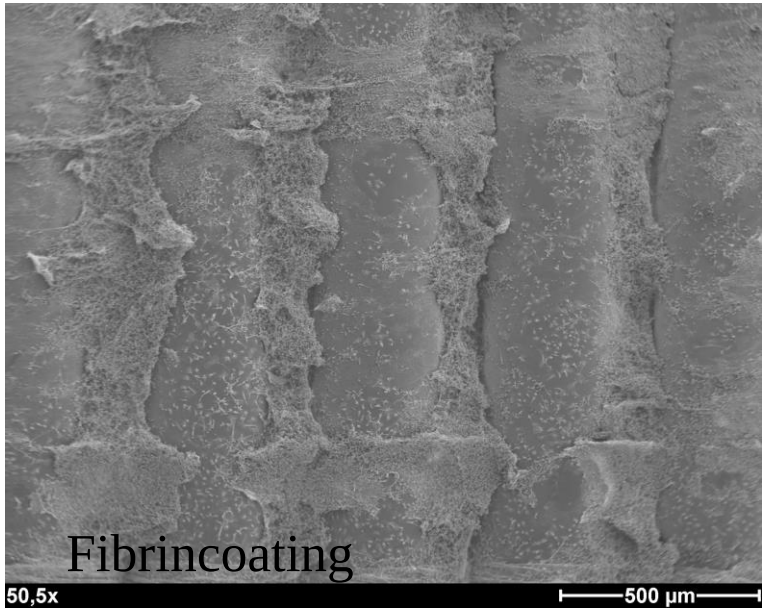
Impaired gasexchange







D-Dimeres as an early marker for oxygenator exchange in extracorporel membrane oxygenation

Lubnow M., Philipp A., Dornia C., Schroll S., et. al.; J. of Critical Care, 2014

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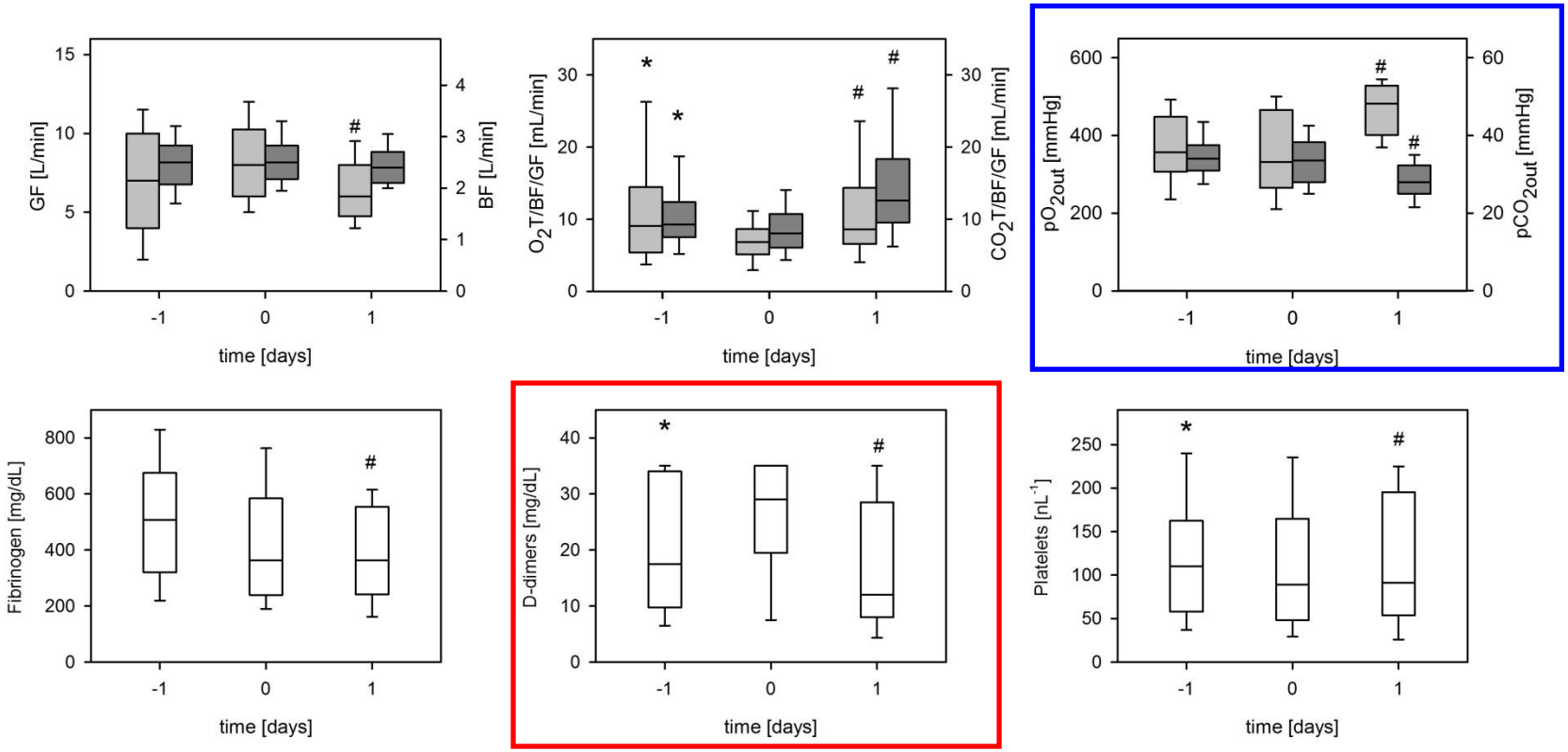

PLOS | ONE

inikum Regensburg

RESEARCH ARTICLE

Technical Complications during Veno-Venous Extracorporeal Membrane Oxygenation and Their Relevance Predicting a System-Exchange – Retrospective Analysis of 265 Cases

Matthias Lubnow[2]*, Alois Philipp[1], Maik Foltan[1], Tone Bull Enger[1], Dirk Lunz[3], Thomas Bein[3], Assad Haneya[1], Christof Schmid[1], Günter Riegger[2], Thomas Müller[2], Karla Lehle[1]

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Citation: Lubnow M, Philipp A, Foltan M, Bull Enger T, Lunz D, et al. (2014) Technical Complications during Veno-Venous Extracorporeal Membrane Oxygenation and Their Relevance Predicting a System-Exchange – Retrospective Analysis of 265 Cases. PLoS ONE 9(12): e112316. doi:10.1371/journal.pone.0112316

Conclusions: The majority of ECMO system-exchanges could be predicted by regular inspection of the complete ECMO circuit, evaluation of gas exchange, pressure drop across the MO and laboratory parameters (DD, FG, platelets, LDH, frHb). These parameters should be monitored in the daily routine to reduce the risk of unexpected ECMO failure.

Support with V-v ECMO (2006 – 8/2015)

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Results ECMO-Center Regensburg

Support with V-v ECMO (2006 – 8/2015)

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Diagnosis	Total N 546	Gender *[% male]*	Age [years]	ECMO [days]	Weaned %	Discharged 60 %
Pneumonia Sepsis	314	66	51 ± 14	13 ± 10	**76**	**64**
Extrapulmonary sepsis	123	72	50 ± 14	7 ± 6	**62**	**51**
Trauma related **(combat trauma, 16 pat.)**	57	92	**34** ± 17	6 ± 3	**75**	**70**
Others (pre PTx, pulmEmb.)	60	58	52 ± 17	14 ± 13	**53**	**45**

Transport n=250; 46 %